Evaluation of the immediate effects of preclinical treatment of severely injured trauma patients by Helicopter Trauma Team in the Netherlands

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Bernard L. Hübner
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Bernard L. Hübner
Jol 70
1186 SP Amstelveen
the Netherlands

telephone: +31 6 28 26 96 83 / +31 20 441 54 53
e-mail: blhubner@cybercomm.nl

VRIJE UNIVERSITEIT

Evaluation of the immediate effects of preclinical treatment of severely injured trauma patients by Helicopter Trauma Team in the Netherlands

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door

Bernard Laurens Hübner

geboren te Amsterdam

Promotoren: prof.dr. H.J.Th.M. Haarman
prof.dr. J.J. de Lange

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Introduction

On a global scale, it has been estimated that close to 4 million people die worldwide each year because of external causes such as accidents and violence; this constitutes approximately 8 % of all deaths, chiefly among adults [167].

In the Netherlands alone, in 1995 5,173 individuals died because of trauma, which accounted for approximately 3.8% of all deaths in the Netherlands.

Especially high are the relative number of fatalities among adolescents: more than half of all deaths in the age group between 15 and 30 years for males, and in the age-group between 15 and 19 years for females are due to external causes of injury and poisoning [71].

Nature of the accident:	Males:		Females:		Total:	
	Absolute numbers	Males per 100,000 of the population	Absolute numbers	Females per 100,000 of the population	Absolute numbers	Total per 100,000 of the population
Traffic accident	887	11.6	354	4.5	1241	8
Accidental fall	559	7.3	983	12.6	1542	10
Accidental drowning	73	1	18	0.2	91	0.6
Suicide and self-inflicted injury	1000	13.1	511	6.5	1511	9.8
Homicide	118	1.5	75	1	93	1.2
Other external causes	396	5.2	199	2.5	595	3.8
Total	3033	39.7	2140	27.4	5173	33.5

Table 1: Mortality from external causes of injury and poisoning, by nature of accident and sex in 1995 [71]

In table 1 and figure 1 the traumatic causes of death in 1995 for the Dutch population are shown; contrary to popular belief, traffic accidents do not rank as the first cause of traumatic death. Suicide accounts for more deaths among men, whereas for women, more deaths are caused by accidental falls as well as suicide.

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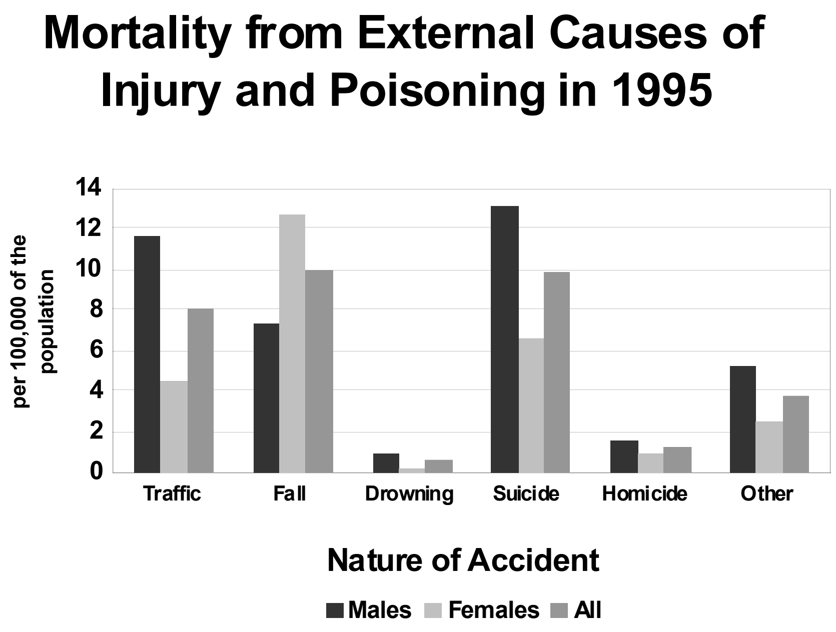

Figure 1: Mortality from external causes of injury and poisoning, by nature of accident and sex [71]

Sex/Age	0	1-4	5-14	15-19	20-29	30-39	40-49	50-59	60-69	70-79	80+	Total
Males	9	46	60	144	462	480	441	293	281	321	496	3033
Females	8	17	28	44	153	167	157	155	167	286	958	2140

Table 2: Absolute number of males and females who died due to external causes of injury and poisoning in the Netherlands in 1995 [34]

Table 2 shows the number of persons who died due to external causes of injury and poisoning per sex. It is most important to note that young males, between 20 and 49 years of age are especially at risk, as are females over 80. Many of the fatal trauma victims of old age suffer relatively minor traumas, such as fractures of the femoral collum, usually following domestic falls, but die later in hospital due to complications of operation and anesthesia in combination with old age and preexistent disease.

	Males 1970 to 1995	1990 to 1995	Females 1970 to 1995	1990 to 1995
Traffic injuries	-2,8	-1,7	-2,7	-3,2
Accidental fall	-2,1	-1,6	-2,9	-2,7
Accidental drowning	-3,9	-18,5	-3,2	-10
Suicide	+0,5	+0,9	-0,4	-1,6
Homicide	+5,3	+5,5	+6,7	6,7
Other causes	-1,9	-4	-2	-5,5
Total	-2,0	-1,2	-2,4	-2,8

Table 3: Percentage change of age-adjusted mortality from six causes of death in the main group of external causes of injury and poisoning, by sex and period in 1970-1995 [71]

Even though all causes of injury - except for homicide and male suicide - have shown a decrease in incidence for the past 25 years, as illustrated in table 3, trauma remains a highly important cause of death and suffering for all age groups. In 1995, the total number of years lost before the age of 65 for the whole population in the Netherlands as a result of external causes of injury and poisoning was 81,253 [34]. Lost by men were 59,662 years, thereby outranking all other causes of death, and the number of lost years by women were 21,591, at third place behind deaths due to malignant neoplasms and diseases of the circulatory system.

Direct medical costs of trauma in the Netherlands in 1988 were calculated at 952 million US Dollars per year, or almost 5% of the total health care budget. Indirect costs of injuries were estimated at 702 million US Dollars per year in a scenario called 'Friction Cost Method' which takes into account 'actual' production losses only (i.e. until injured workers are replaced by others). Using a different scenario called called 'Human Capital Approach', in which indirect costs are calculated as 'potential' production losses, without regard to replacement of the injured workers by others, the indirect costs were 3,293 million US Dollars per year.

Regardless of the method used, indirect costs of injuries rank third behind locomotor diseases and psychiatric diseases. More strikingly, injuries were responsible for a higher proportion in the total indirect costs of diseases than cardiovascular diseases and cancer. Due to the fact that in the age category of 20 to 60, the incidence of injuries of males is much higher than for females and the labour force participating rate in the Netherlands is higher for males than for females, over 80 percent of the indirect costs are the consequence of injuries in males [148].

The total cost of trauma is considerable; reduction of trauma mortality and morbidity would benefit both the individual and the society.

Several approaches for prevention exist to reduce trauma mortality and morbidity. Prevention can be defined as primary, secondary and tertiary prevention.

The goal of primary prevention is to prevent accidents from happening. This can be achieved by improving road safety (providing a safer road infrastructure, enforcing speed limits, banning alcohol consumption from traffic, improving car maintenance and safety standards), eliminating occupational hazards (especially in industries and agriculture), banning dangerous sports (boxing, 'free-fight' and alike) and improving social safety (restricting fire-arm possession, reducing crime, preventing acts of war). The role of the clinician is limited herein, as this is mainly the responsibility of politicians and social medicine. Clinicians can contribute to this with initiatives such as the American Academy of Neurology's formal call for a ban on boxing [6], and by promoting safer lifestyle habits to individual patients.

Much has been achieved in primary prevention in the Netherlands, although this opinion is open to criticism [24]. Despite increased traffic density, the number of persons killed in road accidents per year has steadily continued to fall from 1,323 in 1985 to 1,241 in 1990, 1,227 in 1995 and 1,099 in 1996 [34]; the number of hospital admissions for road accidents has also fallen, although to a lesser extent (from 5,885 in 1991 to 5,530 in 1996) [35]. More striking is the drop in number of fatal casualties as the result of traffic accidents involving alcohol, from a number of 215 in 1985 to 87 in 1995 and 97 in 1996 [34].

The extremely vulnerable group of young people between the ages of 15 and 24 has a relatively low mortality from external causes in the Netherlands, compared to other European countries and the USA [18].

The aim of secondary prevention is to limit the severity of injuries caused by an eventual trauma, achieved by the promotion of safety belts and air bags in cars, the use of helmets for motorists and in sports, and improving the safety standards of machinery. Again, as in primary prevention, the role of the clinician is limited. An active role in advocation of safer habits should however be a part of daily practice for all physicians.

Tertiary prevention is concerned with limiting the mortality and morbidity following a traumatic incident and its aim is to optimize outcome for patients.

Following trauma, trauma mortality has been described as occurring in a trimodal distribution [27]:

- Mortality at the site of the accident (45%). These patients die because of the severity of the injuries (rupture of the aorta, free ventricle rupture, or decapitation). Even with optimal trauma care, prognosis of this group of patients will remain the same.
- The second category die in the first hours following the accident. Victims die because of exsanguination, insufficient breathing, brain injury or a combination of these. Often this is the result of starting life-saving treatment (thoracic drains in tension-pneumothoraxes, laparotomy in spleen- and liver rupture) too late. The number of these fatalities may be reduced by improving primary care of these patients.
- The third category die in the weeks or months following trauma, often as a result of late complications.

These patients die in a state of Multi Organ Failure ('MOF'), often associated with sepsis. It is understood that MOF highly correlates to:

- periods of shock and/or hypoxemia during the first hours after treatment
- time delays before bleedings are surgically treated
- failures to stabilize fractures of the long bones and pelvis
- useless attempts to save extremities
- insufficient administration of calories and proteins to these patients

Management strategies following trauma therefore have a great impact on patient prognosis and recovery. Even if primary and secondary trauma prevention strategies were optimal, a certain number of accidents would still occur; attention to tertiary prevention must remain at the highest priority.

Initial trauma care

The initial management of severely injured trauma patients, especially on the scene of accident, constitutes one of the most difficult and challenging tasks in medicine.

Treatment should be optimal in terms of speed as well as in technique, with the aim of reducing the early mortality (exsanguination, circulatory and respiratory failure), late mortality and morbidity.

Within minutes, the patient's condition must be correctly assessed, and major decisions about possible interventions must be made, often with far-reaching consequences to outcome. At the scene of accident it is often difficult to establish a clinical diagnosis, where in the absence of ultra-sound, X-ray, CT-scans and other important diagnostic devices, the ambulance paramedic or physician can solely rely on the patient' s history, cause of injury and physical examination. In the unconscious patient, the history is impossible to obtain; exact cause of injury is sometimes unknown and physical examination less easily and reliably performed compared to conditions in hospital, due to noises, unfavourable lighting, entrapment of patients and so forth.

Of primary importance to the preclinical phase of trauma treatment, attention must be focussed on the vital functions:

- Respiratory functions
- Circulatory functions
- State of consciousness

In the case of a traumatic airway obstruction, an alternative airway must be created. Heightened attention should be paid to patients who have sustained trauma to the root of the neck or upper chest: laryngeal or tracheal disruption may be present and blind intubation may be fatal in these cases.

Intubation and assisted ventilation have to be carried out to keep ventilation and oxygenation sufficient, in cases of unconsciousness following severe head trauma, major chest trauma (especially when pulmonary contusion is suspected [76], or on basis of the severity of injuries [144]. Early intubation not only affects the immediate clinical condition of a patient, but is also associated with reducing risk for Multi Organ Failure later in hospital [90].

Intubation is a technically difficult procedure with a high risk of serious complications when performed by inexperienced personnel. In the often hostile environment at the site of accident, intubation and airway management in general is different and frequently more difficult than when performed in hospital. Coniotomy, or cricothyrotomy, are alternative options in the creation of an airway; if a laryngoscope or (for children, the correctly sized) tube is unavailable, extensive injuries of the upper or lower jaw exist, intubation was unsuccessful, as in instances of massive oropharyngeal bleeding, in cases where cervical vertebral fractures are suspected, a foreign body in the larynx is present which cannot be removed, or epiglottitis or laryngeal oedema is present [114].

Hypotension and hypovolemia must be treated by replacement of circulating volume using infusions of intra-venous fluids [29,107] , although this approach has met with serious criticism [106]. A large prospective study by Bickell et al. [19] of 598 patients with penetrating trauma to the torso and systolic blood pressures < 90 mm Hg shows that patients who received fluid resuscitation only after operative intervention had a lower rate of mortality, less complications and a shorter duration of hospitalization than patients who received immediate fluid replacement therapy, due either to accentuation of ongoing bleeding or hydraulic disruption of an effective thrombus, followed by a fatal secondary haemorrhage.

Picture 1: Prehospital care of a trauma patient

© Adam Hart-Davis. Used with permission. Victim played by an actor.

In addition, intra-venous infusion of crystalloids may lead to dilution of coagulation factors and a lower blood viscosity, worsening blood losses. Although this study was performed only on patients with penetrating injuries into the torso, a type of injury which is encountered much more frequently in the United States than in European countries, and though the study does not extend to blunt or head injuries, it nevertheless challenges the 'classic' universal approach of immediate massive intra-venous infusions. Intra-venous infusions following trauma therefore should be handled with caution and by personnel that is experienced in the benefits and risks of this type of treatment.

Both hypoxia and hypercapnia, especially, raises intra-cranial pressure, thus cerebral trauma must be managed by keeping oxygenation and blood pressure at optimal levels by intubation, artificial breathing and intravenous infusions; the prophylactic use of Mannitol and aggressive hyperventilation is point of continuous discussion [150,140], but it must be stressed that a previously damaged cerebrum is most vulnerable to the adversive effects of hypoxia and oedema, and treatment should be aimed at improving cerebral blood flow especially to the areas of the cerebrum at highest risk. Steroids have been proven to be effective in reducing cerebral oedema in cases of brain tumours, metastases and brain abscesses, but their role in the management of severe brain trauma is highly controversial [116].

During the last 2 decades, hyperventilation for severe head trauma has been subject of fierce discussion.

Animal experiments using young pigs [117], suggested that intracranial pressures after volume replacement are least likely to rise when early intubation and managed hyperventilation is carried out, compared to spontaneous breathing and controlled normoventilation, so with cranial injury present, volume replacement alone (thus without care for adequate oxygen saturation) is insufficient and in certain circumstances may even be dangerous.

In practice, however, it is feared that clinical outcome may be worsened by hyperventilation, because the already endangered blood supply to the brain may be reduced even further by cerebral vasoconstriction. Hyperventilation during the first five days following head trauma is not currently advised, especially not within the first 24 hours. Indications for hyperventilation remain acute worsening of neurological condition or signs of acute herniation [54].

Over hydration may worsen brain swelling as well thereby increasing intracranial pressure and therefore should be avoided [172].

Oxygen should be given generously, and should not be reserved to those patients who are already in a state of respiratory failure. The use of a pulse oximeter at the roadside has proven to be practical and of great value [137], and should be part of the monitoring for all trauma patients in the preclinical phase.

Pain, stress, fear and hypothermia are not only highly unpleasant experiences for the patient, but may increase imbalances between oxygen supply and demand throughout the body. The use of anesthetics and sedation is therefore another cornerstone of therapy in the severely injured [15]. Modern analgesics such as Ketamine chloride (Ketamin ®) and Fentanyl citrate (Fentanyl ®) have proven to be highly useful for this purpose. When encountering an indication for inducing anesthesia [126], a considerable number of factors must be taken into account, a critical consideration of the patient's state, the anestesiologic knowledge and skills of the doctor, and all the logistical aspects.

Whenever possible, patients should be kept warm by covering them with warm blankets in order to prevent hypothermia.

In cases of pneumothorax, and especially in tension pneumothorax, thoracic drains should be inserted as rapidly as possible. It should be determined within the first few minutes whether an immediately life-threatening thoracic problem exists. The most serious intra-thoracic injuries may occur with no damage to the chest wall. Diagnosis may be difficult and should depend on prediction and exclusion rather than direct manifestation of injury [164].

Haemorrhages must be controlled in order to reduce blood losses to an absolute minimum. External haemorrhages may be arrested by applying pressure; internal bleedings in the preclinical phase of treatment, may only be managed by replacement of the lost circulating volume.

The Pneumatic AntiShock Garment (PASG), also known as Military AntiShock Trousers (MAST), function as a non invasive device that elevate systemic arterial pressure by increasing peripheral vascular resistance, and will provide a tamponade effect to curtail bleeding from sites underlying the inflated garment; use of this device was popular until the 1980's. In the late '80s, it became clear that use of these devices had an adversive effect on survival in those with penetrating injuries and thus far beneficial effects have not been demonstrated in cases of blunt injury [115]. Although these pneumatic devices are presently still being used by various providers of preclinical care, PASG devices play a marginal role only in current preclinical care.

Fractures must be stabilised, especially in the spine and the long bones. Repositioning of fractures should be postponed until further diagnosis by X-ray has been completed in hospital, unless extreme displacement of the fracture inhibits transfer. Vacuum matrasses, used to stabilise the entire body, neck and air splints must be applied to obtain full stabilization of each part of the body suspected of being fractured. An especially difficult patient category is the one where there may be risk of cervical vertebral body fracture which need to be endotracheally intubated, because manipulation may cause neurological deficits. Orotracheal intubations may well be carried out with these patients provided special attention is paid to proper stabilisation of the neck during the manoeuvre [92].

Traumas involving entrapment are a special category which generally involve a high level of injury and specific management problems (coordination with technical rescue workers, 'detrapment shock') which may only be optimally handled by a highly specialised, and experienced

trauma team [88]. On-site limb amputations may be necessary to enable extraction without unacceptable delay.

The patient's condition during the first hour following trauma is of crucial importance for later outcome; this time period is known as 'the golden hour', originally coined by Dr. R. Adams Cowley of the Maryland Institute for Emergency Medical Services, who is regarded as the pioneer of modern trauma care [30].

As this 'golden hour' following trauma commonly begins outside of hospital, treatment should begin in that place as well, in order to minimize time loss and make optimal use of this hour which is of paramount importance.

The quality of preclinical management of trauma is therefore of highest importance and attention to this phase of treatment should have a high priority in order to improve outcome.

Regel et al. [124] reported that at a German level I trauma centre, which introduced a more aggressive preclinical and clinical approach to severe trauma patients, overall trauma mortality declined from 37% in the period between 1972 and 1981, to only 22% between 1982 and 1991.

Dick [50] observed that little of that which is considered 'standard of care' in traumatology is in fact scientifically proven; our 'standards' may well be false standards, thus further extensive and fundamental research is necessary to critically study the beneficial value of anything considered 'standard' in trauma care critically.

This recommendation makes traumatology one of the most challenging fields of medicine, as its main goal is not only to implement the highest current standards of care into daily care, but also to investigate and improve those standards continuously.

Current organisation of trauma care in the Netherlands

1/ Ambulance services

In the Netherlands, trauma patients are traditionally transported to hospital by road ambulance.

In 1994 there were approximately 105 ambulance services operating in the Netherlands [33], some privately and some community owned. In the Netherlands, none of the ambulances are operated by fire departments, and no hospital based services exist, which is in contrast with the situation in the United States [178], where one third of the ambulance services in the 200 most populous cities are operated by fire-departments and 6 percent are hospital based. Every region of the country is covered by one or more ambulance services.

The objective of ambulance care in the Netherlands is to have an ambulance response time of less than 15 minutes for emergency calls. In 1989, ambulance services succeeded to achieve this in over 95% of all cases [142], this being even slightly better than findings in the USA [173]. The 15 minute limits are exceeded relatively often by the smaller ambulance companies that have less than 6,000 runs per year, whereas bigger companies, located in the cities often perform better [52].

Up until the 1970's, the role of the ambulance consisted of transporting the patient to hospital as fast as possible, "scoop and run", or "load and go" [51]. Effectively, an ambulance served merely as a taxi for the injured: little treatment or none was given before patients reached hospital. Educational requirements for ambulance personnel were of the lowest possible standards, as any serious treatment only began in hospital.

As the realization that the application of para-medical techniques by ambulance personnel enabled prevention of death in some cases grew [89], the role of the ambulance has shifted from transportation only to on site treatment as well, known as "stay and play".

Nonetheless, the minimal educational legislative qualifications in the Netherlands for ambulance personnel remained low for a long time, probably sufficient for the scenario of 'scoop and run', but certainly insufficient for 'stay and play'.

Ambulance personnel in the Netherlands is commonly professionally involved in ambulance care, volunteers play a marginal role only, in contrast to countries like Belgium [132], and Austria where (Red Cross) volunteers are responsible for a significant part of ambulance care.

An ambulance crew in the Netherlands typically consists of two persons: an ambulance attendant (or "nurse") and an ambulance driver. Until 1994 an ambulance attendant was required to be either a registered nurse ("A- or B-verpleegkundige"), or have a basic First Aid diploma ("eenheidsdiploma EHBO") plus a valid driving licence. For an ambulance driver, a standard First Aid diploma was required, in addition to a valid driving license.

In the Netherlands, estimates vary on the number of ambulance attendants who have no registration as nurse. Alblas [1], reported in 1993 that 20% of ambulance attendants were not qualified as nurse, whereas Van Olden et al. [153], reported in 1994 that in 9% of the ambulances no qualified nurse was present. In comparing the emergency care systems between the Netherlands and the United States, they concluded that the situation in the Netherlands is not optimal; training requirements for ambulance attendants should be tightened up.

Even though the legal educational requirements for ambulance personnel were criticised for being outdated more than 20 years ago [136], the law has only recently changed.

Since 1994 ambulance attendants must be registered nurses, for the drivers the requirement is initially simply a basic First Aid diploma, but must complete a course for ambulance driver within four years of taking the job on. Dispensations are awarded by government for those ambulance services unable to operate using the new requisites.

Serious attempts to improve quality standards for ambulance services have been made alongside the changes in law.

Protocols for on scene care have been introduced [67,68,44], and although these were not obligatory, most ambulance services have adopted them.

The protocols developed by Hartman, Lichtveld, van Stiphout & ten Wolde [67,68] including trauma protocols based on 'Pre-Hospital Trauma Life Support' (closely related to the Advanced Trauma Life Support used in hospitals throughout the Netherlands as standard), function as the national standard and are used most widely. Varying regional protocols in use are considered only marginally different. Unclear is to which extent the protocols are truly implemented in daily use, as Bierens and Habets [16] found in a survey among the biggest ambulance providers in the Netherlands, only 29% of the providers said they used the national protocols concerning endotracheal intubation.

The SOSA (Stichting Opleiding en Scholing Ambulance hulpverlening), the national organisation for education of ambulance personnel in the Netherlands, has developed a specific curriculum for ambulance attendants of initially 164 hours of education, combined with 2 days of education every year thereafter. For ambulance drivers an additional course was introduced in 1988, consisting of 82 hours of education in medical assisting skills and an additional advanced driving course [152].

From the beginning these curriculums have proven very popular among ambulance attendants and have been legally obligatory for all ambulance attendants and drivers since 1988.

The main advantage of these specific ambulance curriculums is that their focus lies in preclinical care and daily practice, while traditional nursing school is scarcely involved with this side of care and is subsequently considered suitable [147] to function as the standard of education for ambulance attendants.

Budgetary limitations have meant that ambulance services were unable to implement these improvements at the same level, so that major differences in quality of ambulance care currently persist, with the lowest grade of instruction generally found in small ambulance services serving scantily populated, rural areas, where improvement of standards is especially uneconomic. Furthermore, it is of utmost importance that daily practical experience be blended with the required training component in order to maintain skills.

Teijink [142] found that most emergency manoeuvres are only rarely performed in daily ambulance practice. Depending on the size of the ambulance service provider (small companies had less emergency runs per ambulance attendant than large ones), the number of emergency runs per full time ambulance employee per year, in 1989, varied between 20.0 and 187.1.

Picture 2: Insertion of an IV cannula

Life saving manoeuvres were carried out a mere few times each year. Per full time employee, intubation was performed 0.1 to 2.7 times per year, artificial ventilation 0.3 to 3.2 times a year; IV infusion 0.6 to 14.6 times

per year, depending on the size of the ambulance provider (in smaller companies less routines were performed).

Questioned about the number of occasions per year routines should ideally be performed to retain skills, ambulance personnel responded with: 15 to 29 times for intubation, 4 to 13 times for artificial ventilation and 41 to 75 times per year for IV infusion insertion.

Real emergencies in ambulance practice happen less frequently than commonly believed, and as just illustrated, at such a low frequency that skills once learnt are at risk of being forgotten.

The need for improvement of ambulance services is not at all unique to the Netherlands, similar situations have been reported from countries such as the UK [159] and the USA [83].

In the United States, certain states have absolutely no requirements for ambulance personnel. In rural areas, especially, highly motivated, but barely trained volunteers are responsible for ambulance care.

Many states, however, require that a basic ambulance to be manned by at least one Emergency Medical Technician (EMT-A). EMT-As, who have received 81 - 176 hours of education, are trained to provide Cardio Pulmonary Resuscitation (CPR), oxygen therapy and other types of first aid. Some states have a further certification level, EMT-D, comprising EMT-A and an additional 4 - 36 hours of defibrillation training.

Mobile intensive care units, or paramedic ambulances, are staffed by one or more paramedics or registered nurses, EMT-Ps, who can provide advanced therapy, including defibrillation, administration of certain (cardiac) drugs, infusion of intravenous fluids, and endotracheal intubation, and require 400 - 2000 hours of training. EMT-P's make up most of the personnel in the cities. EMT-I, intermediate level EMT, is another type of certification, requiring 150-300 hours of training; the EMT-I's may be able to endotracheally intubate a patient, give intravenous fluids or a few types of drugs [11]. Regional variations in legislation and education are considerable in the United States; a large number of (other) designations for ambulance personnel exist, that are often not interchangeable between states; even for American insiders this situation is highly confusing [127].

Basic EMT's (EMT-As) form the largest share of US ambulance personnel; there are over half a million practising EMTs in the USA, paramedic ambulance personnel and 'intermediates' numbering only 79,000 each [128].
In Canada, requirements for ambulance care varies from province to province as well. In the province of Quebec, 'Technicien Ambulancier's are responsible for ambulance care. These have received a course consisting of 850 hours, in which Advanced Life Support or advanced skills are not taught. Paramedics are not recognised in Quebec, and a paramedic program offered at a local college in the 1970's was abandoned due to pressure from

the Nurses Association and the Corporation of Physicians (!). Advanced medical routines, including IV lines, as well as administration of medicine may not be carried out by the 'Techniciens' and are strictly physician-performed.

Only in the capital city of Montreal are special vehicles on duty, staffed by physicians, up to a number of 5 on-duty at any given moment, although it is often fewer [120].

In Great Britain, Qualified Ambulance Personnel (QAP) are given a two week driving course, followed by 6 weeks of classroom training in basic first aid, resuscitation techniques, and other essential skills. They are then accompanied on the road by an instructor for a further 4 weeks, after which they are deemed fully trained QAPs and are allowed to operate an ambulance without an instructor present. After a further minimum of 18 months, they may apply for the National Health Training Authority certificate (NHSTA), which involves a further 8 weeks of training of theoretical and practical training. This includes training in intubation, infusion, defibrillation and the administration of a limited number of drugs. In 1991, there were less than 200 NHSTA qualified ambulance personnel in London; there were plans to increase this number in the future [46].

In France, a two-tiered prehospital care system is in use. Ambulances, staffed by Basic Life Support educated personnel are operated by the fire department, and physician-staffed ambulances are operated by hospitals. BLS ambulance personnel is forbidden to perform medical acts, but oxygen administration, bandaging, splinting and immobilization may possibly be carried out, as well as extrications. The hospital ambulances are staffed by 'anestesiste-reanimateurs', who are sometimes accompanied by residents, enabling a high level of care [110].

In Germany, the level of education of ambulance attendants can vary considerably. Although a First Aid diploma is legally the only prerequisite to staff an ambulance, in practice almost all ambulance personnel have some higher education. A large number of various ambulance curriculums exist in Germany. In the nineteen seventies, in certain federal states a course for 'Rettungssanitäter' (RS I) was introduced, consisting of 260 hours of theoretical and practical classes.

In 1977, a definitive national curriculum for 'Rettungssanitäter' (RS II) was introduced, consisting of 520 hours of education. Personnel who were then in possession of RS I were required to follow complementary courses to RS II level. RS I was then renamed 'Rettungshelfer', a level of education that now plays only a minor role in German care.

A course for 'Rettungsassistent/in' was introduced in 1989, consisting of one year of theoretical and practical classes, followed by one year of functioning as third ambulance crew member for an ambulance

company [65]. It is important to remember that in Germany, physicians often accompany ambulances, especially in emergency situations.

Unlike the situation in Germany, where a differentiation exists between basic life-support vehicles, paramedic ambulances and advanced life support vehicles [125], no such general differentiation exists in the Netherlands, and each ambulance is generally considered to be equally capable of handling every type of emergency - regardless of what the qualifications of the crew are. A high total number of nurses/paramedics is therefore responsible for a low number of emergencies which would each require special skills; the experience one individual ambulance crew gains in managing such cases is low indeed.

Differentiation of ambulance vehicles responsible for provision of different levels of care would concentrate experience and skills toward a lower number of ambulance personnel.

Some differentiation has been introduced on a smaller scale, a few specialised baby ambulances, 'bed ambulances', 'high care' and intensive care vehicles have been put into operation. Not only specialised vehicles which provide a higher or more specialised level of care (upward differentiation) have been introduced, but also vehicles that handle non urgent transfers only, for which no treatment is expected to be carried out during transfer ('stretcher taxis'), have been put into service (downward differentiation) [74]. The latter category of transfer is aimed at cutting costs, and could be an effective method in achieving this, but risks reduction of overall level of ambulance care.

So far, the system of ambulance care in the Netherlands is based on the principle that one and the same ambulance vehicle and crew handles all different forms of care and specialised forms of ambulance care play a very minor role only on a national scale.

In Germany, emergency physicians, usually anesthesiologists or internists, are sent out to each case where life-threatening conditions may exist [15].

By contrast, the Netherlands, along with Sweden, are the only European country where physicians are almost never involved in prehospital emergency care [75].

As ambulance personnel must be able to carry out medical interventions that are under all other circumstances restricted to be performed by physicians (administration of drugs, bringing in infuses etc.), all ambulance personnel function under the delegated authority of a physician, the medical director ("medisch leider") of the ambulance service. The function of medical director, however, is strictly administrative, usually without any actual involvement in patient care.

Unlike the situation in many parts of the United States [162], it is uncommon in the Netherlands for on-the-spot ambulance personnel to have radio contact with hospital emergency physicians for reception of medical orders.

2/ Trauma teams

As knowledge grew about the importance of preclinical treatment of trauma victims, it was also realised that ambulance care alone was insufficient as well for this type of patient.

For severe, multiple victim, accidents, so-called "LOTT-teams" ("Landelijke Organisatie Trauma Teams",- National Organisation of Trauma Teams) were formed in 1982. Approximately 30 hospitals in the Netherlands provide the necessary staff for LOTT-teams. These consist of one surgeon, an anesthesiologist and two nurses. The LOTT teams were originally created to take care of medical problems in calamities and disasters.

However, in most cases the LOTT-teams are called into action after the ambulance team has evaluated the situation at the scene and has concluded that further help is necessary in single cases of severe trauma.

Members of the LOTT-teams are not permanently on stand-by, but must interrupt their daily activities to go to the accident site, adding to the loss of valuable time in these cases. Activation time is aimed at 10 to 30 minutes [160].

LOTT teams do not generally have their own vehicles for transportation to the scene, but must reach the site of accident by ambulance, police car, fire brigade vehicle or taxi, possibly escorted by police.

Sets of surgical and anestesiological material provided by the Dutch government are available at 5 main despatch centres in the Netherlands, though until these are brought to the scene of accident, the LOTT teams must use equipment the team members bring in themselves from hospital.

Finally, criteria for use of the LOTT-teams in daily trauma care are unclear; ambulance protocols [67,68] recommend use of mobile medical teams in cases of large accidents or disasters, in cases of entrapment when extrication is expected to take longer than 30 minutes and in cases where surgical coneotomy, thoracic drainage, amputation, or crash intubation with a patient Glasgow Coma Scale higher than 8, are necessary. As a result these teams were only used randomly and sporadically, estimated at approximately 60 times per year nationally [1]. Often, LOTT teams were regarded by ambulance personnel as competitors or rivals, therefore lack of motivation by ambulance personnel to call for LOTT team activation may be another important reason for the low number of times these teams were called into action.

Locally, "crash-teams" have been formed, consisting of a surgeon or anesthesiologist and one or more nurses, but these face comparable

difficulties as the LOTT-teams.

In cases of large accidents or calamities, so called 'Sigma Teams' ('Snel Inzetbare Geneeskundige Medische Assistentie Teams') can be assembled [160]. These teams consist of at least 25 persons - physicians, nurses, but also non medical personnel -, who can be contacted by alarm radio receivers. Indications for assembly of these teams are accidents with a large number of injured, evacuation of buildings in which persons reside who need additional help (such as senior citizens and the medically ill), large events, and assisting in calamities in other than their own CPA region. Sigma teams are set up to assist ambulance workers and trauma teams in these cases; practical use of the Sigma teams heavily depends on the rate of medical professionalism of the individual members. Sigma teams are not designed to assist in single cases of severe accident, their use is limited to the relatively rare cases of large scale calamities.

The Sigma team possess a trailer in which additional medical equipment for ambulance care as well as a rapidly inflatable tent may be stored.

De Man [49] illustrates the minor role of trauma teams in daily care in his review of 61 severely injured patients in the province of Groningen in 1990: in only two of the cases assistance by a trauma team was asked for, in one case the trauma team was successfully dispatched, and in the other case no team was deployed because time needed for assembly was too long. The role of trauma teams in the Netherlands currently receives a fair amount of political attention and the future role of these organisations is being investigated [73]. Government in the Netherlands ceased financial support for the LOTT organisation in July 1998 and so far there are no alternative structures being set up to serve as a replacement [121].

3/ CPA

Ambulance dispatch centers, known in the Netherlands as CPA's (Centrale Posten Ambulancevervoer), are responsible for receiving incoming emergency calls (including calls via the '112' emergency telephone number uniformly introduced in all European community member countries between 1992 and 1995 [149]), the triage of emergency calls, and coordination of the ambulance vehicle movements.

The CPA's are publicly funded, independent, organisations and do not belong to the ambulance services, although in many cases - especially with community owned ambulance services - rather formal ties exist between them. In 1992, 41 CPA's operated in the Netherlands, varying in size from serving 141,000 to 1,236,000 inhabitants [52].

The minimum requirements for dispatch center personnel as outline by Rossi [125] should be: full paramedic education, minimum of two years' experience in the field, minimum of 40 hours dispatch centre training, ongoing ('rotating') experience in the field, as well as continious medical supervision.

In the United States a training curriculum for "Emergency Medical Dispatcher" is obligatory for all personnel. The SOSA in the Netherlands introduced a curriculum for paramedic and non-paramedics dispatch centre operators, each consisting of 122.5 hours of education [139].

According to Van Olden et al. [153] 45% of all dispatch centre staff in the Netherlands have no nursing background whatsoever and 42% have no previous ambulance experience, so the reality concerning dispatch centers is very different from the optimal situation Rossi described.

The use of protocols in the Netherlands has not spread to the level of the American situation, where this is routine.

4/ Hospitals

A well functioning cooperation and coordination between pre-clinical and clinical care is a necessity for optimal treatment results for the severely injured. There is no justification for giving a patient the best possible preclinical treatment and transfer, when the patient must wait two hours in a hospital before being seen. Currently, too little is now known about the quality and speed of initial care to trauma victims in hospital. A study of 126 multiple injured patients treated in the Klinikum Innenstadt in Munich, Germany [171], shows that considerable time is needed to establish any diagnosis and begin treatment for this category of patients. Mean time needed to collect the first blood samples was 17 minutes (SD 11), intubation was carried out after a mean 20 minutes (SD 19), chest tubes after 30 minutes (SD 17), first blood transfusions in shock after 32 minutes (SD 17), and emergency operations after 98 minutes (SD 55). German trauma care is respected world wide for its high standards of quality; "German trauma care is number one" [165], and clinical time intervals are quite possibly even longer in other countries.

This is demonstrated in a study by Yates, Woodford and Hollis [168], who reviewed a total number of 14,648 patients who have sustained major trauma and were treated in 33 hospitals in the United Kingdom. Not only were relatively junior doctors (senior house officers) most often responsible for initial resuscitation on arrival of the patient (57% of all cases with ISS ≥ 16), but a mere 46% of patients judged as requiring early operation were taken to the operating theatre actually only within 2 hours (!) on arrival in hospital, even if there was a tendency to treat more seriously injured patients earlier was evident.

These abysmal results should not only raise alertness to the improvement of quality in general hospital care, but should also suggest strong evidence in favour of a 'stay and play' (or 'field stabilisation') approach to

on-scene trauma care. Opponents of the 'stay and play'-approach, who favour a 'scoop and run' policy, have brought to the forefront the argument that field manoeuvres in critically injured patients often take longer than the travel time to hospital. Smith et al. [138] came to that conclusion after a review of 52 trauma cases in which the patient had a blood pressure of less than 100 mm Hg. In all cases they found that transport time to hospital was less than IV establishment time. Infused fluid volume had little influence on final outcomes and a percentage of patients with correctable surgical lesions may have been salvaged had prompt transport been instituted. Smith et al. [138] failed, however, to take into account the fact that time won by on field IV establishment is not the time interfall between IV insertion and arrival in hospital, but a longer time interfall instead, namely between the time of IV establishment and the time the patient would receive an IV site in hospital. The assumption that all patients 'immediately' receive IV cannulas upon arrival in hospital should indeed be theoretically correct, but in practice small to what can be considerable delays ought to be reckoned with. The additional beneficial effect of 'on-site' stabilisation manoeuvres therefore depend partially on how adequate and efficient shock-room care is in any particular hospital. Other factors contributing to the effects of on field stabilisation include the on-field time added as a result of the stabilisation manoeuvres and the travel time to hospital.

Both in Germany and in the United States attention has been given to the fact that trauma victims need specialised care; in both countries regional EMS-systems have been developed, and certain hospitals in every region have been designated as trauma centers, thereby concentrating both resources and experience to a limited number of specialized hospitals so that overall trauma care is improved. Large studies, comparing outcome before and after implementation of the regional trauma system, have showed that this approach paid off very well. Mullins et al. [105] compared 70,350 hospitalized injured patients admitted to 18 acute care hospitals in Oregon before, in transition to and after establishment of a trauma system, finding that care of the more seriously injured patients shifted to the level I trauma centres, where there was a significant reduction in the adjusted death rate.

In the Netherlands, as well as in Great Britain [3], the situation has not yet developed to this point. Despite calls for institution of trauma centres by Dutch traumatologists [1], these have not been honoured until recently by the responsible politicians, among whom many opposed trauma centres, because of the high cost of initial investments needed to set up such a system.

Recent developments, however, suggested government is changing its attitude [73] and in the autumn 1998 government in the Netherlands decided to designate 10 hospitals as specialised trauma centres.

In the Netherlands, 144 hospitals existed (106 general hospitals, 9 university hospitals and 29 specialised hospitals) in 1996 [34]. All of the university hospitals and most of the general hospitals have Accident and Emergency departments, and are therefore willing to receive trauma patients. These were considered theoretically equally able to treat the severely injured as well, as no special trauma centers were designated in the Netherlands.

However, for the adequate treatment of the severely injured, there should at least be one surgeon, an anestesiologist, as well as one radiologist present in the hospital at the time of arrival of such a patient, as well as a sufficient number of well qualified nurses and laboratory and radiology technicians. In case of neurological injuries, neurosurgical facilities must be present. Other specialists, such as otolaryngologists, paediatricians, and plastic surgeons should be available if their consultation is required. Cooperation with revalidation specialists and clinics should be well established and functional [12].

The ideal situation of a level I trauma centre sets even higher standards, as outlined by the American College of Surgeon's Committee on Trauma [7]:

- staffed by a trauma team
- 24 hours cover by all surgical and nonsurgical subspecialties
- ICU with a minimum nurse to patient ratio of 1:2
- acute hemodialysis capabilities
- local or regional burns and head injury units
- full radiological service - angiography, ultrasound, NMR, CT
- 24-h theatre with operating microscope, cardiopulmonary bypass and craniotomy capabilities
- 24-h full laboratory services
- quality assurance, research and training programmes

In smaller hospitals in the Netherlands, not only do 'in hospital' trauma teams often not exist, but most of the experienced medical staff who are 'on-duty' spend the evenings, nights and weekends 'on call' at home, so that valuable time is lost before diagnosis and treatment may begin in such situations.

In the commonly used ambulance protocol by Hartman et al. [67,68], guidelines are given that every patient with hemodynamic, pulmonary or neurologic instability, with injuries of a severe nature or with additional risk factors such as young, old age or intercurrent illnesses should be transferred to a hospital serving a 'center' function. However, exactly which hospitals were considered as such was often ill-defined and depended on regional

appointments between hospitals, ambulance services and dispatch centres and rarely on objective quality requirements. Until in the near future the system of trauma centres which the government decided to constitute is functional, guidelines do not exist with specifications as to how hospitals must comply in order to function as such a 'regional centre', nor are any hospitals additionally funded to provide for higher quality standards of care yet.

As implementation of the 'choice of hospital'- guidelines given in the ambulance protocols was not obligatory by any means other than by the level of knowledge and experience of the involved ambulance personnel and dispatch center operators- theoretically all trauma patients would still be dispersed among all hospitals in a random pattern. Interhospital transfer of patients is an option for those cases where a smaller hospital is incapable of providing the grade of treatment required for an individual patient; direct transport to a hospital where definitive treatment can be given is far more preferable whereas studies [180] have shown that mortality and morbidity of patients with major trauma is reduced by direct transport compared to secondary transfer after initial stabilisation in lower level facilities.

An interesting study by Bleeker et al. [20] following 59 severely ill and wounded patients who were transferred from rural hospitals in the South Western region of the Netherlands to the Rotterdam's Academic Hospital, adds more evidence to this recommendation. In this study it was found that 24% of these secondary transports were inadequate, and all these transfers concerned patients whose vital functions were threatened; in this group 74% of patients were inadequately transported. For intubation, artificial ventilation and intra-venous access especially were found lacking in the relatively large group of inadequately transferred patients. The fact that these patients had already received some initial care in a rural hospital, but this did not include proper stabilisation, is especially striking. It remains highly questionable if in fact, rural hospitals are sufficiently prepared to give initial care up to acceptable standards to the severely injured.

Possible benefits of the helicopter trauma team

In May 1995, a helicopter trauma team was put into operation for emergency treatment of severe trauma cases. Based at the University Hospital Vrije Universiteit in Amsterdam, this team, consisting of an experienced surgeon or anesthesiologist with ATLS training, a specialised trauma nurse and a pilot, is permanently on 'stand-by' during daylight hours and able to take off within 2 minutes following an emergency call.

Use of a helicopter enables the helicopter trauma team to reach any point within a range of 50 kilometres in less than 15 minutes, where the trauma team is able to start advanced medical treatment of severely injured trauma patients immediately 'on the spot'. Although the helicopter has the necessary equipment and facilities to transport patients, it's primary role lies in the transportation of the trauma team to the scene of accident and thereby shortening the time interfall between trauma and treatment instead of trauma and hospital.

Picture 3: The helicopter trauma team at the site of accident
© Toon van der Poel. Used with permission.

Therefore, a traditional road ambulance is always dispatched to the scene of accident as well. The crew of this ambulance can assist the trauma team and will - in most cases - transport the patient, accompanied by the helicopter physician to the appropriate hospital.

The possible benefits of the addition of a helicopter based trauma team are numerous.

Using a helicopter as vehicle for the trauma team has the advantage of the high speed of travel - for this reason one helicopter is able to cover a large area of land, so only a few, estimated 5 or 6 [12] of these helicopter teams would be sufficient to cover the whole country, whereas many more trauma teams would be necessary if road vehicles would be used instead to achieve equal response times. In Germany, a number of 37 physician

staffed helicopters are needed to cover approximately 90% of the land area [133,134]. Additionally, a helicopter is also able to land at places hard to reach with land vehicles.
As one team is capable of covering such a large area, the experience the trauma team gain in service is enormous due to the high contact frequency which far exceeds that of ambulance crews, who have to deal with severely injured trauma patients on an average of only 3 times a year [12], and of local LOTT-teams.

The presence of a physician in the composition of a trauma team is considered to be responsible for significantly lower morbidity rates by some authors; Baxt & Moody [174] described a 35% lower than predicted mortality in patients who were preclinically treated by a nurse/physician staffed aeromedical team in comparison to patients who received care by nurse/paramedic aeromedic team, in a randomized experiment involving 258 patients with blunt trauma.

Other authors, like Burney et al. [31] reported no differences in outcome between physician/non-physician team composition. Naturally, differences between outcomes comparing physician/non-physician aeromedical staffing highly depend on the level of expertise of the involved physicians and paramedics/nurses, and on the nature and seriousness of the medical problems that a helicopter team is involved with.

Mackenzie et al. [93], conducted a study of 309 autopsy reports of road traffic accident victims who died before, within 30 minutes after, or within 24 hours after admission to hospital and where there was not any physician involvement prior to admission, and examined to which extent the presence of a physician in the field may have made in cases of avoidable causes of death. Amongst other things, pneumothorax was present in 75 patients, hypoxia in 1, airway aspiration in 2, and (other) airway problems in 5 patients. The authors surmised that physician participation in the field would be beneficial in the diagnosis and treatment of pneumothorax, but suggest an alternative - namely to train paramedics and nurses to needle the chest and place chest tubes. It makes minimal difference, of course, who carries out a manoeuvre like chest drainage, as long as it is performed well, but, to educate all ambulance personnel to acceptable levels of pneumothorax diagnosis and treatment carries an unacceptable risk of failure, as the number of times this manoeuvre has to be carried out in daily ambulance practice is so tiny and even if skills are well taught, the necessary frequency to maintain skills is absent.

In Germany and Switzerland, physicians are present on all helicopter flights, whereas this is the case in only 6% of the hospital based US helicopter services [32].

Schmidt et al. [133,134] compared a group of German trauma patients who received care by a physician staffed helicopter with a group of American trauma patients that received care by a non-physician staffed helicopter and found striking differences in treatment given as well as in the observed mortality between the two groups. The German physicians administered more IV fluids, and performed more intubations and thoracic decompressions than their non-physician American counterparts. As measured by survivor based TRISS Z-statistics, overall outcome was improved in the German system compared to the American.

Picture 4: Physician staffed Swiss REGA helicopter at a highway accident
© REGA. Used with permission.

Choosing to include experienced surgeons and anesthesiologists in the crew composition of the University Hospital Vrije Universiteit helicopter team for all flights ascertains the highest level of expertise.

Compared to the traditional ambulance services, the surplus of experience and education is a major benefit, as well as the fact that this team is specialised in trauma care only. An ambulance crew must be capable of dealing with any other kind of emergency, such as cardiac, internal, obstetric and psychiatric illnesses; even with optimal education and training one cannot be an expert in every field.

Finally, another major benefit is the fact that this trauma team is on ‘stand-by’ at any time during operational hours, and is able to leave within 2 minutes, whereas it takes considerably longer to assemble and dispatch a conventional ‘LOTT-team’.

Possible adverse effects of transporting patients by helicopter

Although the helicopter trauma team preferred to use road ambulances to transfer patients to hospital, transfer of patients by air was also possible when circumstances made it necessary.

Therefore, possible negative effects of helicopter transportation for trauma victims need to be weighted.

Because helicopters are not equipped with pressurized cabins, air pressure inside a helicopter at higher altitudes is lower than at ground level. At high altitudes this may cause difficulties with air filled equipment and trapped gasses in body cavities because gasses tend to expand. The Dutch helicopter trauma team flies at sufficiently low altitudes that there are no clinical consequences to speak of.

Most commonly, the helicopter trauma team fly at an altitude of 500 feet, and less commonly at approximately 1,000 feet above ground level. Considering the fact that air pressure drops 1 Millibar per 27 feet, even at an altitude of 1,000 feet change in air pressure from ground level is not more than 37 Millibar, or a change of 3.7% considering an average air pressure of 1,013 Millibar at ground level. This change in air pressure represents less than the normal variability in the ground air pressure over a period of time. For victims of diving accidents, air pressure changes should be kept to the lowest possible, but changes as such are not considered dangerous even for this group of patients.

During flight, the noise helicopters produce, rule out physical examination such as auscultation of pulmonary sounds, and possible alarm sounds produced by monitoring devices may be unheard [100,62].

Transport of combative or violent patients is contraindicated because their behaviour poses a risk to the safety of the crew. The safety of emergency helicopter flight itself should always be a point of concern. In the United States, many accidents involving emergency helicopters are reported. During 1986, the worst year for the total number of fatal accidents, 13 reported accidents (or approximately 15 accidents per 100,000 patients transported) occurred. The National Transportation Safety Board (NTSB) and the Federal Aviation Administration (FAA), took an in depth look into the causes of these accidents and concluded that adverse weather, engine failure, and obstacle strikes were the most important causes of helicopter accidents, with human error involved in all accidents except for the cases of engine failure. Conclusions and recommendations on safety, concerning weather minimums, technical standards of helicopter and equipment, personnel training and work load have been formulated by the NTSB and were implemented by most air medical programs [135].

Experience with emergency helicopters in the Netherlands was marginal until the University Hospital Vrije Universiteit helicopter trauma team began, so it would be prudent to learn from the experiences in the United States and to maintain a high commitment on safety standards in the Netherlands as well.

It must be remembered that road ambulance accidents also occur. Relatively little is published about accident rates for road ambulances. A survey of ambulance services in the Massachusetts area performed by Bruhn, Williams & Aghababian [28] indicated that there were approximately two reportable accidents (accidents with sufficient monetary damage and or personal injury to require police report) annually for each vehicle. Although these number are not necessarily representative in the European situation, it is clear that emergency transfer by road holds hazards as well.

Any good comparison between safety risks for helicopters and road ambulances is difficult to make for various reasons. Equally important as the number of accidents for comparison, is the severity of the accidents - which in cases of helicopter accidents are expectedly higher. Most importantly, any comparison between the two means of transportation will be deeply influenced by the fact that helicopters are generally kept grounded in unfavourable weather conditions, whereas ambulances are expected to be able to make runs in any kind of weather, thereby increasing likelihood of an accident.

The study of the effects of the helicopter trauma team

The use of airborne vehicles enjoys a long history in medicine. The first recorded attempts to transport patients by air date back to 1910, when in the United States Captain Cosman and Lieutenant Rhodes equipped a privately funded aeroplane for this purpose. Although this unofficial experiment attracted little interest, the French pioneered evacuation techniques using aeroplanes to evacuate wounded from battlefields in Europe early on in World War I [101].

After the invention of the helicopter and the successful testing of Igor Sikorsky's VS-300 helicopter in 1940, the first official medical support flight by helicopter was carried out on January 3rd, 1944 when the United States Coast Guard Aviation Training and Development facility in Brooklyn was requested to fly plasma from the Battery in New York City to a hospital in Sandy Hook. Snow falls and sleet had grounded all fixed wing aircraft and the plasma was badly needed for sailors injured in an explosion aboard the USS Turner.

The first ever medical evacuation flight ever was carried out on January 26th, 1945, when a Sikorsky YR-4 was employed to evacuate a wounded weather observer from a 4,700 foot mountain ridge in the Naga Hills in

Burma [69]. Since then, medical evacuation helicopters have been used on the battlefield, with increasing efficiency particularly in reducing transport times to treatment. In World War I, preceding the invention of the helicopter, transport times to treatment took an average 6.0 hours and the mortality rate was 8.1%, in World War II transport took 5.6 hours and mortality was 4.5%, and in the Korean war transport times were reduced to 3.1 hours and mortality to 2.4%. Final breakthrough came in the Vietnam war, when transport times were counted in mere minutes and mortality had fallen to 1.2% [57].

These Vietnam war air medical evacuation successes were so remarkable that applications to civil communities were considered. From 1969 on, the MAST (Military Assistance to Traffic) program was developed to determine if military helicopters could be of use in traffic accidents. The Maryland State Police and the University of Maryland initiated a helicopter program using paramedics/police officers for both law enforcement and prehospital care [42].

In 1972, the first hospital-based helicopter program started in Denver, Colorado.

To date, in the United States alone, there are more than 160 hospital-based helicopter programs and fewer than 40 government operated programs [101]. Fierce competition between various helicopter operators may exist in several states, but also tight cooperation between various programs has been described as in the case of North Carolina [61].

Despite the initial popularity and current heavy use of helicopter services in the United States, 25 to 50 percent of the present helicopter programs are at risk of being closed within 10 years. Few hospital helicopter programs have ever made money and many ran deficits. Especially in markets with significant managed care penetration, where providers have to justify every dollar billed, many hospitals are opting to end their helicopter operations outright or join on the service along with competitors. Oversupply is another reason why some helicopter programs are grounded, such as the one on the Philadelphia area, which has five competing helicopter programs [94]. At the same time, several regions are developing integrated prehospital care systems in which air and ground emergency services cooperate or are operated by the same provider [102].

Wide differences exist between all various helicopter programs, considering equipment, crew composition, level of training, and type of missions flown. A number of professional organisations has been set up. ASHBEAMS (American Society for Hospital Based Emergency Medical Services), later renamed to AAMS (Association of Air Medical Services), was one of the first professional organisations to promote the air medical industries. The AAMS is involved in almost every aspect of air medical care, including research and education, safety, standards and finance. Also, minimum standards and curriculum for helicopter providers were issued by the AAMS, but compliance is voluntary and carry few guarantees that programs maintain minimum standards as air ambulances. In 1991, a separate Commission on Accreditation of Air Medical Services (CAAMS) formed to develop an accreditation service that reviews air medical services, crew training/staffing, dispatching and quality assurance. Programs are 'accredited' only after an intensive review and site inspection by Commission members. Because this accreditation is voluntary and costly, only a handful of programs have gone through this process.

Helicopter professionals have also created organisations, like the National Flight Nurses Association (NFNA), developing a set of standards for flight nurses as well as a specific curriculum for Certified Flight Registered Nurse - a new subspecialty of nursing.

Likewise, the National Flight Paramedics Association (NFPA), the National EMS Pilots Association (NEMSPA) and the Air Medical (Flight) Physician Association (AMPA) have been formed [42].

In most European countries helicopter programs have been implemented in some form; certain programs physician staffed, others staffed by a paramedic crew alone.

In Switzerland, an air medical program operating helicopters and ambulance jets; in 1991 a number of 3,794 primary missions was carried out, primarily for trauma patients, along with 452 flights for medically ill patients; search and rescue missions, repatriation flights, transports of organs, blood and serums and evacuations were also carried out [122]. In 1997, a number of 4,299 primary missions were carried out by helicopter and a total number of rescue missions of 8,369 [123].
Elsewhere, 11 helicopters were in use in the Czech Republic, 7 in Slovakia, fully covering both countries, primarily for trauma care, but also for internal emergencies, donor organs transfers and for newborn babies.

In Finland, a physician attended helicopter began operating as of 1992 in the Helsinki area [79]. In 1993, another helicopter service in Oulu, in the north of Finland, became active serving an area of 450,000 inhabitants within a range of one hour's flying time. This helicopter is staffed by a physician in cases of HEMS (Helicopter Emergency Medical Service) flights, but carries out Search And Rescue (SAR) missions as well, staffed then by a policeman, a fireman or surface diver [97].

Picture 5: ÖAMTC operated Eurocopter above the city of Innsbruck, Austria

In Norway 6 helicopter bases have been operational since 1978 and helicopters are physician staffed [66].

In Gotland, Sweden, EMS helicopter programs have been operating in various shapes since the beginning of the seventies. In its present form, since 1995 it has performed 200 transports, mainly concerning patients who are travelling to or back from specialised clinics for treatment, plus 50 EMS missions per year. This helicopter is not routinely staffed by a physician, but can pick up an anesthesiologist if necessary [145].

