



## Original Article

## Clinical value of bedside abdominal sonography performed by certified sonographer in emergency evaluation of blunt abdominal trauma

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## ABSTRACT

**Purpose:** To investigate the accuracy and efficiency of bedside ultrasonography application performed by certified sonographer in emergency patients with blunt abdominal trauma.**Methods:** The study was carried out from 2017 to 2019. Findings in operations or on computed tomography (CT) were used as references to evaluate the accuracy of bedside abdominal ultrasonography. The time needed for bedside abdominal ultrasonography or CT examination was collected separately to evaluate the efficiency of bedside abdominal ultrasonography application.**Results:** Bedside abdominal ultrasonography was performed in 106 patients with blunt abdominal trauma, of which 71 critical patients received surgery. The overall diagnostic accordance rate was 88.68%. The diagnostic accordance rate for liver injury, spleen injury, kidney injury, gut perforation, retroperitoneal hematoma and multiple abdominal organ injury were 100%, 94.73%, 94.12%, 20.00%, 100% and 81.48%, respectively. Among the 71 critical patients, the diagnostic accordance rate was 94.37%, in which the diagnostic accordance rate for liver injury, spleen injury, kidney injury, gut perforation and multiple abdominal organ injury were 100%, 100%, 100%, 20.00% and 100%. The mean time for imaging examination of bedside abdominal ultrasonography was longer than that for CT scan ( $4.45 \pm 1.63$  vs.  $2.38 \pm 1.19$ ) min; however, the mean waiting time before examination ( $7.37 \pm 2.01$  vs.  $16.42 \pm 6.37$ ) min, the time to make a diagnostic report ( $6.42 \pm 3.35$  vs.  $36.26 \pm 13.33$ ) min, and the overall time ( $17.24 \pm 2.33$  vs.  $55.06 \pm 6.96$ ) min were shorter for bedside abdominal ultrasonography than for CT scan. **Conclusion:** Bedside ultrasonography application provides both efficiency and reliability for the assessment of blunt abdominal trauma. Especially for patients with free peritoneal effusion and critical patients, bedside ultrasonography has been proved obvious advantageous. However, for negative bedside ultrasonography patients with blunt abdominal trauma, we recommend further abdominal CT scan or serial ultrasonography scans subsequently.© 2020 Production and hosting by Elsevier B.V. on behalf of Chinese Medical Association. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

## Introduction

A rapid and reliable assessment for severely injured patients is pivotal prior to treatment. Abdominal trauma patients are common in the resuscitation room, of which the overall mortality rate is 8%–25%. The time lasted for assessment of trauma is related to patient's prognosis. In a subtype of abdominal trauma, a diagnostic delay of 5 h even results in an increased risk of death.<sup>1</sup> However, it is still a

gordian-knot for emergency physicians to reach a quick and accurate detection of blunt abdominal trauma. Early reports using whole-body computed tomography can reduce the overall mortality rates in severely injured patients.<sup>2</sup> Although computed tomography (CT) scan has high specificity for detection of abdominal injury, it is an expensive tool in rural area. In addition, CT scan requires transfer of patients from the resuscitation room to the radiology room, which is risky and not suitable especially for critical patients with unstable-hemodynamic condition or those need surgical intervention.<sup>3</sup> On the other hand, the Focused Assessment with Sonography in Trauma (FAST) is an inexpensive and non-invasive examination method, which can be performed in the resuscitation room and hence obviates the possible risk deriving

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from patients' transfer. Therefore it is firstly recommended precede the use of CT by the Advanced Trauma Life Support guidelines.<sup>4</sup>

However, FAST scan has its own limitations, one of which is that it is operator dependent. In trauma center with defined emergency residency programs, the FAST examination is performed by emergency physicians. The accuracy of FAST performed by emergency physicians raised concern. Recently Akoglu et al<sup>5</sup> reported that the sensitivity of FAST is relatively untrustworthy to exclude thoracoabdominal trauma when performed by emergency physicians. On the contrary, some other trauma centers invite certified sonographer to perform bedside abdominal ultrasonography. They are considered to be more accurate and time saving than emergency physicians owing to their expertise and experience. The purpose of this study was to evaluate the diagnostic accuracy and efficiency of the bedside abdominal ultrasonography performed by certified sonographer, with the results of surgery or CT scan as a gold standard.

## Methods

### Study design

The medical records of consecutive blunt abdominal trauma patients admitted to emergency room of Xinqiao Hospital between May 2017 and September 2019 were collected retrospectively. Data including the mechanism of abdominal injury, ultrasound diagnosis, CT imaging, and clinical management were analyzed.

