

Research Article

The Role of Early Repeat CT Imaging in Traumatic Brain Injury

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Abstract

Background: Routine repeat CT head imaging of trauma patients with Traumatic Brain Injury (TBI) within 24 hours has been a standard of practice. However, the literature does not show the optimal timing of these repeat CT scans to determine need for neurosurgical intervention. The objective of our study is to determine the optimal timing of routine repeat head CTs (CTH) in patients with TBI to assess for progression of injury and determine need for neurosurgical intervention. We hypothesized that patients with a change in Glasgow coma scale (GCS) receiving repeat CTH would show progression and a higher rate of neurosurgical intervention. **Methods:** Retrospective study was performed at a level 2 trauma center and included patients from January 2020 to January 2022. All patients diagnosed with a TBI on initial CTH who did not undergo immediate neurosurgical intervention and underwent a repeat interval CTH were included. Univariate analysis was used to assess patients who underwent intervention vs those who did not to compare the role of early repeat CT imaging. **Results:** 560 patients fulfilled inclusion criteria. 15 patients (2.7%) required neurosurgical intervention after repeat imaging. There was a significantly higher proportion of interval repeat CTH performed early (within 12 hours) in patients ultimately undergoing neurosurgical intervention compared with those that did not (0.80 vs 0.473, $p=0.0165$). The patients taken for intervention after repeat imaging had a significantly higher ISS ($p=0.0001$) and tended to have a lower GCS on admission ($p=0.0573$). **Conclusion:** These findings suggest that there is value in obtaining early repeat CTH (<12 hours) in carefully selected populations that may include more injured patients or patients with a lower admission GCS. However, identification of this high-risk population requires further analysis.

Keywords

Mild Traumatic Brain Injury, Imaging, Head Injury, Repeat Head CT, Injury Severity Score (ISS), Glasgow Coma Scale (GCS)

1. Introduction

Traumatic Brain Injury or TBI is a form of acquired brain injury that occurs with either blunt force or penetrating injury to the brain. TBI has an admission rate to trauma centers at approximately 2.9 million cases each year in the United States, results in about 50,000 deaths annually and about 90,000 cases of lifelong disabilities each year. The estimated cost of

TBI management is about 76.5 billion dollars annually [1].

The leading cause of TBI-related deaths are due to motor vehicle crashes (MVCs), suicides and falls, with the leading cause of non-fatal TBI occurring from falls, MVCs, or blunt force to the head. The impact of TBI can be classified based on type of hemorrhage and its location such as hematoma,

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contusion, intracerebral hemorrhage, subarachnoid hemorrhage, diffuse axonal injury, epidural or subdural hemorrhage [1].

Although there have been improvements in many areas of TBI management, there are still limitations, as data from well-designed, controlled studies on acute management of TBI are sparse. The diagnosis of TBI is a clinical decision, but neuroimaging including CT scans remains essential for guiding management. CT scans are considered the gold standard for assessment of a TBI patient [2]. Routine repeat CT head imaging of trauma patients with TBI within 24 hours has been a standard dogma in practice. This assumes that injury progression occurs within 24 hours [3].

The purpose of our study was to determine the optimal timing of these repeat CT scans to assess for progression of injury, as well as ascertain the necessity for neurosurgical intervention. We hypothesized that patients with moderate to severe TBI with a lower GCS—who are undergoing repeat CT head imaging would demonstrate progression of disease and have a higher rate of neurosurgical intervention.

2. Methods

This IRB-approved study was conducted as a retrospective chart review at a Level 2 trauma center, located in the suburbs of Philadelphia. All patients who presented from January 2020 to January 2022 with a traumatic mechanism and concern for brain injury who underwent neuroimaging were included in this study. This encompassed patients who presented either to the Trauma Bay as a trauma activation or to the Emergency Department with suspected traumatic brain injury. The inclusion criteria were as follows: adult patients (18 years and older), who were diagnosed with TBI on their initial head CT, and who underwent a repeat interval head CT at some point within their hospital stay. We defined TBI as both evidence of mechanism of injury to the head, as well as CT head findings of brain injury. Patients were excluded if they underwent neurosurgical intervention after their initial head CT.

The variables collected for each patient were age, gender, systolic blood pressure on admission, Glasgow Coma Scale (GCS) on admission, and Injury Severity Score (ISS). We also determined whether each patient was on an antiplatelet agent (Aspirin or Plavix) or an anticoagulant (Eliquis, Xarelto, Coumadin, Pradaxa). We also collected details on the type of brain injury suffered by the patients. We compared outcomes between the group of patients who underwent neurosurgical intervention versus those who did not have an intervention after an interval repeat head CT. We calculated the time between the patient's original head CT at presentation and follow up head CT imaging.

Univariate analysis was used to compare the two groups and performed on Microsoft Excel (v16.0, Redmond, WA).

Student t-test was used for comparison of means and Fisher Exact Test was utilized to compare proportions. Statistical significance was set at $p \leq 0.05$.

3. Results

During a two-year timeframe, from January 2020 to January 2022, a total of 758 patients presented with a concern for a brain injury and underwent neuroimaging. 560 patients met inclusion criteria. 15 of these 560 patients required neurosurgical intervention after repeat imaging. Of the 15 patients who underwent neurosurgical intervention, all of them had subdural hematomas and one patient had multicompartiment hemorrhage. Of these patients, two required Bolt placement and 13 underwent craniotomy. Table 1 shows the univariate analysis of our entire study population. The average age of our study population was 64.1. The average GCS on admission was 13.7, along with the systolic blood pressure (SBP) on admission being 149. 152 out of 560 patients were on antiplatelet therapy and 75 out of 560 were on anticoagulation. The average time to repeat head CT for the overall group was 687 minutes.

