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Original Article

A clinical scale to communicate surgical urgency for traumatic brain injury: A preliminary study

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Abstract

Background: While the Glasgow Coma Scale (GCS) provides a tool for evaluating traumatic brain injury (TBI) patients, there is no widely used scale that provides guidance for surgical management. This study introduces a scoring system that physicians potentially could use to determine and communicate the need for surgical decompression in TBI patients. The proposed system is designed to be both comprehensive and easy to use.

Methods: The Surgical Intervention for Traumatic Injury (SITI) scale uses radiographic and clinical findings. Patients were graded based on their GCS: GCS >12 received 0 points, GCS 9-12 received 1 point, and GCS <9 received 2 points. An enlarged unilateral pupil added 2 points. Computed tomography findings were also graded: midline shift <5 mm received 0 points, 5-10 mm received 2 points, and >10 mm received 4 points. The presence of temporal pathology added 1 point, and epidural hematoma (EDH) ≥10 mm added 2 points. Retrospective analysis of 48 patients was then performed using the SITI scale.

Results: Of the 48 patients reviewed, 24 patients underwent craniotomy and the other 24 were treated non-operatively. The mean SITI score was 5.7 (range 3-10) for operative patients and 2.5 (range 1-4) for non-operative patients.

Conclusions: The proposed SITI scale is designed to be a simple, objective system for assisting in communication between clinical services and for suggesting the need for surgical decompression for TBI. Based upon our initial review, a SITI score of 3 or less correlated with non-operative management and a score of 5 or greater correlated with operative management. Given the results of this study, we believe that further development and research of the SITI scale are warranted.

Key Words: Computed tomography, emergency medicine, Glasgow Coma Scale, neurosurgery, traumatic brain injury

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Editorial Comments

This year, 2014, marks the 40th anniversary of the Glasgow coma scale (GCS),[7] which aided in the assessment of comatose patients with traumatic brain injuries (TBI). The GCS has found widespread adoption and been used in thousands of studies to stratify head patients[3] and has furthermore been incorporated into various other scoring systems (e.g. APACHE, TRISS, CRAMS)[2] and has been found useful for prognostication of clinical outcome in various studies.[4]

However, it is rather astonishing that thus far no other reliable scale has been developed aiming to go one step further: At providing a suitable management guideline when encountering such injuries. There is hence a persistent lack of any established standardized assessment tool that allows care providers to communicate the likelihood of the need of any surgical intervention. This could be of considerable importance, for instance, when transferring a TBI patient from a smaller receiving institution to a specialized tertiary care facility or trauma level 1 center and it is especially valuable to have such a scale available for the nonneurosurgical provider.

The current paper by Sribnick and colleagues is therefore a long overdue attempt to introduce a clinically meaningful scoring system (SITI), an acronym for *surgical intervention for traumatic* head *injury*. The author's goal is that "physicians could use such a scale to determine and communicate the need for surgical decompression in TBI patients". The proposed SITI system is designed to be both comprehensive and easy to use, especially for nonneurosurgeons. To this end, the current SITI scale uses basic radiographic aspects obtained by standard computed tomography (CT)-scanning (the existence and degree of midline shift; the presence of temporal pathology or an epidural hematoma) and principal clinical findings (the admission GCS and the possible presence of a dilated pupil), all of which in isolation have proven to be of clinical relevance.

By retrospectively assigning patients of a sizeable cohort with a numeric scoring value, the authors were able to show that low scoring patients did not undergo surgical intervention, whereas high scoring patients had a surgical intervention performed. This retrospective observation is compelling and warrants further prospective study since it could help in appropriate triage decisions, preparation of timely intervention, and allocation of resources to head trauma victims.

