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REVIEW

Focal lesions of the liver: imaging appearances and management

Anitha James[1]

Author details can be found at the end of this article

Correspondence to:
Anitha James;
anitha.james@uhnm.nhs.uk

Abstract

With the increasing use of cross-sectional imaging, the detection of incidental liver lesions has become more common. Accurate and reliable characterisation of these is vital for optimal patient care. Owing to the great improvements in medical imaging technology in recent years, particularly magnetic resonance imaging, it is now possible to characterise a significant proportion of these non-invasively. This is of paramount importance in improving patient safety and reducing costs by avoiding unnecessary biopsies. This article gives a synopsis of the different imaging modalities for liver. It depicts the salient imaging features of the common benign and malignant focal liver lesions on different imaging modalities, with emphasis on magnetic resonance imaging. It demonstrates the pseudolesions, variants, mimics and pitfalls that occur in liver imaging. The tailored magnetic resonance imaging protocols including abbreviated ones, the contrast agents and the pathway for managing incidental liver lesions in the author's institution are covered.

Key words: Cholangiocarcioma; Computed tomography; Focal liver lesion; Focal nodular hyperplasia; Haemangioma; Hepatocellular adenoma; Hepatocellular carcinoma; Imaging; Liver; Magnetic resonance imaging; Radiology; Ultrasound

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Introduction

Incidental focal liver lesions or 'incidentalomas' are common in this age as a result of the remarkable advances in cross-sectional imaging and its frequent use in patient management. This is a double-edged sword. Without a judicious approach and sound management pathways, this can lead to unnecessary patient anxiety and can significantly increase healthcare costs. Radiologists now have excellent tools in their arsenal that help to characterise a significant number of focal liver lesions without resorting to invasive procedures such as biopsy. This article discusses the imaging modalities, radiological appearances of benign and malignant liver lesions, and their management.

Technique, imaging modalities and contrast agents

Several modalities are used to image the liver, each with their own strengths and weaknesses. Ultrasound is often the first line of investigation for imaging the liver. It is cheap, universally available, quick and has no radiation burden to the patient. It is an excellent initial imaging modality for the liver in the right patient, but depends very much on the patient, the operator and the type of lesion. In larger patients or in patients who cannot cooperate with breath holding, it is of limited value. Unenhanced ultrasound can also only characterise a handful of lesions. Contrast-enhanced ultrasound, on the other hand, can characterise a larger repertoire of lesions, but needs more specialist imagers, uses a contrast agent and has longer scanning time. Computed tomography is the workhorse of any imaging department and is very useful for liver surveillance in known cancer patients. It can be performed as single phase for surveillance purposes or triple phase for characterisation of liver lesions. Computed tomography, especially triphasic computed tomography, has a radiation burden, needs intravenous contrast and is inferior to magnetic resonance imaging in contrast resolution. The advantages include very quick scanning time and wide availability. Magnetic resonance imaging is generally considered the imaging modality of choice for the liver. It has a striking advantage in contrast resolution and lack of exposure to ionising

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radiation. It also has many different sequences to help the diagnostic process (Table 1). Some liver lesions can be characterised without intravenous contrast. The disadvantages include availability, cost and relatively long scanning time.

The contrast agents currently used for ultrasound are gas-filled microbubbles stabilised by a shell made by albumin, surfactants or phospholipids (D'Onofrio et al, 2015). They are generally safe, with low risk of hypersensitivity. The gas is excreted by the lungs and the shell by the liver. There is no nephrotoxicity and, as such, these are useful in patients with renal impairment.

Computed tomography uses iodinated contrast agents and, in current practice, non-ionic, iso-osmolar or low-osmolar agents are used. They are relatively contraindicated in patients with significant renal impairment to avoid contrast-induced nephropathy. They have a higher rate of hypersensitivity reactions than the contrast agents used for ultrasound and magnetic resonance imaging.

Magnetic resonance imaging uses mostly gadolinium-based contrast agents, although less commonly, manganese-based agents or superparamagnetic iron oxide agents may be

Table 1. Magnetic resonance imaging sequences for liver imaging

Name of sequence	Description	Uses	Disadvantage	Some vendor-specific acronyms
T1 weighted sequences (T1W)	In phase and out of phase (spoiled gradient echo or GRE sequence)	Helps to detect intralesional fat, liver steatosis and iron overload	Prone to susceptibility artefacts	FLASH SPGR FFE-T1
	3D GRE fat-saturated T1W Pre and post contrast	Pre-contrast T1W sequences help detect blood, fat and protein. Post-contrast multiphasic sequences detect the dynamic enhancement characteristics of different liver lesions helping characterisation	Movement sensitive	VIBE LAVA THRIVE
T2 weighted sequences (T2W)	Single shot fast spin echo or SSFSE Heavy T2W	Valuable overview Relatively resistant to susceptibility and movement artefacts Useful to differentiate cysts and haemangiomas from solid liver tumours	Low overall signal Blurry soft tissue detail Less suitable for fat saturation	HASTE SS-FFE SSH- TSE
	Fast or turbo spin echo Moderate T2W	Very good for lesion detection Allow distinction of solid from cystic-like lesions Fat suppression is regularly applied	Motion sensitive Needs breath hold	TSE/FSE
	PROPELLER-TSE	Correction of motion artefacts	Longer acquisition time	BLADE, PROPELLER, MULTIVANE
	Diffusion weighted sequences Diffusion-weighted imaging-visual assessment Apparent diffusion coefficient map is a graphical representation of diffusion-weighted imaging-quantitative assessment	Valuable for lesion detection and characterisation based on the mobility of water protons in the lesion	Prone to movement and susceptibility artefacts	REVEAL eDWI Body DWI

From Donato et al (2017)

used. They may be extracellular-based contrast or hepatocyte-specific contrast agents, depending on the indication for the scan (Table 2). The latter gives an additional delayed phase where the contrast is excreted by the hepatocytes into the biliary tract. This is very useful to detect lesions containing hepatocytes or 'hepatocytic lesions'. The gadolinium-based contrast agents may also be categorised as macrocyclic or linear and ionic or non-ionic based on their physicochemical properties. Gadolinium-based agents are considered less nephrotoxic and less prone to inducing hypersensitivity reactions because of their lower injected doses. However, they are generally contraindicated in patients with severe renal impairment because of the potential for nephrogenic systemic fibrosis, a very rare but lethal complication. Macrocyclic agents are considered safer in this regard. Some linear agents have recently been withdrawn to improve patient safety. There have been reports that gadolinium is retained in tissues long after administration (Guo et al, 2018). The consequences are currently unknown and there is currently no published evidence to suggest any long-term complications.

Other advantages of magnetic resonance imaging include multiplicity of sequences, which help to detect the tissue characteristics. These may be T1 (T1W) or T2 (T2W) weighted. Another valuable sequence is diffusion-weighted imaging, which detects the random movement of water protons within tissues. Depending on the cellularity and presence of intact cell membrane, different lesions 'restrict' water molecule diffusion to varying extent. Apparent diffusion coefficient is a quantitative measure of diffusion restriction and is calculated by magnetic resonance imaging software to create a map called an apparent diffusion coefficient map. Some magnetic resonance imaging sequences help to detect intralesional fat and some others are very fluid sensitive. Magnetic resonance imaging sequences have generic and vendor-specific acronyms (Table 2). Different departments will have different magnetic resonance imaging protocols for liver imaging depending on the sequences used, whether contrast is given and the type of contrast (Table 3).

Benign liver lesions

Simple cyst

A simple cyst is the most common liver lesion (Figure 1); a clear fluid-filled lesion lined by biliary cuboid epithelium. They are usually asymptomatic and left alone, unless they become large enough to cause pain or get complicated by internal bleeding or infection (Figure 2). On ultrasound, simple cysts are anechoic structures with an imperceptible wall. On computed tomography the attenuation is similar to water (0–15 Hounsfield units or HU). The magnetic resonance imaging signal also reflects that of water with T2 hyperintensity and T1 low intensity.

Table 2. Gadolinium-based magnetic resonance imaging contrast agents

	Examples	Uses and advantages	Disadvantages
Extracellular agents	Gadoterate meglumine (Dotarem) Gadoteridol (ProHance) Gadobutrol (Gadovist)	Standard liver imaging Shorter scanning time compared to hepatobiliary agents Cheaper Better arterial phase image quality	Only dynamic phase available Less sensitive than hepatobiliary phase for detecting small hypovascular metastasis
Hepatocellular agents	Gadoxetic acid (Primovist) Gadobenate dimeglumine (MultiHance)	Detection of hepatocellular lesions like focal nodular hyperplasia and cirrhotic nodules which enhance in the hepatobiliary phase Detection of small hypovascular metastasis before hepatic resection because of added sensitivity, so used for staging colorectal cancer Can be used for detecting bile leak in postoperative or trauma patients	Considerably more expensive Longer scanning time Poorer arterial phase image quality compared to extracellular agents May be less safe as these are linear agents

Table 3. Tailored liver magnetic resonance imaging protocols in the author's department and indications

Protocol	Indications
Non-contrast	If lesions are suspected to be the following based on computed tomography or ultrasound:
	Simple cysts
	Haemangiomas*
	Focal fatty infiltration
	Focal fatty sparing
Magnetic resonance imaging with extracellular contrast agent	Complex cysts
	Haemangiomas with atypical features on initial non-contrast magnetic resonance imaging
	Abscesses
	Metastases
	Primary liver tumours
Magnetic resonance imaging with hepatobiliary contrast agent	Focal nodular hyperplasia vs hepatocellular adenoma
	Assessment of colorectal liver metastasis
	Cirrhotic liver
	Suspected bile leak, post-surgery or trauma

**Non-contrast magnetic resonance imaging is used to characterise haemangiomas only if they are entirely typical: well-defined, intensely T2 bright and without restriction of diffusion. If any features are atypical, the patient will be recalled for contrast*

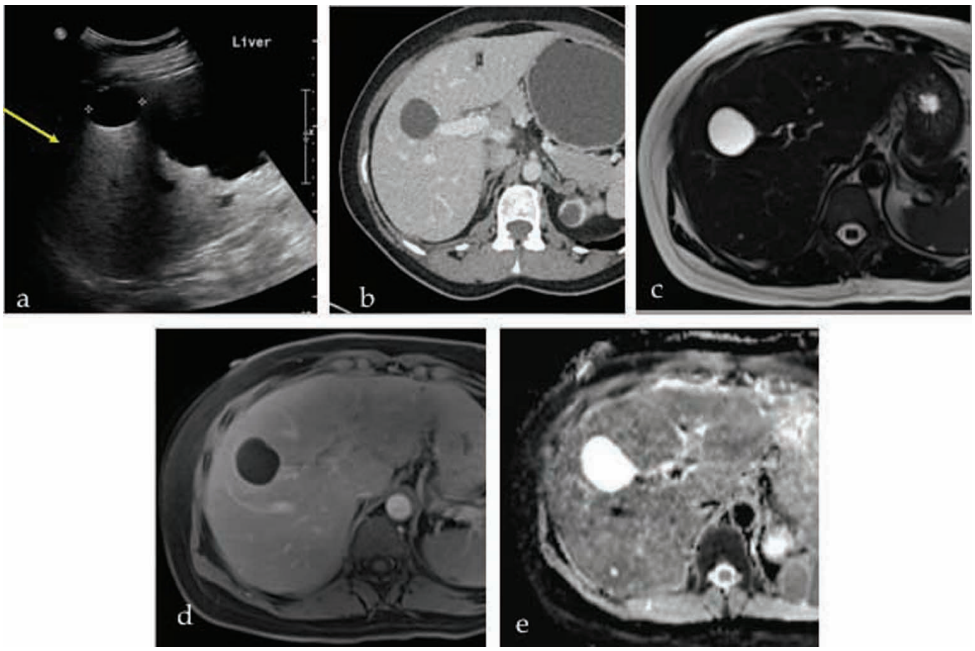

Figure 1. a. Ultrasound image of simple cysts shows well-defined anechoic lesions with posterior acoustic enhancement (arrow). b. Computed tomography image shows a hypodense lesion with imperceptible wall. c. Axial T2W image shows an intensely T2 bright well-defined lesion. d. Axial T1W post-contrast image shows no internal enhancement. e. Apparent diffusion coefficient map shows no restriction of diffusion.