### Procedure

All bedside sonographic examinations were performed by certified sonographer with more than 3 years of experience and at least 700 bedside ultrasound performances per year. The bedside abdominal ultrasonography was performed before the abdominal trauma patients transferred to CT room. VINNO 8 or SONOSCAPE S9 with 3.5–6 MHz abdominal probes was used for bedside abdominal ultrasonography (VINNO 8, Vinno Inc, Suzhou, China; SONOSCAPE S9, Sonoscape Inc., Shenzhen, China). The principle of bedside abdominal ultrasonography scans is to assess the presence/absence of any amount of free fluid that mostly is blood from broken organs. Ultrasound was used to check the signs of effusion in the abdominal

cavity, in other words, whether there was fluid in seven abdominal areas: right upper abdomen, left upper abdomen, pelvic cavity, bilateral paracolic sulcus and bilateral renal fossae. The following signs are detected to confirm whether the contour line of the substantial abdominal organs is continuous; whether the capsule is interrupted; whether the cavity organs have segmental thickening and expansion; whether there is abnormal echo in substantive organs; whether the respiratory movement of abdominal organs in both sides is consistent; and whether the parts inspected by the probe have tenderness and rebound pain. The time spent on the examination of bedside abdominal ultrasonography or CT was recorded. All CT results were evaluated by radiologists who were unknown to the patients' condition as well as the results of the sonographic examinations. The findings of the bedside abdominal ultrasonography were compared with those of either CT or surgery, in which laparotomy findings are preferred if surgery is performed.

### Statistical analysis

All data were analyzed with Graphpad Prism 7.0 statistical software. Dichotomous data were analyzed by  $\chi^2$  analysis with Yates's correction; continuous data were analyzed by Student's *t*-test. Any values of  $p < 0.05$  were considered statistically significant.

## Results

Totally 106 patients consisting of 75 males and 31 females with suspected blunt abdominal trauma were included, whose age ranged from 18 to 72 years with the mean age of  $(34.56 \pm 18.43)$  years. As for the mechanism of injury, 51.89% of the cases were due to road traffic accidents, 35.85% due to fall (Table 1).

### Accuracy of bedside abdominal ultrasonography

All patients underwent a bedside abdominal ultrasonography scan and a CT scan. Exploratory laparotomy (ELAP) was performed in 66.98% patients. As shown in Table 2, liver injury was observed in 14.15% cases, spleen injury in 35.85% cases, kidney injury in 16.04% cases, and multiple organ injury in 25.47% cases. The correct rate of bedside abdominal ultrasonography scan was 88.68% confirmed by CT/ELAP. Among 15 liver injury patients confirmed by CT/ELAP, the detection rate of bedside abdominal ultrasonography is 100%, followed by spleen injury (94.73%), kidney injury (94.12%), multiple organ injury (81.48%), retroperitoneal hematoma (25.00%), and gut perforation (20.00%).

### Accuracy of bedside abdominal ultrasonography in critical patients

All 71 critical patients received surgery. As shown in Table 3, the total accuracy rate for bedside abdominal ultrasonography scan was 94.37%.

**Table 1**  
Components of injury mechanism, *n* (%).

Injury mechanism	Total patients	Ratio of multiple organ injury patients
Traffic accident	55 (51.89)	14 (25.45)
Fall	38 (35.85)	8 (21.05)
Crush	5 (4.72)	3 (60.00)
Compression	8 (7.55)	2 (25.00)
Total	106 (100)	27 (25.47)

**Table 2**  
Comparison of the findings between bedside BAU and surgery or CT scans.

Injury type	Cases	Surgery	CT scan	Positive for BAU	Negative for BAU	Coincidence rate (%)
Liver	15	11	4	15	0	100
Spleen	38	23	15	36	2	94.73
Kidney	17	13	4	16	1	94.12
Gut perforation	5	5	0	1	4	20.00
Retroperitoneal hematoma	4	0	4	4	0	100
Multiple organ injury ( $\geq 2$ )	27	19	8	22	5	81.48
Total	106	71	35	94	12	88.68

BAU: bedside abdominal ultrasonography, CT: computed tomography.

**Table 3**  
Comparison of the findings between BAU and surgery in critical patients.

Injury type	Surgery	Positive for BAU	Negative for BAU	Coincidence rate (%)
Liver	11	11	0	100
Spleen	23	23	0	100
Kidney	13	13	0	100
Gut perforation	5	1	4	20.00
Retroperitoneal hematoma	0	0	0	–
Multiple organ injury ( $\geq 2$ )	19	19	0	100
Total	71	67	4	94.37

BAU: bedside abdominal ultrasonography.

#### Time efficiency of bedside abdominal ultrasonography

The mean time required for overall diagnostic procedure was significantly shorter with the bedside abdominal ultrasonography compared with CT scan ( $p < 0.05$ ). The waiting time for bedside abdominal ultrasonography was significantly shorter than that for CT scan. However the examining time needed for bedside abdominal ultrasonography was longer than CT scan (Table 4).

#### Discussion

In this study we investigated the value of bedside abdominal ultrasonography performed by professional sonographers in blunt abdominal trauma patients. The accuracy rate was satisfactory in simple abdominal parenchymatous organ injury especially in critical patients.

