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ORIGINAL SCIENTIFIC REPORT (INCLUDING PAPERS PRESENTED AT SURGICAL CONFERENCES)

Traumatic Minor Intracranial Hemorrhage: Management by Non-neurosurgeon Consultants in a Regional Trauma Center is Safe and Effective

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Abstract

Background There is debate concerning the need for specialist neurosurgical transfer of patients presenting to Level II trauma centers with a minimal head injury (Glasgow Coma Scale ≥13) and a small non-progressive intracranial bleeding (ICB).

Methods A retrospective chart analysis was performed assessing the outcomes of adult patients presenting with a minor traumatic ICB on initial CT scan (minimal subarachnoid hemorrhage; small-width subdural hematoma without shift; punctate cerebral contusion). Patients with extradural hematomas and those patients on antiplatelet or anti-coagulant therapy were excluded from the protocol.

Results Overall 291 cases were assessed (mean age 69.9 years) with 75% of cases presenting after a fall. There was deterioration of neurological status in 11 patients (3.8%) with 8 hospital transfers and 5 with an abnormal neurological examination (NE). Two patients with an abnormal INR and a worsening head CT were transferred without neurosurgical intervention. Of the 8 transferred cases there were 2 deaths (both >90 years of age with multiple comorbidities) with one craniotomy performed for a subdural hematoma (with full recovery). Three patients meeting transfer criteria were not transferred with one death (patient >90 years of age with severe dementia). The remaining 2 patients were discharged with normal neurological outcomes.

Conclusions Patients with a minimal traumatic brain injury and a non-progressive minor ICB may be safely managed in a Level II trauma center by an acute care consultant with neurosurgical consultation but without the need for neurosurgical transfer.

Level of evidence Retrospective analysis: Level IV.

Introduction

Minor traumatic brain injury (MTBI) is defined as that where there may or may not be loss of consciousness, with or without post-traumatic retrograde amnesia and where the presenting Glasgow Coma Scale (GCS) exceeds 12 [1]. By this definition MTBI is common, accounting for between 1 and 2 million patients evaluated in Emergency Departments across the USA annually [2]. This group of patients as a whole is heterogeneous with about 10% having an acute lesion on head computed tomography (CT), although less than 1% overall will require

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neurosurgical intervention [3, 4]. In this group of patients there are several clinical challenges in a rural referral hospital without a neurosurgical service [5, 6]. In Israel, most hospitals do not have a neurosurgical facility where in 1999, the Israeli Ministry of Health made the recommendation to transfer all patients with an intracranial bleeding (ICB) to centers with consultant neurosurgeons. In this regard, Klein et al. [4] were unable to show benefit by mandatory transfer, suggesting that some patients with low-risk ICB (solitary brain contusion <1 cm in maximal diameter, limited small subarachnoid hemorrhage or stable subdural hematoma <5 mm in width) can be safely managed without specialist neurosurgical transfer.

A second challenge is to identify the clinical utility of repeat CT scanning in low-risk ICB cases with stable neurological examination, where any observable progression of a lesion would mandate patient transfer. The further establishment of practice guidelines in a rural setting for the neurosurgical transfer of patients with MTBI will likely impact in-hospital repeat imaging strategy [7–9] and categorize the neurological outcome as well as better define those at risk of post-concussive symptoms [10, 11]. We present a retrospective analysis examining the safety of a selective neurosurgical transfer protocol for adult patients presenting to a Level II trauma center with MTBI where the initial head CT showed a minor, non-progressing ICB.

