# Necessity of Repeat Head CT and ICU Monitoring in Patients With Minimal Brain Injury

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***Background:*** **Recent publications have dismissed the need for routine repeat computed tomography (CT) scans in patients with minimal brain injury (MBI) (Glasgow Coma Scale score 13–15 with positive initial CT) unless physical examination changes. In an attempt to better allocate scarce resources, we hypothesized that not only was repeat head CT unnecessary but also routine intensive care unit (ICU) monitoring of these patients with MBI and stable examinations were unnecessary.**

***Methods:*** **All blunt injured patients admitted to a level I trauma center from January 2005 through December 2007 who met our criteria for MBI (Glasgow Coma Scale score 14–15 with positive initial CT) were reviewed. All patients had ICU monitoring and repeat CT done (at 12–24 hours) regardless of clinical examination. Patients with skull fractures, facial fractures needing urgent repair, those requiring immediate neurosurgical intervention and those with other injuries requiring ICU monitoring were excluded. Data including demographics, initial brain injury, follow-up CT scan results, changes in clinical examination, neurosurgical interventions, and ICU days were recorded.**

***Results:*** **Two hundred seven patients met criteria. Fifty-eight patients (28%) developed worsening findings on follow-up CT or examination. Eighteen required invasive neurosurgical intervention (6 intracranial pressure [ICP] monitors, 12 craniotomies) and 1 died (stroke). Those requiring ICP monitors had worsening intracranial hemorrhages (IPHs) with clinical examination changes or examination changes only, whereas those requiring craniotomy had worsening subarahnoid hemorrhage (2 patient), epidural hematoma (1 patient), and subdural hematoma (8 patients). Five of the subdural hematoma patients remained asymptomatic before craniotomy. ICU days were significantly increased in those patients with worsening CT findings who did not require neurosurgical intervention compared with those patients with unchanged or improved CT scans (5 days vs. 2.7 days, $p \leq 0002$).**

***Conclusions:*** **Routine follow-up CT scans are beneficial in those patients with MBI and may lead to higher levels of medical management or neurosurgical intervention in patients with worsening CT findings. These patients should be kept in an ICU setting until head CT has stabilized. With these dissimilar results from previous studies, a prospectively randomized multicentered trial would be beneficial.**

***Key Words:*** **Minimal brain injury, Repeat head CT, Traumatic head injury, Brain trauma, Intensive care monitoring, Traumatic brain injury.**

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Patients with minimal brain injury (MBI) constitute a large number of trauma center evaluations and admissions each year. Therefore, significant resources are used for these patients including physician time in evaluation, radiology time and costs, intensive care unit (ICU) costs, and ancillary costs. With the current stresses being placed on the healthcare system for resource allocation, patients with MBI may be able to have their care streamlined while keeping patient safety of paramount importance.

Previous studies have shown that patients with MBI should be evaluated with initial CT scanning.[1,2] Those whose findings of the CT scan were normal were safely discharged.[3,4] Patients with abnormal CT scans findings were often placed in a monitored bed with a scheduled repeat CT scan performed within 24 hours, whether or not their clinical examination changes. Recently, the routine practice of repeated CT scans in these patients has been questioned.[5,6] In an attempt to better allocate scarce resources, we hypothesized that not only was repeat head CT unnecessary but also routine ICU admission of these patients with MBI and stable clinical examinations were unnecessary.

## METHODS

A review of all bluntly injured patients admitted to a level I trauma center from January 2005 through December 2007 was performed using the trauma registry and medical records. MBI was defined in this report as those patients with a history of a loss of consciousness and/or retrograde amnesia to the traumatic event, who had a Glasgow Coma Scale (GCS) score of 14 or 15 on arrival to the trauma center. These patients underwent initial head CT and, if positive, acquired a neurosurgical consultation. Patients with MBI and intracranial injury on CT scan comprised the study cohort. These patients with CT-documented brain injury then were admitted

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**Table 1** Initial CT Abnormalities

| | | | | | | |
|---|---|---|---|---|---|---|
| Single lesions, total = 131 | EDH | SDH | IPH | SAH | IVH | |
| | 4 | 26 | 53 | 45 | 3 | |
| Multiple lesions, total = 76 | EDH/SAH | SDH/IPH | SDH/SAH | SDH/IVH | IPH/SAH | SDH/IPH/SAH |
| | 1 | 7 | 20 | 1 | 35 | 12 |

