Biomedical Sciences and Clinical Medicine 2022;61(4):172-8.
doi:10.12982/BSCM.2022.23
https://www.med.cmu.ac.th/bscm/

BSCM

Original Article Open Access

Factors Associated with Intra-abdominal Injury in Patients with Severe Traumatic Brain Injury

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Received: May 30, 2022;
Revised: July 8, 2022;
Accepted: September 5, 2022

ABSTRACT

OBJECTIVE To identify factors associated with intra-abdominal injuries in patients with severe traumatic brain injury (TBI) to increase the probability of identifying those injuries.

METHODS After receiving Institutional Review Board approval, we conducted this retrospective study at Maharaj Nakorn Chiang Mai Hospital, a level-1 trauma center and university hospital. The records of all patients with severe TBI (Glasgow Coma Scale Score: GCS < 9) who visited the Emergency Department (ED) between July 2015 and September 2016 were included and reviewed. Factors found to be statistically significantly associated with intra-abdominal injury based on univariate analysis were analyzed using multivariate analysis. All data analyses was performed using SPSS software version 22.0.

RESULTS Of the total of 194 patients who underwent routine abdominal CT scans following the institutional protocol, 23 had intra-abdominal injuries (11.86%). Factors found to be associated with positive abdominal CT scans, i.e., scans showing intra-abdominal injuries, using univariate logistic regression analysis include diastolic blood pressure (DBP), mean arterial pressure (MAP), low GCS (3-5), Shock Index ≥ 0.9, Focused Assessment with Sonography for Trauma (FAST) positive or signs of peritonitis, thoracic injury, and pelvic injuries ($p < 0.05$). Factors statistically significantly associated with intra-abdominal injury in multivariate logistic regression were GCS 3-5, FAST positive or signs of peritonitis, thoracic injury, and pelvic injuries.

CONCLUSIONS A routine abdominal CT scan in severe TBI patients can help detect injuries, even in patients with no significant abnormal physical examination and a negative FAST. Four factors associated with positive routine abdominal CT scans are GCS 3-5, positive FAST or signs of peritonitis, thoracic injury, and pelvic injury. A routine abdominal CT scan, however, does take additional time and adds more processes to the management of a trauma patient. A future cost-effective study of this issue is warranted.

KEYWORDS severe TBI, intra-abdominal injury, abdominal CT scan

INTRODUCTION

Traumatic brain injury (TBI) is one of the major health issues globally, with an increasing incidence each year (1,2). Sixty-nine million individuals worldwide are estimated to sustain a TBI yearly, especially in low-and middle-income countries. The proportion of TBIs resulting from road traffic collisions was greatest in Africa and Southeast Asia (both 56%) and lowest in North America (25%) (1). In Thailand, accidents are the second most common cause of death and disability (3). The severity of TBIs are classified into three levels according to the Glasgow Coma Scale Score (GCS score): mild, moderate, and severe.

Medical care in major trauma patients usually requires a physician's high clinical skills, prompt management, and timely evaluation. Delayed diagnosis of occult injuries requiring surgical intervention may lead to late complications and unfavorable outcomes, resulting in an increased mortality rate. Commonly delayed diagnoses usually involve thoracic, intra-abdominal, and pelvic injuries, especially in severe TBI patients (4).

Although the combination of TBI and intra-abdominal injuries is rare, (5) previous studies have shown that trauma patients with severe TBI (GCS score < 9) were significantly associated with a higher Shock Index and a higher incidence of intra-abdominal injuries (6). The Shock Index (SI) is a hemorrhage indicator. The Shock Index shows the risk of major bleeding, with the most frequently suggested cut-off point at 0.9 (7). In the last few decades, routine initial abdominal computed tomography (CT) scans have been used to detect most injuries, especially missed and delayed diagnoses in patients with TBI. A study showed that a routine initial abdominal CT to detect injuries would likely be negative findings in the absence of evidence of bodily injury (8).

