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Authors' Affiliation:

¹Senior Registrar Emergency Medicine, Emergency Department, First Health Cluster, Riyadh, Saudi Arabia
²Saudi Board Emergency Medicine Resident, Second Health Cluster, Prince Mohammed Bin Abdulaziz Hospital, Riyadh, Saudi Arabia
³Medical Intern, College of Medicine, Bisha University, Bisha, Saudi Arabia

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Assessment of blunt abdominal trauma in the emergency department: Systematic review

Mazi Mohammed Alanazi¹, Muayad Mohammed Abdullah Algrairy², Alaa Abdullah Alghamdi², Tamim Khalid Abdullah Abdulrahim³

ABSTRACT

Background: When evaluating blunt abdominal trauma patients initially, it is important to do an extended assessment using with solography exam. This study aimed to conduct a comprehensive analysis of the current literature concerning the diagnostic accuracy of all aspects of trauma assessment utilizing solography examination. **Method:** A comprehensive review of the literature about emergency department studies examining the diagnostic efficacy of contrast enhanced and conventional ultrasonography performed before CT imaging for abdominal injuries was carried out across large databases. The PRISMA statement was adhered to by the study. The research included in the literature search were released between 2007 and 2023. **Result:** The organ that was examined the most was the liver, while the organ that was investigated the least was the pancreas. Of the included studies three showed a variety of abdominal injury types, including the presence of free abdominal fluid, continuous bleeding, and solid organ damage signs. CEUS is more accurate than baseline US and almost as sensitive as CT. CT is more precise and sensitive than contrast enhanced US in identifying prognostic indicators such urinoma and current bleeding. Contrast enhanced US should be considered in the evaluation and follow-up of children who have experienced traumatic abdominal injuries. **Conclusion:** When utilised as the initial examination in the emergency room, CEUS had a higher diagnostic value than conventional ultrasound for discriminating blunt abdominal trauma.

Keywords: Blunt abdominal trauma, assessment, emergency department, ultrasonography

1. INTRODUCTION

Non-operative management of solid organ injury has been proven to be safe and successful by a number of excellent prospective and retrospective studies, and this approach is now widely used in clinical practice (Velmahos et al., 2003; Haan et al., 2005; Stein and Scalea, 2006). Simultaneously, imaging techniques have

undergone a paradigm change, emphasising now the identification of particular discoveries rather than just the presence of intraperitoneal fluid, which does not necessarily indicate the need for action (Shuman et al., 2005). While more computed tomography and ultrasound are available in emergency rooms, this has led to changes in practice as well as new controversies. While diagnostic peritoneal lavage is no longer commonly used, diagnosing hollow viscus injury solely through imaging is still controversial.

For more than 20 years, the assessment of trauma with Sonography, which employs conventional ultrasonography, has been a crucial component of the assessment of trauma patients (Kortbeek et al., 2008). The assessment of trauma with sonography has little value in identifying solid organ injury, especially when there is no intraperitoneal free fluid present (Netherton et al., 2019). Nonetheless, in the context of trauma resuscitation, it is a very useful bedside technique for ruling in intraabdominal free fluid. Many research have looked into whether using contrast-enhanced ultrasonography (CEUS), which combines ultrasound with contrast agents, can improve the specificity and sensitivity of abdominal traumatic lesion detection. Acute solid organ damages can be shown in real time across all vascular stages by using tiny intravenous boluses of inert microbubbles with a phospholipid shell (Borghi et al., 2004; Wei et al., 2001).

Moreover, patients, especially those with shock, hypotension, or renal failure, tolerate these medicines well (Ma et al., 2012). Many studies have been conducted recently that highlight the advantages of using CEUS for identifying abdominal injuries after trauma (Schneider et al., 2013). However, none have directly compared CEUS's accuracy to traditional ultrasound. Because all sonographic tests are performed before computed tomography (CT), in this systematic review we aimed to compare the effectiveness of contrast enhanced and conventional ultrasound when utilized in emergency department for the initial screening for blunt abdominal trauma.

2. METHOD

We conducted a comprehensive analysis of research that contrasted blunt abdominal trauma assessment using CEUS and traditional ultrasound as the first evaluation for before CT imaging. The PRISMA "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" guidelines were adhered to in this investigation.

Eligibility criteria

Studies that examined contrast enhanced and conventional ultrasound diagnostic accuracy for blunt abdominal trauma in humans were deemed eligible to be included in this systematic review; additionally, studies that were both retrospective and prospective that completed all diagnostic testing in the emergency department were also acceptable. The diagnostic tests, both contrast enhanced and conventional ultrasound, had to be completed before performance of CT scan. We excluded animal experiments, reviews, and case reports.