In both Great Britain and Ireland, 8 medical helicopter units are in operation, only one of these having a physician on board, and an additional 14 search and rescue helicopter units, operated by the RAF, the navy or the coastguard, plus another 2 off shore helicopters serving the Shetland Islands. Especially well-known is the physician staffed Helicopter Emergency Medical Service (HEMS) in London that started up operation in 1990.

After the initial helicopter service set off in Munich in 1970 [104], Germany now developed a national network of approximately 50 helicopters, operated partially by the ADAC (the German Motorists Association) and partially by the national forces (Bundeswehr), Katastrophenschutz, Deutsche Rettungsflugwacht and Internationale Flugambulanz, every one of them staffed by emergency physicians. In 1997, a total number of 57,699 missions were carried out, and 50,995 patients were transported [2].

The German model was copied by Austria with 5 helicopters [38], Northern Italy [179] and Spain [119].

In Greece, a company called GAMMA established itself in 1993, specialising in air medical transportation in general, and with the exception of medical repatriation flights by aeroplane, helicopters are used as well for ambulance missions to Greek islands with no airport [60].

In various non-European countries, helicopters have been heavily used for emergency medical purposes, as well.

In Johannesburg, South Africa, the Johannesburg Hospital Trauma Unit, uses a physician staffed helicopter program for treatment of trauma cases in the urban surrounding in conjunction with an intensive care fixed wing aircraft for covering longer distances. This service commenced in 1976 and receives an annual 1500 calls per year [77]. In rural South Africa and other African countries, like Kenya and Zimbabwe small aeroplanes are used to reach ill and injured patients especially in regions without proper hospital facilities and adequate road infrastructure.

The activities of the Flying Doctors in Australia who are capable of reaching the most remote regions of Australia by air to provide medical aid and transfer are notorious.

In Japan, helicopters have been used since 1970 to transfer patients living in remote islands in the Nagasaki prefecture from rural hospitals to a referring hospital in Nagasaki, mainly concerning patients suffering from internal illnesses in addition to a few trauma patients [9].

In Brazil, both helicopters and fixed wing aircraft are used to cover short and long distances of air medical transports in several cities [146].

Even though use of these helicopter services has been extensive, and the popular press have focussed on the virtues of helicopter service [141], little of a more scientific nature has been published about its medical effectiveness.

Until the University Hospital Vrije Universiteit helicopter trauma team was created, the use of helicopters for medical purposes in the Netherlands has only been sporadic. Helicopters had only been used for Search and Rescue (SAR) missions, to evacuate patients from the Wadden Islands, and occasionally for the transportation of severely ill newborn babies [62,55] and for donor organs.

The Coast Guard (Kustwacht) primarily perform -mostly maritime- Search and Rescue missions and Medical Evacuations with the use of airplanes and helicopters. In 1994, 83 hours were flown by airplanes, and 158 hours by helicopters for SAR purposes, saving 39 persons. Dutch Navy (Koninklijke Marine), Airforce (Koninklijke Luchtmacht) and foreign operators carried out the majority of these SAR helicopter missions [84].

Search and Rescue Missions are often carried out by maritime vessels only, without help of helicopters or airplanes. The total number of SAR missions per year is around 1,400 and appears to be rising [85,86].

Especially since the Navy put AB412 helicopters into service, which have more medical equipment on board then the Alouette III helicopter used before, including cardiac monitors and defibrillators, the number of civilian medical evacuation missions to the Wadden Islands has increased from around 80, to 140 - 150 each year [157].

Picture 6: Navy helicopter in use on a maritime search and rescue mission in the Netherlands

A German emergency helicopter based in Aachen, was contracted to carry out missions in the southern part of the Dutch province of Limburg from 1976 onward, but this service was used twice yearly on average, in the majority of cases to rescue patients from places that were difficult to access with land vehicles [158]. In 1998, the provider of this helicopter services changed from the Bundeswehr to the ADAC, who subsequently made significant efforts to improve popularity of this service in the Netherlands [10].

Introduction of the helicopter trauma team in the Netherlands has lead to controversy, in particular over the high costs of this kind of service; among ambulance personnel the fear existed that the costs of operating a helicopter service would be deducted from their own financial budgets and they suggest it may be more efficient instead to use the resources spent on a helicopter program to improve ambulance training and equipment [158].

Preliminary studies of the cost-effectiveness of the use of helicopters in the Netherlands, in advance of the University Hospital Vrije Universiteit helicopter trauma team, were not able to make any estimates of the costs, through lack of empirical findings [103]. Foreign studies of helicopter costs, such as that by Gearhart, Wuertz & Localio [175] for example are all limited by the fact that survival benefits used as the most important factor determining cost-effectiveness, are merely estimated or assumed.

As the helicopter trauma team used offers care only in addition to the road ambulance, direct operational costs of the program will always be higher than for ambulance care alone. Cost analyses that consider helicopter aid as replacement of ambulance care, such as in the study by Bruhn, Williams & Aghababian [28], who replaced 6 road ambulances by one helicopter in their model of the state of Massachusetts to achieve equal response times, are therefore not valid within the situation of the Netherlands. In the University Hospital Vrije Universiteit trauma helicopter service, financial benefits must originate from a reduction of medical expenses, additional years of life saved and a better general outcome rather than from direct operational costs.

As little hard evidence can be found in existing literature about the proven benefits of helicopter trauma teams in other countries, it is quite impossible to simply transfer results of most foreign studies to the Dutch situation.

Airborne medical systems in areas like the rural Cape Province in South Africa, where patients have to be flown over distances of up to 1,500 kilometers in areas which have poor infrastructure and few health care facilities [130,177], or in Switzerland [96], where mountainous areas exist which are virtually unaccessable by any other means of transportation other than helicopter, differ too much in population, geography, and infrastructure to function as a means of comparison with the situation in the Netherlands, where there is an adequate road infrastructure, maximum ambulance response times of 15 minutes countrywide, a large population density and generally good access to hospital facilities in the vicinity.
The helicopter services in Great Britain and Germany probably best resemble the situation in the Netherlands.

Thus, in order to clearly anwer the question whether the use of a helicopter trauma team following severe accidents leads to sufficient health benefits, to outweigh the costs of this kind of stand-by operation, a critical and sound evaluation of the helicopter care was necessary.

Picture 7: Different local conditions: Mountain rescue by REGA, Switzerland

The Health Insurance Funds Council (Ziekenfondsraad) funded an independent evaluation of the VU University Hospital Helicopter Trauama Team. This evaluation was carried out by the Centre for Health Policy and Law (C.G.B.R.) and the Foundation of Scientific Reasearch on Road Safety (S.W.O.V.).

The original study set up [98] was published in 1994.

The study of the effects of the helicopter trauma team effectively started on the first day of helicopter operation, 1 May 1995. In 1998, de Charro & Oppe [48] (C.G.B.R./S.W.O.V.) published the definitive results of their analysis.

Their results are summarized in the final part of Chapter 3 and essentially address the following issues:
- The influence of helicopter trauma team involvement on trauma mortality
- The influence of helicopter care on the quality of life for survivors of severe trauma
- The costs and cost effectivity of helicopter care

The results of de Charro & Oppe [48] answer many essential question regarding helicopter trauma team care. But still, a number of very

important questions remained undiscussed in their study.
Therefore, in this study, a different, additional analysis was performed. The aim of this study is to answer the following questions:

- What is the influence of helicopter trauma team involvement on the preclinical treatment of severely injured trauma patients?
- What is the influence of helicopter trauma team involvement on the prehospital time intervals (i.e. time between accident and arrival in hospital)?
- How does helicopter trauma team involvement influence the clinical condition of severely injured patients upon arrival in hospital?
- Is there a relation between any of these immediate effects of helicopter involvement and the results by de Charro & Oppe [48]

Especially to deal with the latter, in this study the study design was identical to the one used in the study by de Charro & Oppe [98]. Results found in this study, therefore, apply to the same patients as in the study by de Charro & Oppe [48].

Chapter 2

Chapter 2

Description of the study

Description of the study

The following is a description of the set up of the current study of the immediate effects of prehospital care by helicopter trauma team. The identical set up was used in the study perfomed by de Charro & Oppe [48].

General description

This is a study of the immediate effectiveness of a helicopter trauma team, based at the University Hospital Vrije Universiteit in Amsterdam, covering the period from May 1st, 1995 to December 31st, 1996. The team, consisting of an experienced trauma surgeon or anesthesiologist and a specialised trauma nurse, provided expert trauma care to severely injured patients immediately following trauma at the scene of accident. A road-based ambulance was also dispatched to the scene for every accident.

The helicopter operated from 7:00 a.m. to 7:00 p.m. during the daylight period, with shorter winter hours. The helicopter service covered an area of approximately 50 kilometers from the helicopter base located on the roof of the University Hospital Vrije Universiteit in Amsterdam, in the Northwestern part of the Netherlands.

Even though the helicopter is capable of transporting patients, transfer of the patient to hospital was preferably done by road ambulance, and was accompanied by the trauma team physician if found necessary.

Only in special cases was the helicopter patient transport facility used. As depicted earlier, the aim of the helicopter service was to reduce trauma mortality and morbidity by providing expert care as quickly as possible, notably by improving patient condition in that very important 'golden hour' following trauma. In order to clarify what the possible benefits of the use of a helicopter trauma team are, data regarding treatment and outcome of patients treated by the trauma team were compared to those of patients who received ambulance care only.

Setup of the helicopter service and the study of its effects

The ANWB (Royal Dutch Touring Club) funded the helicopter service . A separate daughter company, called Medical Air Assistance, was established by the ANWB so as to have an objective and independent organisation responsible for operation of the helicopter service.

The helicopter platform and the trauma team physicians were provided by the University Hospital Vrije Universiteit.

The trauma nurses were either personnel of the University Hospital Vrije Universiteit, or of one of the two biggest ambulance services in Amsterdam (VZA and GG&GD).

The helicopters were leased from Schreiner Northsea Helicopters BV, a subsidiary of KLM Royal Dutch Airlines.

The Health Insurance Funds Council (Ziekenfondsraad) was responsible for financing of the evaluation of the helicopter service by the SWOV and CGBR.

Description of the helicopter and equipment used

The helicopter used was the BO 105 CBS model, the helicopter used most frequently by the German 'Rettungsdienst'. One helicopter of this type was used on duty, with a second one on standby as backup.

With a cruise speed flying capability of over 200 kilometers per hour, this helicopter could reach any point within a range of 50 kilometers in less than 15 minutes. Landing was possible on any surface free of obstacles of 20 x 20 meters.

In the German situation, the helicopter was capable of landing within a range of 50 meters of the accident site in over 80% of cases.

Equipment of the helicopter consisted of:
- Navigational equipment necessary to locate any place within the area of coverage during daylight.
- Communication equipment enabling the airborne crew to communicate with air traffic control, all ambulance dispatch centres involved, and all police personnel and ambulance vehicles in the area.

Medical equipment consisted of:
- Helicopter Emergency Medical Systems (HEMS) equipment of the Bucher Leichtbau A.G.n company (Industriestrasse 1a, CH 8117 Fällanden), type ARA-BO105S-AC30, with an additional medical luggage container, fixed onto an additional stretcher.

Mobile equipment consisted of:
- 1 Oxylog 2000 artificial breathing device including accessories
- 1 Laerdal Suction Unit
- 1 Propaq 106 LCD monitoring device
- 1 Lifepak 10P defibrillator with pacing capabilities
- 1 Terumo STC-521 infuser
- 2 sets of Stifneck Neck Splints
- 2 sets of Oregon Spine Splints
- 3 Germa vacuum mattresses, type Helicop
- 1 Germa vacuum mattress, type Falck
- 2 Germa vacuum splints (whole leg)

- 2 Germa vacuum splints (lower leg)
- 2 Germa vacuum splints (arm)
- 1 Germa vacuum pump (hand operated)
- 1 Germa vacuum pump (foot operated)
- 10 replantation bags size Small
- 10 replantation bags size Medium
- 10 replantation bags size Large
- 15 sets of artificial ice (Dr. Marx Medizintechnik)

- Sets of disposable sheets and blankets for transfer of patients.

- 3 Hanaulife physician backpacks
- 3 Hanaulife ampulla depots

The helicopter trauma team composition

Helicopter crew used in the investigation consisted of three persons:

A **surgeon** or **anesthesiologist.**
Requirements for the helicopter physicians included:
- Valid registration as physician in the Netherlands
- Registrar (specialist) in either surgery or anesthesiology for over 4 years
- Diploma Advanced Trauma Life Support
- A course of 'Heli Trauma' in the Federal Republic of Germany
- Good social capacities
- Experience with teamwork
- Experience within trauma-teams or LOTT-teams
- Able to cope in stressful situations

A trauma **nurse.**
Requirements for trauma nurses included:
- Registration as nurse (Ziekenverpleging 'A')
- Wide experience as (preferably 2 of the following 3):
  - Ambulance attendant
  - Intensive Care nurse
  - Accidents and Emergencies nurse, possessing the necessary qualifications and diplomas of these specialisations
- Auditor Advanced Trauma Life Support
- A course of 'Heli Trauma' in the Federal Republic of Germany
- A navigational and communication course
- Experience with working in a trauma team or LOTT team
- Good social skills
- Able to cope with stressful situations

A helicopter **pilot.**
Requirements for the helicopter pilots include:
- Necessary qualifications and permissions to fly helicopter missions in the Netherlands
- Flying experience for the type of helicopter used
- Flying experience in the region of use
- Ability to land and take off in difficult locations

A total number of 3 pilots, 10 nurses and 6 physicians were needed for the operation.

Safety procedures

Strict protocols regarding safety were issued to all pilots, physicians and nurses involved. These included general measures concerning behaviour in and around the helicopter, delegation of navigational tasks, communication with dispatch centres and air traffic control, and the safety of bystanders and traffic around the landing site, as well as adequate supply and functioning of medical equipment.

Each task was assigned to one of the crew members, thereby avoiding any possible discussion about responsibilities as well as limiting errors to an absolute minimum.

Area of service

The helicopter trauma team covered an area of 50 kilometers around the helicopter base located at the roof of the VU University Hospital of Amsterdam.

This area of the Netherlands is a densely populated and highly urbanised area of the country, inhabited by approximately 5.4 million people.

Three of the four biggest cities in the Netherlands (Amsterdam, The Hague and Utrecht) are fully situated within the service area.

Road infrastructure is generally well developed and almost any place within the area covered may be reached easily by an ordinary road vehicle. Only one island, Texel, is without road connection to the mainland or to any hospital in the flying area; until this investigation began, patients had to reach hospital either by boat or in the rare case of emergency, by a national forces (SAR) helicopter.

At the time, 11 dispatch centres (CPA's) were operating within the area covered. Some of these dispatch centres cover an area that partly outstretches the 50 kilometer limit that can be reached within 15 minutes by the helicopter. However, a road ambulance, is dispatched for every accident regardless of possible helicopter involvement, and is expected to arrive at the accident site within 15 minutes. A trauma patient was thereby guaranteed to receive standard ambulance aid within 15 minutes, so it has been decided to cover the whole area of the 11 CPA's, and to accept that flying times can exceed the 15 minute flying limit in some cases.

Within the incorporated area 34 ambulance services were then in operation, ranging in size anywhere from 1 vehicle to 25 vehicles.

Criteria for deployment of the helicopter trauma team

The helicopter trauma team should intervene in cases of severe injuries exclusively, as patients with only minor injuries should be directed to road ambulance care.

Superfluous flights not only lay a financial burden upon the operational costs, but also render the helicopter team unavailable for possibly more important missions occurring simultaneously.

However, too many restrictions of the use of the helicopter would certainly mean that many cases where use of the helicopter trauma team are necessary would be missed.

Adequate triage for the deployment of the helicopter trauma team was therefore an absolute necessity to achieve any notable success.

Primary deployments

The following criteria for deployment of the helicopter trauma team were used by CPA operators:

I/ Based on the condition of the patient:

- Open wounds of the skull, thorax or abdomen
- Fractures of the upper leg, pelvis or thorax/spine
- Shot wounds, serious penetrating or blunt trauma of the skull, thorax or abdomen
- Serious burns (thermic or chemical)
- Loss of consciousness
- Amputations of extremities
- Shock
- Serious blood losses
- Immobilized patients

II/ Based on the nature of the accident:

- Accidents of motorcycles or mopeds versus cars or rigid obstacles

- Frontal motor vehicle accidents outside urbanised areas
- Train, tramway, bus or aeroplane accidents
- Explosions (for instance fuel tanks in cars)
- Fall or jump from big heights
- Entrapment
- Accidents in which patients are buried
- Accidents involving electricity, like victims struck by lighting
- Drowning accidents
- Multiple casualties
- Nuclear accidents
- Motor vehicle accident with ejection from vehicle
- Gas poisonings/explosions
- Major fires with entrapped persons (for instance in public buildings)
- Accidents involving ships

Picture 1: The helicopter trauma team on a typical mission
© Toon van der Poel. Used with permission.

On the basis of this criteria the CPA operators handling the incoming emergency calls decided if deployment was necessary.

The Amsterdam CPA coordinated the helicopter movements, and handled all calls for helicopter assistance by from other CPA's.

While the CPA in Amsterdam was responsible for the coordination of all flights, responsibility for decisions to call for helicopter assistance was by the individual CPA of the district where deployment was needed.

Correct triage of the incoming emergency calls is a very difficult task, as the only information about the nature of the accident and the condition of the victims available at the dispatch centre is commonly provided by non-professional bystanders, often in a state of panic, so that a correct assessment of the situation at the scene of accident is frequently problematic.

Secondary deployments

Ambulance personnel were also able to request helicopter assistance via the CPA, when after arriving at a scene of accident the situation was found to be of such severity that helicopter involvement was needed to provide the required care.

Risks for unnecessary flights are virtually zero in this secondary type of deployment; however, its main disadvantage,which is the additional loss of time compared to primary deployments, surely outweigh this advantage. The number of secondary deployments should preferably be kept at the lowest level by optimal triage by the CPA operators of the incoming emergency calls.

Procedures at the scene of accident

Upon arrival at the scene of accident, the helicopter physician assumed medical responsibility from all other (paramedic) personnel already on the site or arriving later.

After initial assessment of the patient, necessary interventions were carried out to improve (‘stabilise’) the haemodynamic, pulmonary, and neurologic condition of the patient, by every available means of surgical and conservative treatment at the scene. The helicopter physician was therein assisted by the helicopter nurse and the road ambulance personnel.

Patient transportation took place once the helicopter physician had assessed their condition to be suitable for transfer. Transfer to hospital then took place by preferred road ambulance; the helicopter physician could accompany patients during the ambulance trip to hospital and monitor their condition.

The helicopter physician could, however, also decide to transfer the patient by helicopter to hospital if the patient condition made this necessary.

Each patient was then transferred to the nearest suitable trauma hospital for treatment. Communication between helicopter physician and hospitals was possible via the dispatch centre. The helicopter physician could inform the receiving hospital about the condition of the patients, so that necessary preparations could be made to guarantee optimal management upon arrival.

Scoring of patients

To enable estimation of the severity of the injuries of all patients involved in this study, two scoring systems have been used, the Revised Trauma Score and the Injury Severity Score.

The Revised Trauma Score is a commonly used scoring system for trauma patients in the Netherlands and is routinely performed by all ambulance personnel for trauma cases, regardless of this study. The RTS was scored as follows:

Glasgow Coma Scale

E: Eye Opening	Respiratory Rate:
1 = none	0 = none
2 = to pain	1 = 1-5/min
3 =to voice	2 = 6-9/min
4 = spontaneous	3= 30/min or higher
4 = 10-29/min	
M: Motor response	
1 = none	Systolic Blood Pressure:
2 = extension	0 = none
3 = flexion	1 = 1-49 mm Hg
4 = withdrawal	2 = 50-75 mm Hg
5 = purposeful movements	3 = 76-89 mm Hg
6 =obeys commands	4 = 90 mm Hg or higher
V: Verbal Response	Glasgow Coma Scale:
1 = none	0 = EMV 3
2 = Incomprehensible sound	1 = EMV 4-5
3 = inappropriate words	2 = EMV 6-8
4 = confused	3 = EMV 9-12
5 = orientated	4 = EMV 13-15

EMV is the sum of the scores for Eye Opening, Motor Response and Verbal Response

RTS is the sum of scores for Respiratory Rate, Systolic Blood Pressure and Glasgow Coma Scale

The **Injury Severity Scale (ISS)**, scored by the Hospital Trauma Index Method, is another scale for injury severity used in hospital. The ISS can be calculated after diagnosis in hospital has been established, within the first 24 hours of admission. This score is based upon 6 anatomical systems in combination with physiological disturbances, that can be graded from 0 (no injuries of that type) to 5 (most severe injuries). The three highest of the 6 possible injury categories are squared individually and added. The sum of these three is the ISS score.

The RTS and ISS have been generally used in the Netherlands as 'gold standard' for scoring patients' injury severity [26]. The practical introduction of these scoring systems into this study was expeditious as virtually every physician and paramedic involved had some prior experience with these scales.

Outside of this study, it is standard practice for all patients transported by ambulance to be routinely scored for RTS on three occasions: upon arrival of the ambulance at the scene, a second time upon leaving to hospital, and a third time upon arrival in hospital.

In the current study, the lowest recorded of these three RTS scores was used to estimate severity of the injuries.

An additional reason for choosing these two scores was their ease of use and the fact that fewer calculations are needed to determine the values, so that risk of error is minimized. When prospective data was missing, it was still possible to retrieve the values retrospectively from patient records without difficulty or loss of reliability.

A limitation of the ISS shows up, however, in the fact that not every kind of injury is fully represented within the scoring scales; in cases of drowning, near-drowning, or inhalation trauma the ISS cannot be used. Scoring these patients using ISS is therefore not possible, limiting its use to a serious extent especially as all of the omissions mentioned are potentially life-threatening conditions about which this study is concerned.

The main disadvantages of both RTS and ISS are that patient age and mechanism of trauma are not measured in these scores. Empirically it is known that trauma patients aged 55 years and over as well as aged 5 years and under, have a considerably worse outcome compared to adults with the same injuries [151]. The use of the Pediatric Trauma Score was considered; however, as it could not be demonstrated by any existing literature that the PTS offered any advantage over the Revised Trauma Score [81], it was decided to use RTS for all age categories.

Patients and methods

Criteria for inclusion

The study group comprised all severely injured patients admitted to any of the 8 hospitals participating in the study:

- University Hospital Vrije Universiteit in Amsterdam (AZVU)
- Academic Medical Center in Amsterdam (AMC)
- Rode Kruis Ziekenhuis in Beverwijk (RKZB)
- Medisch Centrum Alkmaar in Alkmaar (MCA)
- Slotervaartziekenhuis in Amsterdam (SLVZ)
- University Medical Centre Utrecht in Utrecht (AZU)
- Leiden University Medical Center in Leiden (AZL)
- Westeindeziekenhuis in The Hague (WEZ)

Of all trauma patients assessed those who had scores of the Revised Trauma Score at any point of 10 or lower, or of the Injury Severity Scale score of 16 or higher, were included in the study.

Most other studies use a Injury Severity Score of at least 18 for the definition of severely injured patient, although 16 is also used in some studies [63]. In this current study, however, a minimum score of 16 was expected to be a better value so as to include especially those patients who sustained one single injury grade 4 only at any of the constituents of the ISS. Especially notable is the group of patients with trauma of the head, grade 4, as single injury, that would have been excluded otherwise. These injuries, comprising loss of consciousness of more than 60 minutes, with or without focal symptoms, fracture of the cervical spine with paralysis of the lower extremities, and loss of consciousness of more than 24 hours without response (EMV=3), are known to have a high mortality and long term morbidity [151]. Immediate resuscitation attempts as performed by the helicopter trauma team may have an impact on outcome of this very important group of patients, so it was decided to include this grade of injuries as well.

Only patients who suffered trauma during daylight hours were included in the study. The helicopter service did not operate during hours of darkness. As differences were found in the characteristics between patients who received ambulance care during daytime and at night, the decision was made to leave the group of night patients out, so that the helicopter and ambulance groups could be more comparable.

Criteria for exclusion

The following patients were excluded from this study:

- Patients who were transferred to a non-participating hospital during the course of their hospitalisation. Logistical reasons made follow-up for these patients impossible.
- Patients who suffered trauma outside of the flying range of the helicopter. Especially in hospitals located on the external borders of the flying area a number of trauma patients were admitted who suffered trauma at a site outside of the area of study. For logistical reasons preclinical data of these patients could not be incorporated into this study.
  Excluding this group of patients, however, prevents geographical biases. Patients who suffered trauma in foreign countries and were repatriated later in the course of treatment to the Netherlands were also excluded.
- Patients who had Revised Trauma Scores that would be sufficient to be included in the population studied, but upon revision these scores were on basis of internal or cardiac illnesses only (as for instance spontaneous cardiac arrest, non-traumatic rupture of the aorta).
- Patients who were found to be dead on the scene, i.e. died prior to arrival of ambulance or helicopter, and for whom no resuscitation attempts were initiated. For these patients death was considered to be unavoidable; there were no differences between the helicopter or ambulance group to be expected.

Methods

All patients were followed during hospitalisation until discharge.

Further follow-up was performed 9 and 14 months following trauma, by interview.

To compare the differences in treatment between the helicopter group and the ambulance group, the following parameters are analysed in this study:

- Population characteristic (age, sex)
- Mechanism of injury
- Response times, scene time, transfer time to hospital and total preclinical times
- Severity of injuries : RTS prior to admission, ISS in hospital
- Preclinical interventions (intravenous fluids, splints, monitoring, oxygen therapy, intubations, anesthetics, thoracic drainage, other surgical interventions)

Naturally, de Charro & Oppe [48] examined different variables, concerning the scope of their study on mortality, quality of life and cost effectivity.

In this study, the following subgroups are analysed separately:

- Patients with ISS 0-24
- Patients with ISS 25-40
- Patients with ISS 41-75
- Elderly patients, age 65 and older
- Patients with primarily neurologic injuries
- Patients with primarily injuries of the extremities
- Patients with primarily thoracic injuries
- Patients with primarily abdominal injuries
- Patients in haemodynamic shock
- Patients with respiratory insufficiency
- Patients with a lowered Glasgow Coma Scale

For a subset of patients an assessment was performed on the clinical condition upon arrival in hospital. The patients followed in this study concerned all consecutive severely injured patients who received helicopter care and were admitted to the VU University Hospital.

Inclusion and exclusion criteria applied for the selection of patients for this analysis were identical to the criteria used for the analysis of preclinical care.

The following parameters were studied in this group:

- Age
- Sex
- ISS and HTI scores
- Type of accident
- Cause of death
- First recorded oxygen saturation on arrival in hospital
- First recorded Base Excess on arrival in hospital
- First recorded systolic blood pressure on arrival in hospital

Chapter 3

Chapter 3

Results

Results

General experiences of the helicopter trauma team

From May 1st, 1995, to December 1996, the helicopter trauma team received 1,168 calls for assistance, averaging over 58 per months, or almost 2 calls per day.

Of these 1,168 missions, 501 (42.9%) were cancelled prior to landing by ambulance personnel who deemed helicopter involvement to be unnecessary. Two cases have been reported in which the helicopter was cancelled due to involvement of a local trauma team.

On 27 flights (2.3%), no patient was recovered at the location of the accident, and on 3 occasions (0.3%) the helicopter trauma team did not take off due to various other reasons.

Mean time interfall between emergency call and take off was 2.3 minutes (SD 1.7), 75.8% of flights were airborne within 2 minutes, and 95.8% within 3 minutes. One individual case was recorded in which response time was 37 minutes, because the helicopter team was not instantly available due to being on a different call at the time, and was still needed after finishing that mission.

Average distance from the location of the helicopter to the site of accident was 22.1 kilometre (SD 16.8, median 18). A total of 93.9% of the flights had a flying distance of 50 kilometres or less; the maximum distance flown was 97 kilometres.

The mean flying time was 8.83 minutes (SD 5.0, median 8), ranging from 2 to 32 minutes.

The average response time (the time interfall between call and landing) was 11.1 minutes (SD 5.4, median 10), ranging from 2 to 56 minutes. 81.6% of calls had a response time of 15 minutes or less, 95.3% of 20 minutes or less.

Safety

Only one minor accident was reported during the first 20 months of helicopter service in which the helicopter hit a road obstacle during landing.

No personal injuries were reported. The helicopter was damaged but service could be continued using the back-up helicopter during the time the helicopter was under repair.

Dutch aviation authorities thoroughly investigated the accident. No serious safety errors were found during the investigation and the helicopter service could be continued largely unchanged.

Comparison of the helicopter and ambulance patients

Description of the population

In the study a number of 1,786 consecutive trauma patients, arriving by ambulance or by helicopter in the 8 participating hospitals, between May 1st 1995 and December 31st 1996, were assessed prospectively.

Despite extensive efforts to obtain preclinical records of all these patients, 689 patients' preclinical records remained missing after both prospective and retrospective searches. The majority of these patients suffered trauma outside of the helicopter's flying area, but were transferred to one of the participating hospitals. These patients were excluded as variations between the levels of ambulance care within and outside of the helicopter's flying area may exist and possibly interferes in the comparison of the otherwise identical groups of ambulance and helicopter patients within the flying range.

822 patients met all inclusion criteria, excluding the time of accident, 210 helicopter patients and 612 ambulance patients.
After excluding the night-time patients, a total number of 517 patients could be included in the study; 210 received helicopter care (the helicopter group), 307 ambulance care only (the ambulance group).

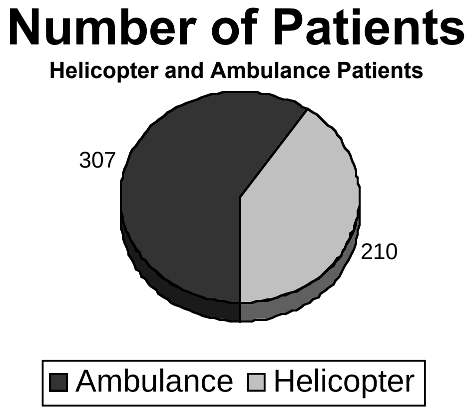

Figure 1: Number of included patients

Geographic Distribution of Patients

The area of study is covered by 11 dispatch centres (CPA's), serving 145,000 to 1.2 million inhabitants each.

Patients who were transferred to hospitals not participating in this study were excluded from the study. The number of these patients is unknown, and the following number therefore does not represent the total number of severely injured patients, however, it is important to study the number of patients per geographic area, as large differences were found.

CPA District	Number of Inhabitants	Included Patients per 100,000 Inhabitants	Percentage of Cases with Helicopter Involvement
Amsterdam and Surroundings	1,236,000	19.1	43.2
Eemland	259,000	3.1	62.5
Flevoland	221,000	5.4	50
Gooi & Vechtstreek	252,000	6	86.7
Haaglanden	944,000	3.4	31.3
Hollands Midden710,000		8	50.9
Kennemerland	381,000	4.2	50
Kop van Noord- Holland	145,000	4.1	100
Noord Kennemerland	234,000	5.1	41.7
Utrecht	811,000	14.5	17.8
West Friesland	175,000	2.9	100
Total	5,368,000	9.6	40.6

Table 1: Number of inhabitants per CPA district, total number of included patients per 100,000 inhabitants, and the percentage of helicopter involvement in the accidents per CPA district during the study (May 1995 - December 1996).

Table 1 shows the total number of inhabitants per CPA area, the number of included (daylight) patients and what the percentage of these patients who received helicopter care was. The number of severely injured per 100,000 inhabitants varies vastly, from 2.9/100.000 inhabitants in West Friesland to 19.1/100,000 in Amsterdam. But also the relative percentage of patients who received helicopter care highly varies per region. Patients who were not transfered to any of the participating hospitals, were not included in these numbers; these numbers therefore do not reflect trauma incidence in the given regions, but only provide the number of patients who were included in this study, by region and prehospital care method. Differences are discussed more in detail in chapter 4.

Although criteria for deployment of the helicopter trauma team were strictly defined, the helicopter was deployed less often than could have been necessary or possible. Dispatch centres have provided limited information on the reason for not calling for helicopter assistance (table 2).

Reason For No Helicopter Involvement	Absolute Numbers	Percentage
Assistance Requested But Helicopter Did Not Land	7	2.3%
Helicopter Not Available	27	8.8%
Cancelled	12	3.9%
Unknown	261	85.0%
Total	307	100%

Table 2: Reasons for no helicopter trauma team involvement for ambulance patients

In the majority of cases dispatch centres did not provide data on why the helicopter trauma team was not involved in these cases. Unavailability of the helicopter (due to visibility or weather conditions (12 cases), technical reasons (2 cases), or as a result of being on a different call (8 cases) or other/unknown (5 cases)) was responsible for 8.8% of cases.

Helicopter assistance was called for in seven cases where the helicopter did not land, for reasons such as helicopter unavailability or absence of suitable landing sites.

Cancelled flights were reported for only 3.9% of cases, but because 42.9% of all helicopter missions were terminated prior to landing having been canceled by ambulance crew makes it very likely that a substantial part of the category 'unknown' reasons for no helicopter involvement is caused by those cancels.

Other probable causes for the decision not to call for helicopter involvement, such as unfamiliarity with the helicopter trauma team, opposition toward helicopter care, inadequate triage may have been responsible for a number of cases in which the reason for no helicopter involvement remained unknown, but such variables were not recorded.

Age distribution

The ambulance patients and the helicopter patients were comparable in age. Mean age for the whole population was 38.5 years. Mean age of the ambulance patients was 39.8 years (Std. Dev. 21.0), ranging from 2 to 89 years; mean age of the helicopter patients was 36.6 years (Std. Dev 19.5), ranging from 2 to 85 years. Differences in age between the two groups were not significant (p=ns, Student's t test for independent samples).

It is important to note that majority of cases concerns young patients - more than 70% of patients in both group are aged 50 or below. Minors, aged 18 or less, made up 15.9% and 18.3% of the ambulance and helicopter population, respectively.

Sex distribution

The ambulance and helicopter group were comparable in sex distribution. The majority of patients in both groups was male, 68.7% in the helicopter group and 68.6% in the ambulance group. (Figure 2, table 3)

Sex	Ambulance Absolute Numbers	Ambulance Relative Percentages	Helicopter Absolute Numbers	Helicopter Relative Percentages
Male	211	68.7	144	68.6
Female	96	31.3	66	31.4
Total	307	100	210	100

Table 3: Sex distribution of patients

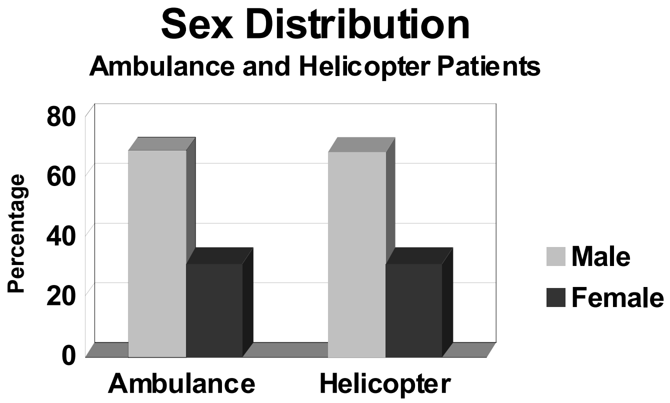

Figure 2: Sex distribution of patients

Mechanism of trauma

Traffic accidents accounted for 57.2% of trauma's in the total group studied, with no significant differences between the helicopter and ambulance group (58.6% in the ambulance group, 55.2% in the helicopter group), although car and motorcycle accidents were relatively more frequently seen in the helicopter group (47.4% and 16.4% of all traffic accidents) compared to the ambulance group (29.4% and 11.7%). This is balanced by a relatively higher number of accidents involving slow traffic (pedestrians, bicycles, mopeds, tractors) and public transportation vehicles (trains, buses and tramways) in the ambulance group (41.7% and 16.7% versus 22.4% and 6.0%). Domestic accidents, including falls, were the second most frequently encountered cause of injury, responsible for 19.2% of admissions in the ambulance group and 20.0% in the helicopter group.

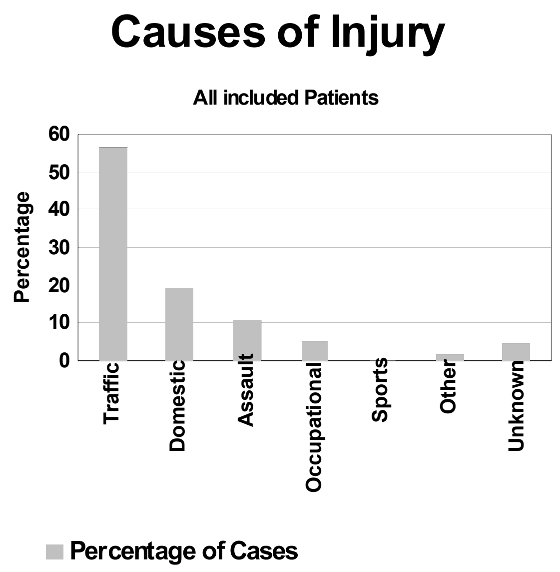

figure 3: Causes of injury for all included patients

Assault is third, accounting for 11.4% in the ambulance group and 10.0 % in the helicopter group.

The very low incidence number of sports injuries are striking, in the population studied. Sports related injuries make up a vast part of the emergency department workload in the Netherlands as well as in most other western countries, but as these numbers make clear, few of all sports traumas turned out to be severe enough to meet inclusion criteria in this study. Also, severe occupational accidents are a minority in comparison with traffic and domestic ones (table 4)

Cause of Injury	All Patients (N=517) (Absolute Numbers)	All Patients (Relative Percentages)
Traffic	296	57.2
Domestic	101	19.5
Assault	56	10.8
Occupational	29	5.6
Sports	3	0.6
Other	8	1.5
Unknown	24	4.6
Total	517	100

Table 4: Causes of injury for all included patients

Causes Of Injury	Ambulance Patients Absolute Numbers	Ambulance Patients Relative Percentages	Helicopter Patients Absolute Numbers	Helicopter Patients Relative Percentages
Traffic	180	58.6	116	55.2
Domestic	59	19.2	42	20
Assault	35	11.4	21	10
Occupational	19	6.2	10	4.8
Sports	2	0.7	1	0,5
Other	8	2.6	0	0
Unknown	4	1.3	20	9.5
Total	307	100	210	100

Table 5: Causes of injury for the ambulance and helicopter group

Accident Type	Ambulance Patients Absolute Numbers (n=180)	Ambulance Patients Relative Percentages	Helicopter Patients Absolute Numbers (n=116)	Helicopter Patients Relative Percentages
Car Accident	53	29.4	55	47.4
Motorcycle	21	11.7	19	16.4
Public Traffic	30	16.7	7	6
Slow Traffic	75	41.7	26	22.4
Truck Accidents	1	0.6	9	7.8
Total	180	100	116	100

Table 6: Nature of traffic accidents for ambulance and helicopter patients

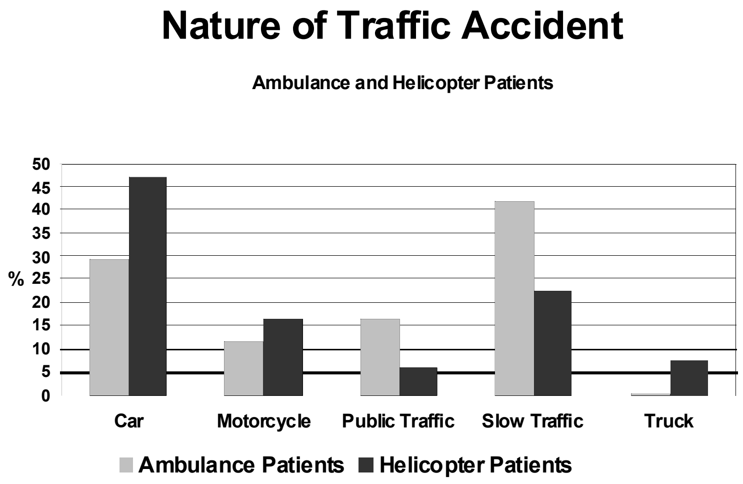

figure 4: Nature of traffic accidents for ambulance and helicopter patients in relative percentages

Scoring

Revised Trauma Score at the scene of accident

Of 242 ambulance patients and 171 helicopter patients, the RTS scores were recorded at the scene of accident, for the remaining 65 ambulance patients and 39 helicopter patients RTS scores were unknown. For all ambulance crew, scoring the RTS for every patient was mandatory, not only as part of the experiment, but also as part of the general administrative routine of all ambulance services in the region. It was unexpected, therefore, to find such a high number of missing RTS scores. A number of possible explanations can be given for not scoring the RTS;

- for patients whose RTS is unaffected (i.e. RTS was 12), RTS scores were possibly not recorded on the ambulance sheets, because it was considered to be an unnecessary effort to do any paperwork for values that are considered 'normal'.
- for patients whose RTS was affected (i.e. lower than 12), so much effort was given to stabilise the patient's condition by the ambulance crew that recording findings on paper had a low priority at the time and was ultimately forgotten.
- Possibly in a number of cases the necessary physiologic parameters for the Revised Trauma Score had not even been checked at the time as the ambulance crew was too busy preparing the patient for the fastest possible transfer to hospital ("scoop and run")

Because all these three possibilities may be responsible for a variable part of the missing RTS-scores and as all three different explanations suggest possible 'missing' RTS-values of an alternate kind, it was not possible to retrospectively re-estimate missing values. Instead, the group of patients with missing preclinical RTS-values was taken as a whole and analysed as a separate group further on.

For the 242 ambulance patients the mean RTS was 9.9 (Std. Deviation 3.0), and median RTS was 11.00. Highest RTS was 12, lowest RTS was 0 in this group.

The 171 helicopter patients had a mean RTS of 9.0 (Std. Deviation 3.6), and median RTS was 10.00. Highest RTS was 12, lowest RTS was 0 in this group.
The difference between ambulance and helicopter patients' RTS was not significant (Student's t-test for independent samples).

RTS Score	Ambulance Absolute Numbers (n=242)	Ambulance Relative Percentages	Helicopter Absolute Numbers (n=171)	Helicopter Relative Percentages
0	8	3.3	13	7.6
1	2	0.8	0	0
2	2	0.8	3	1.8
3	1	0.4	2	1.2
4	4	1.7	3	1.8
5	6	2.5	4	2.3
6	6	2.5	7	4.1
7	8	3.3	11	6.4
8	17	7	15	8.8
9	16	6.6	16	9.4
10	33	13.6	13	7.6
11	27	11.2	19	11.1
12	112	46.3	65	38
Total	242	100	171	100

Table 7: RTS scores for ambulance and helicopter patients

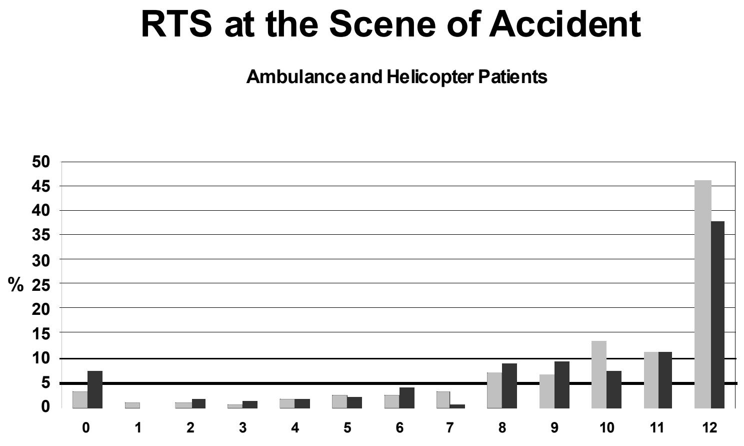

figure 5: RTS scores of ambulance and helicopter patients at the scene of the accident

It is important to note that even in this group of severely injured patients the 'optimal score' of 12 is the most frequently seen of all.

Optimal RTS scores do not rule out severe pathology. Younger patients, especially, are able to compensate for large losses of blood before shock becomes clinically manifest.

Additionally, the Glasgow Coma Scale, as an element of the Revised Trauma Score, is limited to parameters regarding consciousness and coordination only, while other, very important neurological findings as changes of pupil sizes and reflexes, focal pareses and spinal cord lesions can exist without influencing the GCS and RTS.

Revised Trauma Score in Hospital

Once patients were admitted to one of the participating hospitals, Revised Trauma Score for patients were also recorded by the responsible hospital physicians.

The first recorded RTS after arrival in hospital was used in the study.
Recording RTS scores in hospital has a number of important limitations, however. First of all, if RTS scores are not systematically recorded by the hospital physician, it is often impossible to retrieve all necessary information to calculate RTS scores retrospectively. Although generally in medical records attention is paid to blood pressure rate and Glasgow Coma Scale, the respiratory rate is often unnoted in medical records. Also, the Revised Trauma Score can only partially be scored in patients who are intubated, because vocal response is inhibited. Anestetics, as used often by the helicopter trauma team, have a large influence on the Revised Trauma Score (especially by depressing Glasgow Coma Scale) so for these patients the Revised Trauma Score is of little value.

Of 283 ambulance patients Revised Trauma Score was scored in hospital, and of 97 helicopter patients who did not receive anestetics.
Mean RTS for ambulance patients in hospital was 10.5 (SD 2.6), of the non anestesised helicopter patients 9.9 (SD 3.9). Differences were not significant (t test for independent samples) between both groups.
Differences between RTS on the scene of accident and in hospital were also assessed.

In the ambulance group, of 222 patients both at the scene of accident as well as in hospital RTS scores were recorded. In 27.9% of cases Revised Trauma Score was improved, by 1 to 8 points, in 57.2% there was no change in RTS score, and in 14.9% RTS scores were lower in hospital than at the scene of accident.

In the helicopter group, in 79 cases RTS scores were recorded at both locations. Improvement of RTS was present in 15.2% of cases, no change in 67.1% and worsening in 17.7% of cases.

ISS Score

Injury Severity Score was known in 302 of 307 ambulance patients and in 206 of the 210 helicopter patients. In the remaining 8 cases where ISS scores were not recorded, 6 patients died before or closely after arriving at hospital and no premortal clinical diagnosis was recorded.

In the ambulance group, mean ISS was 25.5 (Std. Deviation 11.5, Median 21.0), in the helicopter group mean ISS was significantly higher ($p<0,01$, t-test for independent samples) at 28.6 (Std. Deviation 13.3, Median 25,0).

Lowest ISS in the ambulance group was 4, highest 75; in the helicopter group lowest was 1, highest was 66.

ISS	Ambulance Patients Absolute Numbers	Ambulance Patients Relative Percentages (n=307)	Helicopter Patients Absolute Numbers	Helicopter Patients Relative Percentages (n=210)
<25	174	56.7	96	45.7
25 ~ 40	93	30.3	65	31
>40	35	11.4	45	21.4
Unknown	5	1.6	4	1.9

Table 8: Ambulance and helicopter patients by ISS category

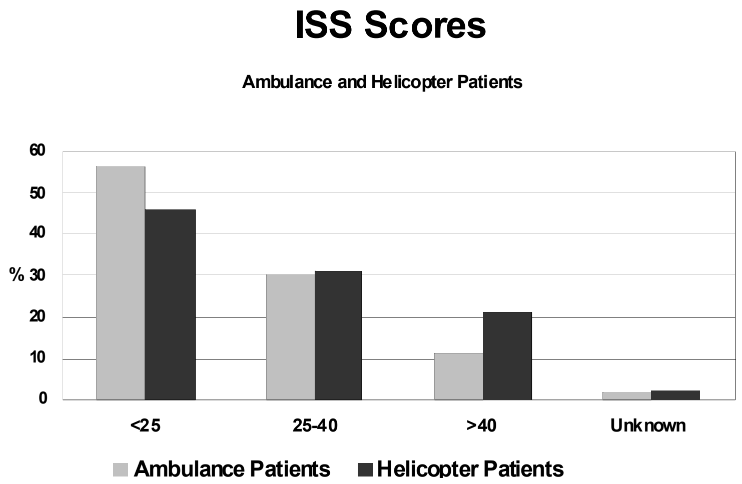

Figure 6: ISS scores of ambulance and helicopter Patients

As a result of the differences found in the ISS scores between the two groups, it was necessary to stratify patients by ISS-score to make possible a comparison between the helicopter and ambulance groups. Patients were divided in 3 groups, the first consisting of patients with ISS scores of 24 or less, the second of ISS scores between 25 and 40, and the final group of ISS 41 and above. The rationale for this division is that in the first group only patients with maximally 1 injury grade 4 of the HTI scale are included, in the second either 1 injury grade 5 or 2 injuries grade 4 (5^2=25, 4^2+4^2=32) could be present. In the final, most seriously wounded, group of patients at least 1 injury grade 4 plus 1 injury grade 5 (4^2+5^2=41) had to be present.

Type of Injury

In the HTI, severity of injuries in 6 individual functional regions of the body is scored separately; the skull and head, the respiratory system, the cardiovascular system, the abdomen, the extremities and the skin and soft tissues.

No important differences existed in the pattern of injuries between the helicopter and ambulance group.

Skull/head and extremities were injured most often (table 9) to a serious extent, followed by the respiratory system.

It is important to note that the majority of severely injured patients have at least minor head and skull injuries, and almost half (48.2%) of all severely injured trauma patients have skull and head injuries of such a de-gree (grade 3 or higher) that observation and treatment in a hospital with specialised neurosurgical facilities is necessary (taking the definition of grade 3 - loss of consciousness of more than 15 minutes, impression fracture of the skull, serious facial fractures, and fracture of the cervical spine without neurological loss as criterium for admission to a specialised facility).

Cardiovascular injuries were present in 70% of cases to at least some extent, though, only few of these injuries were serious.

The same is true for injuries of the skin and soft tissues; in almost 75% of cases there was some injury present, but almost all of these were limited to grade 1 or 2 only. Underscoring may be present to an extent, considering the fact that more skin and especially soft tissue damage is expected coinciding with the number of severe injuries of the extremities.

HTI	*HTI = 0*	*HTI =3, 4 or 5*	*HTI = 4 or 5*	*HTI = 5*
Skull/Head	33.5%	48.2%	37.4%	3.7%
Respiratory	50.0%	35.1%	13.8%	6.9%
Cardiovascular	30.0%	22.7%	14.0%	7.9%
Abdominal	75.2%	13.3%	4.6%	1.6%
Extremities	35.9%	48.3%	31.7%	5.3%
Skin/Soft Tissues	26.8%	4.9%	1.8%	1.0%

Table 9: Distribution of HTI scores in all patients

On site treatment - 'paramedic type' interventions.

Preclinical records provided by the ambulance services and the helicopter trauma team were examined to assess those interventions that can theoretically be expected to be performed by ambulance attendants.

These concern provision of wound care, control of blood losses, splinting, artificial ventilation, insertion of a Mayo tube, endotracheal intubation, applying suction, use of a scoop stretcher, use of M.A.S.T., use of vacuum matrasses, E.C.G. monitoring, cardiac defibrillation, cardiac massage, gaining intra-venous access, use of infusor pumps, use of pulse oximetry, pacing and appliance of neck-splints, as appear on all standard ambulance sheets that have to be completed after each ambulance run - not only as part of the experiment, but also as part of the administrative routine of the ambulance services themselves. The names of all the forementioned preclinical interventions are preprinted on the standard ambulance sheets, used by all ambulance services in the experimental area, and a blank next to any of these has to be circled if the procedure is in fact, carried out during patient contact. An example of an ambulance sheet, which was used in Amsterdam and surroundings, is printed in supplement 1.

Originally, it was part of the study design to use forms, specifically designed for the purpose of this study, and request ambulance crews to fill in these forms following each run for a severely injured trauma patient.

These forms contained more specified information regarding treatment and injuries than the standard ambulance forms, and could have been very useful for the study to have a more universal method of comparison.

Although all ambulance services and dispatch centres operating in the experimental area promised full cooperation in providing data on each individual patient by use of these special forms, this approach was unsuccessful. Only for a very small number of trauma cases these forms were actually filled in and returned.

As it was not possible to retrospectively retrieve all information with any chances of data reliability, it was decided to use standard ambulance sheets instead. These carried less detailed information, but because these forms had to be completed mandatorily following each ambulance run, it was possible to collect all missing ambulance data without any loss of quality of the data provided.

Data concerning patients who were treated by the helicopter trauma team were also provided by the helicopter trauma team itself. The use of the specially designed research forms was rendered successful for this group, unlike the situation with the ambulance services, and the originally developed forms were completed for all helicopter patients

with a high rate of accuracy. In this way, two sources of information were available for helicopter patients regarding preclinical treatment; the limited set of data provided by the ambulance services and the more detailed data provided by the helicopter trauma team.

Theoretically, information on the same preclinical interventions on identical helicopter patients, provided by ambulance crew and helicopter trauma team should be equal.

Whether an intervention of any kind is performed out or not, recording these facts should not be considered very difficult or subjective.

However, examining data from the ambulance sheets and helicopter forms has shown large differences in reported rates for identical interventions for the same patients. Many reasons can be explanatory for the differences found and will be discussed in chapter 4.

Because of this, the results are published as follows:
Ambulance patients:
- data reported by the ambulance crew

Helicopter patients:
- data reported by the ambulance crew
- data reported by the helicopter trauma team
- data reported by either ambulance crew or helicopter trauma team. In this category a specific intervention is considered to be carried out if ambulance crew or helicopter trauma team or both reported the intervention to be carried out.
- data reported by both ambulance crew and helicopter trauma team. In this category a specific intervention is considered to be carried out only if both ambulance and helicopter reported the intervention to be carried out.

Whole population

Ambulance crew provided data regarding preclinical treatment of 280 of the 307 ambulance patients and 189 of the 210 helicopter patients, the helicopter trauma team provided data on 204 of 210 helicopter patients. On 183 helicopter patients preclinical data on treatment was provided for by both helicopter team and ambulance personnel.

In the ambulance group, no information concerning preclinical treatment was provided for 28 ambulance patients and 21 helicopter patients; although these ambulance forms were thought to be completed, all information on preclinical treatment was left blank.

Because it was impossible to retrieve any reliable information on what treatment was given to these patients, these forms were left out of the analysis. So were 6 helicopter patients of whom all preclinical information by the helicopter trauma team was lost.

As the ambulance crew was the only source of information for the ambulance patients, these numbers are used to compare all four groups of helicopter data with (‘reported by ambulance’, ‘reported by helicopter’,’reported by ambulance or helicopter’ and ‘reported by ambulance and helicopter’).

For the helicopter patients, only those cases were considered for the ‘reported by ambulance’ group for which helicopter and ambulance forms were present and filled in correctly (n=183), the same was done for the groups ‘reported by ambulance or helicopter’ and ‘reported by ambulance and helicopter’. For examining the helicopter patients by helicopter reports, all available helicopter records were used (n=204).

Wound Care

The definition of wound-care is subjective. The reported rates are dependent therefore on the personal definition of the ambulance or helicopter crew members who were responsible for filling out the reports. Nevertheless, it is remarkable that reported rates, by ambulance and helicopter crew separately, for helicopter patients are lower than for the ambulance patients. Only when the two sources of information are added, it nears the ambulance group rate.

In majority it is only one of the two teams that report that wound care is given and little overlap (8.7%) exists between the two sources of information for the helicopter group.

Wound Care Provided	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance Crew	38.9% (n=280)	26.2% (n=183)	p<0.01
Reported by Helicopter Trauma Team	38.9% (n=280)	18.6% (n=204)	p<0.001
Reported by Ambulance Crew or Helicopter Trauma Team	38.9% (n=280)	35.5% (n=183)	p=ns
Reported by Ambulance Crew and Helicopter Trauma Team	38.9% (n=280)	8.7% (n=183)	p<0.001

Table 10: Percentage of ambulance and helicopter patients who received wound care recorded by ambulance crew, helicopter trauma team, ambulance crew or helicopter trauma team, and ambulance and helicopter trauma team.

