Traumatic spinal fractures the fall and rise

Smits, A.J.

2020

document version
Publisher's PDF, also known as Version of record

CHAPTER 9

GENERAL DISCUSSION

This thesis aimed to give an overview of the current epidemiology and operative treatment of traumatic spinal fractures in the Netherlands. Part 1 focuses on the current epidemiology and possible preventative measures. Part 2 focuses on specific operative treatments and their outcomes. Part 3 describes aspects of treatment and care after surgical fixation. Finally part 4 describes the outcomes of a surgical treatment for late consequences of traumatic spinal fractures.

Part 1 - Epidemiology

In **chapter 1**, we found that in recent years the incidence of hospitalizations after spinal fractures has increased. The current incidence in the Netherlands (24 per 100.000 inhabitants) is roughly comparable to other western countries. There is a large share of elderly that increased faster compared to younger patients. Incidence might increase because more fractures occur, more fractures are diagnosed due to improved diagnostic modalities or a combination of these two. The increasing elderly population might also play a role. In non-western countries spine fractures are often caused by violence and high energetic traffic accidents in young men. In the Netherlands however, bicycle accidents made up 35% of all traffic related spine fractures and often happened among 50-70 year olds. With the uprise of the e-bike this could possibly increase even faster. While we have a unique bicycle culture, this uprise has also been reported in other countries. Another cause frequently leading to spine fractures is a fall from the same level, often in elderly women. It has been reported before that this age group makes up a large part of spine fractures and this is often linked to osteoporosis. Although a longer active lifestyle in elderly could also make them more prone to spinal fractures. Beside already existing osteoporosis screening programs, further preventative measures in the Netherlands should therefore focus on bicycle accidents and same level falls in elderly. When precautionary actions are developed, regional differences should also be considered of importance. We found that fractures caused by same level falls occurred the most in Amsterdam, which could be related to population density and people living on story's with stairs prone to slipping. Another regional difference found was that in east Netherlands patients are more often referred by a GP before being presented and admitted with a spine fracture compared to the west. This could be due to a geographic differences such as distance or to a different mindset of patients.

Most patients suffered a lumbar level fracture however polytraumatized mostly suffered thoracic fractures. In polytraumatized, special attention should be paid to the possibility of multiple spine fractures. We found that over 50% of these patients with a spinal fracture in one spine region had an additional fracture in another spine region. And although the overall occurrence of fracture associated spinal cord injury (SCI) was low (5,5%), polytraumatized with a cervical fracture had associated SCI in 21,9% of cases. After the emergency department, elderly were longer admitted and only half of them was discharged to a previous living environment.

Combined with the increasing frequency of these patients, this could lead to a serious increase in health care costs in the near future.

Although this study used a reliable large nationwide database, the reported numbers are an underestimation of the true spine fracture occurrence as only admitted patients are registered.

Chapter 2 zooms in on the epidemiology of spine fractures at a level one trauma center in the west of the Netherlands. In comparison to the nationwide data described in chapter 1, the spine fracture occurrence also increased each year. Additionally, a considerable amount of fractures occurred among elderly injured by a same level fall and the share of elderly per year increased faster compared to younger patients. Still the largest patient group consisted of 19-64 year olds in which traffic accidents were the main cause of injury (47,2%). In correspondence with nationwide data (chapter 1) it were mainly younger patients (21-30 years) and often men that were injured by traffic accidents. Overall, bicycle accidents made up for the largest part of traffic related spine fractures.

Most fractures were located in the thoracic region, while nationwide (chapter 1) this was only true in polytraumatized. The mean ISS in this population was however 17,1, which implies a large part of patients suffered polytrauma and probably explains the large share of thoracic fractures. This finding did not come by surprise as the study represents a population presented at a regional level one trauma center. It has been reported before that patients that suffer polytrauma are more prone to thoracic fractures. This is probably due to the high energetic force which the normally protective rib cage cannot withstand. Due to the higher number of polytraumatized patients, SCI also occurred more often compared to nationwide data (chapter 1) (8,5% vs 5,5%).

