Ultrasound in the acute abdomen

Ultrasound is widely used as the first-line imaging modality in the assessment of the acute abdomen and in trauma (Marincek, 2002). Ultrasound has the advantages of low cost, real-time bedside imaging, accessibility, portability, lack of ionizing radiation, non-invasiveness, and multiplanar imaging. Ultrasound is also uniquely interactive and by asking the question 'Where does it hurt?' frequently directs the operator to the pathology. Doppler allows the detection of alteration in vascularity which may be a feature of inflammation, trauma and neoplasia.

Ultrasound can also be used to guide interventions such as nephrostomy and drainage procedures. Limitations include its operator dependence and the fact that bowel gas causes dense acoustic shadowing which may make bowel assessment difficult and limit views of retroperitoneal organs such as the pancreas. This article will give an overview of the role of ultrasound in the assessment of a range of pathologies which may present as an acute abdomen.

Hepatobiliary system

Acute cholecystitis

Acute cholecystitis occurs as a result of gallbladder neck or cystic duct obstruction by a calculus in 90% of cases.

Ultrasound is the initial examination of choice in diagnosis (sensitivity 85–94%). Ultrasound signs include: gallbladder wall thickening (>3 mm), 'splitting' of the gallbladder wall with a echopoor oedematous middle layer, a positive sonographic Murphy's sign, debris in the bile (as a result of pus, blood or sludge), increased colour Doppler flow in the gallbladder wall and pericholecystic fluid (*Figure 1*). Gallstones are identified in more than 90% of cases.

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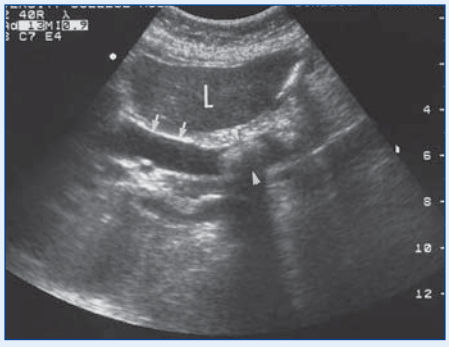
Complications of acute cholecystitis include gangrene of the gallbladder (20%), perforation of the gallbladder (5–10%), emphysematous cholecystitis and empyema of the gallbladder. Ultrasound can be used to guide insertion of a cholecystostomy tube in patients who are unfit for surgery.

Jaundice and biliary obstruction

The main role of ultrasound in the jaundiced patient is to ascertain whether jaundice is the result of an hepatic cause or secondary to obstruction. In obstructive jaundice the biliary tree is dilated and the role of ultrasound is to establish the level and cause. The distal common bile duct may be obscured, requiring further imaging to identify the cause. However, secondary clues as to the site of obstruction can be seen on ultrasound. For example pathologies in the pancreatic head such as a tumour may produce the 'double duct sign'; dilatation of the common bile duct and main pancreatic duct. Ultrasound can be used to guide the biliary drainage procedure.

Figure 1. Acute cholecystitis. The gallbladder wall is thickened and hyperaemic with an obstructing stone in the neck (arrow).

Figure 2. Obstruction of the common bile duct (arrows) by a gallstone (arrowheads). Liver (L).



Ultrasound is the initial investigation of choice in suspected common bile duct calculi but stones are only seen in approximately 50% (*Figure 2*). A liver abscess may present with jaundice and sepsis (*Figures 3a* and *b*). Ultrasound can be used to aspirate or drain the abscess according to size and number.