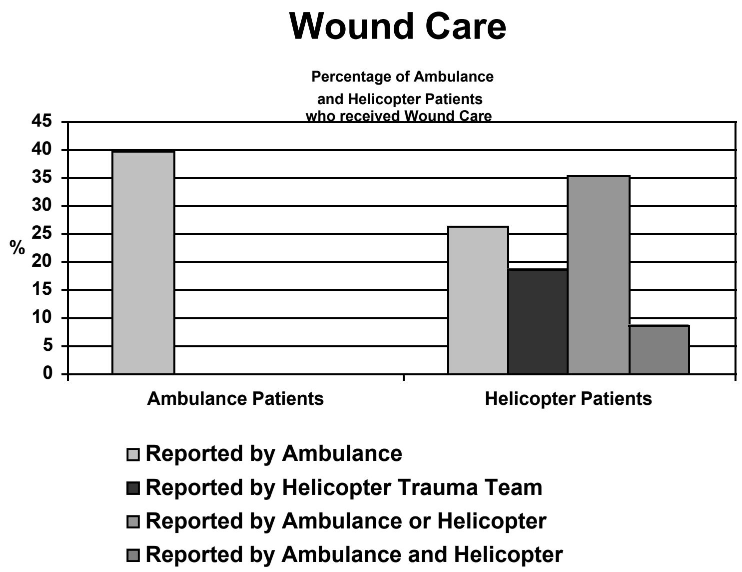

Figure 7: Percentage of ambulance and helicopter patients who recieved wound care

Control of blood losses

Table 11 and figure 8 show that reported rates for control of blood losses is reported to be performed less often in the helicopter group, than in the ambulance group, when considering the reported rates of ambulance and helicopter crew alone. It is remarkable that for the same group of (helicopter) patients, control of blood losses is described to have happened in different individuals by the ambulance crew and by the helicopter crew, possibly due to the subjective definition of control of blood losses. It is not specified to what extent blood losses have been, what the nature (arterial, venous) of the haemorrhages have been, nor the success rate of the procedures.The combined rate for the helicopter group ('reported by ambulance or helicopter') near-equals the reported rate for the ambulance group, but in all other comparisons control of blood losses is reported to have happened less often in the helicopter group.

Control of Blood Losses	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Recorded by Ambulance Crew	21.4% (n=280)	8.7% (n=183)	p<0.001
Recorded by Helicopter Trauma Team	21.4% (n=280)	14.2%(n=204)	p<0.05
Reported by Ambulance or Helicopter	21.4% (n=280)	20.8%(p=183)	p=ns
Reported by Ambulance and Helicopter	21.4% (n=280)	2.7%(n=183)	p<0.001

Table 11: Percentage of ambulance and helicopter patients for whom control of blood losses was applied, reported by ambulance crew, helicopter trauma team and combined

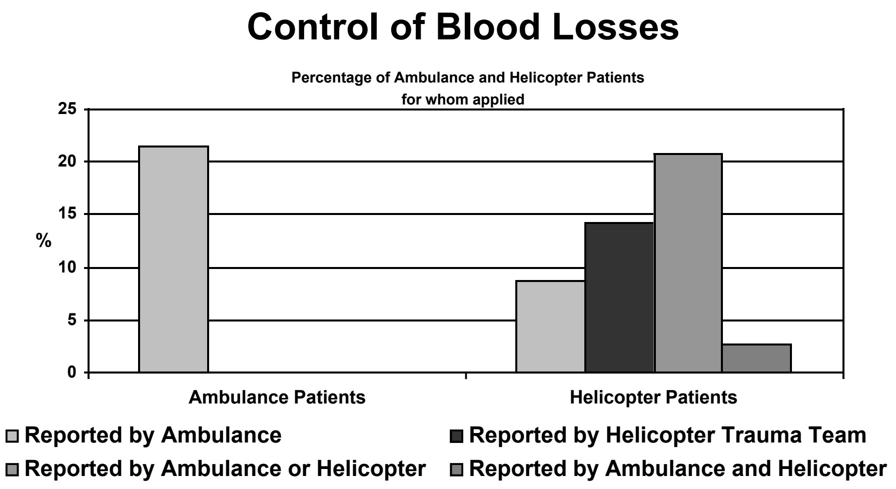

Figure 8: Percentage of ambulance and helicopter patients for whom control of blood losses was applied

Splints

Table 12 and figure 9 show the percentage of ambulance and helicopter patients in whom one or more extremities were splinted. Neck splints are separately considered and are not included in this table.

No significant differences were found between both groups in the rate of splints used when looking at the rates by reported by ambulance and helicopter trauma team separately.

Most remarkable, however, is the fact that when looking at the number of helicopter patients who are described by ambulance or helicopter team to have received a splint, the actual rate is significantly higher than for the ambulance patients, meanwhile when considering only helicopter patients who have been described to have received a splint by both ambulance and helicopter, the actual rate is significantly lower than in the ambulance group.

Splinting	Ambulance Group	Helicopter Group	Significance (Chi-Square Test)
Reported by Ambulance Crew	32.5% (n=280)	30.1% (n=183)	p=ns
Reported by Helicopter Trauma Team	32.5% (n=280)	34.3% (n=204)	p=ns
Reported by Ambulance or Helicopter	32.5% (n=280)	44.8% (n=183)	p<0.01
Reported by Ambulance and Helicopter	32.5% (n=280)	20.2% (n=183)	p<0.01

Table 12: Percentage of ambulance and helicopter patients for whom splints were used reported by ambulance crew, helicopter trauma team and combined

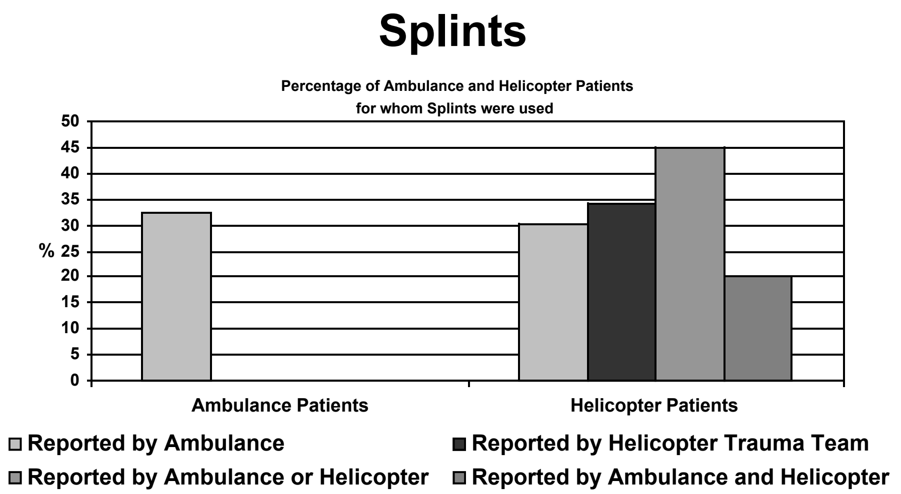

Figure 9: Percentage of ambulance and helicopter patients for whom splints were used

Artificial Ventilation

Artificial Ventilation	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance Crew	17.1% (n=280)	64.5% (n=183)	p<0.001
Reported by Helicopter Trauma Team	17.1% (n=280)	59.8% (n=204)	p<0.001
Reported by Ambulance or Helicopter	17.1% (n=280)	82.0% (n=183)	p<0.001
Reported by Ambulance and Helicopter	17.1% (n=280)	42.1% (n=183)	p<0.001

Table 13: Percentage of ambulance and helicopter patients who received artificial ventilation

Table 13 and figure 10 illustrate that helicopter patients received artificial ventilation significantly more often than ambulance patients did; helicopter patients received artificial ventilation almost 4 times more often (64.5% vs. 17.1%) than ambulance patients did, according to the ambulance report rate.

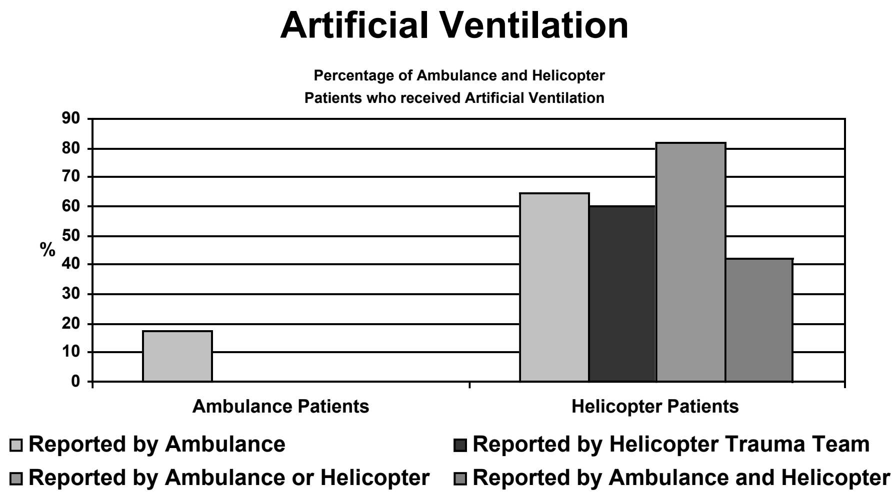

Figure 10: Ambulance and helicopter patients who received artificial ventilation

Artificial ventilation, unlike wound-care or control of blood losses, is not subjectively defined (it is either given or not), so the differences in artificial breathing rates found between the ambulance and helicopter are surprising. Nevertheless, in all cases the reported rate for helicopter patients is by considerably higher than for ambulance patients.

Use of a Mayotube

Mayotube	Ambulance Patient	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	12.9% (n=280)	8.2% (n=183)	p=ns

Table 14: Percentage of ambulance and helicopter patients who received a Mayotube

Table 14 shows that although the percentage of ambulance patients reported having received a Mayotube as means of intubation is somewhat higher than in the helicopter group, differences are not large enough to be of a significant level. As the use of the Mayotube was not part of the helicopter report forms, only this comparison could be made.

Endotracheal Intubation

Table 15 shows major differences in the intubation rates of ambulance and helicopter patients. Only a small percentage of ambulance patients are endotracheally intubated, whereas almost 4 out of 10 patients are intubated in the helicopter group are (39.3%), even in the group ‘reported by ambulance and helicopter’.

Non-physician ambulance personnel may be authorised to intubate patients, still the number of times this routine is carried out is lower than in the helicopter group.

Intubation	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	5.4% (n=280)	40.4% (n=183)	p<0.001
Reported by Helicopter	5.4% (n=280)	57.4% (n=204)	p<0.001
Reported by Ambulance or Helicopter	5.4% (n=280)	58.5% (n=183)	p<0.001
Reported by Ambulance and Helicopter	5.4% (n=280)	39.3% (n=183)	p<0.001

Table 15: Percentage of ambulance and helicopter patients who were endotracheally intubated

The respiratory insufficient but not unconscious patients cannot be intubated by the ambulance nurses, whereas the helicopter trauma team is able to administer general anesthesia to not unconscious trauma patients at the scene creating the possibility to intubate. In the helicopter group, only 42.7% of the 117 intubated patients had a Glasgow Coma Scale of less than 8; the remaining 57.3% were all given additional anesthetics prior to intubation.

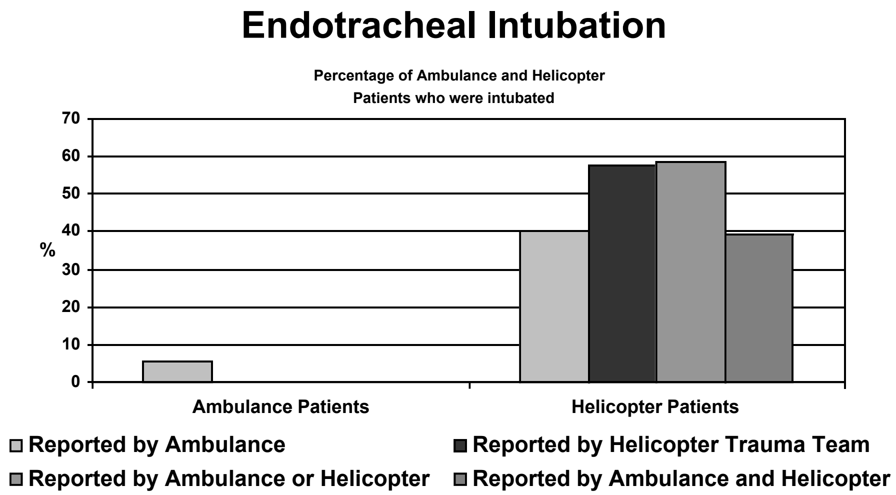

Figure 11: Percentage of ambulance and helicopter patients who were intubated

Suction

Suction	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	8.9% (n=280)	9.8% (n=183)	p=ns
Reported by Helicopter	8.9% (n=280)	27.0% (n=204)	p<0.001
Reported by Ambulance or Helicopter	8.9% (n=280)	27.3% (n=183)	p<0.001
Reported by Ambulance and Helicopter	8.9% (n=280)	8.2% (n=183)	p=ns

Table 16: Percentages of ambulance and helicopter patients for whom suction is applied

Table 16 and figure 12 show that no significant differences exist between the rate of suction reported between the ambulance and the helicopter group, according to the reported rate by ambulance personnel.

However, the helicopter trauma team reported a much higher rate (27.0%), which is significantly higher. It is important to note that most patients reported to have received suction by the ambulance (9.8%) are also reported so by the helicopter (8.2%).

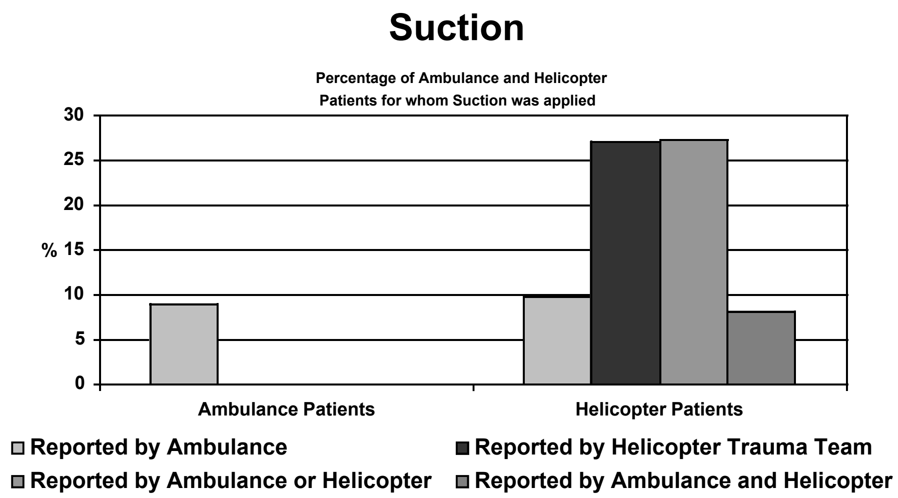

Figure 12: Percentage of ambulance and helicopter patients for whom suction was applied

Use of the Scoop Stretcher

Scoop Stretcher	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	50.4%	28.4%	p<0.001

Table 17: Percentage of ambulance and helicopter patients for whom a scoop stretcher was used for transfer

Table 17 shows that scoop stretchers are reported to have been used less often in the helicopter group than in the ambulance group. Scoop stretchers are used to immobilise and transport patients at risk for instable fractures of the vertebrae in special. No data regarding use of the scoop stretcher was available from the helicopter trauma team.

Use of M.A.S.T.

The use of M.A.S.T. (Military Anti-Shock Trousers) was not reported for any of the ambulance or helicopter patients. Although application of M.A.S.T. features on the list of possible ambulance interventions, M.A.S.T. was not a part of the regular road ambulance equipment in the Netherlands nor of that of the helicopter team.

Vacuum matresses

Vacuum Matresse	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Use of Vacuum Matresses	0.7% (n=280)	3.8% (n=183)	p<0.05

Table 18: Percentage of ambulance and helicopter patients for whom vacuum matresses were used

Table 18 shows that vacuum matresses are used significantly more often for helicopter patients than in ambulance patients, although in both groups vacuum matresses are used only sporadically. No data regarding use of vacuum matresses was available from the helicopter trauma team itself.

E.C.G.

E.C.G.	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	47.5% (n=280)	55.7% (n=183)	p=ns
Reported by Helicopter	47.5% (n=280)	74.0% (n=204)	p<0.001
Reported by Ambulance or Helicopter	47.5% (n=280)	86.9% (n=183)	p<0.001
Reported by Ambulance and Helicopter	47.5% (n=280)	44.3% (n=183)	p=ns

Table 19: Percentage of ambulance and helicopter patients for whom E.C.G. was used for monitoring

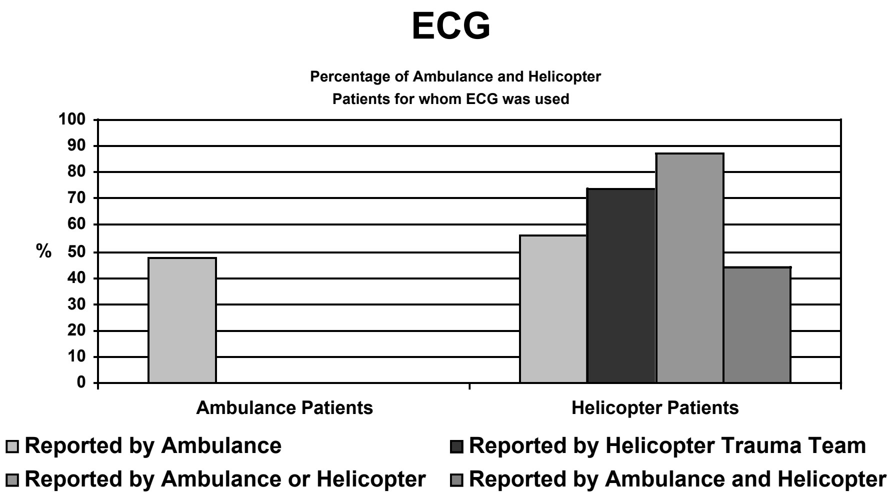

Figure 13: Percentage of ambulance and helicopter patients for whom E.C.G. was used

Table 19 and figure 13 show that no significant differences exist in the rate that Electro Cardiography (E.C.G.) Is used to monitor patient's condition in the ambulance and helicopter group. Use of E.C.G. is most important in those patients who have suffered either thoracic trauma with concussion of the heart or who have suffered considerable blood losses, as the risk of heart rhythm disorders or cardiac arrest is considerable in these two categories of patients. An E.C.G. is of essential value monitoring heart rates in the management of shock.

The reported rate for helicopter patients, as reported by the helicopter team and the 'reported by ambulance or helicopter' rate is considerably higher than the ambulance group rate. Nevertheless, the rate is much lower when being described by the ambulance crew, and by ambulance and helicopter.

Cardiac Defibrillation

Cardiac Defibrillation	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	1.1% (n=280)	2.7% (n=183)	p=ns
Reported by Helicopter	1.1% (n=280)	4.9% (n=204)	p<0.05
Reported by Ambulance or Helicopter	1.1% (n=280)	4.9% (n=183)	p<0.05
Reported by Ambulance and Helicopter	1.1% (n=280)	2.7% (n=183)	p=ns

Table 20: Percentage of ambulance and helicopter patients who received cardiac defibrillation

Table 20 and figure 14 show that cardiac defibrillation was performed in a small percentage of patients in both groups (differences were not significant).

In a number of cases wherein this procedure was performed in the helicopter group, this was not recorded as such by the ambulance crew.

All defibrillations were reported to be successful in both groups.

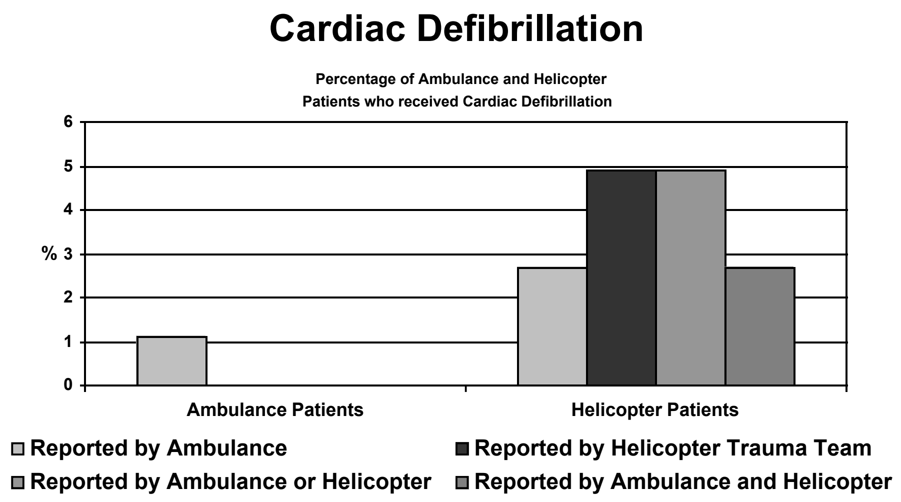

Figure 14: Percentage of ambulance and helicopter patients who received cardiac defibrillation

Cardiac Massage

Cardiac Massage (Chi-Square Test)	Ambulance Patients	Helicopter Patients	Significance
Reported by Ambulance	5.0% (n=280)	7.1% (n=183)	p=ns
Reported by Helicopter	5.0% (n=280)	12.7% (n=204)	p<0.01
Reported by A mbulance or Helicopter	5.0% (n=280)	12.6% (n=183)	p<0.01
Reported by Ambulance and Helicopter	5.0% (n=280)	6.6% (n=183)	p=ns

Table 21: Percentages of ambulance and helicopter patients who received cardiac massage

In table 21 and figure 15 the percentages of patients who received cardiac massage are shown. The helicopter trauma team reported cardiac massage to be performed more often for their patients than the ambulance crew did for the same group.

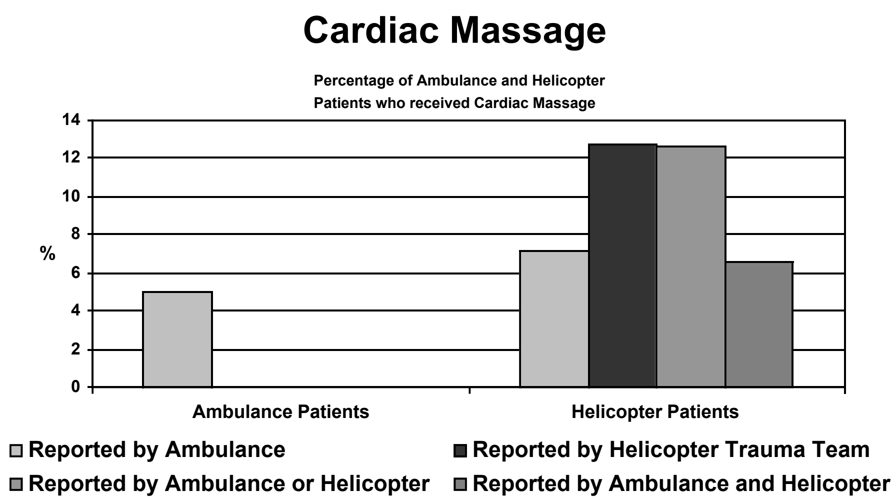

Figure 15: Percentage of ambulance and helicopter patients who received cardiac massage

Total Intra-Venous Access

IV Access	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	81.1% (p=280)	94.0% (p=183)	p<0.001
Reported by Helicopter	81.1% (p=280)	98.5% (p=204)	p<0.001
Reported by Ambulance or Helicopter	81.1% (p=280)	99.5% (p=183)	p<0.001
Reported by Ambulance and Helicopter	81.1% (p=280)	93.4% (p=183)	p<0.001

Table 22: Percentage of ambulance and helicopter patients who have received at least one cannula for IV access.

Table 22 and figure 16 show the percentages of patients who had at least one site for IV access. The volumes and nature (colloids/crystalloids) of fluids administered were not recorded in this study. No reliable data were available for ambulance patients on the number of IV access sites per patient.

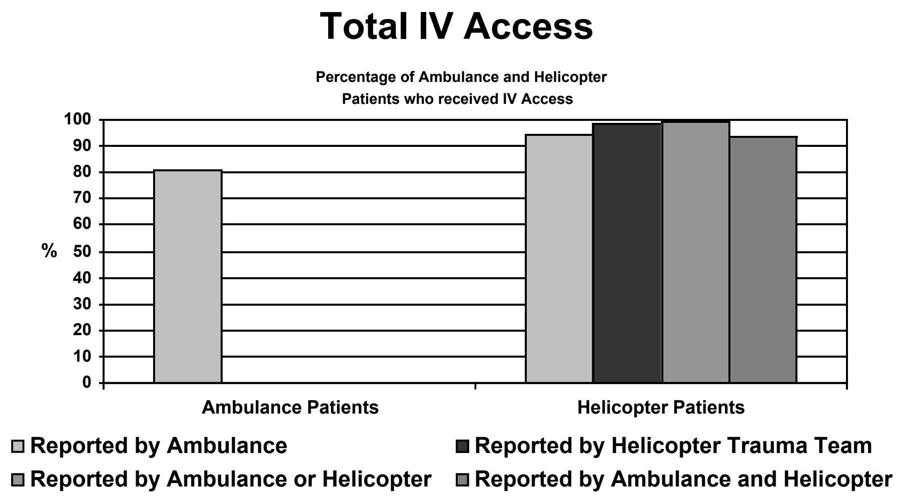

Figure 16: Percentage of ambulance and helicopter patients who received IV access

In the helicopter group, it was recorded by the helicopter team that 38 patients (18.6%) had one site for IV access, 161 patients (78.9%) 2 sites, 2 patients (1.0%) 3 sites and 3 patients (1.5%) had no IV access whatsoever. Also, when patients are not in a clinical state of shock, it is far more preferable to insert the IV cannula then, as chances of successfully inserting IV cannulas are considerably smaller once patients are in shock and their veins are collapsed.

The differences in the relative number of patients who have received at least one IV cannula are huge, 81.1% for the ambulance group compared to well above 90 % for the helicopter group, depending on the source of report. A 100% I.V. access rate is often regarded optimal in such a group of patients. As these figures show, not even the helicopter team succeeded in achieving this, as the difficulty of inserting IV cannulas should never be underestimated; especially facing difficult working conditions on scene with severely injured patients it can be impossible to insert a cannula even for the best skilled. However, when not succeeding in inserting a peripheral IV cannula, for the helicopter trauma team gaining access by venesection or by a central vein (described in 8 helicopter patients) is another alternative, but these options are an impossibility for ambulance crew alone to perform.

The 81.1% IV access rate in the ambulance group can be considered far too low; this low rate can be attributed to two possible factors:

- Management causes. Although ambulance protocols in use always demand IV cannulas to be placed in the category of patients used in this study, possibly the awareness of these protocols is still not of a required level, or ambulance personnel decided not to follow the protocols in the cases where no IV access was gained.
- Technical causes. It might be possible that necessary skills for gaining IV entry were not trained well enough to succeed in gaining IV entry to the same rate of success the helicopter trauma team did.

Intra-Venous Pumps

Table 23 shows that reported rates for the use of IV pumps are marginal for both categories of patients; the difference found was not significant. In both groups it concerned only a small percentage of patients for whom these devices were applied before arrvial in hospital.

No specified information regarding the use of IV pumps was available from the helicopter team.

Intra-Venous Pumps	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	1.1% (p=280)	1.6% (p=183)	p=ns

Table 23: Percentage of ambulance and helicopter patients for whom an IV pump was used

Pulse Oximetry

Table 24 and figure 17 show the use of pulse oximetry for the ambulance and helicopter population. No significant differences were found between the ambulance and helicopter group, considering only the rates provided by the ambulance crews. Using information from the helicopter trauma team, the differences between ambulance and helicopter patients were larger.

Pulse Oximetry	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	50.4%(n=280)	52.5%(n=183)	p=ns
Reported by Helicopter	50.4%(n=280)	88.7%(n=204)	p<0.001
Reported by Ambulance or Helicopter	50.4%(n=280)	94.0%(n=183)	p<0.001
Reported by Ambulance and Helicopter	50.4%(n=280)	46.4%(n=183)	p=ns

Table 24: Percentage of ambulance and helicopter patients for whom pulse oximetry was applied

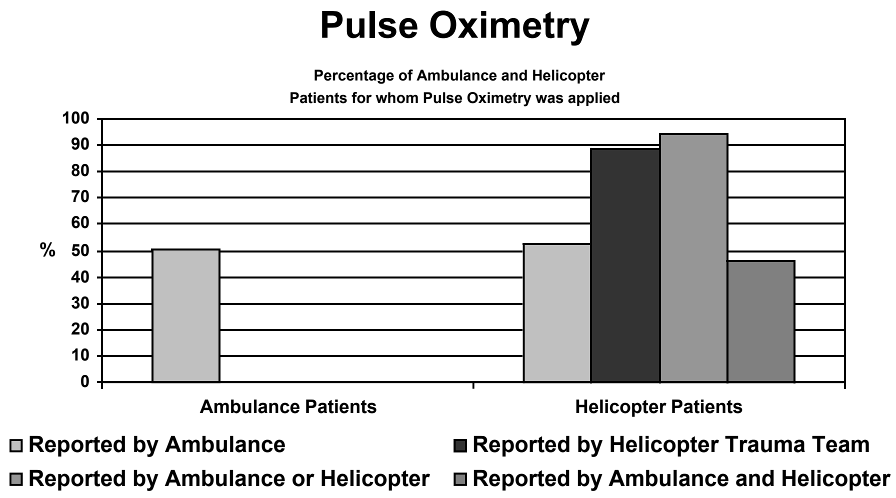

Figure 17: Percentage of ambulance and helicopter patients for whom pulse oximetry was applied

It is unclear if real differences between use of pulse oximetry underlie the differences in the reported rates, as it would also be possible that use of pulse oximetry is such common practice among ambulance personnel that it is forgotten to be mentioned.

Pacing

Pacing	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	0.4% (n=280)	1.1% (n=183)	p=ns
Reported by Helicopter	0.4% (n=280)	1.5% (n=204)	p=ns
Reported by Ambulance or Helicopter	0.4% (n=280)	1.6% (n=183)	p=ns
Reported by Ambulance and Helicopter	0.4% (n=280)	1.1% (n=183)	p=ns

Table 25: Percentage of ambulance and helicopter patients for whom pacing was performed

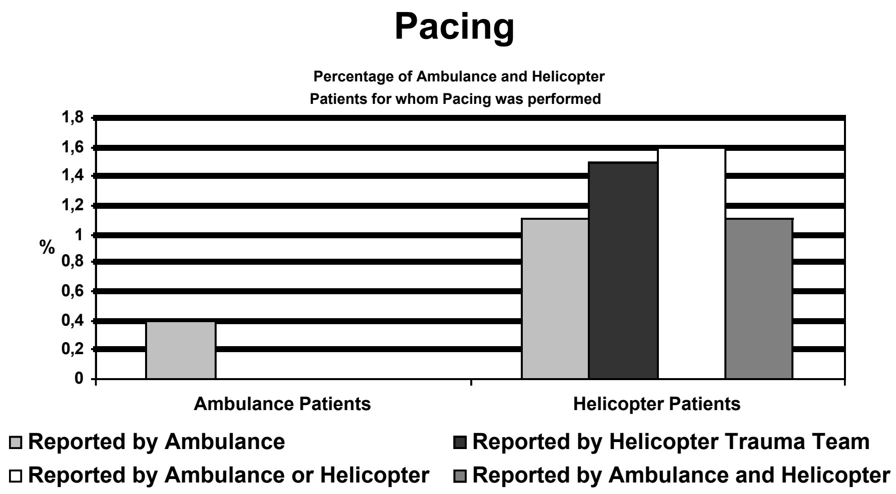

Figure 18: Percentage of ambulance and helicopter patients for whom pulse oximetry was applied

Table 25 shows the percentage of patients for whom pacing was carried out. The percentages are low for both groups of patients and no significant differences were found.

In a number of cases the helicopter trauma team reported pacing to be performed, meanwhile the ambulance crew did not report so.

Neck Splints

Table 26 shows what percentage of ambulance and helicopter patients received neck splint. Contrary to the use of vacuum matrasses, neck splints were applied more frequently in the helicopter group than in the ambulance group to a rate more than double when helicopter reports are considered.

Neck Splint	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
Reported by Ambulance	30.0%(n=280)	45.4%(n=183)	p<0.001
Reported by Helicopter	30.0%(n=280)	76.0%(n=204)	p<0.001
Reported by Ambulance or Helicopter	30.0%(n=280)	81.4%(n=183)	p<0.001
Reported by Ambulance and Helicopter	30.0%(n=280)	41.0%(n=183)	p<0.05

Table 26: Percentage of ambulance and helicopter patients for whom neck splints were used

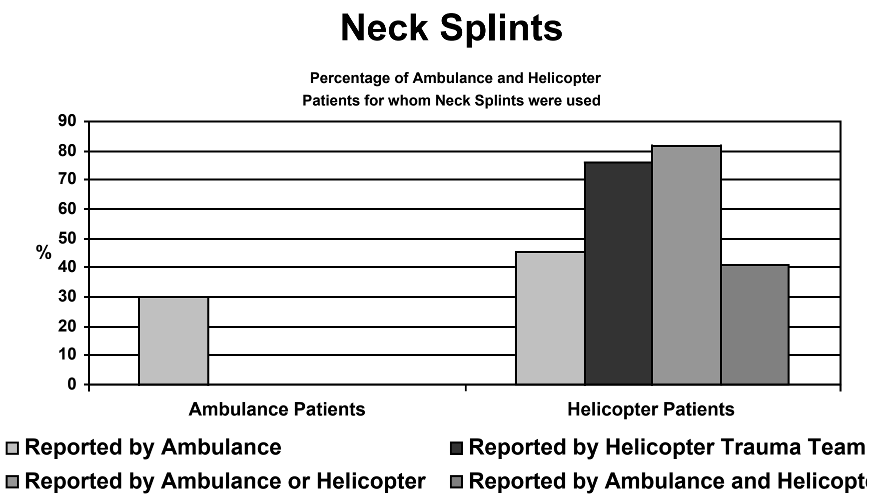

Figure 19: Percentage of ambulance and helicopter patients who received neck splints

Insertion of a Gastric Probe

Insertion of a gastric probe is a routine that ambulance paramedics may be authorised to perform; this routine is often performed in hospitals by nurses, but is not part of standard preprinted ambulance sheets. Therefore, no information could be collected from ambulance patients regarding the use of gastric tubes and no cases of the use of gastric probes are known in this group of patients.

The helicopter team reported 8 patients who received a gastric probe (3.9%).

On site treatment - 'physician type' interventions

Interventions normally carried out only by physicians, and not expected to be performed by ambulance crew alone are considered in this section. These interventions are invasive by nature, and might result in serious complications for patients when not applied using the strict indications or by the correct level of technical skills.

The helicopter trauma team, being headed by an experienced surgeon or anesthesiologist, is able of performing such routines, in contrast to ambulance personnel, as ambulance runs in the Netherlands are not routinely accompanied by physicians.

Therefore, these interventions are not preprinted on the routine ambulance sheets and the only patients information on these interventions was recorded for were helicopter patients (n=204). All the following data will deal with this group of patients only.

It is safe, nevertheless, to assume that none of these 'physician type' interventions was carried out for ambulance patients.

'Physician type' interventions considered are these: insertions of thoracic drains, administering general anesthesia, invasive measurement of arterial pressure, amputations, reposition of fractures and coniotomies.

Thoracic drains

Thoracic drains were inserted in 19 patients (9.3%), of which in 18 cases there was indeed a traumatic pneumothorax present and in one case the patient showed to have no pneumothorax on insertion.

The number of ambulance patients, who would have received a thoracic drain if the helicopter trauma team would have been present, however, is unknown.

The one case in which a thoracic drain was inserted unnecessarily highlights the fact how difficult it can be to establish a correct clinical diagnosis at the scene of accident, deluding even a specialised team such as the helicopter trauma team is, stressing the fact that only very experienced physicians should be authorised to perform these.

General Anesthesia

In 94 patients (46.1%) general anesthesia was induced. Mean RTS of the patients who received general anesthesia was 8.4 (SD 2.9, n=75), significantly lower ($p<0,05$, t test for independent samples) than in the group of patients that did not receive anesthesia that had a mean RTS score of 9.5 (SD 4.1, n=90). The mean ISS score of aneastesized patients was 30.6 (SD 13.0, n=93), significantly ($p<0.05$, t test for independent samples) higher than of patients who did not receive anesthesia and had a mean ISS of 26.4 (SD 12.5, n=107). This illustrates that general anesthesia is administered primarily in cases of the highest severity.

Inducing general anesthesia early on has the benefit of endotracheal intubations taking place in not unconscious patients (57.3% of the intubated patients in the helicopter group was not comatose) as well as other painful invasive procedures such as amputations and repositioning of fractures.

Amputations

Within the group under study, no amputations were carried out at the scene of accident.

Invasive Measurement of Arterial Blood Pressure

Invasive measurement of arterial blood pressure was reported to have been carried out only at one occasion (0.5%). This procedure makes a continuous measurement of blood pressure possible, as often needed in intensive care situations. It has been only sporadically reported, indicating most often other procedures have been carried out with higher priority, leaving this intervention to be carried out in hospital only later on, if necessary.

Reposition of Fractures

Reposition of fractures was carried out in 20 cases (9.8%). In one addition case reposition of a luxated hip was attempted on the scene of accident, but failed.

Ambulance personnel is not supposed to reposition fractures, under normal circumstances, and did not report any of this maneouvre to be carried out. It remains unknown, however, if (and how many) repositioning attempts have in fact been undertaken in the ambulance group.

Coniotomy

Coniotomy has been reported to have performed on one occasion (0.5%). One other case was reported in which a patients was being intubated via a wound in the neck - due to the skilled intubation technique, in this case a coniotomy was most probably prevented.

The number of coniotomies carried out was low, but nevertheless the helicopter trauma team demonstrated that they were able to perform this maneouvre when required.

Preclinical paramedic interventions stratified by ISS class

For the entire population under study differences were found in the rates to which various preclinical manoeuvres were applied by ambulance and helicopter personnel, respectively.

An analysis of all different types of paramedic interventions after stratification by ISS class would not be very practical; therefore, only those techniques are considered that influence vital functioning most: artificial ventilation, intubation, IV access and neck splints.

The following mean values are found for ISS scores after stratification:

ISS Class	Ambulance Patients n	Ambulance Patients Mean ISS (SD)	Helicopter Patients n	Helicopter Patients Mean ISS (SD)	Significance (t Test for Independent Samples)
-24	166	18.1 (2.9)	93	18.0 (4.4)	p=ns
25 - 40	80	29.6 (3.9)	64	29.1 (3.7)	p=ns
41 - 75	30	51.7 (10.1)	43	49.3 (7.5)	p=ns

Table 27: Mean values of ISS Scores for ambulance and helicopter patients after stratification into 3 classes of ISS scores.

No significant differences in mean ISS scores were found in any of the three classes of ISS scores between the ambulance group and helicopter group.

To keep a practical overview, ambulance patients are only compared to helicopter patients using the data provided for by the helicopter trauma team. The consequences of the choice for this method of comparison are discussed in chapter 4.

Artificial Ventilation

Artificial Ventilation	Ambulance Patients Percentage	Helicopter Patients Percentage	Significance (Chi-Square Test)
ISS <25	11.4% (n=166)	44.1% (n=93)	p<0.001
ISS 25 - 40	17.5% (n=80)	68.8% (n=64)	p<0.001
ISS 41 - 75	46.7% (n=30)	79.1% (n=43)	p<0.01
ISS Unknown	25.0% (n=4)	75.0% (n=4)	p=ns

Table 28: Percentage of ambulance and helicopter patients by ISS class who received artificial ventilation

In table 28 and figure 20 clearly demonstrate that for both groups there is a positive relationship between severity of injuries and the rate of artificial ventilation given. Table 31 also shows that in all groups of injury severity (except for the very small number of patients whose ISS is not known) the helicopter patients received artificial ventilation far more often than ambulance patients. Relative differences are smallest for the most severely injured but are still significant.

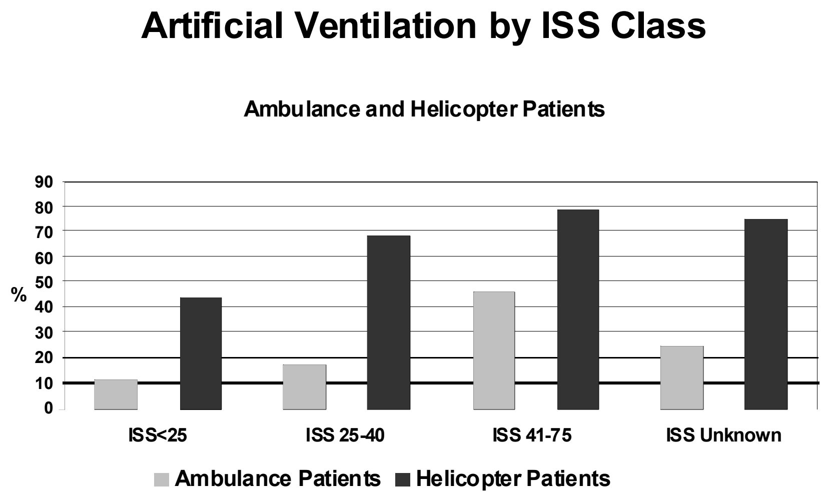

Figure 20: Artificial ventilation for ambulance and helicopter patients by ISS class

Endotracheal intubation

Endotracheal Intubation	Ambulance Patients Percentage	Helicopter Patients Percentage	Significance (Chi-Square Test)
ISS <25	1.2% (n=166)	45.2% (n=93)	p<0.001
ISS 25 - 40	6.3% (n=80)	60.9% (n=64)	p<0.001
ISS 41 - 75	23.3% (n=30)	76.7% (n=43)	p<0.001
ISS Unknown	25.0% (n=4)	75.0% (n=4)	p=ns

Table 29: Percentage of ambulance and helicopter patients by ISS class who were endotracheally intubated

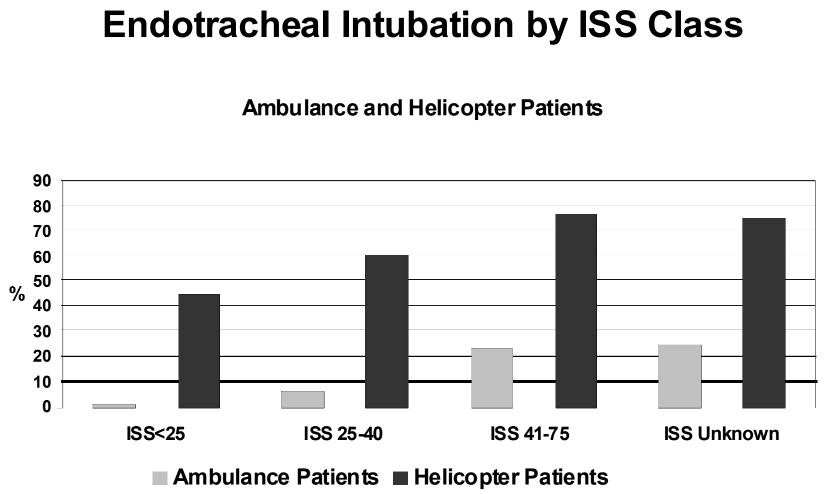

Figure 21: Endotracheal intubation for ambulance and helicopter patients by ISS class

In table 29 and figure 21 it is shown that in both groups of patients the rate of endotracheal intubation is positively correlated to the severity of the injuries, similar to the artificial ventilation rate. One major difference between endotracheal intubation and artificial ventilation rates in the ambulance group is that intubation rates are considerably lower than the rates for artificial ventilation. Especially low are intubation rates for the least or moderately severely injured ambulance patients, indicating a trend

that ambulance personnel is more likely to intubate most seriously injured patients than the less severily injured.

A major role for the lower intubation rates found in the ambulance group, especially in the least (ISS <25) and moderately (ISS 25-40) injured patients is the fact that ambulance personnel is not authorised to administer drugs to enable intubation in the not unconscious patients.

In all groups, but particularly so in the least or moderately injured group, intubation rate by helicopter trauma team considerably exceeds than of ambulance personnel.

Total IV Access

In table 30 and figure 22 it is shown that generally, the rate for intra-venous access is higher for helicopter patients than for ambulance patients. The rate for intra-venous access is positively correlated with injury severity in the ambulance group and is at a steady near-100% in the helicopter group for all classes of injury severity.

Because it is generally more difficult to insert intra-venous cannula in more severely injured patients, the positive relationship of IV access rate with injury severity in the ambulance group suggests management factors responsible for the lower than 100% rates rather than technical causes (in which case the number of IV access sites would be expected to be lower in the more seriously injured group).

Total IV Access	Ambulance Patients Percentage	Helicopter Patients Percentage	Significance (Chi-Square Test)
ISS <25	79.5% (n=166)	98.9% (n=93)	p<0.001
ISS 25 - 40	83.8% (n=80)	98.4% (n=64)	p<0.01
ISS 41 - 75	90.0% (n=30)	97.7% (n=43)	p=ns
ISS Unknown	75.0% (n=4)	100.0% (n=4)	p=ns

Table 30: Percentage of ambulance and helicopter patients by ISS class who at least had one site for IV access.

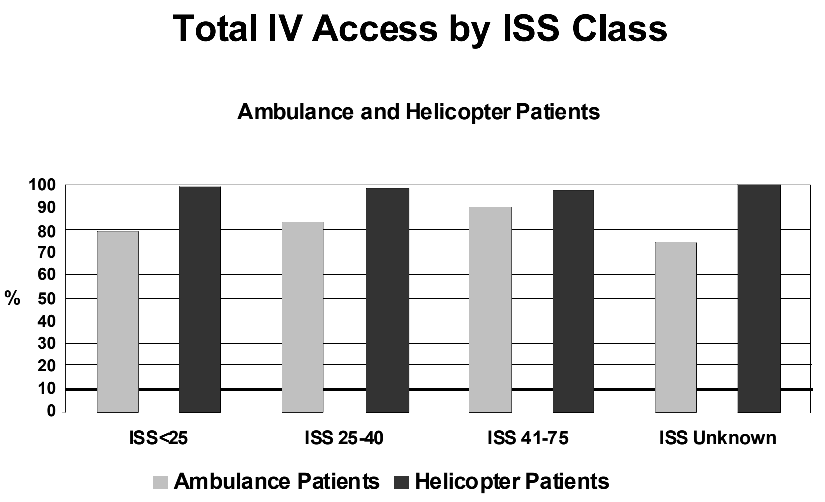

Figure 22: IV access for ambulance and helicopter patients by ISS class

The use of Neck Splints

Table 31 and figure 23 show the percentages of ambulance patients and helicopter patients who received a neck splint. Most interesting finding is the fact that the largest differences are observed in the number of neck splints used are in the group of least injured patients (ISS<25); in the ambulance group there is a trend that neck splints are applied more often

Neck Splint	Ambulance Patients Percentage		Helicopter Patients Percentage		Significance (Chi-Square Test)
ISS <25	24.7%	(n=166)	80.6%	(n=93)	p<0.001
ISS 25 - 40	38.8%	(n=80)	70.3%	(n=64)	p<0.001
ISS 41 - 75	40.0%	(n=30)	79.1%	(n=43)	p<0.01
ISS Unknown	0.0%	(n=4)	25.0%	(n=4)	p=ns

Table 31: Percentage of ambulance and helicopter patients by ISS class who received a neck splint

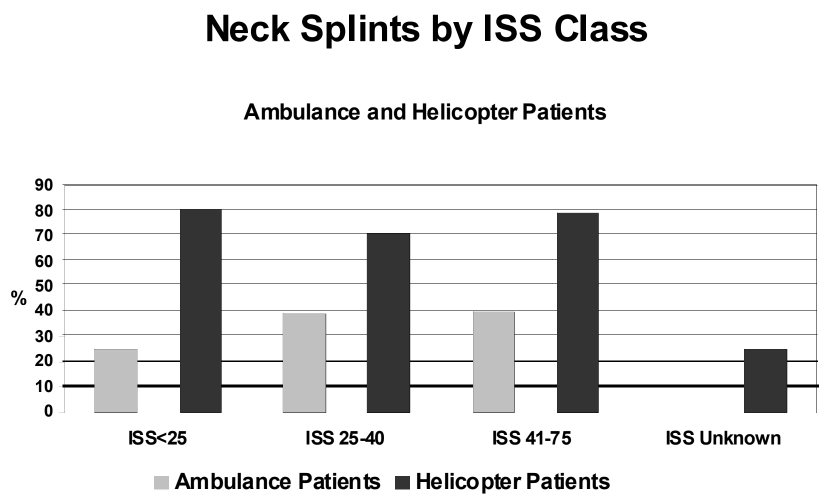

Figure 23: Neck splints for ambulance and helicopter patients by ISS class

with higher grade of injury, but in the helicopter group for all levels of injury the rate neck splints are applied is almost constant around 80 percent. In the group of most severily injured patients, almost double the number of helicopter patients received neck splints compared to ambulance patients.

Preclinical interventions stratified by RTS class

Ambulance and helicopter patients were stratified in four different categories of RTS scores and preclinical interventions were compared in all subgroups as performed for classes of ISS scores.

Artificial Ventilation

The following values were found for the frequency artificial ventilation was performed by RTS class for ambulance and helicopter patients.

As table 32 and figure 24 show, in both groups higher percentages of patients who were artifically ventilated increased with lower RTS scores. Most outspoken are differences in the category of patients with RTS scores between 8 and 10 and between 3 and 7; in these groups only a minority of ambulance patients received artificial ventilation, but the almost all helicopter patients in the group with score between 8 and 10, and all patients below that did.

Artificial Ventilation	Ambulance Patients	Ambulance Patients %	Helicopter Patients	Helicopter Patients %	Significance (Chi Square Test)
RTS 0 - 2	n=10	90	n=16	100	p=ns
RTS 3 - 7	n=24	41.7	n=27	100	p<0.001
RTS 8 - 10	n=61	18	n=40	87.5	p<0.001
RTS 11-12	n=132	8.3	n=82	23.2	p<0.01
Unknown	n=53	13.2	n=39	64.1	p<0.001

Table 32: Percentage of ambulance and helicopter patients who were artifically ventilated by RTS class

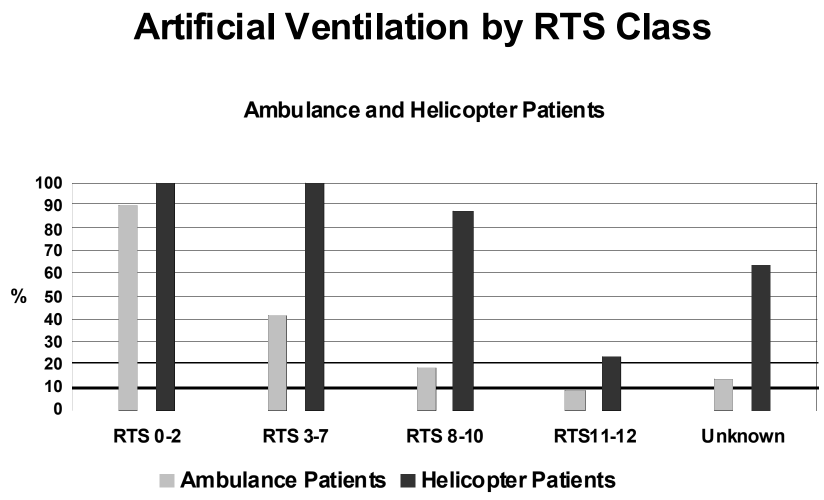

Figure 24: Artificial ventilation for ambulance and helicopter patients by RTS class

Endotracheal Intubation

Intubation	Ambulance Patients	Ambulance Patients %	Helicopter Patients	Helicopter Patients %	Significance (Chi Squaret test)
RTS 0 - 2	n=10	60	n=16	100	p<0.01
RTS 3 - 7	n=24	29.2	n=27	96.3	p<0.001
RTS 8 - 10	n=61	1.6	n=40	90	p<0.001
RTS 11-12	n=132	0	n=82	17.1	p<0.001
Unknown	n=53	1.9	n=39	64.1	p<0.001

Table 33: Percentage of ambulance and helicopter patients by RTS class who were endotracheally intubated

Endotracheal Intubation by RTS Class

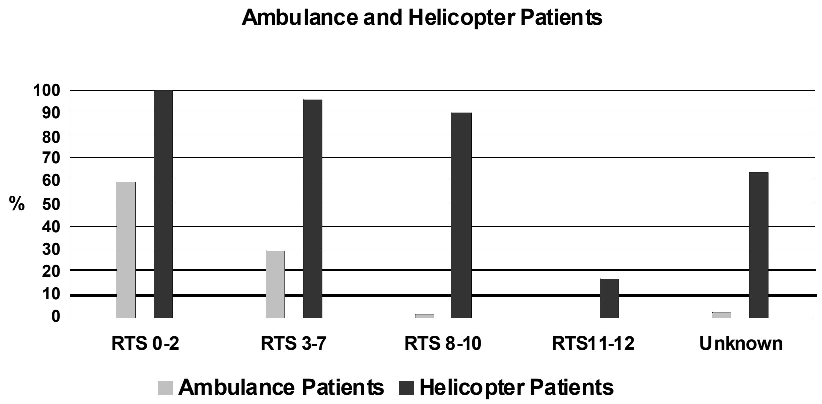

Figure 25: Endotracheal intubation for Ambulance and Helicopter patients by RTS class

Table 33 and figure 25 show the percentages of helicopter and ambulance patients by RTS class who were intubated. Although differences were found in all sub-groups, the relative differences are most outspoken in the patients who had RTS scores between 3 and 10.

Total IV Access

IV Access	Ambulance Patients	Ambulance Patients %	Helicopter Patients	Helicopter Patients %	Significance (Chi Squaret test)
RTS 0 - 2	n=10	80	n=16	93.8	p=ns
RTS 3 - 7	n=24	79.2	n=27	100	p<0.05
RTS 8 - 10	n=61	83.6	n=40	100	p<0.01
RTS 11-12	n=132	80.3	n=82	98.8	p<0.001
Unknown	n=53	81.1	n=39	97.4	p<0.001

Table 34: Percentage of ambulance and helicopter patients by RTS class who received at least one IV access site

IV Access by RTS Class

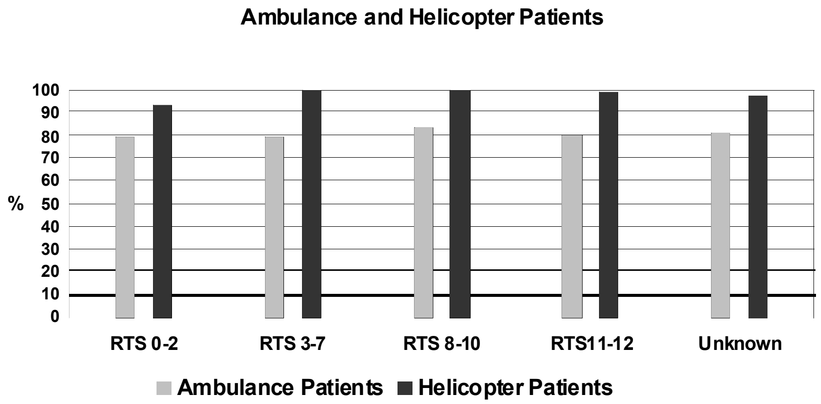

Figure 26: IV access for ambulance and helicopter patients by RTS class

Table 34 and figure 26 show the percentage of ambulance and helicopter patients who received a site for IV Access by RTS class. Different from artificial ventilation and intubation, there seems to be no relationship between RTS scores and IV Access rate. In all subgroups of ambulance patients the rate is around 80%, and in the helicopter group this percentage is near 100%.

Neck Splints

In table 35 and figure 27 it is shown that in the ambulance group there is a trend to give less neck splints to patients with lower RTS scores. The opposite is true for helicopter patients, with the exception of the patients with the lowest RTS scores (0-2) that have a very low rate (50%) that neck splints are applied compared to patients with slightly higher RTS scores (93% in the group with RTS scores 3 - 7).