Developmental cyst

Developmental cysts include adult polycystic kidney disease, biliary hamartomas or Von Myenberg complexes and ciliated hepatic foregut cysts (Figure 3). Adult polycystic kidney disease is usually associated with liver and renal cysts but rarely can have isolated liver involvement. The cysts are often numerous and large and can be complicated by haemorrhage, rupture, infection and, very rarely, liver failure if there is extensive involvement. Biliary

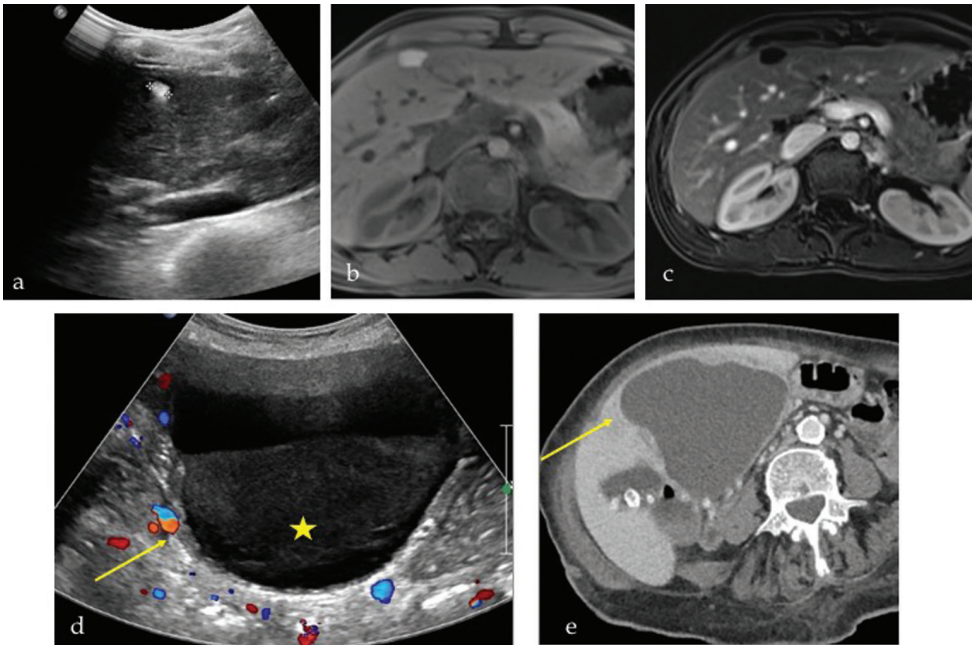

Figure 2. Haemorrhagic cyst on (a) ultrasound, (b) pre-contrast T1W magnetic resonance imaging and (c) post-contrast T1W magnetic resonance imaging. It is echogenic on ultrasound, T1 bright and shows no enhancement. Infected cyst on (d) ultrasound and (e) postcontrast computed tomography. Note thick, enhancing wall and internal debris (star).

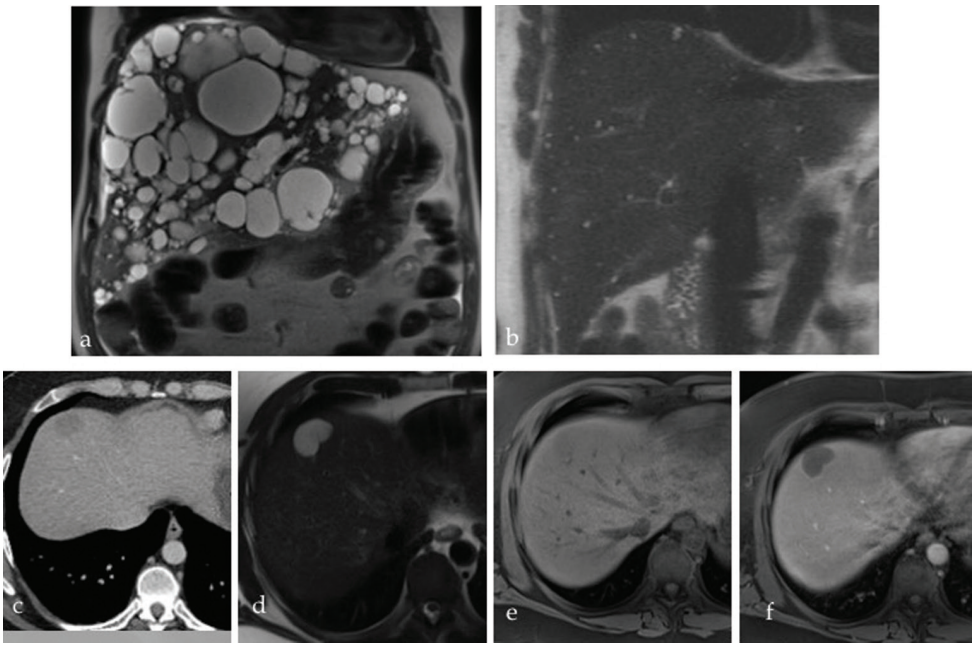

Figure 3. a. T2W magnetic resonance imaging shows polycystic liver disease with innumerable cysts replacing the liver. B. T2W magnetic resonance imaging of biliary hamartomas with numerous tiny cyst-like lesions. c. Computed tomography, (d) T2W magnetic resonance imaging, (e) T1W pre- and (f) post-contrast magnetic resonance imaging of ciliated hepatic foregut cyst, seen as a well-defined hypodense lesion on computed tomography, T2 bright and isointense on T1W without enhancement.

hamartomas are small (<1.5 cm), numerous, nodular, cystic lesions with similar imaging characteristics as simple cysts. Owing to their small size, they are asymptomatic in the vast majority and are left alone. Ciliated hepatic foregut cysts are rare congenital foregut duplication cysts. Cyst contents may vary from serous to mucoid. Imaging features reflect the contents of the ciliated hepatic foregut cyst and may be iso or hypoechoic on ultrasound and hypodense to isodense on computed tomography. They may be hyperintense

on T2W magnetic resonance imaging and hypo, iso or hyperintense on T1W magnetic resonance imaging. The cysts do not enhance with contrast. Very rarely these lesions can have malignant transformation and hence they are usually followed up. If symptomatic, resection also may be considered.

Mimics

These include pseudocysts and cholangitic abscesses (Figure 4). Pseudocysts are usually subcapsular and have can have internal echoes on ultrasound and higher density or signal on computed tomography and magnetic resonance imaging depending on the contents. Cystic tumours can also mimic haemorrhagic cysts (Figure 5) but will have tell-tale features such as rim or internal enhancement.

Haemangioma

This is the most common solid benign liver lesion. Small lesions are typically echobright on ultrasound and cause posterior acoustic enhancement, but can appear hypoechoic if the background liver is fatty (Figure 6). If typical appearances are seen, it can be completely diagnosed on ultrasound. On computed tomography the hallmark is peripheral discontinuous enhancement with centripetal filling on the delayed phase. The contrast density matches the blood pool in all phases. On magnetic resonance imaging, the lesion is intensely bright on T2W and low on T1W, with a similar enhancement pattern as in computed tomography (Figure 7). Variants include small haemangiomas, which fill instantly, called flash filling haemangioma, and giant cavernous haemangioma, which measure over 5 cm in diameter.

Pitfalls in imaging haemangiomas

Sclerosed or hyalinised haemangioma will have atypical imaging features (Figure 8) because of the presence of fibrous tissue and thrombosis of vascular channels. This leads to variable imaging features (Doyle et al, 2007), which cannot usually be distinguished from malignant lesions without biopsy. Another pitfall is apparent 'washout' in haemangiomas on magnetic resonance imaging using hepatocyte-specific contrast (Figure 9). Washout refers to hypointensity (magnetic resonance imaging) or hypodensity (computed tomography) of

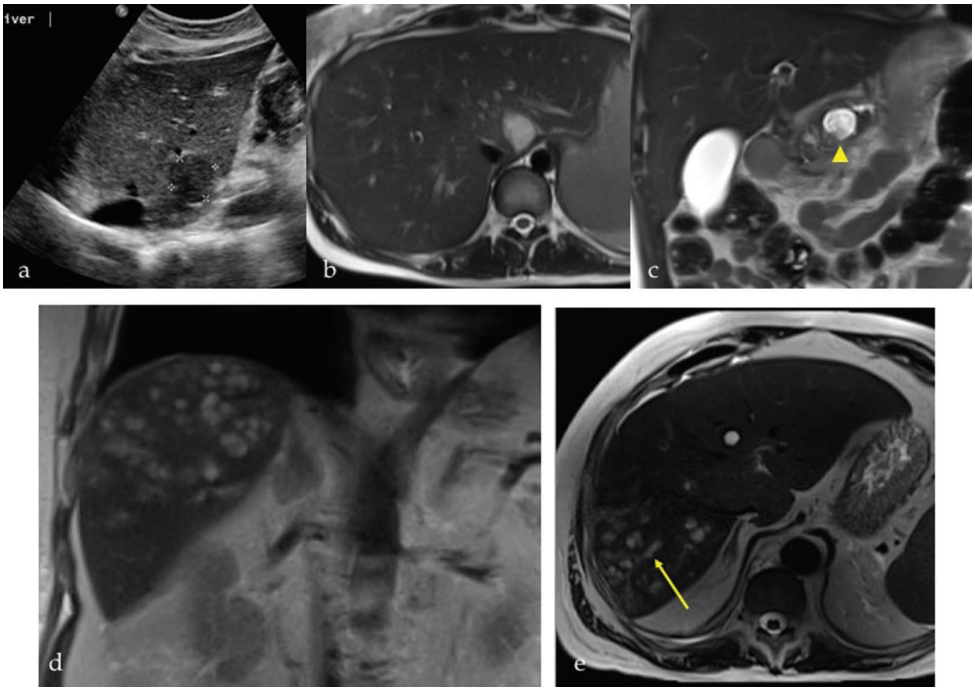

Figure 4. a. Pseudocyst on ultrasound seen as a hypoechoic lesion. b. T2W magnetic resonance imaging shows hepatic pseudocyst. c. Coronal T2W magnetic resonance imaging shows an intrapancreatic pseudocyst in the same patient as b. d and e. Cholangitic abscesses seen as T2 bright lesions clustered around a dilated bile duct (arrow). These are less well-defined than simple cysts.