A study in the pediatric population using clinical prediction rules such as abnormal physical findings on the chest wall or abdomen, abdominal pain, and decreased breath sound, reported that CT scans tend to have a higher sensitivity than the physician's decision itself (9). Routine initial abdominal CT is currently used in many institutes although it has not shown a clear benefit and may not be cost-effective. This study was conducted to identify factors associated with intra-abdominal injuries in patients with severe TBI that could help predict the possibility of intra-abdominal injuries and help physicians decide when to perform abdominal CT scans.

METHODS

Study design and setting

This study was conducted retrospectively at Maharaj Nakorn Chiang Mai Hospital, a level-1 trauma center and university hospital with approximately 30,000 Emergency Department (ED) visits annually after receiving approval from the Research Ethics Committee, Faculty of Medicine, Chiang Mai University (Certificate number: 483/2559).

Population

All patients with severe TBI (GCS < 9) who visited the ED of Maharaj Nakorn Chiang Mai Hospital between July 2015 and September 2016 were included in this study. The exclusion criteria included: (1) patients who did not undergo routine abdominal CT scans within the first 24 hours after presenting to the ED, (2) patients with unstable vitals, and (3) patients with penetrating head injuries.

Data collection

This retrospective study aimed to identify factors associated with a positive event, i.e., intra-abdominal injuries. We collected data from the hospital records, including age, sex, mechanism of injury, physical examination findings, Focused Assessment with Sonography for Trauma (FAST) results, chest and pelvic radiograph results, and abdominal CT scan findings.

