Computer Tomography (CT) And Magnetic Resonance Imaging (MRI) Of Normal Liver (Part 1)

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INTRODUCTION

The knowledge of the cross sectional anatomy of the liver is essential for localisation of the disease process and guiding the management. Imaging helps in understanding anatomical details especially the segmental anatomy of the hepatic parenchyma and vascular and biliary anatomy which are of paramount importance to reduce the morbidity, due to any intervention (including surgery) on the liver. This article provides a general overview about CT and MRI of the liver, the commonly performed cross sectional imaging.

IMAGING TECHNIQUES OF THE LIVER

Computer Tomography (CT) is the most commonly performed cross sectional imaging for the evaluation of the liver as it is more readily available, objective, easy to interpret, less time consuming especially in trauma patients and less claustrophobic. CT involves radiation as X ray with 10 times more exposure dosage.[1] CT of the liver is usually performed as a part of whole abdomen imaging and contrast is often used and the technique is usually termed as Triple phase imaging to denote the different phases of perfusion of the liver. A precontrast imaging is always done and hence it is also called as Quad phase imaging.

CT IMAGING TECHNIQUE:

CT abdomen imaging is usually covered from the lower chest (below carina) to the pelvis. Precontrast imaging is essential for having a baseline snapshot, second and more importantly, for detecting air, fluid, blood, calcification, stones or any other radiopaque material in the liver and the biliary system. (Fig.1a) The Hounsfield units (HU) helps in distinguishing these entities.[2] Especially in liver, the plain CT helps in finding out the gross fatty changes which make the liver hypodense compared to the spleen.

Contrast imaging is performed for evaluating a lesion, its precise location based on the vascular anatomy and more importantly the characterization. The liver lesions are distinguished by their differential enhancement characteristics in the various phases of the contrast images against the background of the liver parenchyma. As this is a perfusion based study, a mechanical injector is often required for precise timing and usually a non-ionic low osmolar iodinated contrast material is injected at a dose of 2ml/ kg body weight at a rate of 3-4 ml/second.[3]

ARTERIAL PHASE:

The arterial phase which is commonly performed in any liver imaging is the late arterial phase[4]

Late arterial phase – 30-35 sec p.i. All abdominal structures that get their blood supply from the aorta will show optimal enhancement. This phase is primarily used for the arterial enhancing tumours like HCC, hypervascular metastases, FNH etc. In fact, HCC are often diagnosed by imaging itself rather than biopsy. (Fig.1b)

Early arterial phase - 20 sec p.i. This is an optional angiographic sequence which is done in cases of trauma, suspected arterial bleed and also in evaluation of the arterial anatomy in case of a living donor. The differentiating feature from late

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arterial phase is that there is no enhancement of the organs and other soft tissues in this phase.

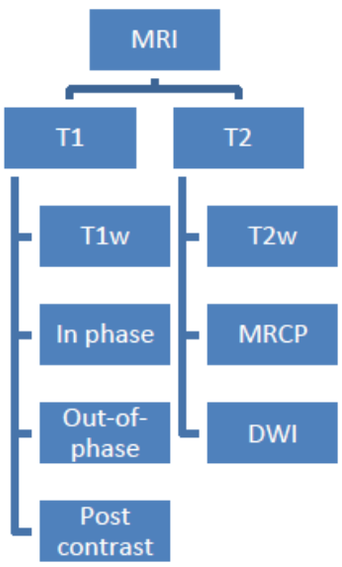
Late portal phase – 60-80 sec p.i. This is the phase where the parenchymal perfusion of the liver has peaked with optimal opacification of both portal veins and the hepatic veins. This phase often stands outs the hypovascular metastasis and portal vein pathologies on a well perfused background liver. This phase is also used to evaluate the washout characteristics of HCC and capsular enhancement. The dilated bile ducts are well seen in this phase. (Fig.1c)

Delayed phase – 3-10 minutes p.i. Sometimes called as "wash out phase", in view of the wash out of contrast in all abdominal structures except for fibrotic tissue which has a relatively delayed venous washout. This feature helps in diagnosing lesions with more stromal component like cholangiocarcinoma, hemangioma, also for the evaluating pseudoaneurysms which are well filled at this phase. (Fig.1d)

The different terminologies used for describing a lesion differs between modalities based on their imaging physics like echogenicity for ultrasound, density for CT and intensity for MRI.

