Low rate of delayed deterioration requiring surgical treatment in patients transferred to a tertiary care center for mild traumatic brain injury

ANDREW P. CARLSON, M.D.,¹ PEDRO RAMIREZ, M.D.,¹ GEORGE KENNEDY, M.D.,² A. ROBB MCLEAN, M.D.,² CRISTINA MURRAY-KREZAN, M.S.,³ AND MARTINA STIPPLER, M.D.¹

Departments of ¹Neurosurgery and ²Emergency Medicine, and ³Clinical and Translational Science Center, University of New Mexico, Albuquerque, New Mexico

Object. Patients with mild traumatic brain injury (mTBI) only rarely need neurosurgical intervention; however, there is a subset of patients whose condition will deteriorate. Given the high resource utilization required for interhospital transfer and the relative infrequency of the need for intervention, this study was undertaken to determine how often patients who were transferred required intervention and if there were factors that could predict that need.

Methods. The authors performed a retrospective review of cases involving patients who were transferred to the University of New Mexico Level 1 trauma center for evaluation of mTBI between January 2005 and December 2009. Information including demographic data, lesion type, need for neurosurgical intervention, and short-term outcome was recorded.

Results. During the 4-year study period, 292 patients (age range newborn to 92 years) were transferred for evaluation of mTBI. Of these 292 patients, 182 (62.3%) had an acute traumatic finding of some kind; 110 (60.4%) of these had a follow-up CT to evaluate progression, whereas 60 (33.0%) did not require a follow-up CT. In 15 cases (5.1% overall), the patients were taken immediately to the operating room (either before or after the first CT). Only 4 patients (1.5% overall) had either clinical or radiographic deterioration requiring delayed surgical intervention after the second CT scan. Epidural hematoma (EDH) and subdural hematoma (SDH) were both found to be significantly associated with the need for surgery (OR 29.5 for EDH, 95% CI 6.6–131.8; OR 9.7 for SDH, 95% CI 2.4–39.1). There were no in-hospital deaths in the series, and 97% of patients were discharged with a Glasgow Coma Scale score of 15.

Conclusions. Most patients who are transferred with mTBI who need neurosurgical intervention have a surgical lesion initially. Only a very small percentage will have a delayed deterioration requiring surgery, with EDH and SDH being more concerning lesions. In most cases of mTBI, triage can be performed by a neurosurgeon and the patient can be observed without interhospital transfer. (DOI: 10.3171/2010.8.FOCUS10182)

Key Words • mild traumatic brain injury • cortical contusion • skull fracture • traumatic subarachnoid hemorrhage • subdural hematoma • brain concussion

MILD traumatic brain injury is common due to various causes including sports-related accidents, assault, and motor vehicle collisions. Optimal treatment of these patients likely involves some degree of imaging and observation in a medical environment due to the potential fear of delayed deterioration.¹⁵,²² The need for and timing of repeat imaging as well as the length of the observation period remains controversial, although basic treatment paradigms have been developed.⁸,²⁸ Furthermore, many community hospitals do not have the neurosurgical coverage that might be needed if deterioration were to occur. It has been shown that patients with mild-to-moderate TBI, with a lesion on the initial head CT scan that does not require immediate intervention, can safely be observed at a peripheral hospital without neurosurgical coverage. If surgery is required, as determined by a neurosurgeon via a teleradiology system, the decision can be made to transfer the patient to a tertiary care facility.⁴ Because of inexperience in the treatment of patients with TBI, as well as concerns about potential litigation, patients are frequently transferred. These transfers are often at a high cost, use limited resources in tertiary referral centers, and may result in further unnecessary expenditure (for example, due to a lack of transportation back to the referring facility when observation period is complete). We sought to evaluate the need for neurosurgical intervention in a cohort of patients transferred from other hospitals to UNM for evaluation and treatment of mTBI.

Abbreviations used in this paper: EDH = epidural hematoma; GCS = Glasgow Coma Scale; LOS = length of stay; mTBI = mild traumatic brain injury; SDH = subdural hematoma; TBI = traumatic brain injury; UNM = University of New Mexico.
Methods

A retrospective review from the UNM databases for the period January 2005 to December 2009 was performed with local institutional review board approval. Patients who were transferred to UNM for evaluation of mTBI (GCS Scores 13–15 at admission to UNM) were included and all patients with GCS scores < 13 were excluded. The GCS score at admission to UNM was used because such GCS scores are not routinely available from the other facilities involved. In pediatric patients, the pediatric modification of the GCS was used. The UNM trauma center is the only Level 1 trauma center in New Mexico and serves a catchment area that includes New Mexico and the surrounding regions of border states, with a total population of around 2.2 million. There is limited emergency neurosurgical coverage throughout the remainder of the state of New Mexico.

