Traumatic Brain Injury patients
-identified by computed tomography imaging
-treated as in-patients at
Oslo University Hospital in 2015 - 2017

A compulsory science project for the medical students

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Summary

OBJECTIVE The aim of this study was to describe a cohort of Traumatic Brain Injury (TBI) patients identified by computed tomography imaging treated as in-patients at Oslo University Hospital (OUS) in 2015 – 2017.

METHODS A retrospective study of 1231 consecutive TBI patients. Data regarding trauma mechanism, co-morbidity, triage, diagnostics, treatment and discharge destination were collected from chart review and entered into the hospital approved quality database for acute management of TBI at OUS made in MedInsight. The present study and the MedInsight database were approved by PVO-OUS.

RESULTS 1231 consecutive TBI patients were registered during the 3-year period. The annual referral rate was 25/100 000 for the Oslo population, while the annual referral rate for the remaining regions of Helse Sør-Øst (HSØ), Oslo excluded, was 10/100 000. Median age was 55.1 years and 69% were males. Among the 1231 patients, 128 (10%) were below 18 years old and 321 (26%) were over 70 years and classified as elderly. The severity of TBIs, classified according to Head Injury Severity Scale (HISS), were 80 (7 %) minimal, 479 (39%) mild, 315 (26 %) moderate and 357 (29%) severe. The most common cause of injury was falls, transport accidents and assaults. 593 (48%) had multi-trauma (trauma affecting the head and at least one other body region). The most common injuries on head CT were subdural hematoma, traumatic subarachnoidal hemorrhage, cerebral contusion and skull fracture. The two most common neurosurgical procedures were ICP monitor (n=311) and evacuation of mass lesion (n=202). On average TBI patients occupied 9.2 beds and 3.3 patients were on ventilator every day during the study period. Overall in hospital mortality were 8.6%. For severe TBI the in-hospital morality rate was 25%. One month mortality for minimal-,mild-, moderate- and severe TBI was 1,3 %, 2,5 %, 7,6 % and 29, 1 %, respectively. Only 16% of the patients were discharged directly to a rehabilitation unit.

CONCLUSIONS This study clearly demonstrates that hospital admitted TBI patients is a large patient group requiring considerable hospital resources.

Introduction

Traumatic brain injury (TBI) is defined as damage to the brain as a result of external mechanical force where the brain function can be permanently or temporarily affected (1). A substantial number of people die from TBI. However, a much higher proportion of these patients will experience long-term effects of TBI including physical, cognitive, behavioral, and emotional consequences. Even mild TBI can cause long-lasting cognitive impairment that affects a person's daily life and functioning. TBIs contributes strongly to costs in the health care system, and head injuries are often shown to involve young people. The result is loss of life, reduced working years, expensive treatment and rehabilitation that inflicts society a great economic burden. The aim of this study is to give an overview of patient load, gender, age, injury mechanism, severity of TBI, concomitant multi trauma, neurosurgical procedures, days on ventilator, length of hospital stay, in-hospital mortality and discharge destination. Such data is important for future hospital planning. Since this is an educational student project, a brief overview of TBI is given as part of the introduction.

Incidence

The incidence of traumatic brain injury (TBI) in the general population may be as high as 790/100,000 (2) The vast majority of these TBIs are minimal or mild and not in need of in-patient hospital treatment. For citizens of Oslo, Angelic et al found an annual TBI hospital admission rate of 83.3/100,000 people (3). Of the TBI patients admitted in Andelics study only 32% had acute TBI pathology on CT. Thus, the admission rate of Oslo citizens with a CT positive TBI was 26/100,000.

Classification

There are several classification systems available for TBI. None of them works perfect by themselves. A classification system should be as easy to use as possible, but sensitive enough to discriminate TBI into all subtypes and should be useful for therapeutic and prognostic purposes (4). In this report we are combining several different TBI classification systems ranging from injury mechanism, description based upon symptom severity and consciousness impairment and pathoanatomic injury description.