Search strategy

The following search phrases were used in a standardised search of PubMed, Web of Science, OVID MEDLINE, and Embase: (blunt abdomina trauma, contrast enhanced sonography, contrast enhanced ultrasonography, CEUS). Studies published between 2007 and 2023 were included in the search, without regard to language limitations. There were 521 results for our search. Following the evaluation of the titles and abstracts, 36 complete texts were assessed, as shown in (Figure 1).

Study selection

Based on the previously mentioned criteria, each author independently reviewed and chose studies; differences were settled by consensus with the help of supervisor. After screening, studies found in various databases were separated out. The complete text of the articles that made it beyond the first screening stage was examined.

Data collection and processing

Individual data (such as sample size, study site, study design, trauma mechanism, tissue damaged, sonographer and interpreter, and population mean age) were retrieved for the included studies. When only a portion of the information was accessible, CT imaging findings were considered the gold standard. Damaged organs were. The liver, spleen, pancreas, and kidneys were among the affected organs.

3. RESULTS

Our search turned up 521 results. 36 complete texts were reviewed after the titles and abstracts were evaluated, as indicated in (Figure 1). Six studies—representing a total of 917 patients—met our inclusion criteria after we compared the studies to the eligibility requirements. Only one research was undertaken in Asia Lv et al., (2014), whereas five investigations were conducted in Europe, mostly in Italy (Catalano et al., 2009; Menichini et al., 2015; Regine et al., 2007; Sessa et al., 2015; Valentino et al., 2010). Two of the investigations were structured as multi-center studies Catalano et al., (2009), Lv et al., (2014), while two were done prospectively (Catalano et al., 2009; Regine et al., 2007). Of the 10 investigations, four reported utilising the SonoVue contrast agent (Catalano et al., 2009; Lv et al., 2014; Menichini et al., 2015; Regine et al., 2007).

The liver was the organ most frequently studied Catalano et al., (2009), Menichini et al., (2015), Sessa et al., (2015), Valentino et al., (2010), whereas the pancreas was the organ least frequently studied (Lv et al., 2014). A range of abdominal injury types, such as evidence of solid organ damage, the presence of abdominal free fluid, and the presence of ongoing bleeding, were documented in less than half of the investigations (Catalano et al., 2009; Menichini et al., 2015; Valentino et al., 2010). Conversely, two investigations Lv et al., (2014), Regine et al., (2007) concentrated on a specific target organ or damage. Hypoechoic or hypodense, well-defined sections of solid organs were indicative of hypoperfused regions, whereas areas with mild and uneven echogenicity without mass effect or parenchymal vascular displacement were indicative of contusions.

While hematomas were defined as weakly demarcated inhomogeneous collections inside the parenchyma, hypoechoic linear or organ surfaces branching bands were thought to represent lacerations. Anechoic intraperitoneal fluid was the definition of the free abdominal fluid. Indicators of parenchymal active bleeding were identified by CEUS as microbubbles inside solid organ lesions or localised microbubbles extravasation outside of a lacerated organ. In all included studies, examinations by conventional ultrasonography and CEUS were finished an hour after the patient arrived at the emergency room. Table 1 displays the characteristics of the studies that were included.

Menichini et al., (2015) state that baseline US is less accurate and baseline CEUS is almost as sensitive as CT. CT is more precise and sensitive than CEUS in identifying prognostic indicators such urinoma and current bleeding. CEUS should be considered in the evaluation and follow-up of children who have experienced severe abdominal injuries (Table 2). The findings of a CEUS can be used to accurately detect blunt pancreatic injuries, according to (Lv et al., 2014). Consequently, CEUS is a promising diagnostic technique for blunt pancreatic injury, especially in institutions that use emergency CEUS as a first line of diagnosis.