Neck Splint	Ambulance Patients	Ambulance Patients %	Helicopter Patients	Helicopter Patients %	Significance (Chi Squaret test)
RTS 0 - 2	n=10	20	n=16	50	p=ns
RTS 3 - 7	n=24	29	n=27	93	p<0.001
RTS 8 - 10	n=61	33	n=40	90	p<0.001
RTS 11-12	n=132	36	n=82	72	p<0.001
Unknown	n=53	13	n=39	69	p<0.001

Table 35: Percentage of ambulance and helicopter patients by RTS class who received neck splints.

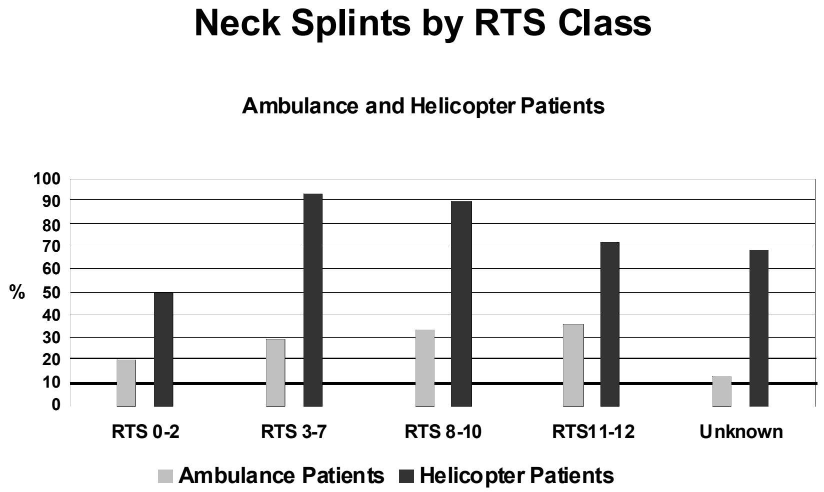

Figure 27: Neck splints for ambulance and helicopter patients by RTS class

Preclinical interventions for patients in haemodynamic shock

Treatment of shock can start immediately in the field and at least consists of intra-venous fluid infusion in order to maintain blood pressure. Artificial ventilation and intubation secure an adequate oxygenation of blood supply and are often considered necessary for patients who are in shock.

Intra-Venous Access

Systolic Blood Pressure (mm Hg)	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
>89	80.2% (n=126)	98.7% (n=75)	p<0.001
76 - 89	83.3% (n=24)	100.0% (n=11)	p=ns
51 - 75	69.2% (n=13)	100.0% (n=9)	p=ns
1 - 50	85.5% (n=69)	98.6% (n=74)	p<0.01
0	n=0	n=0	

Table 36: Rate of intra-venous access of ambulance and helicopter patients by class of systolic blood pressure

Table 36 and figure 28 show the rate of intra-venous access of ambulance and helicopter patients by systolic blood pressure.

Most important it is to note that in none of the two groups the rate of intra-venous access seems to be influenced by the systolic blood pressure. For helicopter patients, this is the case because already almost 100% of patients have at least one site for intra-venous access. Almost one out of five ambulance patients who are not in shock (systolic blood pressure >89 mm Hg) do not have a site for intra-venous access, and this rate is hardly any lower for patients who are in shock and even higher for the small number of patients with a blood pressure between 51 and 75 mm Hg.

IV Access

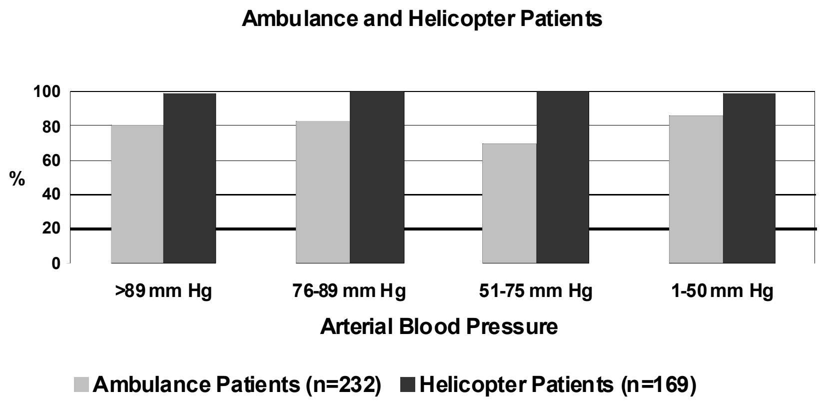

Figure 28: IV access rate for ambulance and helicopter patients by blood pressure rate

Preclinical interventions for the respiratory insufficient

Airway management, especially in patients who are respiratorily insufficient, should be aimed at optimizing oxygen supply to the body and consist of securing an airway, followed by endotracheal intubation and artificial ventilation if neccessary.

Artificial Ventilation

Table 37 and figure 29 show that artificial ventilation is applied more often by helicopter trauma team than by ambulance personnel. This is the case most outspokenly for those patients whose respiratory rate is not affected (respiratory rate 10-29 per minute) and patients who do hyperventilate (respiratory rate >29 per minute).

In the group of patients who suggest need ventilatory support most, i.e. those with depressed respiratory rates, almost all helicopter patients receive artificial ventilation, whereas this is the case for a minority of ambulance patients with respiratory rates of 6-9 per minute, 100% for ambulance patients with respiratory rates of 1 to 5 per minute (note that this concerns a group of 3 patients only) and less than 100% for those patients who show no respiratory action at all.

Artificial Ventilation

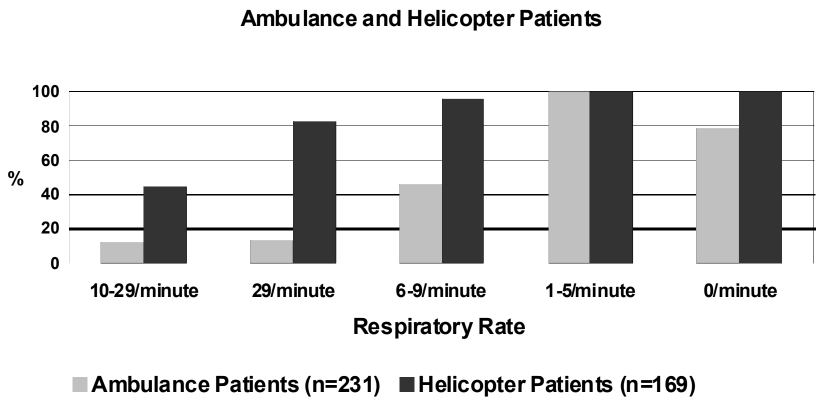

Figure 29: Artificial ventilation for ambulance and helicopter patients by respiratory rate

Respiratory Rate (per minute)	Ambulance Patients		Helicopter Patients		Significance (Chi-Square Test)
10 to 29	12.0%	(n=191)	44.9%	(n=118)	p<0.001
>29	13.3%	(n=15)	83.3%	(n=12)	p<0.001
6 to 9	46.2%	(n=13)	95.5%	(n=22)	p<0.01
1 to 5	100.0%	(n=3)	100.0%	(n=3)	p=ns
0	77.8%	(n=9)	100.0%	(n=14)	p=ns

Table 37: Percentages of ambulance and helicopter patients who received artificial ventilation by class of respiratory rate

Endotracheal intubation

In table 38 and figure 30 is shown what the intubation rate is of ambulance and helicopter patients by class of respiratory rate. Helicopter personnel carries out intubations in a considerable number of patients whose respiratory rate was unaffected (40.7%), meanwhile intubations only seem to take place by ambulance patients when patients have signs of severe respiratory failure. In the most severely affected groups, with respiratory rates of 5 and below, all helicopter patients receive a tube, while this is not the case for ambulance patients.

Respiratory Rate (per minute)	Ambulance Patients		Helicopter Patients		Significance (Chi-Square Test)
10 to 29	1.0%	(n=191)	40.7%	(n=118)	p<0.001
>29	0.0%	(n=15)	83.3%	(n=12)	p<0.001
6 to 9	30.8%	(n=13)	95.5%	(n=22)	p<0.001
1 to 5	66.7%	(n=3)	100.0%	(n=3)	p=ns
0	66.7%	(n=9)	100.0%	(n=14)	p<0.05

Table 38: Rate of endotracheal intubation of ambulance and helicopter patients by class of respiratory rate

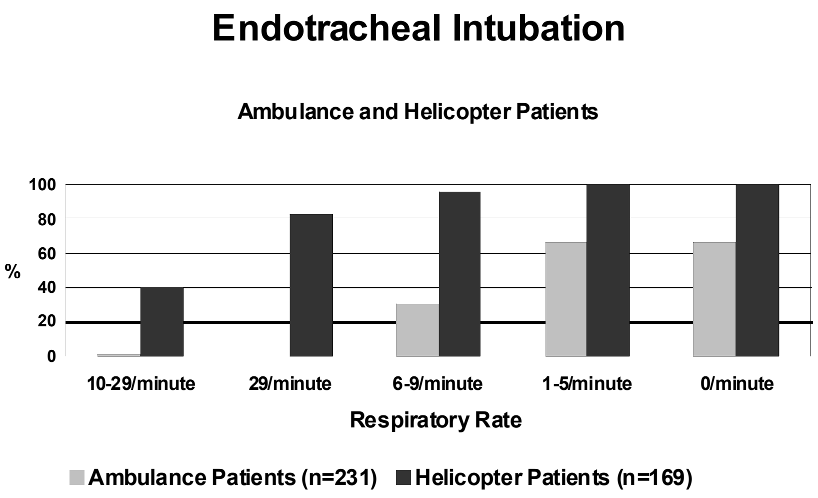

Figure 30: Endotracheal intubation for ambulance and helicopter patients by respiratory rate

Total IV Access

In table 39 and figure 31 is shown what percentages of ambulance and helicopter patients receive at least one site for intra-venous access, by class of respiratory rate. The table suggests that the only significant differences in the intra-venous access rate exist in the group of patients whose respiratory rate is unaffected.

Respiratory Rate (per minute)	Ambulance Patients		Helicopter Patients		Significance (Chi-Square Test)
10 to 29	80.1%	(n=191)	99.2%	(n=118)	p<0.001
>29	93.3%	(n=15)	100.0%	(n=12)	p=ns
6 to 9	84.6%	(n=13)	100.0%	(n=22)	p=ns
1 to 5	66.7%	(n=3)	100.0%	(n=3)	p=ns
0	77.8%	(n=9)	92.9%	(n=14)	p=ns

Table 39: Rate of total IV access for ambulance and helicopter patients by class of respiratory rate

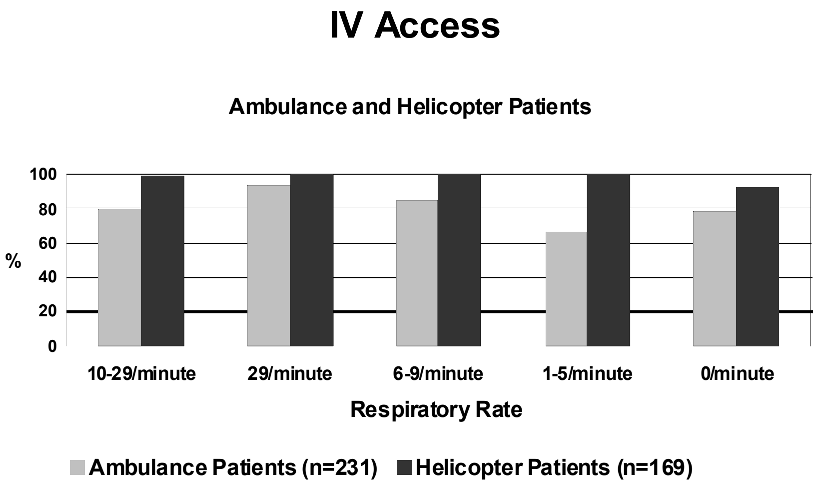

Figure 31: IV access for ambulance and helicopter patients by respiratory rate

Preclinical interventions for patients by Glasgow Coma Scale

The immediate care for patients with neurological injuries must consist of an optimal airway and circulatory management until further diagnosis and treatment in a suitable facility can be initiated. Therefore, intra-venous access, intubation and artificial ventilation are cornerstone of preclinical therapy.

Especially important is to compare the number of intubations in patients who are in coma (Glasgow Coma Scale of less than 8). These patients can generally be intubated without having the need for sedation and muscle relaxation prior to the procedure. This is especially interesting because ambulance personnel are most likely to be able to carry out intubations in this group, while not comatose patients can generally only be intubated after drugs have been administered by a helicopter physician.

Artificial Ventilation

Table 40 and figure 32 show the rate to which artificial ventilation is given to ambulance and helicopter patients by class of Glasgow Coma Scale.

In the group of patients with an optimal Glasgow Coma Scale in both groups only a minority of patients receive artificial ventilation, but still helicopter patients receive this treatment almost at a rate triple that of ambulance patients.

In the group of patients with an depressed Glasgow Coma Scale of 8 to 14, who are not comatose, the rate to which artificial ventilation is applied rises in both groups, but most outspokenly in the helicopter group. Almost 2 out of 3 patients in the helicopter group were artificially ventilated, meanwhile this was the case in less than 15% of the ambulance patients.

Still less than half of the comatose ambulance patients (with Glasgow Coma Scale <8) received artificial ventilation, while a near 100% of the helicopter patients of the same class did.

Glasgow Coma Scale	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
15	6.6% (n=91)	19.3% (n=57)	$p<0.05$
8 to 14	14.6% (n=89)	62.3% (n=53)	$p<0.001$
<8	42.6% (n=47)	98.1% (n=53)	$p<0.001$

Table 40: Rate of artificial ventilation by class of Glasgow Coma Scale

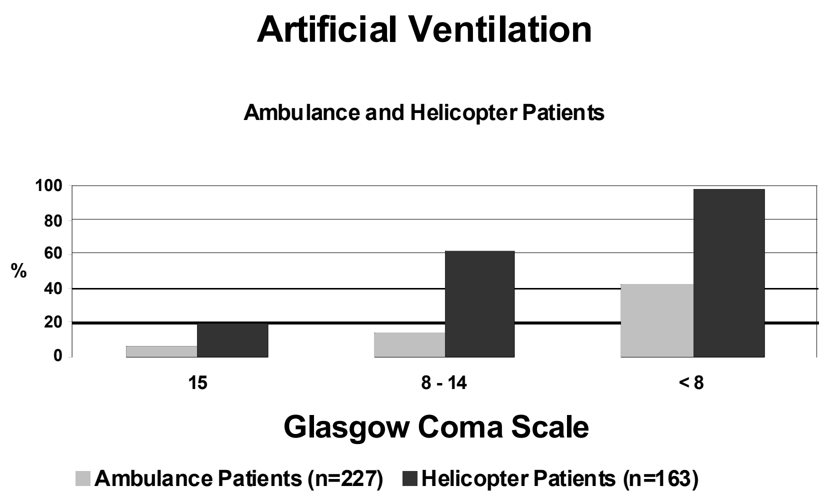

Figure 32: Artificial ventilation for Ambulance and Helicopter patients by Glasgow Coma Scale

Endotracheal Intubation

Table 41 and figure 33 demonstrate that endotracheal intubations were only performed by ambulance personnel in those patients who were comatose (GCS < 8 [168]). A small percentage of patients with optimal coma score weres intubated in the helicopter group, and also a large majority of patients whose coma scales were affected but not to the level of coma (GCS 8-14). This was due to the fact that anesthesia was possible to be given out by the helicopter trauma team, while the paramedic/nurse staffed ambulance services did not have this option. Almost all comatose helicopter patients were intubated, in the ambulance group in this group only a minority of patients was.

Glasgow Coma Scale	Ambulance Patients	Helicopter Patients	Significance (Chi Square Test)
15	0.0% (n=97)	10.5% (n=57)	p<0.01
8 to 14	0.0% (n=89)	67.9% (n=53)	p<0.001
<8	29.8% (n=47)	94.3% (n=53)	p<0.001

Table 41: Rate of endotracheal intubation of ambulance and helicopter patients by class of Glasgow Coma Scale

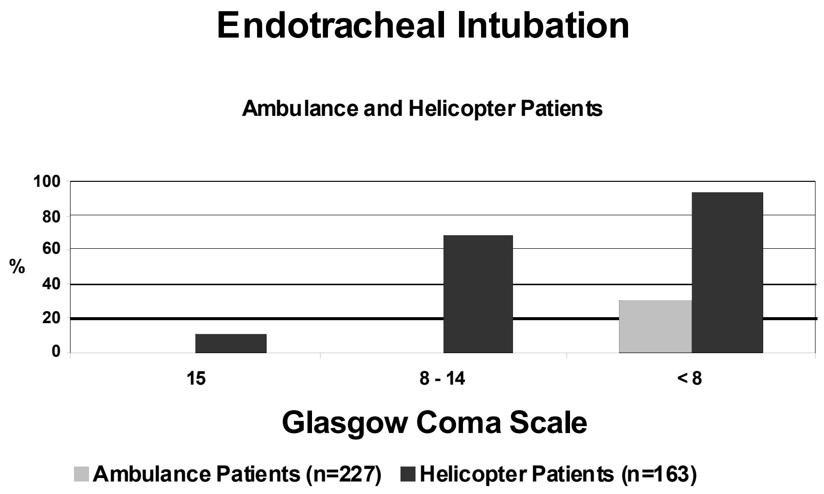

Figure 33: Endotracheal intubation for ambulance and helicopter patients by Glasgow Coma Scale

IV access

In table 42 and figure 34 is demonstrated that in all categories of Glasgow Coma Scale almost all helicopter patients received at least one site for intra-venous access, meanwhile a much lower percentage of ambulance patients did. The rate of IV access is barely higher in the ambulance group for patients with lowered Glasgow Coma Scale scores compared to patients with unaffected scores.

Glasgow Coma Scale	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
15	80.2% (n=91)	98.2% (n=57)	p<0.01
8 to 14	82.0% (n=89)	100.0% (n=53)	p<0.01
<8	80.9% (n=47)	98.1% (n=53)	p<0.01

Table 42: Rate of IV access for ambulance and helicopter patients by class of Glasgow Coma Scale

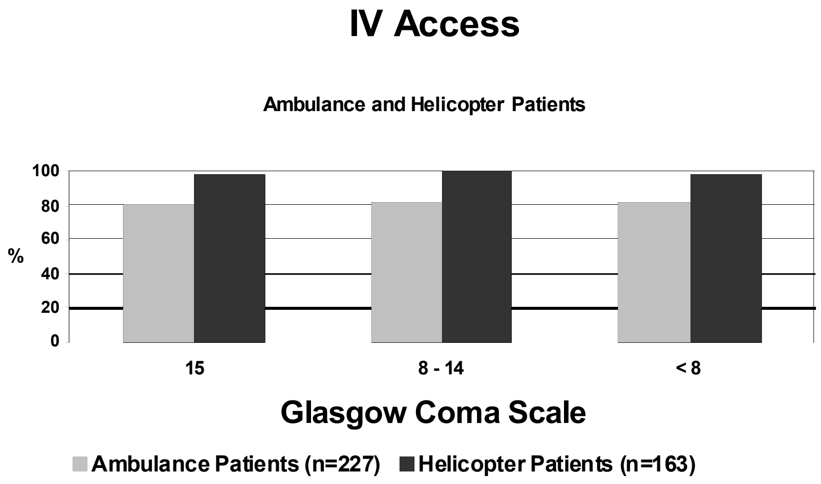

Figure 34: IV accessn for ambulance and helicopter patients by Glasgow Coma Scale

Neck Splints

The use of neck splints should be considered in all those patients that are at risk of a fracture of the cervical vertebrae. In unconscious patients naturally it is impossible to obtain any patient history of pain in the neck following the trauma, so the indications for the use of a neck splint should be generous to include all cases wherein cervical injury is a possibility. When Glasgow Coma Scale scores are depressed, most commonly this is due to trauma to the head - accompanying trauma to the adjacent region of the neck is therefore more likely in those patients who have depressed GCS scores, so in these patients one should expect a more frequent use of neck splints than in patients who did have an unaffected GCS.

Glasgow Coma Scale	Ambulance Patients	Helicopter Patients	Significance (Chi-Square Test)
15	34.1% (n=91)	54.4% (n=57)	p<0.001
8 to 14	39.3% (n=89)	79.2% (n=53)	p<0.001
<8	29.8% (n=47)	83.0% (n=53)	p<0.001

Table 43: Rate of use of neck splints for ambulance and helicopter patients by Glasgow Coma Scale class

In table 43 and figure 35 it is demonstrated that, overall, the helicopter trauma team used neck splints more often than the ambulance personnel. Not only was that the case in those patients with an unaffected Glasgow Coma Scale, but even more outspokenly was this the case in patients whose GCS was depressed. The rate of use of neck splints is the lowest for ambulance patients in the comatose patients, even lower than for patients who have optimal Glasgow Coma Scales. The reverse is true for helicopter patients; in this group, the highest percentage of neck splints were found in the group of comatose patients, but still in the group of patients with Glasgow Coma Scale 15, the rate of neck splints was higher than in the group of comatose ambulance patients.

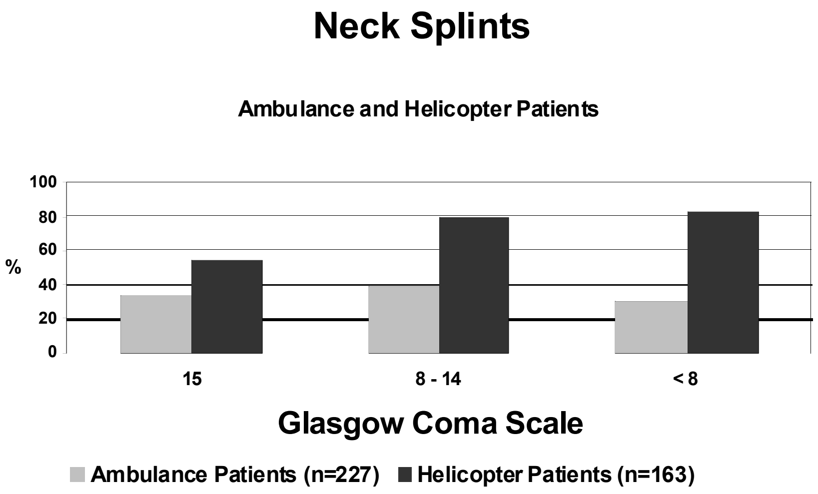

Figure 35: Neck Splints for ambulance and helicopter patients by Glasgow Coma Scale

Preclinical paramedic type interventions for patients with severe neurological injuries

It is to be expected that in general high HTI scores for head and skull injuries scored as part of the ISS correlates with low Glasgow Coma Scale scores.

The Glasgow Coma Scale is scored immediately at the scene of accident and considers diagnostic findings on the level of consciousness only without regard to the final diagnosis.

The HTI - as part of the ISS - can be scored in hospital only after diagnostics and clinical observation or treatment have taken place and consists of the level of injury according to the clinical diagnosis.

Differences between these two scoring systems imply that not all patients with low Glasgow Coma Scale scores need to have a high HTI score for brain and skull, and opposite.

Patients that suffered a concussion of the brain might have very low initial Glasgow Coma Scale scores, but when recovery is swift and uncomplicated final HTI scores for head and skull are modest and well below the score of 4.

The opposite might also be the case for patients that suffered isolated but severe vertebral cord injuries. These patients therefore score 4 and above on the HTI scale. Nevertheless, because the Glasgow Coma Scale involves parameters regarding consciousness only, the Glasgow Coma Scale might be even optimal for these patients.

Considering patients with HTI scores of 4 and above separately identifies those patients that sustained most extensive and definitive neurological injuries, in contrast to the patients with low Glasgow Coma Scale scores that showed bad initial neurological findings only.

The importance of optimal preclinical care for patients that proofed to have high HTI scores for neurological injuries can be considered at least as important as for patients that had lowered Glasgow Coma Scale scores 'only'.

Preclinical management for these patients is the same, consisting of air-way management by artificial ventilation and intubation, intra-venous access and the use of a neck splint.

These findings show that ambulance personnel does use advanced methods of airway management only in a minority of cases in this group of a very high severity of injury, in contrast to the helicopter trauma team wherein intubation and artificial ventilation is most common.

Manoeuvre	Ambulance Patients (n=95)	Helicopter Patients (n=80)	Significance (Chi-Square Test)
Artificial Ventilation	31.6%	88.8%	p<0.001
Endotracheal Intubation	12.6%	90.0%	p<0.001
IV Access	88.4%	100.0%	p<0.01
Neck Splint	29.5%	92.5%	p<0.001

Table 44: Rate of appliance of prehospital maneouvres for ambulance and helicopter patients with HTI scores for head and skull injuries of 4 and above

The rate to which neck splints are applied by ambulance personnel is different from that by helicopter trauma team. In this group of proven very high neurological severity, neck splints are applied in a minority of cases (29.5%) by ambulance personnel.

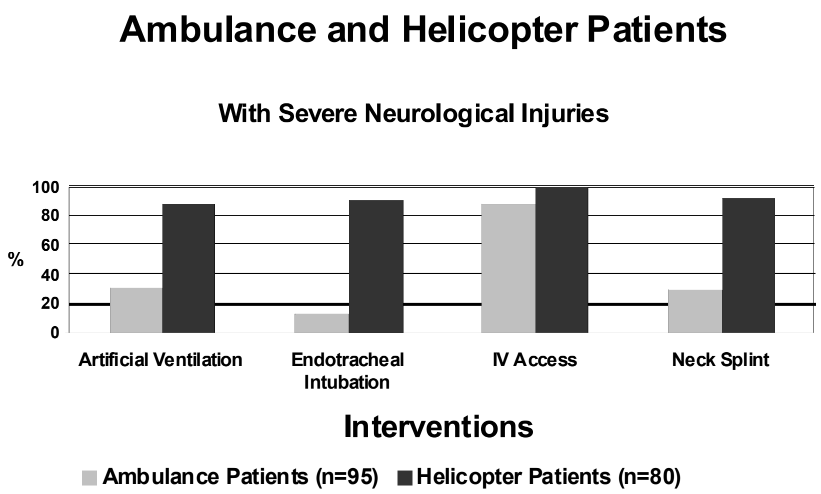

Figure 36: Prehospital interventions for ambulance and helicopter patients with HTI scores of 4 and higher for head/skull injuries

Preclinical interventions for patients with severe injuries of the respiratory system

Considering the group of patients with HTI scores of 4 and above for injuries of the respiratory tract, airway management is of main concern.

Adequate oxygen supply to the body tissues should be secured especially in this group, which can be achieved by providing artificial ventilation and intubation.

Manoeuvre	Ambulance Patients (n=29)	Helicopter Patients (n=33)	Significance (Chi-Square Test)
Artificial Ventilation	37.9%	84.8%	p<0.001
Endotracheal Intubation	17.2%	78.8%	p<0.001
IV access	82.9%	93.9%	p=ns

Table 45: rate of appliance of prehospital maneouvres for ambulance and helicopter patients who had HTI scores of 4 and higher for respiratory injuries

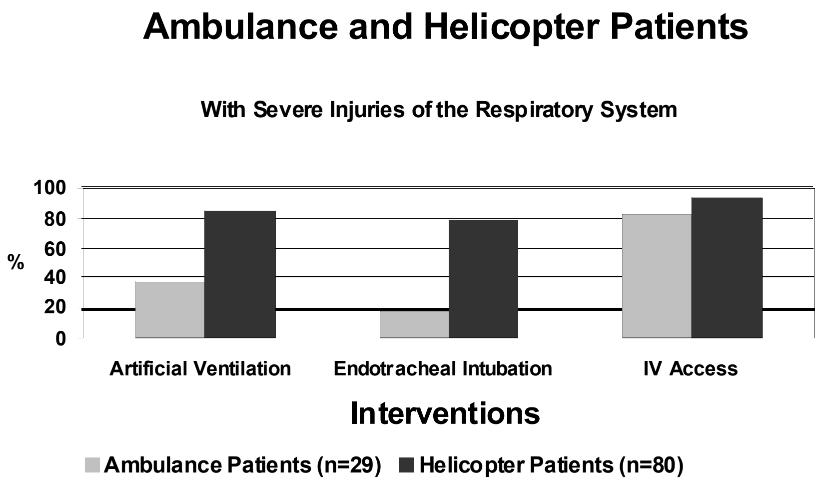

Figure 37: Prehospital manoeuvres for ambulance and helicopter patients with HTI scores of 4 and higher for respiratory injuries

Even in cases that no other than respiratory injuries are found, intra-venous access should be gained to be able to start fluid resuscitation as soon as necessary.

In this category of patients, differences exist between the rate that IV access, intubation and artificial ventilation were carried out by ambulance and helicopter trauma team.

Preclinical paramedic type interventions for patients with severe cardiovascular injuries

The most important parameter that is used for scoring the HTI for injuries of the cardiovascular system is the extent of blood losses. Patients with a HTI score of 4 and higher have either blood losses of 1,500 millilitre or more, cardiac contusion with reduced blood pressure (less than 80 mm Hg), a cardiac tamponade with reduced blood pressure or a cardiac arrest on basis of blood losses.

Naturally, establishment of IV access is an important maneouvre in the preclinical treatment of these patients.

Manoeuvre	Ambulance Patients (n=28)	Helicopter Patients (n=38)	Significance (Chi Square Test)
IV Access	92.9%	97.4%	p=ns
Artificial Ventilation	39.3%	71.1%	p=0.01
Intubation	21.4%	65.8%	p<0.001

Table 46: Rate to which prehospital techniques are applied for ambulance and helicopter patients with a HTI score for injuries of the cardiovascular system of 4 and higher

The differences found in the rate of IV access for patients with a HTI score for cardiovascular injuries of 4 and higher between ambulance and helicopter patients were not significant; the number of patients in both groups is however, relatively small.

Despite this small group size, the rate of artificial ventilation and intubation is higher in the helicopter group to a significant level, indicating that airway management is more extensive in the helicopter group.

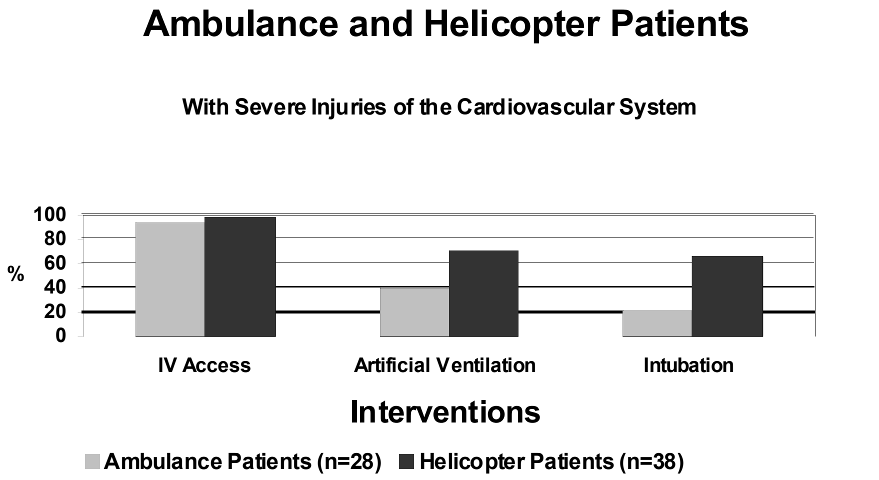

Figure 38: Prehospital manoeuvres for ambulance and helicopter patients with HTI scores of 4 and higher for injuries of the cardiovascular system

Preclinical paramedic type interventions for patients with severe injuries of the extremities

Most important preclinical interventions are compared for ambulance and helicopter patients who had HTI score of 4 or higher for injuries of the extremities.

In these cases attention should not only be given to the local injuries of the extremities, but also to the general haemodynamic and respiratory condition of the patient, because this remains of vital importance and should not be lowered due to excessive attention focussing on the injured extremities only.

Most remarkable of table 47 is which shows the rate of appliance of various techniques to ambulance and helicopter patients, is the fact that within this group of patients with proven severe injuries of the extremities, the rate of use of splints is much higher in the helicopter group than in the ambulance group.

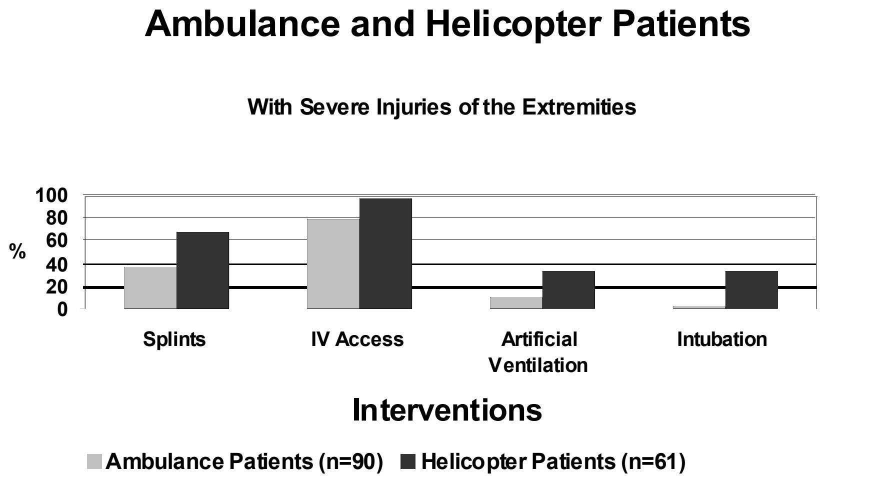

Figure 39: Prehospital manoeuvres for ambulance and helicopter patients with HTI scores of 4 and higher for injuries of the extremities

In the whole population under study, thus including those patients that had no severe injuries of the extremities no significant differences in the rate of use of splints were found - in the helicopter group splints were even used less frequently than in the ambulance group, but in the group of patients with severe extremital injuries, the reverse is found.

Manoeuvre	Ambulance Patients (n=90)	Helicopter Patients (n=61)	Significance (Chi Square Test)
Use of Splints	37.8%	68.9%	p<0.001
IV Access	80.0%	98.4%	p<0.01
Artificial Ventilation	10.0%	34.4%	p<0.001
Endotracheal Intubation	3.3%	34.4%	p<0.001

Table 47: Rate of appliance of various prehospital techniques by ambulance personnel and helicopter trauma team for patients with a HTI score of 4 and higher for injuries of the extremities

Preclinical Interventions for the elderly

The elderly constitute a special and delicate category in preclinical trauma care. Compared to young trauma patients, physiologic reserve capacities are reduced, leading to a higher overall mortality. Compared to young patients, the elderly are more at risk for developing Multi Organ Failure.

Initial treatment of elderly patients, beginning at the scene of accident, should be based on the same principles as used for the younger patients. Because the elderly are even less likely to tolerate hemodynamic shock and respiratory failure than younger patients, these conditions should be treated as rigorously as in the young. One should be careful not to over hydrate elderly patients, considering for the higher incidence of pre-existent heart failure in this group of patients, therapy might harm more than it benefits.

Manoeuvre	Ambulance Patients (n=42)	Helicopter Patients (n=21)	Significance (Chi Square Test)
Artificial Ventilation	16.7%	66.7%	$p<0.001$
Endotracheal Intubation	9.5%	61.9%	$p<0.001$
IV Access	78.6%	100.0%	$p<0.05$
Neck Splint	21.4%	85.7%	$p<0.001$

Table 48: Rate to which prehospital maneouvres are applied to ambulance and helicopter patients who are 65 years or older

Table 48 shows that all listed prehospital techniques are applied more extensively for helicopter patients than for ambulance patients.

No IV access is gained in more than 20% of ambulance cases, differences in other maneouvres are also outspoken.

Preclinical time

In the management of severely injured trauma patients, time plays a role of paramount importance.

The objective of the helicopter trauma team was to bring advanced medical care to the scene of accident as soon as possible, instead of simply

shortening the time interval between trauma and arrival in hospital. The choice for this ‘stay and play’ approach was expected to lead to a longer mean on-scene time and has been criticised for this delay in transportation.

Careful analysis of the different time intervals between trauma and arrival in hospital is therefore necessary to study if helicopter involvement indeed prolongs preclinical time intervals and to what extent.

The following time intervals can be defined analysing preclinical treatment:

- Response time (of ambulance and helicopter)
  Response time is defined as the time interval between emergency call and arrival of an ambulance or the helicopter. Within this time interval the patient does not receive any professional care, except for in cases wherein first responders (i.e. police or fire-men) or bystanders commence basic life support until professional help arrives.
- On scene time
  On scene time is defined as the time interval between arrival of expert care and the moment the patient is ready for transfer to hospital.
- Transfer time to hospital
  Transfer time to hospital is defined as the time interval between the moment the patient is being transferred to hospital until the time of arrival in hospital
- Total preclinical time
  Total preclinical time is defined as the time interval between emergency call and arrival of the patient in hospital. Within this time interval, ambulance and/or helicopter need to reach the patient, provide on-scene treatment and transport the patient to hospital. Not included in this ‘total preclinical time’ is the time interval between the accident itself and the time of call. Considerable variances may exist here, but in general, it is not possible to make reliable estimates about this time interval.

These times were fully recorded for ambulance patients (n=264) and helicopter patients (n=172), following exclusion of unrealistic values:

- 2 cases wherein a scene time of 0 minutes was provided for, but some form of on-site treatment was also given
- 2 cases wherein scene times found were 1 and 3 minutes respectively, but extensive treatment was given (6 different manoeuvres within 1 minute, in the other case 5 manoeuvres including IV access, suction, and wound care within a time span of 3 minutes)
- 3 cases wherein transfer time to hospital was provided 0 minutes, but wherein the scene of accident was not located around or very near the receiving hospital.

Response time

Response time of the ambulance

Mean response time of the ambulance was 6.5 minutes (Std. Dev. 4.1) for the ambulance group, mean response time of the ambulance for the helicopter group was 6.9 minutes (Std. Dev. 4.1).

These difference are not statistically significant (p=ns, Student's t test for independent samples). In both groups over 95% of all ambulance runs had a response time of 15 minutes or less, as required by Dutch law.

Shortest response time was 0 minutes in both groups in which cases an ambulance happened to be at the scene when the accident occurred, longest was 38 minutes in the ambulance group, 30 minutes in the helicopter group.

On scene time

Mean on scene time for the ambulance group was 21.1 minutes (SD 14.3), for the helicopter group mean on-scene time was more than 15 minutes longer at 36.4 minutes (SD 18.0).

This difference was highly significant (p<0.001, Student's t test for independent samples).

Shortest on-scene time was 2 minutes for both groups, longest 116 minutes for the ambulance group and 122 minutes for the helicopter group.

Transfer time to hospital

No differences were found in transfer times to hospital between the ambulance and helicopter group. Mean transfer time for the ambulance group was 13.3 minutes (SD 10.2), for the helicopter group 14.1 minutes (SD 11,6). These differences had no statistical significance (p=ns, Student's t-test for independent samples).

Minimum transfer time was 1 minute for the ambulance group, 1 minute for the helicopter group, maximum transfer time was 77 minutes for the ambulance group and 94 minutes for the helicopter group, indicating that even within the relatively small area of service, with a high hospital density, transfer times can still be high due to unfavourable circumstances such as unavailability of intensive care facilities in the surroundings. It might have been expected that by incidentally using the helicopter to transfer patients with, the mean transfer times in the helicopter group would be lower than in the ambulance group, but the results found show no influence of this factor, most probably because of the effect of the benefit of speed was used to transfer patients to facilities that were located more distantly.

Total preclinical time

As only differences in the on scene times were found, and no differences in response times or transfer times were found, it was to be expected that differences in the total preclinical time following trauma spent by the two groups of patients would also be determined by the on scene time.

Mean total preclinical time for ambulance patients was 40.9 minutes (Std. Dev. 19.1), for helicopter patients 59.7 minutes (SD23.8)

As with on scene time, these differences were highly significant (p<0.001 Student's test for independent samples).

Minimum total preclinical time for ambulance patients was 10 minutes, for helicopter patients 22 minutes, maximum preclinical time for ambulance patients was 144 minutes, for helicopter patients 171 minutes.

Preclinical Time Intervals	Ambulance Patients Mean (SD) in Minutes (n=264)	Helicopter Patients Mean (SD) in Minutes (n=172)	Significance (Student's t Test for independent samples)	Range Ambulance Patients	Range Helicopter Patients
Response Time	6.5 (4.1)	6.9 (4.1)	p=ns	Min 0 Max 30	Min 0 Max 38
Scene Time	21.1 (14.3)	36.4 (18.0)	p<0.001	Min 0 Max 116	Min 0 Max 122
Transfer Time	13.3 (10.2)	14.1 (11.6)	p=ns	Min 1 Max 77	Min 1 Max 94
Total Preclinical Time	40.9 (19.1)	59.7 (23.8)	p<0.001	Min 10 Max 144	Min 22 Max 171

Table 49: Preclinical times of ambulance and helicopter patients

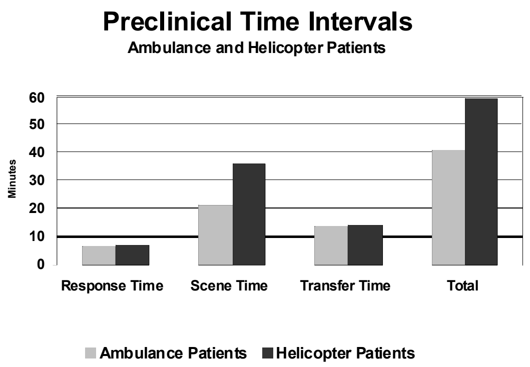

Figure 40: Preclinical intervals for ambulance and helicopter patients in minutes

Preclinical Time Intervals after Exclusion of Traffic Accidents

Extrication of patients who are trapped in vehicles prolongue scene time -often considerably-, without actual on site medical care being responsible for the additional time spent on scene. Unfortunatelly, the number of these accidents in both ambulance and helicopter groups were not systematically recorded, nor the actual time spent on extrication alone for these cases.

Preclinical Time Intervals	Ambulance Patients Mean (SD) in Minutes (n=109)	Helicopter Patients Mean (SD) in Minutes (n=70)	Significance (Student's t Test for Independent Samples)
Response Time	6.2 (4.7)	7.2 (4.1)	p=ns
Scene Time	19.7 (11.8)	33.0 (15.2)	p<0.001
Transfer Time	13.7 (11.3)	12.8 (9.4)	p=ns
Total Preclinical Time	39.6 (16.8)	53.0 (17.9)	p<0.001

Table 50: Preclinical time intervals for ambulance and helicopter patients after exclusion of traffic accidents

Therefore, differences in the number of extrications and time needed for this might be responsible for some of the differences in scene time between ambulance and helicopter group.

As lengthy extrications are almost exclusively needed in the case of a traffic accident, exclusion from analysis of patients who suffered traffic accidents will avoid this possible source of error.

In table 50, it is shown that after exclusion of traffic accidents, overall scene time is marginally lower than in the entire group of patients, but differences between ambulance and helicopter group essentially remain unchanged.

Choice of vehicle for transfer to hospital

In the helicopter group, three methods for patient transfer were possible:

- transfer to hospital by road ambulance without the physician present in the vehicle
- transfer to hospital by road ambulance with the physician present in the vehicle
- transfer to hospital by helicopter

Method of Transfer	Number of Patients	Percentage of Patients
Road Ambulance without Physician	49	23.3%
Road Ambulance with Physician	126	60.0%
Helicopter	24	11.4%
Not Recorded	11	5.2%
Total	210	100.0%

Table 51: Choice of vehicle for patient transfer in 210 helicopter patients

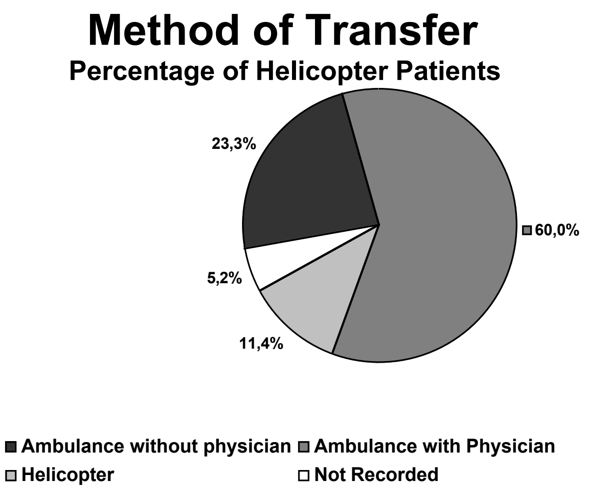

Figure 41: Method of transfer to hospital for helicopter patients

Table 51 and figure 41 show that transfer to hospital by ambulance accompanied by the helicopter physician was most frequent. A smaller percentage of patients were well stabilized in order to be transferred without a physician present, while only a small percentage was transferred by air. Most commonly patients were transported by air because of the severity of their injuries or because the admitting hospital was located distant to the scene of accident.

	Air (n=24)	Ground (n=186)	Significance
RTS	7.35 (SD 4.68)	9.26 (SD 3.39)	p<0.05 a)
ISS	27.50 (SD 10.6)	28.62 (SD 13.73)	p=ns a)
Mortality	33.3%	26.9%	p=ns b)

a) Student's t-test for independent samples b) Chi-Square Test

Table 52: Mean RTS, ISS and mortality rate for helicopter patients who were transferred by air or by ground vehicle.

Comparing helicopter patients who were transferred by air to helicopter patients who were transferred by road vehicle, a significantly lower RTS score is found in the helicopter transfer group.

Differences in ISS and mortality were not significant however, indicating that the maximum possible level of care given to this highly vulnerable group kept mortality rate low. Mean transfer times were not significantly different, 12.1 minutes (SD 7.4) for patients transferred by air and 14.4 minutes (SD 12.2) for patients transferred by road vehicle.

Helicopter patients' condition upon arrival in hospital

77 helicopter patients who met all criteria for inclusion were admitted to the VU hospital in Amsterdam. Detailed information regarding their physiologic condition upon arrival in hospital was available.

Age and sex distribution

Mean age of the patients was 33.0 years (Std. Dev. 18.2). The youngest patient was 1 year of age, the oldest 83 years. 54 of 77 patients were male (70.1%).

Mechanism of trauma

The most important cause of trauma in this group of patients were traffic accidents (55.8%), followed by domestic accidents (19.5%) and assault (11.7%). No sports accidents happened in this group of patients and only few severe occupational accidents (3.9%). (Table 53)

Cause of Injury	Number of Patients (Absolute Numbers) (n=77)	Percentage of Patients (Relative Percentages) (n=77)
Traffic	43	55.8
Domestic	15	19.5
Assault	9	11.7
Occupational	3	3.9
Sports	0	0
Other	7	9.1
Unknown	0	0
Total	77	100

Table 53: Causes of injury for all patients

Penetrating trauma was present in 6 of 77 patients (7.8%), in all cases due to assault.

ISS Score

The mean ISS score of patients was 28.7 (SD 14.1).
Minimum ISS was 1, maximum was 66.

RTS Score

The mean RTS Score was 8.5 (SD 4.1), lowest was 0 and highest was 12.

Table 57 shows that the largest number of patients have the optimal RTS scores of 12.

More than 50% of patients had RTS scores of 10 or higher, and over 10 percent of patients had the worst RTS score of 0.

RTS Score	Number of Patients (n=76)	Relative Percentage
0	9	11.8
1	1	1.3
2	1	1.3
3	2	2.6
4	1	1.3
5	3	3.9
6	2	2.6
7	2	2.6
8	7	9.2
9	4	5.3
10	10	13.2
11	8	10.5
12	26	34.2

Table 54: RTS scores of 76 helicopter patients admitted to the VU University Hospital

Mortality

Twenty two of 77 patients died (29.9%).

The scene of death was recorded for these patients. The majority of these patients died at the Intensive Care Unit (14 of 22, 63.6%), followed by death at the Emergency and Accidents Department (6 of 22, 27.3%). Two patients died during their stay at the general ward (9.1%), and one patient died in the operating theater (4.6%).

Patients who died had significantly higher ISS scores (mean 35.6 SD 17.5) than patients who survived (25.8 SD 11.3, p<0.01, t test for independent samples). The mean RTS score of deceased patients was 3.9 (SD 3.6), and for survivors 10.5 (SD 2.4), the difference being even more significant (p<0.001, t test for independent samples).

The most common cause of death were neurological injuries, which were responsible for 14 of 22 deaths (63.6%). Respiratory insufficiency was responsible for 5 fatal cases (22.7%), all of which concerned drowning accidents. Two patients died of fatal blood losses (9.1%), and in one case Multi Organ Failure was cause of death (4.6%).

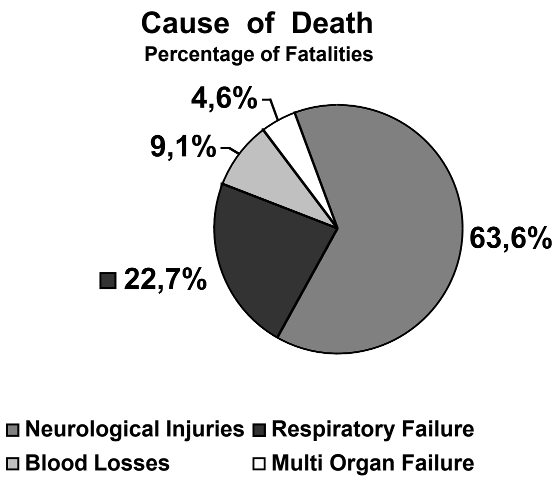

Figure 42: Cause of death in 22 helicopter patients who died in the VU University Hospital

Mortality was extremily high in the group of drowning victims - 7 of 8 patients who suffered such an accident died. Six of the drowning victims who died had an RTS score of 0 at the scene of accident, and one had a score of 1. The one surviving victim had an RTS score of 4.

Physiologic parameters on arrival in hospital

Oxygen saturation

In 75 of 77 patients, oxygen saturation was recorded upon arrival in hospital.

Mean oxygen saturation on arrival in hospital of all patients was 94.7 % (SD 14.0). The lowest saturation measured in this group was 10%, highest was 99%. Patients who survived had a higher mean saturation rate of 97.6% (SD2.9) than patients who died who had a mean saturation rate of 87.0% (SD25.0).

8 of 75 patients had saturation values of less than 90%, which equals 10.7% of all patients. Saturation values of these patients were compared by RTS score (table 55)

RTS Score	Number of Patients (n=)	Mean Oxygen Saturation (SD) (%)	Minimum Saturation (%)	Maximum Saturation (%)	Percentage of Patients with Saturation <90%
0 - 2	10	77 (33.4)	10	99	40
3 - 7	9	95.4 (7.5)	77	99	11.1
8 - 10	21	98.5 (1.9)	90	99	0
11 - 12	34	97.6 (2.7)	88	99	5.9
Unknown	1	87	87	87	100

Table 55: Oxygen saturation of helicopter patients upon arrival in hospital. Mean oxygen saturation value, minimum and maximum values and percentage of patients with oxygen saturation values less than 90%,by ISS class.

Table 55 shows that except for the group of patients in the lowest class of RTS scores, only a minority of patients have oxygen saturation rates of less than 90%. The lowest saturation measured upon arrival of patients with RTS scores of 8 or higher, was 88%.

Out of 26 patients who died, 5 had saturation values of less than 90% (19.2%) which ocurred more often than in survivors (3 of 57, 5.3%), the difference being significant (p<0.05, Chi -Square test).

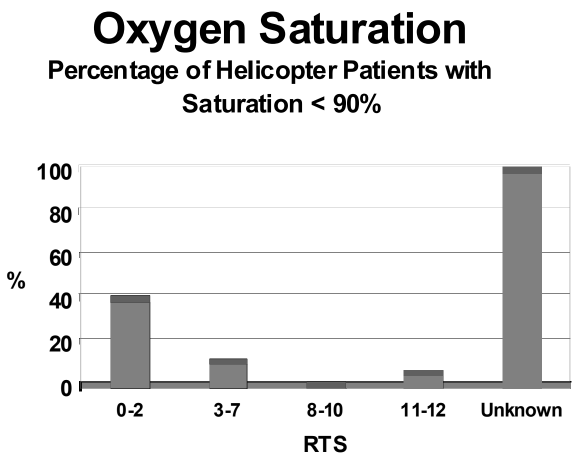

Figure 43: Percentage of patients with saturation < 90% upon arrival in hospital, by RTS score

Of the five patients who arrived in hospital with saturation values less than 90% and who died during admission, four of them were victims of drowning accidents who had RTS scores of 0 at the scene of accident. Of the surviving patients with saturation rates less than 90%, there were no patients who suffered drowning accidents.

All 5 patients who had saturation values of less than 90% and who died were preclinically intubated and artificially ventilated; of the surviving patients 1 of 3 was not intubated and artificially ventilated. Of the 14 patients who died of neurological injuries, one patient arrived in hospital with a saturation lower than 90% and this concerned a drowning accident in which the patient died later of post hypoxic encephalopathy.

Arterial systolic blood pressure

Arterial blood pressure on arrival in hospital was recorded in 74 of 77 patients. Mean systolic blood pressure was 116 mm Hg for the whole group of patients. Highest blood pressure on admission was 220 mm Hg, lowest 0.

After stratification of patients into different classes of blood pressure, the following results are found:

Systolic Blood Pressure (mm Hg) on Arrival in Hospital	Number of Patients (n=74)	Relative Percentage
>=90	64	86.5
76 - 89	1	1.4
50 - 75	1	1.4
1 - 50	0	0
0	8	10.8

Table 56: Systolic blood pressure of 74 helicopter patients on arrival in hospital

As table 56 shows, almost all patients fall into one of two groups: either having a blood pressure of over 90 mm Hg, or no measurable blood pressure at all. Only two patients had blood pressure values that were between these extremes.

Six out of eight patients who had systolic blood pressures of 0 suffered drowning accidents; the two other patients who had no pulse during admission, arrested because of severe head and brain injury.

In table 57, the systolic blood pressure upon arrival is set out against RTS scores.

RTS Score	Number of Patients (n=)	Mean Systolic Blood Pressure (SD) (mm Hg)	Minimum Blood Pressure (mm Hg)	Maximum Blood Pressure (mm Hg)	Percentage of Patients with Blood Pressure <90 mm Hg (%)
0 - 2	11	62.2 (74.7)	0	182	54.5
3 - 7	9	114 (53.3)	0	180	22.2
8 - 10	21	116.7 (33.0)	0	160	9.5
11 - 12	33	137.8 (26.0)	100	210	0

Table 57: Mean Systolic Blood Pressure, minimum and maximum values and percentage of patients with Systolic Blood Pressure lower than 90 mm Hg of helicopter patients upon arrival in hospital

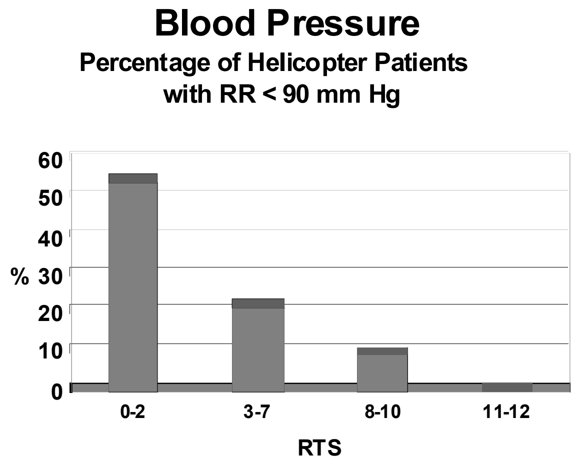

Figure 44: Percentage of patients with systolic blood pressure < 90 mm Hg upon arrival in hospital, by RTS score

As table 57 shows, an inverse relation exists between the number of patients who arrive in hospital with low blood pressure rate and the height of the RTS scores. In the group of patients with the lowest RTS scores of 0 to 2, over half of the patients had blood pressure rates of less than 90 mmHg, but in the group of patients with RTS scores of 11 and 12, all patients have at least blood pressure rates of 90 mm Hg. It is also important to note that in all groups of RTS scores, except for 11 and 12, there were patients who had no measurable pulse during time of arrival in hospital.

Nine additional patients (12.0%) had blood pressure rates of 90 or above, but pulse rates over 100 beats per minute, and should be considered to be in a compensatory state of hemodynamic shock.

All patients received intra venous fluids prior to arrival in hospital.

Base Excess

Base Excess (BE) at arrival in hospital was measured and recorded in 74 of 77 patients. The first arterial blood sample taken at the Accident and Emergency Department was used for this analysis.

