An evolution of trauma care evaluation: A thesis on trauma registry and outcome prediction models
Joosse, Pieter

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Chapter 9

THE EFFECT OF THE INTRODUCTION OF THE AMSTERDAM TRAUMA WORKFLOW CONCEPT ON MORTALITY AND FUNCTIONAL OUTCOME OF PATIENTS WITH SEVERE TRAUMATIC BRAIN INJURY

PH PING FUNG KON JIN
NIELS PENNING
PIETER JOOSSE
ALBERT HJ HIJDRA
GERT J BOUMA
KEES J PONSEN
J CAREL GOSLINGS

Chapter 9

ABSTRACT

Background
The purpose of this study was to analyze the effect of the introduction of an all-in workflow concept that includes direct computed tomography (CT) scanning in the trauma room on mortality and functional outcome of trauma patients with severe traumatic brain injury (TBI) admitted to a Level I trauma center.

Methods
To this end, a retrospective comparison was made of a 1-year cohort prior to the implementation of the all-in workflow concept (Pre-CT in trauma room cohort [Pre-TRCT]) and a 1-year cohort after the implementation (Post-TRCT). All severely injured TBI patients aged 16 years or older that were presented in our Level I trauma center and that underwent a CT of the head were initially included. Severe TBI was defined as an abbreviated injury scale (AIS) score of > 2 of the head region following trauma. Primary outcome parameter was TBI-related mortality during primary hospital admission. Secondary outcome parameter was the functional outcome based on GOS-Extended.

Results
A total of 59 patients were included in the Pre-TRCT and 49 in the Post-TRCT. Median age was 49 years in the Post-TRCT and 44 years in the Pre-TRCT (not significant[NS]). Median ISS was similar (ISS=25). Median Head-AIS was higher in the Post-TRCT (5 vs. 4, NS). Initial CT scanning was completed faster in the Post-TRCT. There was a significant difference of 23% mortality in favor of the Post-TRCT for TBI-related mortality during primary hospital admission ($p < 0.05$). For acute neurosurgical interventions, time until intervention tended to be faster in the Post-TRCT (NS). Functional outcome for survivors was higher in the Post-TRCT (6 vs 5, NS).

Conclusion
In two 1-year cohorts of severe TBI patients (before and after the introduction of a new trauma workflow concept that includes CT scanning in the trauma room), a significant difference for primary and overall mortality in favor of the Post-TRCT was found. Functional outcome tended to be higher in the Post-TRCT (NS).
Traumatic brain injury (TBI) is the most common cause of death in young adults and has a significant impact on quality of life following injury. In the United States, approximately 500,000 patients are presented with TBI annually, of which 20% die of their injuries. Severe TBI, often defined as an initial emergency room Glasgow Coma Scale (GCS) score ≤ 8, shows an even higher mortality rate ranging, of 36 - 51%. Recent studies have shown the major role of "time until intervention" and the prominent role of diagnostics in the prognosis of this population. Even small delays in an accurate assessment and treatment of significant injuries to the brain can result in severe, irreversible damage. Several guidelines and studies recommend decompressive craniectomy to be performed within 4 hours.

In 2004, the "Amsterdam Trauma Workflow Concept" was introduced and implemented in our Level I university hospital. In this newly constructed trauma room, conventional imaging is combined with a moveable sliding computed tomography (CT) scanner that can serve two mirrored and adjacent trauma rooms. This has enabled the trauma team to complete radiological imaging in one location, thus eliminating the need to physically move the patient, as was previously necessary. This has lead to a faster initial diagnostic workup of the trauma patient. We believe that this concept has a positive effect on outcome in the more severely injured trauma patients, including the severe TBI patients, by providing a faster and more complete workup for severely, and often multiple injured patients.

The purpose of this study is to analyze the effect of the introduction of the Amsterdam Trauma Workflow (ATW) concept on mortality and functional outcome of trauma patients with severe TBI admitted to a level-1 trauma center.