Needless to say, any new scoring system needs to stand the proof of time and further prospective proper evaluation and will change and develop over time. The incorporation of further physiological data and interventions will be needed[1,6] and other clinical parameters will modify its applicability (e.g. the presence of anticoagulation, presence of base deficit).[5,8,9] Obviously, any scale that incorporates the GCS or a modified ranking system based on it will carry its intrinsic flaws (such as the question as to use the admission GCS or the postresuscitation GCS but also the known numerical bias toward motor scores) with it. As with the intention of the original GCS, it should be stressed that for clinical use, the patient's clinical status score should better be reported by the three separate components to allow for better validity.[2] But time will tell how one should go about these specific aspects.

We hope that the proposed SITI scale will initially instigate widespread use of it and thus raise attention to the need for further research in this area. May it prove its usefulness and allow the development of it or subsequent tools into a meaningful instrument to effectively communicate the needs of respective patients for better surgical planning and thereby ultimately improve outcome.

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INTRODUCTION

Traumatic brain injury (TBI) remains a major health concern in the United States with an estimated 1.36 million emergency room visits, 275,000 hospital admissions, and 52,000 deaths.[3] Currently, there are no recommended pharmacotherapeutic agents for the treatment of TBI, and recommendations regarding the medical treatment of TBI lack class 1 evidence.[1] There is experimental evidence that early surgical intervention may improve the functional outcome in TBI.[9]

While the Glasgow Coma Scale (GCS) provides a reproducible and convenient way of quickly assessing the level of consciousness in TBI patients,[8] the GCS score alone does not provide enough information to guide surgical decision making.[2] The decision to perform craniotomy for the treatment of TBI is multi-factorial, incorporating both clinical and radiographic findings.[2] Therefore, a scoring system designed to describe a patient's need for surgery should also incorporate this information. We propose a scoring system called the Surgical Intervention for Traumatic Injury (SITI) scale and provide a retrospective analysis of TBI patients to demonstrate its possible utility in communicating the need for surgical intervention.

METHODS

Patient data

This is a retrospective study evaluating the possible utility of the SITI scale. Patient data was gathered from a TBI database of neurosurgery patients at Grady Memorial Hospital (Atlanta, GA), a Level 1 trauma center. Patients included in this study were admitted from March 2012 to October 2012. All patients were originally evaluated by the Emergency Department and found to have a TBI possibly requiring neurosurgical intervention, prompting a neurosurgical consultation. Clinical exam data was gathered from the electronic medical record and radiographic data was obtained from the picture archiving and communication system (PACS). This research was approved by the Internal Review Board at Emory University. Patient treatment (i.e. operative versus non-operative intervention) was at the discretion of the attending neurosurgeon.

SITI scale

The SITI scale was designed to provide a numeric score to the initial assessment that clinicians perform on TBI patients, and both physical exam findings and radiographic findings were incorporated to create the scoring system. The SITI scale was designed based on previously published surgical guidelines[2] and prior clinical experience. The patient's GCS score was assessed and points were added according to the following algorithm: GCS >12 received 0 points, GCS 9-12 received 1 point, and GCS <9 received 2 points. In addition, an enlarged unilateral pupil added 2 points.

Several pathologic findings on non-contrast head computed tomography (CT) can add to the SITI score. Midline shift at the septum pellucidum was measured and given a score based on severity: 0 points for midline shift <5 mm, 2 points for midline shift measuring 5-10 mm, and 4 points for midline shift >10 mm. In addition, pathology of the temporal lobe was given 1 point, and epidural hematoma (EDH) ≥ 10 mm was given 2 points [Table 1]. Temporal pathology was defined as either hemorrhage or edema noted in the temporal lobe on the head CT report.

After obtaining the clinical exam data and radiographic data, this information was applied to the SITI scale, and the score for each patient was determined. As the authors intend to use the SITI scale as a clinical tool for initial evaluation of a trauma patient, all data used to determine the SITI score were based on the patient's initial presentation. Patients were divided based on whether they ultimately required a craniotomy, and the operative and non-operative groups were compared.

