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In-hospital management and disposition outcomes for patients with mild traumatic brain injury and isolated traumatic subarachnoid hemorrhage

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Research Article

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Title

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Abstract

Objective:

This study aims to review the in-hospital management and disposition of patients with traumatic brain injury (TBI) and a Glasgow coma score (GCS) ≥13 with isolated traumatic subarachnoid hemorrhage.

Materials and methods:

Retrospective single-center cohort study, using prospectively collected data from patient charts. All patients admitted to a neurosurgical department at a Danish university hospital, after TBI with radiological confirmed intracranial hemorrhage and GCS ≥13, were included. Data on the type of hemorrhage was collected. The outcomes of interest were length of hospital stay (LOS), repeated head CT (RHCT), discharge to in-patient rehabilitation, and neurosurgical intervention. Adjusted relative risk (RR) for discharge to inpatient rehabilitation and RHCT was calculated with traumatic subarachnoid hemorrhage (tSAH) as reference for acute subdural hemorrhage (aSDH), traumatic intracerebral hemorrhage (tICH) and epidural hemorrhage (EDH) as a pooled category.

Results:

In the period April 1st, 2022, to December 31st, 2024, a total of 127 patients were included. The adjusted RR of discharge to in-patient rehabilitation was 2.6 (1.1-5.8, 95%-confidence interval) for the pooled group compared with tSAH. The RR of RHCT was 1.3 (1.1-1.6, 95%-confidence interval) for the pooled group compared with tSAH. The mean LOS was 2.0 days for tSAH and 3.2 days for the pooled group. Two patients from the pooled group required neurosurgical intervention. In the tSAH group, antiplatelet treatment did not increase the risk of discharge to inpatient rehabilitation.

Conclusion

Patients admitted with mild TBI and isolated radiologically described tSAH have a shorter LOS, lower risk of RHCT, and a lower risk of requiring inpatient rehabilitation at discharge, compared to patients with mild TBI and other types of intracranial hemorrhage. However, the current study is limited to a single-center retrospective design. Therefore, larger multi-center studies on the subject are needed.

Introduction

Traumatic brain injury (TBI) is a common cause of hospital admissions through emergency departments [1]. Patients presenting with a Glasgow Coma Scale (GCS) score ≥13 are classified as having mild TBI (mTBI) [2,3]. It is common practice for patients with mTBI and radiologically confirmed intracranial hemorrhage to be admitted for observation in case of neurological deterioration, regardless of the type of hemorrhage [4–7]. Consequently, mTBI with intracranial hemorrhage represents a significant proportion of admissions to emergency, neurosurgical, and intensive care units, thereby consuming substantial healthcare resources.

Many institutions follow The Brain Injury Guidelines (BIG) [7], which recommend against hospitalization for patients with only trace traumatic subarachnoid hemorrhage (tSAH). However, BIG recommends hospitalization for patients with localized tSAH, and hospitalization, neurosurgical consultation, and repeated head computed tomography (CT) for those with scattered tSAH or those receiving anticoagulant or antiplatelet therapy. Isolated tSAH is generally considered to carry a lower risk of radiological progression, and when progression occurs, it is often associated with minor neurological consequences. It is well established that mTBI with tSAH as the sole radiological finding rarely requires neurosurgical intervention [8–11].

Several studies have suggested that repeated head CT (RHCT) is often unnecessary in the absence of clinical deterioration [9, 12]. However, literature addressing broader clinical outcomes—such as length of stay, discharge disposition, and need for rehabilitation—among patients with mTBI and isolated tSAH remains limited.

The hypothesis of the present study was that patients with mTBI and isolated tSAH have more favorable clinical outcomes than those with other types of traumatic intracranial hemorrhage. Such findings could support a more conservative management approach and reduce unnecessary hospital admissions for observation. Therefore, the aim of this study was to evaluate in-hospital management and outcomes in patients with mTBI and isolated tSAH, including the need for neurosurgical intervention, RHCT, and discharge to inpatient rehabilitation.

