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Computed tomography lesions and their association with global outcome in young people with mild traumatic brain injury

Lennart Riemann¹, Ana Mikolic², Andrew Maas³, Andreas Unterberg¹, Alexander Younsi¹#, and the Collaborative European NeuroTrauma Effectiveness Research in Traumatic Brain Injury (CENTER-TBI) Investigators and Participants*

¹ Department of Neurosurgery, University Hospital Heidelberg, Germany
² Department of Public Health, Erasmus MC University Medical Center Rotterdam, The Netherlands
³ Department of Neurosurgery, Antwerp University Hospital, University of Antwerp, Edegem, Belgium

# Corresponding author

* List of the CENTER-TBI Investigators and Participants at the end of the article

AUTHOR DETAILS
Lennart Riemann, M.D.
University Hospital Heidelberg
Department of Neurosurgery
INF 400
69120 Heidelberg
Germany
Phone: +4962215636305
Mail: lennart-riemann@posteo.de

Ana Mikolic
P.O. Box 2040
3000 CA Rotterdam
The Netherlands
Phone: +31682217921
Mail: a.mikolic@erasmusmc.nl

Andrew I.R. Maas, M.D., Ph.D.
Antwerp University Hospital
Drie Eikenstraat 655
2650 Edegem
Belgium
Phone: +3238214632
Mail: andrew.maas@uza.be

Andreas Unterberg, M.D., Ph. D.
University Hospital Heidelberg
Department of Neurosurgery
RUNNING HEAD
Association of CT lesions with outcome after TBI
ABSTRACT

Mild traumatic brain injury (mTBI) can be accompanied by structural damage to the brain. Here, we investigated how the presence of intracranial traumatic computed tomography (CT) pathologies relates to the global functional outcome in young patients one year after mTBI.

All patients with mTBI (Glasgow Coma Scale: 13-15) ≤24 years in the multi-center, prospective, observational Collaborative European NeuroTrauma Effectiveness Research in TBI (CENTER-TBI) study were included. Patient demographics and CT findings were assessed at admission, and the Glasgow Outcome Scale Extended (GOSE) was evaluated at 12 months follow-up. The association between a “positive CT” (at least one of the following: epidural hematoma, subdural hematoma, traumatic subarachnoid hemorrhage (tSAH), intraventricular hemorrhage, subdural collection mixed density, contusion, traumatic axonal injury) and functional outcome (GOSE) was assessed using multivariable mixed ordinal and logistic regression models.

A total of 462 patients with mTBI and initial brain CT from 46 study centers were included. The median age was 19 (17-22) years, and 322 (70%) were males. CT imaging showed a traumatic intracranial pathology in 171 patients (37%), most commonly tSAH (48h), contusions (40%), and epidural hematomas (37%). Patients with a positive CT scan were less likely to achieve a complete recovery 12 months post-injury. The presence of any CT abnormality was associated with both lower GOSE scores (Odds ratio (OR): 0.39 [0.24-0.63]) and incomplete recovery (GOSE <8; OR: 0.41 [0.25-0.68]), also when adjusted for demographical and clinical baseline factors.

The presence of intracranial traumatic CT pathologies was predictive of outcome 12 months after mTBI in young patients, which might help to identify candidates for early follow-up and additional care.

KEYWORDS

Mild TBI, intracranial lesions, CT findings, children, adolescents, outcome
INTRODUCTION

Traumatic brain injury (TBI) is one of the most common injuries in young people, displaying an overall prevalence of ~30% among individuals ≤25 years.\textsuperscript{1–3} The vast majority of those patients (approximately 80-90%) is classified as mild TBI (mTBI), clinically defined by a Glasgow Coma Scale (GCS) of 13-15.\textsuperscript{4,5} Though termed “mild”, increasing evidence from both pediatric and adult observational studies suggests that in a substantial proportion of patients with mTBI, the injury course is in fact not benign but associated with serious long-term sequelae such as diminished functional capacity and persistent post-concussive symptoms.\textsuperscript{6–9}

Computed tomography (CT) scans are typically used to detect brain lesions in the acute care setting. However, exposure to radiation poses a strong incentive to limit the use of CT imaging to a very selected group of high-risk patients, especially among young people.\textsuperscript{10,11} Still, a study of >43,000 pediatric and adolescent mTBI patients found that 19%-69% of patients undergo CT scanning across hospitals in the United States.\textsuperscript{12} At the same time, according to the Center for Disease Control, intracranial injuries are only identified in 7.5% of pediatric and adolescent mTBI patients (<18 years) on brain CT.\textsuperscript{13}