Renal tract

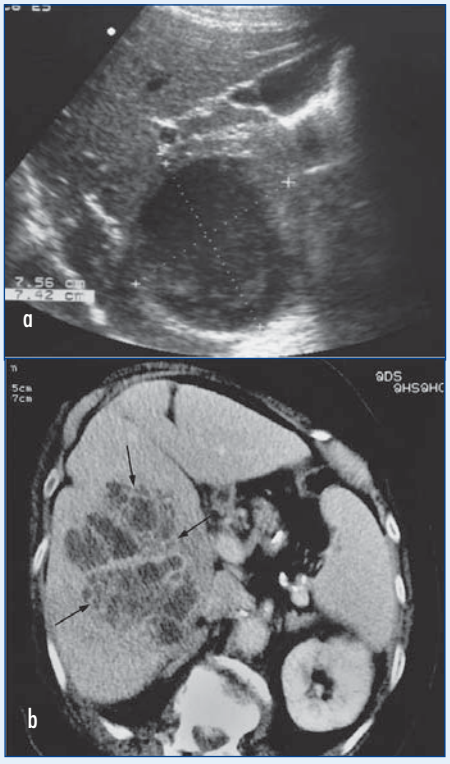
Renal colic and loin pain

Ultrasound is often the first imaging modality in the investigation of loin pain. This section will only outline renal emergencies but a more comprehensive review of the role of ultrasound in the renal tract has recently been published in *BJHM* (Niewiarowski et al, 2008).

Obstruction

Ultrasound is a very sensitive method for detecting pelvicalyceal dilatation, the hallmark of obstruction. However, the exact level and cause may be difficult to

Figure 3 Liver abscess. a. Ultrasound shows the abscess (between callipers) as an echopoor lesion full of debris. b. Computed tomography shows a rim enhancing multiloculated lower density area (arrows).



identify on ultrasound. The level is best demonstrated by intravenous urography or computed tomography (CT) intravenous urography.

If the site of obstruction is distal, dilated proximal ureters can often be traced for a few centimetres until they are hidden behind bowel gas. Dilated distal ureters may be seen in pelvic or bladder pathologies. The presence of ureteric jets in the bladder is useful for excluding complete obstruction. Pyonephros (seen as low level echoes in the renal collecting system) (*Figure 4*) may develop in an obstructed kidney which is an indication for nephrostomy guided by ultrasound.

Renal calculi

Ultrasound has a 96% sensitivity for renal stone detection (*Figure 5*) which is slightly inferior to CT. Stones bigger than 5 mm are detected with 100% sensitivity. Renal calculi are highly echogenic foci with well-defined posterior acoustic shadowing. The shadowing may, however, be difficult to demonstrate because of the proximity of the hyperechoic sinus echoes distal to the stone and if the calculus is smaller than the width of the ultrasound beam. Small stones may also be missed in the renal sinus because of the similar echogenicity of the renal sinus fat. For these reasons false-positive and false-negative studies are well recognized and the CT intravenous urogram is now the investigation of choice for calculi detection.

Figure 4. Pyonephrosis. Obstructed kidney with sludge level (arrow) in a hydronephrotic collecting system.

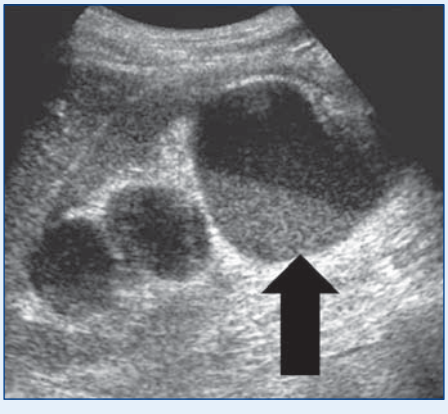
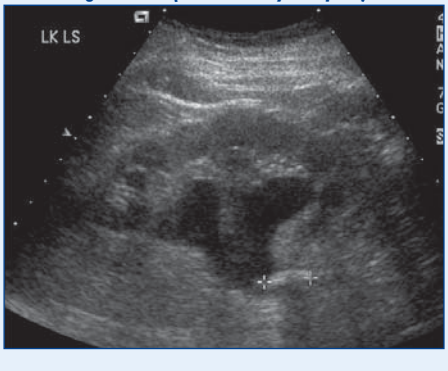


Figure 5. Hydronephrotic kidney caused by an obstructing calculus (measured by callipers).