**METHODS**

**Study design and study setting**

The Academic Medical Center in Amsterdam, the Netherlands, is a university hospital and one of the two level I trauma centers for the region of Amsterdam. Yearly, around 600 trauma team alerts are issued in our center, of which 25% eventually have an Injury Severity Score (ISS) ≥ 16. Prior to January 2004, all trauma patients were initially seen by a complete multidisciplinary trauma team in a pre-designated trauma room that included conventional X-ray imaging and ultrasound. For additional CT imaging, patients required transportation to the radiology department, located 2 floors above the trauma room and accessible by emergency priority elevator. All CT imaging was performed on a multislice four-slice CT scanner (MX 8000, Philips Medical Systems).

After the introduction of the Amsterdam Trauma Workflow (ATW) concept in 2004, all trauma patients were seen by the complete multidisciplinary trauma team in the new trauma rooms that included the moveable CT scanner. All required CT imaging was performed without leaving the trauma room using the moveable multislice four-slice CT scanner (SOMATOM Sensation 4, Siemens). During both study cohorts, the same trauma protocols were applied and all radiological interpretation was performed by the radiologist on call.
Chapter 9

A retrospective comparison was made of two one-year cohorts separated by a three-month period in which the ATW concept was introduced and implemented in the Academic Medical Center. The Pre trauma room CT cohort (Pre-TRCT) initially included all trauma patients evaluated in the trauma room from January 1, 2003 until December 31, 2003. The Post trauma room CT cohort (Post-TRCT) initially consisted of all trauma patients presented to the trauma room from April 1, 2004 until March 31, 2005.

All severe TBI patients aged 16 years or above that were presented were initially screened. Severe TBI was defined as an Abbreviated Injury Scale (AIS) score of > 2 of the head region (H-AIS). Patients with only an H-AIS score were defined as isolated TBI. Patients without a CT of the head and patients younger than 16 years at time of admittance were excluded.

Data collection and comparisons

The data from the primary hospital stay for all patients in both cohorts were collected from the medical charts, the hospitals' electronic patient information system, and the trauma registry. Collected data included standard demographic data, GCS score at arrival in the trauma room, length of hospital and intensive care unit (ICU) stay, Injury Severity Score (ISS), and mechanism of injury. The neurological injuries sustained were collected from chart history and radiological imaging. The time interval from admittance until completion of CT imaging was extracted from the Picture Archival and Communication System (Agfa Impax; AGFA Netherlands, Rijswijk, The Netherlands).

Neurosurgical procedures were categorized as either intracranial pressure (ICP) monitoring or interventional sessions. For all acute neurosurgical sessions, defined as neurosurgery immediately following the primary trauma evaluation (including CT imaging), time from admission to the trauma room until start of operation was collected.

Primary outcome parameter was TBI-related mortality, determined for the primary hospital stay. Overall mortality was determined for both the primary hospital stay and following at least 12 months after discharge. Out-of-hospital mortality was gathered through the general practitioner’s database and state population registry. Secondary outcome included functional neurological outcome using the Glasgow Outcome Scale – Extended (GOS-E). For all survivors at the time of the study, GOS-E was determined through either telephone interviews or GOS-E questionnaire forms sent by post. Survivors that refused to participate with the study, could not be reached by phone, or did not return the questionnaire were excluded for the secondary outcome.

Statistical analysis

Data were analyzed for all included patients. All continuous variables are presented as median values with interquartile ranges (IQR) and are compared using Mann-Whitney U test, or as mean values with standard deviations (SD) and compared with independent t-test depending on data distribution. Categorical variables were calculated as percentage of frequency of occurrence. Discrete variables were compared using Fisher’s Exact analyses. Statistical significance was declared at the 0.05 level. All data management and statistical analyses were performed using SPSS Base for Windows, version 12.02 (SPSS Inc., Chicago, IL).
Effect of ATW concept on severe traumatic brain injury

RESULTS

A total of 558 (Pre-TRCT) and 586 (Post-TRCT) trauma patients were initially evaluated in the trauma room during the respective cohort periods and extracted from the trauma registry. Included for analysis based on the AIS criteria and the age criterion, a total of 59 patients in the Pre-TRCT cohort and 49 patients in the Post-TRCT cohort were included.