While the role of CT imaging to acutely diagnose intracranial brain lesions and guide treatment is widely acknowledged, it is decisively less clear whether the presence of intracranial pathologies on CT imaging can be used to make predictions on the long-term global outcome in young mTBI patients. Earlier studies found no additional value of CT findings compared to clinical predictors alone when predicting global outcome after mTBI in adult cohorts.\textsuperscript{14,15} For example, Jacobs et al. found that age, extracranial injuries and alcohol intoxication were the most important predictors of outcome, with no additional benefit of including CT findings in the prediction model for functional outcome developed in 2784 mTBI patients.\textsuperscript{15} Similarly, CT abnormalities were not predictive of incomplete recovery after mTBI in the UPFRONT study.\textsuperscript{16} In contrast, recent results from large, multicenter observational studies reported a significant association between pathological CT scans and functional outcome.\textsuperscript{6,17,18} This was demonstrated in both the Transforming Research and Clinical Knowledge in TBI (TRACK-TBI) and Collaborative European NeuroTrauma Effectiveness Research in TBI (CENTER-TBI) mTBI cohorts, also when adjusted for other known outcome predictors.\textsuperscript{6,17,18} In a study by Yuh et al.\textsuperscript{17}, intracranial traumatic CT
Pathologies were shown to be strongly associated with outcome up to one year post-injury. Those studies were conducted in adults with mTBI. In this study, we aimed to assess how intracranial findings on CT imaging relate to the global functional outcome 12 months after brain injury in a cohort of young people (children, adolescents, and young adults) with mTBI.

METHODS

Study Design and Patient Selection

CENTER-TBI is a prospective, multicenter, observational cohort study of patients presenting with TBI of all severities and was conducted from December 2014 to December 2017 at 65 participating study centers in Europe and Israel. Patients were eligible for enrollment when presenting with a clinical diagnosis of TBI to a participating study center within 24 hours and when a CT scan was performed at presentation. The indication for CT imaging was made at the discretion of each participating study center/the treating physician. The study protocol was approved by the institutional review boards of each participating study center (https://www.center-tbi.eu/project/ethical-approval) and informed consent from each patient or their legally acceptable representatives was obtained prior to inclusion. The present study includes children, adolescents, and young adults aged ≤24 years at the time of enrollment who had an available initial brain CT scan and presented with a GCS score of 13-15. Data (CENTER Core version 3.0) were accessed via the clinical study data management tool Neurobot (RRID: SCR_017004).

CT imaging

CT scans were reviewed by a central review panel of three trained reviewers (one neuroradiologist with over 25 years of clinical experience and two neuroanatomists with training in head CT reading and 1-2 years of experience) who evaluated the CT characteristics according to the National Institute of Neurological Disorders and Stroke (NINDS) TBI Common Data Elements (TBI-
CDE). Reviewers were blinded to clinical information except for sex, age, and clinical care pathway (discharge, admission to the regular ward, ICU admission). For the present study, we defined “CT Positive” when any of the following trauma-related intracranial abnormalities were present (vs. absent) on initial brain CT: epidural hematoma (EDH), subdural hematoma (SDH), traumatic subarachnoid hemorrhage (tSAH), intraventricular hemorrhage, subdural collection mixed density, contusion and traumatic axonal injuries (focal hyperdense axonal injuries, including isolated ones that do not span multiple areas of the brain). “CT Negative” indicated a non-pathological CT scan or isolated skull fractures (i.e., absence of all the above-mentioned CT characteristics). CT findings coded as “indeterminate” by the central reviewers (4 findings) were counted as negative findings. The final CT report was based on a consensus between the neuroradiologist and one of the two neuroanatomists.

**Outcome Measure**

The primary outcome of this study was the global functional capacity at 12-months follow-up defined by the Glasgow Outcome Scale Extended (GOSE) that ranges from 1=death to 8=fully returned to normal life. Complete recovery was defined as a GOSE score of 8, while scores of 7 or lower were regarded as incomplete recoveries. We used the 12-month GOSE endpoint variable provided in the Neurobot database, which includes both observed ratings and, when GOSE ratings were missing at 12 months, but available at other time points, centrally imputed values using a multi-state model.

**Statistical Analysis**

Group comparisons were performed using the Mann-Whitney U test for continuous variables and Fisher’s exact test for categorical variables. Missing data was imputed using multilevel multiple imputation (100 datasets) that included the variables 12-months GOSE (outcome), sex, age, extracranial injury severity scale (ISS), GCS <15, and intracranial CT abnormality (predictors) and study center (cluster variable). The ‘extracranial’ ISS – to reflect extracranial (poly-)traumatic injuries – was calculated as the sum of ISS scores.
of all body regions except for those of the brain/head. Missing data was assumed to be missing at random. The association between the presence of an intracranial CT lesion on the 12-month GOSE score was evaluated using mixed ordinal regression models. We also assessed the association between those predictors and complete recovery at 12 months using mixed logistic regression models. Models were adjusted for age, sex, extracranial ISS, GCS score <15, +/- intracranial surgeries and included a random intercept for study center. Covariables were selected based on previous literature and clinical reasoning.\textsuperscript{24–27} Regressions were performed on the multiply-imputed datasets, and effect estimates were subsequently pooled according to Rubin’s rules.\textsuperscript{28} Odds ratios and their 95\% confidence intervals are reported. The outcome analysis was repeated as a complete-case-analysis (n = 388). As additional analyses, we examined the predictive value of the Rotterdam CT score\textsuperscript{29}, which provides an estimation of prognosis based on several CT imaging findings (basal cisterns, midline shift, epidural mass lesion, intraventricular or traumatic SAH), the four most frequent intracranial traumatic CT pathologies (traumatic SAH, contusion, EDH, and SDH), and, additionally, that of isolated skull fractures, using multivariable ordinal regression models with the same covariables as before. To examine the added value of CT beyond a model of clinical predictors alone, we performed a likelihood ratio test in the imputed data\textsuperscript{30} in the comparing a full model (clinical data + CT abnormality) against a restricted model (clinical data alone). For this analysis, we extended the clinical predictor variables to additionally include injury cause (high-vs. low-energy), American Society of Anesthesiologists Classification class (healthy vs. having a mild, moderate, severe, or life-threatening systemic disease), and psychiatric history. Additionally, area under the curve (AUC) characteristics were calculated for the full and restricted model and were compared using DeLong’s test. All analyses were conducted with the software R (version 4.1.1).\textsuperscript{31}
RESULTS

