

## Original Article

# Indications for repeated computed tomography after mild traumatic brain injury with intracranial haemorrhage

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## ABSTRACT

**INTRODUCTION.** Traumatic brain injury (TBI) with intracranial haematoma and a Glasgow Coma Scale (GCS) score  $\geq 13$  is classified as complicated mild TBI (mTBI). Patients are often admitted for observation, and some undergo repeated brain CT (CTc), though the need for routine repeated imaging remains debated. This study examined the prevalence and indications for repeated CTc in complicated mTBI at a single neurosurgical centre.

**METHODS.** This was a retrospective review of adult patients admitted between April 2022 and December 2024 with complicated mTBI. The exclusion criteria were immediate surgery, a GCS score  $< 13$ , age  $< 18$  years or interdepartmental transfer. Data collected included demographics, comorbidities, antithrombotic/anticoagulant therapy, repeated CTc indications, radiographic progression, neurosurgical intervention, discharge status and 30-day mortality. Descriptive statistics were applied.

**RESULTS.** Among 127 patients, 94 (74.0%) underwent repeated CTc; 64.9% were routine or had undocumented documentation. Radiographic progression was more frequent in cases with documented clinical indication (39.5% versus 18.0%). Neurosurgical intervention was performed in three patients (2.4%), all following clinical deterioration; no intervention was based solely on routine CTc.

**CONCLUSIONS.** Routine repeated CTc in neurologically stable patients with complicated mTBI rarely alters management. Clinical deterioration, rather than radiological progression alone, dictated intervention. Repeated CTc should be reserved for patients with worsening neurological status, potentially reducing unnecessary resource use and radiation exposure.

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Traumatic brain injury (TBI), defined as an alteration in brain function or other brain pathology caused by exposure to an external force, is a common cause of admission in emergency and neurosurgical departments [1]. The annual global incidence is estimated at 27-69 million cases [2].

Mild TBI (mTBI), defined as a Glasgow Coma Scale (GCS) score  $\geq 13$ , accounts for most TBI (80%) [3]. In the present study, patients with mTBI and an intracranial haematoma on brain CT (CTc) were defined as having complicated mTBI [3].

It has long been well established that routine repeated CTs are unnecessary when no intracranial haemorrhage is detected on the initial CT in patients with mTBI. This finding also applies to patient groups receiving anticoagulant or antithrombotic treatment [4-8]. Studies have shown that the risk of developing delayed

intracranial haemorrhage on routine repeated CTs falls in the 0.6-2% range, regardless of anticoagulant or antithrombotic status [5-7]. Therefore, the assumption that routine repeated CTs are necessary for patients with complicated mTBI on the initial CT should also be reconsidered.

Patients with complicated mTBI are typically admitted for observation. Several studies have examined routine repeated CTc as part of standard institutional protocol. A study by Rosen et al. [9] included 85 patients with mTBI presenting with contusion haemorrhage, acute subdural haematoma (aSDH) and traumatic subarachnoid haemorrhage (tSAH), reported that 7% required intervention, of whom 3% demonstrated clinical deterioration. A study by Brown et al. [10] found that, in 142 patients with complicated mTBI, 27% of routine CTc scans showed radiographic progression, but none led to intervention. A study by Velmahos et al. [11] showed similar results. Among 179 patients with complicated mTBI undergoing repeated CTc, 21% showed radiographic progression and 4% required intervention. All interventions occurred after clinical deterioration, and no patient without deterioration had a management change. Furthermore, this study reported that more patients on anticoagulant or antithrombotic therapy had radiographic progression and more patients with radiographic progression were discharged to rehabilitation or other hospital facilities. A study by Fadzil et al. [12] included 189 patients with complicated mTBI and high risk of haemorrhage progression (age > 65 years, anticoagulant and antithrombotic treatment; patients with epidural, subdural, contusion and multiple tSAH) who underwent routine repeated CTc. In this patient group, 18% showed radiographic progression and 0.5% required neurosurgical intervention after clinical deterioration.

Two other studies included only patients with isolated tSAH [13, 14]. These studies found no evidence of clinical consequences of a routine repeated CTc. One study still recommends routine repeated CTc for all patients to identify new lesions or progression of haemorrhage [13].

Furthermore, some authors have argued that the use of a repeated CTc for complicated mTBI is a safe way to optimise flow in departments. In cases with no progression on repeated CTc, the patient can be discharged without a longer period of observation [14, 15]. While this may facilitate a faster patient flow, it is a highly resource-intensive protocol. The indication for repeated CTc is important because of its implications for departmental efficiency, healthcare costs and the cumulative radiation exposure associated with repeated imaging.