Demographics

Demographic data for both cohorts can be found in Table 1. Median age was 44 years in the Pre-TRCT cohort versus 49 years in the Post-TRCT cohort. A total of 61% and 69% were males in both cohorts, respectively. Median ISS for both cohorts was 25. Median AIS for the head/neck region (H-AIS) was 4 in the Pre-TRCT cohort and 5 in the Post-TRCT cohort (not significant [NS]). A total of 59% and 41% of the Pre-TRCT and Post-TRCT cohorts, respectively, were categorized as isolated TBI (difference NS).

In Table 2, the mechanisms of injury and the sustained neurological injuries are shown for both cohorts. There were no significant differences between the two cohorts regarding either mechanism of injury or injuries sustained. There tended to be more subdural hematoma injuries, more patients showing signs of midline shifting and less patients with subarachnoid hemorrhage in the Post-TRCT cohort (difference NS).

In the Pre-TRCT cohort, 52 patients (88%) had a GCS of ≤ 8 at arrival against 38 patients (77%) in the Post-TRCT cohort (difference NS). Of all patients in the Post-TRCT cohort with a GCS above 8, seven patients were diagnosed with an H-AIS of 5 or higher. In the pre-TRCT cohort, two patients had an H-AIS of 5 or higher.

Average time until completion of initial CT imaging in the Pre-TRCT was 70 minutes (SD ± 82 minutes) and in the Post-TRCT 48 minutes (SD ± 28 minutes). Initial CT imaging was completed 22 minutes faster during the Post-TRCT cohort (95% CI, 11-32 minutes, p < 0.01).

<table>
<thead>
<tr>
<th>General demographics</th>
<th>Pre-TRCT (n = 59)</th>
<th>Post-TRCT (n = 49)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median age on arrival (years, IQR)</td>
<td>44 (31 – 59)</td>
<td>49 (34 – 69)</td>
</tr>
<tr>
<td>Gender (% males)</td>
<td>61%</td>
<td>69%</td>
</tr>
<tr>
<td>Median ISS (IQR)</td>
<td>25 (16-29)</td>
<td>25 (25-34)</td>
</tr>
<tr>
<td>Median H-AIS (IQR)</td>
<td>4 (4-5)</td>
<td>5 (4-5)</td>
</tr>
<tr>
<td>Isolated neurological trauma</td>
<td>35 (59 %)</td>
<td>20 (41 %)</td>
</tr>
<tr>
<td>GCS ≤ 8 on arrival</td>
<td>52 (88 %)</td>
<td>38 (77 %)</td>
</tr>
<tr>
<td>Neurosurgical procedures</td>
<td>33 (56 %)</td>
<td>27 (55 %)</td>
</tr>
<tr>
<td>ICP monitoring</td>
<td>18 (31 %)</td>
<td>16 (33 %)</td>
</tr>
<tr>
<td>Interventional sessions</td>
<td>20 (34 %)</td>
<td>19 (39 %)</td>
</tr>
<tr>
<td>ICU admittance</td>
<td>48 (81 %)</td>
<td>41 (84 %)</td>
</tr>
</tbody>
</table>

Table 1 | General demographics
Pre-TRCT: cohort prior to implementation of the Amsterdam Trauma Workflow concept, post-TRCT: cohort after implementation of the Amsterdam Trauma Workflow concept, IQR: interquartile range, ISS: Injury Severity Score, H-AIS: Abbreviated Injury Scale for the head region, GCS: Glasgow Coma Scale, ICP: intracranial pressure, ICU: intensive care unit.
Table 2 | Mechanism of injury and neurological injuries
Pre-TRCT; cohort prior to implementation of the Amsterdam Trauma Workflow concept, post-TRCT; cohort after implementation of the Amsterdam Trauma Workflow concept.