**Table 2** Comparison of Worsening MBI and Noworsening MBI Patients

| | WORSE (58) | NOWORSE (149) | *p* |
|---|---|---|---|
| Average age | 47 (47.2 ± 19.8) | 45 (45.5 ± 18.7) | 0.560 |
| Average admission SBP | 152 (152.3 ± 28.3) | 143 (143.1 ± 25.9) | 0.03 |
| Average admission pulse | 87 (86.9 ± 15.3) | 88 (88.5 ± 16.1) | 0.556 |
| Average HAIS | 4.2 (4.21 ± 0.55) | 3.8 (3.84 ± 0.54) | <0.0001* |
| Average ISS | 22.3 (22.3 ± 6.25) | 19.6 (19.6 ± 6.9) | 0.018* |
| Average ICU length of stay | 8.1 (8.1 ± 9.9) | 2.7 (2.272 ± 2.8) | <0.0001* |
| Male | 47 (81%) | 104 (70%) | |
| Female | 11 (19%) | 45 (30%) | |

to a monitored bed and a repeat head CT was done between 12 hours and 24 hours later, regardless of clinical examination. To focus on only those patients with MBI and no other possible reason for ICU monitoring, patients with skull fractures, facial fractures needing urgent repair, those who went directly for neurosurgical intervention after initial head CT findings and those with other injuries requiring ICU monitoring were excluded.

Data included demographic information on the mechanism of injury, age, sex, vital signs at admission, head Abbreviated Injury Score (AIS), Injury Severity Score (ISS), GCS at admission, ICU days, and disposition. Findings of the initial CT scan and follow-up scan were recorded. Worsening by radiology staff interpretation was documented by injury type and location. Clinical examination change was noted. Surgical intervention, either craniotomy or intracranial pressure (ICP) device placement was also reported.

Data were analyzed using the Fisher's exact test and the Wilcoxon's rank sum test.

## RESULTS

A total of 8890 bluntly injured patients were admitted during the time period with 207 patients meeting criteria for the study. There were 56 women and 151 men. The average age was 46 years (SD 18.9 years), with the youngest patient with 15 years and the oldest 94 years. All were bluntly injured with motor vehicle crashes (43%) most prevalent followed by falls (23%), assaults (16%), and other mechanisms like motor cycle crashes, pedestrian, ATV crashes, etc. (18%). Head AIS score was on average 3.9 (SD 0.57) and ISS scores were an average of 20 (SD 6.8). Initial head CT lesions are indicated in Table 1. Most patients were admitted with solitary lesions commonly intracranial hemorrhage (IPH) and subarahnoid hemorrhage (SAH). However, it must be noted that 37% were admitted with multiple lesions with the combination of IPH and SAH being most prevalent.

**Table 3** Comparison of Mechanism of Injury

| | NOWORSE (149) | WORSE (58) |
|---|---|---|
| Assault | 25 (17%) | 9 (15%) |
| Fall | 32 (21%) | 15 (26%) |
| Ped struck | 4 (3%) | 4 (7%) |
| MVC | 69 (46%) | 20 (34%) |
| MCC/ATV | 14 (9%) | 8 (14%) |
| Jump from vehicle | 1 | 2 (3%) |
| Bike | 1 | 0 |
| Unknown | 3 (2%) | 0 |

Fisher's exact test $p = 0.2528$.

Of the 207 total patients, 58 (28%) developed worsening findings on follow-up CT or worsening clinical examination requiring an intervention. When comparing the two groups, those with worsening (WORSE) versus those without worsening (NOWORSE) (Table 2), there is no clinically significant difference in demographic data including age, initial systolic blood pressure, and initial pulse. Head AIS and ISS were both higher in the WORSE group. There were more women in the NOWORSE group in comparison with the percentage of women in the WORSE group. ICU length of stay was significantly increased in those patients with worsening CT or surgical intervention with clinical change. Even when the patients who had surgical interventions and therefore a reason for a longer ICU course are removed from the WORSE group, the WORSE patients without surgical intervention still had significantly longer ICU stays compared with those patients whose CT scans were unchanged or improved (5 days vs. 2.7 days, $p = 0.0002$). Another interesting subgroup was with those patients who had a change in their clinical examination, more agitation or confusion, but did not have any surgical intervention or CT worsening. This group had an average LOS in the ICU of 6.7 days again significantly longer than that in the NOWORSE group ($p = 0.002$). Mechanisms of injury were not different between the two

groups (Table 3). There is a logical difference in final disposition with 88% of the NOWORSE going home while 74% of the WORSE went home. Also, only 6% of the NOWORSE went to rehab compared with 15% of the WORSE group (Table 4).