This study hypothesised that routine repeated CTc is unnecessary and should be performed only based on clinical indication. Therefore, this study aimed to investigate the prevalence and causes of repeated CTc in patients admitted to a neurosurgical department for observation of complicated mTBI to clarify the extent of potentially unnecessary CTc repetitions.

## Methods

This retrospective observational study used patient chart data and was approved by the local board as a quality improvement study in compliance with national data protection regulations.

At our facility, patients with a complicated mTBI who need observation are admitted to the neurosurgical department after the initial CTc. From 1 April 2022 to 31 December 2024, all patients discharged from the neurosurgical department with a TBI diagnosis were identified using International Classification of Diseases, version 10 (ICD-10) codes, including S063C, S064, S065A, S065B, S066, S068A, S068C and S068D.

Exclusion criteria included patients who underwent surgery after their initial CTc, had a GCS score <13 at admission, were under 18 years of age or were transferred between neurosurgical departments. Duplicate records from readmissions were excluded to avoid double-counting. Incorrectly coded patients were also

excluded.

All patient records were reviewed by a physician. The data collected included initial CTc findings, comorbidities, anticoagulant/antithrombotic therapy and repeated CTc results (categorised as regression, stable or progression), as well as the indication for repeated CTc. Data on subsequent neurosurgical interventions, other causes of hospitalisation (e.g., fractures, post-traumatic seizures or cardiac causes related to the trauma), clinical status at discharge and 30-day mortality were recorded.

Due to the limited sample size, descriptive statistics were applied.

*Trial registration:* not relevant.

## Results

Between 1 April 2022 and 31 December 2024, 203 contacts were discharged with an ICD-10 code of interest. After chart review, 76 cases were excluded: 23 were readmissions and four were incorrectly coded (all had non-traumatic intracranial haemorrhage); nine patients were transferred between neurosurgical departments with a GCS score < 13 at initial admission. Six patients were under 18 years, and three underwent surgery after the initial CTc. Overall, 31 patients had a GCS score < 13 at admission. Therefore, 127 patients were included in the final cohort.

Most of the cohort were male (64.6%), with a mean age of 69 years. Comorbidities were evenly distributed across the group. A total of 24.5% received antithrombotic treatment, and 16.5% were on anticoagulant therapy. The distributions of age, gender, comorbidities, trauma mechanism and therapies were comparable between patients who underwent repeated CTc and those who did not. Regarding functional status at discharge, 24.5% of the patients who underwent repeated CTc were discharged to inpatient rehabilitation, compared with 6.1% of those who did not undergo repeated CTc. Three patients underwent cardiological follow-up and subsequently had a pacemaker implanted due to unexplained syncope identified as the cause of trauma; all underwent repeated CTc. Additionally, five patients experienced seizures during hospitalisation, all of whom had repeated CTc. Both patients with isolated aSDH and those with mixed haemorrhage types were more likely to undergo repeated CTc (**Table 1**).

**TABLE 1** Patient characteristics.

	Repeated CT (N <sub>r</sub> = 94)	Non-repeated CT (N <sub>n</sub> = 33)	Total (N <sub>tot</sub> = 127)
Age, mean, yrs	68.5	69	69
<i>Gender, n (%)</i>			
Male	60 (63.8)	22 (66.7)	82 (64.6)
Female	34 (36.2)	11 (33.3)	45 (35.4)
<i>Charlson Comorbidity Index, n (%)</i>			
None: 0 points	27 (28.7)	10 (30.3)	37 (29.1)
Low: 1-2 points	28 (29.8)	14 (42.4)	42 (33.1)
High: ≥ 3 points	39 (41.1)	9 (27.3)	48 (37.8)
<i>Trauma, n (%)</i>			
Fall from one's own height	54 (57.4)	18 (54.5)	72 (56.7)
Fall above one's own height	11 (11.7)	3 (9.1)	14 (11.0)
Bicycle accident	9 (9.6)	5 (15.1)	14 (11.0)
Pedestrian accident	8 (8.5)	1 (3.0)	9 (7.1)
Motor vehicle accident	5 (5.3)	1 (3.0)	6 (4.7)
Violence	2 (2.1)	2 (6.1)	4 (3.2)
Hit by construction materials	3 (3.2)	1 (3.0)	4 (3.2)
Interaction with domestic animals	2 (2.1)	1 (3.0)	3 (2.4)
<i>Antithrombotics, n (%)</i>			
ASA	8 (8.5)	4 (12.1)	12 (9.5)
Clopidogrel	14 (14.9)	5 (15.2)	19 (15.0)
Anticoagulants: NOAC/DOAC/warfarin	17 (18.1)	4 (12.1)	21 (16.5)
<i>Location of intracranial haemorrhage, n (%)</i>			
Subarachnoid	45 (47.9)	24 (72.6)	69 (54.3)
Epidural	4 (4.2)	2 (6.1)	6 (4.7)
Parenchymal	3 (3.2)	2 (6.1)	5 (3.9)
Acute subdural	2 (2.1)	0	2 (1.6)
Mixed	40 (42.6)	5 (15.2)	45 (35.5)
<i>Other consequences of admission, n (%)</i>			
Facial fracture: all treated conservatively	11 (11.7)	3 (9.1)	14 (11.0)
Orthopaedic conservatively treated fracture	6 (6.4)	4 (12.1)	10 (7.9)
Orthopaedic operated fracture	3 (3.2)	1 (3.0)	4 (3.2)
Seizures	5 (5.3)	0	5 (3.9)
Pacemaker implantation: cardiac reason for trauma	3 (3.2)	0	3 (2.4)
<i>Clinical status at discharge, n (%)</i>			
Discharged home	64 (68.1)	30 (90.1)	94 (74.1)
Transferred to the medical department	6 (6.4)	0	6 (4.7)
In-hospital rehabilitation	23 (24.5)	2 (6.1)	25 (19.7)
In-hospital death	1 (1.1)	0	1 (0.8)
<i>Mortality, n (%)</i>			
30-day mortality	4 (4.3)	1 (3.0)	5 (3.9)