Physical mechanism

The easiest way to classify a TBI is by sorting them into blunt, penetrating or blast injuries. Blunt injuries are by far the most common and consist of physical impacts to the head by a blunt object or surface. Typically, these injuries are caused by falls, vehicle accidents, violence or sporting accidents. Penetrating head-injuries are caused by an object penetrating the scull and the outer meningeal layer, the dura mater, consequently leading to a potential passage for incoming bacteria and possible cerebrospinal fluid leakage. Blast injuries to the head are caused by the direct effect of blast overpressure (5). This type of injury is typically seen after explosions in war. In the civilian population this type of injuries is rare.

Glasgow Coma Scale (GCS)

Glasgow coma scale (table 1) is a clinical scale evolved for assessing the depth and duration of impaired consciousness and coma (6). The scale has three characteristics, motoric response, verbal response and eye opening. The scoring system can give a maximum of 15 points, meaning that the person is unaffected, and a minimum of three points, meaning that the patient is in coma (6). The GCS was developed to improve clinical care and to better understanding the prognosis of patients suffering a brain injury. It has been an integral part of clinical practice and research worldwide for the last 40 years. Today the GCS has several applications, including risk assessment, trend monitoring, classification and prognosis. In research the GCS is fundamental for characterizing patient populations with brain damage (7). The GCS is an effective and easy-to-use scale.

Table 1. Glasgow Coma Scale (GCS)

Response	Score
Eye opening	
Spontaneous	4
To speech	3
To pain	2
No response	1
Verbal response	
Oriented to time, place and person	5
Confused	4
Inappropriate words	3
Incomprehensible sounds	2
No response	1
Motor response	
Obeys commands	6
Moves to localized pain	5
Flexion to withdraw from pain	4
Abnormal flexion	3
Abnormal extension	2
No response	1

Head Injury Severity Scale (HISS)

The Head Injury Severity Scale (HISS) (table 2), originally published by Stein and Spetell (31, 32), divides TBI-patients into **Minimal**: GCS= 15, and no loss of consciousness (LOC). **Mild**: GCS = 14 or 15 with <5 minutes LOC or amnesia, or impaired alertness or memory. **Moderate**: GCS= 9-13, or LOC ≥ 5 minutes or focal neurological deficit. **Severe**: GCS= 3-8 (8-9).

Table 2. Head injury severity scale (HISS)

Category	Characteristics
Minimal	GCS score 15 and no LOC*
Mild	GCS 14 or 15, or < 5min LOC or amnesia or impaired responsiveness
Moderate	GCS 9-13 or LOC > 5 min or focal neurological deficits.
Severe	GCS 3-8

LOC* loss of consciousness

Pathoanatomic

A pathoanatomic classification of TBI describes the injury of the brain tissue, hematomas surrounding the brain, skull fractures and injuries to the blood vessels surrounding, or leading to the brain. Computed tomography (CT) is the imaging modality of choice in the investigation for abnormalities after a traumatic brain injury. CT is noninvasive, fast and reliably demonstrates acute hemorrhage, midline shift, intracranial masses and fractures. The main disadvantage by using CT is the exposure for radiation, especially in children. Magnetic tomography imaging (MRI) is more sensitive in identifying non-hemorrhagic brain contusions and is also used if diffuse axonal injuries (DAI) are suspected.

Fractures

The presence of a skull fracture proves that there have been a traumatic injury and that great impact and force has been implied to the skull. Most fractures are closed linear fractures, meaning a simple fracture radiating outward from the point of impact. These fractures rarely require surgical intervention. An impression fracture, also called depressed fracture is defined by bony parts of the skull being depressed against or into the brain parenchyma. This type of fracture may cause epileptic seizures, and there for often require surgical management. Skull base fractures are fractures involving the base of the skull. They are often associated with cerebrospinal fluid rhinorrhea or otorrhea, hematotympanon, Battles sign, periorbital ecchymoses, intracranial air and sometimes vascular injury. However, most cranial fractures do not require surgical treatment.

Hemorrhage and contusion

In TBI patients, hemorrhages develop in the epidural, subdural, subarachnoid, parenchymal or intraventricular space. An epidural hematoma is an accumulation of blood between the skull and dura mater (figure 1). In elderly, the dura mater is most often adherent to the skull, leaving no room for bleeding. Hence, this type of injury is more prevalent in the younger patients. The size of the hematoma depends on the origin of the bleeding that could be both arterial and venous. Some patients may experience a lucid interval (loss of consciousness, and then a brief regains of consciousness).