Statistical analysis

Clinical findings and the SITI scores of operative and non-operative patients were compared using Student's *t*-test (IBM SPSS Statistics Package Version 19.0, Armonk, NY, USA). For binary variables, Fisher's exact test was used. Multivariate analysis was also conducted using a logistic regression analysis to examine simultaneously the associations between the SITI features and the neurosurgeon's decision to operate. Statistical significance was defined as $P < 0.05$.

RESULTS

Calculation of the SITI score involved evaluation of the neurological exam and non-contrast head CT. For example, a 26-year-old female was brought to the Grady Memorial Hospital Emergency Department by Emergency Medical Services [Figure 1a-c]. On initial

Table 1: Components of the SITI score

Feature	Finding	Points
GCS	>12	0
	9-12	1
	<9	2
Eyes (Unilateral Enlarged Pupil)	Yes	2
	No	0
Head CT (Midline shift)	<5 mm	0
	5-10 mm	2
	>10 mm	4
Temporal blood	Yes	1
	No	0
Epidural hematoma (≥10 mm)	Yes	2
	No	0

SITI: Surgical intervention for traumatic injury, CT: Computed tomography evaluation, her history indicated that she was intoxicated and had a fall from the roof of a moving car. Her initial GCS was 8: she opened her eyes to painful stimuli, made incomprehensible sounds, and withdrew to painful stimuli. She was intubated prior to head CT and had a GCS of 6 at the time of neurosurgical consultation. The patient had no evidence of unilateral enlarged pupil on exam. Her initial head CT revealed a subdural hematoma with 9 mm of resultant midline shift and subdural hematoma extended over the temporal lobe [Figure 1a-c]. Following initial evaluation by the neurosurgery service, the patient was taken for an emergent left hemicraniectomy. On retrospective analysis of this case, the patient's SITI score was calculated to be 5 (GCS contributed 2 points, midline shift contributed 2 points, and blood near the temporal lobe contributed 1 point).

An example of a non-operative patient reviewed using the SITI scale is a 23-year-old female who was brought by Emergency Medical Services to Grady Memorial Hospital. She was a restrained passenger involved in a motor vehicular collision with a semi-trailer truck. On initial evaluation, she was found to have a GCS of 8T: she opened her eyes to painful stimuli, was intubated, and localized to painful stimuli bilaterally. Her pupils were equal and reactive bilaterally. Her initial head CT revealed a thin subdural hematoma over the left frontal convexity [Figure 1d–f]. There was no evidence of midline shift or pathology at the temporal lobes. On retrospective analysis of this case, the patient's SITI score was calculated to be 2 (GCS contributed 2 points).

Medical charts and imaging from 48 patients were retrospectively reviewed to determine SITI scores [Table 2]. Of those patients, 24 were taken for an emergent neurosurgical procedure (operative group) and the other 24 were not (non-operative group). The mean age of patients was similar in the two groups: 39.6 years in the non-operative group and 45.9 years in the operative group ($P = 0.23$). The gender composition of the two groups was also similar with 83% in the non-operative group being male, as compared to 79% in the operative group ($P = 0.77$). The percentage of patients intubated was 54% in the non-operative group and 58% in the operative group ($P = 0.72$).

The admission GCS score of the non-operative group was 10.7, as compared to 9 in the operative group ($P = 0.093$). None of the patients in the non-operative group demonstrated an enlarged unilateral pupil on exam, while 25% of patients in the operative group had a unilateral enlarged pupil ($P = 0.02$). Patients in the non-operative group had a mean 0.25 mm of midline shift on initial