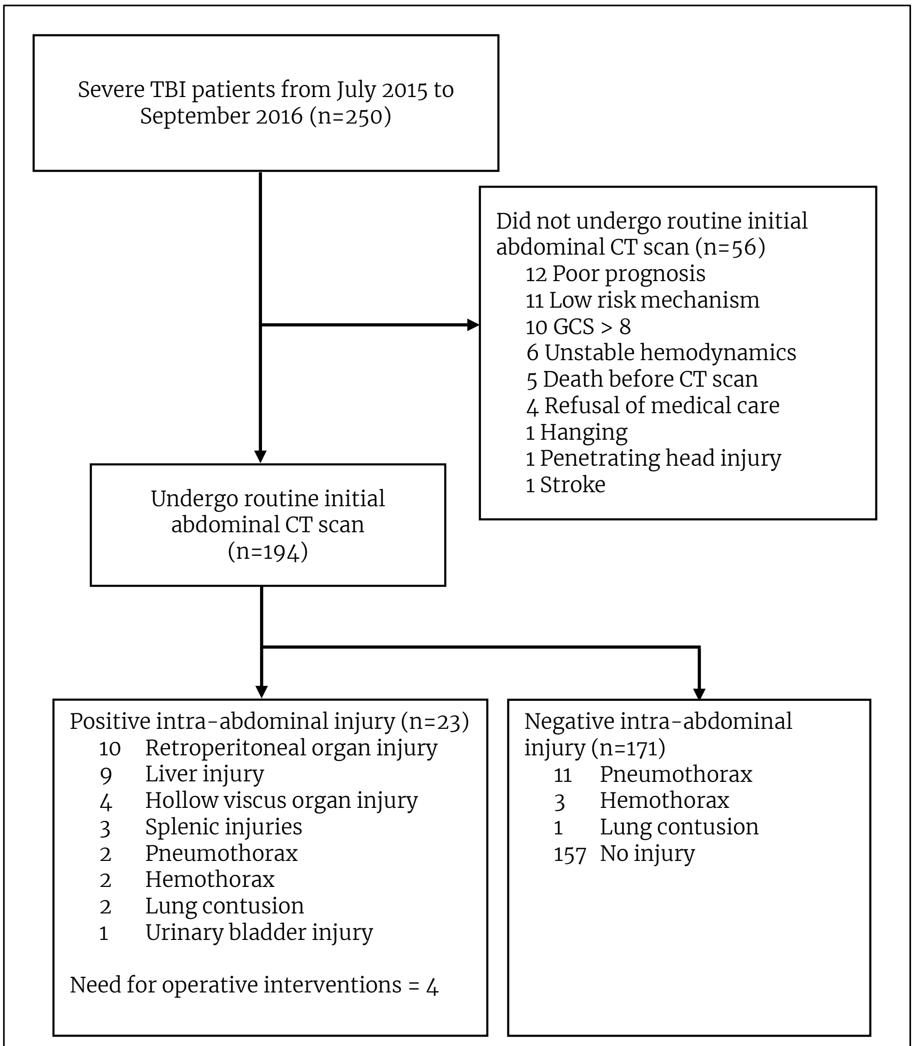
Statistical analysis

The sample size calculation formula for logistic regression analysis was 5-10 cases for each independent factor. With thirteen independent factors, the sample size was 65-130 cases (10). Statistical analysis was conducted for continuous data which is reported as percent, mean, median, SD, and interquartile range. For categorical data, the chi-square test or Fisher's exact test were used for between groups analysis. Factors that had statistical significance in the univariate analysis ($p < 0.05$) were further analyzed using multivariate analysis and forward LR binary logistic regression. Results with $p < 0.05$ were considered statistically significant. All data analysis calculations were done using SPSS software version 22.0.

RESULTS

During the study period, 250 patients with severe TBI were seen by the Emergency Department. One hundred ninety-four (77.6%) of those patients underwent routine abdominal CT scans following the institutional protocol (Figure 1). The median age was 29 and 161 were male (83.0%). There were 11 pediatric patients, the youngest being two years old. The most frequent mechanism of injury was traffic injury (165 cases, 85.1%). Of the patients who underwent abdominal CT scans, 23 were found to have intra-abdominal injuries (11.9%). The baseline characteristics of the included participants are shown in Table 1. Patients in the CT-positive group (those with intra-abdominal injuries) had a lower diastolic blood pressure and lower GCS. The number of patients with a Shock Index ≥ 0.9, thoracic injury (abnormal physical examination of thorax or chest x-ray (CXR)), FAST positive or with signs of peritonitis, and those with pelvic injury (abnormal physical examination of the pelvis or of the pelvic film) was also higher in the CT positive group. Median systolic blood pressure (SBP), mean arterial pressure (MAP), and heart rate were not statistically different between the groups.

In the positive routine abdominal CT group, 13 of 23 patients had solid organ injuries, 10 had retroperitoneal organ injuries, and 4 had