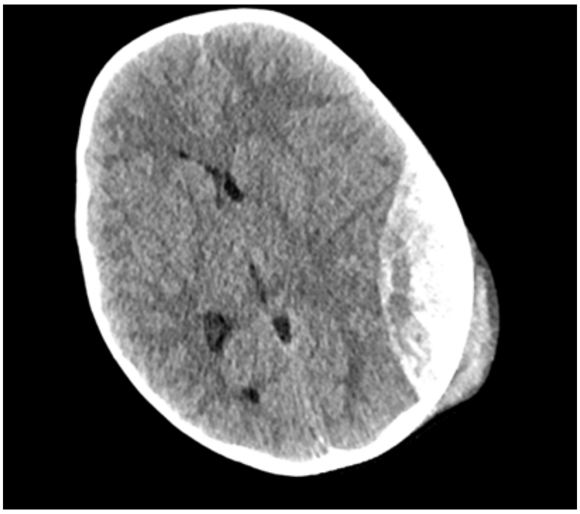


Figure 1. 4-year-old patient with an epidural hematoma and an ipsilateral dilated pupil. The patient had a lucid interval.

A subarachnoid hemorrhage caused by trauma (tSAH) is an accumulation of blood the subarachnoid space. There is a strong, association between the presence of tSAH and bad outcomes. A study from Servadei et.al. reported that in a population of moderate and severe TBI-patients 41% of patients without tSAH achieved good recovery whereas only 15% of patients with a tSAH present achieved the same outcome (8). Traumatic intraventricular hemorrhage (IVH) is often associated with extensive associated intracranial injury and is a strong negative prognostic factor for outcome. Previous studies show that IVH is found in nearly 10% of those with severe TBI, and that involvement is often seen with accompanying corpus callossum injuries which often leads do disability (9). A subdural hematoma (SDH) (figure 2) is blood between the dura and the middle brain membrane (arachnoid mater). Often these types of hematomas are found over the cerebral convexities and are often caused by rupture of bridging veins. Subdural hematomas could be acute, subacute or chronic, depending on the interval from injury to symptoms.

Figure 2. 70 years old male with an acute SDH and mass effect causing a midline displacement of 17mm. GCS.

A brain contusion is a focal injury of the neural parenchyma and small parenchymal blood vessels. Contusions have predilection sites for basal frontal and temporal lobes (10). Additional contusions may also arise on the opposite side of the impact place.

This is called a "contrecoup" contusion. Brain contusions are dynamic lesions, which evolve over time. The disruption of blood vessels and the breakage of the blood brain barrier starts cellular cascades that often lead to inflammation, infarction, edema and an enlarged contusion volume.

Diffuse axonal injury (DAI)

Diffuse axonal injuries are injuries usually caused by acceleration/deceleration movement of the head, resulting in rotation and shearing forces on the brain parenchyma. When the shearing forces exceed the axonal mechanical strength of the axons, it causes permanent or reversible damage to the nerve fibers (11). DAI injuries are classified after location of the injury. DAI 1 represents lesions in the cerebral grey-white matter interfaces in the cerebral hemispheres. DAI 2 represents lesions in the corpus callosum. DAI 3 represents lesions in the brain stem (12). MRI is the most sensitive modality for diagnosing this type of injury.

Traumatic vascular injuries (TVI)

Traumatic vascular injuries could be injuries to either the arteries or veins and may be either intra or extra cranial. The true incidence of traumatic vascular injuries (TVI) is not known, but a more aggressive use of cerebral computed tomography angiography has led to an increase in patients diagnosed with such injuries. Medical management is most often aimed at stroke prevention with oral anticoagulants or platelet inhibitors (13-16).

Rotterdam CT score

Rotterdam CT score is a score of the initial CT scan to predict six months mortality and are only valid for patients with moderate or severe head injury (17). Table 3 illustrates the classification. Probability of 6 months postinjury mortality according to the Rotterdam score is as follows:

- Score 1, 0%
- Score 2: 11%
- Score 3: 16%
- Score 4: 26%
- Score 5: 53%
- Score 6: 61%

Table 3. Rotterdam CT-score.