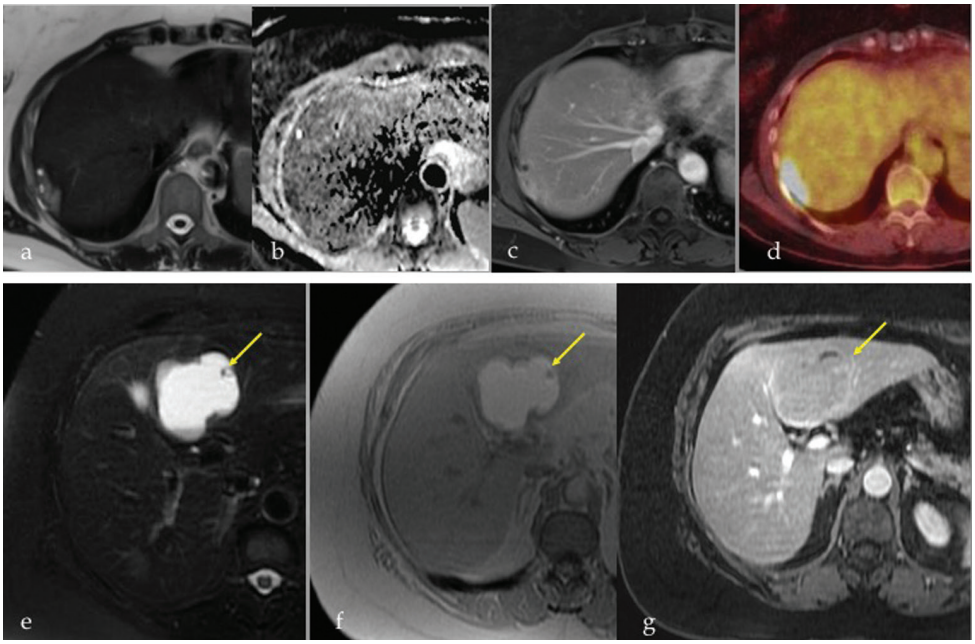

Figure 5. a. Cystic capsular metastasis from ovarian cancer on T2W magnetic resonance imaging. b. Apparent diffusion coefficient map which shows restricted diffusion. c. Post-contrast T1W magnetic resonance imaging shows internal enhancement. d. Positron emission tomography-computed tomography fused image showing intense fluorodeoxy glucose uptake. Biliary cystadenoma on (e) T2W magnetic resonance imaging, (f) pre- and (g) post-contrast magnetic resonance imaging. A mural nodule is seen (arrows) which shows enhancement. Internal contents are T1 bright suggesting mucin or blood products.

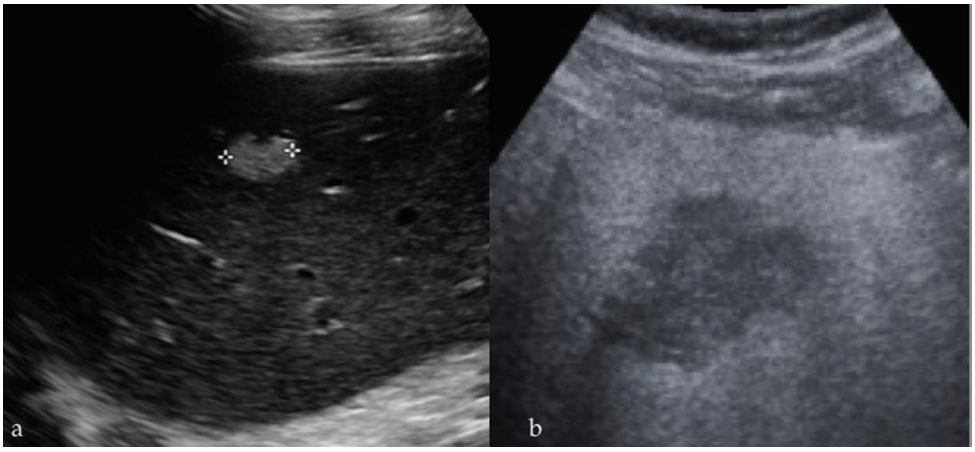

Figure 6. a. Ultrasound of a haemangioma in a normal liver. It is well-defined and echobright. This appearance is diagnostic of a haemangioma without further imaging. b. Ultrasound of a haemangioma in a fatty echogenic liver. It appears hypoechoic and needs further imaging to characterise.

the lesion compared to hepatic parenchyma in the portal venous or more delayed phases. The washout can occur at 5 minutes because the hepatobiliary phase may start as early as 5 minutes. As haemangiomas lack hepatocytes they do not retain hepatobiliary contrast.

Focal nodular hyperplasia

This is the second most common solid benign liver lesion (Darai et al, 2015). It is a regenerative nodule thought to be a response to vascular insult; it is more common in women, with a male:female ratio of 1:8. It is composed of functioning hepatocytes and hence retains hepatobiliary contrast agent. Twenty per cent are multiple and classical lesions have a central scar. The lesions are usually homogenous and well-defined. On ultrasound it is hypoechoic or isoechoic; the larger lesions may demonstrate a central scar. On computed tomography (Figure 10) and magnetic resonance imaging with extracellular contrast (Figure 11), the

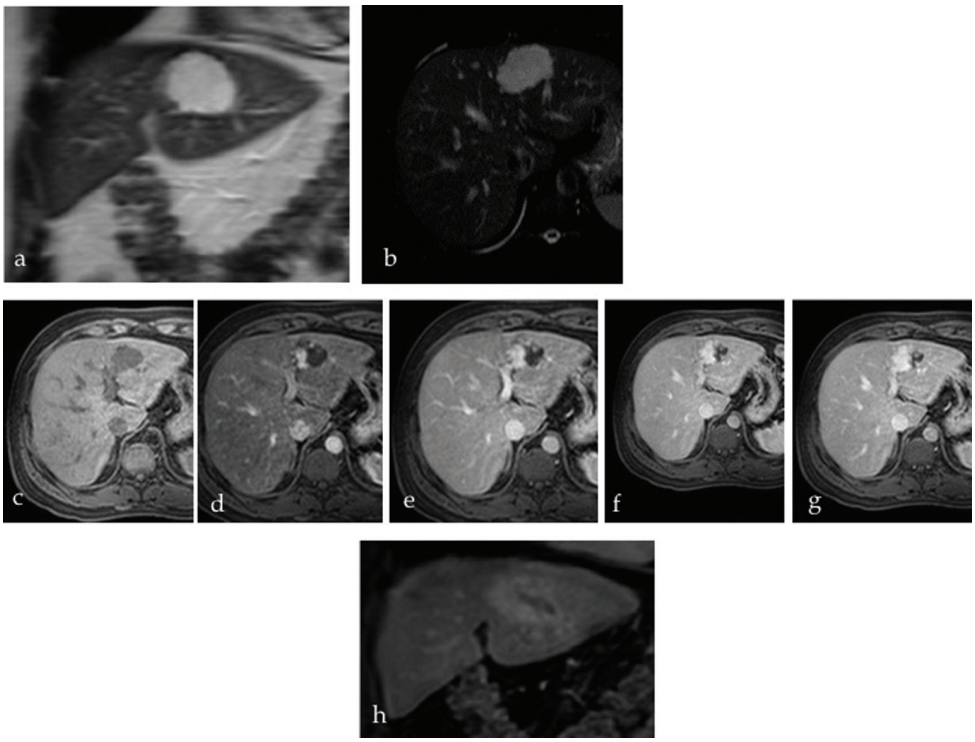

Figure 7. Haemangioma on magnetic resonance imaging. a and b. T2W images show an intensely bright well-defined lesion. c–h. Pre- and dynamic post-contrast images at different phases show nodular peripheral enhancement with centripetal filling.

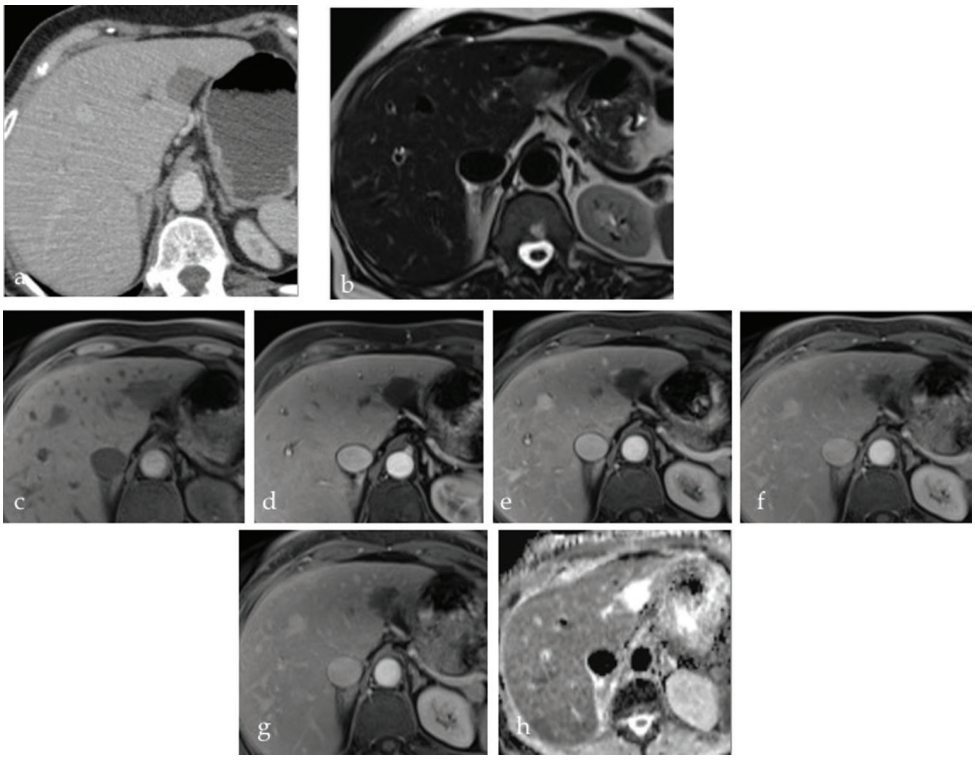

Figure 8. Sclerosed haemangioma. a. Computed tomography shows a hypodense lesion resembling a cyst, but is not T2 bright on (b) magnetic resonance imaging. c–g. Pre- and post-contrast multiphasic magnetic resonance imaging does not demonstrate the typical pattern of haemangioma. h. Apparent diffusion coefficient map shows no restriction of diffusion. The lesion was biopsied and proven to be a sclerosed haemangioma, which can have variable appearance.

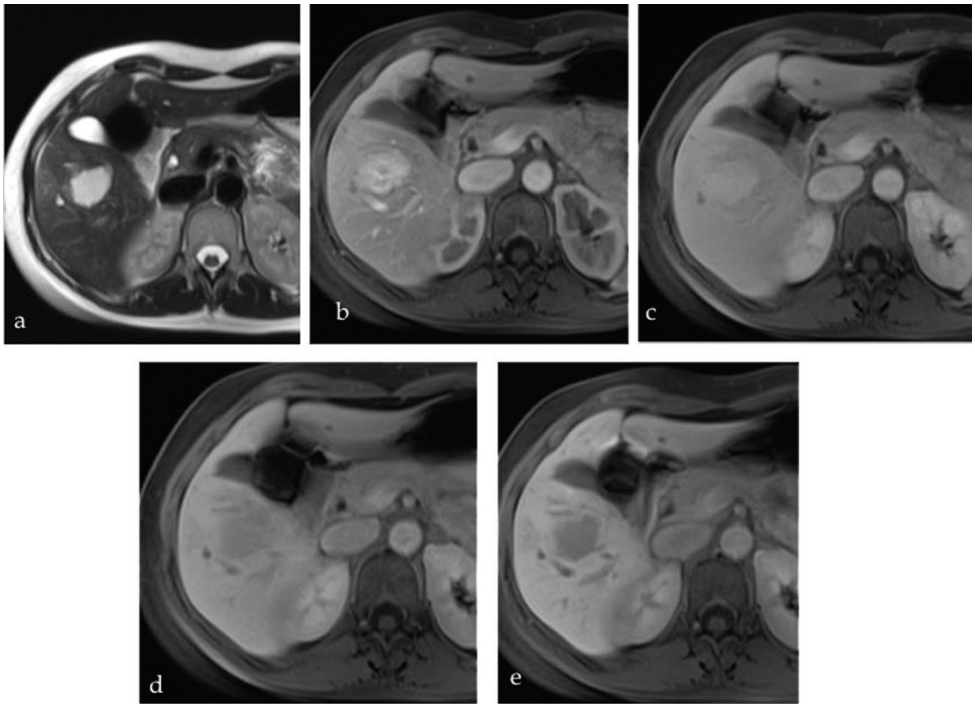

Figure 9. Haemangioma on hepatobiliary contrast. a. Intensely T2 bright lesion suggesting benign nature. b and c. Post contrast magnetic resonance imaging shows brisk enhancement with (d and e) apparent 'washout' from 5 to 15 minutes.