Method:

The study was designed as a retrospective cohort study. All patients with mild traumatic brain injury (mTBI) and radiologically confirmed intracranial hemorrhage admitted to the Neurosurgical Department at Aalborg University Hospital between April 1, 2022, and December 31, 2024, were identified using International Classification of Diseases, 10th Revision (ICD-10) codes. A longer study period was not feasible due to changes in the hospital's electronic medical record system.

The following ICD-10 codes were used for case identification: S063C, S064, S065A, S065B, S066, S068A, S068C, and S068D. Patient health records were accessed after approval by the local institutional review board. In accordance with Danish health data privacy regulations,

studies conducted for quality assurance and treatment improvement purposes are exempt from individual patient consent when approved by local health authorities, provided that all published data are anonymized.

All medical records were reviewed from the time of primary admission up to 30 days post-discharge to identify any relevant readmissions. Chart review was performed by a medical doctor.

Exclusion criteria were: 1) Patients who underwent neurosurgical intervention prior to admission for ward observation following the initial head CT, 2) patients with a GCS at admission <13, 3) patients <18 years and 4) patients transferred between neurosurgical departments were excluded due to unavailable chart data.

All types of traumatic hemorrhage were identified and grouped according to the radiological description as acute subdural hematoma (aSDH), epidural hematoma (EDH), traumatic intracerebral hematoma (tICH), tSAH and several types (mixed). Furthermore, a category of aSDH, tICH, EDH and mixed was pooled, due to the low number solely aSDH, tICH and EDH. Due to differences in radiological description, there was no differentiation between trace, localized and scattered tSAH.

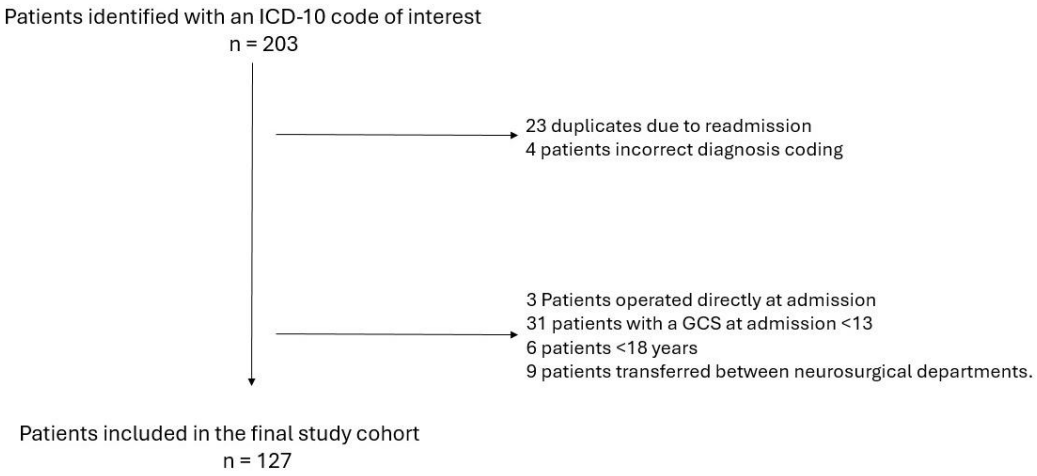
Outcome of interest was: 1) length of hospital stay (LOS) calculated in days of admission, including mean, median and inter quartile range (IQR). 2) RHCT. During the study period, there were no standard indications for RHCT. Therefore, RHCT was a clinical decision based on the clinician's knowledge of the patient's risk factors for hematoma expansion, comorbidity and medication, consciousness status and focal neurologic deficits. 3) Discharge to in-patient rehabilitation. All patients underwent assessment by a physiotherapist as part of admission. After interdisciplinary discussion between physician, physiotherapist and if found relevant, also a neuropsychologist, the patient would be discharged to specialized neurorehabilitation if needed. Therefore, the assessment of discharge to in-patient rehabilitation was based on a combination of both focal neurological deficits, other medical issues, and cognitive deficits. 4) Neurosurgical interventions, such as external ventricular drainage or decompressive craniotomy/craniectomy.
Crude relative risk (RR), Adjusted RR and adjusted risk difference (RD) for aSDH, tICH, mixed and pooled group were calculated for discharge to in-patient rehabilitation and RHCT with tSAH as reference. Furthermore, for the tSAH group, crude RR, adjusted RR and adjusted RD for discharge to in-patient rehabilitation and RHCT was calculated for patients in antiplatelet- and anticoagulant treatment with no antiplatelet- or anticoagulant treatment as reference. The analyses were adjusted for antiplatelet- and anticoagulant treatment and GCS at admission. All analyses were calculated with 95% confidence intervals (95%-CI). Adjusted analysis was calculated using log binomial regression analysis. Sensitivity analyses stratifying for patients age (≥65 years vs <65 years) were performed. All statistical analysis was performed using R [13].