Patients and methods

Ethical permission for the collation and analysis of data was obtained by the local hospital ethics committee. The study was a retrospective cohort design including adult patients presenting with MTBI and an admission GCS of 13–15 with an initial head CT scan which was positive for ICB. All patients were admitted under the care of the general trauma service of our 650 bed Level II rural trauma center where there was a non-transfer policy to an institution with neurosurgical facilities and expertise for specific ICB categories. Inclusion ICB criteria were: (A) minimal or small traumatic subarachnoid hemorrhage confined to one area (Fig. 1), (B) punctate cerebral contusion or parenchymal hemorrhage (<1 cm in maximal diameter) or (C) a small-width stable subdural hemorrhage (<5 mm in maximal depth) without any shift or mass effect (Fig. 2). Both the CT scan and the clinical status of the patient were reviewed by consulting neurosurgeons at the transfer facility with a consensus decision not to transfer. Exclusion criteria were: (A) those patients with an associated coagulopathy, (B) basilar skull fractures, (C) cases with CSF leakage, (D) spontaneous subarachnoid hemorrhages, (E) extradural hematomas and (F) cases of diffuse axonal injury.

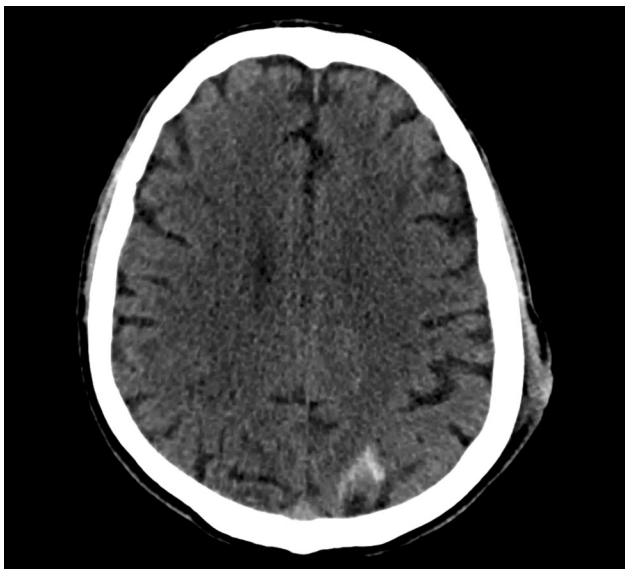


Fig. 1 Small traumatic subarachnoid hemorrhage confined to one area

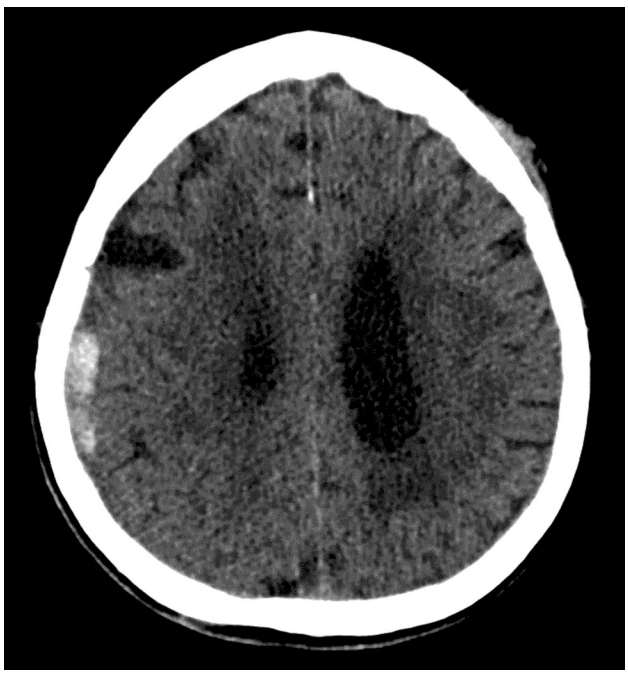


Fig. 2 Small subdural hemorrhage

Demographic data were collected including age and gender along with the length of loss of consciousness (LLOC), admission injury severity score (ISS), admission GCS and hospital length of stay (LOHS). The protocol for the performance of a head CT was followed in Kaplan Hospital where the triggers included: a GCS <13 (or higher if obtunded through alcohol/drugs/dementia), a GCS = 14 that failed to upgrade within 2 h of observation, an LLOC exceeding 10 min, retrograde amnesia, coagulopathy, skull

fracture, an abnormal neurological examination (NE) and age <2 years or >70 years.