ASA = acetylsalicylic acid; DOAC = direct oral anticoagulant; NOAC = non-vitamin K antagonist oral anticoagulant.

Among the 127 patients, 94 (74.0%) underwent repeated CTc, whereas 33 (26%) did not. Among the 94 patients who underwent repeated CTc, 61 (64.9%) had no documented indication for repeated scanning, or the reason was listed as “routine CTc” (Table 2). Four patients who did not undergo repeated CTc at initial admission were readmitted within 30 days and subsequently underwent repeated CTc. Two were readmitted due to a decline in GCS score, one due to headache and one due to hemiparesis. Radiographic progression was observed in three of these patients. At readmission, three patients were observed for an additional 24 hours, and one patient underwent a neurosurgical intervention.

**TABLE 2** Reasons for repeated computed tomography of the brain.

Reason	n (%)
Routine or not stated	61 (64.9)
Decline in Glasgow Coma Score $\geq$ 2 points	7 (7.5)
Thrombocyte inhibitor treatment	7 (7.5)
Anticoagulant treatment	5 (5.3)
Rule out vascular origin <sup>a</sup>	4 (4.3)
Change in neurology <sup>b</sup>	4 (4.3)
Headache	4 (4.3)
Haemorrhage in fossa posterior	2 (2.1)

a) Suspicion of an aneurysmal cause of haemorrhage.

b) 2 patients developed aphasia, 1 developed hemiparesis and 1 developed oculomotor paresis.

Neurosurgical interventions were performed in three patients (3.2% of those who underwent repeated CTc and 2.4% of the overall cohort), with two undergoing craniotomy and one receiving an external ventricular drain. All patients who required neurosurgical intervention showed progression on repeated CTc and had a component of aSDH. Two of these patients were on anticoagulant therapy.

When evaluating radiographic outcomes of repeated CTc, categorised as regression, unchanged or progression, a trend was observed: haemorrhagic progression was more frequent in patients with a documented indication for repeat scanning (39.5% versus 18.0%), whereas haemorrhagic regression was more frequent in those without a stated indication (36.1% versus 12.1%). Furthermore, patients with a documented indication for repeated CTc were more likely to be transferred to other departments (9.1% versus 4.9%) or discharged to rehabilitation (36.4% versus 18.0%) (Table 3).

**TABLE 3** Comparison between patients with a routine or unstated indication for repeated computed tomography of the brain versus patients with documented indication.

	Routine or unstated indication (N <sub>r</sub> = 61)	Documented indication (N <sub>d</sub> = 33)
<i>Radiological progression in haemorrhage, n (%)</i>		
Regression	22 (36.1)	4 (12.1)
Unchanged	28 (45.9)	13 (39.5)
Progression	11 (18.0)	16 (48.5)
<i>Clinical status at discharge, n (%)</i>		
Discharged to home	47 (77.1)	17 (51.5)
Transferred to medical department	3 (4.9)	3 (9.1)
In-hospital rehabilitation	11 (18.0)	12 (36.4)
In-hospital death	0	1 (3.0)

Radiographic outcomes varied by the timing of repeated CTc, with progression being observed across all time intervals, but most frequently after 48 hours ([Supplementary table 1](#)). Among patients receiving anticoagulant or antithrombotic treatment, 11 demonstrated radiological regression, 12 remained unchanged and 16 showed radiological progression ([Supplementary table 2](#))

### Discussion

This study reviewed patients with complicated mTBI admitted for observation to assess the prevalence and causes of repeated CTc. The main finding is that routine repeated CTc after complicated mTBI neither altered clinical management nor led to neurosurgical intervention, which occurred only in cases of clinical deterioration.