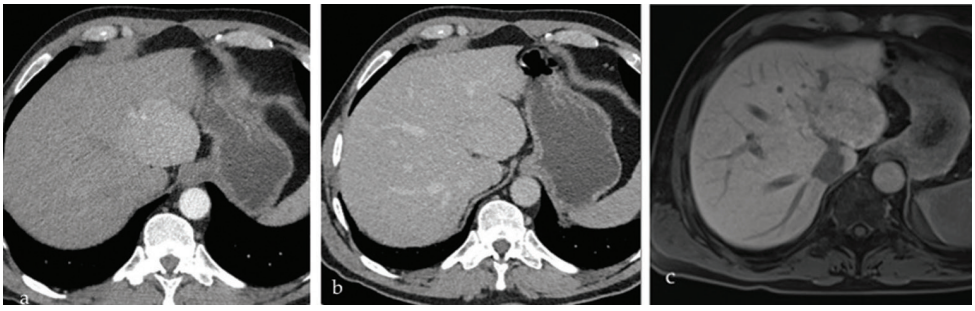

Figure 10. Focal nodular hyperplasia. Computed tomography in (a) arterial and (b) portal phases show a well-defined homogeneous mass with arterial enhancement and isodensity on portal phase. c. Subsequent magnetic resonance imaging in hepatobiliary phase shows the mass to be isointense to liver, proving that it is focal nodular hyperplasia.

lesion shows brisk arterial enhancement without washout. In the delayed phase, the central scar typically enhances. In magnetic resonance imaging with hepatobiliary contrast, a further sequence is performed at 15–20 minutes. Focal nodular hyperplasia retains hepatobiliary contrast or remains bright in this phase with a low signal central scar (Figure 12). Focal nodular hyperplasia has no malignant potential and is considered a 'leave alone' lesion.

Pitfalls of imaging focal nodular hyperplasia

Fewer than 50% of cases of focal nodular hyperplasia will have a classical prominent central scar. Retention of hepatobiliary contrast helps to characterise those without the typical scar. Some cases of focal nodular hyperplasia have a variant pattern of enhancement in the hepatobiliary phase (van Kessel et al, 2013)(Figure 13), but other characteristics usually help to clinch the diagnosis. If in doubt, follow-up imaging (liver magnetic resonance imaging in 3 months' time) is usually adequate.

Hepatocellular adenomas

These are rare benign tumours, seen predominantly in women. There is a strong association with use of oral contraceptive pills. It is rarely seen in men, but when it is, it is often with

a history of use of anabolic steroids. Hepatocellular adenomas can be complicated by haemorrhage, rupture or malignant transformation. Pathologically there are four different subtypes, the most common of which is the inflammatory subtype, which is associated with

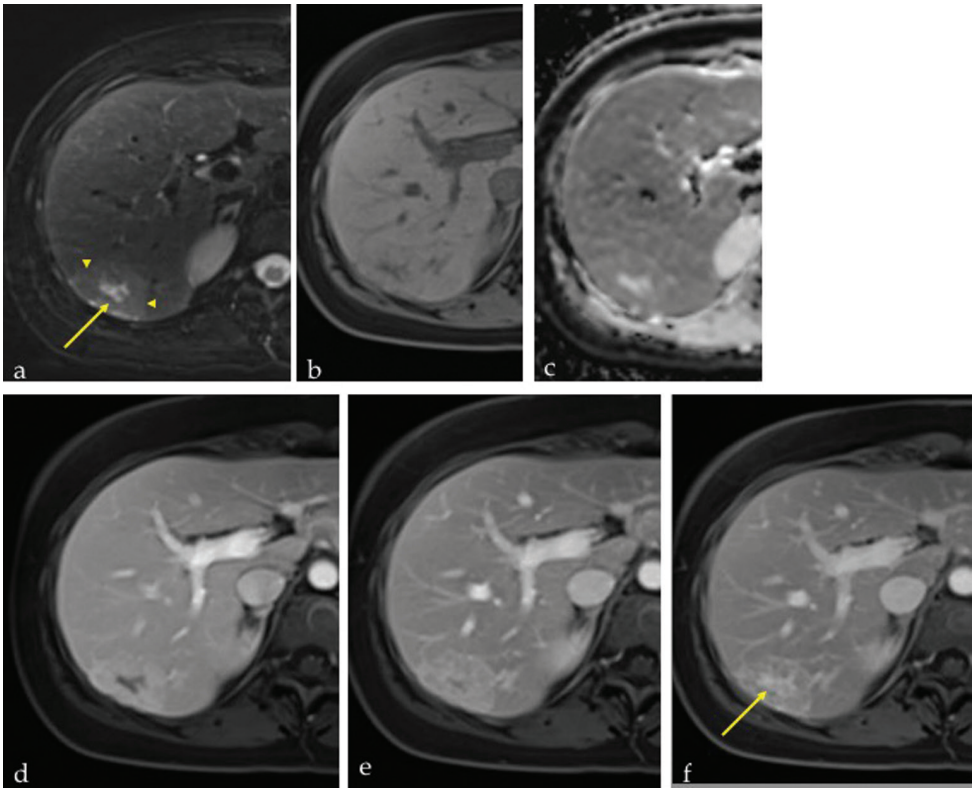

Figure 11. Focal nodular hyperplasia shown with extracellular contrast agent. a. T2W, (b) T1W pre-contrast and (c) apparent diffusion coefficient map shows an isointense lesion with a T2 bright central scar (arrow) and no restriction of diffusion. Post-contrast images in (d) arterial, (e) portal and (f) delayed phases show an enhancing lesion with a central scar that fills in the delayed phase.

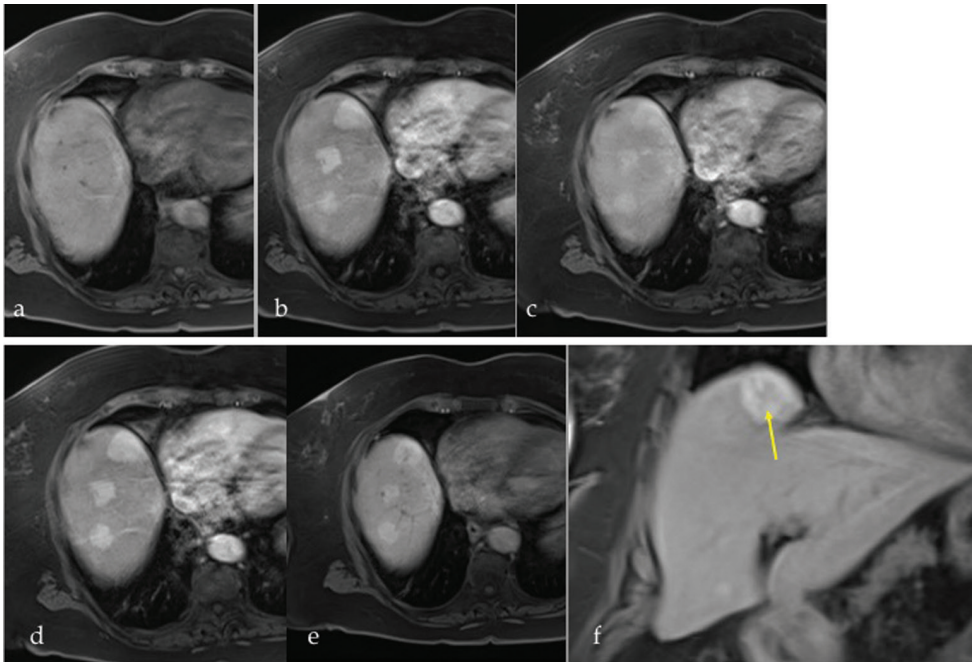

Figure 12. Focal nodular hyperplasia on hepatobiliary contrast agent. a–f. Multiple focal nodular hyperplasia which are isointense on pre-contrast and show brisk enhancement. These retain hepatobiliary contrast at 15 minutes (arrow).

use of oral contraceptive pills. On imaging these are generally heterogeneous with variable amount of fat, haemorrhage and necrosis. The non-contrast imaging features reflect the presence of fat and haemorrhage (Figure 14). On T2W sequence, they may demonstrate the 'atoll' sign (Xiang et al, 2018), a hyperintense rim along the periphery of the mass (Figure 14). They show inhomogeneous arterial enhancement with no washout in typical lesions (Figures 15 and 16). Some lesions may have a pseudocapsule. In view of potential complications, these lesions are usually either resected or followed up (Shao et al, 2018).

Variants and pitfalls of hepatocellular adenomas

Liver cell adenomatosis is a rare condition seen in young women where there are more than ten adenomas. The lesions show similar imaging features to solitary adenomas. Patients are monitored for development of complications. Owing to the number of lesions, resection is not usually possible, but lesions can be embolised if there is a risk of bleeding. Some

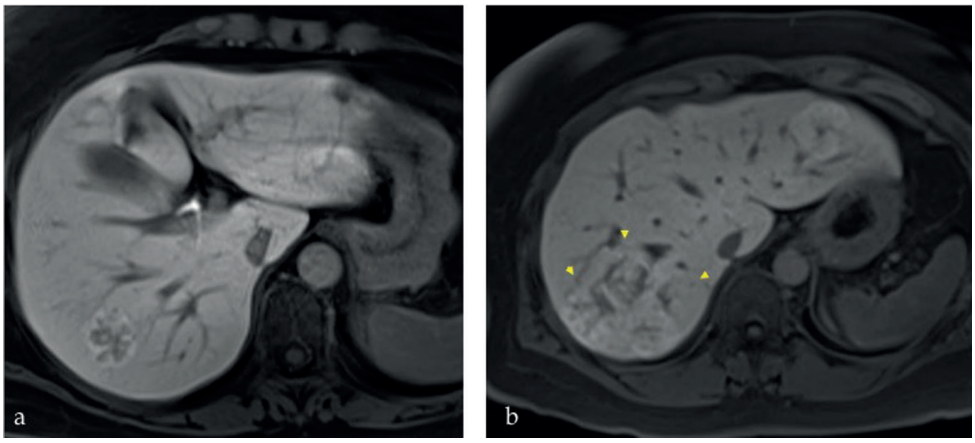

Figure 13. Atypical enhancement pattern in hepatobiliary phase: (a) rim and (b) heterogeneous enhancement patterns.

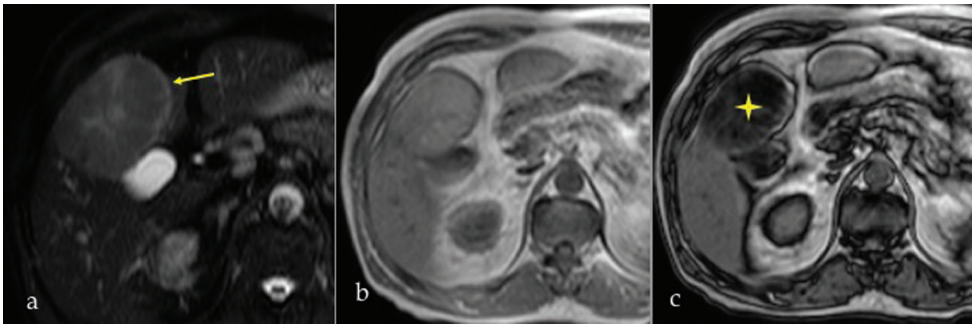

Figure 14. Hepatocellular adenoma on magnetic resonance imaging. a. T2W shows a mass with a T2 hyperintense rim giving atoll sign (arrow), (b) in phase and (c) out of phase images show out of phase signal drop (star) indicating abundant fat.

