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*Review*

# A review of the roles of clinical ultrasound technology in blunt abdominal trauma

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**Advances in gray scale imaging, contrast- enhanced harmonic imaging and Doppler technologies have improved the effectiveness of ultrasonography in the evaluation of blunt abdominal trauma (BAT). The use of ultrasonography in the evaluation of the abdomen benefits from an understanding of the abdominal anatomy and familiarity with the acoustic signatures of lesions encountered in parenchymal injuries and the echogenicity of hemoperitoneun at different stages of transition.**

**Key words:** Ultrasonography, blunt abdominal trauma, contrast agent, free fluid.

## INTRODUCTION

Trauma is the third leading cause of death in the United States and is the leading cause of death in the age group of 15 to 44 years (Jacobs and Jacobs, 1996). The recent past has seen numerous entries in the literature citing the benefits and limitations of ultrasonography used for the first line objective evaluation of the abdomen after blunt abdominal trauma (BAT) (Mcgahan et al., 1997; Mckenney et al., 1996; Mckenney et al., 1998; Rozycki et al., 1995; Rozycki et al., 1998; McElveen and Collin, 1997; Mckenney et al., 1994; Nordenholz et al., 1997; McGahan et al., 1999; Jehle et al., 1993; Shanmuganathan et al., 1999; Brown et al., 2001; Rothlin et al., 1993; Yoshii et al., 1998; Healy et al., 1996; Bode et al., 1999). The ultrasound examination of patients to assess the nature and extent of injury on trauma is refered to as traumasonography. In BAT, the examination may consist of the assessment of organ(s) parenchyma and survey for fluid within the peritoneal or retropentoneal regions. Many authors use free fluid as the only criterion for a positive finding (Mcgahan et al., 1997; Mckenney et al., 1996; Mckenney et al., 1998; Rozycki et al., 1995; Rozycki et al., 1998; McElveen and Collin, 1997; Mckenney et al., 1994; Nordenholz et al., 1997; McGahan et al., 1999; Jehle et al., 1993; Chiu et al., 1997; Shanmuganathan et al., 1999), whereas some describe findings other than fluid as suggestive of traumatic injury as well (Brown et al., 2001; Rothlin et al., 1993; Yoshii et al., 1998; Healy et al., 1996; Bode et al., 1999).

The inability to show injury without hemoperitoneum has been shown to be a limitation of ultrasonography and may occur in 29% to 34% of patients with injuries caused by BAT (Chiu et al., 1997; Shanmuganathan et al., 1999).

In the following sections, we reviewed the scanning techniques as well as free fluid seen during screening abdominal ultrasonography in patients with blunt trauma.

## ULTRASONOGRAPHY EXAMINATIONS

This is mainly performed by qualified medical imaging scientists, sonographers or Radiologists. Patient is scanned in a supine position. The study is usually performed with a 3.5 MHz sector probe but a 2.25 or 5 MHz sector probe could be used depending on the patients' body size to optimize imaging when appropriate. Color and spectral duplex Doppler ultrasonography could be used if indicated on the basis of clinical suggestion or gray scale findings. The 7 areas evaluated for fluid are the right and left upper quadrants, the epigastrium, the right and left paracolic gutters, the retroperitioneum, and the pelvis (Brown et al., 2001). In addition, the heart, liver, spleen, and kidneys are scanned for potentially traumatic abnormalities. Empty bladders are distended with 250 to 300 ml of sterile saline via Foley catheter if there is no contra-

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diction to catheterization such as suspected urethral injury.

## CONTRAST-ENHANCED SONOGRAPHY OF INTRA-ABDOMINAL HEMORRHAGE

Just as in contrast Radiological investigations, contrast enhanced sonography could be used for the assessment of trauma victim. The addition of a contrast agent has the potential to enable rapid and dynamic detection of on-going hemorrhage in a solid organ and bleeding into the retro- peritoneal or abdominal spaces (Schmiedl et al., 1999; Hochmuth et al., 2000).

The addition of contrast agent would increase the sonographic detectability of even a small amount of extravasated blood, improve the ability to identity the bleeding site, and also improve the ability to determine the severity of bleeding (Liu et al., 2002). This additional information facilitates trauma patient care. In the absence of active bleeding, or if serial examinations show cessation of active bleeding, nonsurgical therapy might be indicated. Because contrast-enhanced sonography would help identify the specific location of the injury, it has the potential to reduce surgical exploration and to expedite surgical repair (Liu et al., 2002). Contrast-enhanced sonography can be used postoperatively to confirm the presence or absence of active bleeding.

