Chapter 10

English Summary
Summary
In the present dissertation we investigated current practice of prehospital emergency care in patients with moderate or severe traumatic brain injury (TBI) in the Netherlands. We particularly focused on the deployment of Advanced Life Support by a physician-based helicopter emergency service and airway management as prehospital intervention modality in relation to patient survival. We further evaluated the impact of hemostatic abnormalities on outcome after severe neurotrauma.

In Chapter 1 we provide an introduction to the aim of this thesis in the context of the guidelines of the Brain Trauma Foundation, and include the study objectives.

Chapter 2 gives an overview of current opinion and recent literature regarding different modalities of basic and advanced prehospital life support in severe traumatic brain injury. The potential advantages of Advanced Life Support over Basic Life Support are described, with particular focus on prehospital endotracheal intubation and subsequent adequate mechanical ventilation. The overview reveals the importance of the prevention of hypoventilation, hyperventilation and hyperoxemia, and describes the role of prehospital volume resuscitation and hemostatic derangements in patient outcome after severe traumatic brain injury. Finally, this chapter emphasizes that the benefit of prehospital endotracheal intubation in patients with severe traumatic brain injury is likely to depend on multiple factors, such as the organization of the prehospital care system, the training and competence level of Emergency Medical Service providers and the expected prehospital run time.

Chapter 3 describes the findings of a retrospective single center investigation of patients with moderate to severe traumatic brain injury admitted to a level 1 trauma center (VU University Medical Center Amsterdam) between 2003 and 2007. This study investigated whether patients with severe traumatic brain injury were treated according to current prehospital treatment guidelines as published by the Brain Trauma Foundation. These guidelines recommend prehospital endotracheal intubation in all patients with suspected traumatic brain injury and a Glasgow Coma Scale score equal or less than 8. In the Dutch prehospital setting, these patients should preferably be intubated by a
physician-based helicopter emergency medical service.
We observed a low degree of adherence (56%) to ruling intubation guidelines in our trauma region. The most important reasons for low guideline compliance were the unavailability of specialized care, the choice for “scoop and run” strategies and the absence of a specialized physician in cases where intubation was recommended.

In Chapter 4, we further evaluated secondary risk factors for unfavorable outcome in patients with severe traumatic brain injury in the context of the fast access to specialized trauma care. This fast access to specialized care is mainly due to the specific geographical layout of the Netherlands. The study investigated whether and to what extent hypoxia and hypotension, and interventions such as endotracheal intubation, affected outcome in a patient population with severe traumatic brain injury admitted to a level 1 trauma center between 2003 and 2007. In contrast to our expectations, we found no differences in the incidence of a hypoxia, observed mortality due to trauma, arterial blood gas analysis upon emergency department admission nor the predicted 14-day mortality between prehospital intubated and non-intubated patients. Our findings further showed that a disturbed pupillary reflex, a low Glasgow Coma Scale score, and a hypotensive event in the prehospital phase were strong prognostic factors for patient outcome, whereas prehospital hypoxia was not conclusive for patient outcome.

Chapter 5 is a retrospective evaluation of the prehospital run time of patients with severe traumatic brain injury admitted to trauma centers located in Amsterdam (VU University Medical Center), Nijmegen (Radboud University Nijmegen Medical Center) and Groningen (University Medical Center Groningen) in the period 2003-2007. In this period, the physician-based emergency medical service dispatch was frequently only available during daylight hours. The literature is inconclusive as to whether prehospital deployment of a physician-based Emergency Medical Service may prolong the on-scene time due to the time consuming nature of Advanced Life Support. In this chapter we investigated whether physician-based emergency medical service dispatch indeed prolonged prehospital run times when compared to a paramedic emergency medical service. We further evaluated how this affected patient outcome. Prehospital run times for patients with severe traumatic brain
injury who received Advanced Life Support by either a paramedic- or physician-based emergency medical service were similar, but with a significant higher rate of prehospital endotracheal intubation in the physician-based emergency medical service group. Regression analysis further showed that physician-based emergency medical service deployment was associated with a reduced risk for unfavorable outcome, despite the higher injury severity score levels in this patient group.

