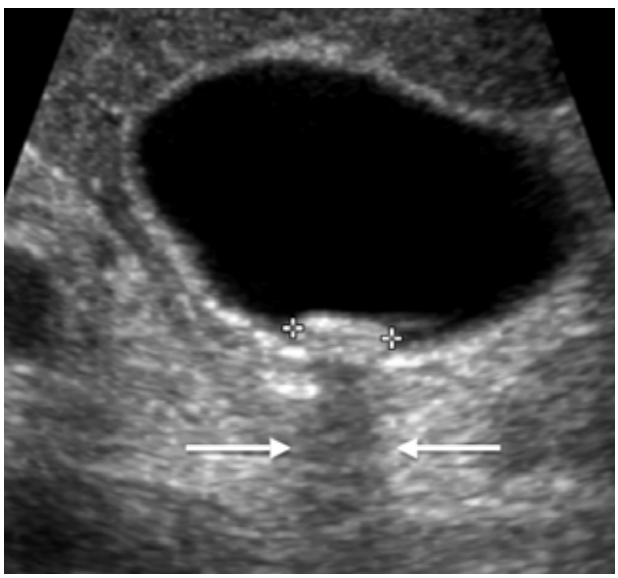
Tom Sutherland
MBBS(Hons), is Senior Registrar, Medical Imaging Department, St Vincent's Hospital, Melbourne, Victoria. tom.sutherland@svhm.org.au

Demystifying abdominal ultrasound

Abdominal ultrasound is an extremely useful test for evaluation of patients with right upper quadrant pain or abnormal liver function tests. The terminology associated with ultrasound can be confusing. However, a basic understanding of ultrasound's language, uses and limitations can eradicate confusion and greatly add to patient care. This article details how the ultrasound can be used in commonly encountered pathologies of the liver and biliary system.

Figure 1. An echogenic gallstone (between the callipers) in the dependent portion of the gallbladder casts an acoustic shadow (arrows)



Ultrasound is noninvasive, radiation free, readily available and cheap compared with computed tomography (CT) and magnetic resonance imaging (MRI). Limitations include its operator dependent nature and suboptimal imaging in many obese patients and in patients with interposed bowel gas.

Ultrasound contrast agents were not widely used until the recent introduction of second generation agents such as Definity and SonoVue, which are administered intravenously and allow the enhancement patterns of focal hepatic masses to be determined. A number of studies[1,2] on these contrast agents have shown good results in differentiating benign from malignant hepatic masses. Despite these improvements, it is safest to use ultrasound as a screening test using CT or MRI to further evaluate sonographically detected focal hepatic masses, and seeking specialist opinion.

Investigation of right upper quadrant pain

Gallstones

Ultrasound is an excellent first line investigation for cholelithiasis. Stones are echogenic structures that cast acoustic shadows (dark bands extending behind the bright calculus) (*Figure 1*). Sludge within the gallbladder appears as an echogenic fluid-fluid level against the normally anechoic (black) bile.

A normal gallbladder wall in a fasted patient measures less than 3 mm. Wall thickness is increased in chronic cholecystitis from chronic inflammation and fibrosis and in acute cholecystitis from oedema. In acute cholecystitis fluid adjacent to the gallbladder (pericholecystic fluid) is often demonstrable and an impacted stone within the gallbladder neck is usually visible; gallbladder tenderness can also be elicited.

Stones within the common bile duct (CBD) have a similar appearance to stones in the gallbladder. It is not uncommon to be unable to visualise the distal common bile duct. In these cases, distal calculi cannot be excluded, and CBD dilatation is a clue to distal pathology. A useful rule of thumb for maximal CBD size is 6 mm plus 1 mm for every decade the patient is over 60 years of

age. The CBD is larger in patients who have had cholecystectomy. Unless a CBD stone is visualised, an obstructing carcinoma must be excluded (duct distension should not be assumed to be due to choledocholithiasis). Appropriate next steps include a CT of the pancreas or a CT cholangiogram (bilirubin must be less than 30 µmol/L for hepatic cholangiogram contrast excretion). Magnetic resonance cholangiopancreatography (MRCP) has a high sensitivity and specificity for detection of choledocholithiasis and biliary strictures and is not limited by the patient's liver function.

Investigation of abnormal liver function tests

Fatty infiltration

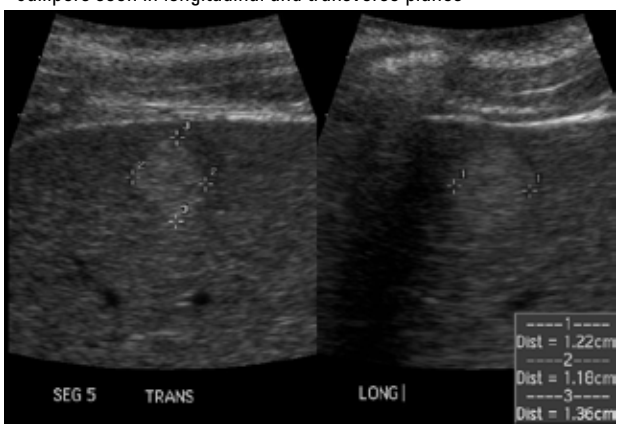
Sonographically fatty infiltration is appreciated as increased hepatic echogenicity (brightness), often with attenuation of the ultrasound beam as the echogenic fat reflects the ultrasound wave and obscures the deep aspect of the liver. Assessment of hepatic echogenicity is subjective, which means the diagnostic utility is limited in mild cases. An echogenic liver is not specific for fatty infiltration and can be seen in cirrhosis and hepatitis.