Patient characteristics

A total of 462 patients met the inclusion criteria for this study and were enrolled at 46 study centers across Europe. The median age was 19 (17-22) years and 70% were males. Road traffic incidents and incidental falls were the most common injury causes. Seventy-seven percent of individuals presented to the emergency room with a GCS score of 15 and the median extracranial injury severity score (ISS) was 10 (5-18). Admission to the regular ward was the most common clinical care pathway (49%). Thirty-eight patients received an intracranial surgery during the hospital course. Twelve months after mTBI, a complete recovery was achieved by almost 70% of young patients. Only four patients were dead or had severe disability at 12-months follow-up. During the first-year post-injury, 56 patients (12%) received rehabilitation (in-patient and/or out-patient) at least once by the time of the follow-up interview. All analyzed patient characteristics are summarized in Table 1.

Indications for CT imaging

The most reported reason to perform a brain CT scan in our study population was the presence of a risk factor in a patient with a GCS score of 15 (Supplement Table 2). The second most common reason was the presence of a head wound (27%), followed by a GCS score <15. In a minority of patients, exclusion of brain injuries prior to discharge (13%) or suspicion of maxillofacial injuries (9%) were given as the reason to perform CT imaging. However, multiple risk factors could be selected for an individual patient in the CENTER-TBI questionnaire by the treating physician.
CT pathologies

Intracranial traumatic CT pathology (“CT Positive”) was detected in 171 of 462 patients (37%; Figure 1). Among those, the most common pathologies on brain CT were traumatic subarachnoid hemorrhages (48%), followed by contusions (40%), and epidural hematomas (37%). Acute subdural hematomas were identified in 29% of CT positive patients and traumatic axonal injuries in 14%. Intraventricular hemorrhages (4 patients) and subdural collection mixed densities (1 patient) were rare.

Comparison of “CT Positive” and “CT Negative” patients

Individuals with a positive CT scan displayed a higher proportion of male sex as well as differences regarding a history of alteration of consciousness and post-traumatic amnesia (Supplement Table 1). Moreover, “CT Positive” patients were more likely to present with a GCS score <15 (35% vs. 16%). While there was no significant difference in extracranial ISS, the median total ISS was significantly higher in individuals with a positive CT scan (16 [9-25] vs. 9 [4-13]). A difference between the two groups was also found regarding the clinical care pathway, where “CT Positive” patients were much more frequently admitted to the ICU (45% vs. 10%). While 77% of patients with a negative CT scan achieved full recovery (GOSE=8) one-year after brain injury, this was only the case in 54% of patients with a positive CT scan (p <0.001).

Association of CT lesions and GOSE in multivariable analyses

Mixed ordinal regression models were used to assess the association between traumatic intracranial CT abnormalities and GOSE scores 12 months postinjury with adjustment for the demographical variables age and sex, and the clinical variables GCS <15 and extracranial ISS. The presence of an intracranial pathology on brain CT scan was associated with a lower likelihood of achieving higher 12-month GOSE scores (adjusted OR 0.387 [0.237 – 0.633]; Supplement Table 2). Similarly, the presence of any intracranial lesion was associated with a lower likelihood of full recovery one-year after mTBI (adjusted OR 0.409 [0.248 – 0.675]). The complete-
case-analyses of the same models yielded similar results (Supplement Table 3). The Rotterdam CT score was significantly associated with the 12-months outcome even in our cohort of young mTBI patients, but the odds ratios were comparable or even smaller than for the “intracranial pathology” variable (Supplement Table 4 and 5). The association between intracranial CT abnormalities and 12-months GOSE scores remained statistically significant when also including intracranial surgeries as a predictor in the model (adjusted OR 0.31 [0.19 – 0.53], Supplement Table 6 and 7). On the other hand, the presence of isolated skull fractures (i.e., without traumatic intracranial abnormalities) was not significantly associated with GOSE scores at 12 months postinjury (Supplement Table 8 and 9).