Acute pyelonephritis

The kidneys usually appear normal. If abnormality is present the kidney may be swollen with reduced cortical echogenicity and loss of corticomedullary differentiation. Haemorrhagic necrosis is seen as areas of increased echogenicity.

Doppler ultrasound often exhibits reduced blood flow as a result of oedema as opposed to hyperaemia which might be expected (*Figure 6*). Hyperaemia can be seen around focal areas of inflammation. In emphysematous pyelonephritis gas characteristically produces focal areas of increased echogenicity with poorly defined posterior acoustic shadowing.

Acute pancreatitis

The majority of cases are caused by gallstones or alcohol and the diagnosis is usually based on clinical and laboratory findings (raised serum amylase). In the early stage of acute pancreatitis ultrasound has a limited role, being mainly used for the detection of gallbladders and bile duct stones. In mild forms the pancreas may appear sonographically normal. With progressive inflammation the pancreas enlarges and becomes echopoor with ill-defined margins. In complicated disease extrapancreatic fluid collections and pseudocysts can be detected, monitored and drained percutaneously or by endoscopic ultrasound if they become infected.

Ultrasound is also useful for looking for complications such as venous thrombosis and aneurysm formation. However, CT is still the imaging modality of choice for grading the severity and extent of necrosis, and for identifying complications.

Figure 6. Focal pyelonephritis or abscess (arrow) shown as a defect on power Doppler.

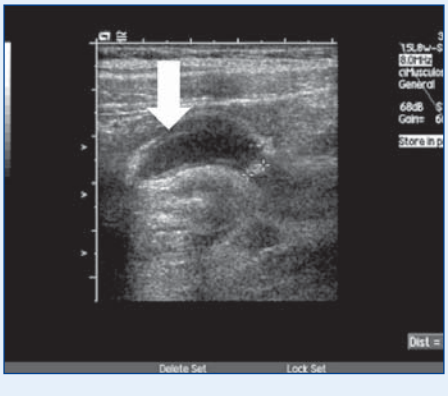
Gastrointestinal tract

Acute appendicitis

Appendicitis is one of the commonest causes of an acute abdomen. It is usually the result of obstruction of the appendix lumen by an impacted faecolith (*Figure 7*). If treatment is delayed perforation and abscess formation may occur. The presentation is usually characteristic but it may mimic gynaecological pathologies and non-surgical conditions such as mesenteric adenitis.

The normal appendix is seen in 2% of adults and 50% of children. Ultrasound has a sensitivity of 77–94% and a specificity of 90% in acute appendicitis. The inflamed appendix is seen as a non-compressible aperistaltic distended blind-ending tubular structure with a thickened echopoor wall of >2 mm and total transverse diameter of >6 mm. There may be increased Doppler blood flow seen in and around the appendix with localized periappendiceal fluid and prominent echogenic mesoappendiceal or caecal fat (indicative of inflammation). If the appendix appears normal it is important to visualize the whole length as inflammation may be confined to the tip (<5%).

Figure 7. Acute appendicitis seen as a thickened dilated appendix (arrow) with an appendicolith (between callipers).



Ultrasound features of acute gastrointestinal conditions

Concentric symmetrical bowel wall thickening may be seen in inflammatory conditions such as Crohn's disease or colitis with hyperaemia. Tumours usually appear as focal echopoor lesions with disruption of the normal layer pattern.

Inflammatory change in the mesenteric fat may be seen on ultrasound as a highly reflective area and may be regarded as a 'sentinel' sign of adjacent pathology.

In obstruction the bowel may be dilated with increased peristalsis and following this distally may lead to the cause. The hernia orifices can also be examined for a cause of obstruction. In ileus peristalsis is absent or reduced. Although CT is the investigation of choice diverticulitis may be diagnosed on ultrasound and is seen as an echogenic focus with or without a hypoechoic rim projecting beyond a thickened bowel wall. Intussusception (*Figure 8*) is seen on ultrasound as an intussusceptum invaginating into a intussuscipiens and has an onion ring configuration in transverse section.