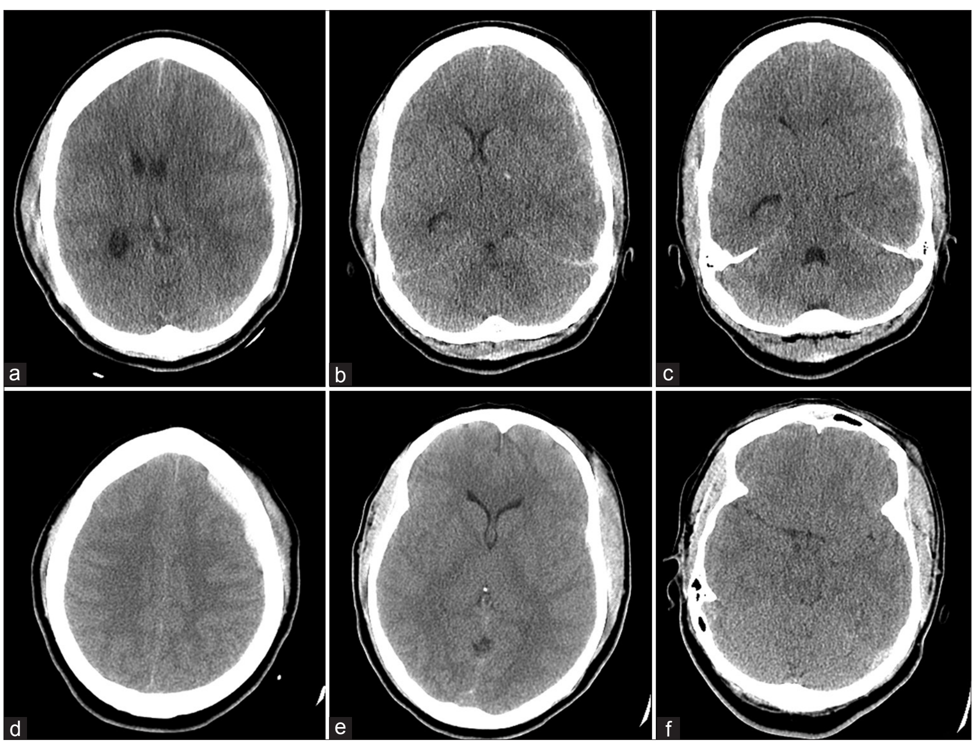

Figure 1: (a-c) Representative sections of a head CT from an operative patient. A 26-year-old female who fell from a car demonstrates findings of left subdural hematoma above the level of foramen of Monro (a). At the level of foramen of Monro (b), there is 9 mm of left to right shift, as measured by displacement of the septum pellucidum. Below the level of foramen of Monro (c), subdural hematoma extends lateral to the temporal lobe. (d-f) Representative sections of a head CT from a non-operative patient. A 23-year-old female involved in a motor vehicular collision demonstrates a thin, left-sided subdural hematoma above the level of foramen of Monro (d). At the level of foramen of Monro (e), there is no midline shift of the septum pellucidum. Below the level of foramen of Monro (f), no temporal lobe pathology is noted

head CT, while patients in the operative group had 7.4 mm of midline shift ($P < 0.001$). Temporal lobe pathology was noted in 62.5% of patients in the non-operative group and 67% of patients in the operative group ($P = 0.73$). The mean SITI score for non-operative patients was 1.75 (range 0-3; 95% confidence interval 1.39-2.11), and the mean SITI score for operative patients was 4.875 (range 2-9; 95% confidence interval 4.15-5.60). There was a significant difference noted between SITI scores of the non-operative and operative groups ($P < 0.001$). There was cross-over between the groups: five patients from the non-operative group were determined to have a SITI score of 3, and from the operative group, one patient had a SITI score of 2 and two patients had a score of 3.

Logistic regression analysis on factors associated with the neurosurgeon's decision to operate indicated that the odds ratios associated with each unit increase in three of the SITI components (GCS, midline shift, and epidural hematoma) were approximately equal, suggesting a correlation between a higher score on the SITI scale and need for surgery [Table 3]. For two of the SITI components, enlarged pupil and midline shift, the odds ratios were not estimable owing to separation of the sample space; however, P values were available by performing exact Chi-square tests. All P values were 0.06 or less, suggesting that all SITI components provided significant contributions to the overall model fit; an exception was the presence of temporal blood, which did not significantly correlate with the need for surgery by itself. But in further analysis, its exclusion from the logistic regression model would have resulted in large changes in the estimated odds ratios of the other SITI features, suggesting that temporal blood may ultimately be an important variable to include in the model (results not shown).