The smaller population allowed us to study more details compared to the nationwide study (chapter 1) such as specific afflicted vertebra and treatment. The most injured vertebra was L1, which is in correspondence with other studies. We found that the majority (83,8%) was treated conservatively and only 16,2% underwent surgical treatment for a spine fracture. As expected the majority (51,9%) of surgical treatment consisted of posterior fixation by pedicle screws.

Preventative measures in this geographic region (north-west Netherlands), should focus on same level falls in elderly and traffic accidents in younger patients with bicycle accidents in particular.

Part 2 – Operative treatment of spinal fractures

The cornerstone of operative treatment for spinal fractures is the pedicle screw. In fracture types with diminished anterior support, too much force on the posterior construction could lead to instrumentation failure such as screw breakage. One way to reinforce the anterior column

is by means of a titanium cage, which has biomechanical stability and reduces bone-graft related problems. Reaching the anterior column comes with associated surgical morbidity and acceptable results have also been reported after a solely posterior approach. We sought to find the additional value of additional anterior support compared to solely posterior fixation. **Chapter 3** is a systematic review of the current available evidence. Few randomized studies on traumatic fractures have been performed looking into this dilemma, therefore cohort studies comparing the two treatments were also included. Due to stringent selection criteria, only three studies were left after initial selection, two RCT's and one cohort study. Operative parameters (operative time & blood loss) were, as expected, all in favor of posterior fixation as combined fixation comes with an additional surgery. Although these parameters were not in favor of anteroposterior fixation, surgical complications did not differ.

As reported before in single-group cohort studies, anteroposterior fixation maintained better kyphosis correction, however this result was neutralized by the non-randomized study due to some cases with cage subsidence. We think that this subsidence can be largely prevented by using additional plating. There was no difference between the two groups in neurologic improvement (if any possible). Additionally no differences in postoperative pain scores were found.

Based on this meta-analysis it is not possible to draw definitive conclusions on the best treatment. The evidence was not graded strong enough, mainly due to the few applicable studies available and heterogeneity of these studies. It seems that additional anterior fixation with a titanium cage mainly has its advantages in highly comminuted or unstable fractures. Although the intended patient group (with acute comminuted fractures) makes it difficult to set up a randomized controlled study into comparing these two treatments, future studies with tight inclusion criteria could provide stronger evidence.

The approach needed to reach the anterior column of the spine comes with surgical morbidity. This morbidity can be largely decreased by using a minimally invasive thoracoscopic approach. In **chapter 4** the long term results and quality of life of patients treated with this approach from 2004 to 2012 are reported. Quality of life scores were collected through questionnaires which were completed after a median of 49 months after surgery. As already suggested in chapter 3, patients that were treated with the anterior approach had more severe fractures compared to patients treated with only posterior fixation. Although they had more severe fractures, no differences in quality of life (QOL) scores were found between these groups. Therefore it seems that the additional thoracoscopic approach did not lead to reduced QOL. Additionally, the complication rate was low, with one re-operation needed. Furthermore, no cases of posterior instrumentation failure were reported which is likely due to sufficient support from the anterior construct.

While we think that QOL scores are substantially more important than radiologic parameters, treatment of spine fractures is often reported in radiologic outcomes. Some correction loss (mean 6,8°) did occur, mainly in the first year and less in patients with one compared to two segments fixated. It is likely that this correction loss was due to 'settling' of the cage, which has been reported before. The questions remains however if this radiologic correction loss is clinically important, moreover no correlation between QOL and correction loss was found. Furthermore, 98% of patients achieved complete bony fusion.

Although the thoracoscopic approach and fixation with titanium cage led to stable situations in specific fracture types (with high risk of collapse and intervertebral disc lesions), the technique is technically demanding. A surgeon with sufficient experience with this technique could achieve satisfactory results with limited operative time and blood loss. Whereas the indications for this treatment are quite specific it might be hard to gain sufficient experience for every spine surgeon. Therefore centralization of patients specifically indicated for this approach could benefit patients as well as surgeons. While centralization is an option it also causes a problem because there is currently no specific score or indication to objectively point out which patients are best treated with this approach. The load sharing classification by McCormack et al. could give an indication, however this score is largely outdated and not designed for this indication.