Figure 8. Intussusception in a child. The intussusceptum (short arrows) invaginates into the intussuscipiens (long arrows). There is a small amount of anechoic trapped free fluid.

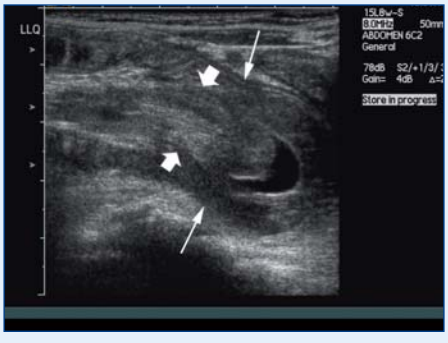
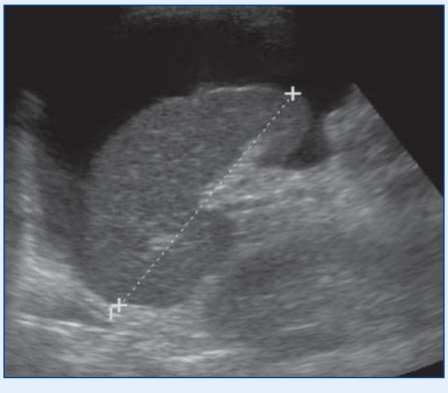


Figure 9. Ascites. Anechoic fluid is seen around the spleen.



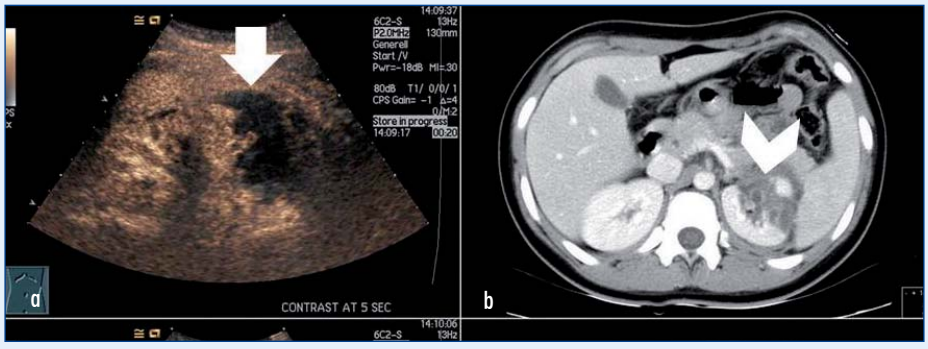


Figure 11. Renal trauma. a. An ultrasound contrast study showing a non-perfused lower pole which corresponds (b) to the unenhanced region (chevron) seen on the computed tomography.

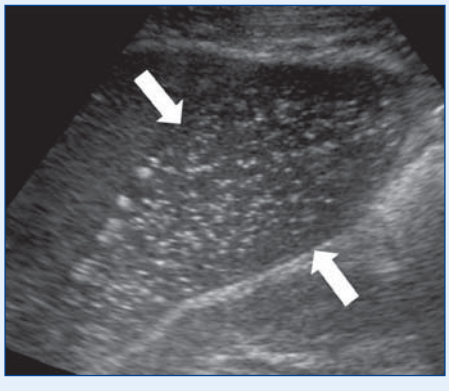
Fluid collections

The finding of fluid is common in the acute abdomen. This may be related to the primary condition or secondary to postoperative complications. The fluid may be free as in ascites (*Figure 9*) or confined as in an abscess (*Figure 10*). The sonographic appearances may help to assess whether it is infected or uncomplicated. The site of the fluid may give a clue to the underlying pathology even though it is not visualized itself, e.g. fluid with gas echoes around a duodenal perforation. A knowledge of facial planes and spaces is essential in assessing possible routes of fluid movement, e.g. appendicitis may produce a paracolic abscess. Ultrasound is useful for diagnostic aspiration and therapeutic drainage.