<table>
<thead>
<tr>
<th>Mechanism of injury</th>
<th>Pre-TRCT (n = 59)</th>
<th>Post-TRCT (n = 49)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falls</td>
<td>39%</td>
<td>45%</td>
</tr>
<tr>
<td>Motor vehicle crashes</td>
<td>15%</td>
<td>22%</td>
</tr>
<tr>
<td>Bicycle/moped crashes</td>
<td>27%</td>
<td>16%</td>
</tr>
<tr>
<td>Pedestrian hit by traffic</td>
<td>9%</td>
<td>8%</td>
</tr>
<tr>
<td>Other trauma mechanism</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Neurological injuries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subdural hematoma</td>
<td>25 (42%)</td>
<td>26 (53%)</td>
</tr>
<tr>
<td>Epidural hematoma</td>
<td>3 (5%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>Contusions</td>
<td>22 (37%)</td>
<td>13 (27%)</td>
</tr>
<tr>
<td>Basal skull fractures</td>
<td>10 (17%)</td>
<td>6 (12%)</td>
</tr>
<tr>
<td>Subarachnoid hemorrhage</td>
<td>8 (14%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>Intracerebral hematoma</td>
<td>7 (12%)</td>
<td>3 (6%)</td>
</tr>
<tr>
<td>Impression fractures</td>
<td>4 (7%)</td>
<td>4 (8%)</td>
</tr>
<tr>
<td>Midline shifting</td>
<td>23 (39%)</td>
<td>24 (49%)</td>
</tr>
<tr>
<td>Cerebral edema</td>
<td>10 (17%)</td>
<td>8 (16%)</td>
</tr>
</tbody>
</table>

Neurosurgery

A total of 33 patients in the Pre-TRCT cohort underwent a neurosurgical procedure, of which 13 solely underwent ICP monitoring and 15 underwent neurosurgical intervention only. A total of 5 patients underwent both ICP monitoring and a neurosurgical intervention during primary hospital stay in the Pre-TRCT cohort. There were 22 patients that underwent immediate neurosurgery following trauma evaluation. Median time until acute neurosurgery was 138 minutes, with a range of 246 minutes (IQR, 73-152 minutes; Figure 1). A total of 12 patients underwent decompressive craniectomy to relieve ICP, three patients were operated for sustained impression fracture of the skull, and 7 patients underwent acute ICP monitoring.

In the Post-TRCT cohort, 27 patients underwent a neurosurgical operation, including 8 ICP monitoring sessions, 11 neurosurgical interventional sessions, whereas 8 patients underwent both ICP monitoring and neurosurgical intervention during the primary hospital stay. A total of 18 patients underwent immediate neurosurgery following the trauma evaluation in the Post-TRCT cohort. Median time until acute neurosurgery was 95 minutes with a range of 148 minutes (IQR, 73-117 minutes; Figure 1). A total of 12 patients underwent decompressive craniectomy to relieve ICP, while 3 patients were operated for a sustained impression fracture of the skull. A total of 4 patients underwent only acute ICP monitoring.

There were no significant differences between Pre-TRCT and Post-TRCT regarding neurosurgical procedures, neurological injuries operated upon, or time until acute neurosurgery.
Effect of ATW concept on severe traumatic brain injury

Figure 1 | Time until acute neurosurgery.
This boxplot figure shows the distribution of time until acute neurosurgery in minutes between the two cohorts. The range of the time until neurosurgery and interquartile ranges along with median value are shown for both cohorts. Pre-TRCT, cohort prior to implementation of the Amsterdam Trauma Workflow (ATW) concept; post-TRCT, cohort after implementation of the ATW concept.

TBI-related mortality
An overview of the primary outcome for the two cohorts can be found in table 3. In the Pre-TRCT cohort, a total of 24 patients (41%) died during primary admission due to brain injury. Of these, 58% was male and their median age at the time of the accident was 45 years (IQR, 34-62 years). After the introduction of the new trauma room concept, a total of 9 patients (18%) died due to traumatic brain injury during their primary admission. In this cohort, 56% was male with a median age at the time of the accident of 52 years (IQR, 41-73 years). There was a significant difference (23%) in favor of the Post-TRCT for TBI-related mortality during primary admission ($p < 0.05$).