Predictor	Score
Basal cisterns	
Normal	0
Compressed	1
Absent	2
Midline shift	
Shift ≤ 5mm	0
Shift > 5mm	1
Epidural mass lesion	
Present	0
Absent	1
IVH or tSAH	
Absent	0
Present	1
	+1
Max score	6

IVH, intraventricular hemorrhage, tSAH, traumatic subarachnoid hemorrhage.

Guidelines for the initial management and treatment of traumatic brain injury

OUH-U is using the Scandinavian guidelines for triage of traumatic brain injuries. Patients with mild, moderate and severe TBI should be evaluated with cerebral CT as soon as respiratory and circulatory status is under control. Unless the patients have known risk factors, all patients with minimal head injuries and mild head injury without any pathological findings on CT could be discharge home with instructions from the hospital. Patients with mild head injury and a positive cerebral CT should be admitted to the hospital for observation. Patients with moderate and severe TBI should be admitted to the hospital for observation and treatment. OUH-U still hasn't implemented the brain damage marker S100B (18).

The treatment of TBI patients at OUH-U adhere to the Brain Trauma Foundation (BTF) guidelines (19). Briefly, the goals of TBI treatment have been to maintain ICP < 22 mmHg and the cerebral perfusion pressure (CPP) > 60 mmHg. A staircase protocolled approach using sedation, osmolar therapy, normothermia, CSF drainage, barbiturates and hemicraniectomy is utilized to fulfill the ICP and CPP goals. Indications for neurosurgical intervention adhere to the BTF and Ullevål trauma manual.

Materials and methods

Study population

Oslo University Hospital, Ullevål (OUH-U) is the major trauma-care facility in the South-Eastern Norway Regional Health Authority (Norwegian: Helse Sør-Øst RHF [HSØ]) It is the only hospital in this region with neurosurgical service. Thus, OUH-U treats most severe neurotrauma within this region, covering a population of 2.9 million people in a geographical area of 110,000 km2. The total Norwegian population is 5.2 million.

Briefly, trauma patients with severe injuries and patients with suspected isolated severe neurotrauma are transported and admitted directly to OUH-U from the entire health region. Patients outside Oslo with less severe injuries are admitted to other acute care hospitals and transferred to OUH-U later if necessary.

Department of Neurosurgery at OUH-U runs a quality control database for trauma patients with TBI identified by computed tomography (CT) imaging treated as in-patients at Oslo University Hospital. The database is approved by the Oslo University Hospital Data Protection Officer (DPO approval number 2016/17569). The DPO has considered this quality control database exempt from patient consent requirements.

Variables recorded in the database: Patient age, gender, comorbidity, time of injury, place of injury, mechanism of injury, injury description, severity of injury, imaging modes, neurosurgical treatment, neurosurgical complications, length of ICU stay (L-ICU), length of ventilator treatment (LVT), length of hospital stay (LOH), discharge destination.

Length of stay and length of ventilator treatment was calculated according to the recommended guidelines for uniform reporting, the "Utstein style" (20).

Inclusion Procedure

A research coordinator was in charge of including new admitted patients with signs of intracranial trauma on cerebral CT (cranial fracture, intracranial hemorrhage, contusion, diffuse axonal injuries, intracranial vascular injury or precerebral vascular injury). Patients were only included if they had a unique 11-digit Norwegian Social Security Number and admitted within 7 days of trauma. In cases of intracranial or precerebral vascular trauma, the time criteria were expanded upon to admittance within 30 days of trauma. Only patients with a known traumatic accident were included. Patients admitted with a chronic subdural hemorrhage (cSDH) without a known trauma were excluded from the study. A small group of pediatric patients with less severe injuries were diagnosed with magnetic resonance imaging (MRI) instead of CT in order of avoiding radiation.

CT-angiography or MR-angiography was used whenever traumatic intracranial cerebral or precerebral arterial injuries were suspected. In a few special cases, conventional cerebral angiography was performed at Rikshospitalet. CT-venography or MR-venography was used for identifying traumatic venous injuries in the sinovenous system.

Ethics

This study is approved by the Oslo University Hospital Data Protection Officer (DPO approval 18/03526).

Statistics

Data not containing name and 11-digit Norwegian Social Security Number was extracted from the PVO approved database and exported to Excel/SPSS. No advanced statistics has been used.