CT scan, computed tomography; GSC, Glasgow Coma Scale

Figure 1. Study flow

Table 1. Baseline characteristic

	All (N=194)	Abdominal CT scan positive (N=23)	Abdominal CT scan negative (N=171)	*p*-value
Male - N (%)	161 (82.99)	17 (10.56)	144 (89.44)	0.238*
Female - N (%)	33 (17.01)	6 (18.18)	27 (81.82)	
Age (year) - median (IQR)	29 (20,46)	35 (20,44)	28 (20,47)	0.376§
Mechanism of injury - N (%)				
Traffic injury	165 (85.05)	20 (12.12)	145 (87.88)	0.516*
Fall from significant height	3 (1.55)	1 (33.33)	2 (76.67)	
Physical assault or simple fall	21 (10.82)	2 (9.52)	19 (90.48)	
Unknown	5 (2.58)	0 (0)	5 (100)	
Physical examination finding				
SBP	136.94±24.61	131.48±39.27	137.67±21.99	0.466†
DBP	83.46±17.80	75.13±21.05	84.58±17.08	0.016†
MAP	101.29±18.17	93.91±24.66	102.28±16.96	0.127†
HR	100.23±24.32	105.30±20.33	99.55±24.78	0.288†
GCS - median (IQR)	7 (5,7)	4 (3,7)	7 (6,7)	0.017§
3 to 5 - N (%)	52 (26.80)	13 (25.00)	39 (75.00)	0.01‡
6 to 8 - N (%)	142 (73.20)	10 (7.04)	132 (92.96)	
Shock index				0.051*
< 0.9 - N (%)	157 (80.93)	15 (9.55)	142 (90.45)	
≥ 0.9 - N (%)	37 (19.07)	8 (21.62)	29 (78.38)	
Abdominal wall injury - N (%)				0.305*
- Positive	22 (11.34)	4 (18.18)	18 (81.82)	
- Negative	172 (88.66)	19 (11.05)	153 (88.95)	
Extremities injury - N (%)				0.238*
- Positive	33 (17.01)	6 (18.18)	27 (81.82)	
- Negative	161 (82.99)	17 (10.56)	144 (89.44)	
FAST or signs of peritonitis - N (%)				0.002*
- Positive	6 (3.09)	4 (66.67)	2 (33.33)	
- Negative	188 (96.91)	19 (10.11)	169 (89.89)	
Thoracic injury‖ - N (%)				0.005*
- Positive	47 (24.23)	11 (23.40)	36 (76.60)	
- Negative	147 (75.77)	12 (8.16)	135 (91.84)	
Pelvic injury¶ - N (%)				0.055*
- Positive	8 (4.12)	3 (37.50)	5 (62.50)	
- Negative	186 (95.88)	20 (10.75)	166 (89.25)	
PE or plain radiograph or FAST				< 0.001‡
- Positive	86 (44.33)	18 (20.93)	68 (79.07)	
- All negative	108 (55.67)	5 (4.63)	103 (95.37)	

*Fisher's Exact Test; †Independent t-test; ‡Pearson Chi-Square; §Mann Whitney U test,
‖Thoracic injury, abnormal physical examination of thorax or CXR; ¶Pelvic injury, abnormal physical examination of pelvis or pelvic film; N, numbers of patients; IQR, Interquartile range; CT, computed tomography; SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; HR, heart rate; GCS, Glasgow Coma Scale; CXR, chest xray; PE, physical examination; FAST, focused assessment with sonography for trauma

hollow viscous organ injuries. Only 4 of 23 required operative interventions, and they also had thoracic and urinary bladder injuries which received conservative treatment (details in supplementary data). Five patients out of 108 (4.6%) had a negative abnormal physical examination with a normal radiograph, including FAST examination, with positive abdominal CT findings; none of these patients required surgical intervention.

In the statistical analysis of factors associated with positive abdominal CT scans using univariate logistic regression analysis, the DBP, MAP, Low GCS at 3-5, Shock Index ≥ 0.9, FAST positive or signs of peritonitis, thoracic injury, and pelvic injury were statistically significant ($p < 0.05$). We analyzed the data further using multivariate logistic regression analysis and found that only GCS 3 to 5 (adjusted OR [95% CI] = 3.72 [1.36 -10.17]), FAST positive or with signs of peritonitis (adjusted OR [95% CI]= 9.37 [1.37 -64.10]), thoracic injury (adjusted OR [95% CI]= 3.50 [1.24 -9.85]), and pelvic injury (adjusted OR [95% CI]= 8.32 [1.60 -43.30]) were statistically significantly higher in the positive CT scans group.