Fatty infiltration can be either focal or diffuse. Focal fatty infiltration typically occurs near the gallbladder or porta hepatis and is largely of no clinical significance. Diffuse fatty infiltration, on the other hand, can occur in nonalcoholic fatty liver disease, which is associated with obesity and diabetes; it can also occur in hepatitis of any cause, including viral and toxic (including chemotherapy), hence further assessment may be warranted.

Chronic liver disease

Ultrasound is frequently used to screen patients with chronic liver disease for complications such as hepatocellular carcinoma (HCC) and portal hypertension. Because many of the early findings are subtle, normal hepatic imaging does not exclude cirrhosis. Classically cirrhotic livers have a coarse echotexture due to the regenerating nodules deforming the normally uniform hepatic parenchyma. Nodularity of the liver capsule can be demonstrated, especially when the liver is outlined with ascites.

Figure 2. A homogenous echogenic haemangioma outlined by callipers seen in longitudinal and transverse planes



Portal hypertension is detected by demonstrating recanalisation of the paraumbilical vein, other varicies, splenomegaly, ascites or altered flow in the portal vein, which may also be enlarged. Normal portal vein flow is toward the liver (hepatopetal); with worsening portal hypertension, flow reverses to pass away from the liver (hepatofugal).

Hepatocellular carcinoma has a variable appearance and can be of any echogenicity relative to the liver. They are typically nodular masses. However, regenerating and dysplastic nodules appear similar sonographically; to further investigate a new sonographic mass in a cirrhotic liver, multiphase hepatic CT is required. Correlation with alpha fetoprotein is also indicated.

Incidental findings

Hepatic cysts

Cysts occur most commonly within the kidneys, with the liver being the next most frequently involved organ. Cysts are anechoic with imperceptible walls. Because the fluid does not absorb or reflect the ultrasound wave, their deep wall and the liver behind them appear abnormally bright (posterior acoustic enhancement).

Clinical significance: usually incidental discoveries of no clinical significance.
Next step: hepatic CT or MRI if complex or atypical or if there are multiple cysts.

Haemangiomas

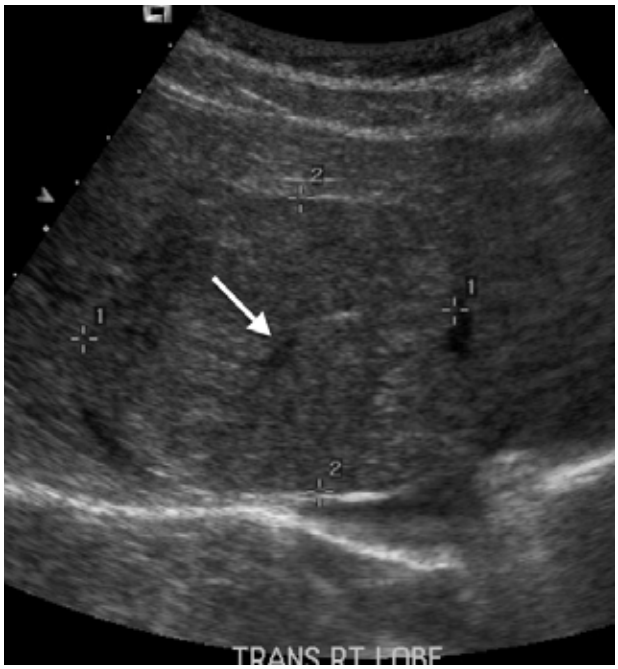
Haemangiomas are common benign masses. They are typically well demarcated and echogenic (*Figure 2*) as the dilated and tortuous vascular channels within them reflect the ultrasound beam. The blood flow within haemangiomas is slow, so no flow is seen on colour Doppler imaging. Large haemangiomas have a less predictable appearance and can be hypo-, iso- or hyper-echoic. Ultrasound contrast agents show characteristic peripheral nodular enhancement with progressive filling in of lesions, with increasing delay postinjection.[3] Multiphase hepatic CT and MRI show the same enhancement pattern.

Clinical significance: none (other than that the haemangioma should not be mistaken for another hepatic lesion).
Next step: ultrasound with contrast or MRI or multiphase CT of the liver to confirm the diagnosis.

