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EMERGENCY RADIOLOGY SPECIAL FEATURE: REVIEW ARTICLE

Ultrasound: the triage tool in the emergency department: using ultrasound first

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ABSTRACT

Ultrasound in the emergency department has long been recognized as a powerful screening and diagnostic tool for both physicians and radiologists. In the emergency department, since time is of the essence, it becomes a critical tool in triaging patients. Over the years, ultrasound has gained several advantages over other modalities because of its non-ionizing radiation, portability, accessibility, non-invasive method and simpler learning curve. As a result, ultrasound has become one of the most frequently used diagnostic tools in the emergency department by non-radiologists. The value of ultrasound is implemented in every acute ailment in the emergency department such as trauma, acute abdomen, acute pelvic pain, acute scrotal pain, appendicitis in children and acute deep venous thrombosis. Our objective is to discuss the benefit of using ultrasound as the primary modality for each of these diseases.

INTRODUCTION

Since the inception of portable ultrasound machine, physicians have attempted to integrate the use of ultrasound with the physical examination. Furthermore, the technological development of various probes and transducers has paved the way for a more accurate and specific physical examination. As a result, the use of ultrasound has been integrated into the education and training of multiple specialities, such as emergency medicine, obstetrics/gynaecology and cardiology.

Later, with the incorporation of contrast media, there has been even a greater role for ultrasonography in the assessment of lesions with the abdomen and pelvis as well as traumatic injuries especially in patients with acute or chronic renal failure.

TRAUMA

From the late 1980s until the 1990s, advanced research conducted throughout the world became pivotal in implementing ultrasound in the evaluation of the patients with trauma, specifically assessing for the detection of haemoperitoneum and haemopericardium. This technique is called focused assessment with sonography for trauma (FAST) examination.^{1,2} The FAST examination has completely replaced the diagnostic peritoneal lavage as the preferred method for the initial evaluation of trauma

patients. In addition, it has been fully integrated into the Advanced Trauma Life Support. While it will not replace cross-sectional imaging, it does effectively triage patients for surgical or medical management. The FAST scan consists of four views of the abdomen and pericardium in order to detect the presence of free fluid. The standard views are Morrison's pouch, pericardial, perisplenic and suprapubic window. While there are limitations to the study, such as subcutaneous emphysema, obesity and abdominal scars, its sensitivity ranges from 82% to 99% and the specificity is from 95% to 99.7%.^{3,4} In addition, the use of contrast enhanced ultrasound has been shown to be valuable in the characterization of paediatric patients with solid organ injuries.⁵ The additional benefit of contrast-enhanced ultrasound is that it is not nephrotoxic. Therefore, it can be used in patients with acute or chronic renal failure.⁶

ACUTE ABDOMEN

Ultrasound is the preferred modality for the evaluation of acute cholecystitis. Positive Murphy's sign (point of maximal tenderness to transducer pressure when localized to the sonographically visualized gallbladder fundus) in combination with the presence of gallstones or presence of an impacted gallstone makes the diagnosis of acute cholecystitis⁷ (Figure 1).

Figure 1. A 30-year-old female with a history of asthma complains of intermittent right upper quadrant pain. The patient reports the pain radiating to the back and worse with eating and tenderness in the right upper quadrant upon inspiration (Murphy's sign). The patient also indicates nausea and vomiting. Greyscale image of the right upper quadrant demonstrates a distended gallbladder with multiple stones, gallbladder wall thickening and pericholecystic fluid. The patient was taken to the operating room and found to have acute cholecystitis.

In addition to the evaluation of the gallbladder, ultrasound is also used to evaluate other causes of the acute abdomen such as hepatitis, pancreatitis, diverticulitis and even inflammatory bowel disease as well as their complications.^{8–11}

Ultrasound has been proved to be the first modality in the evaluation of renal colic to detect renal stones and hydronephrosis. The use of ultrasound as the first modality has been strongly advocated by the American Institute of Ultrasound in Medicine.¹²

The use of ultrasound in the initial diagnosis and as a screening tool of abdominal aortic aneurysm has been well studied and noted to be comparable with CT and MRI without the concern for ionizing radiation, contrast reaction and cost-effective.

ULTRASOUND OF PELVIS

History and physical examination are frequently insufficient in the evaluation of pregnant females complaining of pelvic or lower abdominal pain. This becomes particularly confounding since there is the concern of an ectopic pregnancy, which is associated with a high morbidity and mortality. The primary objective in the ultrasound evaluation is the visualization of an intrauterine pregnancy. However, in cases in which patient is undergoing fertility treatment, a heterotopic pregnancy is also a consideration.

In the emergency department, the primary concern for the non-pregnant females who are in their reproductive age complaining of pelvic pain is ovarian torsion. Because this is difficult to diagnose based on symptoms and physical examinations, ultrasound becomes the primary modality for its evaluation. Morphologically abnormal ovary and pearl of string sign can make the diagnosis of ovarian torsion with confidence. Absence

of blood flow on colour flow Doppler also suggests ovarian torsion. On the contrary, presence of blood flow does not exclude ovarian torsion (Figure 2).

USE OF ULTRASOUND IN THE MALE PATIENT

High frequency transducer ultrasound with colour flow Doppler is the first modality of choice to evaluate acute scrotal pain. The most urgent cause of acute scrotal pain is testicular torsion which is a surgical emergency.