Minimally invasive thoracoscopic techniques are fine-tuned and technical developments progress. **Chapter 5** describes how 3D technique is added to conventional 2D-thoracoscopy for anterior stabilization of spine fractures. 3D-thoracoscopy uses a videoscope with two video sensors that lead to a right and left polarized signal which is sent from compatible screens. The surgeons were special glasses with a left and right polarized lens which causes the brain to compose an image on the screen as if it were three-dimensional. This creates better depth estimation and hand-eye coordination. Additionally the results of the first four patients are described, they were all successfully treated with this technique (all anterior stabilization with a titanium cage). On this small group no differences could be shown in operative time compared to conventional thoracoscopy. Blood loss was less compared to conventional thoracoscopy, although the group is too small to draw definitive conclusions. Moreover, the surgeons and residents deemed the technique a useful addition especially when localizing vital structures.

Future studies should prove whether this technique could lead to results as reported in 3D laparoscopy and lung surgery such as improved outcomes, less blood loss and decreased operative time. In addition, due to the improved spatial orientation the technique could lead to a shorter learning curve for surgeons in training.

Part 3 – Post-operative care

While techniques in operative treatment advance, uncertainty still remains on some post-operative treatments. The use of a post-operative orthosis has not yet been proven effective, nor a burden. **Chapter 6** was designed to create an evidence-based recommendation on this topic. The primary outcome was difference in pain at 6 weeks as reported on the NRS score. Secondary outcomes consist of functional scores, quality of life and radiologic parameters at several time points up to 12 months. To achieve sufficient power if a clinically significant difference is found, 46 patients are needed. While many patients were treated with posterior fixation for spine fractures, the inclusion rate was not as expected. This was due to extensive exclusion criteria that were needed because these parameters could influence the primary outcome. Adding another peripheral center did also not increase the inclusion rate as hoped for.

Currently, the ORNOT trial is still running in two centers and has approximately reached two thirds of the needed number of patients. If the amount of patients aimed for is reached, results could lead to a change in protocols on a large scale as currently the choice for a postoperative orthosis is solely based on surgeons' preference.

Chapter 7 describes another post-operative aspect. After a spinal fracture that is posteriorly fixated has consolidated, the fixation material might be removed. There is currently no consensus whether this material should be routinely removed or only in specific indications. Therefore, all patients that had undergone posterior implant removal from 2003 to 2015 after a spine fracture were reassessed. These patients underwent implant removal after a median of 12 months after fracture surgery. Functional scores, quality of life and satisfaction were scored using questionnaires that were completed mean 7 years after implant removal. Patients were organized in pre-operatively asymptomatic, symptomatic and unknown group based on reported symptoms in the outpatient files.

In symptomatic patients, removal often led to a decrease in symptoms and 75% of patients was satisfied. In asymptomatic patients, a large part remained asymptomatic, while in 10% symptoms arised and 95% was satisfied. Additionally, every surgery comes with a risk of complications, in this population this was 8% of which two (wound infections) led to readmission. In most patients some kyphosis increase occurred after implant removal (4.9˚ and 3.5˚ for posterior and antero-posterior fixation respectively). This is unlikely to be clinically significant and is a common finding after implant removal which is probably caused by changes in the intervertebral disk. One patient however had progressive kyphosis with pain after removal for which in a later stage anterior stabilization was performed with good result (more on this indication in Chapter 8).

On QOL the patients scored slightly lower compared to the general population which was expected after a spine fracture and surgery, but had less back pain related disability compared to patients with chronic back pain. No correlations of QOL and function were found with

kyphosis, fracture type or complications. Unfortunately no QOL outcomes for a group without implant removal were described in the literature for comparison.

In conclusion, implant removal might be beneficial especially in symptomatic patients, however symptoms may arise or increase in asymptomatic and symptomatic patients respectively. Most patients are satisfied and there is a group of patients that are satisfied but would not undergo removal again. In addition the risk of complications is small but should be discussed with every patient.