Base Excess has been used as an approximation of global tissue acidosis. Because Base Excess in trauma cases is likely to be negative, more adequately could be spoken of Base Excess as a Base Deficit, which is Base Excess multiplied with -1.

Base deficit is defined as is the amount of base, in millimoles, required to titrate 1 L of whole arterial blood to a pH of 7.40, with the sample being fully saturated at 37.0 degrees Celcius and a PCO2 of 40 mm Hg.

Normal values found in healthy individuals are between -3 and 3. In cases of hypoxia and hypovolemia, the Base Excess becomes more negative, thus the Base Deficit increases.

Mean Base Excess for all patients was -6.1 (SD 7.86). Lowest value found was -36.9, highest 11.0. Patients who died had a lower mean BE of -11.2 (SD 10.5) than patients who survived. Base Excess in the group of survivors was mean -4.2 (SD 5.4), the difference being significant ($p<0.01$, t test for independent samples).

Victims of drowning had a very low mean BE of -19.2 (SD 15.1) in the group of drowning victims who died and -15.8 for the one surviving drowning victim.

Base Excess values by RTS scores result in the following table:

RTS Score	Number of Patients (n=)	Mean Base Excess Value (SD)	Minimum Base Excess Value	Maximum Base Excess Value
0 - 2	9	-17.4 (11.2)	-36.9	0.5
3 - 7	9	-8.2 (7.5)	-21.7	0.3
8 - 10	21	-4.7 (4.3)	-16	1.1
11 - 12	34	-3.5 (5.8)	-25	11
Unknown	1	-5.3	-5.3	-5.3

Table 58: Mean, Minimum and Maximum Base Excess Values for helicopter patients upon arrival in hospital

Table 58 shows that patients with the worst RTS scores at the scene of accident tend to have the most negative Base Excess values. Patients who had RTS scores at the scene of accident of 11 and 12 have the least affected Base Excess values, but even in this group, low values up to -25 occurred.

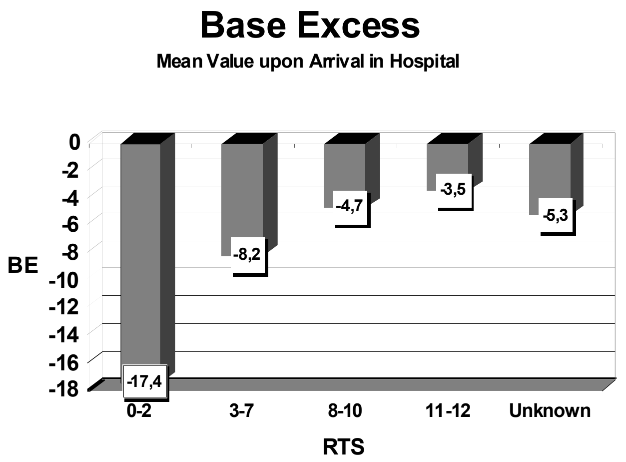

Figure 45: Mean Base Excess of patients upon arrival in hospital, by RTS score

Davis et al. [118] stratified base excess values into mild (2 to -5), moderate (-6 to -14) and severe (<-15). According to this classification, the following distribution of patients is seen:

Base Excess Class	Number of Patients (n=)	Percentage of Patients
>2	2	2.7
Mild (-5 to 2)	13	58.1
Moderate (-14 to -6)	20	26
Severe (<-15)	9	11.7

Table 59: Helicopter Patients' Base Excess values stratified into Classes of Severity (Davis et al. [118]).

As table 59 shows, the majority of patients arrived with Base Excess values between -5 to 2. Nine patients arrived with 'severe' Base Excess values, which made up almost 12 percent of the population. Almost half of these nine patients suffered drowning accidents (four of nine).

A different classification of Base Excess values is that by Rutherford et. al. [129]. Based on a large retrospective studies of 3,791 consecutive trauma patients, for whom Base Excess samples were obtained, a strong relation between the lowest Base Excess value during the first 24 hours of admission and mortality was found. Mortality risk was 25% with Base Excess -15 and steeply increasing with more extreme values for adult patients, <55 years and without head injury (AIS Head/Skull <3). The same was true for BE -8, for patients aged 55 and over without head injury and patients <55 years with head injury.

Upon arrival in hospital, the following number of patients already had Base Excess Values that exceeded these ‘critical values’.

(Adult) Patients	Number of Patients	Critical Base Excess Value	Number of Patients With Base Excess Exceeded	Percentage of Patients With Base Excess Value Exceeded
Age <55 No Head Injury (HTI <3)	23	-15	2	8.7
Age >=55 No Head Injury (HTI <3)	4	-8	1	25
Age <55 With Head Injury (HTI >2)	24	-8	6	25

Table 60: Number of adult patients whose first Base Excess values have exceeded critical values defined by Rutherford et al. (1992) at the time of arrival in hospital

In table 60 it is shown that of the patients aged <55 without head injury, a relatively small number of patients already exceeded the critical Base Excess Value for that group (8.7%); almost triple of that percentage was the case for the other two groups of patients, aged 55 and over without head injury, and aged <55 with head injury. In these groups a quarter of the patients had Base Excess Values that were below the critical value for their group.

As these numbers concern separate sub-groups of the entire population, the percentages of patients who had oxygen saturation rates of less than 90% and systolic arterial blood pressure rates of less than 90 mm Hg were calculated for each sub-group.

(Adult) Patients	Number of patients (n=)	Critical Base Excess Value	Percentage o Patients Exceeding Critical Base Excess Value	Percentage of Patients With Oxygen Saturation <90%	Percentage of Patients With Systolic Blood Pressure <90 mm Hg
Age <55 Without Head Injury (HTI <3)	23	-15	8.7	8.7	8.7
Age >54 Without Head Injury (HTI <3)	4	-8	25	25	0
Age <55 With Head Injury (HTI>2)	24	-8	25	8.3	16.7

Table 61: Helicopter patients by category of critical base excess values and the percentages of patients in these groups that had oxygen saturation values less than 90 percent and arterial systolic blood pressures less than 90 mm Hg upon arrival in hospital

Adverse effects of prehospital treatment

All patients were assessed for eventual immediate complications of treatment performed at the scene of accident.

The following two complications of on site treatment occurred in this group:

- At one occasion, a tracheal tube was erroneously inserted into the esophagus. This mis-intubation was performed by ambulance personnel prior to arrival of the helicopter team; on arrival of the helicopter physician the error was corrected. Nevertheless, the patient, who had suffered a drowning accident, died later in hospital.
- On one occasion, a needle chest decompression was performed unnecessarily by the helicopter physician, i.e. no pneumothorax was present. The patient, who suffered multiple rib fractures, arrived in hospital with an optimal oxygen saturation and no complications of the unnecessary manoeuvre occurred during admission.

Ambulance patients upon arrival in hospital

Data on 141 ambulance patients who were admitted to the VU University Hospital during the time of study and met all inclusion criteria, were also available.

Of the ambulance patients, 68.1% of patients were male.

Mechanism of injury was fairly similar to that of helicopter patients, with the exception of 5 percent of cases in which the mechanism of trauma was not recorded well in the ambulance group, and remained unknown.

Cause of Injury	Absolute Number of Patients (n=141)	Relative Percentage of Patients (n=141)
Traffic Accident	75	53,2
Domestic Accident	30	21,3
Assault	15	10,6
Occupational Accident	4	2,8
Sports Accident	0	0
Other	10	7,1
Unknown	7	5

Table 62: Cause of injury of ambulance patients admitted to the VU University Hospital

Drowning accidents consituted 2 single cases only.

The mean age of patients was 40.0 (SD 20.4) years, mean RTS 10.2 (SD 2.7, range 0-12), mean ISS 22.7 (SD 9.3, range 4 - 66). By comparison, helicopter patients were significantly younger, and had more unfavourable injury severity scores, both on ISS and RTS.

In this group of patients, 31 patient (22%) died.

The mean RTS of patients who died was 7.5 (SD 3.7), lower than of the patients who survived 10.9 (SD 1.7).

The mean ISS of patients who died was 24.9 (SD 12.0), higher than of the patients who survived 22.1 (SD 8.4).

5.6% of ambulance patients for whom oxygen saturation was recorded upon arrival in hospital, had saturation values of less then 90% (n=124). Mean saturation was 96.6% (SD7.7), lowest saturation was 30%, highest 99%.

7.8% of ambulance patients in whom systolic blood pressure was recorded, had a blood pressure <90 mm Hg (n=124). Mean blood pressure was 124.4 mm Hg (SD 41), lowest blood pressure was 0 mm Hg, highest 270 mm Hg.

Mean Base Excess of ambulance patients was -3.4 (SD5.1, n=119), highest was 5.4, lowest -25.0.

In 10.9% of patients, Base Excess was <- 8, 5.0% of patients had Base Excess <-15.

The results are valid for helicopter and ambulance patients separately.

No comparison between the two groups was performed on these parameters, due to essential differences between the two groups. The reasons for incomparability are discussed in chapter 4.

Mortality Analysis

The following is a summary of the mortality analysis performed in the study by de Charro & Oppe [48].

The Simpson paradox

Due to selective activation of the helicopter trauma team for the most severe accidents, direct comparison between mortality of helicopter patients and ambulance patients will lead to a biased result. Because more severe accidents are associated with higher mortality, selective activation of the helicopter team for these cases is expected to result in a higher mortality rate as well.

The effect of this is also known as ‘the Simpson paradox’.

A short, hypothetical example of the ‘Simpson paradox’ is shown to make clear that even if helicopter involvement is responsible for a reduction of mortality in all individual sub-groups of injury severity, still the net effect of the helicopter may falsely suggest that mortality is increased in the helicopter group.

Severe Accidents	Helicopter Patients	Ambulance Patients
Died	48	60
Survived	52	40
Percentage Died:	48%	60%
Reduction in Helicopter Group:	20%	
Less Severe Accidents	**Helicopter Patients**	**Ambulance Patients**
Died	16	200
Survived	84	800
Percentage Died:	16%	20%
Reduction in Helicopter Group:	20%	
Total	**Helicopter Patients**	**Ambulance Patients**
Died	64	260
Survived	136	840
Percentage Died:	32%	24%
Increase in Helicopter Group:	35% (!)	

Table 63: Hypothetical example of the ‘Simpson paradox’

This example shows that in both severe cases as well as in less severe cases, helicopter mortality is lower than ambulance mortality, but taken as a whole, mortality in the helicopter group is higher than in the ambulance group.

Correction for severity of injuries is therefore necessary to avoid this source of error.

After stratification into different classes of ISS and RTS, the following mortality rate was found for the 517 patients:

ISS	Number of Ambulance Patients (n=)	Mortality Rate for Ambulance Patients (%)	Number of Helicopter Patients (n=)	Mortality Rate for Helicopter Patients (%)
0-15	14	21.4	13	38.5
16-25	178	14.6	99	16.2
26-40	80	28.7	53	18.9
41-75	35	62.9	45	60.0
Total	307	24.1	210	27.6

Table 64: Mortality of ambulance and helicopter patients by ISS score

RTS	Number of Ambulance Patients (n=)	Mortality Rate for Ambulance Patients (%)	Number of Helicopter Patients (n=)	Mortality Rate for Helicopter Patients (%)
0-2	12	75	16	81.2
3-7	25	60	27	63.0
8-10	66	27.3	44	25.0
11-12	139	11.5	83	7.2
Unknown	65	24.6	40	27.5
Total	307	24.1	210	27.6

Table 65: Mortality of ambulance and helicopter patients by RTS score

These tables show that helicopter involvement in the higher ISS classes is associated with a lower mortality, but for patients with low RTS scores the opposite seems to be true.

In order to obtain a fair estimate of the effect of helicopter involvement, a precise estimate of injury severity, independent of the rendered care, needed to be carried out. RTS and ISS are part of such estimate, but other variables, such as age and mechanism of injury may also play a role. An indicator of the injury severity was developed for this reason.

This indicator may then be used to estimate the effect of helicopter involvement on mortality.

A multiple regression analysis was performed. A number of variables used in the regression analysis were measured on a nominal scale, which means that these are not directly measured, but classified into categories, without logical order. An example of this is ‘type of accident’: all patients are categorised into one of possible classes, for instance ‘traffic accident’ or ‘private accident’. Although it is likely that some relation exist between injury severity and type of accident, its precise relationship remains to be determined. Something similar goes for ‘age’ as well; although age is a sorted variable and a relation between age and injury severity is to be expected, the relation between age and injury severity does not necessarily have a linear order. Patients of old and very young age might have a higher vulnerability than the group of patients aged within.

To provide a multiple regression analysis with nominal variables, a non-metric method of analysis was used with optimal scaling. This method, called ‘CANALS’ was developed at the University of Leiden especially for this purpose. Given the optimal scaling of the variables, the analysis is an ordinary multiple linear regression analysis. This type of analysis is named ‘CATREG’ in the SPSS ® statistical software package and is found under the heading of ‘optimal scaling’. In SAS ® this technique is called "TRANSREG’. In tables 68 A-C and figures 46 A-C some examples of the results of this scaling method are shown.

A Preliminary Analysis of All Patients

First, the described method of analysis was applied to a set of all patients of whom prehospital and hospital data were available. This set of 822 patients included night-time ambulance patients as well. However, the difference between night-time and day-time was not used as an explaining variable in the analysis.

What has been examined, however, is whether there were differences between night-time and day-time patients in severity. The reason for this, was to check whether it was allowed to include night-time patients in the control group, despite the fact that the helicopter team was only active during daylight hours.

In a first analysis, 34 different variables were included in the analysis. Especially the specific injuries and treatment at the site of accident, provided little predictive value on mortality. The most important reason for this was the fact that these variables were often ‘missing’ (unrecorded) in the records, or seldomly severe.

Thereafter, another analysis was performed in which 20 variables attributing to the solution, or having a relation with the solution, were used as predictors of mortality. The variables were: age, sex, and type of accident, also three specific types of prehospital manoeuvres, the total number of prehospital manoeuvres provided, the RTS and the ISS scores and all their sub scores were used.

The following results were obtained from this analysis.

First, a summary is given of the explaining variables with the results of the CANALS analysis.

In the first row, the regression weights are given, in the second row, the correlations of the (transformed) explanatory variables with the criterium are printed.

Variable	Regression Weight	Correlation
Died/Survived (Dependent Variable)	1.00	1.00
Age	0.30	0.28
Type of Accident	0.16	0.14
Sex	0.09	0.03
Number of Treatment	0.07	0.16
Intubation, Artificial Ventilation, Mayotube, Control of Blood Losses	0.05	-0.28
Intravenous Access, MAST	0.12	0.01
Cardiac Massage, Cardiac Defibrillation	-0.12	-0.31
RTS Blood Pressure	0.17	-0.34
RTS Respiratory Rate	0.12	-0.08
Glasgow Coma Scale - Eyes	0.16	0.09
Glasgow Coma Scale -Motor	-0.20	-0.56
Glasgow Coma Scale - Verbal	0.13	0.25
RTS	-0.52	-0.54
HTI Head/Skull	0.14	0.38
HTI Respiratory System	-0.09	0.16
HTI Cardiovascular System	0.02	0.26
HTI Abdomen	-0.13	0.08
HTI Extremities	-0.19	-0.07
HTI Skin/Soft Tissues	-0.06	0.09
ISS	0.58	0.43
Canonical Correlation: 0.82		

Table 66: Regression weight and correlation with mortality of several variables

The regression weight indicate what role the variables have had in the solution; a regression weight close to zero means that the variable had a marginal role only. A large positive or negative weight indicates that this variable played an important role. A variable with a small weight may nevertheless have a high correlation with the criterium; this is the case with variables which have a relationship with other variables that have an explanatory role.

This solution shows that the final RTS and ISS scores are, as expected, the most important explanatory variables. As may have been expected, the sign (positive/negative) of the correlations shows that higher ISS scores, as well as a lower RTS scores, are associated with higher mortality.

The Motor component from the Glasgow Coma Scale is an additional variable of high value; this sub score even has the highest correlation of all with the criterium (mortality). The Verbal component of the Glasgow Coma Scale, does, surprisingly, show a positive correlation with the criterium, which suggests a compensatory effect of this sub score upon the total RTS score.

Of the ISS sub scores, only the HTI score for Head/Skull injuries is an important additional variable.

Except for RTS and ISS scores, the most important contributions originate from age, type of accident, and number of treatment. From specific treatments, only ‘cardiac massage/defibrillation’ and ‘intra-venous access/MAST’ do contribute to the solution. The relatively high correlation, but low weight, of ‘intubation/artificial ventilation/Mayotube/control of blood losses with ‘severity’ is due to a strong correlation with ‘cardiac massage/defibrillation’.

The correlation between the dependent variable and all the explanatory variables is 0.83: this correlation is higher than that of any of the individual variables alone. Especially interesting is that the predictive value of the ISS is not better than that of the RTS, but it is especially the combination of both which gives a fair prediction. Nevertheless, other variables play a role as well.

Random fluctuations in the variables under study may affect the solution in a regression analysis.

This effect may result in a flattered prediction, especially when many - especially nominal - explanatory variables are present with only a relatively small number of observations (patients). The number of patients in the current analysis is very large, so that it is to be expected that a solution found is stable despite the large number of explanatory variables. To assess this effect, first an analysis was performed on the same set of patients, but with reduction of the number of explanatory variables to the 12 most important. The solution was hardly changed, and the correlation was only reduced to 0.81.

In an additional check, a split-half technique was used: patients were randomly assigned to one of two groups, after which both groups were individually analysed. When the solution is influenced by random fluctuations due to an inadequate small sample size, reduction of the number of observations by one half would increase the predictability of the criterium. However, application of this 'split-half' technique resulted in no increase, or only marginal increase in the predictiveness (r = 0.84, r = 0.83, respectively).

A 'bootstrap' analysis was then performed. By use of this technique, a random sample of patients was drawn from the entire set of patients with replacement, the selected cases were not removed from the sample population after each draw. As is most common in this type of analysis, the sample size used is this study was equal to the original size of the set of patients. Using such a bootstrap analysis, some patients feature multiple times in the sample, while others are missing from that sample. By repeating this procedure many times and by analysis of the distribution in the results, a fair impression was gained of the stability of the solution. This bootstrap analysis showed that the solution found was stable.

Except for the correlation values, the interpretation of the values found is also of main importance. It has been found that the variables, which were expected to be of prime importance indeed were the most important. Also, the results of the transformations (rescaling) was well interpretable. Therefore, the conclusion is justified that an analysis of mortality in which CANALS scores are used as indicator of injury severity, is useful and enables a more refined correction than would have been possible on basis of RTS and ISS scores alone.

Important differences were found to exist between the victims of accidents during daylight and nighttime hours; a certain difference in severity existed, with a higher percentage of non-survivors during daylight hours. The distribution in the type of accident varied with an comparable percentage of traffic accidents, but large differences for other types of accidents. Also in age, differences existed; younger and older patients are under represented during the night.

Therefore, as these differences may influence any analyses of the effect of helicopter care on mortality, all analyses were only performed on the group of 517 patients who suffered trauma during daylight.

The following results of the CANALS analysis were obtained for this group:

Variable	Regression Weight	Correlation
Died/Survived	1.0	1.0
Age	0.35	0.28
Type of Accident	0.11	0.05
Sex	0.12	0.17
RTS Blood Pressure	0.16	-0.24
RTS Respiratory Rate	-0.13	-0.15
Glasgow Coma Scale - Eyes	0.25	0.06
Glasgow Coma Scale - Motor	-0.25	-0.59
Glasgow Coma Scale - Verbal	0.27	-0.11
RTS	-0.61	-0.47
HTI Head/Skull	0.04	0.12
HTI Respiratory System	-0.22	0.19
HTI Cardiovascular System	-0.28	0.16
HTI Abdomen	-0.10	0.12
HTI Extremities	-0.23	-0.04
HTI Skin/Soft Tissues	-0.07	0.47
ISS	0.89	0.47

Canonical Correlation: 0.84

Table 67: Regression weight and correlation of several variables on mortality (daytime accidents only)

A few transformations are provided to give an example of the scaling:

RTS

RTS Value	Number of Patients	Scaling	Mean Score
0	21	3.05	1.29
1	2	3.05	2.06
2	5	3.05	1.84
3	3	2.24	2.05
4	7	2.19	1.02
5	10	2.19	1.95
6	13	1.32	0.99
7	19	0.52	0.30
8	32	0.12	0.49
9	32	0.12	0.15
10	46	0.08	-0.31
11	45	0.08	-0.24
12	177	-0.54	-0.49
Unknown	105		0.00

Table 68A: Scaling of RTS scores in the CANALS analysis

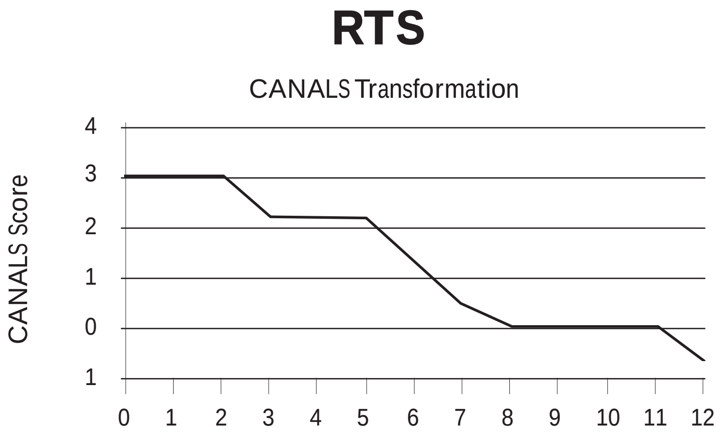

Figure 46A: Graphical representation of the scaliing of RTS scores in the CANALS transformation

Age

Age	Number of Patients	Scaling	Mean Score
0-5	18	0.87	0.21
6-9	20	-0.71	0.12
10-14	17	-0.60	-0.54
15-18	34	-0.43	-0.46
19-24	58	-0.34	-0.04
25-34	101	-0.26	-0.16
35-44	87	-0.23	-0.10
45-54	54	-1.36	-0.24
55-64	54	0.01	-0.09
>65	70	2.20	0.79
Unknown	4		2.02

Table 68B: Scaling of age in the CANALS analysis

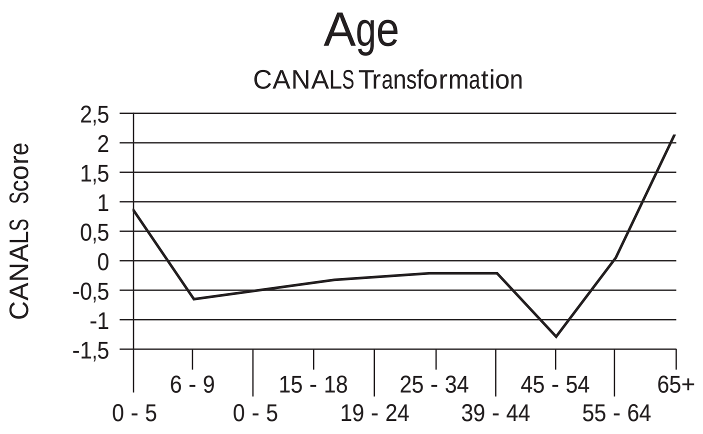

Figure 46B: Graphical representation of the scaling of age categories in the CANALS transformation

Type of Accident

Type of Accident	Number of Patients	Scaling	Mean Score
Traffic Accident	296	-0.11	-0.03
Assault	33	1.36	-0.04
Suicide	23	1.49	0.26
Occupational Accident	29	-0.37	-0.61
Private Accident	101	0.12	0.28
Other	11	-1.45	0.05
Unknown	24		-0.26

Table 68C:Scaling of type of accident in the CANALS analysis

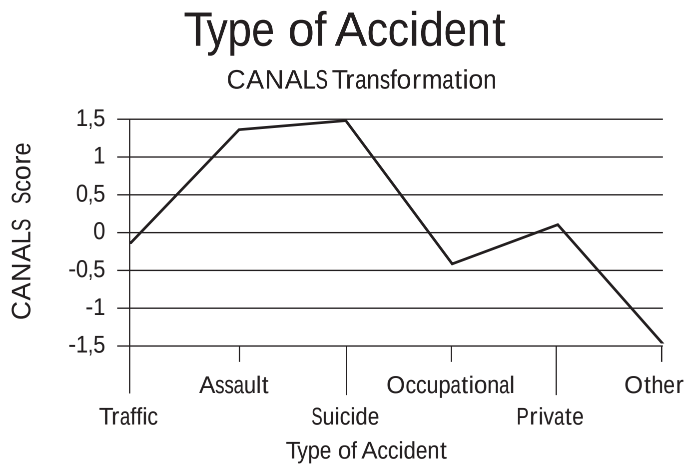

Figure 46C: Graphical representation of the scaling of type of accident in the CANALS transformation

Analysis of the 517 patients

In the first, preliminary, analysis, the objective was to discriminate for those variables which have a predictive value on mortality. What the objective of a definitive analysis should be, however, is to allow for such a correction for the selection differences between both groups, that effects on mortality which are caused by helicopter involvement will be attributed to the helicopter. Therefore, only variables are allowed in the correction which are independent of the rendered care, and may include age, sex, mechanism of injury and level of injuries, but not the type or extent of prehospital treatment provided.

When all variables, independent of care, are added, mortality may be predicted with a very high accuracy. However, this leaves little room for helicopter involvement to serve as explanation for any differences found between helicopter and ambulance mortality and, in fact risks that any beneficial effects of the helicopter are falsely attributed to other factors.

When the number of explanatory variables is too limited, the differences found may be attributed to the helicopter team, while in fact other factors may be responsible for it. Also, injury severity may be under-corrected, in which case the effect of helicopter care is underestimated.

To assess the influence of the choice of variables in the analysis on the helicopter-effect, seven analyses were performed each with a different choice of explanatory variables. For each of these seven models, CANALS scores were calculated and an estimation was made on the mortality risk with and without helicopter involvement.

By putting patients in order of CANALS score, the relation between this score and mortality can be accomplished. By analysing ambulance and helicopter patients by severity classes of CANALS scores a rough estimation of mortality is possible.

If helicopter care is indeed effective, in every class of severity mortality risk in the helicopter group has to be identical at least and, on average, smaller.

The Effect on Mortality

Stratification of patients into classes of mortality risk, on basis of the CANALS scores resulted in the following:

Probability of Mortality	Number of Ambulance Patients	Number of Ambulance Patients Who Died	Percentage of Ambulance Patients Who Died	Number of Helicopter Patients	Number of Helicopter Patients Who Died	Percentage of Helicopter Patients Who Died
0-0.124	215	7	3.3	124	1	0.8
0.125-0.249	17	5	29.4	13	0	0
0.250-0.499	11	5	45.4	13	3	23.1
0.500-0.749	11	7	63.4	16	10	42.5
0.750-1.00	53	50	94.3	44	44	100
All	307	74	24.1	210	58	27.6

Table 69: Mortality of ambulance and helicopter patients by class of probability of mortality

Table 76 shows that in almost all classes,, except for the class of patients with the highest severity, helicopter patients have a lower mortality rate. Especially is this true for patients with a mortality risk up to p=0.5.

In the group of patients with the highest injury severity, all patients in the helicopter group died, but three patients in the ambulance group survived.

These results suggest that patients may be categorised into three categories: 339 patients with only minor injuries, who have a low mortality risk and have little benefit from helicopter involvement; a group of 97 patients with a very high level of severity, who are moribund despite any emergency efforts, and a ‘critical group’ of 81 patients between these extremes for whom helicopter involvement leads to better chances of survival.

Logit analysis

Every classification of patients is, however, sub-optimal. A more precise indication of mortality is found not by stratification of patients into classes, but by analysing mortality risk for every patient individually.

This was performed using a 'logit' analysis.

By application of the logit analysis, mortality risk is reasoned to increase from 0 to 1, by the level of injury severity. This increase of mortality risk is supposed to be logistic by nature. The origins of this analysis are Bayesian: the ratio between the probability to die (p) and to survive (1-p) plays a central role. The log(-likelihood) ratio, is supposed to have a linear relation with injury severity:

log [p/(1-p)]=a+b multiplied by the injury severity score.

The parameters a and b are to be discovered.

For the risk p, this means there is an S-shaped (logistic) association with severity. With low injury severity few patients will die, with high injury severity almost all patients will die. Within, there is a critical area in which the probability to die strongly increases with injury severity.

With this limitation on mortality risk, it is possible to calculate the values for a and b, so that for all patients the likelihood of mortality, given the severity score and the actual outcome, is maximal. A comparison between the predicted outcome obtained from this model and the actual outcome for ambulance and helicopter patients, shows that the number of patients who actually died, is in fact smaller for the helicopter group, and for the ambulance group, higher.

The logistic model is, as described above, in fact a linear regression model, applied to a transformation of the dependent variable.

This dependent variable, 'the probability to die', cannot be observed directly.

Every patient died or survived (did, or did not die). This binary information for all individual patients together was used to calculate mortality risk for every level of injury severity.

The observed variable thus exclusively has the value 0 or 1, meanwhile the estimated probability may have any value between 0 and 1. The mortality risk for any patient (p) can be estimated by application of a linear transformation model on the transformation y=log(p/1-p). This transformation causes that the dependent variable y can take on every value between minus infinite to plus infinite, which is a requisite for the linear regression model.

Three different logistic models were compared in this analysis:

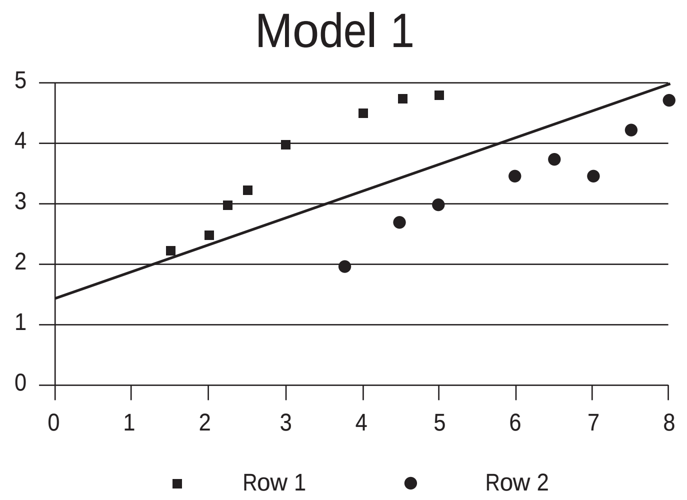

Figure 47: Example of regression model 1

In logistic model 1 it is supposed that for both (ambulance and helicopter) groups of patients, with identical injury severity, no differences exist in mortality risk. The solution is a straight line which suits the data best. The predicted y-value can be calculated for every x-value by the formula y=a+bx.

The identical regression model is only valid for both groups of patients when no differences between them exist. If indeed no differences exist between both groups, the mean deviation between the expected and observed values for both groups are equal to zero. The mean deviations therefore provide information retrospectively on the solidity of this hypothesis. If the means vary significantly, this model is invalid.

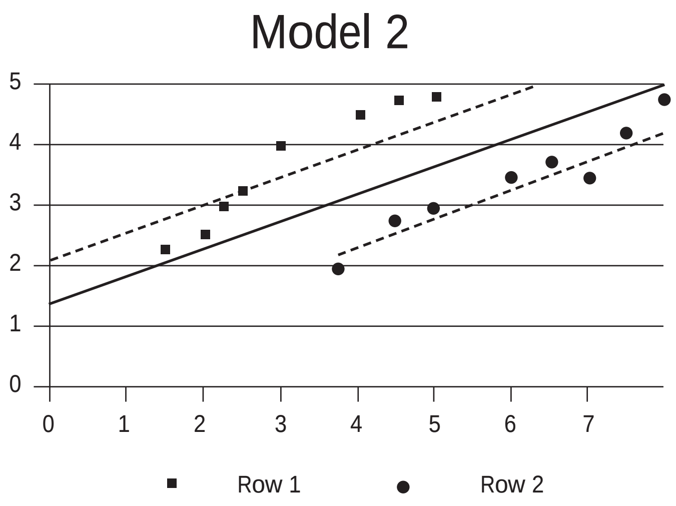

Figure 48: Example of regression model 2

In logistic model 2 it is supposed that both groups may be described with the identical basic model, with the only difference being in the level. The same straight and symmetrical regression line is valid for both A and B, but now with a change in level - upward or downward. In the case of a helicopter effect, this means that the relation between 'probability to die' and 'level of injury severity' does not change, but that there is, in general, an additional helicopter effect. The predicted y-value for the first group can be calculated by the formula y=a1+bx, for the second group by the formula y=a2+bx.

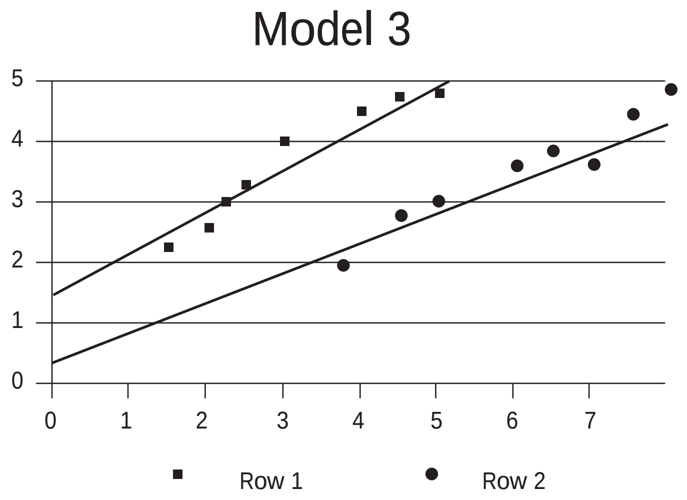

Figure 49: Example of regression model 3

In logistic model 3, not only the level is different, but also the angle of the regression line with the X-axis. Not only can be spoken of an additional helicopter effect then, but the relationship between injury severity and mortality risk changes. The formulas to calculate y-values are y=a1+b1x and y=a2+b2x.

In the analysis, first it must be assessed if the simplest model 1 is applicable, or that it should be enhanced with additional parameters for differences between A and B.

For the definitive choice for the best applicable model, the best suitable CANALS model had to be chosen as well as the best suitable logit model.

Ultimately, seven models were used for the CANALS analysis. In all models the RTS, ISS and sub-scores were used. The models varied from the most basic model in which only RTS and ISS are used, to a model in which all explanatory variables were included. The canonical correlation varied from r=0.76 in the basic model to r=0.83 in the most extensive model. In all CANALS models therefore, a fair prediction of mortality was possible.
For each of the seven CANALS analyses subsequently the logit analyses were applied. First, the CANALS injury severity scores were awarded to the patients, then the variable a and b were calculated in logit model 1. Subsequently, the additional parameter was calculated in logit model 2 for the helicopter-effect. The basic model is the model without helicopter-

effect: addition of the helicopter parameter shows the effect for the helicopter group.

CANALS Model	Variables	Patients	Canonic Correlation	Helicopter Parameter	SD	t-Score	Single Sided Test	Likelihood Ratio	Double SidedTest
1	RTS + ISS	All	0.755	-0.621	0.3383	-1.836	p<0.05	3.528	p=ns
1		Non-Traffic		-0.199	0.5438	-0.366		0.136	
1		Traffic		-0.89	0.4356	-2.043	p<0.05	4.491	p<0.05
2	RTS + ISS	All	0.774	-0.754	0.3562	-2.117	p<0.05	4.733	p<0.05
2	+ RTS-Motor +	Non-Traffic		-0.065	0.5624	-0.116	0.013		
2	HTI Head /Skull	Traffic		-1.19	0.4696	-2.534	p<0.01	7.121	p<0.01
3	RTS + ISS	All	0.792	-0.468	0.3613	-1.294	p=ns	1.713	p=ns
3	+ Sex + Age	Non-Traffic		0.157	0.578	0.2716		0.074	
3		Traffic		-0.865	0.4713	-1.835	p<0.05	3.559	p=ns
4	RTS + all Sub	All	0.800	-0.869	0.3888	-2.235	p<0.05	5.347	p<0.05
4	Scores + ISS +	Non-Traffic		-0.312	0.6409	-0.486		0.242	
4	all Sub Scores	Traffic		-1.19	0.4933	-2.412	p<0.01	6.441	p<0.05
5	As in Model 2	All	0.807	-0.486	0.3772	-1.287	p=ns	1.691	p=ns
5	+ Sex + Age	Non-Traffic		0.3948	0.5953	0.6632		0.441	
5		Traffic		-1.083	0.5091	-2.126	p<0.05	4.88	p<0.05
6	As in Model 4	All	0.827	-0.607	0.4106	-1.478	p=ns	2.254	p=ns
6	+ Sex + Age	Non-Traffic		0.1807	0.6591	0.2742		0.075	
6		Traffic		-1.087	0.5356	-2.03	p<0.05	4.437	p<0.05
7	As in Model 6 +	All	0.830	-0.597	0.4147	-1.439	p=ns	2.137	p=ns
7	Type of Accident	Non-Traffic		0.2531	0.6696	0.378		0.142	
7		Traffic		-1.103	0.5394	-2.045	p<0.05	4.503	p<0.05

Table 70: Results of seven different CANALS models

In the following tables, the results of the logit-analyses for the seven different CANALS-scores are shown.

The analysis provides for a (log-likelihood) ratio which is indicative of what improvement there is in predicting mortality with addition of the helicopter parameter. The Chi-square value derived from it may be used to test if the improvement by the helicopter effect is significant. The parameters b, also known as the intercept, a for severity, and for the helicopter-effect are estimated. For the parameter of the helicopter effect, a value t is calculated, which shows if the parameter is contributing significantly to the model. This t-value represents the optimal value for the helicopter-effect and not, like the likelihood-ratio-test, the improvement which the helicopter-effect adds to the model without helicopter-effect. It is possible to find a significant t-value, but no significant likely-hood-ratio, also due to the fact that the helicopter-parameter is tested single sided, but the likelihood-ratio test does not discriminate for the sign of the effect.

The likelihood-ratio test shows for the entire group of patients that the addition of the helicopter variable in the explanation is significant in two models, but not significant in five models. In CANALS model 1, in which only the RTS and ISS scores are used, the correction for injury severity seems not to be optimal. Although in this model, the possible value of the helicopter variable in the explanation is largest, the effect is not significant according to the likelihood-ratio test. The same is true for model 3, in which besides RTS and ISS also age and sex are included. In models 2 and 4, where there is a sufficient correction for injury severity (RTS, ISS and one or more of their sub-scores - age, sex and type of accident are not included), a significant effect was found.

The sign of the helicopter parameter indicates what influence the helicopter-parameters stands for: a negative parameter indicates that mortality risk is reduced in that group. This helicopter parameter is significant in three of seven cases following single sided testing, which is allowed due to the expected effect.

When patients are divided by type of accident, it is shown that the effect of the helicopter is almost exclusively limited to patients who suffered traffic accidents, and thus not to patients who suffered any other kind of accident. For the latter, the likelihood-ratio test, and the helicopter-parameter were both not significant. In four out of seven cases, the helicopter parameter has even a small positive value. For patients who suffered traffic accidents, the opposite is true; the helicopter-effect, as well as the likelihood-ratio is, in all but one model, significant ($p<0.05$) to highly significant ($p<0.01$).

The conclusion therefore may be drawn that helicopter involvement leads to a significant reduction of mortality for patients who suffered traffic accidents, but not for other patients. For patients who suffered traffic accidents, even in the CANALS model with all parameters included, including the type of accident (wherein patients are thus split between traffic and non-traffic causes of injury), there is a significant helicopter-effect.

CANALS model 4, in which all information on injury severity (RTS, ISS and all sub-scores) is incorporated, but none of the other explanatory variables (age, sex and type of accident), shows a larger helicopter-effect for the entire group of patients than CANALS model 7, in which all the other variables are included.

Both CANALS model 4 and 7 will be described; CANALS model 4 is called the maximal model, because the entire effect is attributed to the helicopter. CANALS model 7 is called the minimal effect, as only those effects are attributed to the helicopter, which cannot be explained by any other variable.

The maximal model (CANALS model 4)

Intercept	Severity	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
1.75	-3.05	132	132.00	58	64.33	74	67.67

Table 71A:: Logit model 1 applied to all patients

Intercept	Severity	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
1.69	-2.90	72	72.00	27	32.63	45	39.37

Table 71B:: Logit model 1 applied to traffic accidents only

Tables 71A and 71B show the results of the models used on the results of CANALS analysis 4, the maximal model.

When logit model 1, in which the assumption is that there are no differences between helicopter and ambulance group, is applied, the mortality in the helicopter group is 6.33 patients less than expected. For patients following traffic accidents, the difference is 5.63 lives. This means that the assumption of logit model 1 can be rejected and logit model 1 does not apply.

Patients	Intercept	Severity	Helicopter Parameter Mortality	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
All	1.43	-3.22	0.87	132	143.74	58	69.74	74	74.00
Traffic Accidents Only	1.25	-3.12	1.19	72	82.57	27	37.57	45	45.00

Table 72A:: Application of logit model 2 without helicopter effect

Patients	Intercept	Severity	Helicopter Parameter Mortality	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
All	1.43	-3.22	0.87	132	117.83	58	58.00	74	59.83
Traffic Accidents Only	1.25	-3.12	1.19	72	59.70	27	27.00	45	32.70

Table 72B:: Application of logit model 2 with addition of the helicopter effect

Logit model 2, in which one basic model is applied with a change in height due to the helicopter-effect, is better suitable. Assuming logit model 2 on CANALS analysis 4, the estimated number of fatalities is 11.74 higher in the entire group - or 17% -, had the helicopter patients not received helicopter care but ambulance care instead.

When the helicopter-effect is added to the ambulance group, the number of patients who would have been saved if the helicopter were present, can be calculated. Had all ambulance patients received helicopter care, mortality is expected to be reduced by 14.17 lives, or 19%. The estimated number of fatal cases for the entire group is 117.8 when all patients would have received helicopter care, and 143.74 when none of the patients would have received helicopter care. When this model is applied exclusively to patients who suffered traffic accidents, the reduction of mortality is 10.57 lives, or 28%. When all ambulance-patients would have received helicopter care, 12.30 lives would have been saved additionally, or a reduction of 27%. This finding confirms the earlier conclusion that the helicopter-effect mainly concerns patients following traffic accidents.

Application of logit model 3, in which the basic model is different between helicopter and ambulance patients, showed that the addition of an extra parameter does not result in any improvement of the description of any group of patients.

The conclusion is that there is a basic model which is applicable to all groups of patients which shows how the estimated CANALS injury severity score is related to the chances of survival.

To assess the helicopter-effect, only one parameter has to be added for helicopter patients in the basic model, without the need for a new model. Finally, the conclusion is that the estimated effect for helicopter care is significantly larger for the patients following traffic accidents than for other types of patients.

The minimal model (CANALS model 7)

Tables 73A and 73B show the results of the analysis based on CANALS model 7, in which except for RTS and ISS and sub scores, also age, sex and type of accident are included.

As in the maximal model, the assumption of the logit model 1 is rejected. The number of fatalities in the helicopter group is 3.62 higher than the actual observed number.

Intercept	Severity	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
2.05	-3.78	132	132.00	58	61.62	74	70.38

Table 73A: Logit Model 1 applied to all patients

Intercept	Severity	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
1.97	-3.96	72	72.00	27	31.19	45	40.81

Table 73B:: Logit Model 1 applied to patients following Traffic Accidents

For logit model 2, a reduction of mortality is found in the helicopter group of 6.83 lives, or 11%, i.e. the expected mortality is higher by this amount if only ambulance care would have been given to the helicopter patients. The estimated number of patients who would have been saved if all patients would have received helicopter care, is 7.79, again a reduction of 11%.

The estimated number of dead in the entire group, had all patients received helicopter care, is 124.21. When helicopter care would not have been given at all, 138.83 patients are estimated to have died.

For the victims of traffic accidents, the estimated reduction is 8.15 lives, or 23%. The estimated reduction in the ambulance group, were helicopter care is given, is 8.76 lives, or 19%. These numbers are actually higher than the reduction in the entire group, which can be explained by the fact that for other types of accidents the helicopter has a slight - not significant - negative effect on mortality.

Patients	Intercept	Severity	Helicopter Parameter Mortality	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
All	1.81	-3.86	0.60	132	138.83	58	64.84	74	74.00
Traffic Accidents Only	1.53	-4.13	1.10	72	80.15	27	35.15	45	45.00

Table 74A:: Application of logit model 2 without helicopter effect

Patients	Intercept	Severity	Helicopter Parameter Mortality	Total Observed Mortality	Total Expected Mortality	Observed Helicopter Mortality	Expected Helicopter Mortality	Observed Ambulance Mortality	Expected Ambulance Mortality
All	1.81	-3.86	0.60	132	124.21	58	58.00	74	66.21
Traffic Accidents Only	1.53	-4.13	1.10	72	63.24	27	27.00	45	36.24

Table 74B:: Application of logit model 2 with addition of the helicopter effect

As in the maximal model, logit model 3 offers no additional value over model 2.

Following the analysis of the 517 patients of whom both clinical and pre-clinical information was available, an additional analysis was performed of 1.025 of 1.026 patients of whom only hospital, but no prehospital information was available.

Except for the patients who also featured in the group of 517 patients, the prehospital RTS, type and time of accident remained unknown. However, the total RTS-score upon arrival in hospital was used instead. The type of accident was also not available.

Due to the more limited information on this, albeit larger, group of patient, the canonical correlation was 0.79.

The results found in this analysis were highly similar to the results of the 517 patients.

The likelihood-ratio (7.05, d.f. = 1), as well as the t-value for the helicopter parameter (2.56) were both highly significant.

The total number of patients who died was 248, 56 in the helicopter group and 192 in the ambulance group. If no helicopter care would have been provided, 61.21 patients would have died in the helicopter group, which means 5.21 lives are estimated to have been saved by the helicopter involvement. The number of additional lives that could have been saved if all patients would have received helicopter care, is 20.73. The large difference between the two numbers is mainly due to the fact that relatively many more patients who died only received ambulance care.

Conclusions of the mortality analysis

Due to the non-randomized selection of patients, a correction for injury severity differences between ambulance and helicopter patients needed to be carried out. In the CANALS analysis used for this purpose various sources of information about the patient and the accident were combined after rescaling in one severity indicator, so that an optimal prediction of mortality risk was possible for every individual patient. Due to the fact that uncertainties exist to what extent mortality differences may be attributed to some other variables as sex, age and type of accident, as well as to the helicopter involvement, 7 different models were used. The 7 models varied from a model wherein only RTS and ISS were used and the role of the helicopter in the explanation of the differences is maximal, to a model wherein also all RTS and ISS sub-scores, age, sex and type of injury were used as explanatory variables, and the role of the helicopter in the explanation of mortality is limited. In all models a good correlation with mortality was found, ranging from r=0.755 to 0.830.

For the definitive assessment two of these models were applied in a logit analysis: a maximal model, consisting of only RTS, ISS and all their sub-scores, and a minimal model in which not only RTS, ISS and all their sub scores were used, but also sex, age and type of injury.

Calculated effects on mortality ranged from a reduction in mortality from 11 to 17 percent, due to involvement of the helicopter. Had all ambulance patient received helicopter care, the estimated (potential) reduction of mortality is 11 to 19 percent. The effects on mortality were almost exclusively present in the group of patients following traffic injuries.

Stratification of ambulance and helicopter patients into classes of severity shows that mortality is hardly changed in a group of 339 patients who have minor injuries only, nor in a group of 97 patients with the highest severity. The effects of the helicopter team concern 81 patients in the critical group, wherein the mortality is reduced.

Other results of the study of de Charro & Oppe (1998)

Quality of Life

In the study of de Charro & Oppe [48] oral interviews were taken from 432 patients; in 389 cases 9 months, and in 43 cases 15 months following trauma. In 202 cases patients were interviewed both 9 and 15 months following trauma.

Short Form 36 (SF-36) and Euroqol 5D (EQ-5D) were used as methods to assess the quality of life.

The Short-Form 36 is a list of 36 questions. What the answers to these questions the quality of life may be scored on 8 dimensions (physical functioning, impairment by physical problem, impairment by emotional problems, social functioning, mental health, vitality, pain, general rating of health). The individual dimensions are scored on a scale from 0 to 100, where higher scores represent a better state of well-being.

The Euroqol 5D classifies health status on 5 dimensions (mobility, self care, daily activities, pain, fear) as well as a general valuation of health status by use of a visual analogue scale (‘thermometer’). The scores on the various dimensions are: no problems, some problems, and severe problems.

The thermometer is scaled from 0 to 100, in which 0 represents the worst imaginable health status and 100 the best. Valuation studies have been performed for the population in various countries, for the EQ-5D. , The most extensive of these studies was performed in Great Britain and published in 1997 by Dolan (*Dolan P., Modelling Valuation for Euroqol Health States. Med Care 1997; 35(11): 1095-108*). By statistical analysis weights have been attributed to the dimensions of the EQ-5D. The resulting model is used to calculate the scores for the various dimensions of the EQ-5D. These results were used as an index in the study by de Charro & Oppe [48] to assess the patients’ responses, the scores of which range from very bad (score:index<0.50), average (0.5<score:index<1.0), to perfect (score:index=1.0).

At the time of the first interview, patients’ mean scores ranged from 0.76 for patients with ISS 0-15, to 0.60 for patients with ISS 26-40. The most seriously injured patients with ISS 41-75 responded with a mean score of 0.68.

During the time of the second interview, there was a general improvement of the score, from a mean 0.67 to 0.71 for all interviewed patients. Especially the group of 26 patients who were in a very bad state of health at the first interview (mean score 0.09) improved considerably to a mean 0.43; these patients were nevertheless still in a very bad state of health at the time of the second interview, with extreme problems on one or more dimensions of the EQ-5D. For patients who were in an average state of health, the situation seemed to be stable, while for respondents who claimed to be in perfect health (index) at the first interview, 33 patients mentioned to have some problems during the second interview. Although for the latter it is questionable if these problems were related to the accident 15 months earlier.

Comparison of ambulance and helicopter patients showed that for the entire group of patients 9 months following trauma, as well as 15 months following trauma, helicopter patients on average have lower index scores than ambulances patients.

When patients were compared stratified by classes of ISS, CANALS scores, and intensity of treatment by the helicopter physician, no differences were found. Also, patients with and without severe neurological injuries (HTI Head/Skull >=4) were assessed separately. Patients with severe neurological injuries had lower scores for self care, daily activities and mood than patients without neurological injuries, but the opposite was true for mobility and pain. An explanation for this may be that patients without neurological injuries often have injuries of the lower extremities. In these groups no differences between ambulance and helicopter groups were found.

One sub-group of patients was identified, however, of patients who sustained very severe injuries, and had somewhat more problems than similar ambulance patients; an additional medical analysis of this group was recommended.

The analysis of the SF-36 results in similar finding. These results show, that one quarter of the patients with the most severe injuries have more health-related problems in cases of helicopter involvement. For the other groups, no conclusive differences were found.

A slight improvement of approximately 5 percent was noted on the quality of life 15 months following trauma compared to that 9 months following trauma, but this did not imply that patients are fully recovered by then. However, no differences were found to exist between the rate of improvement between ambulance and helicopter patients.

The final conclusion of this analysis is that no significant differences were found on EQ-5D, and SF-36 on the quality of life 9 and 15 months following trauma between ambulance and helicopter patients.

Costs of the helicopter service

De Charro & Oppe assessed the costs of the helicopter service. A nation-wide, daytime only network of helicopter services, comprising 4 helicopter bases within the Netherlands and an equivalent of 0.5 helicopters by use of German and Belgian helicopter services for some parts of the country, is

estimated to cost 22 million Dutch Guilders per year. Every helicopter service, costs about 4.7 million guilder per year. This amount is made up of the costs of the medical trauma team (1.8 million Dutch Guilders), costs of the helicopter (1.4 million Guilders), insurance fees (0.7 million Dutch Guilders), pilot salaries (0.6 million Dutch Guilders), landing fees and other operational expenses (0.2 million Guilders).

The additional costs of helicopter trauma teams make up a considerable part of all expenses currently spent on emergency ambulance care. However, the costs of land based trauma teams having the same availability, are without doubt a multitude of this amount.

The costs of the initial hospitalisation of a severely injured trauma patient were assessed in this study. 306 severely injured patients met all inclusion criteria and were admitted to the University Hospital Vrije Universiteit during the time of study. After exclusion of patients who were transferred to other hospitals prior to definitive discharge from hospital, or whose records were missing, the clinical records of 237 patients were assessed. Initial hospitalisation lasted a mean 33 days.

By destination of discharge, the following duration of hospitalisation was found:

Destination of Discharge:	Died	Home	Revalidation institute	Nursing Home	Total
Number of Patients	72	100	58	7	237
Mean Length of Hospitalisation (Days)	11	22	55	97	33

Table 75: Lenght of hospitalization by destination of discharge

Patients who died during hospitalisation, had the shortest mean duration of admission of 11 days, followed by patients who were discharged home (22 days), to a revalidation institute (55 days), and to a nursing home (97 days).

The time spent at the Intensive Care Units varied considerably by destination of discharge:

Destination of Discharge:	Died	Home	Revalidation Institute	Nursing Home	Total
Number of Patients	72	100	58	7	237
Mean Number of Intensive Care Hours (SD)	87.6 (189.2)	83.1 (174.7)	260.8 (309.1)	343.5 (341.2)	135.6 (236.9)
Minimum Number of Hours	0	0	0	0	0
Maximum Number of Hours	1173.6	1065.8	1222.8	820.8	1222.8
Median Number of Hours	11	15.9	103	422.3	17.7

Table 76: Number of hours spent at ICU units by destination of discharge

The (relatively) large standard deviations point at the fact that considerable differences exist between length of Intensive Care admission within one class of patients with an identical destinations of discharge. In such cases, the median value is a more useful parameter. Of the 237 patients, 71 did not receive surgery. For the remaining 166 patients, the total number of hours spent in the operating theatre was assessed:

Destination of Discharge:	Died	Home	Revalidation Institute	Nursing Home	Total
Number of Patients	72	100	58	7	237
Mean Number of Hours in Operating Theatre (for 166 Patients) (SD)	1.83 (2.7)	2.4 (3.2)	5.9 (6.8)	1.5 (1.3)	3.0 (4.5)
Minimum Number of Hours	0	0	0	0	0
Maximum Number of hours	11.8	16	42.2	3.7	42.2
Median Number of Hours	0.4	1.5	4.6	0.9	1.5

Table 77: Number of hours in operating theatre by destination of discharge

The average costs of the initial hospitalisation of a severely injured trauma patient were calculated at approximately 38,000 Dutch Guilders. For the estimated total number of 5,000 severely injured patients annually in the Netherlands, about 190 million Dutch Guilders is spent to cover initial hospitalisation costs. No differences were found to exist between the costs of initial hospitalisation between ambulance and helicopter patients.

Costs per life-year won

In the Netherlands, it is estimated that 2,925 to 3,428 patients are severely injured every year in the service area of a to be instituted national network of helicopter services. For the whole of the Netherlands, this figure is almost 5,000.

The efficiency of the helicopters depends on the rate to what percentage of all severely injured patients indeed receive helicopter care. For the calculation, a 30% rate is used as a conservative estimate and 50% as a more liberal one. Depending on this estimate and the estimate of the entire number of severely injured trauma patients, the number of additional lives won varies from 18 to 35 per year. Considering the mean age and life expectancy of severely injured trauma patients, 40 life-years won per additional survivor may be expected.

However, after discounting for future benefits by a 5% annual ‘discount rate’, as commonly accepted in similar calculations, the number of additional years won is approximately 18.

The additional costs of the additional survivors are the costs of the helicopter services, which are estimated for the national operators at almost 20 million Dutch Guilders, plus direct medical costs of an estimated 50,000 Guilders per survivor. This amount includes the costs of initial hospitalisation, revalidation and medical treatment following discharge from initial hospitalisation.

However, in this calculation the fact that actual labour participation will be increased by the additional number of persons saved, is not included.

The costs per life-year won are between 33,000 and 63,000 Dutch Guilders, depending on the estimate of the number of severely injured patients who receive helicopter care, the total number of severely injured trauma patients and the estimated medical costs.