Results

During the study period, 203 patients were discharged with an ICD-10 diagnosis of interest. After chart review, 27 cases were excluded: 23 were readmissions and 4 were incorrectly coded, all of which involved non-traumatic intracranial hemorrhage. In addition, 9 patients were transferred between neurosurgical departments, each presenting with a GCS score <13 at the initial admission. Six patients were under 18 years of age, and 3 underwent surgery following the initial head CT. In total, 31 patients had a GCS score <13 at presentation. Consequently, 127 patients were included in the final analysis. For a detailed outline of exclusion criteria, see figure 1.

Figure 1:

Identification of study cohort



Of the 127 patients, 69 had a radiological description of isolated tSAH while 58 had a description of either EDH, aSDH, tICH or a mix of more than one type. The majority of the cohort was male (65 %) with a mean age of 62 years. The tSAH group was older with a mean age of 65 compared with the pooled group where the mean age was 59. The tSAH group were more comorbid with 42 % having a Charlson comorbidity index (CCI) score ≥3 compared with the pooled group where 38 % had a CCI score ≥3. In the tSAH group, more patients were in antiplatelet treatment (34 %) compared with the pooled group, where 14 % were in antiplatelet treatment (table 1). Two patients were readmitted with seizures within 30 days of initial admission; both were from the pooled group. Three patients underwent neurosurgical intervention after observation; both were from the pooled group. The mean LOS was 2.0 days (median = 1 and IQR = 2) for tSAH and 3.2 days (median = 2 and IQR = 2) for the pooled group (Table 1).

Table 1.
Patient characteristics

	tSAH n = 69	EDH n = 6	tICH n = 5	aSDH n = 2	Mixed n = 45	Pooled n = 58	Total n = 127
Mean age (SD)	65 (18)	51 (26)	64 (12)	59 (25)	59 (21)	59 (21)	62 (19)
Sex							
Male	44 (64 %)	2 (33 %)	3 (60 %)	2 (100 %)	32 (71 %)	39 (67 %)	82 (65 %)
Female	25 (36 %)	4 (67 %)	2 (40 %)	0	13 (29 %)	19 (33 %)	45 (35 %)
Charlson Comorbidity Index							
None (0 points)	16 (23 %)	3 (50 %)	1 (20 %)	1 (50 %)	16 (35 %)	21 (36 %)	37 (29 %)
Low (1-2 points)	24 (35 %)	3 (50 %)	3 (60 %)	0	12 (27 %)	18 (31 %)	42 (33 %)
High (≥ 3 points)	29 (42 %)	0	1 (20 %)	1 (50 %)	17 (38 %)	19 (33 %)	48 (38 %)
Antiplatelet							
ASA	10 (15 %)	0	0	0	2 (4 %)	2 (4 %)	12 (10 %)
Clopidogrel	13 (19 %)	0	0	0	6 (13 %)	6 (10 %)	19 (15.0 %)
Anticougulants (NOAC/DOAC/Warfarin)	12 (17 %)	2 (33 %)	1 (20 %)	1 (50 %)	5 (11 %)	9 (16 %)	21 (17 %)
Repeated CT of cerebrum	45 (65 %)	4 (67 %)	3 (60 %)	2 (100 %)	40 (89 %)	49 (85 %)	94 (74 %)
Discharge to in-patient rehabilitation	7 (10 %)	2 (33 %)	2 (40 %)	1 (50 %)	10 (22 %)	15 (26 %)	22 (17 %)
neurosurgical interventions	0	0	0	0	3 (6 %)	3 (6 %)	2 (2 %)
Length of hospital stay in days	Mean: 2.0 (SD 1.4) Median: 1.0 (IQR 2.0)	Mean: 5.0 (SD 6.8) Median: 2.0 (IQR 2.3)	Mean: 2.6 (SD 2.3) Median: 1.0 (IQR 2.0)	Mean: 2.5 (SD 1.5) Median: 2.5 (IQR 0.75)	Mean: 3.0 (SD 3.3) Median: 2.0 (IQR 2.0)	Mean: 3.2 (SD 3.8) Median: 2.0 (IQR 2.0)	Mean: 2.5 (SD 2.8) Median: 2.0 (IQR 2.0)