Focal nodular hyperplasia

Focal nodular hyperplasia (FNH) is a benign, nonneoplastic proliferation of hepatocytes. Between 80–95% of cases occur in females, typically in those aged in their 20s and 30s.[4] Compared to normal liver, FNH are classically slightly hypo- or iso-echoic and have a central hypoechoic 'scar' (*Figure 3*) with radiating, spoke-like vessels that contain flow on colour Doppler imaging. Often the findings are not characteristic enough to make a definitive

Figure 3. A spherical focal nodular hyperplasia (outlined by callipers) is slightly hypoechoic to normal liver. Central scar (arrow) contained flow on Doppler images



diagnosis and further imaging is required. Ultrasound contrast agents show enhancement of the central scar with the enhancement spreading in a peripheral direction.[5] Sulphur colloid scans, while diagnostic if positive, have a false negative rate of up to 30%. Magnetic resonance imaging with hepatocyte specific contrast agents such as Primovist is widely used to differentiate FNH from other hypervascular masses such as metastases, HCC and hepatic adenomas.

Clinical significance: none (other than that FNH should not be mistaken for another hepatic lesion).
Next step: MRI with Primovist if ultrasound is not diagnostic, specialist referral.

Hepatic adenoma

Hepatic adenomas are uncommon benign neoplasms of hepatocytes that typically occur in young females and are associated with use of the oral contraceptive pill.[6] Appearing as solitary or multiple masses, they are hormonally responsive and can shrink with cessation of the pill and increase in size during pregnancy. Although usually asymptomatic, they may cause symptoms by mass effect on adjacent structures or by haemorrhage (either contained within the liver or spilling into the peritoneal cavity). Rare transformation into HCC has been described. Due to the risk of haemorrhage and malignant transformation, surgical review is recommended. Sonographically, adenomas are well defined, of varied echogenicity and are often heterogenous due to intralesional haemorrhage, necrosis, calcification and fat.

Clinical significance: tendency to bleed, which can be catastrophic, rarely have malignant potential.
Next step: hepatic MRI, surgical referral.

Metastases

Metastases can be solitary or multiple and are generally spherical, hypoechoic (dark) masses that have vascularity on colour Doppler imaging. Many metastases are unexpected findings that represent a new diagnosis of malignancy. Thorough explanation, history, examination and investigation are obviously required. A CT of the chest, abdomen and pelvis helps with staging and possible identification of the primary malignancy.

Clinical significance: prognosis depends on the primary malignancy.
Next step: thorough explanation, history, examination and tailored investigation. A CT of the chest, abdomen and pelvis is usually required.

Adenomyomatosis

Adenomyomatosis is usually asymptomatic, often coexists with gallstones and has no malignant potential. Pathologically there is hyperplasia of the gallbladder wall and intramural mucosa lined diverticuli (Rokitansky-Aschoff sinuses) that accumulate cholesterol crystals.[7] Sonographically there is focal or diffuse wall thickening coupled with a characteristic comet tail or ring down artifact. (This is produced from the cholesterol in the sinuses – echogenic spots with multiple smaller echogenic dots in a line.) (*Figure 4*).

Figure 4. Transverse view of the gallbladder with comet tail artefact (arrow) consistent with adenomyomatosis

Figure 5. Soft tissue polyp (between callipers) on the antidependent gallbladder wall is similar echogenicity to adjacent liver and does not cast a shadow

Clinical significance: none.
Next step: no further action required.

Gallbladder polyps and carcinoma

Gallbladder polyps are asymptomatic and are usually discovered incidentally. Approximately 50% are cholesterol polyps with no malignant potential. They can also be gallbladder adenomas, which are benign, although a small number will progress to carcinoma. Polyps greater than 10 mm in size are 24 times more likely to be malignant than polyps under 10 mm;[8] therefore surgical referral is warranted fir larger polyps. Polyps appear as echogenic, polypoid masses that protrude into the gallbladder lumen with no acoustic shadow (*Figure 5*).

Gallbladder carcinomas are uncommon, and are often found during a cholecystectomy rather than on preoperative imaging. They appear as focal gallbladder masses that have usually invaded directly into the liver at presentation or have associated hepatic metastases.

Clinical significance: polyps <10 mm are usually of no significance. Polyps >10 mm have a risk of malignant change. Gallbladder carcinoma has poor prognosis as it is usually disseminated at diagnosis.
Next step: polyps <10 mm require annual ultrasound review. Polyps >10 mm warrant surgical referral. Gallbladder carcinoma require referral and further investigation.

Summary of important points

- Ultrasound is a useful initial imaging modality for patients with right upper quadrant pain or abnormal liver function tests.
- Patients with an incompletely imaged, dilated CBD need further evaluation with CT or MRI to exclude choledocholithiasis, strictures or malignancy.
- Focal hepatic lesions discovered on ultrasound should be further characterised with multiphase CT or MRI. Specialist opinion is also recommended for all hepatic masses (other than definite cysts and haemangiomas).
- Patients with gallbladder polyps >10 mm should be referred for a surgical opinion. Polyps <10 mm can be monitored with annual ultrasound.

Conflict of interest: none declared.

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AFP CORRESPONDENCE afp@racgp.org.au