Results

Incidence rate and severity of TBI

During the time period 2015–2017, 1231 head injured patients with a positive cerebral CT were included in this study. The annual incidence rate was 25/100,000 in the Oslo population. The incidence rate for the remaining regions of Helse Sør-Øst (HSØ), Oslo excluded, was 10/100 000. The Oslo population has the highest relative proportion of mild head injuries and is also the only part of the study population with minimal head injuries. Patient characteristics are given in table 4. Median age for the total population was 55.1 years. The male preponderance for the entire study population was 2.3:1.0. Men were overrepresented in every age group except for elderly above 90 years, with a female preponderance of 3.8:1.0 (Figure 3). The distribution of severity according to HISS were minimal (6,5%), mild (39%), moderate (25,7%) and severe (29%).

Table 4. Patient characteristics.

	Total sample (n= 1231)
Age, median	55.1
Gender	
Male	853 (69)
Female	378 (31)
Mean age (year) ± SD	51 ± 25
Head injury severity	
Mean GCS± SD	9 ± 4.2
Minimal	80 (7)
Mild	479 (39)
Moderate	315 (26)
Severe	357 (29)
Multi trauma	
Yes	593 (48)
No	638 (52)
Cause of injury	
Fall	661 (54)
Transport accidents	296 (24)
Assault	102 (8)
Others	172 (14)

GCS: Glasgow Coma Scale, SD: Standard deviation,

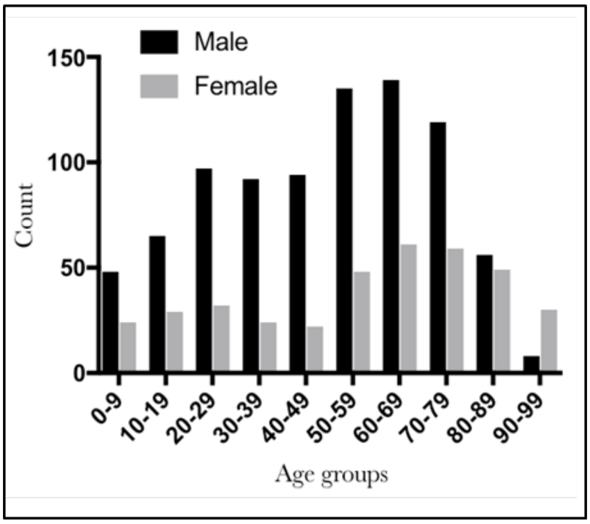


Figure 3. Gender and age based distribution of TBI patients admitted to OUS 2015-2017

In this cohort of TBI patients 593/1231 (48.2%) were multi trauma patients (table 5).

Table 5. Multi trauma. Body regions affected.

	N (% of 1231)
Facial injury	299 (24)
Thoracic injury	268 (22)
Extremity injury	181 (15)
Cervical spine injury	153 (12)
Thoracolumbar spine injury	119 (10)
Abdominal injury	85 (7)
Pelvic injury	68 (6)
Spinal cord injury	17 (1)

The three most frequent intracranial pathologies were SAH (56%), SDH (53%) and brain contusion (47%). Skull roof fractures and skull base fractures were almost equal in frequency, with 37% and 35%, respectively. Most patients had multiple pathologies identified on CT (table 6).

Clinical suspicion of DAI was indication for cerebral MRI. MRI was done in 29% of the patients. DAI pathology was seen in 15% of our patients.

CT-angiography (CT-A) or MR-angiography (MRA) were done in 44% of the patients. CT-venography (CTV) or MR-venography (MRV) were done in 21% of the patients. Many patients did a combined CTA/CTV. 12% of the patients were confirmed having vascular injuries (table 6).

Table 6. CT/MR pathology.