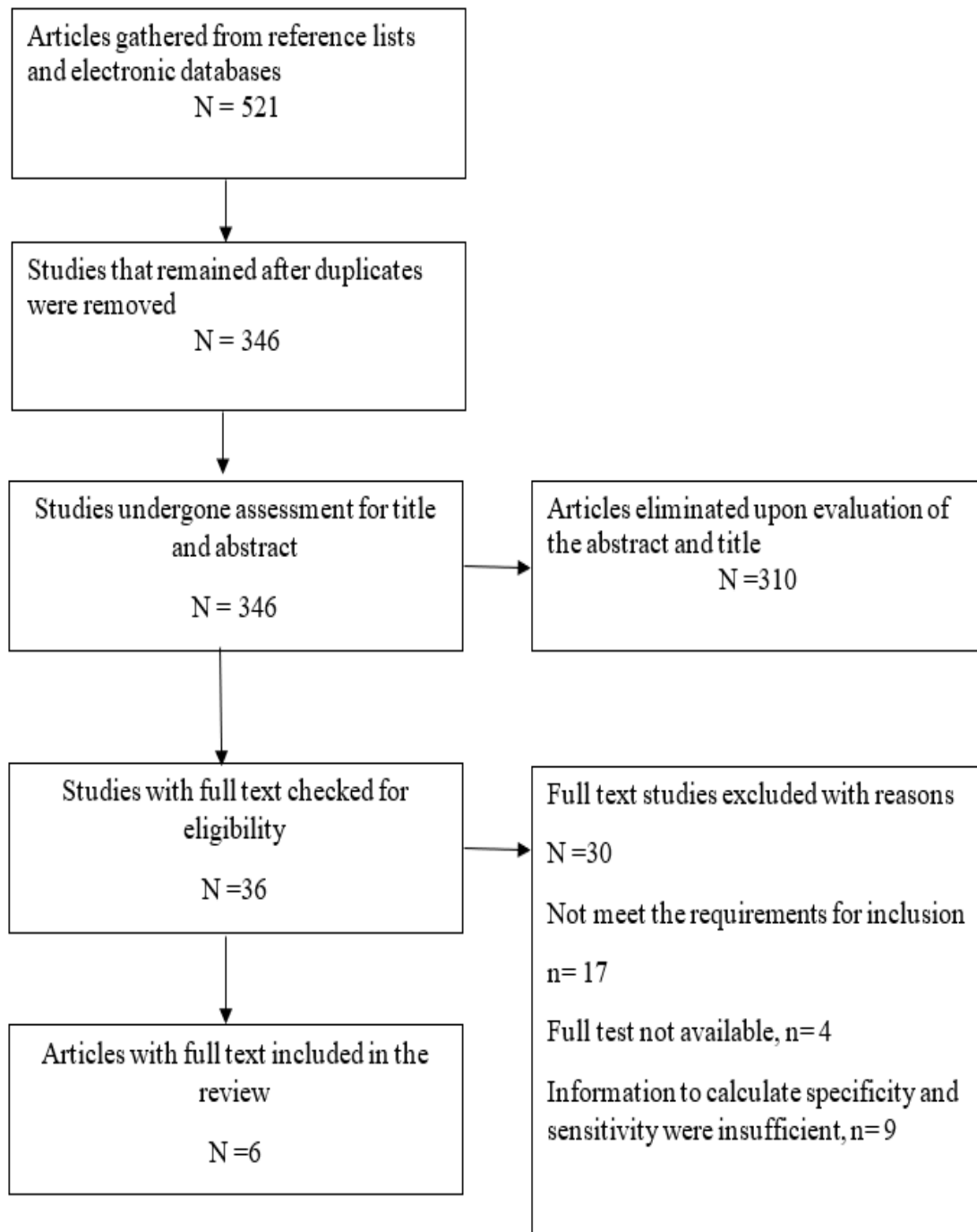


Figure 1 Consort chart of selection process

Table 1 Assessment of blunt abdominal trauma emergency department; systematic review

Citation	Study setting	Study design	Tissues injured	Trauma mechanism	Interpreter	Sonographer	Number of patients	Mean Age
Menichini et al., 2015	Emergency department	Single centered Retrospective	Kidney, adrenal glands, spleen and liver	Blunt trauma	Radiologists with more than 10 years of experience	Radiologists with more than 10 years of experience	73	9
Lv et al., 2014	Emergency department	Multi centered Retrospective	Pancreas	Blunt trauma	Ultrasound specialists	Ultrasound specialists	22	29
Sessa et al., 2015	Emergency department	Single centered Retrospective	Kidney, adrenal glands, spleen and liver	Blunt trauma	Not recorded	Radiologists with more than 5 years' experience	256	41
Valentino et al., 2010	Emergency department	Single centered Retrospective	Kidney, adrenal glands, spleen, pancreas and liver	Blunt trauma	Radiologist	Radiologists	133	40
Catalano et al., 2009	Emergency department	Multi center prospective study	Liver, Spleen, adrenal gland and kidney	Blunt trauma	Radiologist	Radiologist	156	39
Regine et al., 2007	Emergency department	Single centered Retrospective	Adrenal glands and kidney	Blunt trauma	Not reported	Not reported	277	NA