Table 2: Patient characteristics

	Non-operative	Operative
n	24	24
Mean age	39.6	45.9
Female*	4 (17)	5 (21)
Male*	20 (83)	19 (79)
Intubated*	13 (54)	14 (58)
Mean GCS	10.7	9
Enlarged pupil*†	0 (0)	6 (25)
Mean midline shift (mm)‡	0.25	7.7
Temporal lobe pathology*	15 (62.5)	16 (67)
SITI score		
Min.	0	2
Max.	3	9
Mean	1.75	4.875

*Parentheses indicate percentage of total. †Indicates difference between the non-operative and operative groups is $P<0.05$. ‡Indicates difference between the non-operative and operative groups is $P<0.001$

Table 3: Results of logistic regression analysis on features that correlated with need for surgery*

	Odds ratio	*P* value
GCS	2.33	0.06
Enlarged pupil†	N/A	0.02
Midline shift†	N/A	<0.001
Temporal blood	2.54	0.20
Epidural hematoma	2.64	0.03

*The features were entered into the model using the SITI scale shown in Table 1. †Odds ratios for two features were not estimable owing to complete separation of the sample space: Enlarged pupil, 6/24 in surgical group and 0/24 in non-surgical group; midline shift ≥5 mm, 17/24 in surgical group and 0/24 in non-surgical group. For these two features, an exact Chi-square test is reported

DISCUSSION

This retrospective analysis of prior TBI patients with application of the SITI scale demonstrates a statistically significant difference in the SITI score between the operative group and the non-operative group. Because this study was retrospective, the presented data cannot validate this scale for use, but instead suggest that a higher SITI score may correlate with a patient's need for surgical intervention. While a neurosurgeon's discretion is the final arbiter regarding surgery for TBI, retrospective application of the SITI scoring system suggests that patients with a SITI score of 0-1 correlate with non-operative treatment and patients with a SITI score of 4 or above correlate with a need for operative intervention. Cross-over between the groups was seen with SITI scores of 2 or 3.

Application of the proposed SITI scoring system should not be difficult as the clinical findings (GCS and pupillary light reaction) are examined in all TBI patients. The radiographic findings (midline shift, temporal pathology, presence of an epidural hematoma) could be quickly interpreted by a radiologist or other clinician who is familiar with head CT scans. The measurement of midline shift is easily quantified and, in other studies, has demonstrated little interobserver variability.[5]

A similar scale for grading surgical need in traumatic cervical spinal injury has been introduced,[10] and the benefit of this type of scoring system is that it allows for easier communication of urgency regarding a surgical consultation. While the creation of another grading scale may be met with some resistance, the possible benefits of such a scale might include facilitating communication between emergency department personnel and their neurosurgical colleagues. In the past, system changes that have allowed for improved communication regarding TBI patients have been shown to improve patient outcome and the efficiency of healthcare delivery.[6] The ability to triage patients quickly and appropriately to a necessary level of care was one of the early recognized benefits of the GCS on neurotrauma;[4] we believe that the SITI scale may ultimately provide a similar benefit by more quickly alerting neurosurgeons of the patients who will likely need emergent craniotomy. Finally, use of the SITI scale for assessing neurotrauma patients for surgery could also potentially facilitate research by providing a standard method for evaluation and a numeric output for data analysis.[7]

There are several limitations to this study, including the limited number of patients and the use of retrospective analysis. Future work will involve the use of a prospective study of the SITI scale in order to validate its utility as a predictive tool and will focus on refining the criteria used to determine the SITI score.

We have described a simple method for grading neurotrauma patients and their potential need for emergent craniotomy. We believe that the creation and use of a scoring system to signify a patient's clinical and radiographic findings will allow for easier communication between emergency care personnel and their neurosurgical colleagues. Given the results of this study, we believe that further research and design of the SITI scale are warranted. Future studies examining the SITI scale will likely be both prospective and multi-institutional.

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