**Association between tSAH, EDH, SDH, contusion and GOSE**

Both tSAH (adjusted OR 0.52 [0.30 – 0.89]), EDH (adjusted OR 0.41 (0.23 – 0.73]), and SDH (adjusted OR 0.52 [0.29 – 0.96]) were significantly associated with a lower likelihood of achieving higher GOSE scores at 12-months (Supplement Table 10 A-C). Contusion was also associated with GOSE outcome; however, this association had wider confidence intervals (Supplement Table 10 D).

**Comparison of a model with clinical predictors + CT pathology vs. a model with clinical predictors only**

Finally, we tested whether including intracranial traumatic CT pathology significantly adds to the predictive capability of a model with clinical variables only. The model with clinical data plus CT abnormality showed a significantly better fit than the model with clinical data alone (F-value 19.4, p <0.001), indicating that the presence of a CT abnormality has a predictive value beyond clinical data alone in this cohort. Furthermore, the AUC for the model with clinical data plus CT abnormality was significantly greater than that of the model with clinical data only (0.71 [95% CI 0.65–0.77] vs. 0.65 [95% CI 0.59–0.71], DeLong’s test: p = 0.029).
DISCUSSION

In this study, the presence of intracranial traumatic CT pathologies was predictive of lower GOSE scores and incomplete recovery 12 months post-injury in a cohort of young people with mTBI. While the value of CT imaging for the detection of significant brain lesions is well-established, its role in predicting long-term outcome remains controversial. On one hand, some studies showed no additional value compared to clinical factors alone; on the other hand, recent multicenter studies demonstrated a significant association with poorer outcome. Of note, those studies were conducted in adult TBI patients and data in younger cohorts, especially regarding long-term outcome, is scarce. As CT scans are performed in a considerable proportion of patients even in the young population, such young people form a large and clinically important group of TBI patients at risk of being understudied. Levin et al. described a significant relation between CT abnormalities and diminished neuropsychological recovery in children with mTBI over the first year. With a median age of 19 years, which is distinctively lower than in previous (adult) studies, our patient cohort of young people further underlines the association between the presence of traumatic intracranial CT abnormalities and global GOSE scores 12 months after TBI. This is a clinically important finding, because identifying patients at risk for an incomplete recovery is an essential aim in the management of mTBI. Firstly, providing an accurate prognosis is important for patients and their relatives. Secondly, despite a general lack of high-quality studies, there is evidence that interventions such as patient education as well as psychological and rehabilitative measures can be effective to treat mTBI symptoms in both young and adult patients. The results of this study thus indicate that the presence of intracranial CT findings should be considered when predicting the outcome of young patients with mTBI, especially because adding the variable intracranial CT abnormality was found to improve the predictive ability of a ‘clinical variables only’ model. Of note, the Rotterdam CT score had no greater predictive value than the presence of any intracranial traumatic CT pathology in our cohort of young mTBI patients. An explanation could be that this score was developed for adults with moderate to severe TBI, and its predictive value might be limited in the setting of mTBI. In fact, its first two categories (basal cisterna
compression and midline shift) are rarely seen in mTBI, and in our cohort, more than 80% of patients were given a Rotterdam CT score of 2, suggesting that it was more of a general indicator of intracranial lesion than a measure of lesion severity in this setting.

In this study, we focused on intracranial abnormalities on CT and did not analyze abnormalities on magnetic resonance imaging (MRI). CT imaging is suitable for the detection of intracranial hemorrhages and contusions; however, it might miss small cortical contusions and hemorrhagic axonal injuries that are detectable by MRI. In fact, 27% of patients with mTBI and normal CT scans on admission had abnormal findings on early brain MRI in the multicenter TRACK-TBI study. Subtle changes in the white matter detected by early (advanced) MRI scans have shown to be associated with functional recovery and post-concussion symptoms, and additional MRI findings might improve outcome prediction compared to clinical and CT characteristics alone. However, while the role of CT is firmly established in the acute TBI care, the utility of MRI in early management setting remains unclear. In light of high costs, often limited access, low frequency of findings, and possibly limited treatment consequences, MRI findings, as opposed to CT findings, will currently not be available for outcome prediction in most health care settings.

This study emphasizes the need for more research on mTBI in young people. Although widely regarded as a benign disease entity, almost one third of our study participants did not achieve complete recovery 12 months after the injury. While they were by study design (indication for CT imaging as an inclusion criterion) likely on the more serious spectrum of mTBI, this still aligns well with recent evidence from multiple studies about the unfavorable implications of sustaining a mTBI.