In the WORSE group, it is evident that those patients with multiple lesions seemed to worsen more often than solitary lesions. IPH, SAH, or the combination of both was the most prevalent lesions (Table 5). Of the 58 patients in the WORSE group, most had enlargement or new appearance of IPH (Table 6). Eighteen required invasive neurosurgical intervention with 6 ICP monitors placed and 12 craniotomies. Also, one died of a stroke and one died after craniotomy. Of those who required ICP monitor placement, three had worsening IPH's with clinical examination changes consisting of decreasing GCS or increasing agitation and two had clinical changes only with stable CT scans. Those who required craniotomy had worsening SAH (2 patients), epidural hematoma (1 patient), and or subdural hematoma (SDH, 8 patients). Five of the SDH patients remained clinically unchanged before craniotomy with the operative decision made solely on follow-up CT worsening. The one patient who had both ICP monitoring and craniotomy had no change on his CT scan but had clinical deterioration in his GCS (Fig. 1).

Two patients in the NOWORSE group and one in the WORSE group were on Coumadin on arrival. The patient in the WORSE group had worsening of IPH and IVH lesions but required no surgical intervention.

**Table 4** Disposition Comparison

| | NOWORSE (149) | WORSE (58) |
|---|---|---|
| Home | 131 (88%) | 43 (74%) |
| Rehab | 9 (6%) | 9 (15%) |
| Death | 0 | 2 (3%) |
| Jail | 5 (3%) | 1 |
| AMA | 1 | 1 |
| Transfer | 2 (1%) | 2 (3%) |
| Nursing home | 1 | 0 |

Fisher's exact test, $p = 0.0277$.

**Table 5** Initial CT Abnormalities WORSE Group

| | | | | |
|---|---|---|---|---|
| Single lesions, total = 27 | EDH | SDH | IPH | SAH |
| | 1 | 6 | 11 | 9 |
| Multiple lesions, total = 31 | SDH/IPH | SDH/SAH | IPH/SAH | SDH/IPH/SAH |
| | 3 | 8 | 12 | 8 |

**Table 6** Worsening Lesions on Repeat CT Scans

| | |
|---|---|
| EDH | 1 |
| SDH | 11 |
| IPH | 23 |
| SAH | 8 |
| IPH/SAH | 4 |
| SDH/SAH | 1 |
| SDH/IPH | 3 |
| SAH/IVH | 1 |
| SDH/IPH/SDH | 1 |
| IVH | 1 |
| Clinical change only (CT unchanged) | 4 |

## DISCUSSION

Many hospitals are faced with financial difficulties and therefore the streamlining of services is a priority. It is not infrequent that a bluntly injured patient is admitted with an isolated MBI. These patients often do well and are discharged home without consequence. But, while in the hospital, it is our current protocol that these patients be monitored in an ICU and received a repeat head CT 12 hours to 24 hours after arrival. This often leads to clogged CT scanners and ICU beds, all for a patient who will most likely go home later the next day.

Recent literature has disputed the need for follow-up CT scans in all blunt traumatic brain injury patients, if the patient has no clinical changes. Brown et al.[7] in 2004 reported that few traumatic brain injury patients had any management alterations as a result of a routine repeat head CT and advocated not performing routine serial head CTs in patients without neurologic deterioration. The study by Kraups et al.[8] concurred with this view in that none of their patients (GCS average score of 9) had changes in their repeat CT without preceding clinical deterioration that included hypotension, ICP elevation, decreased GCS, or coagulopathy. These studies are provocative but in the group of moderate to severe brain injury, most neurosurgeons are adamant about repeat CT scans. This is primarily due to the difficulty with clinical examination in a patient who is under significant medical management with sedation, etc., for ICP control.