Overall mortality
Total mortality for the Pre-TRCT cohort, including non-TBI deaths and out-of-hospital deaths at time of follow-up was 53%, of which 8% died after primary discharge. In the Post-TRCT cohort, a total mortality at the time of follow-up was 31%, of which 6% died after primary
discharge. The difference in overall mortality (22%) was significantly lower in the Post-TRCT cohort (p < 0.05).

**ICU and hospital stay**

A total of 81% of the patients in the Pre-TRCT cohort was admitted to the ICU during primary hospital admission, with a median ICU stay of 5 days. In the Post-TRCT cohort, 84% was admitted to the ICU, for a median of 8 days. There were no significant differences in both ICU admittance and ICU length of stay (LOS). The median LOS of the primary hospital admission for the patients that left the hospital alive was 11 days in the Pre-TRCT cohort. This LOS stay was significantly longer in the Post-TRCT cohort with a median stay of 24 days (p < 0.05).

**Functional outcome data**

Twenty-four patients (86%) of all surviving patients in the Pre-TRCT cohort returned the functional outcome questionnaires. Median follow-up time was 35 months after trauma. Median GOS-E score of the survivors was 5 (IQR, 4 - 7). In the Post-TRCT cohort, functional outcome was determined in 25 surviving patients (74%). Median follow-up time was 22 months after trauma and a median GOS-E score was 6 (IQR, 5 - 7).

<table>
<thead>
<tr>
<th></th>
<th>Pre-TRCT (n = 59)</th>
<th>Post-TRCT (n = 49)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TBI related mortality</td>
<td>24 (41 %)</td>
<td>9 (18 %)*</td>
</tr>
<tr>
<td>TBI related mortality GCS &gt; 8 at arrival</td>
<td>3 / 7</td>
<td>0 / 11</td>
</tr>
<tr>
<td>TBI related mortality GCS ≤ 8 at arrival</td>
<td>19 / 52</td>
<td>9 / 38</td>
</tr>
<tr>
<td>Overall mortality</td>
<td>31 (53 %)</td>
<td>15 (31 %)*</td>
</tr>
<tr>
<td>Survivors of primary stay</td>
<td>33 (56 %)</td>
<td>37 (76 %)*</td>
</tr>
<tr>
<td>Hospital stay for survivors in days (median, IQR)</td>
<td>11 (7 - 36)</td>
<td>24 (8 - 64</td>
</tr>
<tr>
<td>ICU stay for survivors in days (median, IQR)</td>
<td>7 (3 - 16)</td>
<td>11 (3 - 17)</td>
</tr>
<tr>
<td>Survivors with GOS-E follow-up</td>
<td>24 (73 %)</td>
<td>25 (68 %)</td>
</tr>
<tr>
<td>Median GOS-E (IQR)</td>
<td>5 (4 - 7)</td>
<td>6 (5 - 7)</td>
</tr>
</tbody>
</table>

Table 3  | Primary outcome

Pre-TRCT; cohort prior to implementation of the Amsterdam Trauma Workflow concept, post-TRCT; cohort after implementation of the Amsterdam Trauma Workflow concept, TBI; traumatic brain injury, IQR; interquartile range, ICU; intensive care unit, GOS-E; Glasgow Outcome Scale-Expanded, *p < 0.05.

**DISCUSSION**

In this study, we compared 1-year cohorts of severe traumatic brain injury patients from before and after the introduction of a new trauma workflow concept that incorporates a sliding CT scanner in the initial trauma workflow. A significant difference for primary and overall mortality was found in favor of the Post-TRCT cohort, the cohort after the introduction of the new workflow concept.