Severe abdominal injury patients can quickly become hemodynamically unstable even in the emergency department, which is associated with poor prognosis. Therefore, a rapid evaluation to identify the potential sources of bleeding or other severe injuries is critical. CT scan is highly recommended for the assessment of trauma patients. However, in unstable hemodynamic conditions, CT may not be appropriate for it takes time to transfer patients as well as the complicated procedure including a bolus of intravenous contrast material. On the contrary, Ultrasonography proved to be a fast-performed and noninvasive bedside method. Unlike the expensive cost and radiation expose of CT scan, ultrasonography could be repeatedly used on patients. Our study aimed to evaluate the efficiency and accuracy of bedside ultrasonography in blunt abdominal trauma patients. In recent years, a modified bedside abdominal ultrasonography, so-called FAST, has been frequently used in emergency departments to detect the presence of intraabdominal bleeding, and it is increasingly important in the triage, diagnosis, and treatment modalities for the management of abdominal injury.<sup>6</sup> FAST differs from CT as it does not require transfer of the patient to another unit from the emergency department, and thus it can be used easily for critical patients who have a hemodynamically unstable condition or need surgery. Our data shows that the total accuracy rate is 88.68%, and the accuracy rate for critical patients is 94.37%. Our result is in accordance with that of previous study, which found that the sensitivity of FAST in abdominal injury was 85%–95%.<sup>7</sup> Our results suggest that ultrasound appears to be more valuable in severe cases.

**Table 4**  
Comparison of the time needed for BAU and CT scan at emergency room.

Time period (min)	BAU ( $n = 24$ )	CT ( $n = 24$ )	$p$ value
Waiting time	7.37 $\pm$ 2.01	16.42 $\pm$ 6.37	<0.05
Examining time	4.45 $\pm$ 1.63	2.38 $\pm$ 1.19	<0.05
Report time	6.42 $\pm$ 3.35	36.26 $\pm$ 13.33	<0.05
Total time	17.24 $\pm$ 2.33	55.06 $\pm$ 6.96	<0.05

BAU: bedside abdominal ultrasonography, CT: computed tomography.

Moreover, all the ultrasonography scans were performed by experienced sonographers in this study. To some extent, these certified sonographers had a more accurate detection rate and efficiency in this term than emergency physicians. An earlier UK study found that the sensitivity of FAST performed by emergency physicians was only 78%. They had to repeat FAST scanning and the sensitivity was accordingly improved from 78% to above 90%.<sup>8</sup>

Generally, organ laceration is the main cause of shock and death in blunt abdominal injury, which is exhibited as intraabdominal free fluid under ultrasound probes. Hence, the FAST protocol only aims to detect free intraabdominal fluid in four specific areas. The specificity of FAST is consistently between 98% and 99%, and the sensitivity ranges from 22% to 78%.<sup>9</sup> By contrast, in order to make a clear diagnosis, bedside abdominal sonography is more accurate but may take more time if the examiner is inexperienced. Our study showed a higher overall accuracy compared with former studies. This result can be explained by the fact that instead of performed by emergency physicians, in this study all bedside abdominal ultrasonographies were performed by experienced and certified sonographers.

Blunt hollow viscus injuries, as included in this study, is a rare but underestimated subtype of abdominal injury. The occurrence is less than 1%.<sup>1</sup> For this type of injury, an immediate CT scan has a higher sensitivity.<sup>10</sup> As to multiple organ injury missed in the bedside abdominal ultrasonography, cautious clinical follow-up plus whole-body CT scan is required to avoid a missed diagnosis.<sup>11,12</sup>

Performing a prompt treatment is often critical for these patients. Any delayed management for these patients is deemed to be associated with increased in-hospital mortality. Bedside abdominal ultrasonography can be performed at the bedside as soon as the patient arrival; hence most emergency physicians supported that the immediate use of bedside abdominal ultrasonography can facilitate to save diagnostic time and accordingly can rapidly perform treatment protocol.<sup>2</sup> Our results showed that the time for performance and interpretation of a bedside abdominal ultrasonography by an experienced sonographer is less than half of the time for CT scan. In this way, emergency physicians are able to make a timely diagnosis and an appropriate treatment schema can be carried out without delay.

We proved that bedside abdominal ultrasonography performed by sonographers has high accuracy and time efficiency in diagnosis and clinical assessment of blunt abdominal trauma especially in critical patients. Therefore, physicians in emergency departments or trauma centers should cooperate with sonographers in order to get an early and accurate diagnosis of parenchymal organ injury in trauma patients and thus to optimize the management as soon as possible.

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## Ethical Statement

The Ethical Committee of the Second Affiliated Hospital of Army Medical University has approved before the conduction of the study.

## Declaration of Competing Interest

All authors declared no conflict of interests.

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