The quality of the life-years won due to helicopter involvement is, as found in the analysis of quality of life, not identical to that of healthy individuals who did not suffer from trauma, but reduced. A correction was applied to the costs to discount for this loss in quality of life (the estimated quality of life for the survivors was taken to be 0.75), and so the costs per life-year won were calculated to be between 44,000 and 83,000 Dutch Guilders.

Chapter 4

Chapter 4

Discussion

Discussion

Choice of Methods

Revised Trauma Score (RTS) and Injury Severity Scale (ISS) were used to score patients before and after arrival in hospital. Both scores are considered as 'gold standard' for scoring patients' injury severity [26]. The introduction of these scoring systems in this study as well as in the study of de Charro & Oppe [48] was very practical as almost all physicians and paramedics involved had at least some prior experience with these scoring systems.

Both scoring systems are also relatively easy to use. Few mathematics are needed to calculate both scores, so that the risk of errors is minimized. As both scoring systems are based on variables that are routinely recorded for most patients regardless of the study, it was often possible to retrieve missing data retrospectively from patients' medical records if data was prospectively missing.

A large number of other scoring systems have been developed in the past, and discussion has been extensive of which scoring system is superior. The ISS has proven to have a fair correlation with mortality, but also with the duration of hospitalisation, duration of artificial ventilation and need for blood products [108]. The ISS based on the Hospital Trauma Index used in the study was reported to be more reliable than the ISS based on the Abbreviated Injury Scale in predicting death rate [161].

The ISS is, however, seriously limited by the fact that not all types of injury can be scored; for instance drowning, near-drowning and inhalation traumas cannot be scored using the ISS, albeit all of these injury types are potentially life threatening.

Optimal Revised Trauma Scores do not rule out severe pathology. Younger patients especially are able to compensate for large losses of blood before systolic blood pressure drops. Also, on-site treatment can influence RTS score - for example by fluid resuscitation RTS scores can be influenced positively. The Glasgow Coma Scale is a constituent of the Revised Trauma Score; only parameters regarding consciousness and coordination are scored with this, while other very important neurological findings, such as asymmetric pupil sizes and reflexes, focal pareses and spinal cord lesions can exist without influencing the Glasgow Coma Scale.

Another main disadvantage of both RTS and ISS is, that a patient's age and mechanism of trauma are not scored in these scoring systems. It is known empirically that trauma patients aged 55 years and over, as well as aged 5 and less, have considerably worse outcomes compared to adults

with the same injuries [151], but these facts are not anticipated in the RTS and ISS. The use of the Pediatric Trauma Score (PTS) was considered, but in existing literature the PTS was found to have no advantages over the Revised Trauma Score [81], and RTS was used for all age categories.

As most standard trauma scoring systems have been developed and validated in the United States, and as trauma differs between the USA and Europe, Bouillon et al. [23] validated eight current scoring systems in Cologne, Germany in 625 seriously injured trauma patients and found that all scoring systems had high accuracy rates.

To estimate the effects of a helicopter trauma team, a prospective and randomized set-up would be ideal. Such a study set-up would result in two comparable groups of patients, those who have and have not received care by helicopter team, and any differences found between the two groups in treatment and outcome can then be attributed to the involvement of the helicopter group. However, no such study has ever been held yet due to ethical reasons and it is not likely that such study will ever be held.

The main implication of performing a study like the present one in which a helicopter is selectively activated, especially for those accidents where the level of injuries is expected to be of at least a certain high level of severity; helicopter patients are then compared with ambulance patients, who did not receive helicopter care for any known or unknown reason. Using this approach, two groups of patients are created that are different in many aspects. In the present study, many differences between the two groups were obvious. Overall, helicopter patients had more serious injuries than ambulance patients. As higher injury severity is associated with higher mortality, it would be a false conclusion to think that helicopter involvement actually increases mortality, if these differences were disregarded in an analysis.

Nichol et al. [109] analysed the effects of the London helicopter medical service in a study set-up comparable to the present. In his study, helicopter patients were more seriously injured to a greater proportion having both major trauma and severe head injury than ambulance patients. Stratification of patients into different categories of severity and appliance of a case by case analysis of mortality failed to provide a sound estimate of helicopter effects on mortality.

As explained in Chapter 3, de Charro & Oppe [48] used a more sophisticated statistical model, in which all scoring systems used as well as all possible confounders were individually analysed for predictive value on mortality. The weighted combination of these factors was assembled into one variable for overall injury severity and only by using this approach could a realistic calculation be made about the effects of helicopter care on mortality.

In an attempt to study the effectiveness of helicopter care in the state of Pennsylvania, Bratwaite et al. [25] carried out an assessment of 22,411 trauma patients who were brought to 28 trauma hospitals by helicopter (n=15,938) or ground ambulance (6,473).

In this study, differences between the two populations existed mainly in the transport modality, rather than in the level of prehospital treatment, since only ambulance trips with Advanced Life Support were considered and there was no mention given to any physician presence in the helicopter staff. In this study, helicopter patients had higher mean injury severity, a younger mean age and a lower mean blood pressure than ambulance patients.

A one-way analysis of variance and logistic regression was carried out to correct for these differences, which, although being less sophisticated, resembled to some extent the approach used by de Charro and Oppe [48]. The results showed an improved survival rate for patients with ISS scores between 16 and 60. The focus of their study was on the effectiveness of helicopter transport, and since these patients who showed improved survival made up only a minority of all cases transported, their conclusion was that triage criteria need to be reappraised. Nevertheless, their finding of the improved survival benefit of the middle group, is a remarkable one and is consistent with the findings of the current study. Adequate triage to select patients with a minimal severity of injuries is of key importance for the efficiency of a helicopter system.

In the analysis of preclinical care as performed by helicopter trauma team and ambulance personnel, this injury severity variable was not taken into account. The variable of injury severity is based on many parameters (for instance ISS) that are still unknown during the preclinical phase of treatment. Analysis of preclinical care is performed from a clinical viewpoint, in which only parameters that are already known determined therapy. Also, therapy provided is not to be based on other variables that may affect survival, such as type of accident and age, but on the clinical condition of the patient at the time which is most accurately described by the RTS.

Patients

Patients were unequally distributed per participating CPA region. The number of patients included in the study per 100.000 inhabitants, as printed in table 1, varies considerably from 2.9 patients in West Friesland to 19.1 in Amsterdam and surroundings, as does the percentage of the included patients who received care by helicopter team, from 17.8 percent

in Utrecht to 100 percent in Kop van Noord-Holland.

Although genuine differences in the incidence of severe trauma per CPA region may have an influence on the number of patients included, other factors most probably had an even larger impact. Patients who were not transferred to any of the eight participating hospitals were not included in the study; this may explain the low number of patients in CPA areas in which no participating hospitals were located (Eemland, Gooi en Vechtstreek, Flevoland, Kennemerland, Kop van Noord Holland and West Friesland), or in CPA regions where participating hospitals as well as non participating important trauma hospitals were located (Haaglanden). A considerably larger part of patients in these areas may have been transferred to other hospitals and thus were not included in the study.

The rate of helicopter involvement in the included patients probably depends on a number of factors. In CPA areas especially in which no participating hospital was located, helicopter patients may have been preferably transferred to one of the participating hospitals due to the preferences of the helicopter physicians, though ambulance patients were probably more frequently transferred to non participating facilities located more in the proximity. Local familiarity with helicopter care as well as the attitude toward this new form of prehospital care may also have had an extensive impact on the relative number of occasions the helicopter was or was not called into action.

Quality of data

The original set-up to collect data prospectively from ambulance services by requesting ambulance personnel to complete specially designed forms for all severely injured patients at all their ambulance runs, had to be abandoned and the majority of ambulance data was collected instead retrospectively.

This move was necessary because the original approach did not develop as expected; ambulance personnel was either unaware of the fact that the study was interested in all severely injured patients, regardless of helicopter involvement, or ambulance personnel did not complete the forms because of lack of time, lack of interest in the study or by the fact that they were not used to completing long detailed forms for research purposes.

Data supplied by the helicopter personnel was prospectively collected. There were only a small number of physicians involved who felt personally responsible for an accurate supply of research data. The helicopter personnel was, as well, already used to cooperating in research settings, and used the time between flights to complete research forms.

Completed helicopter forms were often audited by senior hospital staff, not only to discuss treatment given, but also to ensure that completion of the forms was accurate.

Therefore, it is safe to assume that the data regarding treatment of the helicopter patients, as supplied by the helicopter team, has the highest possible level of accuracy.

However, when the treatment data supplied by helicopter trauma team and ambulance personnel are compared regarding identical patients, as shown in chapter 3, significant differences between the two sources of information are discovered.

If the helicopter-provided data is correct, ambulance personnel both over-reported manoeuvres (i.e. reported by ambulance but not by helicopter), and under-reported manoeuvres (i.e. reported by helicopter but not by ambulance) that were actually carried out.

The rate of under-reportage of manoeuvres by ambulance forms can be calculated by:

- Subtracting the 'reported by ambulance or helicopter' value from the 'reported by ambulance' value and dividing the value found by the 'reported by ambulance' value.
- The value found multiplied by 100 gives the percentage of unreported, but performed manoeuvres relative to the rate ambulance personnel provided themselves

The rate of over-reportage can be calculated by:

- Subtracting the 'reported by ambulance' value from the 'reported by ambulance and helicopter' value and dividing the value found by the 'reported by ambulance' value.
- The value found multiplied by 100 gives the percentage of reported, but not performed manoeuvres relative to the rate ambulance personnel provided themselves.
- Net rate of under-reportage is the value for under-reportage, subtracted from the value for over reportage

When calculated like this, the following values are found:

Manoeuvre	Rate of Under-Reportage	Rate of Over-Reportage	Net Under-Reportage
Wound Care	35.5%	66.8%	-31.5%
Control of Blood Losses	139.1%	69.0%	70.1%
Splints	48.8%	32.9%	15.9%
Artificial Ventilation	27.1%	34.7%	-7.6%
Endotracheal Intubation	44.8%	2.7%	42.1%
Suction	178.6%	16.3%	162.3%
ECG	56.0%	20.5%	35.5%
Cardiac Defibrillation	81.5%	0.0%	81.5%
Cardiac Massage	77.5%	7.0%	70.5%
IV Access	5.9%	0.6%	5.3%
Pulse Oximetry	79.0%	11.6%	67.4%
Pacing	45.5%	0.0%	45.5%
Neck Splints	79.3%	9.7%	69.6%

Table 1: Rate of Under Reportage, Over Reportage and Nett Under Reportage of Prehospital Manoeuvres for Helicopter Patients in Ambulance Run Reports

The tendency for ambulance personnel to under-report manoeuvres than to over-report is clearly visible, except in cases of wound care and artificial ventilation.

Possible causes of under and over reportage

It is not surprising that ambulance personnel under-report manoeuvres in cases with a helicopter trauma team present, especially since the attending physician was responsible for treatment given, ambulance personnel was actively involved in only part of all routines performed and may have felt less responsible for the actions undertaken: ambulance personnel was less likely to report all the treatment given.

In some cases the high rate of over-reportage may be explained in various possible ways.

In part, differences in the definition used by ambulance and helicopter personnel over what to consider a ‘routine’ may be responsible. Especially for poorly defined routines, such as control of blood losses and wound care, this is to be expected. In these two conditions, the extent for both under- and over-reportage are high, so that the usefulness of these parameters is doubtful. The same might be the case for artificial ventilation. Although it is generally agreed upon that artificial ventilation is considered to be defined as active artificial ventilation, it may be that on some occasions ambulance personnel reported plain administration of oxygen without artificial ventilation wrongly as such.

In addition, routines that might be considered ‘standard of care’ by many for every trauma patient, such as pulse oximetry and ECG, have a higher risk of remaining unmentioned in run reports.

Another possible explanation for part of the over-reportage is the fact that some manoeuvres may have been carried out by ambulance personnel before arrival of the helicopter trauma team. Procedures that leave little trace especially, such as suction, may be influenced by this possibility.

Then, although every effort was made to avoid this, under-reportage by the helicopter trauma team may still play a partial role in explaining the ‘over-reported’ manoeuvres.

Consequences of inaccuracies in the data supplied

Significant differences are found between the reported treatment by ambulance and by helicopter regarding identical (helicopter) patients. This is suggestive that the retrospective data collected from ambulance services is not fully representative for what actually happened in the field.

Regarding the treatment of helicopter patients another, strongly reliable source of information was present for this group of patients (the helicopter trauma team).

However, the question is: to what extent is data regarding the treatment of ambulance patients affected by inaccuracies? For these patients no second observer was present, and the ambulance personnel who made the reports about treatment is thus known to be inaccurate.

It would have been easy to translate the rate of inaccuracies found in the helicopter group to the ambulance group, but this approach would arguably lead to a gross overestimation of the rate of inaccuracies.

Arguably, a great part of the inaccuracies, especially concerning under reportage of treatment in the helicopter group, may be caused by the fact that the presence of the helicopter acted disturbingly on the reportage of manoeuvres by the ambulance personnel.

Although it was expected that all manoeuvres carried out in the field would be reported by the ambulance personnel, on many occasions manoeuvres may have not been reported by ambulance personnel because of the fact that they were not involved in performing the manoeuvre, did not feel responsible for the manoeuvre or were even unaware of the manoeuvre (especially in manoeuvres that leave little trace, such as suction).

For ambulance patients, the ambulance personnel were the only ones present, and were personally responsible for each manoeuvre: therefore the manoeuvre was more likely to have been reported having been actually carried out.

Inaccuracies in the group of ambulance patients are therefore likely to be smaller than in the helicopter group, only the rate to which this is true, remains unknown.

The decision was taken to publish the results ‘as is’, considering the data for helicopter patients as supplied by the helicopter trauma team to be correct, and data for ambulance patients as supplied by the ambulance crew as the most correct - bearing in mind that margins in the correctness of treatment data of ambulance patients may exist.

These margins are likely to be smaller than the values found for the rate of under- and over-reportage by ambulance personnel for helicopter patients, so if treatment of ambulance data would be corrected to the net rate of under reportage found in the helicopter group, errors would likewise be over-corrected as well.

However, using this method of calculation, the following results have been found:

Manoeuvre	Ambulance Patients (readjusted rate) (n=280)	Helicopter Patients (n=204)	Significance (Chi Square Test)
Wound Care	26.7%	18.6%	p<0.05
Control of Blood Losses	36.4%	14.2%	p<0.001
Splints	37.7%	34.3%	p=ns
Artificial Ventilation	15.8%	59.8%	p<0.001
Endotracheal Intubation	7.7%	57.4%	p<0.001
Suction	23.3%	27.3%	p=ns
ECG	64.4%	74.0%	p<0.05
Cardiac Defibrillation	2.0%	4.9%	p=ns
Cardiac Massage	8.5%	12.7%	p=ns
IV Access	85.4%	98.5%	p<0.001
Pulse Oximetry	84.4%	88.7%	p=ns
Pacing	0.6%	1.5%	p=ns
Neck Splints	50.9%	76.0%	p<0.001

Table 2: Rate of appliance of prehospital techniques by ambulance and helicopter personnel using recalculated values for ambulance rates

Using the exaggerated assumption accuracy of ambulance forms to correct for ambulance patients, the differences between rate of appliance of the various forms of treatment, except for wound care and artificial ventilation that have a net over reportage, between the ambulance and helicopter group of patients naturally are smaller than without. However, if differences in this analysis between ambulance care and helicopter care still persist, this strongly supports the argument that differences found truly reflect differences in treatment given. Even using this 'unfavourable' method of correction, the overall clinical picture remains the same.

The techniques affecting vital functioning most directly are applied more frequently in cases of helicopter involvement: artificial ventilation, endotracheal intubation, intra venous access and neck splints.

The differences that remain reflect different treatment at the scene of accident. This may have two causes: management differences (wanting to perform) and difference in skills (able to perform) to apply certain manoeuvres. As it is impossible to examine which of these reasons caused a certain manoeuvre not to be carried out by ambulance personnel, the results as found suggest that both mechanisms are expected to play a role.

Management differences are probably most directly observed in the frequency that certain manoeuvres are carried out which are not difficult technically to carry out and which all ambulance personnel are expected to perform with a high rate of success, such as the appliance of splints and neck splints. The interesting observations that neck splints in the ambulance group are used less commonly for comatose patients than for non-comatose patients, and splints more often for patients with limited injuries of the extremities than for patients with severe injuries, cannot be explained by any thing other than that no decision was made by ambulance personnel to apply these devises for the patients.

Differences in skill are probably responsible for at least a part of manoeuvres that are more difficult and have a higher rate of failure when tried. It is not known what the failure rate was in the ambulance group for IV access attempts, but expectedly these have an influence on the results found. The percentage of ambulance patients in whom IV access was gained who were in shock, was almost equal to that of patients with normal blood pressure. Experience tells us that obtaining intravenous access in patients who are in shock carries a higher failure rate than in patients who are not in shock; if the percentages of IV access are equal in both groups, this suggests that more attempts must have been made in the group of patients in shock, otherwise the percentage of patients who are in shock with IV access would be lower than in the group of patients who are not in shock.

It is most likely therefore that treatment differences between helicopter and ambulance care are caused by differences in both management and technical skills.

Study of prehospital treatment

So far, no studies are known of that systematically compare prehospital treatment performed by nurse/paramedic staffed ambulances with that of a physician staffed helicopter trauma team.

This is a surprising finding, especially as presumably in all countries run reports are written following each ambulance run and could be used well for this purpose.

However, in the present study, it is well demonstrated that the use of ambulance reports to analyse preclinical treatment given is a less than ideal method of research.

Collecting data from ambulance workers is a logistically difficult matter, as in almost all areas more than one company is responsible for transport of sick and injured patients. Setting up a structure to collect data from numerous different organisations requires a huge investment of time and organisational efforts.

Also, ambulance run reports are not designed for scientific purposes. In the original study design used in the present study, this fact was well recognised and introduction of specially designed forms was used as a better alternative. However, in practice this approach turned out to be unsuccess-ful and standard ambulance run reports had to be used instead.

Ambulance run reports are often filled out in a hurry, after a run has been completed. Ambulance run reports serve mainly as data source for financial purposes, for billing purposes, but the medical information provided on the ambulance run reports is frequently barely looked at after completion.

It is then to be expected that ambulance personnel are unmotivated to pay more attention than is necessary to filling out the sheet.

Recently, an interesting study by Visser [156] assessed the practical use of the standard ambulance forms. In this study a randomly attained retrospective sample of 188 ambulance run reports concerning patients who were transferred to the Emergency and Accidents department of the Academisch Medisch Centrum in Amsterdam by two large local ambulance providers were assessed for completion. Patients' personal data, used for financial administration were filled out best and were present in 95.2% of cases. Data regarding the nature of accident were at least partially filled out in 71.8%, data regarding the patients' general condition in 77.1%, but regarding Revised Trauma Score/Glasgow Coma Scale only in 59.0% (including 21.8% in which this was only partially completed). Worse, even, were completion scores for the treatment provided for, which was present in 51.1%, patients' injuries (36.2%), localisation of injuries (18.6%) and medication (14.9%). However abysmal these results may be, given the huge inaccuracies found in the current study in the data that was present, the general accuracy and practical value of ambulance run reports is even worse than these numbers alone suggest. In the same study, a questionnaire was completed by 52 ambulance attendants on what data, in their opinion, was important enough to be provided on ambulance sheets. Strikingly, data regarding the - in practice - least well completed parameters, were considered to be important or very important by over 90% of respondents, highly unlike what is actually being filled out by themselves and by their colleagues.

Because of the aforementioned difficulties in obtaining useful data on ambulance care, most attempts to perform systematic research on ambulance care may have stalled prematurely and up to the present, too little is known on how ambulance care really is. Little research on prehospital care has been conducted in general, and even what has been published is often of a very poor quality [163].

In an attempt to analyse prehospital treatment for patients with severe head trauma and its influence on outcome in Germany, Lehr at al. [91] recruited special documentation assistants, who were stationed at helicopter bases and accompanied the emergency team for all cases. This approach ensures a high reliability of data, but serious problems with data collection were encountered nevertheless. Using this approach only patients who received helicopter care could be included in the study and no patients for whom only road ambulance care was given. This method of data collection to assess prehospital care performed by many road ambulance providers, as needed in the present study, would be logistically impossible to carry out regarding the huge number of 'documentation assistants' that would be needed to cover all road ambulances in service.

Only one other detailed study of preclinical ambulance care has been published, notably in Trinidad and Tobago, a small Caribbean island with 1.3 million inhabitants [4,5]. Most probably the small size of the island enabled the authors to monitor all ambulance reports personally during the course of the study, having the benefit of a simple infrastructure of only one referral hospital and a small number of ambulance vehicles.

In this study prehospital interventions to trauma patients are assessed prior to (n=332) and after (n=350) introduction of a PHTLS course to non-paramedic ambulance personnel on the island. The result of the study show a decrease in overall mortality from 15.7% to 10.6%, and remarkable increases in the appliance of preclinical interventions, consisting of (basic) airway control, cervical spine control, splinting of fractures, haemorrhage control, and oxygen use.

The authors did not, however, mention what the number of ambulance records were to be excluded from the study because of missing or erroneous data.

Two important studies on ambulance care in the Netherlands have been performed in the past, by Teyink [142], and de Man [49]. Both authors concluded that ambulance care was in need of improvement.

However, since 1992, many things in ambulance care have changed. A number of smaller ambulance companies have merged to form bigger and more professional organisations, ambulance protocols have been put into use more generally, and various forms of quality programs have been introduced to improve ambulance service in general. Ambulance protocols in the Netherlands are based on ATLS (or PHTLS).

The helicopter trauma team is providing trauma care using the same principles, so if ambulance care in the Netherlands would be optimally functioning and ambulance protocols would have been implemented to the full, 'paramedic type' treatment provided for by ambulance personnel would be (near) identical to that provided for by the helicopter trauma team.

Major differences still existed between the two forms of care, however. All ambulance patients received at least some form of treatment on the site of accident, so it would be unjust to consider ambulance treatment to be of a 'scoop and run' approach. Also, the comparison of treatment between helicopter patients and ambulance patients must not be seen as a comparison between 'stay and play' and 'scoop and run', but more as a comparison between two forms of 'stay and play', of which the helicopter has shown to be more extensive.

Major differences in the rate ambulance and helicopter personnel apply to the most important routines affecting vital functioning, namely intubation (inclusive of unconscious patients), artificial ventilation, intra-venous access and neck splints have been demonstrated in this study.

The reduction in mortality in the helicopter group must therefore be associated with two different mechanisms:

1/ The helicopter trauma team provided treatment which could also may have been performed by a non-physician ambulance crew; consisting of artificial ventilation, intubation, intravenous access and use of neck splints, these manoeuvres were applied more often in cases of helicopter team involvement than in cases ambulance care only was provided for comparable patients.

2/ The helicopter trauma team also performed routines for a considerable number of trauma patients, that were well beyond the capabilities of any non-physician, consisting of thoracic drainage, administration of anesthetics, and coniotomy.

The Role of a Physician in the Helicopter Trauma Team

Baxt & Moody [14] compared 150 consecutive trauma patients who were transferred to hospital by physician staffed helicopter and 150 trauma patients who received care by EMT/paramedics only, and found a highly significant reduction in predicted mortality of 52% in the helicopter group, whereas the mortality rate in the road ambulance group was not different from that of a large trauma population treated at a major trauma centre. In this study, the physicians were capable of performing advanced care procedures, consisting of drug administration, oral and nasal intubation, cricothyroidotomy, open venous catheter placement, arterial catheter placement, cardiac pacemaker placement, thoracostomy tube placement and open thoracotomy. Ambulance paramedics were only allowed a administer a limited number of drugs, perform IV fluid replacement therapy, place esophageal obturator airways and MAST suits. EMT's in this study were only capable of CPR and advanced first aid. Unfortunately, factual differences in preclinical treatment between physician and non-physician were not measured in this study, but likely treatment by helicopter physicians was more extensive than by ambulance paramedics and EMT's.

Since then, a number of studies have been published on what the role of a physician is in the crew composition of a helicopter trauma team.

Study by Burney et al. [31] and Hamman et al [176] found no differences in patient outcome when comparing helicopter flights performed by physician/nurse and nurse/nurse composition. However in both studies patients were not randomly assigned to one of the two possible crew compositions, and the physicians involved in the study by Hamman et al. consisted of second and senior level residents and not fully trained and experienced emergency physicians. Burney et al. did not specify the grade of the helicopter physicians. One can expect that care performed by a relatively inexperienced physician will be less extensive than that performed by a more experienced and specialised one. Barely any difference was found in the form of preclinical treatment in the study by Hamman et al. between (the relatively inexperienced) physician and paramedic. Studies comparing physician/nurse crew compositions should therefore address the level of training of the helicopter physician/nurse before conclusions may be drawn that might be valid for other helicopter services.

Another important issue is the specialization of the helicopter team into trauma care only; Gahr, Hasse & Hofman [59] described the institution of preclinical emergency services, in which initially emergency physicians stationed at centers for Surgery of Traumatology were responsible mainly for the management of victims of road accidents. During the initial phase, emergency physicians were not able to cope well with non-traumatic types of emergencies; whereas attention focussed on improving training for this type of patient, the average emergency physician lost practical experience with trauma patients, which could not be compensated sufficiently in compulsatory postgraduate training courses. Therefore, the authors recommended that emergency medical services for trauma patients should be specialized in this field. The helicopter trauma team described in the current study is involved in trauma care only, and although it may be likely that non-traumatic patients may benefit from early medical intervention in some cases , it should be stressed that extending coverage to all types of emergencies risks lowering standards of care for the population for whom the helicopter team was originally intended for.

Schmidt et al. [133,134] compared a German trauma helicopter manned by an experienced physician with an American one, staffed only by paramedics. The results not only suggest an improved overall outcome in the German group, but also that care given before arrival in hospital was significantly different. The authors found that in the two groups of trauma patients, who had mean ISS scores of 19.8 in the American and 18 in the German group, the rate of endotracheal intubation was different; 13.4% in the American group and 37.1% in the German group. So was the rate of thoracic decompressions, with 0.5% in the American group and 9.1% in the German group. Also, the mean volume of intra venous fluids administered was higher in the German group than in the American (1800 ml vs. 825 ml) and intra venous anesthesia was administered frequently by German physicians (62.4% of patients).

The comparison by Schmidt et al. involved two separate, highly specialised providers of trauma care, and even so significant differences in prehospital treatment existed.

As discussed earlier, unfortunately no studies have been published in which prehospital physician helicopter care itself is compared to paramedic road ambulance care. Because the American paramedics in the study of Schmidt et al. were specialised and experienced in trauma care, differences found between helicopter physician care and general paramedic ambulance care would be expectedly even higher, so that the results in the present study may not come as any surprise.

In the VU University Hospital Helicopter Trauma Team, all participating physicians had a high level of training as well as extensive prior experience in trauma care. Although a separate study would be necessary to prove this, it is likely that the differences in preclinical care and mortality between helicopter and ambulance would be smaller if the physician would have this lower level of training or would be replaced by a paramedic.

Purpose of the helicopter

Helicopters alone do not save lives.

In regions with a poor or difficult infrastructure as well as in out-stretched rural areas, helicopters can provide for faster transfer of patients to hospital and benefits for patients are expected to arise from a shortening of preclinical time. These helicopter programs are often not staffed by physicians, because the aim lies in providing fast transfer rather than treatment. Little treatment is given in the field as attention is focussed on rapid transfer; some American helicopter personnel are proud to report average scene times of less then 10 minutes, but it must be noted that many routines, such as intubation, are frequently carried out during flight by American flight nurses, while treatment is preferably performed prior to transfer in the Netherlands.

As the Netherlands is a small and highly urbanised country with an adequate road infrastructure and a dense network of hospitals, little gain may be expected from a further reduction of preclinical time intervals of trauma patients. Introduction of the helicopter was aimed at providing advanced medical care at the scene instead, even if this leads to a longer time before arrival in hospital. Time won using this completely different approach is achieved by bringing the hospital to the patient instead of the opposite.

In the majority of cases, trauma patients could be transferred by road ambulance; in a few cases patient transfer by helicopter was carried out and suitable hospitals that were further off could be reached using the high speed of travel of the helicopter. This is an additional benefit of the helicopter, but its main purpose is in providing advanced medical care by a physician, so the patient does not necessarily reach hospital earlier, but life saving manoeuvres that require high level of skill, knowledge and experience that outstretches that of ambulance paramedics can be performed immediately following trauma.

As soon as the 10 trauma centres are operational as such and will be responsible for handling all severe cases of injury, as government in the Netherlands recently decided [166], inevitably, travel distances from accident site to trauma centre will increase in many cases, and the role of helicopters in patient transfer may become more important.

Results of foreign studies

Studies, where it is not clear if a helicopter is aimed at reducing transfer time or at the provision of advanced care at the scene, have little value.

Recently, a study performed by Cunningham et al. [45] compared a group of 1,346 trauma patients transferred by helicopter and 17,144 trauma patients by road ambulance in North Carolina.

Presence of a physician in the helicopter team composition remained unknown, nor was any attention given to possible differences between the level of preclinical care when comparing the two methods of transfer.

Transport times for helicopter patients were, on average, 33 minutes. This group of patients was compared with ambulance patients who had a mean transport time of only 17 minutes (and thus suffered trauma generally at locations that were more in the neighbourhood of the trauma hospital), so the effect of reduction of travel time by helicopter speed is hereby ne-glected, for helicopter patients should have been compared to patients that suffered trauma at equal distance from the trauma hospital (and would therefore need longer travel time to reach hospital by road).

In this study a higher level of preclinical treatment compared to ambulance care was doubtful and the effect of faster transfer was left out due to an inadequate control group of land patients, it is no surprise therefore that hardly any positive effect on patient outcome was demonstrated.

If a correct group of ambulance patients would have been chosen to compare the helicopter patients with, the results may have been different, and at least it would have been useful to know if any differences in treatment given or preclinical time intervals would have been calculated.

Unfortunately, studies that use an inadequate methodology can thus influence common opinion about helicopter usefulness negatively without solid evidence.

The purpose of the VU University Hospital Helicopter Trauma Team is clearly to start advanced treatment at the site of accident instead of aiming at shortening preclinical time interval.

Although it is difficult to compare foreign results, a number of studies on more or less similar helicopter programs show interesting results.

A study was published by Graf et al. [64], in which 107 patients who were transported by physician-staffed helicopter were compared to 131 patients who were transported by non-physician staffed road ambulance to the University Hospital in Basle, Switzerland. Although helicopter patients showed a higher injury severity grade and consequently a higher mortality, length of stay in hospital was shorter and morbidity was equal in both groups. Most importantly, 4 ambulance patients, but none of the helicopter patients arrived in hospital in a state of circulatory shock. No information on the type of preclinical treatment is provided in this study, but these facts suggest that physician presence indeed makes a difference in management of the severely injured.

In a study by Nardi et al. [179] in Northern Italy three groups of severely injured trauma patients were compared. One group consisting of patients who received care by EMTs with BLS training, were transported to a

regional hospital for stabilisation and subsequently transported to a trauma centre. The second group was rescued by EMTs and directly transported to a trauma centre. The third group received care on the scene by an emergency helicopter medical team including an experienced anesthesiologist and were directly transferred to a trauma centre.

Mortality was significantly lower in the third (helicopter) group than in the other two groups. Large differences in preclinical treatment existed. In the first group, the majority of patients received an IV line before arrival at the regional hospital; most but not all patients were intubated before transfer to the trauma centre. Time between emergency call and admission in the trauma hospital (rescue time) was a mean 162 minutes.

In the second group, in nine of 98 cases a physician was present on the scene of accident. All patients in this group received an IV line, but none were intubated. Mean rescue time was 28 minutes.

In the third group 81% of patients were intubated on the scene, 14% had a thoracic drainage performed and all patients had two IV lines. Mean rescue time was 55 minutes.

These results are similar to the results in the present study, with the difference that ambulance personnel in the Netherlands is more likely to perform intubations than their Italian colleagues, even though physicians were present in some of the Italian ambulance cases.

Nicholl et al. [109] conducted a study of the London Helicopter Emergency Medical Service and estimated that 13 extra patients per year could survive if attended by the helicopter. Helicopter patients spent approximately 6 minutes longer on the scene and arrived 10-20 minutes later in hospital than patients who received ambulance care only. In this study patients who received helicopter aid were compared to patients who received care by road ambulance, but included only those ambulance patients for whom so called ‘extended skills’ were used, but all children and patients with isolated head injury for whom extended skills were rarely used by land ambulance. This approach thus excluded patients with major trauma for whom no extended skills were used, and as the present study suggests, a considerable number of severely injured ambulance patients may not have received such extended care. The possible beneficial effects of the helicopter team in London may have been underestimated for this reason.

Although Nichol et al. claim that helicopter patients are more intensively managed than comparable land patients, detailed information on what the exact differences were was not given. The authors described one individual case of a patient with non-patent airway who required crico-thyroidotomy and was considered definitely not to have survived if attended by a non-medical crew. Notably, in the present study a similar case of surgical airway management has also been described.

The differences found in this study between preclinical treatment performed by physician-staffed helicopter trauma team and non-physician road ambulance personnel are thus likely not to be unique to the Netherlands. Detailed and reliable information on what treatment is given by road ambulance personnel to severely injured trauma patients has proven to be difficult to obtain and is also not readily available in literature.

Foreign authors suggest that similar differences between helicopter and ambulance care exist and that differences between these two methods of trauma care are likely to be highest if a helicopter trauma team is staffed by an experienced physician, rather than by a junior physician or paramedic.

Especially in urbanised situations, where survival benefits for trauma patients have to be expected originating from immediately providing advanced medical care at the scene of accident rather than by reducing transfer time, the choice for an experienced physician in the crew composition of a helicopter trauma team is most likely to optimize treatment and outcome results.

The findings of de Charro & Oppe [48] that mortality in the helicopter group is reduced, must be attributed to different management of the severely injured trauma patients by the helicopter physician, namely by performing more paramedic type interventions that ambulance personnel are authorised to carry out as well, but also by performing a considerable number of physician type interventions that go beyond the capabilities of ambulance personnel.

Logistics

The helicopter trauma team is capable of providing advanced medical care at the scene of accident for severely injured patients. A number of ‘physician type’ techniques can be performed at the scene of accident that no ambulance personnel is capable of performing, comprising thoracic drainage, cricothyroitomy, amputation and induction of anesthesia. As well as this, important and directly life-saving techniques which ambulance paramedics are allowed to perform, especially intubation, artificial ventilation, intra-venous access and the use of neck splints, are applied more intensively by the helicopter team than by ambulance paramedics. Severely injured patients thus receive more extensive treatment in the field by helicopter trauma team than by ambulance personnel alone.

In order to function effectively, it is most important that the helicopter is deployed for trauma patients who indeed benefit from helicopter team involvement as often as possible, and that unnecessary flights (cancelled

flights and flights for patients with minor injuries only) are kept to a minimum - mainly because of the unavailability for more useful missions during such a flight.

Adequate triage by dispatch centre operators and ambulance personnel at the scene of accident is a necessity for helicopter efficiency.

Only those patients are likely to benefit from helicopter involvement for whom on-site treatment is performed differently by helicopter trauma team than by ambulance personnel.

In the population under study, at least all the patients who received one or more of the ‘physician type’ interventions fall within this category.

The effects of a helicopter trauma team extend though, to a far bigger group of patients for whom no ‘physician type’ interventions were necessary and just ‘paramedic type’ interventions were needed.

When considering all patients who were intubated by the helicopter trauma team, it is most probable that a majority of these would not have been intubated if only the ambulance personnel would have been present, so that in these cases helicopter presence indeed made a difference in treatment.

The additional treatment performed by helicopter trauma team and the usefulness of deployment is thus also dependent on the level of skills of the road ambulance crew involved and where there is helicopter trauma team involvement at least all patients are ensured that care needed is indeed given.

It is impossible to identify all individual helicopter patients retrospectively to find out which patients did benefit from helicopter deployment, but it may be clear that the number of patients who received different (and more extensive) care is much larger than only those patients who received ‘physician type’ interventions.

For dispatch centre operators it is very difficult, but most important, to triage incoming emergency telephone calls for helicopter deployment adequately.

On the basis of the incoming emergency call and the list of deployment criteria (Chapter 2) the dispatch centre operators made a decision about whether helicopter involvement was necessary.

In some helicopter programs triage criteria for helicopter involvement are vague or even non-existent [154,41].

Dashfield, Smith & Young [47] assessed air ambulance flights in Bosnia and concluded that even in the apparently ideal conditions for a helicopter service, a high percentage of trauma, a rural setting and poor road communications, the percentage of patients who benefitted from air evacuation was low and they stress the need for proper screening.

Many urban helicopter programs use deployment criteria which are very similar to those used in the helicopter service under study [113].

In fact, the present criteria for deployment in association with the level of experience of a dispatch centre operator are probably the best predictor for seriousness of injuries.

Considering the fact that more patients than only those who require 'physician type' interventions are likely to receive different and more adequate treatment by helicopter physician, criteria for helicopter activation should not be too restrictive, as all severely injured patients need at least some paramedic interventions which may be applied more adequately by a helicopter team.

De Charro & Oppe [48] found that reduction of mortality by helicopter involvement did not concern patients with a very high injury severity and little probability of survival, nor patients with a low injury severity. Survival benefits were restricted to the group of patients between these two extremes. Adequate triage therefore should be aimed at targeting helicopter missions for those patients who have injuries that are indeed potentially life-threatening, though under-triage should still be avoided. Few conclusions can be drawn from the fact that no survival benefits are found in the group of the most severely injured patients. Not only would it be very difficult for dispatch centre operators to discriminate between these patients and those with a less injury severity on the basis of incoming emergency calls, but it would also be unethical and immoral to withhold maximum care for these patients who seem to be in need of it.

The rate of aborted missions of 42.9% found in the present study is a reason for further analysis.

Aborted missions can have several causes; in a number of cases certainly the patients for whom missions have been cancelled by the ambulance crew have only minor injuries needing no advanced management (cancels due to dispatch centre over triage). That said, there is still an unknown number of cases where ambulance personnel might have cancelled helicopter flights for patients requiring helicopter care as a result of incorrect assessment of injury severity, unfamiliarity with the possibilities of helicopter care, or sometimes what could be hostility toward this form of treatment.

As seen especially in the context of the large number of ambulance patients who did not receive adequate 'paramedic' care by ambulance personnel, cancelled flights are not justified by the fact that no 'physician type' interventions were expected by the ambulance personnel to be performed at the scene.

A separate study of cancelled helicopter flights should be performed to assess the appropriateness of these cancels, and could further improve dispatch centre criteria as well as reduce the number of inappropriately cancelled flights by ambulance personnel.

Home [70] reported that the rate of cancelled flights was in the region of 70% during the first months of operation of the HEMS in London. A 'call-back' system in which an experienced dispatch centre operator interrogated the caller more extensively prior to helicopter lift-off, was launched with the result that cancel rates dropped to 25% of all missions. Little has so far been published about unjustified cancelled helicopter missions.

The aim of the helicopter team is to be in place where its help is needed most, so that the rate of dispatch centre over-triage as well as the number of unjustified cancelled flights by ambulance personnel should be kept as low as possible.

Studies that address this issue [111,154] are aimed at reducing the rate of over-triage, but by doing so risk that the rate of under-triage may rise and life-saving treatment is withheld from severely injured patients. Percentages as high as 25-74% for over-triage are felt necessary to maintain an acceptable level of under-triage.

Choice of hospital

Existing literature has described the mortality rate of trauma patients as being inversely correlated to the volume of severely injured that are treated in a facility. In the Netherlands, where no national trauma registry was functioning at the time of study, it is not known to what extent differences in mortality exist between various types of hospitals.

Almost all severely injured patients who received helicopter care were transferred to one of the participating hospitals. All these hospitals are known to treat considerable numbers of severely injured patients and are capable of providing a similar high level of care.

Patients who suffered major trauma in the area and time of study and who received ambulance care only, were not all necessarily transferred to the participating hospitals, and an unknown number of patients were transferred to lower level facilities. These patients were excluded from the study.

As mortality is expectedly lower in hospitals which have extensive experience in high level trauma care than in rural hospitals which have little experience in the management of the severely injured, the effect of the helicopter of more patients being transferred to high level facilities might have reduced mortality.

As only patients who were treated in the participating hospitals were considered in both groups, the calculated survival benefits are only caused by the immediate helicopter care itself, but not by the shift in patient transfer to high level facilities.

Survival benefits of the helicopter trauma team as calculated by de Charro & Oppe [48] bear a certain risk of underestimation of the entire benefit of helicopter involvement.

Once trauma centres are set up in the Netherlands, ambulance patients will also all be transferred to trauma centres. Exceptions to this rule will be in cases in which assessment of the level of injury by ambulance personnel would be incorrect and patients are in too bad a condition to be transported to a more distantly located trauma centre and need prior 'stabilisation' in a regional facility. Even in this scenario the helicopter would still have a major benefit over ambulance care only, because clinical assessment is not only expectedly more accurate but that rapid patient transfer over longer distances is also possible by air when needed.

Limitations of the study

What has been demonstrated in the study of de Charro & Oppe [48] is that helicopter trauma team involvement resulted in a reduction of mortality and in this study helicopter care was found to be more extensive, compared to ambulance care.

This association is very important and clinically relevant, it is not necessarily the definitive proof that there is a causal link between the two. The study setup in which only accidents happening in the identical area were included and in which patients all received identical level of clinical care, combined with the CANALS analysis, eliminated all possible confounders from influencing the results. Because helicopter involvement did not lead to a shortening of preclinical time interval, it is most likely that differences in the preclinical treatment between helicopter team and ambulance personnel are indeed responsible for the reduction of mortality.

However, it is not impossible that some, unknown, confounders are still responsible for the some of the observed effect. Also, it is not possible to estimate the value of any single manoeuvre on survival, nor to discriminate between the influence of physician type and paramedic type interventions separately.

Therefore, it is not possible to estimate what the effects of the helicopter should have been if not a physician would have been part of a helicopter, but specially trained paramedics only. In order to assess the role of physician and non-physician type interventions separately on mortality as well as to rule out all possible confounders, an 'ideal' study should have to be performed.

In this study, severely injured patients would have to be assigned prospectively and randomly to 4 different groups;

- ambulance care without physician
- ambulance care with physician
- helicopter care without physician
- helicopter care with physician

For an even more optimal scenario, the non-physician groups should be split between patients who receive care by road ambulance personnel and specialised trauma paramedic personnel, who are experienced and well trained and would provide care more similar to the physicians, with the exception of the 'physician type' manoeuvres.

As will be explained, logistic and ethical problems with such a study setup would definitely make this type of study impossible to perform.

The eduction in mortality found by de Charro & Oppe [48] leads to the conclusion that helicopter involvement in its present form is beneficial to severely injured trauma patients.

The association with a different and more extensive level of preclinical care as found in this study is strong and relevant enough that the current physician care should be regarded as superior care in such cases.

Consequences of this should not only be that helicopter involvement should be continued and expanded to reduce trauma mortality, but also to continue improvements of road ambulance training, aimed at providing care to severely injured patients.

Present ambulance protocols are based on the same PHTLS and ATLS principles helicopter personnel uses, so further implementation of these protocols and improved training and education of ambulance personnel will narrow the gap in prehospital treatment between ambulance and helicopter. Treatment differences are nevertheless expected to persist, not only because severe trauma happens rarely in ambulance practice and despite all training and educational efforts practical experience will always lag far behind a helicopter trauma team. Also influencing this is the fact that it is highly unlikely that paramedic personnel will carry out physician type interventions such as induction of anesthesia in the future.

Considering the trend toward improvement in ambulance care, it would be most interesting and important to duplicate this study in the future, once ambulance trauma care is further improved and when it offers care that is more comparable to the helicopter trauma team care, and then to reassess the additional value of the helicopter physician.

Finally, this study did not assess 'scoop and run' versus 'stay and play'. Both ambulance patients and helicopter patients spent, on average, considerable time at the scene of accident in where treatment was provided.

Therefore this study should only be regarded as a comparison of two forms of 'stay and play', where helicopter team management has been shown to be more extensive than the ambulance only variant; the conclusion may be that, within a system in which prehospital care predominantly functions as 'stay and play' a more extensive approach is more preferable and beneficial than a less extensive one.

Clinical condition of patients on arrival in hospital

It has been demonstrated in this study that prehospital treatment performed by helicopter trauma team differs from care performed by ambulance personnel alone.

This, in combination with the results of the mortality analysis performed by de Charro & Oppe [48], suggests that treatment of severely injured by helicopter trauma team must be considered beneficial.

Helicopter and ambulance involvement finishes at the moment that patients arrive in hospital.

This fact, in combination with the theory that the patient's condition especially during the 'golden hour' following trauma is of the highest importance, making it essential to examine the condition of the patient at the time of arrival in hospital, because, if helicopter care is indeed superior to ambulance care, this would also result in an improved clinical condition upon arrival of patients; observation of this effect would provide more fundamental evidence of the helicopter effect.

Bouillon, Kraemer, Paffrath et al. [21] designed a protocol for emergency physicians in the region of Cologne, Germany, for prehospital treatment of severely injured patients with Trauma Score 12 or less, or Glasgow Coma Scale of 7 or less. All patients were required to have IV access, intubation was mandatory, as well as transfer to a trauma centre; scene time was not allowed to last more than 31 minutes. By monitoring obedience to the protocol standards, the authors claimed to have developed a method for measuring quality of prehospital care without having to recourse on hospital data. 91.6% of patients received IV access, 82.7% were intubated, and 62.5% of patients were transported to a trauma centre; mean scene time was 34 minutes. However interesting such numbers may be, since no relation with outcome is provided for, no additional evidence in favour of aggressive prehospital treatment may be deducted from those numbers; in the absence of a reference population, the relevance of treatment on outcome remained unstudied. Furthermore, no data were available about what condition patients arrived in at hospital.

Comparison of patients' clinical condition who received different forms of preclinical care at the moment of arrival in hospital, is, at least theoretically, the best instrument of comparing immediate effectiveness of preclinical care. Surprisingly, no such study has ever been held.

Baxt and Moody [14] held a randomized study in which patients with severe blunt trauma were randomly assigned to care by nurse/paramedic helicopter team or by a nurse/physician team. Although preclinical interventions were compared and a mortality analysis was performed which was in favour of the physician team, in their study no attention is given to the condition upon arrival. Considering the fact that both groups of patients had an identical mean level of injuries, and transfer and scene times were identical in both groups, an interesting comparison could have been performed in this study on this level as well, but was not carried out.

In other studies in which clinical condition of patients is measured upon arrival in hospital, no comparison between any two forms of care is made. Coats, Wilson & Xeropotamous [40], for instance, performed an interesting study in which 63 patients with severe chest injury were involved. Oxygen saturation, blood pressure and pulse rate were described during the prehospital phase and on arrival in hospital. Eighty nine prehospital thoracic procedures were carried out in the field. Improvements on all three variables were noted, which the authors associated with prehospital Advanced Trauma Life Support. These kinds of studies may offer interesting descriptions of what care is like in practice, but since it remains unknown what the benefits may be over a different management scenario, basically few questions.

Due to methodological considerations, any valid comparison between helicopter patients and ambulance patients at the moment of arrival in hospital was impossible to perform.

In the current study, the data was examined that was available of 77 severely injured trauma patients who received helicopter care and were admitted to the University Hospital Vrije Universiteit.

These 77 helicopter patients make up more than one third of all helicopter patients in the study. Demographics, the nature of accidents and severity of injuries were highly similar to the entire group of patients, so to consider this sub group of patients being representative for the entire group under study is justified.

Drowning patients and circulatory arrest

What is most striking is that, within the group of all patients, victims of drowning accidents had an extremely high mortality (87.5%) and arrived in hospital generally in very bad condition, often with low oxygen saturation rates, hypotensive and with low base excess values.

Most drowning patients had prehospital RTS scores of 0, which is the absence of all signs of life including circulatory arrest.

Existing literature has shown that circulatory arrest following trauma has a very unfavourable prognosis. Bouillon et al. [21] examined 636 trauma patients in Cologne (where a physician-staffed prehospital care system was in use), who were found to be pulseless on arrival. 412 of these were pronounced dead at the scene and Cardiopulmonary Resuscitation (CPR) was attempted in 224 patients. Even though CPR was initially successful in 30.4% of cases, only four patients (1.8%) could be discharged alive from hospital and were living one year later.

This largest study to date shows that cardiac arrest generally has a very poor outcome, even despite CPR. No prognostic factors for survival have been identified in this study.

In a different study, Kloss, Roewer & Wischhusen [80] retrospectively analysed 480 cases of preclinical cardiopulmonary resuscitation for all types of causes. Survival was unrelated to age, call times and organisational course, though it was found that patients with multiple injuries or craniocerebral trauma who require resuscitation, do not survive. The authors found a relatively good outcome for resuscitation following drowning; 4 out of 7 patients survived.

In the Netherlands, a retrospective study has been performed on patients by Bierens et al. [17], who analysed 87 patients following submersion in water and found that better survival was predicted by young age, submersion of less than 10 minutes, no signs of aspiration, and a central body temperature of less than 35 degrees Celsius on admission, although no indicator at the rescue site or in hospital was absolutely reliable to death or survival; 33 percent of patients with cardioventilatory arrest survived as did all victims with ventilatory arrest. Similar results were found in a study of Fretschner et al. [58], who retrospectively studied 115 cases of submersion. In this study, 50 percent of resuscitation attempts were initially successful, but only one out of four successfully resuscitated victims survived with little or no neurologic damage and no useful parameters accurately predicting the individual course of a submersion victim was determined.

Therefore, patients who were in cardiopulmonary arrest at the scene of accident as well as patients following drowning accidents, should be regarded as separate groups, for whom, despite all resuscitative attempts, a different outcome, is to be expected.

The high percentage of drowning victims in the group of admitted patients in the helicopter group who were in circulatory arrest (six out of nine patients) probably originates from the possibility that many non-

drowning patients, who were in circulatory arrest, may have been declared dead at the scene and were therefore not excluded from the study.

Partly because drowning patients may have been hypothermic as well, and may only be declared dead after body temperature has been restored, resuscitation attempts were continued in this group of patients.

Restoration of body temperature usually happens after warming therapy has been performed in hospital and only then may patients be declared dead.

The above fact combined quite probably with a selection bias for drowning accidents, and may explain the relative high percentage of drowning victims in the group of patients with circulatory arrest.

Physiologic parameters on arrival in hospital

Endpoints of resuscitation

To assess the effectiveness of preclinical care by helicopter trauma team on the condition of patients upon arrival in hospital, it is necessary to have knowledge of what the endpoints of therapy should be.

Following trauma, therapy should be focussed on improving and restoring respiratory and circulatory functioning.

To assess the success of attempts to restore respiratory functions, the oxygen saturation rate that is measured upon arrival in hospital can be used as a good indicator. In healthy individuals, arterial blood is near fully saturated, with saturation values of 99 percent in most individuals.

Patients in emergency trauma who have saturation values less than 90 percent are considered hypoxic; the value of 90 percent is used by many clinicians as trigger value to start more intensive treatment [13].

Arterial blood pressure can be used likewise. Restoration of pre-traumatic systolic blood pressure must be considered an optimal endpoint of volume therapy. For most trauma patients, pre-trauma blood pressure is unknown during resuscitation. A value of 90 mm Hg in clinical practice is often used as a minimal acceptable blood pressure value in trauma patients and is implemented as such in the Revised trauma Score. Although others use different values for this purpose, like Bauch, Betzler & Lobenhoffer [13] used a systolic blood pressure of 80 mm Hg to discriminate evident shock. For blood pressure values lower than 90 mm Hg, the classification of the Revised Trauma Score was used.

Oxygen saturation and blood pressure are practical markers of clinical condition and are commonly used to assess patients condition, both in hospital as well as in prehospital care.

Endpoint of therapy is not only to restore macrohemodynamics (systemic blood pressure), but also to restore disturbed microvascular perfusion to all organs. Due to redistribution of blood flow in patients with severe haemorrhages, systolic blood pressure can seemingly be of a normal level, but widespread ischaemia of body tissues due to circulatory bypassing can exist with the associated risk for multi organ failure [82]. Measurement of blood pressure and oxygen saturation alone is therefore not enough to have a adequate assessment of the patients' tissue oxygenisation.

To monitor this 'compensated' shock and to assess depth and duration of shock and hypoxia, several methods have been investigated.

Gastric Intra mucosal pH, blood lactate, subcutaneous tissue pO2 and Base Excess can be used to estimate depth of shock [118]. Base Excess was used in our study for this purpose and was routinely calculated for all patients presented in the shock room of the VU University Hospital through the use of an arterial blood sample.

Discussion of the results

Study of the clinical condition in which helicopter patients arrived in hospital shows some remarkable results.

In fact, all variables are highly influenced by RTS scores at the scene. Patients who had the lowest RTS scores were also more often hypoxic, hypotensive and had low base excess values more often than patients with more favourable RTS scores; even in the group of patients with the worst RTS scores of 0 to 2, the helicopter trauma team managed to maintain saturation over 90% in the majority of cases, and almost in half of these cases arterial blood pressure was restored to at least 90 mm Hg.

In patients who had higher RTS scores, only a small percentages of patients were hypoxic or hypotensive.

Regarding blood pressure, patients could be divided into two main categories: those who arrived in hospital with blood pressure values over 90 mm Hg, and patients who had no measurable blood pressure at all. Only a small group of 2.8% of patients had blood pressure values that were between these extremes. The patients who had no measurable blood pressure upon arrival concerned drowning victims and two patients who arrested because of neurological injuries. The results of these findings suggest that in other cases, especially in cases of thoracic, abdominal and extremital injuries, the helicopter trauma team succeeded in maintaining or restoring blood pressure to acceptable levels.

The number of patients who were clinically hypotensive or hypoxic upon arrival in hospital are equal to those having an unfavourably low

Base Excess for patients <55 year of age without head injury; however, for the patients for whom a critical Base Excess of -8 was used, more patients arrived in hospital with low Base Excess than hypotensive for the group >54 year without head injury and also more than hypotensive or hypoxic in the group of <55 year with head injury. This suggests that Base Excess gives more information on the patients condition than saturation or systolic tension alone and indeed reveals 'hidden' shock. There may be a different reason that a higher number of patients had unfavourable Base Excess values compared to the number of patients who were hypoxic or hypotensive; patients might have been in a very bad condition earlier, improved in blood pressure and oxygenation due to preclinical therapy, but this improvement was not commenced long enough in time to restore Base Excess values to normal.

Analysis of patients who died, upon arrival in hospital, suggests not only that drowning concerned a very unfavourable type of injury of the group under study, but also that other patients who died, often arrived in hospital in relatively good clinical condition; only one of the 19 patients who died and did not suffer a drowning accident arrived in hospital with oxygen saturation below 90%.

This suggests that death in these patients is not likely to have been caused by prehospital under-treatment, but was rather due to the severity of injuries alone, and initial therapy by the helicopter trauma team was successful in the majority of cases.

The fact that Multi Organ Failure occurred in a single patient of the 77 and constituted a rare cause of death (4.6 % of non-survivors), is an interesting finding. In a large retrospective study of 1,112 consecutive patients with multiple trauma Lehmann et al. [90], found Multi Organ Failure to be the most frequent cause of death, which accounted for 37.5% of the fatal cases in their group. Although results of the current study may not be compared to the results of Lehmann et al., the fact that few patients suffered post-traumatic MOF is, nevertheless, a favourable sign.

The conclusion may be drawn that, in general, most patients arrived in hospital in an adequate systemic condition. The majority of patients who arrived in hospital with low blood pressure, or low saturation, had low RTS scores at the scene. Still, it must be realised that helicopter care may lead to an improvement of the condition in many cases, helicopter care does not guarantee that all patients' physiologic condition will be restored to normal - as no prehospital or hospital system anywhere in the world is able to.

Adverse effects of preclinical care were identified in two cases in which technically incorrect or unnecessary procedures were carried out. In one case, in which a tube was inserted in the esophagus, the helicopter team was not responsible for the error, but instead corrected it.

In the other case, an unnecessary thoracic decompression was carried out without pneumothorax present.