MRI IMAGING MAGNETIC RESONANCE IMAGING (MRI) :

MRI is the second most commonly used cross sectional imaging for liver. Earlier MRI techniques have established it as the primary modality for biliary system evaluation, due to its superior contrast resolution. However, with advances in MRI sequencing and use of liver contrast agents, it has evolved into a first line investigation for liver lesions, equivalent to CT. However, it is still less popular because it is not readily available, difficult to interpret, more time consuming, claustrophobia, and increased cost. Image acquisition is primarily in the axial plane; additional coronal imaging can be acquired to better depict the lesions in relation to the vascular anatomy and the domes of diaphragm.



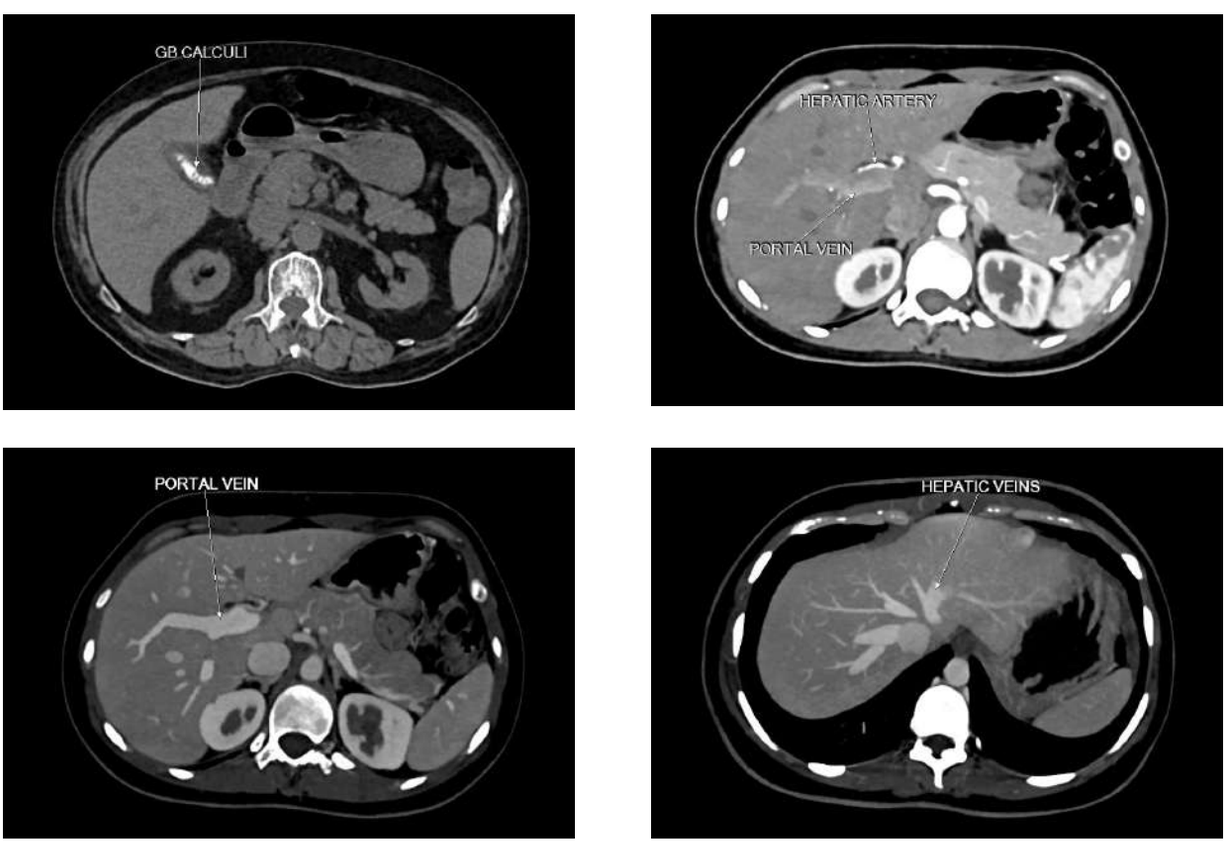


Fig 1. Quad phase CECT abdomen a) Plain CT showing radiodense calculi in the gallbladder(GB) b) Late arterial phase showing the hepatic artery(HA) and early opacification of portal vein(PV). c) Portal venous phase-showing the opacified portal vein and the hepatic veins(HV) with peak enhancement of the parenchyma. d) Delayed phase where there is an opacification of hepatic veins with relative washout of the contrast from the parenchyma.

A MRI sequence is a particular setting of radiofrequency pulse sequences and pulsed field gradients, resulting in a particular image appearance The simplest way to understand the different sequences in modern scanners is to divide them according to the dominant influence on the appearance of tissues. Below we discuss the four main sequence useful in liver imaging. In MRI, high signal intensity = white, intermediate signal intensity = grey and low signal intensity = black.