The protocol for non-transfer admissions included: a GCS >14, a normal NE, no coagulopathy or treatment with anticoagulant therapy or platelet inhibition therapy and a formally reported CT scan with all cases consulted with a Level I neurosurgical consultant who has viewed the CT scan transmitted by a direct picture archiving and communication system (PACS) telemedicine transfer. All positive CT scans were evaluated by the on-call radiologist, the trauma consultant and the off-site neurosurgical consultant. Repeat CT scanning was routinely performed between 16 and 24 h following admission (or earlier if there was any clinical deterioration in the NE). All patients were managed with around the clock analgesics. Patients with nausea and vomiting received antiemetic medications as needed. Anti-seizure prophylaxis was given only if it has been recommended by the neurosurgeon. The drug of choice was Orfiril (valproic acid sodium). In cases of blood pressure >160/100 mm Hg after providing analgesia, captopril has been administered sublingually. When laboratory values at admission were within the normal limits, no further laboratory tests were performed.

All patients underwent a vital signs check, including GCS, by a nurse, every 4 h and a neurological examination by a physician every 8 h. In case of deterioration, a repeated CT and a neurosurgeon consultation were performed immediately.

After discharge, the patients were invited to follow up at the regional outpatient neurosurgery clinics. In cases of subdural hemorrhage, we recommended a repeated CT scan after 2 weeks, to rule out development of a chronic subdural hematoma.

The primary end point of the study was the neurological outcome at discharge with mortality, the need for neurosurgical transfer, the requirement of a neurosurgical procedure and the LOHS as secondary end points. Statistical analysis was conducted using SPSS version 15.0 software (Chicago, IL). Group means of categorical variables were compared with a Chi-square analysis or a Fisher's exact test where appropriate and Student's *t* test and ANOVA were used for continuous variables with *P* values <0.05 being considered significant.

Results

Between January 2011 and December 2016, there were 301 patients who presented with an MTBI and a positive scan for low-risk ICB (as defined). There were 10 patient exclusions from the analysis, all with a GCS <13 on admission (Fig. 3). There were 280 patients with a GCS = 15 and 11 with a GCS between 13 and 15. Of the