The incidence of (tension) pneumothorax and the reliability of field diagnoses is unknown; Dinerman, Rosen & Marlin [51] argued that there are no data available on the accuracy of field diagnoses, and certainly the placement of a chest tube which guarantees that a pneumothorax will be present, there is no proof that a patient had either a tension pneumothorax, or may have died from it, had it not been relieved before the hospital was reached. In alliance with such an opinion, more of the thoracic decompressions may probably have been unnecessary, although it is impossible to prove this, and it is probably even more desirable to perform a number of unnecessary thoracic decompressions with a limited risk of complications, than to have patients die from untreated tension pneumothoraxes.

Although the cases described above are based only on the observation of a relatively small number of patients, it does show that advanced preclinical care procedures are difficult to carry out and are not without dangers; it is best that they remain restricted to the most experienced personnel.

Impossibility of comparison of clinical condition upon arrival in hospital

In the study of preclinical care, a group of patients who received care by helicopter trauma team was compared to a group of patients that received only ambulance care. The set-up was not randomized.

The helicopter trauma team was activated for all accidents expected to involve severely injured patients. These patients were then compared to a group of patients who, for any reason, did not receive ambulance care.
The result of this approach is that the group of helicopter patients was different from ambulance patients with, on average, the helicopter patients having more severe injuries than ambulance patients.
As a consequence of the differences found, a correction for these had to be applied. De Charro & Oppe [48] calculated mortality with a statistical model, which was based on a combination of the Revised Trauma Score and the Injury Severity Scale and the predictive power of the scoring systems was further improved with addition of other variables such as age and cause of injury. In this way, a calculation of mortality differences could be performed.

In the analysis of preclinical care, the CANALS injury severity score calculated by de Charro & Oppe was not used, as this variable included information that was not available at the time prehospital care was given and also included information that should not influence method of care (such as age). This is especially true since the Revised Trauma Score and Glasgow Coma Scale have been studied earlier by Savitsky & Rodenberg [131] about predictability concerning the intensity of preclinical care by helicopter trauma team and they came to the conclusion that these may be used as a guide to predict the degree of prehospital care that may be provided, so that patients were most accurately compared by group of Revised Trauma Score and Glasgow Coma Scale, calculated at the time by the prehospital care providers themselves.

If data on the condition upon arrival in hospital of the 77 helicopter patients were to be compared with that of the 141 ambulance patients, who were also admitted to the VU University Hospital during the time of study, at first, a correction would have to be carried out for the differences found between the two groups. In comparison to ambulance patients, helicopter patients were significantly younger, and had more unfavourable injury severity scores, both on ISS and RTS scoring systems.

Three major difficulties prohibit a reliable comparison of helicopter patients' and ambulance patients' condition upon arrival in hospital.

1/ Due to the non-randomized set-up of the study, two groups of patients were created with many differences. As all patients were scored on two scoring systems for injury severity, mortality differences could be calculated.

The scoring systems used summarize all patients' injuries or physiological disturbances into single numbers which correlate with mortality risk. Not only were these scoring systems designed to function like this [36,37], but validation studies such as those performed by Bouillon et al. [23] in Germany and Werkman et al. [161] in the Netherlands show that both RTS and ISS have a fair predictive value for mortality.

These systems may have a robust correlation with mortality risk, but these scoring systems have not been developed with the aim of predicting clinical condition at the moment of arrival in hospital. Although there is arguably some form of relation between the injury severity scores and the condition upon arrival in hospital with patients with the highest grade of injuries certainly having the highest risk of being in hypotensive and the opposite, but its exact relations have not been investigated in any study so far, and are probably more dependent on the exact type of injury than the severity score awarded for such type of injury.

The Injury Severity Scale is based on the highest three injuries on six sub-scores which represent six physiological systems (head/skull, respiratory system, circulatory system, abdomen, extremities and skin/soft tissues).

The design of the scoring system is such that a patient having a certain level of injuries on one sub-score (for instance head/skull), will have an identical chance of survival as another patient with the same level of injuries in a different system (for instance respiratory system); the chances of being in shock or hypoxic at the time of arrival in hospital may, however, be completely different. Even if patients are compared who have the same level of injuries on one sub-score, chances to be in shock or hypoxic during the time of arrival in hospital may arguably vary considerably. A patient with a liver rupture grade 3 to 4 has a same level of injuries according to the ISS as a patient with a lesion of the colon - both patients have the identical injury score on the same HTI sub score, but the patient with the liver rupture has arguably a higher probability of being in hemodynamic shock prior to arrival in hospital than the patient with the colonic lesion - even though both patients are expected to have a comparable chance of survival.

The Revised Trauma Score itself contains information about the respiratory and circulatory state patients are in at the moment of arrival at the scene. The majority of patients did have optimal RTS scores of 12 at the moment ambulance personnel arrived and were evidently not in shock nor showed any signs of respiratory dysfunction. However, the risk that patients will have respiratory or circulatory dysfunctioning later on, cannot be predicted on the initial 'optimal' RTS score and depends on the injuries present.

Use of injury severity scores to correct for differences between the two groups is therefore invalid and would only lead to speculative results.

Because the initial chances of hemodynamic shock in relation to the type of injuries has not been studied, no other possibility exists than to compare patients who have exactly the identical injuries, instead of only injury severity. Due to the fact that most severely injured patients have multiple injuries of an considerable diversity, it would be possible to match reasonable numbers of patients having identical injuries from a very large database only which includes thousands of patients.

2/ Although the moment of arrival in hospital is, seemingly, a very logical choice to compare both helicopter patients and ambulance patients, it is not the identical moment following trauma for both groups of patients. Due to the longer scene time spent by helicopter patients, these patients arrive over one quarter of an hour later post-accident at hospital than ambulance patients. Given the importance attributed to the first 'golden' hour following trauma especially, the 15 minutes difference in time when helicopter patients and ambulance patients arrive in hospital can influence

assessment of blood pressure, oxygen saturation and Base Excess to an intolerable extent.

The negative consequences of trauma on vital functioning do cases not happen instantly in many cases; even in the group of severely injured patients under study, the majority of patients still have an optimal RTS score of 12 at the moment of ambulance arrival. Patients who have severe haemorrhages are generally not instantly hypotensive, but are so only after a - variable - extent of time. Only after the circulatory functions cannot compensate for the losses of blood, does hypotension occur. Ambulance patients arrive earlier in hospital and therefore have a larger chance of arriving in hospital during the compensatory, normotensive phase of haemorrhage, even if no therapy is given; albeit arriving in hospital 'just in time' before circulation collapses does not mean that proper therapy has been provided for, or that outcome is expected to be improved in any way.

3/ Another problem lies in the fact that an unknown number of patients might have been transferred to hospital by helicopter trauma team who arrived alive, but would have died before arrival in hospital if ambulance only care would have been provided. In the analysis of mortality, this effect was of minor interest because arguably these patients would have the highest level of injury severity, and because no difference in survival were found for helicopter and ambulance patients with the highest severity, this effect had no influence on the calculation of mortality. Although theoretically, it may be possible to trace all injured patients who died before arrival in hospital, still it would be impossible to identify their identical helicopter counterparts who arrived alive in hospital, in order to leave these out of the comparison. Therefore, if a comparison between helicopter patients and ambulance patients at the moment of arrival in hospital would have been performed, the figures would have been disturbed by an unknown additional number of helicopter patients in probably the worst possible condition upon arrival. The fact that these patients are alive at the moment due only to helicopter involvement, and comparable patients who received ambulance care only and died before arriving hospital are not considered in such a comparison, the (temporary) survival benefits of these helicopter patients show only as a larger number of helicopter patients who arrive in hospital in an abysmal condition.

An additional problem arises, because by counting the number of ambulance and helicopter patients who died prior to arrival in hospital, an estimation of the number of such patients is possible. However, even with the correct number of patients who died prior to arrival in hospital and suffered trauma within the area of service, it is still not known to which (participating or non-participating) hospital these patients would have been brought, if they would had remained alive. Only a rough estimation of the number of patients that were to be brought to participating hospitals could be made therefore, with a high margin of error. Even then, identification of the patients in the helicopter group who would have died if ambulance care only would have been provided, is not possible.

Consequences of impossibility of comparison

Research on prehospital care is one of the most difficult and controversial fields of medical science.

Up until the present, personal opinion and sentiment have more influence on prehospital care than scientific results. Even the most basic questions of prehospital care remain unanswered; such as the 'scoop and run' versus 'stay and play' controversies which remains unsolved, with some American trauma surgeons rendering prehospital Advanced Trauma Life Support a waste of time, while in Europe sophisticated prehospital care is predominantly supported. Still, no study has provided definitive proof of one approach being superior over the other [143].

Considering the importance of prehospital care, continuous scientific research on all important concepts used in prehospital care should be performed, in order to study the effectiveness of care and to ascertain that changes in prehospital medicine are for the better.

Several important methological problems exist in performing studies of the effectiveness of prehospital care:

1/ As discussed earlier, the collection of reliable prehospital data on patients is very difficult, which alone may cause efforts to study prehospital care to be stalled.

2/ Obtaining a suitable control group to compare a given population of (helicopter) patients with is a very different and extremely complicated matter.

Different types of unwanted differences between patient groups will exist in all non randomized study designs to some extent:

- differences in hospital care
- differences in population demographics, type and severity of trauma
- differences in infrastructure and transfer times

One of the main problem with research of prehospital trauma care lies in the fact that in all cases of interest, patients under study do not only receive prehospital care but also hospital care later on. All study variables that are affected by hospital care as well, such as mortality, are influenced by possible differences in the level of hospital care between the two groups that are compared.

Experimental setups in which different regions of prehospital are compared, face the problem that if outcome differences are studied, these may not only be caused by differences in prehospital care, but also by differences in hospital care.

Schmidt et al. [133,134] compared German physician staffed helicopter care with that of an American nurse/nurse staffed and found a more favourable outcome in the German system. Although Schmidt et al. clearly demonstrated that prehospital management by German helicopter physicians was more extensive than that of American nurses, still there was no proof given that this might be the reason for the improved survival. Especially the fact that German patients received not only different prehospital care, but also care in a different hospital system than American patients, makes it impossible to draw the definitive conclusion that German prehospital care (and not German hospital care) was responsible for improved outcome. No comparison of the clinical condition in which the patients arrived in hospital was performed in this study.

Historic studies, comparing care currently provided with that of an earlier era within the same region, face the same difficulties: not only changes might have happened in demographics and injury mechanism, but changes of care took place in prehospital care and in hospital care as well, so instead of assessing prehospital care only, the entire chain of care provided is studied.

Fortner et al. [56] performed an exceptional study, which illustrates this problem. In this study, 180 individuals, within a period of 49 years, were assessed who all suffered a - seemingly - identical trauma; all those patients jumped or fell from Seattle's Aurora Bridge - a 50 metre fall. The authors observed an improved survival rate following institution of a sophisticated prehospital emergency care system. Although their observation that more patients who were alive at the scene also reached hospital alive - alongside a trend of more patients landing in water instead of on hard surface-, supports the view that survival benefits are, at least partially, caused by improved prehospital care. However, such study design only allows the suspicion that trauma care has improved in general, without giving any evidence about the extent to which changes in hospital and prehospital care are responsible for the improved survival.

A different and interesting study has been performed by Eisen & Dubinsky [53]. In their study, all emergency ambulance transfers to an urban Canadian hospital were analysed to assess outcome differences between the Advanced Life Support (ALS) and Basic Life Support (BLS) prehospital

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treatment. 1,397 patients with 7 different complaint groups, which included trauma and internal illnesses, received care by ambulance personnel who were either trained only in Basic Life Support manoeuvres, or also in Advanced Life Support. Patients were not randomly assigned to one of the two groups. If dispatchers rated emergency calls ' low priority', BLS personnel only was sent to the scene. In emergency cases, ALS personnel was sent to the scene, but due to limited availability of ALS ambulances, some patients that were considered appropriate for ALS still received BLS only. The authors did not find any outcome differences between the two groups. Also, no differences were found in the severity of illness between the two groups. Emergency Department nurses were responsible for the estimation of 'severity' used in this study; the nurses scored the level of severity on basis of the patients' condition prior to arrival in hospital (which they themselves had not witnessed); instead of classification using a more sophisticated scoring system, patients were divided only into three categories of severity; patients were classified being emergent, urgent or non-urgent.

Although the authors suggested that Advanced Prehospital Care may not be effective, this conclusion may not necessarily be valid. The fact that no differences were found between the two groups of patients may have two possible confounders, which may have important influence on the results found, and cannot be ruled out.

If, indeed, there were no differences in severity between the two groups and patients were 'de facto' randomly divided between the two groups, the major conclusion of this study should not be about efficiency of prehospital advanced care, but about inadequate triage at the dispatch centre. If ALS ambulances are sent out on preference to those calls that are considered needing such an ambulance, it is a very remarkable finding that there is no difference between the two groups, in which case a close examination about the appropriateness of triage criteria at the dispatch centre should be performed. Especially as the estimation of severity was performed with little sophistication in this study, it is more likely that there was a (hidden) selection bias, with patients in the ALS group having a higher severity. The severity in the group of 'emergent' patients may especially vary considerably; probably all patients that were included in the present study of helicopter care would be considered 'emergent' , but mortality risk varied considerably among these patients. It is, therefore, unjustified to base any conclusions on the efficiency of preclinical advanced care on the basis of such a non-randomized study where the authors, in fact, did not fully recognise to what extent the selection and classification biases may have confounded results of their study.

Jones and Brenneis [78] examined nine somewhat older studies in which one form of prehospital care was compared to an other, and were all non-randomized. Results and recommendations of the studies varied, but all studies showed serious flaws in the choice of control population, trauma population, population size and often had minimal outcome data and a frequent lack of statistical support.

Unfortunately, it remains that the difficulties in research of prehospital care are often not recognised by some and invalid studies risk clouding our knowledge. The danger of studies which have no validity, lays in the fact that these may lead to false conclusions and may actually do more harm than good.

Only a small number of studies have actually been performed on issues in prehospital care, which offer direct proof of superiority of one way of treatment over another.

Mattox et al. [99] performed a study of the effectiveness of application of MAST-trousers in the prehospital setting. Patients who had systolic blood pressure levels <90 mmHg were prospectively randomized on alternate days into 'MAST' or 'non-MAST', and results could be interpreted directly (i.e. without correction for differences between the two groups) which showed, at least in patients with penetrating injuries with prehospital times of 30 minutes or less, that MAST application provided no advantages with regard to survival, length of hospital stay or reduced hospital costs.

Both populations were identical in age, mechanism of injury, prehospital management times, prehospital trauma scores, prehospital fluids administered, Injury Severity Scores, emergency centre treatment, operative protocol, and calculated probability of survival.

Another randomized study in prehospital care was performed by Vassar et al. [155], in which patients who had systolic blood pressure <90 mm Hg at the scene of accident, were randomly (and double blind) assigned to receive 7.5% sodium chloride infusion without added dextran 70, with 6% dextran, with 12% dextran, or lactated Ringer's solution. Change in systolic blood pressure upon admission to hospital was measured for all groups, as well as survival statistics were kept. Only by this careful and randomized approach, in which all biases were eliminated, valid conclusions about the effectiveness of one infusion solution over the others could be drawn.

Only in a randomized prospective approach, in which two different groups of patients are created who are equal in all key respects - demographically, by type of accident and hospital care-, an adequate study with a genuine control group may be provided - and as the studies by Mattox et al. [99] and Vassar et al. [155] show, it is, indeed, possible to perform such studies in prehospital setting. Unfortunately, such studies are rare, and have only addressed (albeit important) details of prehospital care.

In studies in which patients are not randomly assigned to one or another form of prehospital care and the outcome is studied, such as the current study of helicopter care, both groups of patients must at least receive an identical level of hospital care.

It is possible for the benefits of one method of care over an other to be measured, for well studied outcome parameters such as mortality only, indirectly after correction has been carried out for the effects of the selection bias between the two groups. Any other approach would ultimately lead to purely speculative results and a high possibility of invalid conclusions.

Ethics

In virtually all fields of clinical medicine, randomized trials have been held in which supposedly more beneficial therapy is compared to conventional therapy.

No such study has ever been performed for helicopter care, mainly inhibited by ethical reasons.

An important difference between randomized clinical trials and a randomized helicopter study lies in the fact that in helicopter studies patients are not able to give permission to take part in the trial, due to unconsciousness on many occasions and logistic difficulties.

Generally, dispatch centre operators have no communication with the patients themselves prior, so patients cannot decide to agree to participate in a trial.

A second objective to randomized trials is the fact that it is often considered to be immoral to withhold optimal care to patients with the sole objective to find out what the effects of this optimal care are. The fact that helicopter care is assumed to be superior to ambulance care has lead to the fact that up until the present, a final and definitive proof of the medical benefit of any helicopter service could not have been established, even 25 years after the first programs have lifted off. All present studies, including the present study, do not answer all the questions raised, and offer only indirect proof of helicopter effectiveness because correction for the differences between the two non randomly selected groups had to be carried out.

The fact that helicopter care is already assumed to be superior to ambulance care, inhibits more fundamental studies in examining if what is assumed is, indeed, correct.

The question may be raised in fact about what is more ethical; to continue prehospital care ‘as is’ infinitely, or to perform randomized studies (of a limited size) to be able to optimize care based on direct evidence, instead of that which are indirect, calculated results of observations.

Ethically, the most bizarre situation would occur if a helicopter program were to be put out of service due to the failure to justify expenses - as the result of an ethical impossibility of a randomized study.

Lackner & Stolpe [87] addressed the ethics of helicopter studies. The authors recommended the following guidelines for helicopter studies:

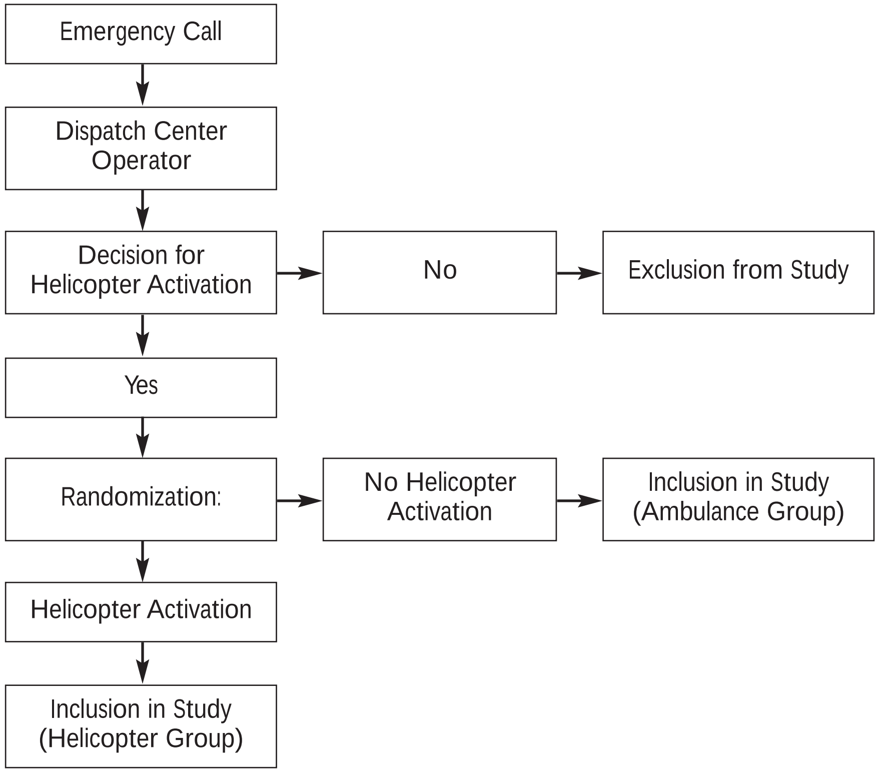
- Randomized studies are essential, especially in this part of out-of-hospital medicine.
- Studies are ethically acceptable if the treatment provided for the study group is at least equivalent to the therapy of the control group.
- Only these preconditions guarantee that the patients always received treatment in accordance with the standard for that treatment.
- Investigations need to be completed within a reasonable time frame, which, as a rule, should not exceed 2 years. Otherwise, too many items might change without being noted.

According to these recommendations, a helicopter study may be ethically right, if such a possible improvement (i.e. a helicopter team) is introduced new to a system of prehospital care. In a system with ambulance care as ‘standard of care’, a helicopter study means that some patients receive supposedly superior care, while the other, control patients receive the usual care. When helicopter care is incorporated into emergency care and is considered ‘standard of care’, what happens in a randomized study is that patients purposefully receive inferior (i.e. ambulance) care instead of the (superior) standard of care (i.e. helicopter care).

The conclusion of this reasoning is that it might have been ethical to perform a randomized study in the Netherlands at the time the current non-randomized study was begun, but currently since helicopter care will be incorporated into the general trauma system in the Netherlands and will become ‘standard of care’, any randomized scenarios which compare helicopter care with ambulance care only, must be considered unethical.

A concept of an ideal randomized helicopter study

In order to answer the question "Does helicopter care benefit patients over identical patients who receive only ambulance care ?", two groups of patients are necessary: one group of helicopter patients (or receiving any alternative prehospital care being subject of study) and a second control group of patients who receive only paramedic ambulance care prior to arrival in hospital. Only prospective, randomized study set ups will result in the creation of two identical groups of patients which are directly comparable.



This figure shows a flow-chart in which a basic model for the process of patient selection and randomization is shown.

As used in the current set up, the dispatch centre operator decides upon every incoming emergency call whether helicopter activation is necessary or not, by use of a formal list of criteria for deployment.

Only patients for whom this helicopter involvement is judged to be necessary, are included in the study. All other patients, regardless of their injury severity, must be excluded from study.
Only following the decision to activate the helicopter, patients are randomly assigned to one of the following two groups:

- a group for whom the helicopter indeed takes off (the helicopter group)
- a second group of patients for whom the helicopter is not activated (the ambulance or control group)

This scenario provides for the unique possibility, to obtain a group of helicopter patients and a control group of ambulance patients which are genuinely non-biased and therefore equal.

Despite the fact that this scenario seems to be uncomplicated, many important pitfalls are to be avoided for the succeeding of a study:

The moment of assigning patients to one of the two groups is of extreme importance.

Patients should not be assigned to one of the two groups from start on, i.e. prior to a positive decision for helicopter activation by the dispatch centre operator; when the dispatch centre operator is aware (for instance because even calendar days are 'helicopter days' and odd calender days are 'non helicopter days') that a given patient belongs to a helicopter or non-helicopter population, this will certainly affect the dispatch centre operator's decision to include patients in the study. Especially in cases wherein the dispatch centre operator is aware that a certain patient belongs to the 'no helicopter' group from start on (and is thus ineligible for helicopter care anyway), the decision to include this patient in the control group will be affected negatively. The reason for this is that when it is already known that a possible call for helicopter activation will not lead to true helicopter activation, inclusion of the patient in the control group has no benefits for immediate care and will most probably only happen less often and only for the most severely injured. The opposite might be true for the patients who are in the helicopter group.

Therefore, randomized assignment to any of the two groups may only take place after a positive decision that helicopter activation is necessary.

It is therefore an absolute necessity for any randomized helicopter study that the result of random assignment of patients into the 'helicopter' or 'no helicopter' group is fully unpredictable for the dispatch centre operator. It is obvious that methods which can be predicted by the dispatch centre operator, like assigning patients depending on odd or even calender date to any of the two groups, are useless for this purpose, and other methods, such as pulling a sealed envelope or a random card are more suitable.

Equally important is that a random assignment to any of the two groups may never be overruled.

Especially in cases of the highest severity, it is to be expected that even if patients are assigned to the 'non helicopter' group, helicopter assistance will -nevertheless- be requested by the dispatch centre operator or the ambulance personnel.

For a study set up, this results in the fact that some patients with the highest level of injuries are selectively transferred from the control group to the helicopter group and, due to this fact, the helicopter group will have a higher mean injury level than the control group.

The physical location of where the randomization takes place is less important: randomization may take place at the dispatch centre, at the helicopter base or at a research centre, as long as the results of the random patient assignment are not overruled and are not known to the dispatch centre operator prior to the decision to call for helicopter activation.

A number of different possible sources of selection have to be ruled out:

Cancelled flights. When road ambulance arrives earlier at the scene than the helicopter and ambulance personnel judges helicopter involvement to be unnecessary, a helicopter flight will be terminated prior to landing ('cancelled'). When any flight is terminated as such, the patients concerned naturally receive no helicopter care and may - erroneously - be excluded from the helicopter group as a consequence.

For control patients, who receive no helicopter care, cancelling of a helicopter flight is of course an impossibility.

There are several possible reasons why the helicopter may be cancelled, ranging from the situation wherein no patient is found at the site of accident, the patient is dead upon arrival of the ambulance, or the patient has minor injuries only, to the situation wherein the patient has extensive injuries, but due to reasons as proximity of a receiving hospital, or simply hostility toward helicopter care. In general, it is to be expected that patients for whom helicopter flights are cancelled are less seriously injured than for whom helicopter was indeed involved in, although this need not always be the case. Identification of exactly identical patients to exclude from the control population is necessary to keep the two groups of patients comparable. However, it is unpractical and prone to failure to request ambulance personnel to 'cancel flights' for

control patients prospectively when no helicopter is activated anyway. Retrospective identification of similar ambulance patients as the helicopter patients for whom the helicopter was cancelled is also barely an option, due to the high level of subjectivity involved in such selection.

Therefore, other possibilities must be considered to rule out this possible source of bias. One option is to decide that cancelling of flights by ambulance personnel is not allowed during the time of study. The main advantage of this approach is that indeed two equal groups of patients are created, which are fully comparable. However, by not allowing flights to be cancelled at all, not only many unnecessary flights are carried out for cases wherein no patients are recovered, which is not only impractical and prevent availability for other, more important missions, but also results in a study population which is different from a population in a functional, non study system. Most of these problems may be avoided by an intelligent set up of the study, in which cancelling of flights is allowed for some cases. These should concern cases wherein the patient already died at the scene, or no patients were found at the site. However, for cases wherein patients either need any form of treatment or transfer, cancelled flights should ruled out.

Cancelled flights, in which patients died at the scene or no one was found, must be documented well, and be included as helicopter cases. Although still more patients are treated in this scenario than would have been the case when no study would have been carried out, it is certainly the least of both evils.

Secondary deployments. Secondary deployments, which are requested by ambulance personnel, who decide upon arrival at a site of accident that helicopter assistance is needed, form another possible source of bias.

Arguably, patients for whom ambulance personnel request helicopter deployment, have a high level of injury severity.

Secondary deployments result therefore in the fact that a number of highly injured patients are shifted from the control group to the helicopter group, which may cause a serious selection bias. Therefore, secondary deployments should not be carried out during the time of study for any of the patients in the control group. In other cases, concerning patients for whom the dispatch centre operator initially decided that no helicopter involvement was necessary, secondary deployments may be carried out, but the patients involved in such missions should not be included in the study.

Hospital of choice. Differences in the choice of hospital between ambulance and helicopter personnel may be responsible for a serious bias which may alter results. When ambulance personnel, for instance, should most commonly decide to transfer severely injured patients to the 'nearest possible' hospital, and helicopter personnel generally to the 'best possible' hospital, differences in clinical treatment may affect the results of the study; possible benefits caused by shift of patients to more suitable hospitals may falsely be attributed to prehospital medical treatment of the helicopter trauma team.

It is most important that such effects are readily anticipated upon prior to the beginning of any study; if the effect of a helicopter team is solely an improvement of outcome due to transfer to better hospitals, such is still a valid and highly useful result of a study. Nevertheless, to study the effects of immediate medical care by a helicopter team exclusively, this bias should be avoided.

To prevent such bias, it is either necessary to restrict studies to areas in which only one single hospital is operational, or have a fully functional system of obligatory transfer of all ambulance and helicopter patients to trauma centres, which offer a comparable level of care. No, or only very few patients may be transferred to other hospitals then. When many patients are transferred to small hospitals, simple exclusion of those patients who are transferred to small hospitals still holds the risk of serious biases; for instance when ambulance patients are transferred to large hospitals only when their condition is stable, but to 'nearest possible' hospitals when their condition is unstable, but all helicopter patients are transferred to 'best possible' hospitals under all circumstances, exclusion of patients admitted to small hospitals result in comparison of an ambulance population which was more often in a stable condition during transfer with a helicopter population which was relatively more often in an unstable condition.

Awareness of the study by ambulance personnel may also affect results. The knowledge that the treatment provided at the scene for control patients, is subject of a comparison with helicopter care, may result in some cases in ambulance personnel more likely to perform other, probably more extensive, treatment than commonly. Although it is impossible to quantify these effects, it seems likely that the impact may affect results strongly. The only real solution to this problem is to withhold information to the ambulance personnel if a given case is a study control case, or not.

What is described above is a basic study design for a randomized helicopter experiment.

In short, the following criteria must be met:

- Formal criteria for deployment at the dispatch centre
- Assignment to 'helicopter' or 'control' group only after a positive decision that helicopter care is necessary
- Assignment to either of two groups cannot be changed and is unpredictable
- Helicopter flights should only be cancelled by ambulance personnel when no patient if found at the scene or when the patient died at the scene
- Secondary deployments should only be carried out for patients who are not included in the control group and must remain excluded from study
- All patients must be transferred to the same hospital or exclusively to hospitals which offer the same level of care
- Ambulance personnel is not allowed to have knowledge that a patient is included in the control group

Any experiment in which helicopter care is compared to ambulance care must meet all these criteria, otherwise inevitably some biases will occur and affect results.

Many subtle variations of this scenario can be though of, which can be applied according to local conditions, as long as the basic set up essentially remains unchanged.

The main disadvantage of the basic set up described above is the fact that the helicopter team is only activated in 50 percent of cases wherein its help would be possible.

A very interesting, alternative, study design therefore, which is applicable only in large areas in which no other helicopter operators exist, is the 'one helicopter- two helicopter bases'-scenario.

In this scenario, there is only one helicopter team operational at a time, but this helicopter serves one of two different areas having no overlap.

The helicopter is stationed at a helicopter base in either one of the two areas and is then only available for deployment within that area. For dispatch centre operators it must remain unknown if the helicopter is available or not. Only after a positive decision is made that helicopter care is necessary, the dispatch centre operator is informed about the availability of the helicopter in the given area. To enhance unpredictability of availability for the dispatch centre operators, the helicopter must be capable of switching from one area to the other during the day also; so when in the morning the helicopter is available in one area, it's availability is still uncertain for the afternoon.

The main disadvantage of such set up is the time lost during transfer from one area to the other, but its advantages are numerous. First of all, the number of missions (and patients who receive helicopter care) is only slightly affected compared to 'routine' service - and not reduced by 50%, such as in the basic randomization scenario. As a result, almost an identical number of patients receive care as if the helicopter would have been stationed in one area full-time. This is especially interesting is such scenario may be ethically as suitable as a non-randomized scenario, such as in the current set up which is limited to one part of the country only, while inhabitants of parts of the country which is not covered by the helicopter service do not benefit and are indirectly randomized by their place of residence. A second, very important advantage of this set up is that not one, but two different experiments are held at the same time and the usefulness of the helicopter is investigated in two different areas. For instance, an experiment with this scenario held in one urban area and one rural area of service would provide very interesting results.

Comparison of helicopter patients with a selection of 'similar patients' in an otherwise highly identical region where no helicopter care exists, is another option. In this set up there is no randomized assignment of patients to helicopter or ambulance group. However, the fact that control patients have to be selected in the non-helicopter area is a major possible source of bias, and thus are such approaches by far inferior to randomized setups.

The helicopter trauma team is selectively activated for accidents with a likely high level of injuries present; however, a helicopter service is expected to handle a certain part of all severely injured persons in the given region only and not all severely injured patients. Therefore, matching similar patients to act as control patients from a large pool of patients in a different area without helicopter service, is a difficult task, with a high risk of subjectivity. One possibility to obtain control patients is to instruct dispatch centre operators in the area with no helicopter service to report those cases for which they would have requested helicopter activation, provided it would exist ('virtual helicopter flights'). These patients then act as control patients. Still, this approach is prone to subjectivity and, as a consequence, will cause a biased patient selection. All problems described to exist with possible cancelling of flights in randomized settings exist in this scenario as well. However, in a situation wherein randomization is definitely impossible, this approach would probably be best.

Conclusion

The difficulties described result in research of prehospital and helicopter care being one of the most difficult, but also the most challenging fields of medicine. Except for variables that are easily described, such as transfer times and level of education of ambulance personnel, prehospital care is mainly uncharted territory. No instruments are available (without randomization) to measure immediate medical effectiveness of prehospital care in a direct way, which, given the importance attributed to prehospital care, is an undesired situation. In the study of de Charro & Oppe [48], it was possible to measure helicopter effectiveness by mortality analysis; in the helicopter group a reduction of mortality of 12 to 17 percent was calculated. For calculation of these mortality differences, a sophisticated model for the correction of selection biases was used by use of injury severity scores which were predictive for mortality risk. In the current analysis, a different and generally more extensive type of treatment at the scene of accident by the helicopter trauma team was associated with this mortality benefit.

Chapter 5

Chapter 5

Conclusions and recommendations

Conclusions and recommendations

Conclusions

As the study of de Charro & Oppe [48] has shown, in its present set up, the helicopter trauma team involvement reduced mortality 12 to 17%, with no difference in quality of life for the survivors.

This observed reduction of mortality suggests that the introduction of emergency trauma care by the physician-staffed helicopter trauma team must be considered a useful contribution to the system of trauma care in the Netherlands.

Collection of data on the preclinical treatment that was performed by ambulance personnel alone proved to be very difficult, due to organisational and logistical causes. In the prehospital care provided for helicopter patients, large differences were found in the description of the identical patients by ambulance personnel and helicopter personnel.

Similar practical problems probably resulted in a lack of studies on ambulances care.

Differences in the preclinical management of severely injured trauma patients have been found between patients who received helicopter care and those who received ambulance care only. Differences were of a size that may be spoken of a fundamentally different approach to the patient.

The involvement of the specialised and experienced physician in the helicopter trauma team was responsible for the more extensive treatment that was given to the helicopter patients.

Two different kinds of manoeuvres at the site of accident could be discriminated, manoeuvres which ambulance personnel should be capable of fulfilling and manoeuvres that can be carried out only by physicians.

Overall, patients who received care by the helicopter trauma team received more extensive ‘paramedic type’ preclinical care.

Especially procedures affecting vital functioning most directly, namely artificial ventilation, endotracheal intubation, intra-venous access and neck splints were applied more frequently in cases of helicopter trauma team presence than in cases where ambulance personnel were alone.

Analysis by sub-group did not alter these results. The differences found in preclinical treatment extended to all the different categories of patients, and included those patients whose vital signs were affected at the scene of accident.

Because the helicopter trauma team was staffed by a physician, it was also possible to carry out more difficult and invasive procedures at the scene of accident that specifically require a physician experienced with performing those procedures.

For considerable percentages of the helicopter population insertion of central venous lines, thoracic drains, induction of general anesthesia and coniotomies have been performed. In patients, who received ambulance care only, these manoeuvres could not be performed at the scene but only after arrival in hospital.

The reduction of mortality found for the helicopter patients in association with the more extensive treatment at the scene of accident, strongly favours the current approach of helicopter care in which advanced care in the field is provided during the most valuable period of time following trauma (‘the golden hour’).

The helicopter was mainly used to provide for rapid transportation of the trauma team itself to the site of accident.

Although one benefit of the helicopter was that patients could be transferred to more distantly located hospitals if necessary, overall time from accident to hospital was not reduced in cases where the helicopter team was activated, but instead, prolongated.

The more extensive treatment provided by the helicopter trauma team lead to a 15 minutes longer ‘on scene time’ compared to that for ambulance patients. Still, the mean time for helicopter patients from accident to arrival in hospital was within ‘the golden hour’, in which these patients had already received advanced medical treatment, which otherwise would have been postponed until after arrival in hospital.

Presence of a physician versus paramedic involvement

The large differences in preclinical treatment found in the population under study may be explained by the presence of a highly specialised trauma physician as part of the helicopter trauma team.

At present, care provided by nurse/paramedic road ambulance personnel has, in general, shown to be less extensive, in comparison with the treatment of the helicopter trauma team.

Educational standards have been considerably improved for ambulance personnel over the past decades. Severely injured patients, however, constitute a relatively rare and very complicated type of patient for which ambulance personnel generally lack sufficient experience in management.

Ambulance personnel alone carried out prehospital treatment as well, to an extent that it is safe to conclude that a ‘stay and play’ policy has generally been adapted in ambulance care. It is in the content and volume of the ‘stay and play’ type of preclinical care for severely injured patients in which the helicopter trauma team offered additions over ambulance care only.

Under all circumstances, education and further training of ambulance personnel should have high priority. Theoretical knowledge of trauma physiology, correct patient assessment and indications for emergency manoeuvres should be trained, as well as the practical skill to perform the necessary interventions.

With further improvement of education and training, differences between ambulance and helicopter care are likely to become smaller.

The PHTLS based protocols in use by ambulance service are based on the same principles as the ATLS protocols used by the helicopter trauma team. Full implementation of these protocols by ambulance personnel is likely to narrow the gap in the extent of preclinical care that currently exists between ambulance and helicopter team.

The introduction of protocols and training programs in various ambulance services is very important in this, but more changes must happen than simply a formal adaption to the protocol. Personnel must be educated and to be trained. Smaller ambulance companies especially that are already in a financially weak position, cannot always afford these additional expenses. Without fundamental changes in the allocation of financial resources, it seems unlikely that all ambulance care in the Netherlands will be identical. A positive development regarding this is that many of the small ambulance companies have merged with larger providers, which have more financial power.

Differentiation of ambulance vehicles into different classes according to the level of training of the paramedics/nurses is the case in Germany and parts of the United States. Only the most experienced staff is sent out to the most serious emergencies. In the Netherlands such a scenario might be considered, although this is hardly an option in rural areas where little choice of ambulance vehicle exists.

Further improvement of ambulance personnel's knowledge and skills will probably make differences between ambulance and helicopter care smaller, but paramedic staffed ambulances will still not be authorised to carry out all the types of manoeuvres that a physician staffed trauma team would be.

Because ambulance paramedics are unauthorised to administer the sedation and muscle relaxantia necessary for intubation in the conscious patient, even when intubation skills of all ambulance personnel would be optimal, the number of intubations performed for patients who receive only ambulance care would be lower than for those patients that receive helicopter care. This is the case with other procedures: thoracic drains, central venous lines, invasive blood pressure monitoring, amputations and coniotomies are presently not performed by ambulance personnel.

In the present situation, it is more realistic to improve ambulance training in 'paramedic' type interventions than add potentially more dangerous and complicated interventions to the list of manoeuvres that ambulance personnel should be authorised to do.

A physician staffed helicopter trauma team offers specialised treatment to a select group of patients.

Notably, the fact that the helicopter trauma team is specialised in trauma treatment only, must be regarded as being of major benefit, in addition to the experience the helicopter team members obtain which is otherwise hard, or impossible, to surpass.

The use of a helicopter as vehicle

Using the combination of a road ambulance and a helicopter has proven to be successful.

Because the study was held in a region of the Netherlands that was highly urbanised, containing a dense network of hospitals, with ambulance emergency response time of maximum 15 minutes, the helicopter was not intended primarily to quicken patient transfer times, but to provide advanced medical care by a specialised medical team at the scene of accident. In fact, helicopter presence increased prehospital time by 15 minutes.

Combining the presence of both helicopter team and ambulance personnel, a large number of techniques could be carried out in a short time-span, which could otherwise have been performed only after arrival in hospital.

The possibility of the choice of vehicle for patient transfer, be it road ambulance or helicopter, is of additional benefit. Road ambulances are more comfortable, but in cases of long transfer distances to facilities, road blocks or bad driving conditions, or in cases of highest severity, transfer by air was a useful option. The introduction of 10 specialised trauma centres in the Netherlands which will be responsible for treatment of all severely injured patients will lead to longer distances between accident site and hospital in some instances, so that the role of the helicopter in patients transfer is expected to become more important.

Often, air medical programs have received criticism for being too expensive, but in fact use of a helicopter can be considered a method of reducing costs in providing this high level care. The fact that in this way, a vast area of land may be covered by only one single helicopter is most important herein.

To achieve equal response times within the same area of service, a multitude of road-based trauma teams would be required instead. In addition to the financial burden of having so many trauma teams, the experience gained by one helicopter trauma team outstretches by far that of a single land trauma team.

Naturally, the unavailability of the helicopter during night hours and with bad weather conditions limits its use.

Helicopters may be used to fly in almost all circumstances, and now that the additional life-saving value of the helicopter has been established, studies of the possibilities and usefulness of night and bad weather flights should be studied.

Study of its effects

Due to the non randomized set up of the study, a patient selection bias resulted in helicopter patients forming a different group of patients than ambulance patients, having a higher mean injury severity than ambulance patients.

De Charro & Oppe [48] could only calculate the survival benefit by use of a sophisticated correction for these differences including two injury severity indices, and taking account influences on mortality of cause of trauma, and age. In this way, a survival benefit was calculated which showed a reduction of mortality in patients who received care by the helicopter trauma team.

In combination with the surplus of therapy the helicopter patients received compared to ambulance patients found in the current study, it is most likely that - because no other differences than those of the modality of preclinical care existed between both groups - the survival benefits are caused by the additional therapy given.

If helicopter care is indeed medically superior to ambulance care alone, helicopter patients should also arrive in hospital in overall better clinical condition than ambulance patients, i.e. less helicopter patients would be in shock or hypoxic at the end of helicopter treatment than if these patients had received ambulance care only.

However, differences between helicopter and ambulance groups prohibited such comparison of these immediate effects. First, differences in injury severity existed between both groups. Injury severity indices were designed and validated for their predictive value on mortality, but not for clinical condition upon arrival in hospital. Even two patients having identical ISS scores based on the same sub-score may have completely different chances of being in shock, although their chances of mortality may - in the end - be the same. Use of these severity indices to correct for the differences in clinical condition, especially in a study design in which a selection bias was imminent, is therefore methodologically wrong and would only lead to speculative conclusions.

Second, because helicopter patients arrive in hospital more than 15 minutes later than ambulance patients, the condition of both groups of patients is measured at a fundamentally different moment in time ‘post trauma’. Because the negative effects of trauma on the physiologic condition in time do generally not occur immediately, but only after some time has expired, and tend to become worse with time - especially when causal therapy is not given -, comparison of the clinical condition at the time of arrival of both groups of patients is another impossibility.

Only in a randomized set up of a helicopter study, in which two identical groups of patients are created, a more fundamental analysis of the immediate effects of helicopter involvement can be performed.

No randomized comparisons of helicopter and ambulance care have been performed anywhere in the world yet, and due to ethical reasons it is unlikely that such studies will be held.

The lack of fundamental studies goes beyond the focus of this study of the immediate effectiveness of the helicopter trauma team, and makes preclinical care in general one of the most difficult and controversial subjects in medicine.

Given the huge importance of prehospital care and its influence on patients’ outcome, attention should not be withdrawn from this subject, but should instead be intensified.

Role of the helicopter trauma team in general trauma care

The availability of a helicopter trauma team is only part of what is necessary to reduce trauma mortality and morbidity. A helicopter trauma team can only become fully efficient within a well functioning system of high quality trauma care.

The role of the dispatch centres must be emphasised in, for their responsibility to call for helicopter involvement. The present rate for cancels is 42.9% of flights, which not only leads to unnecessary expenses, but also to unavailability of the helicopter for other, more important missions.

The need for a continuous process of monitoring all calls and cancelled flights should be necessary to improve further efficiency of the helicopter and lead to a situation wherein those patients receive helicopter care who benefit from it. Close cooperation between dispatch centres, ambulance services and the helicopter trauma team is an absolute necessity for this.

Ambulance services remain to fulfill an essential role in the overall trauma care. Good cooperation between helicopter and ambulance personnel should be a necessity, to improve on-scene efficiency and to avoid the inappropriate cancellation of flights.

It has to be stressed that helicopter care must not be seen as a competitor with ambulance services, but as an addition to enable specialised, advanced care for the relatively rare and difficult cases of high severity in which the experience and training of ambulance personnel alone are insufficient. Education of ambulance personnel should, under all circumstances be further improved.

The fact that only a basic First Aid diploma was considered to be a sufficient level of education for ambulance personnel until a few years ago, represented a major underestimation of the role of this important part of medical care.

Not only theoretical education should be improved, but also communication between ambulance personnel and hospital personnel.

Often no feed-back is currently given to the ambulance personnel by hospital staff after transfer of a patient. Valuable information should be provided by hospital staff to ambulance personnel on the appropriateness of prehospital diagnoses and care, to enhance the experience of the ambulance personnel.

Hospitals provide a key role in trauma care. This present study involved a small number of high care facilities only, which were all familiar with the treatment of large numbers of severely injured trauma patients and offered a comparable level of care.

In the Netherlands, it is unknown to what extent mortality and morbidity of trauma patients is influenced by treatment in either a high care facility, or a small general hospital. Foreign studies have shown that trauma mortality is inversely correlated with the volume of patients received by a hospital. During the time of study, no specially designated trauma centres existed as such in the Netherlands, and an unknown number of severely injured trauma patients were transferred to small hospitals, unfit to handle this type of patient well.

Positive effects on the survival of helicopter involvement diminish if hospital care is of sub-standard quality. Government in the Netherlands has decided to designate 10 trauma centres, which will be responsible for all severe trauma cases and receive necessary funding for this goal.

Institution of the trauma centres in association with a nationwide cover by four trauma helicopters, must be regarded as a milestone for trauma care in the Netherlands and is expected to improve trauma outcome further on.

Recommendations for future research

In this study combined with the study of de Charro & Oppe [48], an important link was established between prehospital trauma care and survival. However, preclinical care remains a part of medicine that is still based on assumptions and on personal opinion rather than on scientific evidence. Little of what is performed in prehospital care is proven to be effective by controlled experiments, and even fundamental questions like the ‘scoop and run’ versus ‘stay and play’ therefore remain unanswered. Also the present findings may not be considered as a ‘proof’ of helicopter effectivity, especially given its design. In fact, the findings call for a follow-up study in the form of a randomized experiment.

Fundamental studies are essential to provide a base for further improvement of prehospital treatment. Non-randomized study designs have many pitfalls which limit their usefulness in some aspects, but nevertheless provide crucial information if biases and limitations are recognised.

The ethical possibilities of randomization should be reflected upon in every new study of prehospital care which might be held, but it seems more realistic to expect that randomized studies will remain rare exceptions and these may not provide the ultimate solution for all uncertainties of prehospital care.

Little scientific evidence exists in prehospital medicine, but, as well data of prehospital care alone is difficult to obtain and often of a poor quality. Ambulance services should improve administrative registration of the paramedic procedures carried out on the scene to a more acceptable level; not only is registration of prehospital routines legally mandatory, but in the context of any serious quality improvement efforts, a basic knowledge of paramedic activities in the field is essential.

Likewise, to the present it is still unknown what the number of severely injured patients in the Netherlands are and in which facilities these receive treatment. The only reliable national statistics on trauma patients so far concern traffic accidents and mortality. A nationwide trauma registry in which data on incidence, severity and outcome of injured patients is systematically kept, is necessary to a better understanding of trauma and trauma care in the Netherlands.

A functioning trauma registry does not only allows monitoring of important trends in traumatology, but possibilities of use extend to direct quality control, and facilitation of future research.

A continuous monitoring of helicopter flight must also be carried out, to reserve activation for only severely injured patients and prevent distraction from its original purpose.

Conclusion

The introduction of a physician staffed helicopter trauma team in the Netherlands has been associated with a decrease in patient mortality and no change in morbidity in the study of de Charro & Oppe [48].

In the present study, differences in preclinical treatment of the severely injured were found to exist between ambulance care and helicopter care.

The helicopter trauma team is performing more extensive treatment in the field than non physician ambulance personnel does for comparable patients.

Part of the more extensive treatment in the field is caused by the direct presence of a physician in the crew composition of the trauma team, who was authorised and able to carry out invasive procedures that specifically require a physician to be performed, such as thoracic drainage, cricothyrotomy, administration of anesthesia, and amputation.

In cases of helicopter trauma team involvement, procedures that could also have been provided by ambulance personnel alone, were carried out more often. Intubation, artificial ventilation and appliance of neck splints were performed considerably more often in cases of helicopter trauma team presence than in cases of ambulance care alone. Nearly all helicopter patients received IV access, while this was the case for only a majority of patients who received only ambulance care.

Differences were outstanding for patients who showed depressed levels of vital signs, too.

Improvement of the level of knowledge and skill in trauma management of ambulance personnel should have a high priority.

An optimally educated and trained ambulance care system would certainly make differences between ambulance and helicopter care smaller, but because of the additional therapeutic possibilities a physician has in the field compared to non physician ambulance personnel, the helicopter trauma team would still offer the possibility of different treatment.

The use of a helicopter has proven to be practical and enabled the trauma team to reach patients within a large area of land within a short time span and made patient transfer possible by air, if necessary.

Using helicopters, only a few trauma teams are sufficient to cover the whole of the Netherlands. The small number of teams each gain unsurpassable experience in advanced trauma care, which enables the highest level of expertise in this form of care.

Benefits of the use of the helicopter trauma team are likely to be highest in an optimally functioning system of trauma care. Every participant in trauma care, ambulance personnel, dispatch centre operators, and hospital facilities must all function optimally in order to reduce trauma mortality and morbidity to the highest possible degree.

However relevant and important the association between helicopter team, a different prehsopital treatment and survival may be, extreme caution should be observed. Since all results were obtained from a non-randomized set up, these may not be considered as a definitive 'proof' of helicopter beneficiency. Only a genuine experiment under controlled circumstances, in which a non-biased, fully identical, control group of patients is used, may claim so. In order to obtain a definitive proof of helicopter beneficiency, another necessity is a considerable improvement of patient documentation. Presently, especially the documentation of prehospital care by ambulance personnel is not only quantitatively, but also qualitatively lacking and inconsistent. In any study claiming to provide definitive proof of helicopter care, this problem must be resolved.

Unfortunatelly, no such experiment has ever been performed. The prersent findings, and our present, poor knowledge of prehospital care in general, in fact demand such well set up experiments to be held.

Institution of designated trauma centres in the Netherlands, in which treatment of all severely injured patients will be centralised, is necessary in order to be able to continue the advanced level of care started in the preclinical phase by the helicopter trauma team.

Naturally, under all circumstances, attention to primary and secondary prevention may not be lessened, for prevention is better than even the best cure.

In order to improve efficiency of the helicopter trauma team, a separate analysis of the appropriateness of the cancelled flights should be carried out.

Chapter 6

Chapter 6

Summary

Summary - English

In Chapter 1 the importance of trauma and trauma care within the society is stressed.

Trauma incidence and mortality in the Netherlands have shown a decreasing trend, but remains a very important cause of death and suffering, and especially affect young individuals.

Trauma was responsible for 5,173 deaths in 1995, and 81,253 lost years of life. Direct medical costs of trauma in 1988 were calculated at 952 million US Dollar; indirect costs are a multitude of this amount.

Reduction of trauma mortality and morbidity would benefit both the individual and society at large.

Trauma prevention can be aimed at either preventing accidents from happening (primary prevention), limiting the extent of injuries caused by an eventual trauma (secondary prevention), and at optimising outcome following a traumatic incident (tertiary prevention).

Death following trauma occurs in a trimodal distribution, 45% of deaths occur at the scene of accident due to a unsurvivable level of injuries. The second peak is during the first hours following trauma, often caused by starting life-saving treatment too late.

The third peak, occurring weeks to months following trauma is often due to late complications, correlating with inadequate medical treatment performed earlier following trauma.

Trauma care constitutes one of the most difficult and challenging tasks in medicine.

The objective of initial trauma care is to secure vital functions, consisting of state of consciousness, circulatory functions and respiratory functions.

A large number of techniques can be applied in the field for severely injured trauma patients, among which advanced airway management, circulatory management, anesthesia and stabilisation of fractures play an important role.

The patient's condition especially during the first one hour following trauma is of crucial importance for later outcome; for this reason this hour is also known as 'the golden hour'.

Trauma care should begin as soon as possible. To use the golden hour most advantageously treatment should start in the preclinical phase already.

Trauma victims in the Netherlands are usually transferred to hospital by road ambulances, staffed by a driver and a paramedic. Minimal educational requirements for ambulance attendants were only recently lifted from a First Aid diploma to registration as nurse plus a specialised course for ambulance attendant. Still, large differences in quality of care between various ambulance operators persist up to the present. The rate at which ambulance personnel encounter severely injured trauma patients and must perform more advanced techniques in ordinary practice is too infrequent to maintain adequate skills in these fields.

Ambulance protocols have been introduced over the past years, including protocols in trauma care, but the impact of this on practical care is still unclear.

Trauma teams consisting of hospital physicians and nurses called 'LOTT-teams' were introduced in 1982 in the Netherlands, originally designed to take care of medical problems in calamities and disasters, but also for single cases of severe trauma. Logistical difficulties as well as unclear indications for activation of these teams made practical use of these teams very limited. In July 1998 financial funding for these teams was terminated; it is unclear what the future of trauma teams in the Netherlands will be.

Dispatch centres handle the incoming emergency telephone calls and coordinate ambulance vehicle movements. No legal minimum educational requirements exist for dispatch centre operators and many operators have no ambulance or paramedic experience at all. Protocols, like those in use routinely in the United States, are still not in use in the Netherlands at such a level.

Hospitals play a key role in trauma care. Adequate facilities, personnel, and experience must be available in a hospital to enable ultimate treatment of severely injured trauma patients well. In Germany and parts of the USA trauma care has been regionalised and specialised trauma centres have been instituted, thereby concentrating resources and experiences to a limited number of hospitals. Experiences with this form of care are very favourable for patient outcome, but in the Netherlands, still, no such trauma centres exist.

In May 1995, an investigation began in which a physician staffed helicopter trauma team, based at the University Hospital Vrije Universiteit in Amsterdam, was permanently on stand-by to treat severely injured trauma victims at the scene of accident.

Helicopters as a means of transport have the advantage of offering high speed of travel, so that a large area of land can be covered by only one helicopter.

Helicopters are able to reach places that are impossible or hard to access by road vehicles.

The crew composition included a physician, which some authors in literature consider as leading to a reduction of mortality compared to non-physician staffed teams, while others did not find differences in outcome.

Having an experienced and specialised physician on board, as in the current team composition, ascertains the highest level of expertise and care possible.

Safety of helicopter transport must remain an important issue; it is very difficult to compare helicopter and road ambulance safety records.

Helicopters and other airborne vehicles have a long history in medicine.

In 1972, the first hospital-based helicopter program started up in Denver, Colorado.

Approximately 200 helicopter programs are presently operational in the USA, and helicopter programs have been introduced in many European and other countries.

In the United States, a physician is part of the helicopter team only in 6% of helicopter programs, in Germany a physician is present on all flights.

Use of helicopters in the Netherlands for medical purposes had been sporadic up until the experiment with the University Hospital Vrije Universiteit Helicopter Trauma Team began.

Introduction of the helicopter in the Netherlands was received with some scepticism especially concerning the high costs involved.

Lack of conclusive studies and the impossibility of transferring foreign results to the Dutch situation caused by regional differences, made it necessary to perform a study of the effects. De Charro & Oppe held a study of the effectiveness of helicopter care on mortality and quality of life, as well as on the costs and cost effectivness of helicopter care. In this additional study, the immediate effects of helicopter care are studied, using the identical set up de Charro & Oppe used. The aim of this study is to asesss effects of helicopter involvement on prehospital care, prehospital time intervals, especially in relation with the results found by de Charro & Oppe.

Recently, the Dutch government made the decision to put a total number of four helicopter trauma teams into operation and to designate ten trauma centres for the treatment of severely injured patients.

In Chapter 2 the investigation is described.

A helicopter trauma team, consisting of a pilot, a trauma nurse and an experienced surgeon or anesthesiologist, was permanently on stand-by at the helicopter base on the roof of the University Hospital Vrije Universiteit in Amsterdam.

During daylight hours, the helicopter was able to take off within two minutes following a call for activation and reach any point within 50 kilometres in less than 15 minutes.