Table 2 Main finding of included studies

Citation	Main results	Conclusion
Menichini et al., 2015	Through the use of CEUS, all patients were shown to have parenchymal lesions: They included lesions of the right kidney (9.6%), spleen (35.6%), liver (28.8%), and 26%left kidney. Given that the sensitivity and specificity of CEUS were 100 and 100 and 38.8 and 100 for US, respectively, the diagnostic performance of CEUS was superior to that of US. Prognostic markers discovered by CEUS in certain individuals included parenchymal bleeding in 8 instances and 1 case of partial devascularization; no occurrences of urinoma or vascular bleeding	CEUS is nearly as sensitive as CT and more accurate than baseline US. When it comes to detecting prognostic signs like current bleeding and urinoma, CT is more accurate and sensitive than CEUS. When evaluating and keeping track of children who have suffered traumatic abdominal trauma, CEUS should be taken into consideration.

	were found. Every parenchymal lesion was verified by MDCT. There were 16 cases of parenchymal active bleeding, 2 vascular bleeding cases, 2 cases of urinoma, and 1 case of partial devascularization.	
Lv et al., 2014	Using CEUS, 21 of the 22 patients—eight of whom had lesions in the pancreatic neck, nine in the body, three in the tail, and one in the head—were found to have had a blunt pancreatic injury. On CEUS pictures of the parenchyma and capsule, the injury sites showed up as anechoic or hypoechoic perfusion defect areas with erratic boundaries. The CEUS measurement of the lesion diameters was 1.8 ± 0.8 cm. With CT serving as the benchmark, 95.5% of cases of blunt trauma were detected using CEUS.	The results of a CEUS can be utilised to reliably diagnose blunt pancreatic trauma. Therefore, CEUS shows promise in the evaluation of blunt pancreatic damage, particularly in facilities where emergency CEUS is employed as a preliminary diagnostic tool.
Sessa et al., 2015	45 instances of intraperitoneal fluid and 84 abdominal lesions (spleen = 35, liver = 28, kidney = 21) were found by MDCT. 96.4% traumatic lesions and 91% instances of free peritoneal fluid were found by CEUS, compared to 50/84 traumatic lesions and 41/45 cases of free peritoneal fluid shown by US. For CEUS and US, the corresponding sensitivity and specificity for identifying traumatic lesions were 59 and 99 for US and 96 and 99 for CEUS, respectively. The results for the US and CEUS indicated that the haemoperitoneum could be identified with values of 91 and 99, respectively. 72 out of 81 traumatic lesions were effectively staged by CEUS with an 88% sensitivity.	Since CEUS has a high sensitivity for lesion detection, it should be used as the first-line method in low-energy abdominal injuries patients instead of US. In order to rule out current bleeding and urinomas in individuals with a positive CEUS, CE-MDCT testing is usually necessary.
Valentino et al., 2010	CT revealed 84 lesions in 133 patients: 48 instances with splenic injury, 21 cases with liver injury, 13 cases with kidney or adrenal gland injury, and 2 cases with pancreatic injury. In 59/84 patients who tested positive on CT, US found free fluid or parenchymal abnormalities; in 20/49 patients who tested negative on CT, free fluid was found. 81/84 traumatic injuries found by CT were found by CEUS, whereas 48/49 traumatic injuries were ruled out by CT. For the US, the corresponding values for sensitivity and specificity were 70.2% and 59.2%; for the CEUS, the corresponding values were 96.4% and 98%.	According to the study, CEUS is a more accurate method than US and CT, hence it is recommended that patients who have suffered severe abdominal trauma be evaluated with CEUS initially.
Catalano et al., 2009	Of the 156 patients that were included, 91 (38	Regarding identification of solid

	liver, 26 renal, and 43 spleen) exhibited abnormalities at CT. Following an increase in contrast enhanced ultrasound readings to 69%, and 99%, the sensitivity and specificity, for renal trauma at baseline US were 36% and 98% respectively. Baseline ultrasound values for the liver were 68% and 97%; values following CEUS were 84% and 99%. Results for the spleen were 93% and 99% following CEUS and 77% and 96% at baseline US.	organ damage, contrast enhanced ultrasound is more sensitive than ultrasound, which may minimize further imaging need. Minor injuries are the cause of false negative results from contrast enhanced ultrasound, which have little bearing on the prognosis or treatment of the patient.
Regine et al., 2007	At baseline US, 18% traumatic parenchymal lesions with perirenal fluid collection were seen. Using contrast-enhanced ultrasound, all cases with renal parenchymal lesions – with or without perirenal or retroperitoneal hemorrhage – were detected. All of the cases that tested positive on contrast-enhanced US were validated by multiphase MDCT, which also showed that the urinary tract was intact throughout the delayed phase.	Second-generation sonographic contrast material is diagnostically accurate for both diagnosis and proper patient care. Specifically, it has been demonstrated that contrast-enhanced sonography is a dependable method for monitoring and assessment of low-grade renal damage. Its primary benefit is less radiation exposure because fewer MDCT exams are required; nevertheless, if the technology is applied to unselected individuals, it can be costly.