Table 1. Univariate Analysis of Study Population.

	Entire Group N=560
Average age (years)	64.1 (22.3)
Proportion Female	235 / 560 = 0.42
GCS on Admit	13.7 (2.82)
SBP on Admit (mm hg)	149 (29.4)
ISS on Admit	12.6 (9.08)
Proportion on Antiplatelet	152 / 560 = 0.271
Proportion on Anticoagulation	75 / 560 = 0.134
Proportion of Early CT (≤ 720 min)	270 / 560 = 0.482
Time until repeat CTH (min)	687 (440)

Legend:

GCS = Glasgow Coma Scale

SBP = Systolic Blood Pressure

ISS = Injury Severity Score

CTH – CT head

Univariate analysis was used to assess patients who underwent intervention versus those who did not (Table 2). There was a significantly higher proportion of interval repeat head CTs performed early or within 12 hours in patients ultimately undergoing neurosurgical intervention compared with those who did not.

Table 2. Univariate Analysis of Comparing Intervention vs. No Intervention.

	No intervention (std) N=545	Intervention (std) N=15	P value
Age (years)	64.1 (22.2)	64.8 (24.1)	P=0.904
Proportion Female	231/545=0.424	4/15=0.267	P=0.293 (Fisher Exact)
GCS on Admit	13.7 (2.78)	12.3 (3.75)	P=0.0573
SBP on Admit (mmHg)	149 (29.2)	147 (37.0)	P=0.795
ISS on Admit	12.2 (8.71)	26.5 (11.0)	P=0.0001
Proportion on antiplatelet	148/545=0.272	4/15=0.267	P=1 (Fisher Exact)
Proportion on anticoagulation	74/545=0.136	1/15=0.066	P=0.706 (Fisher Exact)
Proportion of early CT ($\leq$ 720 minutes)	258/545=0.473	12/15=0.80	P=0.0165
Time until repeat CTH (minutes)	691 (445)	585 (267)	P=0.359

Legend:

GCS = Glasgow Coma Scale

SBP = Systolic Blood Pressure

ISS = Injury Severity Score

CTH – CT head

Of the 15 patients taken for intervention after repeat imaging, 80% (12/15) had a CT head within 12 hours of their initial scan versus 47.3% (74/545) in the group who did not undergo intervention ($p=0.0165$). The patients who resulted in undergoing neurosurgical intervention, after repeat imaging, had a significantly higher ISS (26.5 vs. 12.2, $p=0.0001$) and tended to have a lower admission GCS (12.3 vs 13.7, $p=0.0573$). There was not a statistical significance shown between groups in terms of antiplatelet or anticoagulation usage.

4. Discussion

We retrospectively reviewed patients at our institution who were diagnosed with a TBI and underwent neuroimaging upon presentation and had an interval repeat CTH. Our objective was to determine whether there is an optimal time interval for repeat CTH and determine the subset of patients who would benefit from early repeat CT head imaging.

The literature does not identify the optimal timing of repeat head CTs in higher risk patients (i.e. lower GCS, higher ISS) to determine the need for neurosurgical intervention. There have been studies which look at type of injury and dimensions on cross-sectional imaging to determine if there is need for repeat imaging or continued observation of the patient [4]. There is no consensus on how frequent repeat head CT needs to be done [5, 6] or if we even need to do repeat scans within 24 hours [3, 4]. Select studies have concluded that there may be minimal or no benefit from repeated CT scans in patients with mild TBI [7-10] and if they remain stable from a neurologic standpoint, then a repeat scan may be safely delayed as much as up to 48 hours from the initial CT scan [11].

Our study suggests that there is value in obtaining early repeat CT head imaging, within 12 hours of presentation, in carefully selected patient populations with TBI. These patients include severely injured patients with higher anticipated ISS and lower admission GCS. Certain prior papers have found that GCS score along with other clinical parameters can help guide timing of neuroimaging and neurosurgical consultation [12-15]. Of the 15 patients who were taken for neurosurgical intervention, 12 of them had a repeat CTH within 12 hours of their initial scan.

Our study had several limitations which includes a relatively small number of patients over a period of 2 years, a single center retrospective administrative database and a restricted number of patients who underwent neurosurgical intervention. Future studies need to investigate the subset population of patients with severe injuries and a lower GCS score who may require neurosurgical intervention. Further studies could also incorporate the stratification of patient categories into types of brain injuries (i.e. epidural hematoma, subdural hematoma, subarachnoid hemorrhage) in order to establish a targeted time interval for repeat CT scan.

Despite the limitations of this study, our data indicates that there are certain patients who could receive early repeat CTH imaging, and this could be a topic for future multicenter prospective trials.

Abbreviations

TBI	Traumatic Brain Injury
CTH	Computed Tomography Head
GCS	Glasgow Coma Scale
MVCs	Motor Vehicle Collisions

ISS Injury Severity Score
SBP Systolic Blood Pressure

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Author Contributions

Lia Michos: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing

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Olivia Galloway: Methodology, Writing – review & editing

Anirudh Kohli: Conceptualization, Formal Analysis, Investigation, Methodology, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest.

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