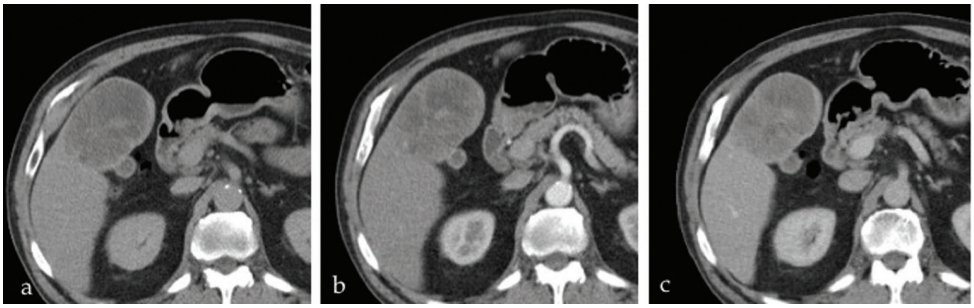

Figure 15. Hepatocellular adenoma on (a) pre, (b) arterial and (c) portal phase computed tomography showing an indeterminate heterogeneous mass with some internal enhancement, subsequently imaged by magnetic resonance imaging.

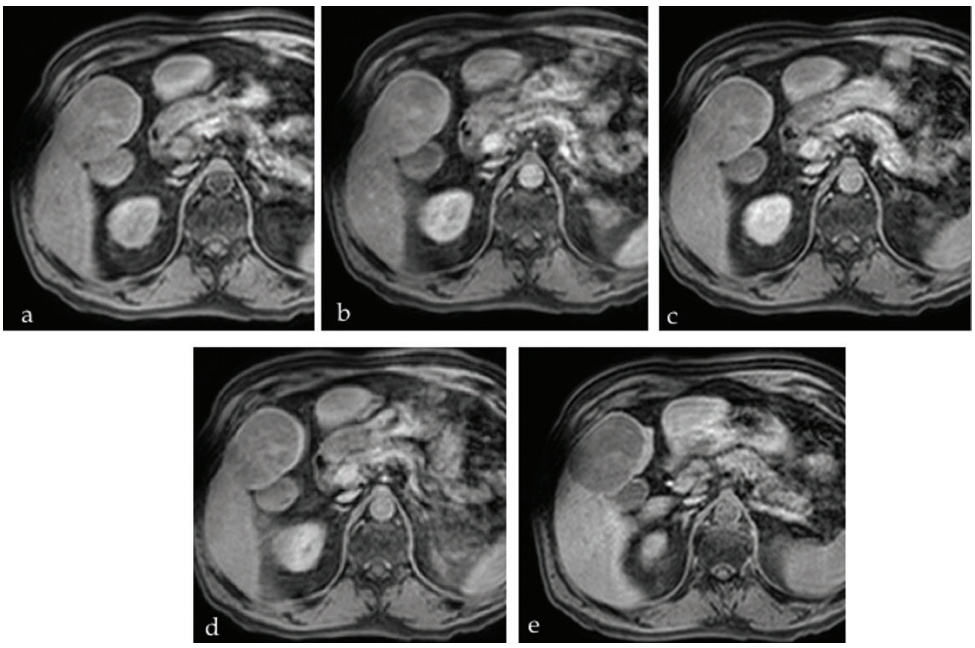

Figure 16. a–e. Hepatocellular adenoma on pre- and post-contrast T1W magnetic resonance imaging in multiple phases. This particular lesion is relatively hypovascular with mild inhomogeneous enhancement. There is an apparent capsule appearance.

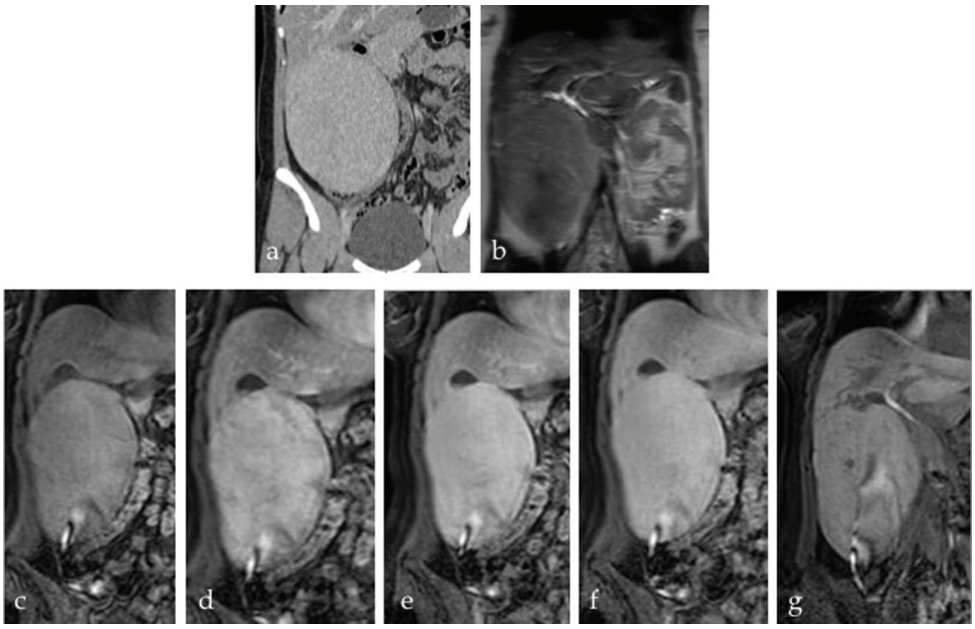

Figure 17. Large exophytic hepatocellular adenoma in a young woman with recent miscarriage, and a prior history of contraceptive pill usage. a. Computed tomography shows a solid liver exophytic mass with background fatty liver. b. T2W coronal image of the lesion. c–f. Arterial to delayed phase shows sustained enhancement with no washout. g. Hepatobiliary phase shows some retention of contrast which can rarely occur in hepatocellular adenoma.

adenomas can retain hepatobiliary contrast because of the presence of hepatocytes and be confused with focal nodular hyperplasia (Figure 17), although the enhancement is usually less than that of focal nodular hyperplasia.

Pseudolesions

Transient hepatic attenuation differences

These appear as a peripheral wedge-shaped area of hyperenhancement on computed tomography and magnetic resonance imaging in the arterial phase (Figure 18). Absence

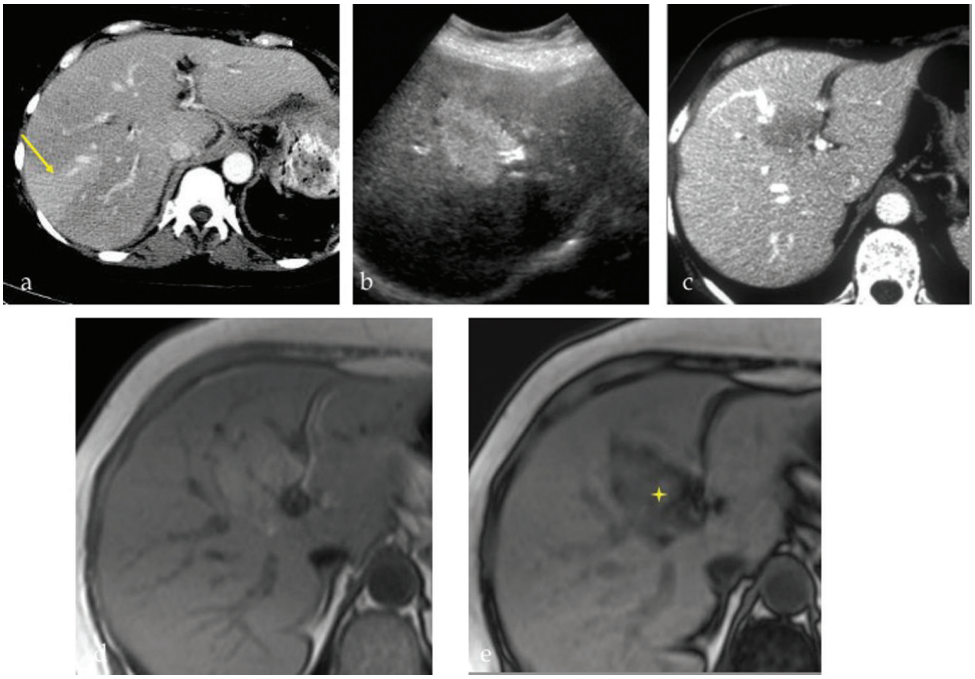

Figure 18. a. Transient hepatic attenuation differences – a peripheral wedge-shaped area of hyperenhancement with no mass effect. b. Focal fatty infiltration on ultrasound – a triangular echogenic lesion in periportal region. c. Focal fatty infiltration on computed tomography seen as a well-defined triangular area of low density. d. In and (e) out of phase magnetic resonance imaging with signal drop (star) on the out of phase indicating fat.

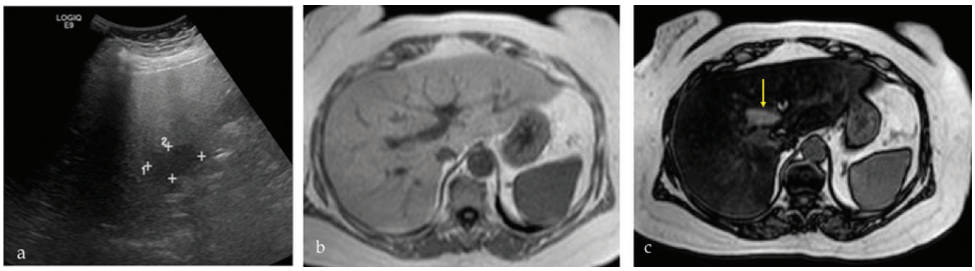

Figure 19. Focal fatty sparing. a. Ultrasound shows an echogenic fatty liver with a triangular area of sparing in the periportal region. b. In and (c) out of phase magnetic resonance imaging of the same case shows marked out of phase signal loss in the background liver with a triangular area of high signal as a result of focal fatty infiltration.

of mass effect on the vessels is characteristic, which becomes isodense or isointense in the portal phase. These are usually easy to diagnose and require no further imaging.

Focal fatty infiltration and focal fatty sparing

Both these entities have a geographic or triangular shape and certain site predilections, such as around the gallbladder fossa and porta hepatis (Figures 18 and 19). These combined with absence of mass effect help to make the diagnosis. These can be characterised on magnetic resonance imaging with fat sensitive sequences.

Pitfalls in imaging focal fatty infiltration and focal fatty sparing

Nodular fatty infiltration can mimic metastases on computed tomography and ultrasound but can be characterised on non-contrast magnetic resonance imaging (Figure 20).

Inflammatory lesions

Pyogenic abscess

These are seen as complex cystic lesions on imaging, often with surrounding hepatic oedema (Figure 21). Echogenicity, density and signal characteristics on ultrasound, computed

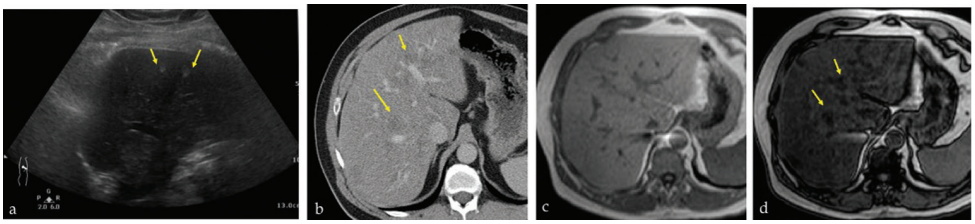

Figure 20. Nodular focal fatty infiltration. a. Ultrasound shows nodular echogenic foci. b. On computed tomography these are hypodense, simulating metastases c. In and (d) out of phase magnetic resonance imaging shows nodular signal drop in these lesions indicating their fatty nature.