	N (% of 1231)
Cerebral-CT	
Traumatic SAH	695 (56)
Subdural hematoma	582 (53)
Brain contusion	579 (47)
Fracture – skull convexity	456 (37)
Fracture – skull basis	430 (35)
Epidural hematoma	187 (15)
Intraventric. hemorrhage	130 (11)
Fracture – impression	80 (7)
Cerebral-MR*	
DAI grade 1	64 (5)
DAI grade 2	52 (4)
DAI grade 3	74 (6)
Cerebral CTA/MRA**	
Venous sinus injury***	67 (5)
Injury ICA extracranial	29 (2)
Cerebral vasospasm	25 (2)
Injury vertebral artery	25 (2)
Injury ICA intracranial	13 (1)
Other vascular injury	10 (1)
Carotid cavernous fistula	6 (0,5)
Traumatic aneurism	6 (0,5)
Dural arteriovenous fistula	3 (0,2)

SAH: Subarachnoid hemorrhage, ICA: Internal carotid artery, CT: computerized tomography, DAI: Diffuse axonal injury,

MR, CTA/MRA and CTV/MRV were only done in 29%, 44% and 21% of the patients, respectively. Thus, the numbers of diffuse axonal injuries (DAI) and cerebrovascular injuries are minimum estimates.

Surgical procedures

One or more neurosurgical procedures were done in 35% of the patients during the primary visit. Type and number of neurosurgical procedures done is this cohort of TBI patients are given in Table 7. The three most common neurosurgical procedures were intracranial ICP monitor, evacuation of mass lesion and external ventricular drain (EVD).

Table 7. Acute neurosurgical interventions during primary hospital stay in 2015-2017.

	N (% of 1231)
ICP monitor	311 (25)
Evacuation of mass lesion	
SDH	117 (10)
EDH	53 (4)
Brain contusion	32 (3)
EVD	76 (6)
Cranioplasty	54 (4)
Duraplasty	52 (4)
Lumbar drain	44 (4)
Hemicraniectomy	27 (2)
Vascular surgery	6 (0.5)

ICP: Intracranial pressure monitor, SDH: Subdural hematoma, EVD: External ventricular drain

Length of Hospital stay

A median of 4 days (range 0–90), mean 8.2 days were spent in hospital (figure 4). This adds up to a total of 10,138 patient days. On average TBI patients occupied 9.2 hospital beds every day during the study period. The mean LOH for minimal, mild, moderate and severe head injury were 5.7, 6.0, 8.1, 11.9 days respectively.

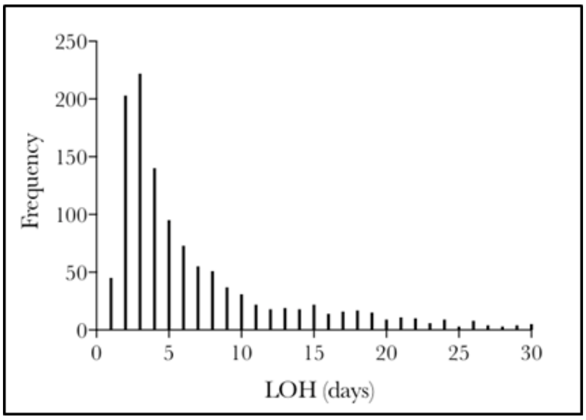


Figure 4. Length of Hospital stays.

Length of ventilator treatment (LVT)

For the 448 (36%) patients put on ventilator (figure 5), median time on ventilator was 5.0 days range (1–74), mean 8.4 days and a total of 3776 days. On average, 3.3 patients were on respirator every day during the study period.