With a reported mortality percentage reaching up to 51%, severe brain injury remains one of the most prominent causes of death in the early phases following trauma-inflicted injuries.3-7 It is widely assumed that this group of severely injured trauma patients will benefit from early
Effect of ATW concept on severe traumatic brain injury
diagnostics and interventions to minimize secondary brain injury and thus increase survival.\textsuperscript{5,17} Bulger et al., in their multicentered study found that increased head CT scan utilization was one of the institutional variations in the management of severe head injury associated with a significant reduction in the risk of mortality for severe head injuries.\textsuperscript{6} CT imaging has become the reference standard for diagnosing most traumatic injuries.\textsuperscript{18-20} It has become an essential component of the early trauma evaluation to obtain a complete diagnostic workup of the patient and to create a complete and adequate treatment plan.\textsuperscript{18-23} However, CT imaging often requires more time than available, especially when facing severely injured multitrauma patients. This can be partially explained by infrastructural and logistical reasons; many trauma centers have located its (multislice) CT scanner outside the trauma resuscitation room, thus requiring patient transfers, when CT imaging is indicated and prioritizing injuries.\textsuperscript{24}

In 2004, the ATW concept was implemented in our hospital.\textsuperscript{14} This new concept makes CT imaging available without patient transfers by placing a sliding CT scanner in the trauma room itself, leading to an improvement of the workup times of trauma patients requiring CT imaging and providing a more complete diagnostic workup in less time, and before leaving the relative safe confines of the trauma resuscitation room. We speculated that especially the most severely injured patients, such as patients with severe traumatic brain injuries, would benefit the most from this “all-in-one” setting. The detailed information obtained through CT imaging within a shorter workup time can help make those critical decisions on treatment strategies that would be even more difficult to make when weighing the potential delay when CT imaging can only be performed at a different location in the Emergency Department or elsewhere in the hospital.

In this retrospective cohort study, we compared the 1-year cohort with 59 severely injured TBI patients from before the implementation of the ATW concept with a 1-year cohort that included 49 severely injured TBI patients after the implementation. We found a significant reduction in TBI-related mortality for severe TBI patients by 23\% during primary hospital stay. When looking at the overall mortality including deaths not caused by the sustained neurotrauma and deaths after initial discharge, a still significant reduction of 22\% overall mortality was found. This converts into a Number Needed to Treat (NNT) of less than 4.5; in other words, this study would suggest that less than five patients have to be evaluated with the new trauma room concept to save one life.

While the reduction in mortality supports our hypothesis that the new ATW concept has a positive effect on severely injured patients, we are aware of various other possible explanations for the differences found in this cohort study, including demographic variables and injury severity. Several studies have shown that age is one of the primary determinants of survival following isolated TBI.\textsuperscript{25,26} However, no significant difference in age between the two cohorts was found. The patients in the Post-TRCT cohort tended to be older than the Pre-TRCT, contradicting a possible influence on mortality. The injury severity as measured through the ISS an H-AIS also did not appear to be favoring the Post-TRCT cohort. Not only were there more multiple injured trauma patients in the Post-TRCT cohort, the extent of the injuries in the head region tended to be more severe in this group when compared to the Pre-TRCT cohort.

Furthermore, the sustained neurological injuries did not differ significantly between the two
cohorts. There tended to be more subdural hematoma with midline shifting in the Post-TRCT cohort, while there were more subarachnoid hemorrhage injuries in the Pre-TRCT cohort, but the differences were not significant. But in spite of the non-significant differences found in the neurological injuries, each patient remains different and the small number of patients might have had an influence on the actual mortality found.

When injury severity was expressed in GCS at arrival, the Pre-TRCT cohort had more patients with a GCS of 8 or lower, suggesting a possible worse neurological state at admittance. However, the GCS at arrival did not correlate with the H-AIS at discharge or death, as can be seen in the H-AIS of the patients with a GCS above 8 at arrival. This suggests that GCS did not predict the neurological outcome in our cohorts. These findings could implicate that patients are transported faster from the accident site to our trauma center in the Post-TRCT cohort, but could also stipulate the advantage of having immediate availability of CT imaging, because none of the 11 patients in the Post-TRCT with a GCS above 8 died of neurological injuries.