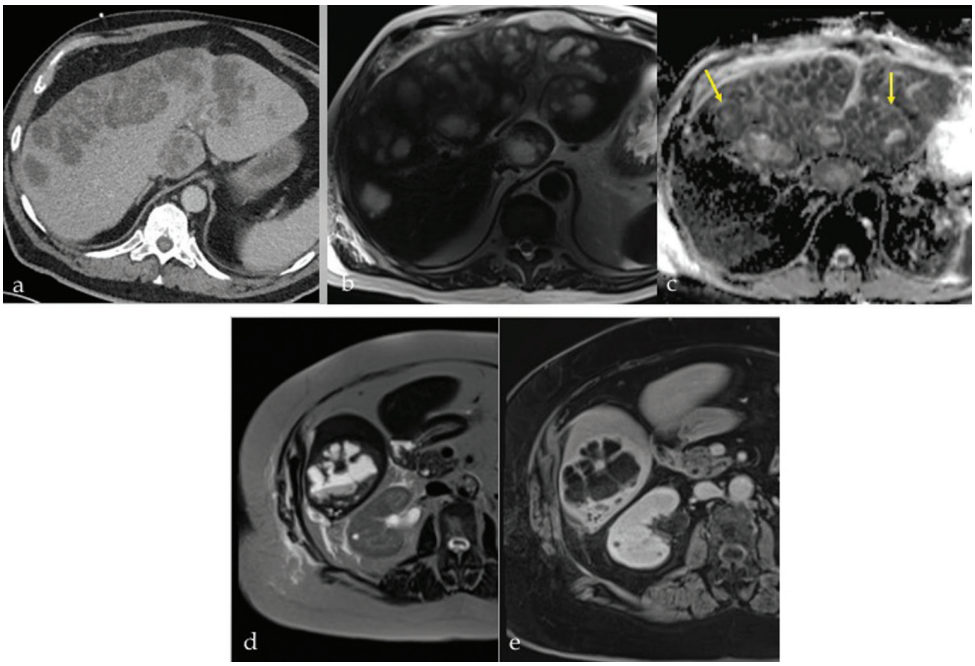

Figure 21. Pyogenic abscesses. Multiple liver abscesses on (a) computed tomography, (b) T2W magnetic resonance imaging and (c) apparent diffusion coefficient map. These are seen as septated cystic lesions with internal restriction of diffusion (arrows). Another case of liver abscess on (a) T2W and (b) T1W post contrast images, showing multiple enhancing septations.

tomography and magnetic resonance imaging depend on the viscosity of contents. The lesions may be single or multiple are usually multiseptated. The septae enhance with contrast with non-enhancing contents. There is usually prominent restriction of diffusion by the contents because of their high viscosity.

Fungal abscess

These are typically small (<2 cm), multiple and seen in neutropenic patients. They may demonstrate bulls-eye configuration with a central nidus (Bächler et al, 2016) that is hyperintense on T1W, intermediate signal on T2W and enhances (Figure 22). Other features, including restriction of diffusion, are similar to pyogenic abscesses.

Hydatid cyst

This is a zoonosis caused by the larval stage of echinococcus tapeworms: *Echinococcus granulosus* and *E. multilocularis*. They are divided into four types: simple cysts, cysts with internal architecture (Figure 23), calcified cysts and complicated cysts (Mehta et al, 2016). The hallmark on imaging is the presence of peripheral daughter cysts. Hydatid cysts are prone to complications, such as rupture with peritoneal dissemination, secondary bacterial infections and systemic dissemination. Symptomatic or active lesions may be treated by anti-helminthic therapy combined with surgical resection or percutaneous transhepatic aspiration and injection (Rajesh et al, 2013).

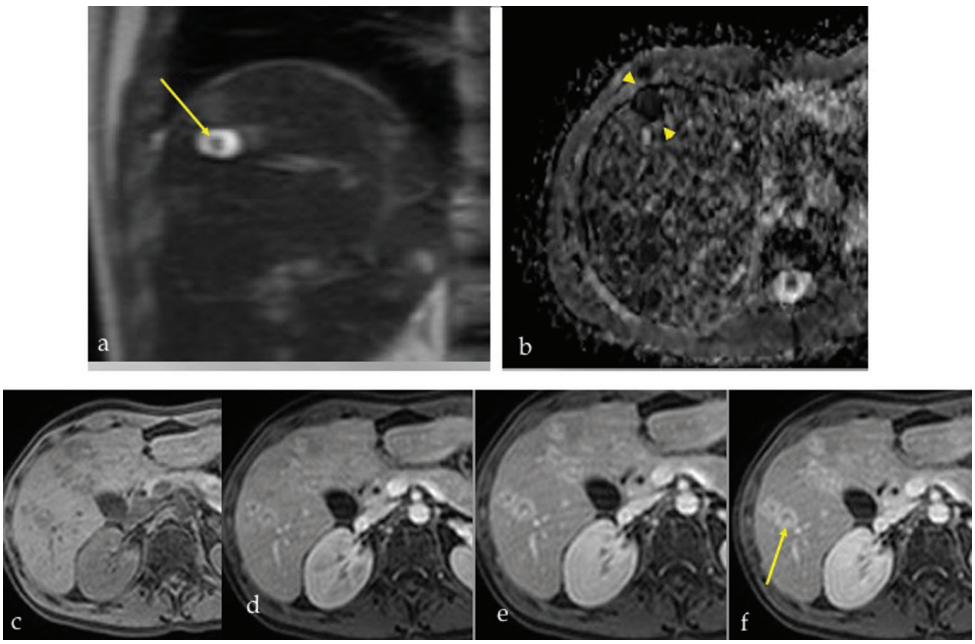

Figure 22. Fungal abscesses. a. T2W coronal image showing bulls eye appearance. b. Apparent diffusion coefficient map show intense restriction of diffusion within. c–f. Pre-and post-contrast multiphasic T1W images show rim and central enhancement. Note the characteristic central nidus (arrows).

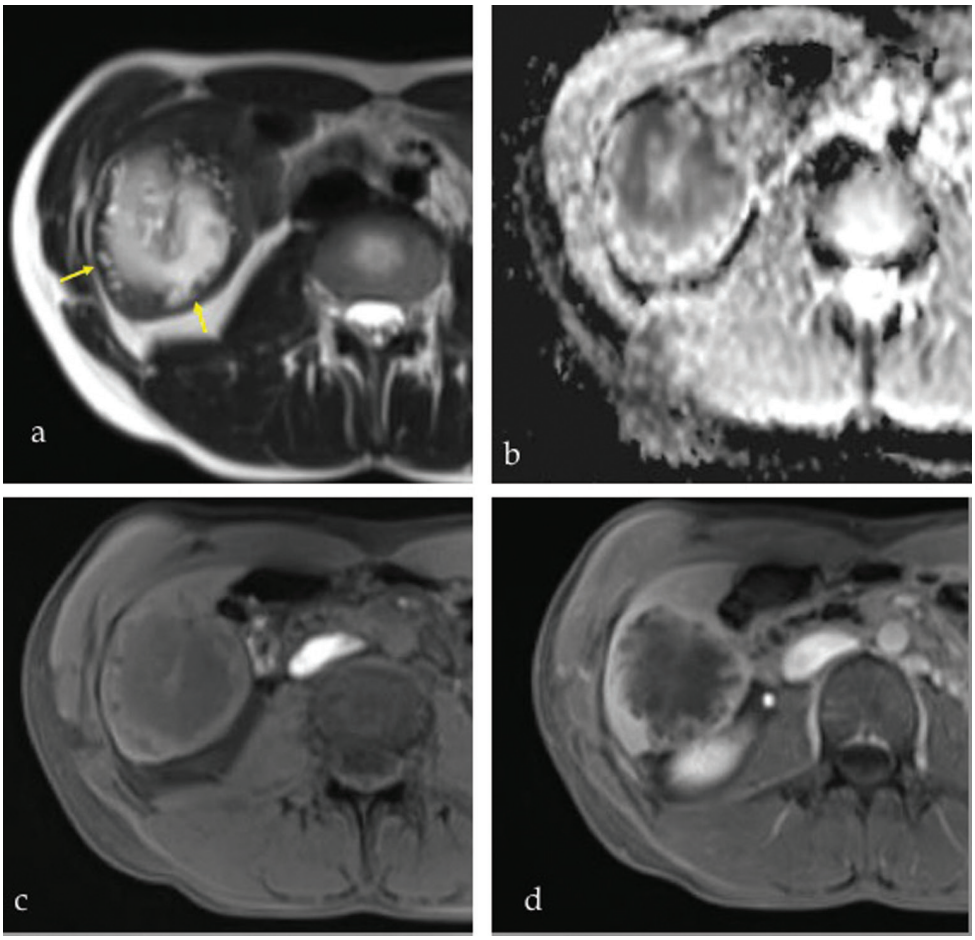

Figure 23. Hydatid cyst. a. T2W magnetic resonance imaging shows complex cyst with peripheral daughter cysts (arrows). b. Apparent diffusion coefficient map shows internal restriction of diffusion. c. Pre- and (d) post-contrast T1W images show rim enhancement.

Malignant liver lesions

These may be primary or metastatic. Metastasis is the most common malignant liver lesion.

Primary hepatic malignancy

Hepatocellular carcinoma

Hepatocellular carcinoma is increasing in incidence because of the prevalence of hepatitis C infection and non-alcoholic steatohepatitis. It is far more common in patients with cirrhosis or chronic hepatitis B infection, but can also arise in normal-looking livers. Serum alfa-fetoprotein is a useful tumour marker. It has characteristic appearances on contrast-enhanced computed tomography (Figure 24) and magnetic resonance imaging (Figure 25), including arterial hyperenhancement, portal to delayed phase low density or intensity which is termed 'washout' and delayed capsule appearance (Choi et al, 2014a). Magnetic resonance imaging features also include T2 hyperintensity, intralesional fat and restricted diffusion (Figure 26). In the hepatobiliary phase, the lesion is usually hypointense to the liver (Figure 27), although a minority of hepatocellular carcinomas can retain some contrast (Choi et al, 2014b). Hepatocellular carcinomas are usually diagnosed by imaging, if classical features are present. They are discussed in specialist multidisciplinary team meetings to decide on the best treatment options for the patient, depending on lesion characteristics, number and presence and state of underlying chronic liver disease. If classical imaging features are present, resectable lesions are not usually biopsied. Other treatment modalities include ablative therapies and chemotherapy, depending on the stage of disease.

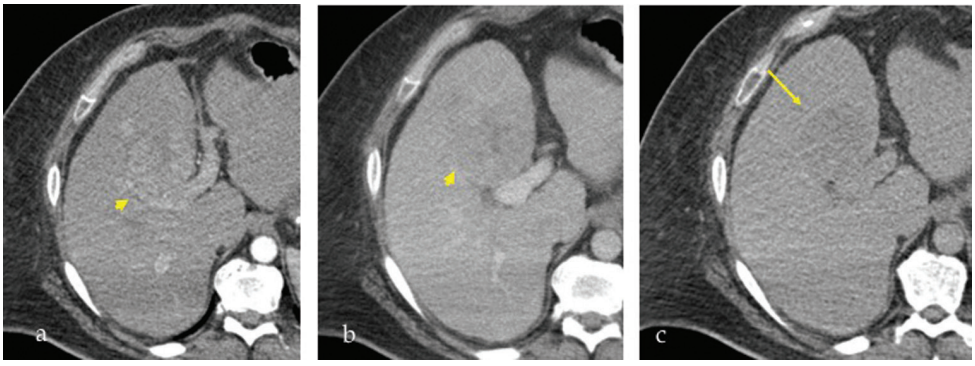

Figure 24. Hepatocellular carcinoma on triphasic computed tomography. a. Arterial and (b) portal phase images show hypervascularity and washout in the lesion (arrow head). c. Delayed phase shows capsule appearance (arrow).