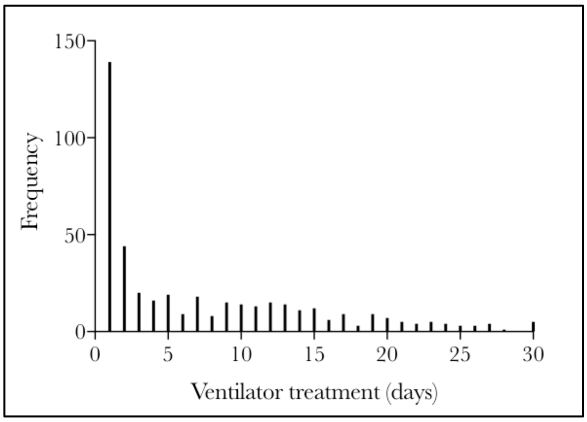


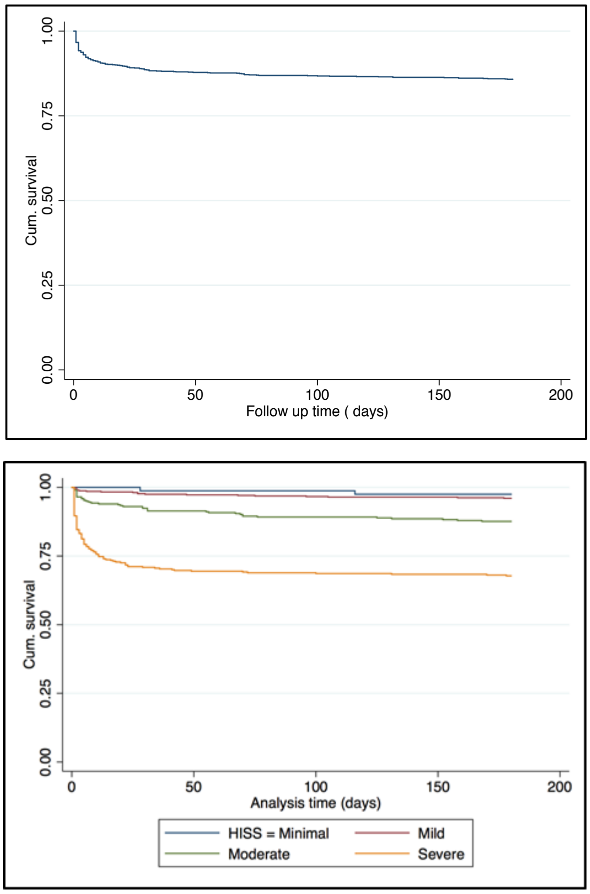
Figure 5. Length of ventilator treatment.

Survival and mortality

Over all In-hospital survival were 91.4%. (figure 6A).

In-hospital mortality for minimal-, mild-, moderate- and severe TBI was 0%, 1.5%, 3.5% and 24.6%, respectively. (figure 6B) One-month mortality for minimal-, mild-, moderate- and severe TBI was 1.3%, 2.5%, 7.6% and 29.1%, respectively.

Figure 6. A – Overall survival**. B** – overall survival according to HISS class.



Discharge destination

Table 8 shows discharge destinations sorted after head injury severity. Discharge to local hospital or home were the two most common discharge destinations for the entire cohort. Minimal, mild, moderate and severe head injury patients had a likelihood of being discharged home of 61%, 50%, 24%, 7% respectively. In total 179 (16%) of the patients alive at the date of discharge were send directly to a rehabilitation unit.

Table 8. Discharge destination by HISS after end of acute TBI management at OUH-U

Discharge destination	Minimal	Mild	Moderate	Severe	Total sample (n=1231)
Home	49	244	76	24	393
Local hospital	19	167	154	140	480
Rehabilitation unit at OUS.	3	19	42	73	137
Sunnaas Rehab. Hospital	1	8	7	20	36
Other rehabilitation centers	1	0	2	3	6
Nursing home	7	26	20	8	61
Dead at OUH-U	0	7	11	88	106
Other discharge destinations	0	8	3	1	12

Discussion

Incidence rates and severity

This study describes a 3-year cohort of Traumatic Brain Injury (TBI) patients identified by computed tomography imaging treated as in-patients at Oslo University Hospital (OUS) with respect to case load, demographics, injury severity, injury mechanism, type of injury, neurosurgical procedures, resource use, discharge destination and 1-month mortality. The average patient had a moderate head injury with a GCS of 9. The fact that the inclusion criteria for the study were a positive cerebral CT makes this patient population more severely injured compared to a population of TBI patients just fulfilling the TBI criteria. Previous studies with ordinary TBI criteria (head injury from an external force) report 86% of cased suffering from mild TBI (3). In this study mild head injuries only accounted for 39%. The higher incidence of males is well known from previous studies (3, 21-22) .

Among the patients in our study, 321 (26%) were over 70 years of age. As expected, the elderly patients account for a big part of the patient group. This is probably associated with the trend of overall ageing in the population (23).

The number of TBI patients from Oslo were 25/100 000 person-years. From the other counties in HSØ the number of TBI patients admitted were ~10/100 000. Only more severe TBIs were referred to OUS-U from all counties except Oslo. OUS-U has also primary trauma responsibilities for Oslo, thus much higher referral numbers from Oslo.