DISCUSSION

In this study, we reviewed the positive abdominal CT scan results in patients with severe TBI. We found that 11.86% had positive intra-abdominal injuries, higher than in a previous study which reported only 2.6% with the same mechanism of injury (11). Interestingly, many patients with positive CT scans did not have an abnormal physical examination and had no signs of peritonitis. The negative FAST examination cannot absolutely exclude intra-abdominal injuries. FAST can only detect intraperitoneal free fluid and can miss retroperitoneal organ injuries as recognition of these injuries depends on the operator's experience in detecting these abnormalities. Using multivariable logistic regression analysis, only three factors were found to be associated with positive routine abdominal CT scans: GCS 3-5, positive FAST or signs of peritonitis, and pelvic injury. Patients with low GCS, who were unresponsive to verbal stimuli and who did not cooperate well with the physical examination, suggested the presence of a higher injury mechanism. In our study, patients with a lower GCS (3-5) had a significantly higher risk of a positive abdominal CT scans than those with a higher GCS (6-8) (p = 0.01), similar to a previous study by Yanagawa et al. (6). Positive FAST examination or signs of peritonitis were also associated with intra-abdominal injuries. These findings highlight the significance of a thorough physical examination to look for signs of peritonitis (presence of guarding or rigidity on physical examination), indicating intra-abdominal injuries, especially in hollow viscous organ injuries. Furthermore, a negative FAST examination and the absence of signs of peritonitis do not exclude intra-abdominal organ injuries. Some patients had positive abdominal CT results but had negative signs of peritonitis or a negative FAST examination (10.11%). FAST accuracy may depend on the operator's experience in performing the examination, so it is possible that hollow viscous organ and retroperitoneal organ injuries might be missed in some cases. Even with experienced operators, many studies have reported false-negative FAST results (12,13).

The presence of a thoracic injury is another factor that increases the chance of abnormal abdominal CT scan findings (adjusted OR [95% CI] = 3.50 [1.24 -9.85]). These may be due to these anatomical areas involving the thorax and abdomen as thoracoabdominal regions. Both in physical examination findings and with abnormal pelvic plain film, pelvic injuries are also associated with positive abdominal intra-abdominal CT scans because this type of injury is an indication of a high-energy impact. Our study found a significantly higher incidence of positive abdominal CT scans if a pelvic injury was present (adjusted OR [95% CI] = 8.32 [1.60 -43.30].

Another factor we studied is the association between a higher Shock Index and severe TBI with the presence of intra-abdominal injuries. A study conducted by Yanagawa et al. (6) reported a significantly higher Shock Index with severe TBI than with moderate TBI. In our study, univariable analysis of the Shock Index showed a p-value of 0.047. However, the Shock Index was found not to be statistically significantly correlated with positive abdominal CT scans in our further multivariable analysis, which may be a result of relatively low Shock Index in our population (80.9% had a Shock Index <0.9).

Interestingly, five patients out of 108 (4.6%) had a negative abnormal physical examination with normal radiographs and FAST examination but still had positive abdominal CT findings. None of these patients, however, required surgical intervention.

Limitations

This study was a single-center study in a level one trauma center in which routine abdominal CT scans could be performed in all severe TBI patients. Without a prepared protocol, it may not represent all the severe TBI patients in other settings. Although univariable analysis showed that the Shock Index tends to be a statistically significant indicator of positive abdominal CT scans, the association was not statistically significant when analyzed further using multivariable analysis, a finding which may be the result of the relatively lower Shock Index in our population. One of the factors we investigated to find associations with positive abdominal CT scans is the mechanism of injury. However, eleven severe TBI patients did not undergo routine abdominal CT scans as prescribed in the hospital protocol because the attending physicians did not request scans as they thought the mechanism of injury was minor. That deviation from the hospital protocol might have resulted in selection bias and may have affected the outcomes of this study. Additionally, the 194 patients included in this study was a relatively small sample. Further study with larger populations could help to detect more of the factors associated with intra-abdominal injury we set out to find. Finally, we cannot infer a cause-effect relationship based on this study design. Further research using prospective pre-specified factors is needed to address this issue.

CONCLUSIONS

A routine abdominal CT scan in severe TBI patients is beneficial as it helps detect injuries even in patients with no significant abnormal physical examination and with a negative FAST. Four factors associated with positive routine abdominal CT scans are GCS 3-5, positive FAST or signs of peritonitis, thoracic injury, and pelvic injury. However, a routine abdominal CT scan requires more time and adds more processes to the management of the trauma patient. A future cost-effectiveness study concerning this issue is warranted.

ACKNOWLEDGMENTS

We would like to thank Maharaj Nakorn Chiang Mai Hospital for providing essential medical data.

FUNDING

No funding was received.

CONFLICTS OF INTEREST

This research study had no commercial sponsorship, and no authors have commercial conflicts of interest with respect to its content.

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