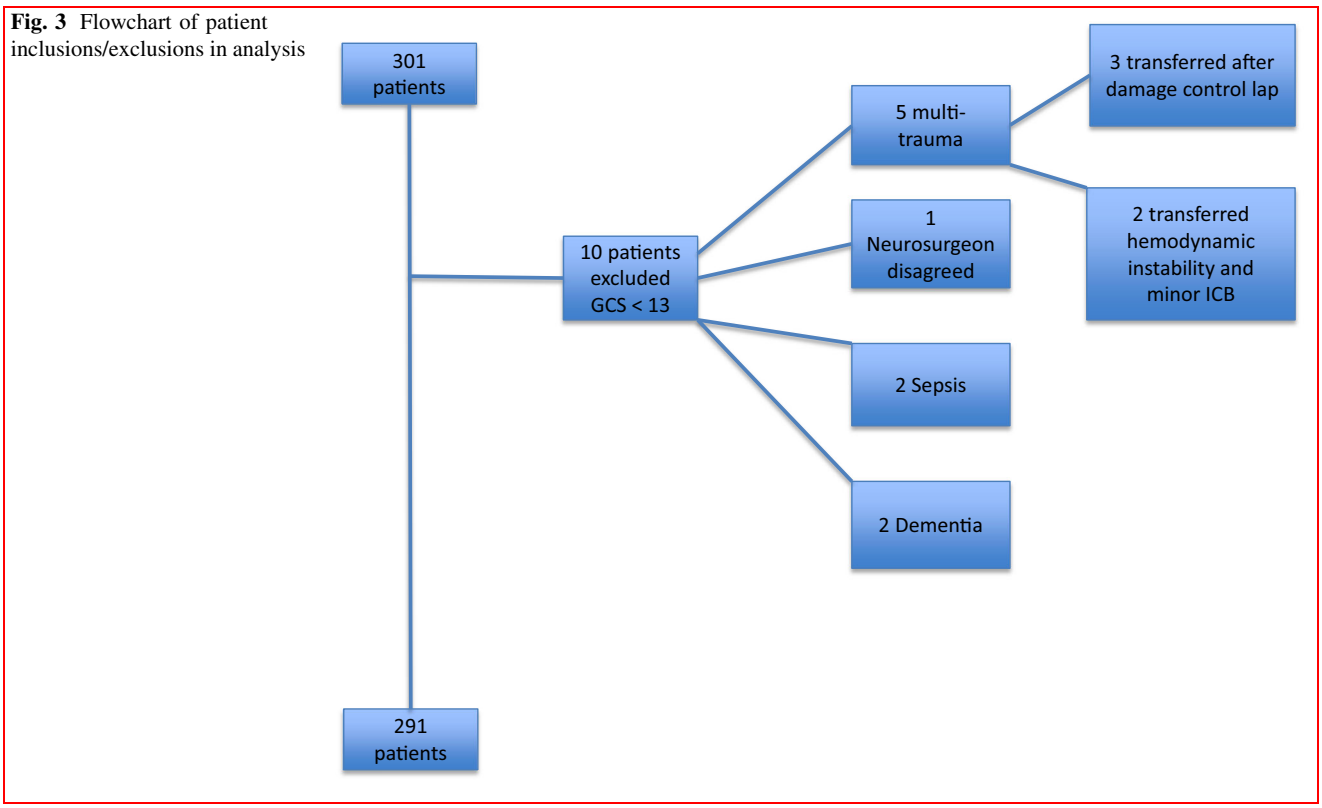
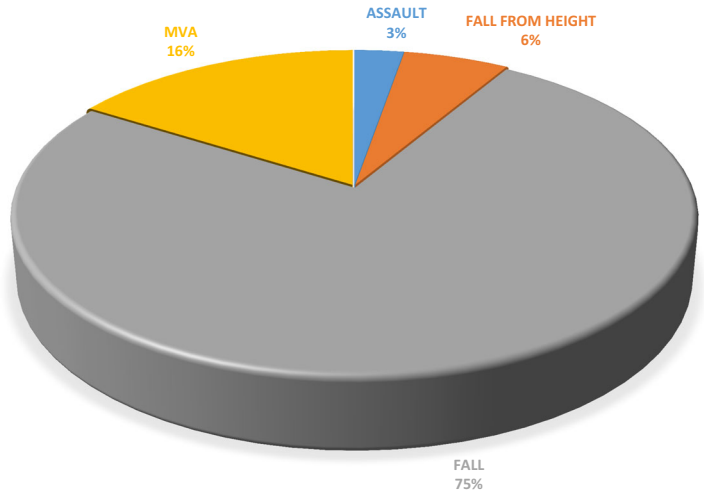


Fig. 3 Flowchart of patient inclusions/exclusions in analysis



Mechanism	Number (291)	%
Motor vehicle accident (MVA)	47	16.2 %
Fall	219	75.3%
Fall from height or stairs	17	5.8%
Assault	8	2.7%

Fig. 4 Mechanisms of injury ($N = 291$)

cohort, there were 139 females and 152 males with a mean overall age of 69.9 ± 18.7 years. In the cohort 20% of patients had no registered comorbidities with 24% having associated diabetes, 50% hypertension and 18% ischemic heart disease. Figure 4 is a schematic representation of the mechanisms of the trauma with 219 patients (75.3%) experiencing a fall, 17 (5.8%) a specific fall from a height or stairs and 47 patients (16.2%) involved in motor vehicle accidents (MVA). Figure 5 shows the types of ICB with 113 patients (39%) presenting with subdural hematomas, 91 patients (31%) with subarachnoid hemorrhage and 47 (16%) with an intraparenchymal hemorrhage. There were 38 patients (13%) who incurred multiple-site ICB.