Causes of injury

In accordance with previous Norwegian studies, falls remains the leading cause of injury, followed by transport accidents and assaults (3, 21-22, 24). The group "other" consists of sport injuries, unknown injury cause, self-inflicted injuries and other subgroups not fitting other injury categories. Almost half the study population was suffering a multi trauma, meaning they had accompanying injuries to other body parts then the head. Facial, thoracic and extremity injuries were the most common. This corresponds with an Austrian study with moderate and severe TBI-patients were 47,5% had concomitant injury and injuries to the face (18.7%), thorax (14%) and extremities (11%) were most common (25).

Radiological findings

All patients in this study were having one or more traumatic lesions visible on cerebral

CT. The likelihood was roughly the same of getting a SAH (56%), SDH (53%) or a brain contusion (47%). EDH was seen in 15% of the patients. In a Swedish study of severe injured TBI-patients the relative incidence of SAH, SDH and brain contusion were 73-77% (26). The higher incidence of intradural hemorrhages and contusions is probably due to a more severed injured population. In another Norwegian TBI-population ranging from minimal to severe, Heskestad found the incidence of CT-verified SAH, SDH and brain contusion to be 28 (6%), 39 (8%) and 44 (10%) respectively. Furthermore it could be difficult to differentiate the origin of small hemorrhages on CT (27).

When the clinical condition of the patient does not correlate with the cerebral CT, it raises suspicion of diffuse axonal injuries. A total of 29% of our patients were suspected of having DAI and were examined with a cerebral MRI. Half of the persons got a positive MRI confirming the injury.

Blunt cerebrovascular injury (BCVI) was detected in 5.9% in this TBI cohort. This number includes injuries to the internal carotid and vertebral arteries: dissections, occlusions, transections, intimal flaps, traumatic aneurism and carotid cavernous fistulas. In recent literature, the incidence of BCVI in blunt trauma is reported in the range 0.1 to 1.7% and for patients with severe head injury the rate could be as high as 9.2% (28).

The frequency of sinus vein injury in our cohort was 5.4%. A recent study reported 50% sinus vein injury in patients with a skull fracture adjacent to a dural venous sinus (13). Risk factors for sinus vein injury will be studied later.

Surgical procedures

The neurosurgical intervention rate in this TBI cohort was 35%. We will later study if these interventions are done according to the BTF guidelines (29).

Hospital stay

Mean LOH was 8.2 days, and on average TBI patients occupied 9.2 hospital beds every day during the study period. Mean LOH increased with severity of TBI. The discharge destination of this TBI-population closely relates to injury severity grade. Predictors of length of hospital stay will be studied later.

Discharge destination

Only 16% of the patients were discharged directly to a rehabilitation unit. Most likely would more patients have benefited from direct discharge to a rehabilitation unit ("unbroken chain"). This will be studied later.

Mortality

One-month mortality for minimal-, mild-, moderate- and severe TBI in this cohort was 1.3%, 2.5%, 7.6% and 29.1%, respectively. The incidence of In-Hospital mortality for severe TBI patients treated in Norwegian hospitals has earlier been reported to be 29% (22). In present study we had an In-Hospital mortality of 9% for the entire cohort, and 25% in the severe TBI-group. Predictors of mortality will be studied in detail later.

There is a steady decrease in traumatic accidents with fatal outcome in Norway. This decrease could among other things be attributed to the road safety and safer cars (30).

Conclusion

- During the time period 2015–2017, 1231 head injured patients with a positive cerebral CT were treated as inpatients at OUS-U.
- The annual referral rate was 25/100,000 for the Oslo population.
- The annual referral rate for the remaining regions of Helse Sør-Øst (HSØ), Oslo excluded, was 10/100 000.
- Men are overrepresented.
- 26 % were older then 70 years of age.
- The most common cause of injury was falls.
- SDH, SAH and brain contusions were the most common intracranial findings on CT.
- 50% were multitrauma patients.
- ICP-monitor and evacuation of intracranial mass lesion were the most frequent neurosurgical procedures.
- TBI patients occupied 9.2 beds in the ICU/neurosurgical ward every day.
- For severe TBI the in-hospital morality rate was 25%.
- Only 16% of the patients were discharged directly to a rehabilitation unit.
- Overall in hospital mortality were 8.6%.

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