4. DISCUSSION

Regarding the exclusion of any solid organ damage relevant to abdominal trauma, CEUS outperformed conventional ultrasonography by a wide margin. However, both modalities performed equally well in detecting abdominal free fluid. Based on a direct comparison, our findings indicate that CEUS performs better than conventional ultrasonography as the first screening test for patients who have had abdominal injuries. This raises the question of whether CEUS should be included as standard procedure when doing the assessment of trauma with Sonography evaluation. First, compared to traditional ultrasonography, CEUS has a far higher diagnosis accuracy for severe abdominal injuries. Previous studies have demonstrated that, due to its low sensitivity, a negative result on the assessment of trauma with Sonography exam will not rule out injury for abdominal trauma patients (Quinn and Sinert, 2011; Stengel et al., 2015).

It has been argued that a negative assessment of trauma with sonography either gives false confidence, encourages more testing due to its finding, or has no evidence-based value when deciding whether to do additional diagnostic testing (Stengel et al., 2015). The limitations of the US approach in general, such as the challenges faced by patients who are macrosomic, cannot be solved by CEUS, but recently updated US equipment allows inspection in circumstances where it was previously thought to be impossible. In general, CEUS should not be performed on individuals who are not appropriate candidates for B-mode evaluation. It is still challenging to identify mesenteric and intestinal injuries with US; the contrast chemicals used now do not allow for an appropriate investigation of the kidney's excretory system since there is no urine elimination (Valentino et al., 2010).

Due to their inferior diagnostic accuracy, either contrast enhanced ultrasound (CEUS) or contrast enhanced computed tomography CECT indirectly identified pancreatic ductal damage based on a lesion involving more than 50% of the pancreatic thickness. Endoscopic retrograde cholangiopancreatography (ERCP) has been recommended as an efficacious procedure for both diagnosis and therapeutic interventions, such as stent placement, because it is the most dependable diagnostic technique for precisely defining the

continuity of the main pancreatic duct following pancreatic trauma (Hall et al., 1986). Recent researches indicate that CEUS can also detect active bleeding cases, such as the thorax Sugihara et al., (2010) and gastrointestinal system (Manabe et al., 2010).

In order to further understand the potential function of CEUS in diagnosing active bleeding in the future. Moreover, the capacity to observe contrast extravasation in a continuous or pulsatile manner through the use of CEUS Cozzi et al., (2020) shows significant promise for dynamically characterizing static CT results. Our idea is that when extravasation is detected by CT imaging, CEUS plays additional resuscitative and monitoring clinical ultrasonography functions, adding a new dimension to the assessment of trauma with Sonography. When compared to US, the contrast enhanced US use during trauma emergency cases should result in comparable, if not superior, survival rates.

When it comes to patients who have suffered severe trauma, a multicenter randomized control trial that was published in the *Lancet*—revealed no mortality benefit over standard work up, which includes radiographs and the assessment of trauma with sonography examination, with selective CT scans performed after additional assessment and resuscitation (Sierink et al., 2016). Trauma teams need to make certain that there will be enough time before the assessment of trauma with Sonography assessment to inject the contrast agent. Catalano et al., (2005) observed that the baseline conventional ultrasonography and CEUS room time was, six minutes for the evaluation of nine hemodynamically unstable patients. If scheduled effectively, we think the CEUS examination time may be optimized to take place concurrently with the trauma survey.

5. CONCLUSION

In the emergency department blunt abdominal trauma work up, contrast enhanced US proved more diagnostically valuable than conventional ultrasonography. Strong sensitivity demonstrated by CEUS positions it to counter the objections currently levelled at conventional ultrasound evaluation. Future research should look into whether using contrast enhanced US as a first assessment tool during blunt abdominal trauma evaluation of morbidity and mortality.

Ethical Approval: Not applicable.

Informed consent: Not applicable.

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Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

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