Baseline demographic data were extracted from the databases along with information regarding CT examinations (whether the patient had CT scanning of the head performed at UNM, the timing and findings of the first and second CT scans, and rate of worsening). In addition, data regarding need and timing of surgical intervention were recorded, as were disposition, LOS, and discharge GCS score. The group of cases involving patients who were surgically treated was examined for risk factors for surgery based on initial imaging.

Statistical analysis was performed by a professional statistician using SAS 9.2 software. Logistic regression was performed using stepwise variable selection to determine factors associated with the need for surgery based on initial CT findings.

Results

A summary of when CTs were performed and when patients went to the operating room is presented in Fig. 1. Of 292 patients, 15 (5.1%) were taken to the operating room either on arrival or after the first CT at UNM. In some cases, CT scans performed at other facilities were available to the treating team (indicated by the fact that 3 patients were taken to the operating room on arrival without an initial CT at UNM). The presence of these CTs and the images themselves were not available for analysis for this retrospective review. In a significant number of cases, either the patients never needed a CT or the imaging performed at the facility from which they were transferred was thought to be adequate, as evidenced by the 22 patients (7.5%) who never had a CT performed at UNM. Furthermore, in 85 cases (25.1%) the initial CT showed no acute findings (negative CT group). Overall, the initial CT was performed relatively early (an average of 3 hours, 22 minutes after the patient’s arrival). The group characteristics are summarized in Table 1. All patients had GCS scores in the 13–15 range.

In 182 cases (62.3%) some type of traumatic lesion was evident on the initial CT scan. Table 1 compares the characteristics of the patients with a lesion on initial CT imaging to those with a nondiagnostic CT scan and the whole group. Of the 182 patients with a lesion seen on the initial CT, 12 patients (6.6%) were taken immediately to the operating room for neurosurgical procedures. In 60 cases (33%), it was not deemed necessary to obtain a follow-up CT scan, and the remaining 110 cases (60.4%) were managed with clinical observation and follow-up imaging. (Of note, 5 patients with negative findings on initial CTs also had follow-up CT imaging; in all 5 cases

![Flowchart](image-url)
the findings on follow-up CT were also negative.) Follow-up CT scans were performed an average of 18 hours, 41 minutes after the initial scan.

Of the 110 patients who underwent follow-up imaging to assess for progression, 13 demonstrated radiographic worsening on the second CT study, but only 4 patients were taken unexpectedly to the operating room (that is, despite plans for conservative treatment) some time after the second CT for neurosurgical procedure (see Table 2). In 3 of these cases, the second CT showed radiographic progression and in the third case, the patient showed clinical signs of deteriorating neurological condition. These 4 patients represent 1.4% of the overall group of transferred patients, 2.2% of patients with a traumatic finding on the initial CT, and 3.6% of patients observed with a follow-up CT. Table 2 summarizes the findings on the initial head CT in the overall group, the surgically treated patients, and the patients with radiographic worsening on the follow-up CT.

Of the 4 patients who were treated surgically after initial plans for observation, 2 had fairly large temporal contusions that progressed on follow-up imaging. In addition, both of these patients had clinical worsening prior to intervention (Fig. 2A and B). One patient had an EDH associated with a fracture extending down into the floor of the middle fossa. Though the patient was neurologically intact and showed no signs of neurological deterioration, the hematoma was thought to be slightly increased in size on the follow-up images (Fig. 2C), and surgical evacuation was recommended to the patient. The fourth patient had suffered a concussion while playing football a week prior to admission, and was found to have an early subacute SDH after he presented with a seizure. He was neurologically intact at admission, but had a second seizure, and did not recover to baseline. Though the lesion remained stable, the decision was made to evacuate the hematoma because of neurological decline, and the patient subsequently recovered. All these patients recovered to a discharge GCS score of 14 or 15. Table 3 summarizes the characteristics of all patients who were treated surgically.