Approximately three-quarters of patients underwent repeated CTc. In 64.9% of cases, the indication was either routine or undocumented, suggesting that many scans were performed as part of the standard admission procedure.

Patients with a documented indication for repeated CTc were more likely to be discharged to inpatient rehabilitation, had a higher 30-day mortality and exhibited more haemorrhagic progression, indicating that clinicians requesting repeated CTc often identified patients with poorer outcomes.

These findings align with prior studies [10-12], which reported radiological progression in 18-27% of routine repeated CTc after mTBI, compared with 18% in our cohort. Neurosurgical intervention rates ranged from 0 to 7% in previous studies [9-12], compared to 2.4% in the present study. As in earlier reports, all neurosurgical interventions occurred after clinical deterioration prior to repeated CTc. Similar to Velhmond et al., the present study found that patients in anticoagulant or antithrombotic therapy were more likely to show radiographic progression. However, as in previous studies, radiographic progression alone did not lead to changes in treatment management without clinical deterioration.

These consistent findings suggest that clinical status, rather than routine repeated CTc, is the key factor in determining the need for surgical intervention in complicated mTBI. However, small sample sizes across studies warrant cautious interpretation.

## Strengths and limitations

This study only included patients admitted to the neurosurgical department. According to local protocols, all patients in the urban area of Aalborg University Hospital with intracranial haemorrhage are admitted to the neurosurgical department, whereas patients initially admitted to peripheral hospitals are transferred only after approval by a neurosurgeon. Consequently, it is likely that a considerable number of patients with complicated mTBI were managed at peripheral hospitals following neurosurgical consultation. Thus, the true proportion of patients undergoing repeated CTc after complicated mTBI may be even higher. As a result, the actual proportion of patients requiring neurosurgical intervention is probably even lower than the 2.4% observed in this study.

The study is limited by its single-centre, retrospective design and a relatively small sample size of only 127 patients. Therefore, the findings should be regarded as hypothesis-generating only and may not be generalisable beyond the study department. Data from all patients identified using the relevant ICD codes were included. The number of unrecorded cases - specifically, patients with complicated mTBI who were not assigned an appropriate ICD code - remains unknown. However, only four patients were excluded due to incorrect coding (all four had non-traumatic intracranial haemorrhage). Thus, the number of patients with true complicated mTBI missed due to miscoding is expected to be of a similar magnitude. Furthermore, any missing cases would only affect the precision of the study estimates, not the overall conclusions. All patients who were excluded due to transfer between neurosurgical departments had a GCS score < 13 at admission. Therefore, these patients would not have been included in the final study cohort.

Lastly, this study may be subject to potential unmeasurable confounders and selection or reporting bias due to the retrospective design, in which data extractors are not blinded to the study's design and aim.

## Clinical implication

Despite literature suggesting that routine repeated CTc may not be necessary after complicated mTBI, many departments still follow this practice, especially for patients in anticoagulant or antithrombotic therapy. This may be rooted in uncertainty regarding surgical indications. Even with haemorrhage progression on repeated CTc, this should be deemed clinically insignificant if the patient's neurological status remains unchanged.

Surgical indications should be based on clinical features. Since most mTBI patients are awake, neurological assessment, including GCS score, should guide the decision for repeated CTc, regardless of anticoagulant therapy, comorbidities or haemorrhage type.

Routine repeated CTc should be reserved for multi-trauma patients and those with decreased consciousness, such as sedated or intubated individuals. In these cases, repeated CTc is valuable for assessing haematoma expansion when clinical evaluation is not feasible.

## Conclusions

Most patients with complicated mTBI admitted to the study department underwent repeated CTc, often without documented indication, suggesting a routine practice. Neurosurgical intervention for complicated mTBI is rare. Based on this and prior studies, clinical observation with repeated CTc reserved for patients with a decline in GCS score or neurological changes may be a safe management strategy. However, evidence remains limited due to small, retrospective studies. For awake patients, repeated CTc should be clinically indicated, reducing healthcare costs, improving workflow and minimising radiation exposure. This approach may also apply to patients in anticoagulant or antithrombotic therapy.

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**Supplementary materials** [a08250642-supplementary.pdf](https://ugeskriftet.dk/dmj/a08250642-supplementary.pdf)

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