A clinical study using contrast-enhanced harmonic and intermittent imaging to evaluate solid organ injury in 12 patients has been reported (Mattrey et al., 2000), and the study concluded that contrast-enhanced sonography depicted solid organ injury similarly to computed tomography and that this technique should further limit the need for computed tomography in abdominal trauma.

Sonazoid (Amersham Health, Buckinghamshire, England) is considered a tissue-specific sonography contrast agent, because after injection into the bloodstream, the microbubbles are removed by specific cells of the reticuloendothelial system in the liver and spleen. Sonazoid is a lipid.-stabilized suspension of perfluorobutane micro-bubbles having a median diameter of 2.4 to 3.5 µm. Unlike vascular or blood pool sonographic contrast agents which only enhance the detection of blood flow or blood-containing tissue, there are 2 phases of enhancement achievable with sonazoid, the initial vascular phase occurs immediately after intravenous injection of the contrast agent and is characterized by enhanced detection of blood flow (Liu et al., 2002). Vascular phase enhancement persists for several minutes and is useful for improving Doppler flow analyses as well as gray scale harmonic imaging (HI) nodes when assessing flow throughout the body (Forsberg et al., 2000). The delayed or tissue phase of enhancement occurs after the microbubbles have been phagocytosed by the cells or the reticuloendothelial sys-tem. This tissue “uptake” phase begins almost immediately after the contrast agent arrives in the liver and spleen; however, it is usually more beneficial to wait several minutes (10-15 min) after injection to ensure sufficient uptake of the contrast agent and clearance of the agent from the blood stream (Forsberg et al., 2000). During the delayed phase, both gray scale HI and color Doppler imaging can be used to evaluate normal tissue as well as to differentiate between areas of the liver and spleen that do and do not contain sonazoid micro-particles (Forsberg et al., 2000; Forsbery et al., 1998; Hagen et al., 2000; Forsbery et al., 2000). In contrast enhanced gray scale harmonic imaging, the bleeding sites appear more echogenic than the normal tissue. The improved spatial and temporal resolution of gray scale HI (compared with color Doppler modes makes this the preferred method of evaluation when using a contrast agent (Liu et al., 2002). When the microbubbles of sonazoid are insonated they initially oscillate and then rupture, resulting in an acoustic emission (AC) Phenomenon. This AE phenomenon is not unique to sonazoid. However, as a tissue specific agent, sonazoid also has the delayed enhancement phase, which gives added benefit of enhancing the detection of hematomas and other abnormalities in the liver and spleen as well as improving the ability to rule out splenic and hepatic parenchymal injuries (Liu et al., 2002).

Sonazoid combined with real-time sonography has the potential to aid in the detection of active bleeding in its initial vascular phase. The area found to have the blood vessels would be expected to correspond to the bleeding site. Once the microbubble of sonazoid rupture, they no longer provide enhancement, and if no additional contrast is administered, contrast enhancement is no longer provided. This is important in identifying active bleeding. If the AE effect from microbubble rupture is present initially but not present in a later study, it would suggest that bleeding has stopped. Claude et al. (2001) concluded that splenic, hepatic, and extraperitoneal injuries have over lapping but different patterns of fluid accumulation, which may prove beneficial in predicting the site of injury in clinical setting.

Hemoperitoneum can easily be seen in its varying echogenicity depending on the stage of transition of the blood but accurate evaluation and interpretation of findings other than free fluid require more ultrasonography experience and training. It is not part of the surgeon-performed focused abdominal sonography for trauma (FAST) examination currently in use at several trauma centers (Brown et al., 2001). Parenchymal findings help to localize injury in patients who do not present with hemoperitoneum. While a laceration of the liver could appear as echogenic lesion, a splenic injury could appear as a hypoechoic parenchyma lesion. Although hemodynamically stable patients undergo CT, localizing injury is important for unstable patient who may proceed directly to laparatomy. Hence evaluation of organ parenchyma and close examination of retro-peritoneum can help detect injury in patients without sonographic evidence of hemoperitoneum.

## CONCLUSION

Ultrasonography continues to be a fast and effective modality for evaluation of patients with BAT. Advances in contrast enhanced harmonic imaging, Doppler technology and spatial resolution have improved the accuracy of ultrasound studies in BAT. The use of ultrasonography in the evaluation of the abdomen benefits from an understanding of abdominal anatomy and familiarity with the acoustic signatures of lesions encountered in parenchymal injuries and the echogenicity of hemoperitoneum at different stages. In this review, we have presented the pertinent scanning technique, and sonographic features which illustrate the utility of both 2-Dimensional and 3-Dimensional ultrasonography in the assessment of patients with blunt abdominal trauma (BAT)

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