On the contrary, patients with MBI are not sedated and have, therefore, reliable clinical examinations. Velmahos et al.[5]

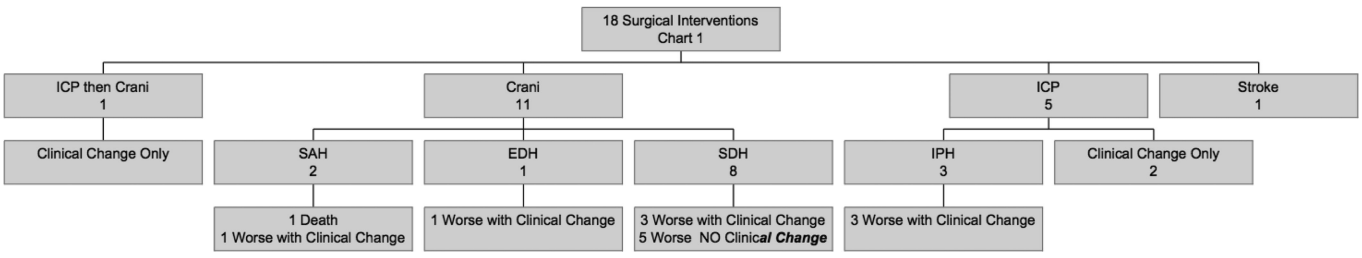


**Fig. 1.** *Surgical intervention patients.*

in 2006 found that of the 21% of patients with MBI who showed worsening on routine repeat CT scans, seven required surgical intervention. In their study, all seven patients showed clinical deterioration before the repeat CT scan. It is interesting to note that all but one of the patients who required intervention in this study were older than 70 years and three were on coumadin therapy. Sifri et al. studied 130 patients with MBI. Of the 99 patients who had unchanged clinical examination at the time of repeat CT none required intervention or change in management.[6] Of the 31 patients with abnormal neurologic examination, two patients required intervention. Notably, both of these patients died after their craniotomies, one from complications from craniotomy and one from heart disease. They concluded that repeat cranial CT has no diagnostic value when performed routinely.

This study data demonstrate a similar rate of worsening at 28%. However, we have a much higher rate of intervention at 31%. Other differences in our data include the fact that we only included patients with isolated MBI and no other reason to receive ICU care or cranial surgery. We also have a much younger population with our WORSE group having an average age of 47 years. The most alarming difference in our study is that all patients with worsening did not reveal clinical changes. In fact, five of the patients with worsening SDH who progressed to needing craniotomy had no change in their examinations. The decision to operate was solely based on worsening CT scan results. This subset of patients is concerning. Borovich et al.[9] reported on the delayed onset of traumatic extradural hematomas and saw seven patients who had insignificant or not present original CT findings only to have significant increase requiring evacuation in six of seven patients. In these patients, it is reported that only one had clinical changes with four patients unchanged and two with an improved neurologic examination. It is possible that these patients may go on to develop neurologic symptoms and would then, per the above cited literature, undergo repeat head CT scanning when such change occurs. This delay in treatment may be devastating. Mendelow et al.[10] showed, in the time before widespread CT scan availability, that in patients with extradural hematomas delay exceeding 2 hours generally produced poor results. Delay time started from the first recorded depression in level of response. They recommended early diagnosis and immediate action to reduce intracranial pressure by removing the clot. Routine repeat head CT in our relatively young patients with SDH resulted in rapid craniotomy before symptoms being seen. A recent study by Stein et al.[11] supports routine CT scans in MBI patients, because it was more cost effective especially in the younger population than awaiting clinical deterioration.

In regards to the hypothesis that patients with MBI may not require ICU monitoring, we will continue our current practice of close ICU monitoring of these patients. With a 31% intervention rate of those patients in the WORSE group, we are dealing with a large number of patients with MBI who may indeed need further and expedient intervention. This cannot be done on a "floor" setting. This is especially true in patients with multiple lesions as 31 of 76 patients with multiple lesions went into the WORSE group. More data need to be analyzed to possibly find a subset of single lesions that may indeed be manageable in a nonmonitored environment, but from our present data our hypothesis has been proven wrong. It was obvious from this data that those patients with worsening CT or clinical deterioration who did not undergo surgical intervention often times did require more diligent medical interventions, e.g., Na management, osmolar management, or more frequent neurologic examinations. This was seen by the significantly higher length of ICU stay in those patients with worsening CT scans or clinical examinations treated with medical intervention only compared with those with unchanged or improved CT scans and stable neurologic examinations.

## CONCLUSION

Follow-up CT scans are beneficial in patients with MBI and may lead to higher levels of medical management or surgical intervention in patients with worsening CT findings. These patients should be monitored in an ICU until head CT has stabilized even if the clinical examination remains unchanged.

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