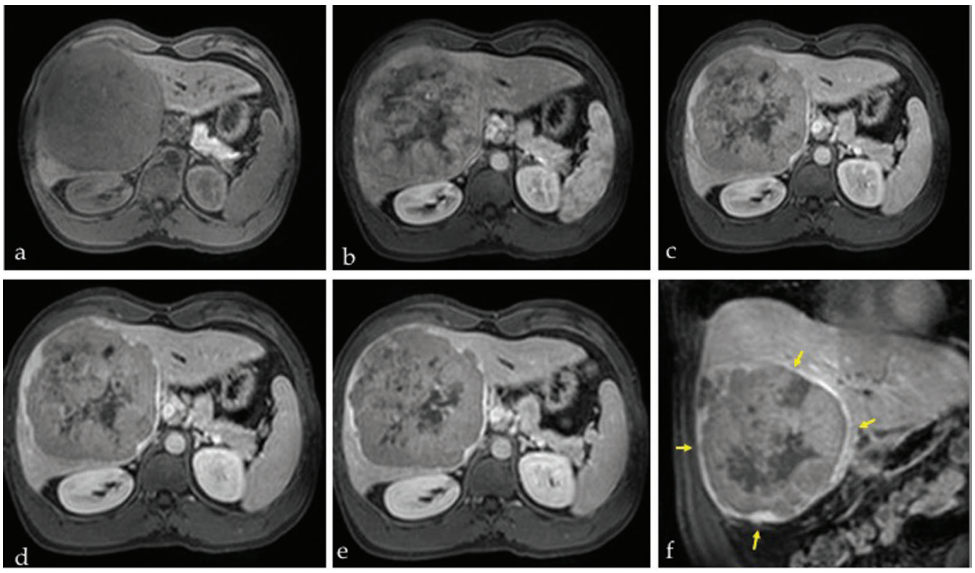

Figure 25. a–f. Hepatocellular carcinoma with extracellular contrast. b. Heterogeneous arterial enhancement. c. Portal phase washout. f. Enhancing capsule (arrows).

Variants

Fibrolamellar hepatocellular carcinoma

This is a rare liver tumour that differs significantly from conventional hepatocellular carcinoma. It occurs in young patients with no underlying cirrhosis or hepatitis and serum

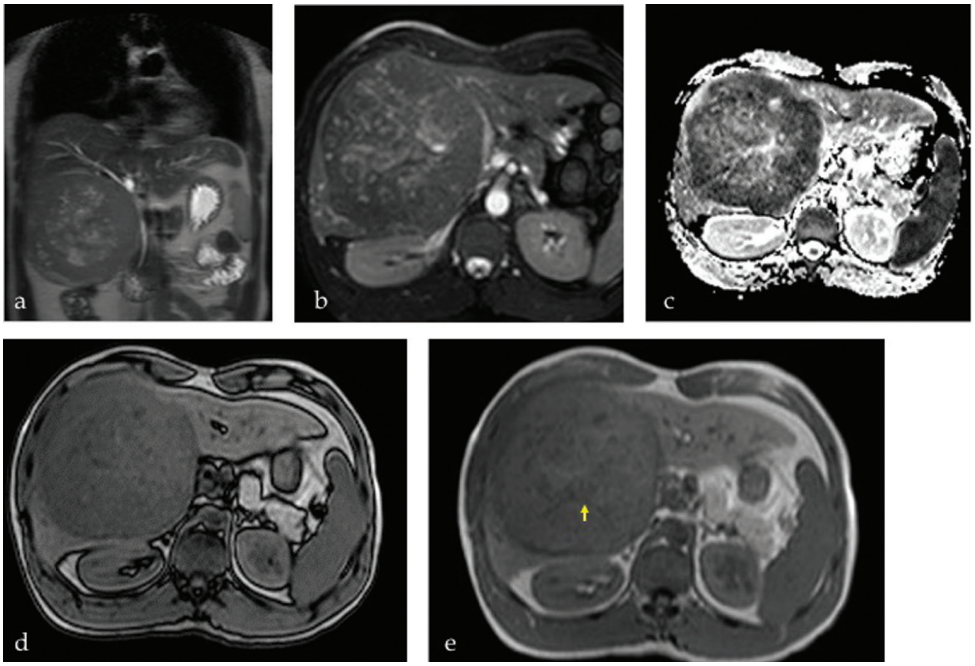

Figure 26. Hepatocellular carcinoma on magnetic resonance imaging. a and b. T2W images show a large heterogeneous mass. c. Apparent diffusion coefficient map demonstrates marked restriction of diffusion. d. In and (e) out of phase images show a small focus of fat with signal drop on out of phase (arrow).

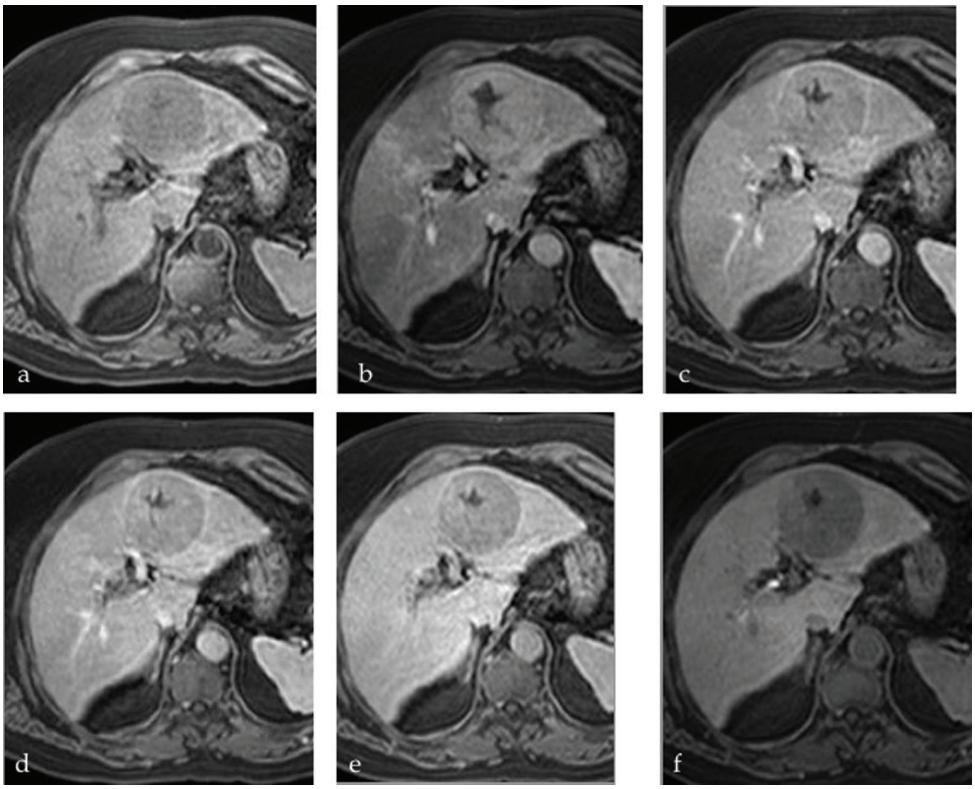

Figure 27. a–f. Hepatocellular carcinoma with hepatobiliary contrast. b. Arterial phase image shows hypervascularity with subsequent washout and capsule appearance. There is a central scar. f. Hepatobiliary phase shows no retention of contrast in the lesion.

alfa-fetoprotein is not usually elevated (Ganeshan et al, 2014). The lesions are heterogeneous, frequently calcify and have a central scar (Figure 28). They show arterial hypervascularity but have variable portal and delayed phase density. Thirty-five per cent may have a pseudocapsule. There is frequent association with abdominal and thoracic lymphadenopathy.

Intrahepatic cholangiocarcinoma

This is the second most common primary liver malignancy (Blechacz, 2017). The predisposing factors include primary sclerosing cholangitis, chronic inflammation, hepatolithiasis and cirrhosis. Serum Ca-19–9 is a useful tumour marker. The three main types are mass-forming, periductal infiltrating and intraductal growing. On imaging, cholangiocarcinoma is typically lobulated and association with retraction of the liver capsule (Figure 29). It is hyperintense on T2W, low on T1W and restricts diffusion. Post-contrast, the lesion shows continuous peripheral enhancement with gradual centripetal enhancement up to the delayed phase (Joo et al, 2018). If presenting early, cholangiocarcinoma is resected after a specialist multidisciplinary team meeting discussion; solitary lesions are not usually biopsied.

Pitfall

As a result of the centripetal enhancement, cholangiocarcinoma can be confused with large or atypical haemangiomas. It should be remembered that cholangiocarcinoma has continuous rim enhancement while haemangiomas have discontinuous rim enhancement. Diffusion restriction and heterogeneity may help to differentiate cholangiocarcinoma from haemangiomas.

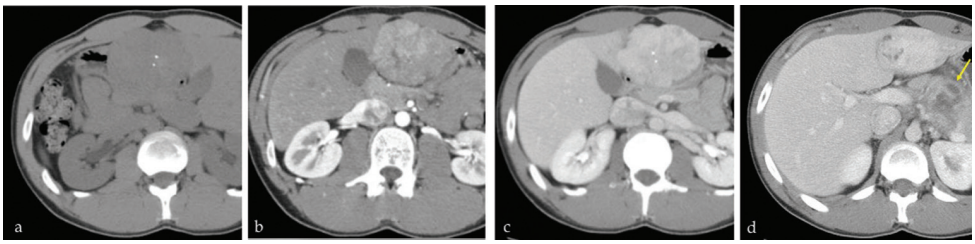

Figure 28. a–d. Fibrolamellar hepatocellular carcinoma on multiphasic computed tomography. a. Pre-contrast image shows calcification. b. Irregular arterial enhancement without washout. c. Portal phase image shows absence of washout. d. Bulky upper abdominal lymphadenopathy (arrow).

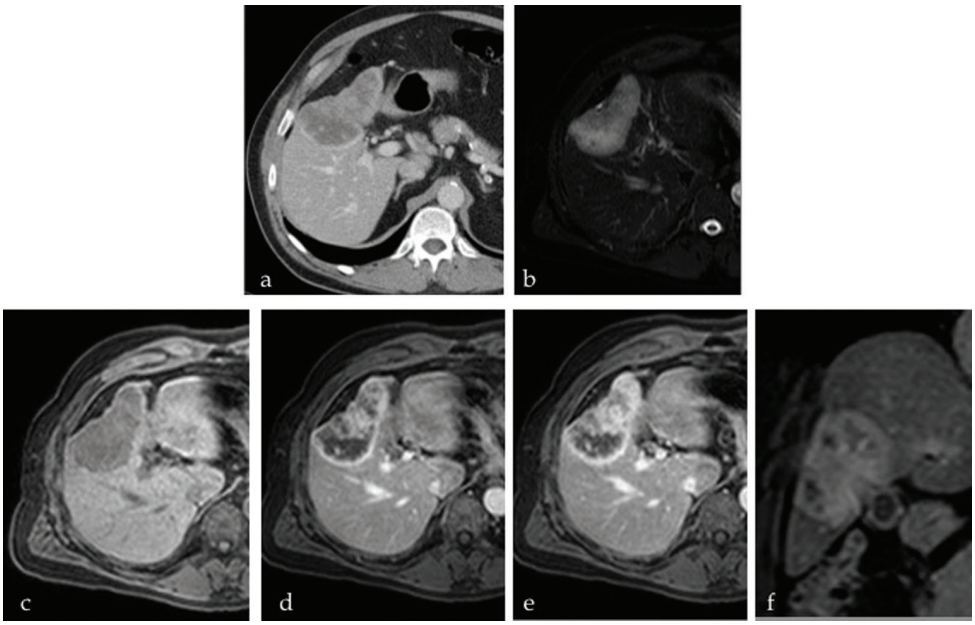

Figure 29. Intrahepatic cholangiocarcinoma. a. Computed tomography shows a lobulated mass with capsular retraction. b. T2W magnetic resonance imaging shows a hyperintense lesion. c–f. Pre- and post-contrast T1W magnetic resonance imaging shows continuous peripheral enhancement initially with centripetal filling.