In Chapter 6 we investigated whether the national 24-hour availability of a physician-based emergency medical service changed the incidence of advanced life support in severe traumatic brain injury. Data were retrieved from the Prospectief Observatienel COhort Onderzoek Neurotrauma (POCON) registry. This registry included prehospital data of 334 patients with severe traumatic brain injury who were dispatched to a trauma center located in an urban (Amsterdam and Rotterdam) or rural (Nijmegen and Groningen) trauma region. We investigated the hypothesis that the 24-hour availability of a physician-based emergency medical service led to an increased dispatch of this service, and improved prehospital treatment guideline compliance when compared to chapter 3. However, we found no increase in physician-based emergency medical service dispatch after 24-hours availability. Moreover, our findings indicated that the rate of physician-based emergency medical service deployment was the highest in patients with severe traumatic brain injury with extracranial injuries. In case of physician-based emergency medical service, patients were in most cases endotracheally intubated in the prehospital setting, irrespective of the absence or presence of extracranial injuries. The incidence of prehospital endotracheal intubation by patients solely treated by paramedic emergency medical service was low, particularly in patients without extracranial injury. Our study also showed that physician-based emergency medical service dispatch was considerably less in urban than in rural regions, while the injury severity score was comparable between regions.

Chapter 7 and Chapter 8 both focus on hemostatic abnormalities as a novel prognostic factor for patient outcome after severe traumatic brain injury. Neurotrauma induces an excessive release of cerebral tissue factor and alterations in the thrombomodulin-protein C pathway, both contributing to a disparity in clot formation and breakdown.
In Chapter 7, we describe a retrospective single center study performed in the VU University Medical Center that investigated the development of coagulopathy at different stages after the initial traumatic incident in patients with moderate or severe traumatic brain injury without extracranial bleeding. In this investigation it was evaluated to what extent the mere presence of, but also the time course of coagulopathy, holds predictive value for patient outcome. In addition, the possible relationship of the development of coagulopathy after traumatic brain injury with the Traumatic Coma Data Bank cranial computed tomography (TCDB CT)-classification was investigated. In this study we did not find a significant difference in specific cranial CT characteristics for patients with or without coagulopathy. Our data further showed that acute sustained coagulopathy is associated with the largest changes in hemostatic and metabolic parameters upon emergency department admission. We also found that patients with acute temporary coagulopathy or delayed coagulopathy had the most profound brain injury severity levels according to the TCDB CT classification, while mortality rates were the highest in patients with hemostatic abnormalities in the hours following emergency department admission.

Chapter 8 provides more insight into the association of coagulopathy in patients with isolated traumatic brain injury without extracranial injuries to outcome as reflected by the extended Glasgow Outcome Scale (GOSE) and mortality rates. Data for this analysis were retrieved from the POCON registry, which is described in chapter 6. Our findings showed that a large proportion of patients with isolated traumatic brain injury were admitted to the trauma centers with hemostatic disturbances (early coagulopathy). In addition, an equal proportion of patients develop late onset coagulopathy within in the first 48 hours after trauma. There was no difference in the relative risk for in-hospital mortality between patients with early short-lasting coagulopathy or delayed/sustained coagulopathy, while patients with delayed or sustained coagulopathy more frequently showed intracranial hemorrhage and signs of increased intracranial pressure. The presence of delayed/sustained coagulopathy was associated with a higher risk for blood transfusion, prolonged ICU and hospital stay and a lower functional outcome at 6 months following trauma. From both Chapters 7 and 8 we conclude that coagulopathy in patients with traumatic brain injury is an independent prognostic factor for patient outcome.

In Chapter 9, the main conclusions of this thesis are described and discussed.