The median length of hospital stay was 3 days (range 1–20, SD 2.48). A repeat CT scan was performed as part of the hospital protocol between 16 and 24 h after admission in all cases showing no change in 242 patients (83.1%), improvement in 38 cases (13.1%) and deterioration in 11 patients (3.8%). Figure 6 shows the outcome of the 11 cases with worsening head CT scans, 8 of whom were transferred to a Level I trauma center. Nineteen patients (6.5%) presented with an INR >1.5 as a result of coincident Coumadin therapy with the head CT deteriorating in 2 cases, both of whom were transferred for neurosurgical care. Both patients were discharged without any intervention. In each of the 5 patients (1.7%) where there was development of an abnormal neurological examination, deterioration in the clinical findings preceded the performance of their repeat head CT scan. Three patients (1%) died, all with multiple comorbidities (each >90 years of age). In each of these cases there was no neurosurgical intervention (NSI) with 2 cases being transferred. Of the entire cohort, one patient with a subdural hematoma underwent a craniotomy with full neurological recovery.

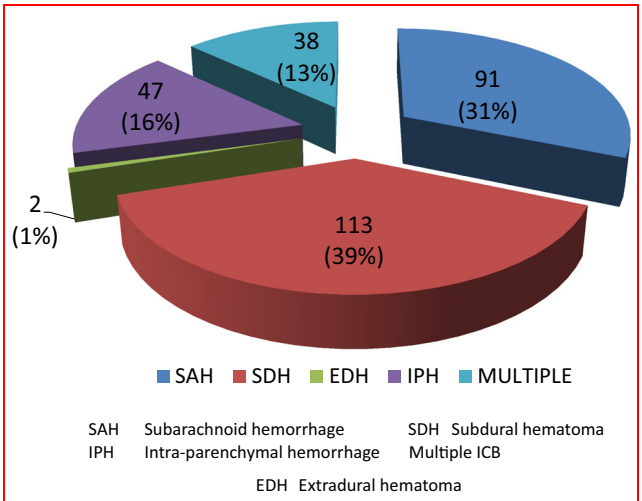


Fig. 5 Types of intracranial bleed

Three patients with transfer criteria based upon a worsening CT scan were not transferred (2 patients with a normal NE and a favorable neurological outcome and one patient >90 years of age with severe dementia who died).

Discussion

Our retrospective analysis was of adult patients specifically presenting with a minimal traumatic brain injury (MTBI) and a GCS ≥13 where the initial CT scan showed a minor intracranial bleed (ICB) that did not progress on repeat head CT scanning. It would appear in our unit that these patients can be safely managed by local hospital trauma specialists in consultation with neurosurgeons but without