The helicopter was activated by dispatch centre operators for all emergency calls suggestive for severe injury. Road ambulances were always sent out as well to the scene of accident and although the helicopter was also capable of transporting patients, patients were usually transferred to hospital by ambulance.

Ambulance personnel once arrived at the scene could also request helicopter activation. Patients who received care by helicopter trauma team were compared with patients who received ambulance care only.

The two scoring systems (RTS and ISS) for injury severity used in this study are explained. Only patients who had either a RTS at the scene of 10 or lower, or an ISS score in hospital of 16 or higher and received treatment in one of eight participating large trauma hospitals were included in the study.

In Chapter 3 the results are published.

The helicopter team received 1168 calls for activation within the first 20 months of study. In 42.9% of cases helicopter missions were aborted prior to landing.

Mean time for activation was 2.3 minutes, average distance from the helicopter pad to the site of accident was 22.1 kilometre. 517 severely injured patients met all criteria for inclusion, of whom 307 patients received only ambulance care and 210 care by the helicopter trauma team.

Patients were generally young (mean age 38.5 year), and male (68.7%). Traffic accidents were responsible for the majority of trauma cases, followed by domestic accidents and assault.

Mean RTS scores of ambulance and helicopter patients were not significantly different, the unaffected score of 12 was the most common for both groups of patients. Helicopter patients showed a higher mean ISS (28.6 vs 25.5, $p<0.01$).

High ISS scores correlated with high mortality. The Foundation for Scientific Research of Road Safety (SWOV) and the Centre for Health Policy and Law (CGBR) calculated survival benefits using a sophisticated statistical method called CANALS for the identical set of patients used in this study. Compared to ambulance care alone, helicopter involvement reduced mortality with 12 to 17 percent according to a minimal and maximal method of calculation, or an additional 6 or 7 lives saved in the group under study. In the maximal model, mortality was reduced almost exclusively in the group of patients who suffered traffic accidents.

Mortality was not reduced in the group with the highest mortality risk, nor with the lowest mortality risk, but concerned patients between these extremes.

Overall mortality was highest in the relatively small group of 'other causes of injury', followed by domestic accidents and assault. Mortality was highest in young children and in patients aged 60 and over.

Preclinical treatment can be divided into two categories; those interventions which well-trained ambulance personnel in the Netherlands are supposed to be able to perform ('paramedic type') and those interventions that are restricted to physicians ('physician type').

Preclinical treatment was assessed for ambulance and helicopter patients. Treatment of ambulance patients was assessed by analysing ambulance run reports, and of helicopter patients by analysing ambulance run reports, helicopter forms and a combination of both.

For all patients the most important differences are found for intra-venous access rate - nearly all helicopter patients received at least one site for intra-venous access, and this is only the case for just over 80 percent of ambulance patients - artificial ventilation and endotracheal intubation - which is performed in well over half of helicopter patients and only for 5.4% of ambulance patients and the use of neck splints, which are also applied more frequently by the helicopter trauma team.

Of the physician type interventions, thoracic drains were placed in 9.3% of patients and anesthesia was induced in 46.1% of cases (enabling intubation in non comatose patients). Amputations were not performed in the group under study. Fractures were repositioned in 9.8% of cases. In one case coniotomy was necessary and carried out, and in one other case invasive measurement of arterial blood pressure was done.

Paramedic type interventions were analysed stratified by ISS class. Generally, the higher the ISS score is, the more treatment is performed in both groups. However, significant differences are found in the rate of artificial ventilation, intubation, intravenous access, and neck splints used. Except for intra-venous access, differences remain significant even in the category of patients with the most unfavourable injury scores.

Analysis of patients who are in haemodynamic shock shows that intra-venous access rate in the ambulance group does not exceed 85.5%, not even in the state of deepest shock, whereas nearly all helicopter patients received an intra-venous access site.

Artificial ventilation was carried out more frequently by the helicopter trauma team than by ambulance personnel; this is most true for patients with a normal, or only mildly affected respiratory rate. Endotracheal intubation in the ambulance group is carried out almost exclusively in patients with a severely affected respiratory rate (9 or lower), but at a rate significantly lower than by helicopter trauma team in which the intubation rate

is almost 100% for these patients, and for 40.7% of patients with an unaffected respiratory rate.

Artificial ventilation rate and intubation rate correlate inversely with Glasgow Coma Scale scores. In all categories helicopter trauma team carried out these routines more often than ambulance personnel alone, and especially noteworthy is that intubation is only carried out in the ambulance group for patients with a Glasgow coma Scale of lower than 8.

The rate to which neck splints are used in the ambulance group does not increase with lower GCS- instead, in comatose patients the rate is even lower than in non-comatose patients. In the helicopter group the rate of neck splints is highest in the comatose group and for all categories of GCS higher than for the ambulance group.

Separate analysis of patients with severe neurologic, respiratory, cardiovascular and extremital injuries does show similar results; IV access, artificial ventilation, intubation and neck splints were generally performed, or used, more frequently for helicopter patients than for ambulance patients.

Especially interesting is to note that for all patients, the rate at which splints were used did not significantly differ between the helicopter and ambulance patients, but for patients with severe injuries of the extremities helicopter patients received significantly more splints than ambulance patients with the same level of injury, indicating that ambulance personnel used splints primarily for minor injuries of the extremities and the helicopter trauma team reserved use for the most serious cases.

Preclinical time intervals for ambulance and helicopter patients vary. The surplus of treatment by helicopter trauma team lead to a longer time spent at the scene of accident by approximately 15 minutes. Response time and transfer time to hospital were not different between helicopter and ambulance patients.

Most frequently, patients were transferred to hospital by road ambulance accompanied by the helicopter physician (60%). In 11.4% of cases only the transfer to hospital was performed by helicopter, and these patients had a significantly lower RTS than patients who were transferred by road.

Also, data is provided on the clinical condition upon arrival in hospital of 77 helicopter patients, who were transferred to the VU University Hospital. Oxygen saturation, systolic blood pressure and Base Excess values are provided. Patients who had low RTS scores at the scene of accident generally had the worst condition upon arrival in hospital. Drowning victims formed a separate group with an unfavourable outcome.

Most patients arrived in hospital with oxygen saturation ≥90% and systolic blood pressure ≥90, and a smaller part with no measurable blood pressure. Only few patients had systolic blood pressure between these extremes.

In the final part of Chapter 3, a summary is given of the study by de Charro & Oppe:
An advanced statistical model, called CANALS, was used to correct for differences between helicopter and ambulance patients. This model is described in detail in Chapter 3. The results of this analysis show that the mortality is reduced in the helicopter group by 12% in a conservative ('minimal') model, to 17% in a more liberal ('maximal') model. The reduction of mortality is almost exclusively limited to victims of traffic accidents. In the group of patients with the highest level of injuries no reduction of mortality was found, nor in the group ofpatients with only minor injuries. But, in the critical group of patients between these extremes, the mortality was lower.

Interviews were taken from 432 patients, 9 and 15 months following trauma. Analysis of the quality of life, by use of Short Form 36 and Euroqol 5D questionaires, did not reveal any significant differences between ambulance and helicopter patients.

The costs of initial hospitalization of a single severely injured patient were estimated to be 36,000 Dutch Guilders. The annual costs of one daytime only helicopter service are 4.5 million Dutch Guilders. The costs per life-year won vary between 33,000 and 63,000 Dutch Guilders when no correction is applied for the reduction in quality of life for the survivors, and between 44,000 and 83,000 when the reduction of quality of life is included in the calculation.

In Chapter 4, the results are discussed.

Data on medical treatment that was carried out by helicopter trauma team was collected prospectively, using specially developed research forms. Data on treatment provided by ambulance personnel was mainly collected retrospectively and standard ambulance run reports were used for analysis. Ambulance run reports are not specially designed for research purposes, and are often filled in with less accuracy than the forms completed by the helicopter team.

Differences were found for identical helicopter patients in the medical treatment described by ambulance personnel and helicopter trauma team. Some of the differences found can probably be attributed to the fact that some treatment was indeed performed by one of the two medical teams, without involvement of the other, but are probably also indicative of the inaccuracy of the data provided by the ambulance teams.

The level of inaccuracy in the group of helicopter patients is most probably an overestimation of the inaccuracy in the group of ambulance patients. Recalculation of the values found for ambulance patients using this exaggerated rate of error, shows that differences in the frequency of treatment between helicopter patients and ambulance patients remain significant nevertheless for rate artificial ventilation, endotracheal intubation, IV access and neck splints are used in both groups.

Therefore, to conclude that genuine differences in treatment exist for these highly important and directly life-saving manoeuvres is justified.

What is striking is how little scientific research exists on preclinical (ambulance) care, especially considering its significant importance for general care. Logistical difficulties encountered in preclinical research may well be responsible for the lack of qualitative studies.

The role of the physician in the helicopter team composition has been associated with a reduction of mortality by some authors, but not all. Studies in which physician and paramedic/nurse team compositions are compared must address the level of education and experience of both physicians and non physicians involved, as a very experienced physician in comparison to a lowly-skilled paramedic/nurse is likely to have a greater impact on survival than an inexperienced physician in comparison to a specialised and well trained paramedic/nurse. The choice for an experienced and specialised surgeon or anesthesiologist in the crew composition of the helicopter trauma team in the current study ensures the best possible care at the scene.

Helicopter programs are most likely to be successful if its purpose is well defined. In outlying rural areas with poor infrastructure, the benefits of a emergency helicopter can originate from faster transfer alone. In this set-up, emphasis is put on faster patient transfer to hospital rather than on 'on-site treatment' in order to improve survival.

In the Netherlands with its small size, good road infrastructure, rapid and nationwide availability of paramedic-staffed road ambulances and a dense network of hospitals, the use of helicopters for transfer of patients would, in most cases, result only in marginal reduction of preclinical time intervals. Under these circumstances, benefits of helicopter involvement must originate from the possibility of advanced medical care being already performed at the scene of accident that would not otherwise be provided by ambulance personnel, alone.

What is essential for the effectiveness of the helicopter program is that the helicopter be indeed activated for those patients who benefit from physician involvement and that the number of superfluous flights are kept to a minimum. In the time span under study, 42.9% of all flights were cancelled prior to landing. This percentage seems high, but the decision for helicopter activation had to be made on the basis of a telephone call only which is a difficult task. In existing literature, percentages of 25-74% of over-triage are felt to be necessary to maintain acceptable levels of under-triage.

It has been acknowledged that patient mortality for severely injured patients correlates inversely with the number of this category of patients treated in a hospital. As almost all helicopter patients were transferred to one of the participating, large trauma hospitals, where for ambulance patients a considerable - but unknown - number of patients were transferred to small, non-participating hospitals and were excluded from this study, the survival benefits that were calculated by de Charro & Oppe might be even an under-estimate of the net effect of the helicopter.

Especially since helicopter involvement did not lead to a net reduction of preclinical time intervals, it is most likely that survival benefits in the helicopter group are caused by the surplus of care provided by the helicopter physician. The possibility that some other, unknown confounders exist cannot be fully ruled out. In an ideal study set-up, patients should be assigned to four different groups prospectively; ambulance care with and without a physician, and helicopter care with and without a physician present. Ethical and logistical difficulties make such a study impossible to perform.

Results suggest that the helicopter trauma team in its present set-up is effective and beneficial for trauma patients.

The impact of all medical routines that are carried out more frequently by the helicopter physician cannot be assessed individually. Since the protocols of ambulance personnel in the Netherlands are highly similar to the ATLS protocols used by the helicopter physician, further implementation of these protocols in daily ambulance care will narrow the gap between helicopter and ambulance care concerning paramedic type interventions. Even with improved ambulance care, paramedic personnel will not be authorised to perform those interventions that are restricted to physicians, such as thoracic drainage and anesthetics, so differences between the two forms of care will persist. Once ambulance care is improved, it would be most interesting to compare the impact of helicopter involvement again, and then the impact of the ‘physician type’ interventions could be evaluated separately.

Although mortality differences could be calculated using a sophisticated model for correction for the selection bias in this non-randomized study, the same was impossible for parameters of clinical condition upon arrival in hospital. The relationship between injury severity scores and mortality is different than between injury severity scores and chances of shock and hypoxia, but so is the time difference between the moment of arrival (‘post trauma’) of helicopter patients and ambulance patients, as well as the fact that some patients in the helicopter group might have reached the hospital alive, where they would have died if only ambulance care would have been provided, inhibited such a comparison. Although clinical condition upon arrival in hospital would theoretically be the best possible instrument with which to measure effectiveness of prehospital care, no such studies exist in which this is used, due to a lack of randomized studies.

Finally, the ethical inhibitions of randomized experiments of helicopter care are discussed. It is stressed that randomized experiments in prehospital care are essential; a basic concept of a randomized helicopter experiment is given.

In Chapter 5 the conclusions and recommendations are given.

As found in the study by de Charro & Oppe, helicopter involvement has shown to lead to a decrease in mortality rate of 12 to 17 percent compared to cases in which ambulance care is given; no difference in quality of life between both groups of patients was found. This alone suggests that care provided by the helicopter team in its present form is a major contribution to the Dutch system of trauma care.

More extensive preclinical care was performed in cases in which the helicopter trauma team was present than in which ambulance personnel alone was present - to such an extent that it can be considered as a fundamentally different approach to preclinical care.

The different kinds of treatment that were performed more frequently by the helicopter physician can be divided into two groups; manoeuvres which a well-trained ambulance crew is also able to perform (‘paramedic type’) - consisting of artificial ventilation, endotracheal intubation, intravenous access, and neck splints - and manoeuvres that are restricted to physicians to be performed (‘physician type’) - consisting of central venous lines, thoracic drains, general anesthesia, and coniotomies. It is important to note that differences were generally found for those interventions that were of a directly life-saving nature.

The fact that these techniques were applied at the scene instead of being postponed until arrival in hospital in association with the observed reduction in mortality, underlines the importance of high quality care at the scene of accident.

As a result of the surplus of care given, preclinical time intervals were prolonged by 15 minutes compared to patients who received only ambulance care.

Physician presence explains the large differences in the preclinical treatment between the two groups of patients. All patients in the ambulance group received at least some form of treatment, so the 'scoop and run' approach seems to have been abandoned. Although improvements have been made in this field, educational and training standards of ambulance personnel should be tightened up further to ensure a higher level of care by ambulance personnel, especially in cases where the helicopter is not available. Differentiation of ambulance crews into different classes according to the level of training might be considered, but this may hardly be an option in rural areas where there is already little choice of ambulances.

Improvement of ambulance personnel's skills will hopefully narrow the gap in 'paramedic type' treatment between helicopter trauma team and ambulance - as long as these are not performed up to desired standards it is unrealistic and even dangerous to extend ambulance training to include the more invasive and difficult 'physician type' interventions as well.

A helicopter trauma team staffed by a physician is therefore of the highest necessity, not only because of its specialisation in this form of treatment, but also because of the unsurpassable experience gained in service.

The combination of both land ambulance and helicopter has proven to be very successful. Having both helicopter and ambulance personnel present at the same time, a large number of life-saving techniques could be carried out within a short time span. In addition, the choice between ambulance and helicopter for patient transfer to hospital existed also, ambulances are more comfortable, whereas the helicopter was used for cases where ambulance transfer would take too long a time.

Although helicopter programs are sometimes criticised for being too expensive, the fact that a single helicopter is able to cover a vast area of land must be considered to act as a method of cost reduction, because to achieve equal response times with land-based trauma teams, many more would be needed that each would individually have less experience.

A helicopter trauma team is only a part of what is needed to reduce trauma mortality and morbidity.

Close cooperation between dispatch centre, ambulance services and the helicopter trauma team is needed to ensure effective on-site cooperation, deployment to those patients who benefit from helicopter care, and to avoid inappropriate cancelling of flights.

The level of education of ambulance personnel should be improved, as well as the communication between hospitals and ambulance personnel.

It is important to realise that bringing advanced care to the scene of accident will only result in a reduction of mortality if continued care in hospital is at an equal level as well. Therefore, all severely injured trauma patients should be transferred to large trauma hospitals, and the specialised trauma centres that will be instituted in the Netherlands are another important asset to optimise care for this category of patients.

It must be stressed that there is still no definitive 'proof' of helicopter trauma team beneficiency given, as only a randomized experiment can claim so. The need for such an experiment is therefore still there, maybe even more than ever before.

Samenvatting - Nederlands

Evaluatie van de onmiddellijke effekten van preklinische behandeling van ernstig gewonde ongevalspatiënten door een helikopter trauma team in Nederland.

In Hoofdstuk 1 wordt eerst het belang van trauma en traumazorg benadrukt.

De incidentie en mortaliteit van trauma vertonen een dalende trend, maar blijven een zeer belangrijke oorzaak van sterfte en lijden, waarbij het in het bijzonder jonge personen betreft.

In 1995 was trauma oorzaak van 5.173 doden en 81.253 verloren levensjaren. De directe medische kosten hieraan verbonden in 1988 waren berekend op 952 miljoen US Dollars, en indirecte kosten bedragen een veelvoud van dit bedrag.

Vermindering van trauma mortaliteit en morbiditeit zal zowel voor het individu als de samenleving baten. Preventie van trauma kan gericht worden op het voorkomen van trauma (primaire preventie), het beperken van de ernst van letsels bij een trauma (secundaire preventie) of het verbeteren van de prognose na een ongeval (tertiaire preventie).

Sterfte na een ongeval kan worden verdeeld over drie pieken, 45% van alle gevallen sterft op de plaats van ongeval ten gevolge van een onoverleefbaar hoge letselernst.

De tweede piek is gedurende de eerste uren volgend op het ongeval, dit is vaak omdat levensreddende behandeling te laat wordt begonnen. De derde piek, die na weken tot maanden volgend op het ongeval plaatsvindt, is vaak ten gevolge van late complicaties, die samenhangen met inadequate medische behandeling, eerder volgend op het ongeval.

Traumazorg is een van de ingewikkeldste en meest uitdagende opgaven in de geneeskunde. Het doel van de aanvankelijke behandeling is om de vitale functies, bestaande uit ademhaling, circulatie en bewustzijn te bewaken en in stand te houden.

Een groot aantal technieken kan worden toegepast ter plaatse voor ernstig gewonde ongevalsslachtoffers, waarin met name ‘advanced airway management’, ‘circulatory management’, anesthesie en stabilisatie van fracturen een belangrijke rol spelen.

In het bijzonder is de conditie van de patiënt in het eerste uur volgend op het trauma van cruciaal belang voor de latere prognose; om deze reden staat dit uur ook wel bekend als ‘het gouden uur’.

Zorg voor ongevalsslachtoffers dient zo spoedig mogelijk te beginnen. Om maximaal resultaat te behalen zou behandeling reeds voor aankomst in het ziekenhuis, in dit gouden uur, moeten beginnen.

Ongevalsslachtoffers in Nederland worden doorgaans per ambulance naar het ziekenhuis gebracht. De bemanning van een ambulance bestaat uit een chauffeur en een ambulanceverpleegkundige. De minimale opleidingseisen voor ambulanceverpleegkundigen zijn pas onlangs verhoogd van een standaard eerste hulp diploma tot registratie als verpleegkundige met een aanvullende opleiding tot ambulancebegeleider. Echter nog steeds bestaan er grote verschillen in de kwaliteit van de ambulancehulpverlening. De frequentie waarin ambulancepersoneel in aanraking komt met ernstig gewonde ongevalsslachtoffers in de dagelijkse praktijk is te laag om adequate vaardigheden op dit gebied te behouden.

Ambulance protocollen zijn de afgelopen jaren geïntroduceerd, waaronder ook protocollen betreffende traumazorg, maar de invloed hiervan op de praktisch geboden zorg is nog niet duidelijk.

Trauma teams, bestaande uit ziekenhuisartsen en verpleegkundigen, zijn in Nederlands als ‘LOTT-teams’ in 1982 geïntroduceerd en waren oorspronkelijk bedoeld om medische hulp te bieden in gevallen van calamiteiten en rampen, maar ook voor enkelvoudige ernstige ongevalsslachtoffers.

Logistieke problemen alsmede onduidelijke indicaties voor het inzetten van deze teams hadden tot gevolg dat het gebruik van deze teams in de praktijk zeer beperkt bleef. In juli 1998 werd de financiële steun voor deze teams beëindigd en tot op heden is niet bekend hoe de toekomst van zulke traumateams in Nederland zal zijn.

Ambulancecentrales, Centrale Posten Ambulancevervoer (CPA’s) zijn verantwoordelijk voor het afhandelen van de binnenkomende telefonische spoedoproepen en coördineren de bewegingen van ambulancevoertuigen. Momenteel bestaan wettelijk gezien nog geen minimale opleidingseisen die aan deze centralisten gesteld worden en vele centralisten hebben noch ambulance- noch verpleegkundige ervaring. Het gebruik van protocollen, zoals dat in de Verenigde Staten tot de routine behoort, is in Nederland nog geen standaard procedure.

Ziekenhuizen spelen een sleutelrol in de traumazorg. Adequate faciliteiten, personeel, en ervaring moeten aanwezig zijn in een ziekenhuis om ernstig gewonde ongevalsslachtoffers goed te kunnen behandelen. In Duitsland en in delen van de Verenigde Staten is de traumazorg geregionaliseerd en zijn er gespecialiseerde traumacentra aangewezen. Op deze wijze worden fondsen en ervaring geconcentreerd in een beperkt aantal ziekenhuizen. De ervaringen met deze wijze van zorgverdeling zijn zeer gunstig ten aanzien van de prognose voor de patiënten, maar in Nederland bestaan dergelijke centra niet.

In mei 1995 ging een studie van start waarin een helikopter trauma team, waar ook een arts van deel uit maakt, gestationeerd werd op de helikopterbasis op het dak van het Academisch Ziekenhuis Vrije Universiteit in Amsterdam. Het trauma team was permanent paraat om ernstig gewonde slachtoffers ter plaatse te behandelen.

Helikopters als vervoermiddel hebben als voordeel de grote snelheid van transport, zodat slechts een enkele helikopter een groot gebied aan land kan bestrijken. Daarnaast kunnen helikopters ook op plaatsen landen die niet of moeizaam over land zijn te bereiken.

Aanwezigheid van een arts in de samenstelling van het trauma team werd in de literatuur door sommige auteurs geassocieerd met een reductie van de trauma sterfte vergeleken bij teams die niet de beschikking over een arts hadden, terwijl andere auteurs geen verschillen in prognose vonden.

De aanwezigheid van een ervaren en gespecialiseerde arts, zoals dat in de huidige opzet het geval was, verzekert echter de hoogste standaard van expertise en zorg.

De veiligheid van helikopter transport moet een belangrijk onderwerp blijven; het is evenwel moeilijk vergelijkingen te maken tussen de veiligheid van helikopters en weg-ambulances.

Helikopters en andere luchtvaartuigen kennen een lange historie binnen de geneeskunde. In 1972 startte het eerste ziekenhuis helikopterprogramma in Denver, Colorado.

Momenteel zijn er circa 200 helikopter programma's actief in de Verenigde Staten, en in vele Europese en andere niet Europese landen bestaan eveneens dergelijke programma's.

In de Verenigde Staten is slechts in 6% van de programma's een arts aan boord, terwijl dit in Duitsland op alle helikopters het geval is.

In Nederland werd tot aan het begin van de proef met de helikopter aan het Academisch Ziekenhuis Vrije Universiteit slechts sporadisch gebruik gemaakt van helikopters voor medische doeleinden.

De invoering van de helikopter werd met enige scepsis ontvangen, in het bijzonder vanwege de hoge kosten die ermee gemoeid zijn. Onlangs heeft de Nederlandse regering besloten vier traumahelikopters in te voeren om het gehele land te voorzien in deze zorg en zullen er tien ziekenhuizen worden aangewezen om als traumacentra te fungeren.

Het ontbreken van conclusieve studies samen met de onmogelijkheid buitenlandse resultaten in de Nederlandse situatie te gebruiken, maakte het noodzakelijk een studie uit te voeren naar de effecten. De Charro & Oppe hebben een studie verricht van de effectiviteit van hulpverlening per helikopter op de mortaliteit, kwaliteit van leven, kosten en kosteneffectiviteit.

In deze aanvullende studie zijn de onmiddellijke effecten van helikopter-hulp geanalyseerd, waarbij gebruik werd gemaakt van dezelfde studie-opzet als gebruikt door de Charro & Oppe. Het doel van deze studie is om vast te stellen welke effecten het helikopter trauma team heeft op de preklinische behandeling, het preklinische tijdsverloop en de klinische conditie van patiënten bij opname, in het bijzonder in relatie tot de resultaten van de Charro & Oppe.

In Hoofdstuk 2 wordt de studie beschreven.

Een helikopter trauma team, bestaande uit een piloot, een trauma verpleegkundige en een ervaren chirurg of anesthesioloog was permanent paraat op de helikopterbasis op het dak van het Academisch Ziekenhuis Vrije Universiteit te Amsterdam.

Tijdens daglicht was het mogelijk om binnen twee minuten volgend op een oproep op te stijgen en ieder punt binnen een straal van 50 kilometers in minder dan 15 minuten te bereiken.

De helikopter werd ingezet door de CPA centralisten voor alle noodmeldingen die suggestief waren voor ernstige letsels, maar ook door de ambulancebemanning als die eenmaal ter plaatse vaststelde dat assistentie noodzakelijk was.

In alle gevallen werd tevens een ambulance naar de plaats van ongeval gestuurd, en hoewel de helikopter in staat was patiënten te vervoeren, gebeurde dit gewoonlijk door ambulances.

De twee scoringsschalen voor letselernst die in deze studie gebruikt werden (Revised Trauma Score en Injury Severity Scale), worden uitgelegd. Alleen patiënten die ofwel een RTS voor aankomst in het ziekenhuis van 10 of lager hadden, of een ISS in het ziekenhuis van 16 of hoger en zijn behandeld in een van acht deelnemende grote trauma ziekenhuizen zijn in deze studie opgenomen.

In Hoofdstuk 3 worden de resultaten gepresenteerd.

Het helikopter trauma team ontving 1168 oproepen voor inzet gedurende de eerste 20 maanden van de studie. In 42,9% van alle gevallen werden de vluchten voortijdig afgebroken ('gecancelled').

De gemiddelde tijd om op te kunnen stijgen was 2,3 minuut, de gemiddelde afstand van de helikopterbasis tot de plaats van ongeval bedroeg 22,1 kilometer.

517 patiënten voldeden aan alle inclusie criteria, van wie er 307 uitsluitend ambulancehulpverlening ontvingen en 210 patiënten zorg door het helikopter team.

In het algemeen waren de patiënten jong (gemiddelde leeftijd 38,5 jaar) en van het mannelijke geslacht.

Verkeersongevallen vormden de meest voorkomende groep ongevallen, gevolgd door huiselijke ongevallen en geweldsdelicten.

De gemiddelde RTS scores van de ambulance en helikopterpatiënten verschilden niet significant, en de onaangedane score van 12 was de meest voorkomende.

Helikopterpatiënten hadden een gemiddeld hogere ISS score (28,6 vs. 25,5, $p<0.01$) dan ambulancepatiënten.

Hoge ISS scores correleerden met een hogere mortaliteit. De Stichting Wetenschappelijk Onderzoek Verkeersveiligheid (SWOV) en het Centrum voor GezondheidszorgBeleid en Recht (CGBR) berekenden de besparing van mortaliteit door middel van een geavanceerd statistisch model, genaamd 'CANALS' voor dezelfde patiëntengroep als in deze studie. Vergeleken bij de groep die uitsluitend ambulancehulpverlening heeft ontvangen was de mortaliteit bij de helikopterpatiënten 12 tot 17 procent lager, afhankelijk van een minimaal en maximaal berekeningsmodel, ofwel 6 of 7 levens die in deze groep gespaard zijn.

In het maximale model was de besparing van mortaliteit bijna uitsluitend toe te schrijven aan de groep van verkeersslachtoffers.

De reductie van mortaliteit vond niet plaats in de groep patiënten met de hoogste sterftekans, noch in die van de laagste, maar in de groep tussen deze twee extremen.

Gemiddelde sterftekans was het grootste in de groep 'overige ongevallen', gevolgd door huiselijke ongevallen en geweldsdelicten. De mortaliteit was het hoogst in de groep patiënten van 60 jaar en ouder en jonge kinderen.

Medische behandeling voor aankomst in het ziekenhuis kan worden onderverdeeld in twee categorieën; handelingen die, in Nederland, ook door goed opgeleid ambulancepersoneel verricht kunnen worden ('paramedisch type'), en handelingen die voorbehouden zijn aan artsen ('medisch type').

De preklinische behandeling is vergeleken voor beide groepen patiënten. De behandeling van ambulancepatiënten is geïnventariseerd door gebruik te maken van ambulanceritformulieren, en die van helikopter patiënten door gebruik te maken van ambulanceritformulieren, helikopterformulieren en een combinatie van beide.

Voor alle patiënten zijn zeer belangrijke verschillen gevonden in frequentie waarin intraveneuze infusen werden toegediend. Bijna alle helikopterpatiënten ontvingen tenminste een infuus, terwijl dit percentage slechts boven de 80% lag bij de ambulancepatiënten. Tevens werden verschillen gevonden in de frequentie van beademing en intubatie; dit laatste werd toegepast in meer dan 50 procent van alle gevallen van helikopterinzet, en

in slechts 5,4 procent van de helikopterpatiënten. Ook nekspalken werden meer frequent toegepast in gevallen van helikopterinzet dan bij uitsluitend ambulance hulpverlening

Wat betreft de 'medisch type' interventies, die alleen plaats hebben gevonden bij de helikopterpatiënten, werd in 9,3% van de gevallen thoraxdrains ingebracht, en anesthesie werd in 46,1% van de gevallen gegeven, hetgeen ook bij niet comateuze patiënten intubatie mogelijk maakt.

Er hoefden in de groep onder studie geen amputaties verricht te worden. In 9,8% van de patiënten werden fracturen gereponeerd. In een enkel geval is een coniotomie verricht en in een ander geval invasieve meting van de arteriële bloeddruk.

De 'paramedische type' handelingen werden gestratificeerd naar ISS klasse. Algemeen werden er in beide groepen patiënten bij hogere ISS graad meer handelingen uitgevoerd dan bij lagere ISS. Echter, de verschillen tussen helikopter en ambulance groep bleven significant voor de gevallen dat beademing en intubatie werd uitgevoerd en infusen en nekspalken werden gebruikt in alle categorieën. Met uitzondering van de frequentie van infuus bleven de verschillen significant ook in de groep patiënten met de hoogste letselernst.

Analyse van die patiënten die zich op de plaats van ongeval in een staat van haemodynamische shock bevonden, leert dat in de ambulancegroep zelfs in de groep met de laagste bloeddruk de frequentie van het inbrengen van infuus niet hoger is dan 85,5%, terwijl bijna alle patiënten in de helikopter groep een infuus ontvingen.

Beademing werd vaker toegepast in de helikoptergroep dan in de ambulancegroep; het meest uitgesprokene was dit het geval in de groepen die een normale, of matig veranderde ademhalingsfrequentie vertoonden. Intubatie in de ambulancegroep is bijna uitsluitend voorbehouden voor die gevallen waarin patiënten een zeer afwijkende ademhalingsfrequentie vertoonden (9 per minuut of lager), maar ook dan in een significant lagere mate dan bij inzet van het helikopter team in welke gevallen de intubatiefrequentie bijna 100% is voor deze patiënten en 40,7% voor de patiënten met een normale ademhalingsfrequentie.

De frequentie van toepassing van beademing en intubatie vertoont een negatief verband met de hoogte van de Glasgow Coma Scale scores. In alle categorieën worden er door het helikopter trauma team meer intubaties verricht dan door de ambulancebemanning, en van speciaal belang is het op te merken dat intubatie bij ambulancepatiënten uitsluitend uitgevoerd is bij patiënten met een Glasgow Coma Scale van lager dan 8.

De frequentie waarin nekspalken werden toegepast in de ambulancegroep nam niet toe met dalende Glasgow Coma Scale scores, integendeel -

bij comateuze patiënten was het gebruik van nekspalken zelfs minder frequent dan bij niet comateuze patiënten. In de helikoptergroep is de frequentie van de nek spalken het hoogst in de comateuze categorie van patiënten en in alle subgroepen hoger dan bij de ambulancepatiënten.

Aparte analyse van patiënten met ernstige neurologische, respiratoire, cardiovasculaire en extremiteitsletsels laat een vergelijkbaar beeld zien; infusen, intubatie, beademing en nek spalken vinden vaker toepassing in de helikoptergroep dan in de ambulancegroep.

In het bijzonder interessant is het dat spalken voor de patiëntengroep als geheel niet significant vaker werden toegepast in de helikoptergroep dan in de ambulancegroep, terwijl dit in de groep van patiënten met ernstig extremiteitsletsel juist vaker is toegepast in de helikoptergroep dan in de groep van ambulance patiënten met een vergelijkbare ernst van extremiteitsletsel. Dit toont aan dat ambulancepersoneel vaker bij minder ernstig extremiteitsletsel een spalk aanbrengt, terwijl het helikopter team spalken voornamelijk voor de ernstigste groep gebruikt.

Het preklinische tijdsverloop verschilt tussen ambulance en helikopterpatiënten. De extra handelingen die in gevallen van helikopterinzet werden verricht, leidden tot een verlenging van de tijd die op de plaats van ongeval werd doorgebracht met gemiddeld ongeveer 15 minuten. De tijd die nodig was om ter plaatse te komen en de tijd tussen vertrek met de patiënt en aankomst in het ziekenhuis verschilde niet significant.

Het vaakst werden patiënten naar het ziekenhuis vervoerd in een ambulance met aanwezigheid van de helikopterarts (60%). Slechts in 11,4% van alle gevallen vond het vervoer naar het ziekenhuis plaats per helikoper en dit betrof een groep patiënten met een significant lagere RTS score dan die patiënten die over de weg werden vervoerd.

Daarna wordt een overzicht gegeven van de klinische conditie bij aankomst in het ziekenhuis van 77 helikopterpatiënten die naar het VU Ziekenhuis zijn vervoerd.

Zuurstofsaturatie, systolische bloeddruk, en Base Excess worden beschreven bij deze groep patiënten. De meeste patiënten die lage zuurstofsaturatie of systolische bloeddruk hadden, hadden lage RTS scores op de plaats van ongeval.

De meeste patiënten arriveerden in het ziekenhuis met saturatie ≥90% en systolische bloeddruk ≥90 mmHg. Een kleiner aantal patiënten arriveerde in het ziekenhuis zonder meetbare bloeddruk. Weinig patiënten waren in de middengroep tussen deze twee extremen.

Slachtoffers van verdrinking hadden een slechte prognose en vormden een aparte groep binnen de groep van patiënten.

Tenslotte wordt een samenvatting gegeven van de resultaten van de studie van de Charro & Oppe:

Met behulp van een geavanceerd statistisch model, CANALS geheten, werd gecorrigeerd voor verschillen tussen ambulance- en helikopterpatiënten. Deze methode wordt in Hoofdstuk 3 in detail beschreven. De resultaten van deze analyse tonen dat de mortaliteit in de helikoptergroep 12% (in een ‘minimaal’ model) tot 17% (in een ‘maximaal’ model) vermindert. De reduktie aan sterfte vond bijna uitsluitend plaats in de groep patiënten na verkeersongevallen. Patiënten met een zeer hoge letselernst, alsook patiënten met geringe letsels hadden weinig baat van helikopter-inzet; juist in de ‘kritieke groep’ tussen deze extremen werd de daling van sterfte gevonden.

432 patiënten werden geïnterviewd, 9 en 15 maanden volgend op het ongeval. Er werd gebruik gemaakt van de Short Form 36 en de Euroqol 5D vragenlijsten. Analyse van de kwaliteit van leven liet geen verschillen zien tussen ambulance- en helikopterpatiënten.

De kosten van initiële ziekenhuisopname van een ernstig gewonde patiënt zijn geschat op circa 36.000 Nederlandse gulden; er werden echter geen verschillen gevonden tussen de ambulance- en helikoptergroep hierin. De kosten van een enkel, uitsluitend tijdens daglicht opererend, helikopterteam zijn circa 4.5 miljoen Nederlandse Gulden. De kosten per gewonnen levensjaar bedragen tussen de 33.000 en 63.000 Nederlandse gulden, afhankelijk van de effectiviteit van inzet van de helikopter, als er geen rekening wordt gehouden met de reductie van levenskwaliteit van de overlevenden, en tussen 44.000 en 83.000 Nederlandse Gulden, als dit wel in de berekening is opgenomen.

In Hoofdstuk 4 worden de resultaten besproken.

De gegevens betreffende de medische behandeling die door het helikopter team is uitgevoerd werden prospectief verzameld waarbij gebruik werd gemaakt van speciaal voor dit doel ontwikkelde onderzoeksformulieren. De gegevens over de ambulancehulpverlening werden hoofdzakelijk retrospectief verzameld en standaard ambulance ritformulieren werden gebruikt voor de analyse.

Deze ambulance ritformulieren zijn niet speciaal voor onderzoeksdoeleinden ontwikkeld en werden dikwijls met minder nauwkeurigheid ingevuld dan de helikopterformulieren.

Betreffende identieke patiënten werden er verschillen gevonden in de medische behandeling zoals beschreven door helikopterarts en ambulancepersoneel.

Een gedeelte van de verschillen kan wellicht verklaard worden door het feit dat bepaalde handelingen inderdaad verricht zijn door één van beide teams, zonder dat het andere team hierbij betrokken was, maar de verschillen zijn daarnaast waarschijnlijk ook indicatief voor de inaccuraatheid van de gegevens die door het ambulancepersoneel is verstrekt.

De inaccuraatheid van de ambulancegegevens in de helikoptergroep is waarschijnlijk een overschatting van de inaccuraatheid van de gegevens van de ambulancepatiënten. Herberekening van de waarden die zijn gevonden voor de verschillende handelingen waarbij gebruik wordt gemaakt van deze overschatte foutmarge toont dat de verschillen in de behandelingsfrequentie tussen helikopterpatiënten en ambulancepatiënten significant blijven voor beademing, intubatie, infuus, en nekspalken. Daarom mag worden geconcludeerd dat de geobserveerde verschillen wat betreft deze belangrijke en direct levensreddende handelingen berusten op daadwerkelijke verschillen.

Het is opvallend hoe weinig wetenschappelijk onderzoek er bestaat op het gebied van preklinische (ambulance) zorg, zeker gelet op het grote belang van deze vorm van zorg. Logistieke problemen die ondervonden worden in dit soort onderzoek zouden verantwoordelijk kunnen zijn voor het gebrek aan kwalitatieve studies.

De rol van een arts in een helikopter team wordt door enkele, maar niet alle auteurs geassocieerd met een vermindering van sterftekans. In onderzoek, waarin team samenstelling met en zonder arts wordt vergeleken, moet goed rekening worden gehouden met het niveau van opleiding en ervaring van de betrokken artsen en verpleegkundigen. Een vergelijking tussen een ruim ervaren arts en een laag opgeleide verpleegkundige zal een groter verschil kunnen laten zien op overleving dan een vergelijking tussen een onervaren arts en een gespecialiseerd en hoog opgeleide verpleegkundige.

De keuze voor een ervaren en gespecialiseerd chirurg of anesthesioloog in de samenstelling van het helikopter team verzekert echter de best mogelijke zorg op de plaats van ongeval.

Helikopter programma's hebben de grootste kans van slagen als hun doel helder gedefinieerd is.

In uitgestrekte, landelijke gebieden met een slechte infrastructuur kunnen voordelen alleen al afkomstig zijn door de grotere snelheid van vervoer. In deze set-up ligt de nadruk erop om de snelheid van vervoer naar een ziekenhuis te verhogen, meer dan op de behandeling ter plaatse.

In Nederland, gelet op de geringe afstanden, goede weg infrastructuur, snelle en het gehele land omvattende beschikbaarheid van met verpleegkundigen bemande wegambulances en een dicht netwerk van ziekenhuizen, zou gebruik van helikopters voor patiëntentransport in de meeste gevallen alleen leiden tot marginale reductie van het preklinische tijdsinterval. Onder deze omstandigheden zullen de voordelen van het gebruik van een helikopter afkomstig moeten zijn van de mogelijkheid om geavanceerde

medische hulp te verlenen op de plaats van ongeval die op andere wijze niet verricht kan worden door uitsluitend ambulancepersoneel.

Voor de effectiviteit van het helikopter programma is essentieel dat de helikopter wordt ingezet voor die patiënten die er daadwerkelijk baat bij hebben dat er een arts aanwezig is, en dat het aantal onnodige vluchten beperkt blijft. Tijdens deze studie is 42,9% van de vluchten voortijdig afgebroken. Dit percentage lijkt hoog, maar de beslissing om de helikopter in te zetten wordt gemaakt op grond van uitsluitend een telefonische melding, hetgeen een juiste inschatting van de toedracht en te verwachten letselernst bemoeilijkt. In de literatuur worden percentages van 25 tot 74 procent overtriage noodzakelijk gevonden om acceptabele niveaus onder triage te hebben.

Het is erkend dat de mortaliteit van ernstig gewonde ongevalsslachtoffers invers correleert met de aantallen van deze patiënten die in een ziekenhuis worden behandeld. Omdat bijna alle helikopterpatiënten naar één van de acht deelnemende, grote trauma ziekenhuizen zijn gebracht, maar een aanzienlijk - maar onbekend - deel van de ambulancepatiënten ook naar andere, kleine niet deelnemende ziekenhuizen zijn gebracht en derhalve uit de studie zijn geëxcludeerd, is de reductie van mortaliteit zoals die door de Charro & Oppe is berekend, mogelijk slechts een onderschatting van het daadwerkelijke 'helikopter-effect'.

In het bijzonder omdat het inzetten van de helikopter de gemiddelde tijdsduur tussen ongeval en aankomst in het ziekenhuis van patiënten niet heeft bekort, maar zelfs heeft verlengd, is het meest waarschijnlijke dat de beperking van de mortaliteit veroorzaakt is door de extra behandelingen die ter plaatse door de helikopterarts zijn uitgevoerd. De mogelijkheid dat er nog andere, onbekende, confounders bestaan, kan echter niet volledig worden uitgesloten. Voor een ideale studieopzet zouden prospectief patiënten gerandomiseerd moeten worden toegewezen aan vier groepen, ambulancehulp met en zonder arts, helikopterhulp met en zonder arts. Ethische en logistieke problemen maken de uitvoering van een dergelijke studie echter onmogelijk. Er kan en moet echter worden geconcludeerd dat in de huidige opzet helikopterhulpverlening effectief en voor de patiënten van gunstige waarde is.

De invloed van alle afzonderlijke handelingen die door de helikopterarts meer worden verricht in vergelijking tot de ambulanceverpleegkundige kan niet worden bepaald in deze studie. Aangezien de protocollen die het ambulancepersoneel gebruikt in hoge mate gelijk zijn aan de ATLS protocollen die het helikopterteam gebruikt, valt te verwachten dat een verdergaande implementatie van deze protocollen het verschil tussen ambulancehulpverlening en helikopterhulpverlening verkleinen zal. Echter, zelfs bij meer intensieve ambulancezorg zullen ambulanceverpleegkundigen niet geautoriseerd zijn om die handelingen te verrichten die uitsluitend aan artsen voorbehouden zijn. Als ambulancezorg veranderd is, zal het zeer interessant zijn nogmaals het effect van helikopterinzetten te bepalen, waarbij in dat geval de afzonderlijke invloed van de 'medisch type' handelingen bepaald kan worden.

Tenslotte wordt besproken waarom het onmogelijk is om een vergelijking te maken tussen helikopterpatiënten en ambulancepatiënten in de conditie bij aankomst in het ziekenhuis. Meting van de conditie bij aankomst in het ziekenhuis zou theoretisch een uitstekende methode zijn om de effectiviteit van preklinische hulpverlening vast te stellen. Echter, door de non gerandomiseerde inzet van de helikopter, hadden helikopterpatiënten gemiddeld een hogere letselernst. Daarvoor is bij de mortaliteitsanalyse met behulp van gesofisticeerde technieken gecorrigeerd. Nu is er voor de mortaliteit te corrigeren omdat patiënten gescoord zijn op letselernstschalen die voorspellend zijn voor overlijden, maar de relatie met shock en hypoxie is waarschijnlijk heel anders. Bovendien waren er verschillen in het moment dat helikopterpatiënten en ambulancepatiënten 'post trauma' in het ziekenhuis arriveerden en is er de mogelijkheid dat bepaalde patiënten uitsluitend doordat er helikopterhulp is verleend nog levend het ziekenhuis bereikten, terwijl als er uitsluitend ambulancehulp verleend zou zijn de patiënten voor aankomst al zouden zijn overleden. Vanwege deze redenen is het helaas niet mogelijk om op dit niveau een vergelijking te maken van de effectiviteit van de helikopterhulpverlening.

Tenslotte worden de ethische bezwaren met gerandomiseerde helikopterstudies besproken. Het wordt benadrukt dat gerandomiseerde studies essentieel zijn in de preklinische hulpverlening. Een basis-concept voor zo een gerandomiseerde studie wordt gegeven.

In Hoofdstuk 5 worden conclusies en aanbevelingen gegeven.

Zoals in de studie van de Charro & Oppe is gevonden, is inzet van de helikopter geassocieerd met een daling van de mortaliteit van 12 tot 17 procent vergeleken met die gevallen waarin uitsluitend ambulancehulpverlening werd gegeven. Geen verschillen werden gevonden in de kwaliteit van leven bij de twee groepen overlevenden. Alleen dit al suggereert dat de hulp die wordt verleend door het helikopter trauma team een belangrijke aanvulling is op het systeem van de Nederlandse traumazorg.

Meer uitvoerige preklinische zorg werd verleend door het helikopter trauma team vergeleken bij die gevallen waarin uitsluitend hulp door ambulancepersoneel is gegeven - de verschillen zijn dermate groot dat er gesproken kan worden van een fundamenteel andere aanpak van preklinische zorg.

De verschillende vormen van behandeling die door de helikopterarts vaker zijn uitgevoerd kunnen verdeeld worden in twee verschillende groepen. Die handelingen die door een goed opgeleide ambulancebemanning alleen ook uitgevoerd kunnen worden, beademing, intubatie, infuus, en nekspalken, en die handelingen die voorbehouden zijn aan artsen, bestaande uit centraal veneuze lijnen, thoraxdrainage, anesthesie, en coniotomieën. Het is belangrijk dat in het algemeen de verschillen juist voor die handelingen werden gevonden die het vitaal functioneren het meest direct beïnvloeden.

Het feit dat deze handelingen reeds op de plaats van ongeval werden verricht in plaats van later, na aankomst in het ziekenhuis, samen met de geobserveerde reductie van mortaliteit benadrukt het belang van een hoge kwaliteit van zorg op de plaats van ongeval.

Doordat er meer handelingen ter plaatse werden uitgevoerd, duurde de preklinische tijd (tussen ongeval en aankomst in het ziekenhuis) gemiddeld ruim 15 minuten langer vergeleken met patiënten die uitsluitend ambulancezorg ontvingen.

De aanwezigheid van een arts is verantwoordelijk voor de grote verschillen in behandeling die zijn gevonden. Alle patiënten in de ambulancegroep ontvingen tenminste enige therapie ter plaatse, zodat mag worden geconcludeerd dat de aanpak van 'scoop and run' is verlaten. Hoewel er al vele verbeteringen hebben plaatsgevonden op dit gebied, zou het niveau van opleiding en training van ambulancehulpverleners verder moeten verbeteren om een hogere kwaliteit van zorg te garanderen. Differentiatie van ambulances naar de graad van training zou een mogelijkheid kunnen zijn, maar met name in plattelandsgebieden met ab ovo al een geringe keuze uit ambulances is dit wellicht geen optie.

Verbetering van de vaardigheden van het ambulancepersoneel zal het verschil wat betreft de 'paramedisch type' handelingen tussen ambulancezorg en helikopterzorg verkleinen. Echter zeker zolang deze nog niet op het gewenste niveau worden uitgevoerd, is het onwenselijk en zelfs gevaarlijk de training van ambulancepersoneel verder uit te breiden met de meer invasieve en ingewikkelde 'medisch type' interventies.

Daarom is een helikopterteam waar een arts deel van uitmaakt noodzakelijk, en niet alleen vanwege diens specialisatie in deze vorm van behandeling, maar ook vanwege de niet te evenaren mate van ervaring die tijdens diens werk wordt verkregen.

De combinatie van zowel wegambulance en helikopter heeft bewezen zeer succesvol te zijn. Met beide bemanningen ter plaatse kon een groot aantal levensreddende handelingen in een kort tijdsbestek worden uitgevoerd. Ook bestond zo de keus van vervoermiddel naar het ziekenhuis,

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waarbij de ambulances meer comfort boden, en de helikopter kon worden gebruikt voor die gevallen waarin ambulancevervoer een te lange tijd zou duren.

Hoewel helikopterprogramma's soms de kritiek krijgen dat deze te duur zijn, moet er ook rekening worden gehouden met het feit dat één enkele helikopter een groot gebied kan bestrijken en dit zo tot kostenbesparing leidt. Met - als alternatief - trauma teams die over land-transport beschikken zouden er hiervan vele nodig zijn om dezelfde aanrijtijden te garanderen en bovendien zouden deze trauma teams ieder minder ervaring opdoen.

Een helikopter trauma team is slechts een onderdeel van dat wat nodig is om trauma mortaliteit en morbiditeit te reduceren. Nauwe samenwerking tussen CPA, ambulancediensten en helikopter trauma team is noodzakelijk om te komen tot een effectieve samenwerking ter plaatse, en tot die inzetten te komen waar patiënten van profiteren, en onterechte cancellingen van vluchten te voorkomen.

Het niveau van opleiding van ambulancepersoneel dient te worden verhoogd, alsmede de communicatie tussen ziekenhuizen en ambulancepersoneel.

Het is belangrijk te realiseren dat het uitvoeren van geavanceerde medische zorg op de plaats van ongeval alleen zinvol is als de zorg die in het ziekenhuis wordt voortgezet van gelijke kwaliteit is. Daarom zouden alle ernstig gewonde patiënten naar grote trauma ziekenhuizen moeten worden vervoerd en de gespecialiseerde trauma centra die binnenkort worden opgericht in Nederland om de zorg voor deze categorie patiënten verder te optimaliseren moeten daarom ook worden beschouwd als een aanwinst.

Het blijft echter belangrijk dat het ' bewijs' van de effectiviteit van helikopter trauma teams nog niet is gegeven; alleen een gerandomiseerde studie kan dat pretenderen, de noodzaak hiervoor is dan ook, misschien wel meer dan tevoren, aanwezig.

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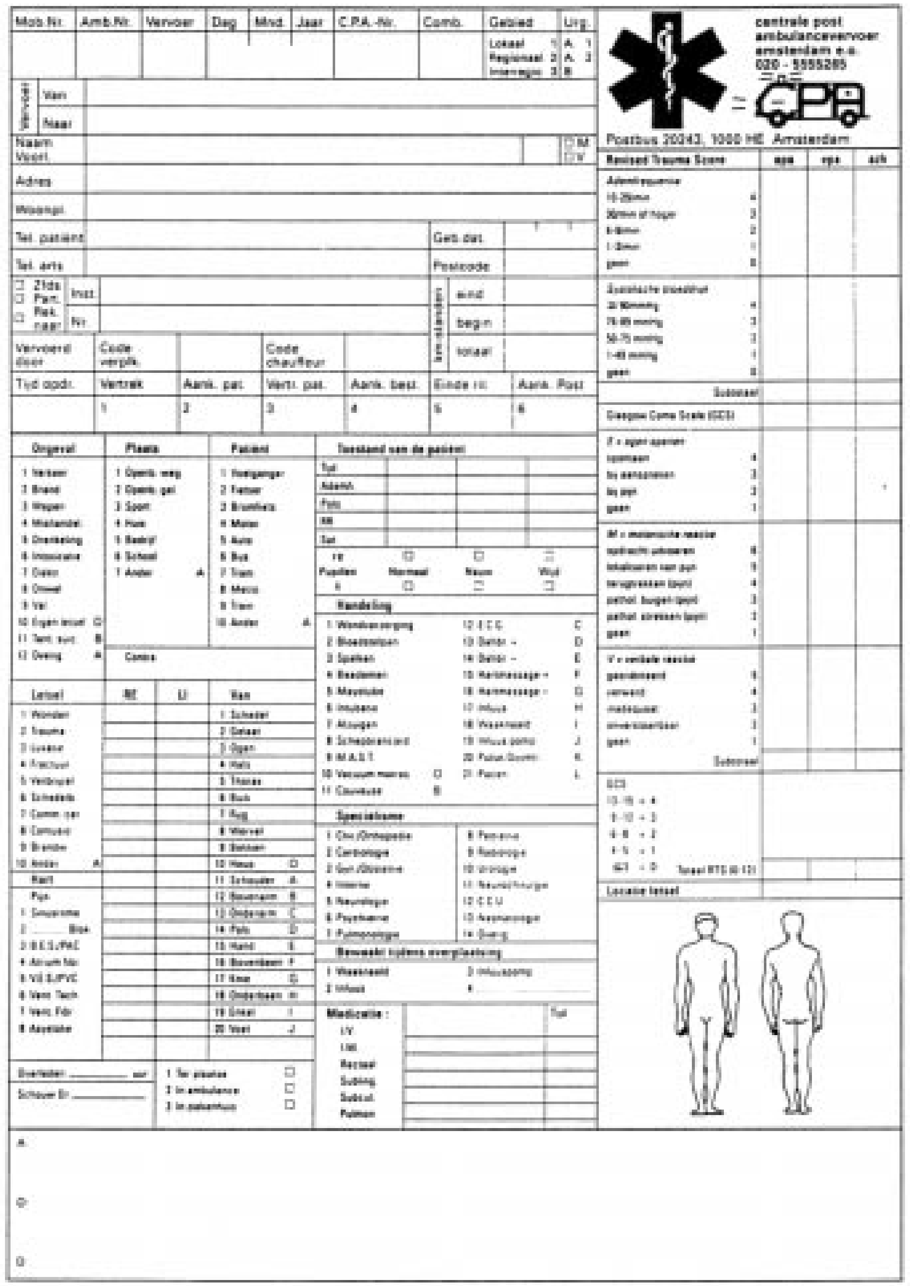
Supplements



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								Lokaal 1 / Regionaal 2 / Interregio 3	A 1 / A 2 / B

centrale post ambulancevervoer amsterdam e.o. 020 - 5555285

CPA

Postbus 20243, 1000 HE Amsterdam

Vervoer: Van / Naar

Naam / Voorl. — M / V

Adres

Woonpl.

Tel. patiënt — Geb.dat.

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Vervoerd door — Code verpl. — Code chauffeur

Tijd opdr.	Vertrek	Aank. pat.	Vertr. pat.	Aank. best.	Einde rit	Aank. Post
	1	2	3	4	5	6

Revised Trauma Score

Ongeval — Plaats — Patiënt — Toestand van de patiënt

Handeling — Specialisme — Medicatie

Letsel

Glasgow Coma Scale (GCS)

Locatie letsel

Bestemd CPA

Supplement 1: Example of an ambulance run report as issued by ambulance services in Amsterdam and surroundings.

Supplement 2: Area of service of the Trauma Helicopter

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About the author

Bernard Hübner was born on May 11th, 1971, in Amsterdam, the Netherlands. He attended secondary school at the Ignatius Gymnasium in Amsterdam, where he finished in 1989.

The same year he started to study Medicine at the Vrije Universiteit in Amsterdam.

During his study, he completed additional internships in Traumatology, Vascular Surgery and Urology. In 1996 he obtained his medical degree.

Following this, he joined the research team of the SWOV and CGBR for the study of the trauma helicopter. After completing his part of the project in June 1997, for a short period he was employed as an occupational health physician at the GG&GD in Amersfoort and Soest.

In September 1997 he returned to work in a hospital, as a physician at the Emergency and Accident Department of the Waterlandziekenhuis in Purmerend.

From February 1998 onward, he has worked full-time as a researcher on the current thesis at the University Hospital Vrije Universiteit in Amsterdam. In addition, he worked at the Emergency and Accident Department as well.

He lives in Amstelveen, together with his girlfriend Margreet.