Logistic regression was performed using stepwise variable selection to determine if any of the factors (EDH, SDH, traumatic subarachnoid hemorrhage, contusion, pneumocephalus, or fracture) was independently associated with the need for surgery. Two-way interactions were included in the model, but none were significant. Both EDH and SDH were significantly associated with the patient having surgery, with a stronger association for EDH ($p < 0.0001$) than for SDH ($p = 0.0013$). There were no patients with both EDH and SDH. The odds ratio for a patient with EDH requiring surgery compared with all other patients was 29.5 (95% CI 6.6–131.8), and for SDH it was 9.7 (95% CI 2.4–39.1). A logistic regression model was also used to determine significant factors for worsening on second CT, and none of the findings were significant.

Overall, patients did well, with the discharge GCS score being 15 in 97% of patients and no deaths or patients discharged with a GCS score < 13. Overall, 49 patients (16.8%) were discharged home within 1 day, 62 (21.2%) were discharged from the emergency department, and the average LOS was 6.3 days. The average LOS was slightly longer in the group with positive findings on the initial CT examination (6.8 days) compared with 5.5 days in the group with negative findings (Table 1).

### Discussion

This series demonstrates the potential for deterioration and need for surgical intervention in mTBI. We observed a rate of deterioration—either clinical or radiographic—to the point of needing surgery in 1.4% of all patients transferred with mTBI and in 3.6% of patients who had a positive finding on initial CT and underwent follow-up imaging. Available data suggests that although between 5% and 13% of patients with a GCS score of 15 evaluated in the emergency department will have a trauma...
matic lesion of some type on CT, \( < 1\% \) of patients will require neurosurgical intervention.\(^{13,16} \) Due to the fact that such a lesion is uncommon but potentially devastating if missed, much work has focused on accurate identification of these patients.\(^{5,28} \)

The concept of patients whose condition is initially stable and then deteriorates has been well described,\(^{15,22} \) and it seems that initial mass lesions such as parenchymal hematomas or contusions likely increase the probability of this potentially devastating consequence.\(^{15} \) This was confirmed in our series with 2 of the patients requiring delayed surgery having relatively large temporal hematomas, though overall, due to the large number of small contusions on initial imaging, the finding did not reach significance with regard to the need for surgery. When specific criteria are applied to patients with mTBI (GCS Score 15, no loss of consciousness, amnesia, vomiting, or headache), the risk of developing a lesion requiring neurosurgical intervention is \( 0.1\% - 0.6\% \).\(^{2,10,13} \) There are also clinical and radiographic factors that predict subsequent deterioration and need for neurosurgical intervention. Two attempts to formalize this system include the Canadian CT Head Rule and the New Orleans Criteria.\(^{3,8,21,26-28} \) These systems have both proven to be highly sensitive in identifying high-risk patients and have been externally validated.\(^{26} \) The New Orleans Criteria are likely more...
sensitive for detecting significant CT lesions, but the Canadian CT Head Rule still seems reliable for identifying patients who need neurosurgical intervention.26,27

The need for routine repeat head CT as well as even neurosurgical consultation has been called into question in patients with mTBI as emphasis is increasingly placed on cost savings in medicine. We recently performed a systematic review of the literature looking at the need for routine repeat head CT in patients with mTBI, and found an overall incidence of need for neurosurgical intervention of 2%. When CT was performed for neurological decline, the chance of needing surgical intervention was 58% compared with only 0.3% chance if the CT was done for routine follow-up, suggesting the importance of serial clinical examination as compared with routine imaging follow-up (unpublished data).

On review of the 4 cases with delayed need for neurosurgical intervention, all of the patients would have been defined as high risk based on either the Canadian CT Head Rule or the New Orleans Criteria. Furthermore, the findings on initial imaging were all sufficiently significant that the clinician would be unlikely to pass over the patients for observation at an outside facility. Two patients presented with relatively large temporal contusions (one 3 × 4 cm and one 4 × 5 cm) and likely due to a combination of evolution of the contusions and pericontusional edema progressed to the point of needing surgical evacuation. Though there are no established guidelines, and our data set is too small to make definitive conclusions, it seems reasonable that contusions (especially temporal ones) of significant size should be observed in a tertiary center with a neurosurgeon. The third case was that of a patient with a growing epidural hematoma associated with a fracture. These are well known to be dangerous lesions due to the potential for arterial laceration, and so all cases should probably be observed by a neurosurgeon. This is further supported by the significantly higher rate of patients with epidural hematomas who required surgical intervention based on the initial evaluation (that is, without delayed deterioration). The final case of deterioration was in a young patient with a relatively large subacute SDH with 6 mm of midline shift. This lesion was not a rapidly progressive one, but was evacuated due to the increasingly symptomatic condition of the patient. In all 4 of these cases the patients would probably not have been passed over for transfer, even with a very restrictive policy.