Metastasis

Liver metastasis commonly occurs from the gastrointestinal tract but can also come from other organs. They may be solitary, multiple, hypo or hypervascular. The majority are hypovascular, for example colorectal (Figure 30). Hypervascular metastasis may come from neuroendocrine tumours, melanoma, transitional cell carcinoma, renal cell carcinoma or sarcomas (Figure 31). Treatment of metastases depends on the origin, for example colorectal metastases are resected depending on the extent.

The cirrhotic liver

Cirrhotic liver may contain a wide spectrum of nodules, ranging from benign to intermediate risk to malignant lesions. In the benign end of the spectrum are regenerative nodules and low grade dysplastic nodules. They have overlapping imaging features (Figure 32) and are small, measuring <1.5 cm (Choi et al, 2014a). Regenerative nodules are usually isointense to liver in all sequences, but can have high T1 signal and low T2 signal similar to low-grade

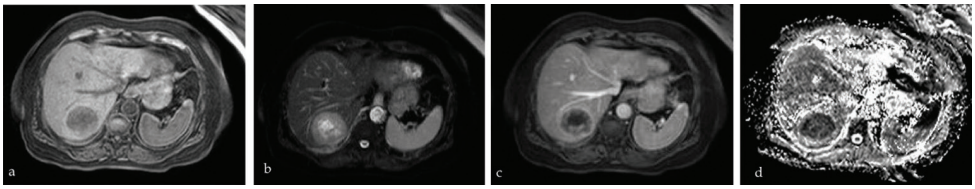

Figure 30. Hypovascular metastasis from colorectal cancer. a. Pre- and (c) post-contrast T1W image shows a hypointense mass with irregular peripheral enhancement. b. T2W magnetic resonance imaging shows heterogeneous high signal. d. Apparent diffusion coefficient map shows marked restriction of diffusion.

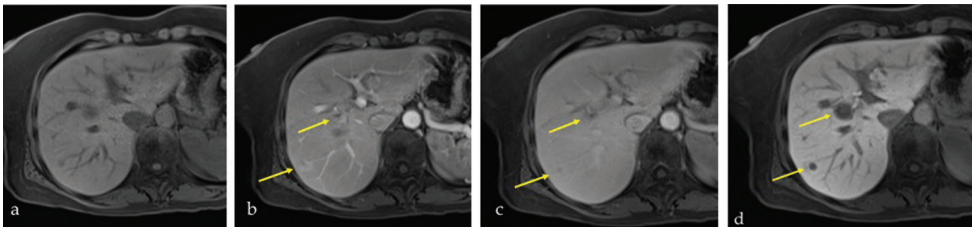

Figure 31. Hypervascular metastases from melanoma. a. Pre, (b) arterial and (c) portal phase images show two lesions with arterial hypervascularity and portal washout (arrows). d. Hepatobiliary phase: these metastases are more conspicuous in this phase.

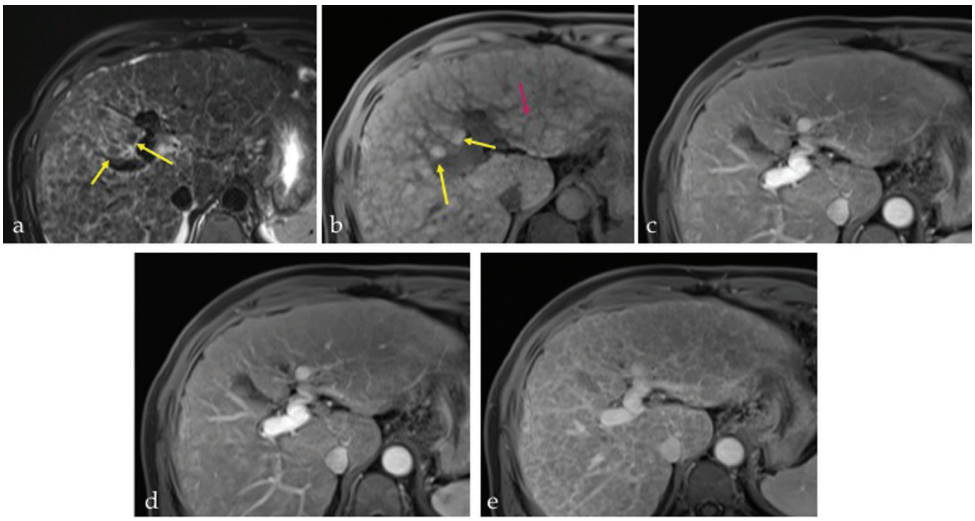

Figure 32. Cirrhotic nodules. a. T2W and (b) pre-contrast T1W showing innumerable tiny nodules. Most of these are isointense (red arrow) consistent with regenerative nodules. A few show T1 hyperintensity and T2 low signal (yellow arrows) and are suggestive of dysplastic nodules. c–e. No enhancement in post-contrast images.

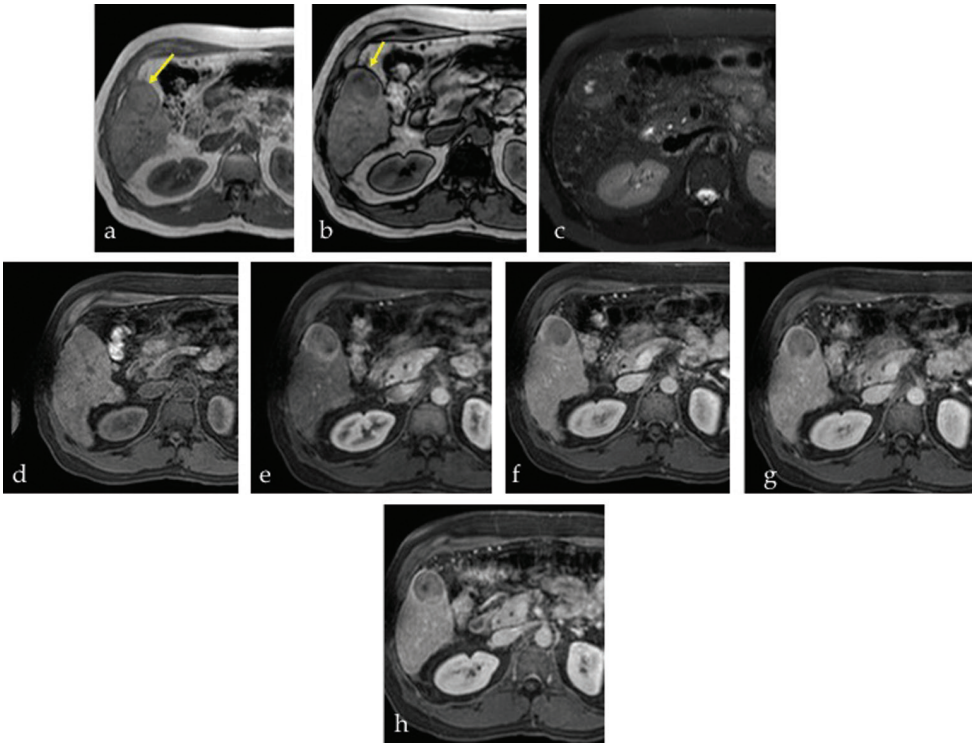

Figure 33. Hepatocellular carcinoma in cirrhotic liver. a. In and (b) out of phase images show intralesional fat with signal drop on out of phase. c. T2W image show heterogeneous high signal. d–h. Pre- and post-contrast at different phases show arterial hypervascularity, washout and capsule appearance.

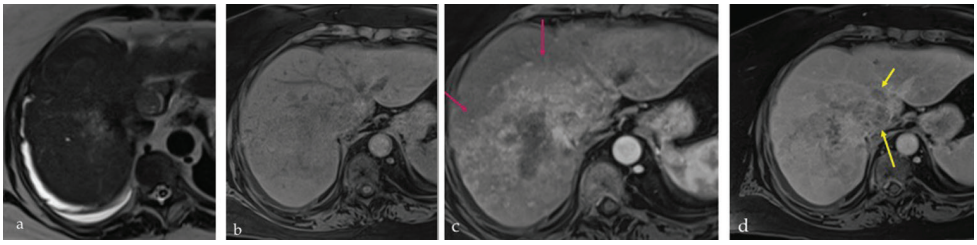

Figure 34. Infiltrating hepatocellular carcinoma. Subtle, ill-defined signal abnormalities on (a) T2W and (b) pre-contrast T1W images. c. Arterial and (d) portal phase images show heterogeneous enhancement and washout. Note thrombus in hepatic veins and inferior vena cava seen as filling defects (arrows).

dysplastic nodules. Neither show arterial hypervascularity. High-grade dysplastic nodules are premalignant and may have overlapping features with early hepatocellular carcinoma, such as foci of arterial enhancement, T2 hyperintensity and fat. Early hepatocellular carcinoma is an incipient form of hepatocellular carcinoma. Progressed hepatocellular carcinoma are frankly malignant. Hepatocellular carcinoma in cirrhotic liver has similar imaging features to hepatocellular carcinoma in normal-looking liver (Figure 33). Cirrhotic liver may have multifocal hepatocellular carcinoma. Infiltrating hepatocellular carcinoma is another aggressive form of hepatocellular carcinoma that may occur in cirrhosis (Reynolds et al, 2015). This can be difficult to delineate from cirrhotic parenchyma, has variable arterial enhancement, and washout (Figure 34). Vascular invasion is common at presentation and the prognosis is very poor.

Pragmatic pathways for hepatic incidentalomas

Having established pathways for imaging incidental liver lesions is vital for appropriate management and to reduce patient anxiety and healthcare costs. It is also crucial for reducing ionising radiation, often in young patients, and decreasing the need for administering

Key points

- Magnetic resonance imaging is a valuable tool for characterising liver lesions.
- Hepatocyte-specific contrast has added value in evaluating specific types of liver lesions.
- Newer imaging modalities and protocols have reduced the need for liver biopsy.
- It is good practice and cost effective to develop tailored and abbreviated imaging protocols.

contrast for magnetic resonance imaging. The author's department has a generic pathway for liver incidentalomas found on ultrasound. This is used as a guide but is not inflexible. Incidentalomas found on ultrasound and computed tomography are usually investigated by magnetic resonance imaging in the author's department. Triphasic computed tomography is mostly reserved for people who have contraindications to magnetic resonance imaging. If the protocolling radiologist feels that the incidentaloma is likely to be a cyst, haemangioma, focal fatty infiltration or focal fatty sparing, non-contrast magnetic resonance imaging is first performed; the author's department has a provision to recall these patients for contrast if the lesion does not show typical features on the initial scan. If the lesion is suspected to be focal nodular hyperplasia, hepatobiliary contrast is used.

Conclusions

Imaging plays a pivotal role in the diagnosis, surveillance and management of focal liver lesions. Many lesions can be completely characterised non-invasively by imaging. Developing tailored and abbreviated protocols will help to streamline the service and decrease the need for contrast administration.

Author details

[1]Imaging Department, University Hospital of North Midlands, Stoke-on-Trent, UK

Conflicts of interest

The author declares no conflicts of interest.

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