Abbreviations: tSAH = traumatic subarachnoid hematoma, EDH = Epidural hematoma, tICH = traumatic intracerebral hematoma, aSDH = acute subdural hematoma, NOAC = Non-vitamin K Oral Anticoagulants, DOAC = Direct K Oral Anticoagulants, SD = Standard deviation, IQR = Interquartile range.

The adjusted RR of discharge to inpatient rehabilitation was 2.6 (1.2 - 5.5, 95%-CI) and the adjusted RD was 0.16 (0.04 - 0.28, 95%-CI) for the pooled group compared with tSAH (table 2).

Table 2
Relative risk and risk difference for discharge to in-patient rehabilitation

	N (%)	Crude RR	Adjusted* RR	Adjusted* RD
Traumatic subarachnoid hematoma	7 (10 %)	Reference (95% - CI)	Reference (95% CI)	Reference (95% CI)
Epidural hematoma	2 (33 %)	3.3 (0.9 - 12.5)	5.5 (2.2 - 13.6)	0.45 (0.09 - 0.82)
Traumatic intracerebral hematoma	2 (40 %)	3.9 (1.1 - 14.2)	4.3 (1.5 - 12.8)	0.33 (-0.05 - 0.73)
Acute subdural hematoma	1 (50 %)	4.9 (1.0 - 23.3)	3.8 (0.7 - 19.2)	0.28 (-0.29 - 0.85)
Mixed	10 (22 %)	2.2 (0.9 - 5.3)	2.1 (0.9 - 4.7)	0.11 (-0.01- 0.23)
Pooled	15 (26 %)	2.6 (1.1 - 5.8)	2.6 (1.2 - 5.5)	0.16 (0.04 - 0.28)

*Adjusted for age, sex, Charlson comorbidity index, antiplatelet- and anticoagulant therapy and Glasgow Coma score at admission using log binomial regression analysis.
Abbreviations: CI = confidence interval, RR = relative risk, RD = risk difference

The adjusted relative risk of RHCT was 1.4 (0.6 - 5.2, 95%-CI) and the RD was 0.18 (0.04 - 0.33, 95%-CI) for the pooled group compared with the tSAH group (Table 3).

Table 3
Relative risk and risk difference for Repeated head CT

	N (%)	Crude RR	Adjusted* RR	Adjusted* RD
Traumatic subarachnoid hematoma	24 (65 %)	Reference (95% - CI)	Reference (95% - CI)	Reference (95% - CI)
Epidural hematoma	4 (67 %)	1.0 (0.6 - 1.9)	1.1 (0.3 - 3.7)	0.03 (-0.35 - 0.41)
Traumatic intracerebral hematoma	3 (60 %)	0.9 (0.4 - 1.9)	1.0 (0.3 - 3.1)	0.01 (-0.40 - 0.39)
Acute subdural hematoma	2 (100 %	1.5 (1.3 - 1.8)	1.6 (0.2 - 19.8)	0.34 (0.23 - 0.45)
Mixed	40 (89 %)	1.4 (1.1 - 1.7)	1.5 (0.7 - 4.6)	0.22 (0.08 - 0.37)
Pooled	49 (85 %)	1.3 (1.1 - 1.6)	1.4 (0.6 - 5.2)	0.18 (0.04 - 0.33)

*Adjusted for age, sex, Charlson comorbidity index, antiplatelet- and anticoagulant therapy and Glasgow Coma score at admission using log binomial regression analysis.
Abbreviations: CI = confidence interval, RR = relative risk, RD = risk difference

The adjusted RR for patients with tSAH discharged to in-patient rehabilitation was 0.8 (0.2 - 3.8, 95%-CI) for the antiplatelet treated group and 1.9 (0.5 - 7.4, 95%-CI) for the anticoagulant treated group. Both groups were compared with no antiplatelet or anticoagulant treatment (Table 4).