There was a second group of patients (including those with SDHs, EDHs, and depressed skull fractures) who required surgical intervention immediately on arrival. Given that these patients were all doing relatively well clinically on admission (GCS Scores 13–15), the decision to operate was made primarily on the basis of radiographic data. We assert that these patients also would have all been transferred to a neurosurgical service if this radiographic information was known. Based on our data, EDH and SDH are the lesions most significantly associated with a subsequent need for surgery, whether immediate or delayed. Many of these lesions were not progressive ones (fracture and chronic SDH), but it is possible that some of the remaining patients had expansion of the lesion in the period between the facility they were transferred from and the arrival at UNM. The imaging data from the other facilities were not available for these patients, though if such expansion occurred, it is possible that several more of these patients would have been considered in the “delayed deterioration” group.

This brings up the role of telemedicine in patient evaluation. The ability of a neurosurgeon to actually see the radiological images obtained in a patient is of critical importance—rather than simply making a decision based on a verbal report. Other neurological fields such as stroke therapy have made excellent process in implementing stroke systems to evaluate and treat these patients in outlying facilities. Image transfer systems have been initiated across the world for many years specifically to address the need for neurosurgeons to evaluate images before the transfer of patients. The effect of these systems, where available, has proved to be significantly beneficial in terms of mitigating cost of unnecessary transfer. One group in Italy found that only 23% of patients (with a mean GCS score of 11) who had images sent on a teleradiology system required transfer after the initial CT images were sent, and only 5% after follow-up CT. A Level 2 trauma center in Israel found that with the implementation of teleradiology, 40% of patients with TBI were successfully treated at their facility, with only 2 patients requiring delayed transfer to a Level 1 center. A recent evaluation of transfers in Germany showed that after image transfer, patient transfer was deemed unnecessary in 67% of potential neurosurgical cases, and the cost of the teleradiology system was amortized in 15 months.

**TABLE 3: Characteristics of the surgical group (19 patients)**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>FU CT findings</td>
<td></td>
</tr>
<tr>
<td>stable</td>
<td>1 (5.3)</td>
</tr>
<tr>
<td>worse</td>
<td>3 (15.8)</td>
</tr>
<tr>
<td>resolved</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>improved</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>postop</td>
<td>11 (57.9)</td>
</tr>
<tr>
<td>no FU or 1st was postop</td>
<td>4 (21.1)</td>
</tr>
<tr>
<td>mean LOS (in days)</td>
<td>7.63 ± 7.6</td>
</tr>
<tr>
<td>discharge from ED</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>discharge w/in 1 day</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>GCS score at discharge</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>16 (84.2)</td>
</tr>
<tr>
<td>14</td>
<td>3 (15.8)</td>
</tr>
<tr>
<td>13</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>surgery after 2nd CT</td>
<td>4 (21.1)</td>
</tr>
<tr>
<td>surgery type</td>
<td></td>
</tr>
<tr>
<td>EDH evacuation</td>
<td>7 (36.8)</td>
</tr>
<tr>
<td>SDH evacuation</td>
<td>6 (31.6)</td>
</tr>
<tr>
<td>fracture elevation</td>
<td>4 (21.1)</td>
</tr>
<tr>
<td>contusion evacuation</td>
<td>2 (10.5)</td>
</tr>
</tbody>
</table>

* Values represent numbers of cases (%) unless otherwise indicated. Abbreviation: FU = follow-up.
of use due to the cost savings. With the recent rapid rise and availability of high-bandwidth wireless systems, the use of handheld devices in making determinations of the need for transfer may allow photographs and even short videos to be sent even from facilities with limited resources. For more complex evaluation, systems of video consultation have been used to determine the need for interhospital transfer as well.