The number of neurosurgical sessions and ICU days did remain the same for both cohorts, implying that our management of traumatic brain injuries has not changed significantly. However, there was a trend towards a reduced time until acute neurosurgery in the post-TRCT cohort. Although the difference between pre-TRCT and post-TRCT is not significant, data suggest an overall reduction in the time needed for primary trauma evaluation and the time until completion of the initial CT imaging is reduced significantly in the Post-TRCT cohort, most likely leading to a consistent reduction in time until acute neurosurgery. Also, all patients seen in the Post-TRCT cohort were operated within the 4-hour timeframe that is recommended for acute neurosurgery by international guidelines. While most of the patients requiring acute neurosurgery in the Pre-TRCT cohort were also operated upon within the 4-hour timeframe, there were 2 patients that exceeded the 4-hour timeframe. Both patients died.

However, the LOS for both ICU and primary hospital stay did show a significant increase during the Post-TRCT. This is most likely the result of the higher injury severity found in this cohort, and the smaller sample with a lower number of deaths, but can potentially also be contributed to the new setting. There were more multitrauma patients in the Post-TRCT group and more multitrauma patients survived. Especially multitrauma patients can benefit from a faster diagnostic workup and multitrauma patients also tend to have longer ICU and primary hospital stays than patients with only an isolated injury. Other issues, such as the availability of beds in rehabilitation centers could also have influenced LOS, but we believe that the differences can only be minimal in such a short timespan.

Our study design has several limitations. The absolute numbers of included patients are small, but 10% severe TBI patients of all presented trauma patients compares well with incidence figures found in other studies around the world. The retrospective character of the study could have influenced several data that are time-dependent, such as an accurate GCS at arrival in the hospital, and prehospital transport times. The retrospective nature of the study also influenced the length of follow-up. The patients in the Post-TRCT cohort had a significant shorter time until follow-up. The follow-up time could possibly also have influenced the total mortality. However, we do not believe that this would change the outcome of this study since the follow-up for the Post-TRCT cohort was postponed for 15 months after admission/discharge.

Further, a selection bias was introduced in the study by comparing two historical cohorts that were separated by a 3-month period compensating for the implementation phase of the ATW
Effect of ATW concept on severe traumatic brain injury

concept. However, during the 27-month period covering this study, no major changes were made to the general treatment protocols of trauma patients, nor to the specific protocols for the treatment of severely head-injured patients. Indications for pharmacological therapy or for performing neurosurgical intervention or ICP monitoring did not change during this period and prehospital protocols regarding prehospital intubation and transport criteria generally remained the same. Personnel changes were limited to residents for neurosurgery, trauma surgery and radiology.

Another explanation for the difference found could be the raised awareness for the management of severe TBI by the introduction of the ATW concept. Although Patel et al., showed that placing more attention on management of TBI can cause a better outcome on itself, and it can be hypothesized that with the introduction of the ATW concept, more attention was placed on the management of (neuro-)trauma patients and thus influenced outcome.

Considering all limitations and other possible explanations for the difference found in mortality, the results of our study show a trend towards a better outcome with the ATW concept. While the patients tend to be older and more severely injured in the Post-TRCT, the only major change between the two cohorts was the implementation of the ATW concept. Thus, given the large influence of institutional variations in management of severe TBI as reported by Bulger et al., we believe that the outcome difference found in this mono-centered study mostly reflects the effect of the new workflow setting. This new setting seems to have a potentially major benefit for TBI patients. Currently, we are conducting a study that investigates the value of early shockroom CT scanning in the management of acute trauma patients in a prospective, randomized multicenter study. We hope that in combination with the results of this trial, the results can be placed in better perspective.

CONCLUSION

In this retrospective study, the effect of a new trauma workflow concept incorporating a sliding CT scanner in the trauma resuscitation room was evaluated in severe TBI patients. The TBI-related mortality in TBI patients evaluated in the ATW concept was 23% lower than in the previous trauma resuscitation room setting. There was a trend towards a reduced time until acute neurosurgery in this cohort when compared with the old trauma setting. Further studies to confirm these findings are warranted.
REFERENCES


Effect of ATW concept on severe traumatic brain injury