1. **T1 W sequence**- T1 weighted sequence is one of the basic MRI sequences which predominantly helps in delineation of anatomy and in evaluating fat containing lesions and steatosis. The dominant signal intensities are fat (white) and fluid (black). The dark black intensity of fluid helps in differentiating it from T2W (*CSF appears dark in T1*). They are performed as in-phase and out-of-phase images to demonstrate the fat and iron containing areas. Steatosis shows signal drop on out-of-phase images and iron overload shows signal drop on in-phase images.[5] T1 fat-saturated images are used to assess the lesions with intrinsic hyperintense T1 signal (eg. haemorrhage, melanin, and proteinaceous debris). (Fig.2a,b)
2. **T2W sequence– It is also a universal MRI sequence and fluid is their dominant signal intensity (Bright white).** Hence it is used for evaluating liver lesions and to differentiate cystic and solid lesions. High T2W imaging is usually the one used for MRCP sequence for the same reasons. (Fig.2c)
3. **Diffusion weighted imaging (DWI)–** This is a subtype of T2W imaging which is highly sensitive in detecting small liver lesions which may not be appreciated in other imaging and to differentiate benign and malignant lesions. DWI is based on the random movement of the water molecules in a region and their restriction demonstrate high signal on DWI, which helps in diagnosing a lesion. DWI is performed with at least two b-values (500 and 1000 s/mm^2). Apparent diffusion coefficient map (ADC) is a quantitative assessment of the degree of diffusion restriction and it is obtained from the DWI data set. Solid lesions,