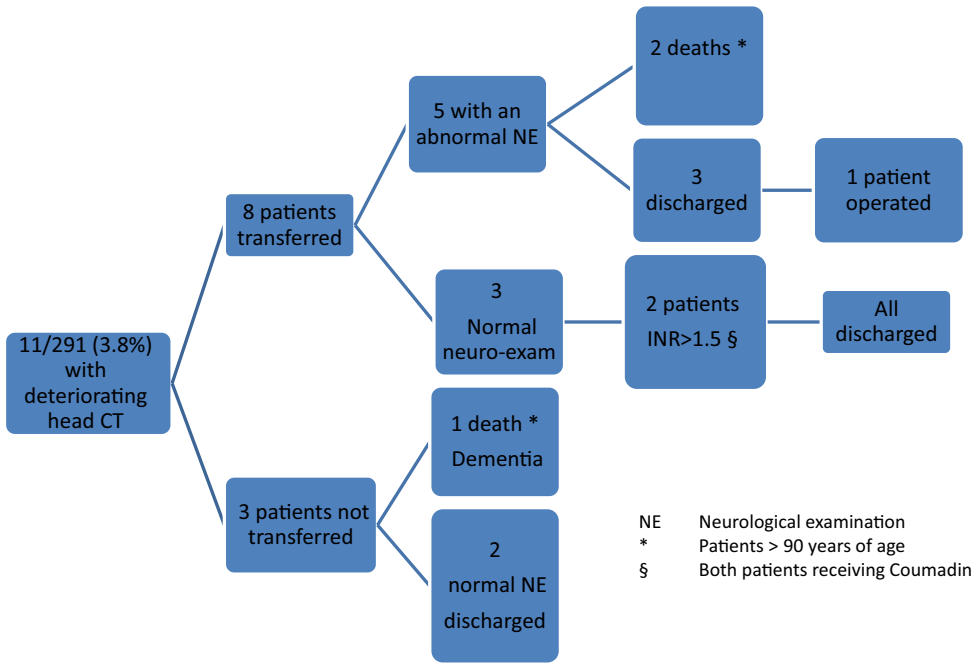


Fig. 6 Outcome of 11 patients with worsening head CT scans

the need for neurosurgical transfer. Current practice requires initial patient stabilization, followed by a head CT scan and a neurosurgical consultation [12] where the focus on resource use for subspecialty services is changing with care shifted to the acute surgeon [13]. The widespread use of CT technology along with its technical advances has also resulted in a greater detection of minor intracranial bleeds (ICB) with a varying clinical importance where the consideration of neurosurgical involvement is debated [14].

In Israel, there are about 25,000 hospitalizations for trauma annually with nearly one-third suffering a head injury [4]. A neurosurgical service is available in 6 of our main hospitals with Level I trauma centers, necessitating development of a protocol of beneficial transfer where there are economic considerations, potential delays in the management of other injuries [15] and the added burden of sending patients to centers which are remote from their home. In this regard, our hospital is a 650-bed general hospital designated as a Level II trauma center located in a rural area as the only trauma center available for immediate transfer of injured cases within a 30 km radius. Direct transfer of these patients to a designated Level I trauma facility would generally add 1 h to the primary evacuation time depending upon local traffic conditions and/or helicopter transport availability. Overall, around 12,000 patients are triaged in the Kaplan Medical Center ER annually with 2500 yearly trauma hospitalizations.

The value of a non-neurosurgical consultant managing neurotrauma patients would be predicated on the view that the only categorical need for a neurosurgeon is the performance of a craniotomy [16]. It is anticipated that the trauma specialist is capable of non-operatively managing mild to severe head injury cases with identification of those patients where there is a higher risk of craniotomy (either in the pre-hospital setting or early after admission) as well as the unsalvageable case where triage and transfer to neurosurgical care would be inappropriate. Concerning the likelihood of NSI after transfer, in a 2007 Israeli study by Ashkenazi et al. [17] where there was a policy of routine transfer, 17 of 116 patients transferred (14.7%) required specialized neurosurgical treatment. Of these, 3/17 (17.6%) only underwent insertion of an intracranial pressure monitor. By comparison, Esposito et al. [13] assessing a large US National Trauma Data Bank showed an extremely low NSI rate (3.6% of all head-injured cases and 1% of all trauma patients), concluding that 24-h neurosurgical cover was not essential for a fully functioning trauma center.

A prior Israeli study by Klein et al. [4] reported on a separation of services into 3 existing models. In one, every patient with an ICB demonstrated on CT scanning was transferred to a specialist neurosurgical unit. In the second model, the available neurosurgeon could decide on transfer based upon the PACS-transmitted CT scan. In the 3rd and our current model, the trauma consultant responsible for the patient care can selectively decide in consultation with the neurosurgeon about transfer by separation of patients into designated low- and higher-risk ICB cases. Comparative data by Joseph et al. [5] using a similar approach to our study where the severity of the head injury was defined

by the admission GCS, confirmed that the vast majority of such cases can be managed successfully by the acute care consultant.