We acknowledge several limitations of this study. While CENTER-TBI was open for patients of all ages, pediatric patients were underrepresented, as most centers were general hospitals which often had separate pediatric units for children with TBI. Therefore, our sample size was limited compared to the overall CENTER-TBI core study population. Another implication is that our cohort of young patients ≤24 years consists mostly of adolescents and young adults with relatively few children. Due to the low numbers of
younger children, we did not conduct a sensitivity analysis either to explore the predictive value of head CT imaging specifically at younger ages. Therefore, our results are not generalizable to young children and more studies are needed in this even younger age group. It has also to be mentioned that the term “CT abnormality” encompasses a broad range of intracranial pathologies which might have different implications for the outcome. Of note, the rate of “traumatic axonal injuries” reported in our study must be interpreted with caution, because such lesions can be challenging to identify on CT imaging and tend to be over- or underrated.20 Also, due to the observational study design, interventions and treatments might have differed between centers and were not analyzed in this study. While we did not perform further analyses with subclassifications into single lesions due to limited patient numbers, further studies are needed to address this important question. Similarly, because even our superior prediction model including cranial CT imaging displayed only a moderate AUC of 0.71, further studies are also needed to investigate and develop more accurate predictive models for young mTBI patients. Lastly, imaging characteristics at the time of follow-up (one year) were not available and could thus not be correlated with the outcome.

In conclusion, we found that intracranial traumatic CT pathologies were significantly associated with an increased likelihood of lower global outcome 12 months after mTBI in individuals ≤24 years in the CENTER-TBI study. This information might be used to develop protocols that aim to identify young patients with mTBI at risk for an incomplete recovery who might benefit from closely monitored follow-up and early treatment interventions.

CONFLICT OF INTEREST

The authors declare no conflict of interest.
FUNDING

CENTER-TBI was supported by the European Union 7th Framework program (EC grant 602150). Additional funding was obtained from the Hannelore Kohl Stiftung (Germany), OneMind (USA), from Integra LifeSciences Corporation (USA) and from NeuroTrauma Sciences (USA).

ETHICS STATEMENT

Ethical approval was obtained for each recruiting site. A complete list is given on https://www.center-tbi.eu/project/ethical-approval. All patients had to give their informed consent prior to enrollment in CENTER-TBI.

ACKNOWLEDGMENTS

Results of this study have been presented at the 73rd annual meeting of the German Society of Neurosurgery, the annual meeting of the European Association of Neurological Societies 2021 and the 15th International Neurotrauma Symposium.
REFERENCES


Figure 1: Occurrence of traumatic intracranial abnormalities on CT-imaging.
Table 1: Patient characteristics, clinical baseline status, and outcome in mTBI patients ≤24 years in the CENTER-TBI study