Since testicular torsion is not an all-or-none phenomenon, the sonographic findings of acute testicular torsion can vary depending on its acuity and degree of torsion. Since there is a dual blood supply to the testis, the Power Doppler, colour flow Doppler and spectral Doppler waveforms are all helpful in establishing the diagnosis. However, the Greyscale findings are non-specific and can vary from normal to complete hypoechoic testis which is suggestive of complete infarction¹³ (Figure 3).

ULTRASOUND OF ACUTE APPENDICITIS IN CHILDREN

Paediatric patients are particularly challenging to physicians because they are unable to describe their symptoms and give an accurate history. One of the major concerns in paediatric patients is acute appendicitis because it is the most common indication of acute abdominal surgery. While CT has sensitivity and specificity better than ultrasound, CT exposes paediatric patients to unnecessary ionizing radiation. According Aspelund et al,¹⁴ ultrasound followed by MR is feasible and comparable with CT without any effect on morbidity or mortality in children with acute appendicitis. Ultrasound examination for acute appendicitis is performed with graded compression, which means where the examiner exerts gentle pressure in the area of interest

Figure 2. Ovarian torsion: a 42-year-old female presents to the emergency department with left lower abdominal pain for two days. The colour flow Doppler ultrasound of the left adnexa demonstrates an enlarged left ovary with absence of follicles and a haemorrhagic cyst and absence of colour flow Doppler. This is suggestive of ovarian torsion.

using the ultrasound probe and either one or two hands to palpate the right lower quadrant in the same way when performing the abdominal examination.

The visualization of the appendix is operator and patient dependent such as obesity, severe abdominal pain or guarding, excessive bowel gas, and unco-operative patients can affect the accuracy of the study.

On ultrasound, a non-compressible blind-ending tubular structure in the longitudinal axis in the right lower quadrant measuring >6 mm in diameter in transverse axis with lack of peristalsis is suggestive of acute appendicitis. The appendiceal wall hyperaemia as seen on colour flow Doppler is another finding in acute appendicitis. Frequently, a round calcification, *i.e.* hyperechoic foci, that casts an anechoic shadow is suggestive of an appendicolith (Figure 4).

Figure 3. Testicular torsion: a 48-year-old male complains of constant right testicular pain for 2 days. He denies any recent trauma. The colour flow Doppler image shows complete absence of flow within the right testis and decreased echogenicity of the right testis. The patient was taken to the operating room and found to have complete torsion and necrosis of the right testis.

Figure 4. Acute appendicitis: a 13-year-old male presents to the emergency department with periumbilical pain for 3 days. He had multiple episodes of vomiting. He has a decrease in appetite. He demonstrated rebound tenderness and guarding at McBurney's point. The colour flow Doppler ultrasound of the right lower quadrant demonstrates a dilated appendix measuring 0.9 cm in length with an appendicolith. There is increased vascular flow surrounding the appendix. The patient was taken to the operating room and found to have acute appendicitis.

Ultrasound is not only important in the initial evaluation of the acute findings of acute appendicitis but also in identification of appendiceal perforation.¹⁵

ULTRASOUND IN THE EVALUATION OF ACUTE DEEP VENOUS THROMBOSIS

Ultrasound is the most sensitive and specific tool for the assessment of patients with symptoms of deep venous thrombosis. There are several sonographic techniques to assess for patency of veins. One of the techniques is compressibility. Compression applied perpendicular to the vein will cause the vein to collapse. If the lumen of the vein disappears completely, this excludes the presence of a clot. An acute clot typically appears hypoechoic

within the vein lumen and will prevent the vein from being compressed. The loss of compressibility of the vein is the most reliable indicator of the presence of a thrombus within the vein.

In addition, colour flow Doppler will also demonstrate a persistent filling defect or thrombus in the vein lumen. In addition, an acutely thrombosed vein (within the first 2 weeks after thrombus forms) is commonly dilated with a diameter greater than the adjacent artery. This is the most accurate parameter for assessing the age of the deep venous thrombosis (DVT).¹⁶ The pulsed Doppler spectral waveform from a normal widely patent lower extremity demonstrates spontaneous and respirophasic flow. The presence of

Figure 5. Acute deep venous thrombosis in the calf veins: a 79-year-old female with a history of chronic kidney disease, hypertension and frequent hospitalizations presents with new onset of hypoxia and high probability of pulmonary embolism. The colour flow Doppler ultrasound of the left lower extremities was performed. There is non-compressibility of the left popliteal vein with lack of augmentation of flow (not shown).

monophasic flow raises the suspicion of venous obstruction proximal to the level of interrogation. In addition to assessing for normal flow, distal augmentation manoeuvres such as squeezing the calf are performed during the spectral Doppler evaluation to further assess the patency of the vein. While the distal augmentation manoeuvre is performed, there should be a sharp “spike” of augmented antegrade venous flow. Blunted or absent flow augmentation suggests venous obstruction distal to the level of interrogation. The evidence of retrograde flow in the venous system after distal augmentation manoeuvre indicates valvular incompetence of the vein which is secondary to either prior DVT or post-thrombotic syndrome (Figure 5).

CONCLUSION

Ultrasound plays an integral role in the evaluation of patients in the emergency department. There are several indications in which ultrasound can be used as the initial modality for the assessment of patients. Patients with traumatic abdominal injury, acute abdomen, pelvic pain, scrotal pain, lower extremity deep venous thrombosis and paediatric patients will benefit from an ultrasound study first. Ultrasound has multiple advantages such as portability, accessibility and non-ionizing radiation. Because it has a simpler learning curve than CT or MRI, multiple specialties have incorporated ultrasound into their graduate medical education as well as patient evaluation. It is predicted that in the near future, ultrasound will replace the stethoscope for physical examination.

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