It is accepted overall that although the GCS score has been used as the discriminator for management, a high admission GCS is not always a sole predictor of a favorable neurological outcome [18, 19]. Prior use of a combination of GCS and the anatomic measures of injury (such as the Abbreviated Injury Score—AIS for the worst head injury—and the Injury Severity Score—ISS) have been found to be effective in the prediction of the outcome of ICB patients [20]. Criteria have been established for neurosurgical consultation in patients specifically with a small ICB on initial head CT who are neurologically intact where Rhodes et al. [21] included in their less severe category those patients with non-depressed skull fractures, an ICB <3 mm in depth and solitary contusions. Similarly, Huynh et al. [12] used solitary contusions, subdural hematomas <4 mm in depth and trace traumatic subarachnoid hemorrhages as their definitions for minor ICB categorization. The patient with an extradural hematoma should be excluded from such management because of a greater likelihood for NSI [22] along with all but the most minimal of subdural hematomas without mass effect [23].

Our study is limited by its retrospective design which may induce biases toward specific treatment plans and favorable outcomes. This group of patients with a normal neurological examination (NE) and minor non-progressive traumatic findings on their head CT scans requires further investigation, and the data should be viewed with caution since there is great variability in reported series in both patient age and injury characteristics [24]. Our only mortalities were in elderly cases where it has been previously reported that mortality in patients with cerebral contusions increases with advancing age. There is frequently a greater time delay between admission and imaging in the elderly and a reduced likelihood that older cases will be transferred to an acute neurosurgical facility even when indicated [25].

Despite evidence suggesting that those patients transferred to neurosurgical care are more likely to be admitted to an ICU or to undergo repeat head CT scanning, these maneuvers do not appear to lead to any specific change in management or to NSI [7, 8, 26]. Future work will need to determine in our hospital the value of routine repeat head CT scanning, where data would suggest that this is unnecessary in those patients maintaining a normal NE [27]. Joseph et al. [9] adjusting for confounding variables reported that only a worsening clinical NE correlates with the likelihood of NSI, and this was confirmed in a systematic review by Stippler et al. [28] who showed that only CT scans performed for a decline in NE were predictors for NSI and not routine follow-up CT scans.

Our approach is not suitable for patients on antiplatelet or anticoagulant therapies who are at higher risk of progression on repeat head CT scan and where the need for NSI can be independent of the NE [29, 30]. In our study, 6.5% of the patients presented with an abnormal INR and 2/19 patients in this higher-risk group showed deterioration in their NE although neither needed NSI. A change in our protocol away from routine repeat head scanning will have a significant impact on hospital charges. A meta-analysis by Reljic et al. [31] examined the role of repeat CT in MTBI in order to determine whether this resulted in a change of management. Subgroup analysis showed a change of management overall in 2.3% (95% CI 0.3–6.3) across 5 prospective studies and in 3.9% (95% CI 2.3–5.7) across 9 retrospective studies. In a further study by Joseph et al. [32] initiated in Arizona, the implementation of Brain Injury Guidelines (BIG) with categorization of a minor BIG Grade I group (subdural hematoma <4 mm., an isolated intraparenchymal hemorrhage <4 mm or a trace subarachnoid hemorrhage), resulted in less neurosurgical consultations and transfers, less ICU admissions, a reduction in repeat head scanning, a shorter length of hospital stay and lower total hospital costs. The implementation of these guidelines was not associated with any change in recordable patient outcomes over time.

In summary, our study would suggest that patients presenting with minimal traumatic ICB can be safely managed in a non-neurosurgical environment without the requirement for specific neurosurgical transfer or intervention unless there are other clinical high-risk features. This approach will not be perfect; however, it aims through the implementation of strict inclusion and exclusion criteria to leave an MTBI subgroup with a very low risk of NSI.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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