<table>
<thead>
<tr>
<th>Variable</th>
<th>Total (n= 462)</th>
<th>CT Positive (n= 171)</th>
<th>CT Negative (n= 291)</th>
<th>P value</th>
<th>Missing/Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19 (17-22)</td>
<td>19 (16-22)</td>
<td>19 (17-22)</td>
<td>0.433</td>
<td>0 (0%)</td>
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<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Female</td>
<td>140 (30%)</td>
<td>35 (21%)</td>
<td>104 (36%)</td>
<td>&lt;0.001</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Male</td>
<td>322 (70%)</td>
<td>136 (80%)</td>
<td>186 (64%)</td>
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<tr>
<td>Care Pathway</td>
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<td>&lt;0.001</td>
<td>0 (0%)</td>
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<tr>
<td>ER discharge</td>
<td>132 (29%)</td>
<td>10 (6%)</td>
<td>122 (42%)</td>
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<tr>
<td>Ward admission</td>
<td>225 (49%)</td>
<td>84 (49%)</td>
<td>141 (49%)</td>
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</tr>
<tr>
<td>ICU admission</td>
<td>105 (23%)</td>
<td>77 (45%)</td>
<td>28 (10%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior TBI</td>
<td>53 (12%)</td>
<td>15 (9%)</td>
<td>38 (13%)</td>
<td>0.126</td>
<td>12 (3%)</td>
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<td>Injury Cause</td>
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<tr>
<td>Road-traffic incident</td>
<td>191 (41%)</td>
<td>79 (46%)</td>
<td>112 (39%)</td>
<td>0.113</td>
<td>2 (&lt;1%)</td>
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<tr>
<td>Incidental fall</td>
<td>165 (36%)</td>
<td>49 (29%)</td>
<td>116 (40%)</td>
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<td></td>
</tr>
<tr>
<td>Other non-intentional injury</td>
<td>39 (8%)</td>
<td>13 (8%)</td>
<td>26 (9%)</td>
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<tr>
<td>Violence/assault</td>
<td>46 (10%)</td>
<td>20 (12%)</td>
<td>26 (9%)</td>
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<td></td>
</tr>
<tr>
<td>Suicide attempt</td>
<td>2 (&lt;1%)</td>
<td>0 (0%)</td>
<td>2 (&lt;1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>17 (4%)</td>
<td>9 (5%)</td>
<td>8 (3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol</td>
<td></td>
<td></td>
<td></td>
<td>0.095</td>
<td>21 (5%)</td>
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<tr>
<td>Definite</td>
<td>68 (15%)</td>
<td>20 (13%)</td>
<td>48 (17%)</td>
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</tr>
<tr>
<td>Suspected</td>
<td>21 (5%)</td>
<td>10 (6%)</td>
<td>11 (4%)</td>
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<td></td>
</tr>
<tr>
<td>Drugs</td>
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<td></td>
<td>0.297</td>
<td>38 (8%)</td>
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<td>Definite</td>
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<td>6 (4%)</td>
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<td>Suspected</td>
<td>5 (1%)</td>
<td>2 (1%)</td>
<td>3 (1%)</td>
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<tr>
<td>GCS</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td>0 (%)</td>
</tr>
<tr>
<td>13</td>
<td>24 (5%)</td>
<td>15 (9%)</td>
<td>9 (3%)</td>
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<tr>
<td>14</td>
<td>83 (18%)</td>
<td>45 (26%)</td>
<td>38 (13%)</td>
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<tr>
<td>15</td>
<td>355 (77%)</td>
<td>111 (65%)</td>
<td>244 (84%)</td>
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<td>LOC</td>
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<td></td>
<td></td>
<td>0.699</td>
<td>44 (10%)</td>
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<td>Yes</td>
<td>201 (48%)</td>
<td>79 (50%)</td>
<td>122 (47%)</td>
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<tr>
<td></td>
<td>Suspected</td>
<td>Ongoing</td>
<td>Resolved</td>
<td>Suspected</td>
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<tr>
<td>------------------</td>
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<tr>
<td><strong>PTA</strong></td>
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<tr>
<td>Ongoing</td>
<td>65 (16%)</td>
<td>28 (20%)</td>
<td>37 (14%)</td>
<td>0.010</td>
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</tr>
<tr>
<td>Resolved</td>
<td>140 (34%)</td>
<td>47 (33%)</td>
<td>93 (34%)</td>
<td>51 (11%)</td>
<td></td>
</tr>
<tr>
<td>Suspected</td>
<td>12 (3%)</td>
<td>4 (3%)</td>
<td>8 (3%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Alteration of Consciousness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Yes, immediate</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Not tested (LOC)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Suspected</td>
<td>77 (19%)</td>
<td>29 (19%)</td>
<td>48 (19%)</td>
<td>54 (12%)</td>
<td></td>
</tr>
<tr>
<td>Delayed onset</td>
<td>53 (13%)</td>
<td>22 (15%)</td>
<td>31 (12%)</td>
<td></td>
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<tr>
<td></td>
<td>11 (3%)</td>
<td>8 (5%)</td>
<td>3 (1%)</td>
<td></td>
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<tr>
<td></td>
<td>12 (3%)</td>
<td>9 (6%)</td>
<td>3 (1%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Extracranial ISS (median)</strong></td>
<td>1 (0-9)</td>
<td>4 (0-9)</td>
<td>1 (0-8)</td>
<td>0.170</td>
<td></td>
</tr>
<tr>
<td><strong>Total ISS (median)</strong></td>
<td>10 (5-18)</td>
<td>16 (9-25)</td>
<td>9 (4-13)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td><strong>GOSE at 12 months</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Full recovery</td>
<td>268 (69%)</td>
<td>80 (54%)</td>
<td>188 (77%)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Incomplete recovery</td>
<td>120 (31%)</td>
<td>68 (46%)</td>
<td>52 (21%)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Unfavorable outcome</td>
<td>4 (&lt;1%)</td>
<td>0 (%)</td>
<td>4 (2%)</td>
<td>0.302</td>
<td></td>
</tr>
</tbody>
</table>

CT = Computed tomography, ER = Emergency Room, GCS = Glasgow Coma Scale, GOSE = Glasgow Outcome Scale Extended, ICU = Intensive Care Unit, ISS = Injury severity score, LOC = Loss of consciousness, TBI = Traumatic Brain Injury
CENTER-TBI INVESTIGATORS AND PARTICIPANTS:

Lindsay Wilson, Stefan Winzeck, Stefan Wolf, Zhihui Yang, Peter Ylén, Alexander Younsi, Frederick A. Zeiler, Veronika Zelinkova, Agate Ziverte, Tommaso Zoerle
1 Department of Physiology and Pharmacology, Section of Perioperative Medicine and Intensive Care, Karolinska Institutet, Stockholm, Sweden
2 János Szentágothai Research Centre, University of Pécs, Pécs, Hungary
3 Division of Surgery and Clinical Neuroscience, Department of Physical Medicine and Rehabilitation, Oslo University Hospital and University of Oslo, Oslo, Norway
4 Department of Neurosurgery, University Hospital Northern Norway, Tromso, Norway
5 Department of Physical Medicine and Rehabilitation, University Hospital Northern Norway, Tromso, Norway
6 Trauma Surgery, Medical University Vienna, Vienna, Austria
7 Department of Anesthesiology & Intensive Care, University Hospital Nancy, Nancy, France
8 Raymond Poincare hospital, Assistance Publique – Hopitaux de Paris, Paris, France
9 Department of Anesthesiology & Intensive Care, S Raffaele University Hospital, Milan, Italy
10 Department of Neurosurgery, Radboud University Medical Center, Nijmegen, The Netherlands
11 Department of Neurosurgery, University of Szeged, Szeged, Hungary
12 International Projects Management, ARTTIC, Munchen, Germany
13 Department of Neurology, Neurological Intensive Care Unit, Medical University of Innsbruck, Innsbruck, Austria
14 Department of Neurosurgery & Anesthesia & intensive care medicine, Karolinska University Hospital, Stockholm, Sweden
15 NIHR Surgical Reconstruction and Microbiology Research Centre, Birmingham, UK
16 Anesthesie-Réanimation, Assistance Publique – Hopitaux de Paris, Paris, France
17 Department of Anesthesia & ICU, AOU Città della Salute e della Scienza di Torino - Orthopedic and Trauma Center, Torino, Italy
18 Department of Neurology, Odense University Hospital, Odense, Denmark
19 BehaviourWorks Australia, Monash Sustainability Institute, Monash University, Victoria, Australia
20 Department of Public Health, Faculty of Health Sciences and Social Work, Trnava University, Trnava, Slovakia
21 Quesgen Systems Inc., Burlingame, California, USA
22 Australian & New Zealand Intensive Care Research Centre, Department of Epidemiology and Preventive Medicine, School of Public Health and Preventive Medicine, Monash University, Melbourne, Australia
23 Department of Surgery and Perioperative Science, Umeå University, Umeå, Sweden
24 Department of Neurosurgery, Medical School, University of Pécs, Hungary and Neurotrauma Research Group, János Szentágothai Research Centre, University of Pécs, Hungary
25 Department of Medical Psychology, Universitätsklinikum Hamburg-Eppendorf, Hamburg, Germany
26 Brain Physics Lab, Division of Neurosurgery, Dept of Clinical Neurosciences, University of Cambridge, Addenbrooke’s Hospital, Cambridge, UK
27 Neuro ICU, Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milan, Italy
28 ANZIC Research Centre, Monash University, Department of Epidemiology and Preventive Medicine, Melbourne, Victoria, Australia
29 Department of Neurosurgery, Hospital of Cruces, Bilbao, Spain
30 NeuroIntensive Care, Niguarda Hospital, Milan, Italy
31 School of Medicine and Surgery, Università Milano Bicocca, Milano, Italy
32 NeuroIntensive Care, ASST di Monza, Monza, Italy
33 Department of Neurosurgery, Medical Faculty RWTH Aachen University, Aachen, Germany
34 Department of Anesthesiology and Intensive Care Medicine, University Hospital Bonn, Bonn, Germany
35 Department of Anesthesia & Neurointensive Care, Cambridge University Hospital NHS Foundation Trust, Cambridge, UK
36 School of Public Health & PM, Monash University and The Alfred Hospital, Melbourne, Victoria, Australia
37 Radiology/MRI department, MRC Cognition and Brain Sciences Unit, Cambridge, UK
38 Institute of Medical Psychology and Medical Sociology, Universität Göttingen, Göttingen, Germany
39 Oxford University Hospitals NHS Trust, Oxford, UK
40 Intensive Care Unit, CHU Poitiers, Poitiers, France
41 University of Manchester NIHR Biomedical Research Centre, Critical Care Directorate, Salford Royal Hospital NHS Foundation Trust, Salford, UK
42 Movement Science Group, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK
43 Department of Neurosurgery, Antwerp University Hospital and University of Antwerp, Edegem, Belgium
44 Department of Anesthesia & Intensive Care, Maggiore Della Carità Hospital, Novara, Italy
45 Department of Neurosurgery, University Hospitals Leuven, Leuven, Belgium
46 Department of Neurosurgery, Clinical centre of Vojvodina, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia
47 Division of Anaesthesia, University of Cambridge, Addenbrooke’s Hospital, Cambridge, UK
48 Center for Stroke Research Berlin, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin, Humboldt-Universität zu Berlin, and Berlin Institute of Health, Berlin, Germany
49 Intensive Care Unit, CHR Citadelle, Liège, Belgium
50 Department of Anaesthesiology and Intensive Therapy, University of Pécs, Pécs, Hungary
51 Departments of Neurology, Clinical Neurophysiology and Neuroanesthesiology, Region Hovedstaden Rigshospitalet, Copenhagen, Denmark
52 National Institute for Stroke and Applied Neurosciences, Faculty of Health and Environmental Studies, Auckland University of Technology, Auckland, New Zealand
53 Department of Neurology, Erasmus MC, Rotterdam, the Netherlands