Abdominal aortic aneurysm

In suspected abdominal aortic aneurysm rupture CT is the investigation of choice with immediate surgery based on findings. However, a mobile ultrasound may be performed in casualty to rapidly exclude an aneurysm from the differential in abdominal pain.

Figure 10. Subhepatic abscess (between arrows) seen as a complex collection with locules of gas.



Trauma

Ultrasound generally has a secondary role to CT in trauma. However, the FAST (focused assessment with sonography for trauma) scanning system has been used as an initial screening tool in blunt trauma and is solely directed at identification of free fluid so that the patient may be triaged to CT and/or laparotomy. FAST is not a complete diagnostic assessment but consists of four basic views: subxiphoid, right upper quadrant, left upper quadrant and suprapubic regions. Ultrasound is more sensitive at detecting free fluid than the organ injury directly and CT is more accurate in this respect.

There is controversy regarding the accuracy of FAST but a study of over 4000 patients showed that hypotensive patients with a positive FAST scan can go directly to laparotomy without the need for further imaging (Lee et al, 2007). The negative predictive value of FAST is high (93–98%). Solid organ injuries are usually assessed by CT but a study showed that contrast-enhanced ultrasound was significantly more accurate than baseline ultrasound and almost as accurate as CT (Valentino et al, 2006) (*Figure 11*). However, ultrasound cannot image bowel, retroperitoneal and spinal injury.

Conclusions

Ultrasound is often the initial modality used in imaging the patient with an acute abdomen. Because of its versatility it can be used in a wide range of clinical environments and is able to accurately identify a large spectrum of pathologies in different viscera. **BJHM**

Figures 1 *and* 7 *are reproduced from Harvey et al (2005) and* Figures 2 *and* 3 *are reproduced from Harvey et al (1999) by kind permission of Oxford University Press.*

Conflict of interest: none.

Harvey C, Roberts H, Davies N, Strickland N, Scurr J (1999) *Radiology. A Casebook for MRCP.* Oxford University Press, Oxford

Harvey C, Roberts H, Shaw P (2005) *Self Assessment Cases in Surgical Imaging.* Oxford University Press, Oxford

Lee B, Ormsby E, McGahan J, Melendres G, Richards J (2007) The utility of sonography for the triage of blunt abdominal trauma patients to exploratory laparotomy. *AJR* **188**: 415–21

Marincek B (2002) Nontraumatic abdominal emergencies: acute abdominal pain: diagnostic strategies. *Eur Radiol* **12**: 2136–50

Niewiarowski S, Lloyd C, Hart J, Harvey C (2008) Ultrasound imaging of the kidneys. *Br J Hosp Med* **69**: M52–5

Valentino M, Serra C, Zironi G De Luca C, Pavlica P, Barozzi L (2006) Blunt abdominal trauma: Emergency contrast-enhanced sonography for detection of solid organ injuries. *AJR* **186**: 1361–7

KEY POINTS

- Ultrasound is widely used as the first-line imaging modality in the assessment of the acute abdomen.
- Ultrasound has the advantages of low cost, real-time bedside imaging, accessibility, portability, lack of ionizing radiation, non-invasiveness, and multiplanar imaging.
- Ultrasound is very sensitive (more than computed tomography) in the detection of gallbladder stones.
- Ultrasound is highly sensitive in the detection of renal stones but computed tomography is the modality of choice in acute renal colic as the entire renal tract can be imaged.
- Ultrasound is highly sensitive in the detection of pelvicalyceal dilatation, the hallmark of obstruction.
- Ultrasound is very sensitive in the detection of acute appendicitis.
- Ultrasound can also be used to guide interventions such as nephrostomy and aspiration and drainage procedures.
- In trauma the FAST (focused assessment with sonography for trauma) scanning system can triage patients to computed tomography and/or laparotomy.