Table 4
Relative risk and risk difference for discharge to in-patient rehabilitation for patients with isolated traumatic subarachnoid hemorrhage stratified in antiplatelet and anticoagulant treatment

	N (%)	Crude RR	Adjusted* RR	Adjusted* RD
No antiplatelet- or Anticoagulant treatment	4 (9 %)	Reference (95% - CI)	Reference (95% - CI)	Reference (95% - CI)
Antiplatelet treatment	2 (9 %)	0.9 (0.2 - 4.7)	0.8 (0.2 - 3.8)	-0.02 (-0.17 - 0.12)

Anticoagulant treatment	3 (25 %)	2.7 (0.7 - 10.4)	1.9 (0.5 - 7.4)	0.07 (-0.10 - 0.24)
*Adjusted for age, sex, Charlson comorbidity index, antiplatelet- and anticoagulant therapy and Glasgow Coma score at admission using log binomial regression analysis. Abbreviations: CI = confidence interval, RR = relative risk, RD = risk difference				

The adjusted RR for patients with tSAH for RHCT was 1.2 (0.6 - 2.4, 95%-CI) for the antiplatelet group and 1.9 (0.5 - 7.4, 95%-CI) for the anticoagulant group (Table 5).

Table 5
Relative risk and risk difference for repeated head CT for patients with isolated traumatic subarachnoid hemorrhage stratified in antiplatelet and anticoagulant treatment

	N (%)	Crude RR	Adjusted* RR	Adjusted* RD
No antiplatelet- or Anticoagulant treatment	25 (58 %)	Reference (95% - CI)	Reference (95% - CI)	Reference (95% - CI)
Antiplatelet treatment	15 (65 %)	1.1 (0.8 - 1.7)	1.2 (0.6 - 2.4)	0.06 (-0.20 - 0.32)
Anticoagulant treatment	10 (83 %)	1.4 (1.0 - 2.1)	1.9 (0.5 - 7.4)	0.18 (-0.10 - 0.47)
* Adjusted for age, sex, Charlson comorbidity index, antiplatelet- and anticoagulant therapy and Glasgow Coma score at admission using log binomial regression analysis. Abbreviations: CI = confidence interval, RR = relative risk, RD = risk difference				

Sensitivity analyses showed an adjusted RR for discharge to in-patient rehabilitation comparing tSAH with the pooled group on 2.41 (1.1 - 5.4, 95%-CI) for patients <65 years and an adjusted RR on 4.7 (0.6 - 36.7, 95%-CI) for patients ≥65 years (supplementary table 1).

The adjusted RR for RHCT comparing tSAH with the pooled group was 2.3 (0.3 - 8.5, 95%-CI) for patients <65 years and an adjusted RR on 1.4 (0.3 - 9.6, 95%-CI) for patients ≥65 years (supplementary table 2).

Stratified for trace, located and scattered isolated tSAH, 22.2 % with scattered tSAH were discharged to in-patient rehabilitation and 83.3 % underwent repeated RHCT. For isolated tSAH, none were discharged to inpatient rehabilitation and 54.5% underwent RHCT (supplementary table 3)

Discussion

This study reviewed the in-hospital management and disposition in the form of discharge to in-patient rehabilitation and RHCT during admission, for patients with mild TBI and radiologically described isolated tSAH, compared with patients with mild TBI and other types of intracranial

hemorrhage. The study found a higher risk for discharge to in-patient rehabilitation and RHCT for all other intracranial hemorrhage compared with only tSAH. Furthermore, patients with tSAH in antiplatelet treatment were not at a higher risk of being discharged to in-patient rehabilitation or having RHCT. Whereas patients with tSAH and in anticoagulant treatment were both at higher risk of being discharged to rehabilitation and having RHCT.