54 Department of Anesthesiology and Intensive care, University Hospital Northern Norway, Tromso, Norway
55 Department of Neurosurgery, Hadassah-hebrew University Medical center, Jerusalem, Israel
56 Fundación Instituto Valenciano de Neurorrehabilitación (FIVAN), Valencia, Spain
57 Department of Neurosurgery, Shanghai Renji hospital, Shanghai Jiaotong University/school of medicine, Shanghai, China
58 Karolinska Institutet, INCF International Neuroinformatics Coordinating Facility, Stockholm, Sweden
59 Emergency Department, CHU, Liège, Belgium
60 Neurosurgery clinic, Pauls Stradins Clinical University Hospital, Riga, Latvia
61 Department of Computing, Imperial College London, London, UK
62 Department of Neurosurgery, Hospital Universitario 12 de Octubre, Madrid, Spain
63 Department of Anesthesia, Critical Care and Pain Medicine, Medical University of Vienna, Austria
64 Department of Public Health, Erasmus Medical Center-University Medical Center, Rotterdam, The Netherlands
65 College of Health and Medicine, Australian National University, Canberra, Australia
66 Department of Neurosurgery, Neurosciences Centre & JPN Apex trauma centre, All India Institute of Medical Sciences, New Delhi-110029, India
67 Department of Neurosurgery, Erasmus MC, Rotterdam, the Netherlands
68 Department of Neurosurgery, Oslo University Hospital, Oslo, Norway
69 Division of Psychology, University of Stirling, Stirling, UK
70 Division of Neurosurgery, Department of Clinical Neurosciences, Addenbrooke’s Hospital & University of Cambridge, Cambridge, UK
71 Department of Neurology, University of Groningen, University Medical Center Groningen, Groningen, Netherlands
108 Department of Anaesthesia, Critical Care & Pain Medicine NHS Lothian & University of Edinburgh, Edinburgh, UK
109 Director, MRC Biostatistics Unit, Cambridge Institute of Public Health, Cambridge, UK
110 Department of Physical Medicine and Rehabilitation, Oslo University Hospital/University of Oslo, Oslo, Norway
111 Division of Orthopedics, Oslo University Hospital, Oslo, Norway
112 Institute of Clinical Medicine, Faculty of Medicine, University of Oslo, Oslo, Norway
113 Broad Institute, Cambridge MA Harvard Medical School, Boston MA, Massachusetts
114 General Hospital, Boston MA, USA
115 National Trauma Research Institute, The Alfred Hospital, Monash University, Melbourne, Victoria, Australia
116 Department of Neurosurgery, Odense University Hospital, Odense, Denmark
117 International Neurotrauma Research Organisation, Vienna, Austria
118 Klinik für Neurochirurgie, Klinikum Ludwigsburg, Ludwigsburg, Germany
119 Division of Biostatistics and Epidemiology, Department of Preventive Medicine, University of Debrecen, Debrecen, Hungary
120 Department Health and Prevention, University Greifswald, Greifswald, Germany
121 Department of Anaesthesiology and Intensive Care, AUVA Trauma Hospital, Salzburg, Austria
122 Department of Neurology, Elisabeth-TweeSteden Ziekenhuis, Tilburg, the Netherlands
123 Department of Neuroanesthesia and Neurointensive Care, Odense University Hospital, Odense, Denmark
124 Department of Neuromedicine and Movement Science, Norwegian University of Science and Technology, NTNU, Trondheim, Norway
125 Department of Physical Medicine and Rehabilitation, St.Olavs Hospital, Trondheim University Hospital, Trondheim, Norway
126 Division of Neuroscience Critical Care, John Hopkins University School of Medicine, Baltimore, USA
127 Department of Neuropathology, Queen Elizabeth University Hospital and University of Glasgow, Glasgow, UK
128 Dept. of Department of Biomedical Data Sciences, Leiden University Medical Center, Leiden, The Netherlands
129 Department of Pathophysiology and Transplantation, Milan University, and Neuroscience ICU, Fondazione IRCCS Ca Granda Ospedale Maggiore Policlinico, Milano, Italy
130 Department of Radiation Sciences, Biomedical Engineering, Umeå University, Umeå, Sweden
131 Perioperative Services, Intensive Care Medicine and Pain Management, Turku University Hospital and University of Turku, Turku, Finland
132 Department of Neurosurgery, Kaunas University of Health Sciences, Kaunas, Lithuania
133 Intensive Care and Department of Pediatric Surgery, Erasmus Medical Center, Sophia Children's Hospital, Rotterdam, The Netherlands
134 Department of Neurosurgery, Kings college London, London, UK
135 Neurologie, Neurochirurgie und Psychiatrie, Charité – Universitätsmedizin Berlin, Berlin, Germany
136 Department of Intensive Care Adults, Erasmus MC– University Medical Center Rotterdam, Rotterdam, the Netherlands
137 iCoMetrix NV, Leuven, Belgium
138 Movement Science Group, Faculty of Health and Life Sciences, Oxford Brookes University, Oxford, UK
139 Psychology Department, Antwerp University Hospital, Edegem, Belgium
140 Director of Neurocritical Care, University of California, Los Angeles, USA
141 Department of Neurosurgery, St.Olavs Hospital, Trondheim University Hospital, Trondheim, Norway
142 Department of Emergency Medicine, University of Florida, Gainesville, Florida, USA
Department of Neurosurgery, Charité – Universitätsmedizin Berlin, corporate member of Freie Universität Berlin, Humboldt-Universität zu Berlin, and Berlin Institute of Health, Berlin, Germany

VTT Technical Research Centre, Tampere, Finland

Section of Neurosurgery, Department of Surgery, Rady Faculty of Health Sciences, University of Manitoba, Winnipeg, MB, Canada