With increasing trends toward the regionalization of care, the need for established guidelines for in-hospital treatment and transfer of patients to a higher level care facility are being increasingly developed and used. In Canada, a pilot project that simplifies and standardizes the treatment of patients with TBI has been implemented, using a simple poster with guideline-based decision tools for treatment of these patients. This regionalization of treatment of mTBI is essential because it has been shown that early aggressive transfer and treatment of patients with severe TBI decreases mortality. Decision rules to identify these patients have been developed. The limited availability of beds and resources, therefore, must be prioritized to these severely injured patients.

The amount of potentially unnecessary transfers for mTBI was relatively high in this series. Though all of the included patients were transferred with some type of mTBI (concussion or decreased GCS), a relatively high number did not require any further diagnostic intervention upon arrival, many had negative findings on head CT, and many were discharged home from the emergency department or within a short stay. No standardized guidelines exist, and transfer of patients is based on the discretion of the accepting neurosurgeon, emergency physician, or trauma surgeon. In addition, if the referring health care provider is uncomfortable with a case, the patient may be transferred to another facility. No definitive statement regarding unnecessary transfers can be made on the basis of our series, because many of the patients needed other trauma or orthopedic intervention, some of whom might have been treated at the referring facility, and some of whom could not have been. Based on these data and the above-described studies, we propose a general algorithm for the treatment of patients referred from an outside facility. This algorithm takes into consideration the availability of telemedicine, the type of lesion seen on initial imaging, and factors such as patient age and anticoagulation therapy (Fig. 3).

![Proposed algorithm for the treatment of patients referred with mTBI. Anticoagulation refers to patients being treated with clopidogrel or with an international normalized ratio > 1.5. DC = discharge.](image-url)
Interhospital transfer for mild TBI

Other limitations of the current study include the lack of imaging data. Some patients may not have had an initial head CT if the facility at which they initially presented was a very small one without a CT scanner. In some other cases, an initial head CT might have been performed at the outside facility, but the CT was not available for review. This leads to the assumption that the initial CT study performed at UNM served as a baseline examination, though it is possible that some of the patients who were treated surgically may initially not have had a surgical lesion on imaging studies performed at the outside facility. If this were the case, the number of patients with delayed surgery could have been slightly higher. In addition, there was no set protocol during the study period for the need of repeat imaging, so follow-up imaging was variable. Data on the reason for ordering follow-up imaging was limited in the charts in terms of the patient’s clinical status, so no statement can be made regarding the role of the clinical examination, except as described in the surgical cases.

Conclusions

In a series of patients transferred to a Level 1 trauma center for mTBI, only a small number will have delayed deterioration requiring neurosurgical intervention. In our case series, these patients presented with significant lesions, including large temporal contusions, SDH, and EDH with fracture, and probably would not have been passed over for transfer. Of the patients with mTBI who underwent a neurosurgical procedure, most had surgical lesions present at the outset. Our findings support the importance of teleradiology systems in patient evaluation for transfer. Most patients with mTBI can likely be triaged and observed without routine interhospital transfer to a Level 1 trauma center, and guidelines should be developed and implemented.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper. Statistical analysis was supported via a grant through the Clinical Translational Science Center at UNM.

Author contributions to the study and manuscript preparation include the following. Conception and design: Stippler, Kennedy, McLean. Acquisition of data: Stippler, Carlson, Ramirez, Kennedy, McLean. Analysis and interpretation of data: Carlson. Drafting the article: Carlson, Ramirez. Critically revising the article: Carlson, Kennedy. Reviewed final version of the manuscript and approved it for submission: Stippler, Carlson. Statistical analysis: Murray-Krezan.

Acknowledgments

The authors thank Dominic Tuteria, Carl Smith, and Jeffrey Reitsema for assistance with data collection.

References


3. Edmonds M: The Canadian CT Head Rule reduced the need for CT scans more than the New Orleans Criteria in minor head injury. Evid Based Med 11:61, 2006


21. Quishmaq I, Cook DJ: The Canadian CT Head Rule was as sensitive as, but more specific than, the New Orleans Criteria for identifying minor head injury. ACP J Club 144:53, 2006

Address correspondence to: Martina Stippler, M.D., Department of Neurosurgery, University of New Mexico, MSC10-5615, 1 University of New Mexico, Albuquerque, New Mexico 87131. email: mstippler@salud.unm.edu.