Strengths and limitations

The study was conducted in a tax-paid, equal for all healthcare setting. And therefore, the risk of bias due to socioeconomic factors is low.

The study's biggest limitation is the small study population of a final 127 patients, and the single-center and retrospective design. This is reflected in the wide confidence intervals of the results. However, there is still a statistically significant increased risk for discharge to in-patient rehabilitation when comparing the pooled group with tSAH. The current study should be observed as hypothesis generating for larger multi-center studies. Along with the small study size and the retrospective study design, several other limitations should be considered when the results are interpreted.

Not all relevant outcomes for hospital admissions were assessed. Admission is based on the clinician’s decision, and therefore, admission due to untenable home situation or admission due to hospital visit late night, is not considered in the current study.

Only the on-call radiologists' description of hemorrhage type was included. It was therefore not possible to stratify hematoma size or classify tSAH according to the BIG guidelines (trace, localized or scattered). However, radiological description is important for many peripheral emergency departments in Denmark, since there is no neurologist or neurosurgeon on call. Therefore, the radiological descriptions are in the current context a clinically relevant proxy for classification of traumatic intracranial hemorrhage.

The study included only patients admitted to the neurosurgical department. Due to local protocols, all patients in the urban area of Aalborg university hospital with intracranial hemorrhage are admitted to the neurosurgical department, whereas patients first admitted to a peripheral hospital are transferred to the neurosurgical department only after approval by a neurosurgeon. Accordingly, it may be expected that more patients with mild TBI were admitted to peripheral hospitals after neurosurgical consultation. These patients might have undergone RHCT but would not be discharged to rehabilitation due to local protocols.

Patients were identified using ICD-10 codes. Four patients were excluded, due to wrongful coding, giving a positive predictive value of 97 %. The negative predictive value for our patient group of interest is unknown. However, this would only affect the precision of our study estimate. Finally, this study may be subject to potential unmeasurable confounders and selection or reporting bias. This is due to the retrospective design, since data extractors are not blinded to the design and aim of the study.

Previous literature

It is well established by a large systematic review from 2022, that patients with mTBI and tSAH have a low risk of progression and rarely require neurosurgical intervention [8]. However, the current study has two important, previously less described findings. Firstly, the outcome of discharge to inpatients rehabilitation in the current study, has previously not been described. This finding is important, both in a taxpaid, equal to all healthcare setting as in the current study. But it can also be considered a proxy for a general health outcome, in settings where not all patients are evaluated by specialized physiotherapists during admission. However, one study found no difference between patients admitted with mTBI and tSAH and patients with mTBI and no intracranial hemorrhage one year after discharge [14]. Secondly, the current study found that patients in antiplatelet treatment and tSAH had the same risk of discharge to inpatient rehabilitation as patients not in antiplatelet treatment. Other studies have covered this subject [10, 15, 16]. However, it is still well practiced and part of BIG that patients with mild TBI and tSAH should be admitted for observation, regardless of antiplatelet status [7]. This study, along with previously literature [17-19] brings this practice into question. However, all studies on this subject are retrospective and of small size. Randomized control trials with larger study populations are needed on this subject.

Surprisingly, the current study found that more patients admitted with tSAH were in antiplatelet or anticoagulant treatment compared to other intracranial hemorrhage types. The clinician may tend to admit patients in antiplatelet- or anticoagulant treatment more often, as it is part of the local guidelines, since antiplatelet- and anticoagulant treatment has long been considered a risk factor for hematoma expansion and worse outcome.

Conclusion

This study found that no patients admitted with mTBI and isolated tSAH, underwent neurosurgical intervention. Furthermore, Patients with mTBI and isolated tSAH had a shorter LOS, and lower risk of being discharged to in-patient rehabilitation and having RHCT during admission compared to patients with mild TBI and other types of intracranial hemorrhage. Furthermore, patients with mTBI and tSAH in antiplatelet treatment were not at greater risk of being discharged to inpatient rehabilitation compared with patients not in antithrombotic treatment. However, the current study is limited to a single-center retrospective design. Therefore, larger multi-center studies on the subject are needed.

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