Part 4 – The consequences of late collapsing spinal fractures

Late progressive kyphosis is an undesirable late consequence of a traumatic spine fracture. This could be due to initial insufficient conservative treatment, instrumentation failure such as screw breakage or vertebral body pathology such as osteonecrosis. Symptoms are spinal deformity and pain. **Chapter 8** describes the results after a minimally invasive surgical treatment for these cases. The anterior column is reinforced and restored by a titanium cage through a thoracoscopic approach. This treatment aims to decrease kyphosis, prevent it from worsening and decrease pain. The minimally invasive approach should further limit surgical morbidity. Because the indication is quite rare, all patients treated from 2007 to 2017 were further analyzed (n=14). These patients were initially treated conservatively or with posterior instrumentation (two had increasing kyphosis after implant removal). While posttraumatic correction directly decreased kyphosis, some correction loss did occur but stabilized. Bony fusion was achieved in almost all patients after 16 months. Two complications occurred, of which one serious (pulmonary embolisms) which were treated successfully. QOL scores were comparable with studies that report these scores after a posterior approach and the EQ5D scores were better compared to patients treated for adult deformities. Additionally, patients reported in over 75% of cases that symptoms decreased largely or completely, 67% was satisfied and 89% was willing to undergo the procedure again.

While the results are mostly satisfactory, the technique is technically demanding for the surgeon as well as anesthetist. The procedure might lead to large blood loss and long operative times, the patient needs to be on single-lung ventilation, cell-saver and undergoes two position changes in one session. We did find a trend towards less blood loss and shorter operative times despite sufficient surgeon experience which could be explained by the relative infrequent application of the technique.

As discussed in chapter 4, patients and surgeons might benefit from centralization of cases, especially for complex and rare surgeries such as the one described. However due to the complexity of these cases and lack of a specific indication score, these patients need to be discussed multidisciplinary with at least a trauma surgeon, orthopedic surgeon and neurosurgeon. Many studies base the radiologic indication on kyphosis severity measured by Cobb angle (CA), although we think that the sagittal index (>15˚) could be a good

alternative to indicate the need for posttraumatic kyphosis correction. This score corrects for the physiologic difference in CA of different spine regions. Furthermore, kyphosis has to be accompanied by pain and/or functional problems and it is obvious that only a radiologic parameter is not enough to indicate a patient to this treatment. In addition the patient should be clearly informed of the risks, serious rehabilitation and varying outcomes.

Future perspectives

We should aim for a stabilization or decrease of spine fracture incidence and it seems that low falls in elderly are best targeted for this as they increase the fastest. In addition, younger patients are often injured by car accidents and self-driving cars could lead to improved traffic safety. The uprise of the e-bike is however another threat to stabilization of spinal fracture incidence and the risks that accompany this relatively new vehicle have been reported already, not only for spine fractures.

In the dilemma of posterior versus anterior-posterior fixation of spine fractures, the RASPUTHINE study, performed in Germany, could provide strong evidence. This is a randomized study for which the pilot reported less disability (ODI scores) and more kyphosis correction for the anterior-posterior group. However it might take a while to reach the powered number of patients (n=266).

As the direct anterior approach evolved, another transpedicular approach was also introduced, this technique involves the use of a stent (vertebral body stent, VBS). While this technique is promising and could decrease complications associated with kypho- or vertebroplasty such as cement leakage, long term results and specific indications are not yet reported. The direct anterior approach with expandable cage provides support in severely comminuted fractures and it will be interesting to see how VBS will hold in these fracture types. Ideally we would see an RCT that compares posterior fixation with added VBS versus posterior fixation with an anterior (thoracoscopic) cage for comminuted fractures. Furthermore, as mentioned before not every surgeon is able to perform all possible treatments. Instead of competing with techniques, it seems that both have their specific best indication. These techniques should be used alongside each other in order to create the best possible outcome for the patient. Therefore borderline patients should be discussed multidisciplinary and also between hospitals if necessary.

As per-operative 3D thoracoscopy is now available, the newest trends are holograms that are projected pre-operatively on the patient to decide on the best approach and treatment strategy. This technique is potentially helpful in spine fracture patients as well. Accompanied with 3D printed anatomic substrates to be placed in the patient, this could broaden surgical options for spine fractures largely. In addition, results of new surgical techniques should focus primarily on quality of life and functional outcomes instead of radiologic outcomes as the latter are not often correlated with the first.