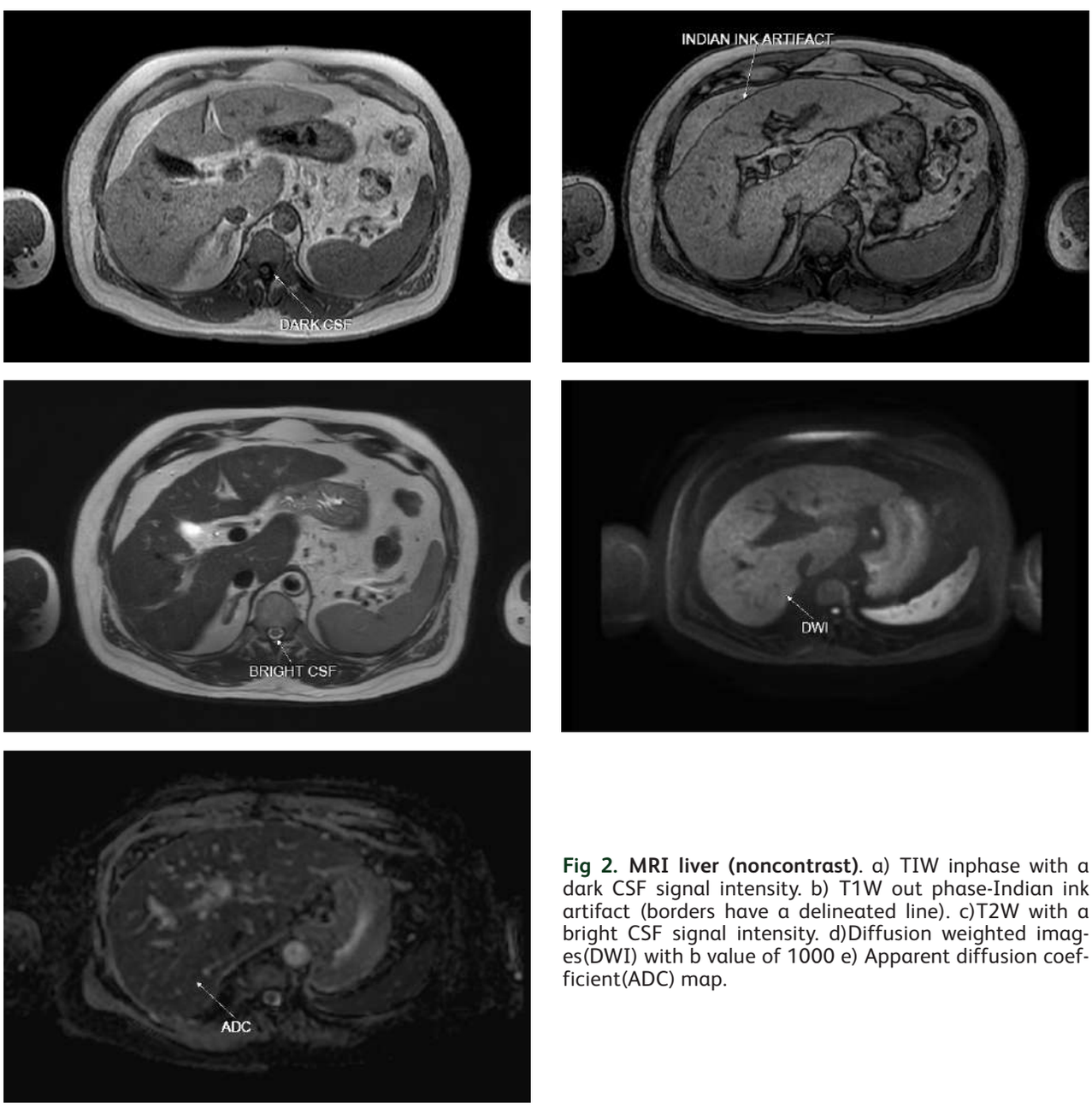


Fig 2. MRI liver (noncontrast). a) TIW inphase with a dark CSF signal intensity. b) T1W out phase-Indian ink artifact (borders have a delineated line). c)T2W with a bright CSF signal intensity. d)Diffusion weighted images(DWI) with b value of 1000 e) Apparent diffusion coefficient(ADC) map.

tumours and abscess have restricted diffusion and low ADC value. Cystic masses and necrosis have high ADC value and unrestricted diffusion.[6] (Fig.2d,e)

4. **Magnetic resonance cholangio-pancreatography (MRCP)–** It is the most commonly utilised non invasive imaging for the evaluation of biliary and pancreatic ductal system. The high T2 signals lights up the bile and pancreatic fluid with high spatial resolution even in a non-dilated system mimicking contrast images. This sequence is primarily used for evaluation of obstructive jaundice, cholangitis, unexplained abdominal pain (biliary and pancreatic cause). The congenital variations and pathologies of the ductal system are well delineated helping in early diagnosis and treatment.

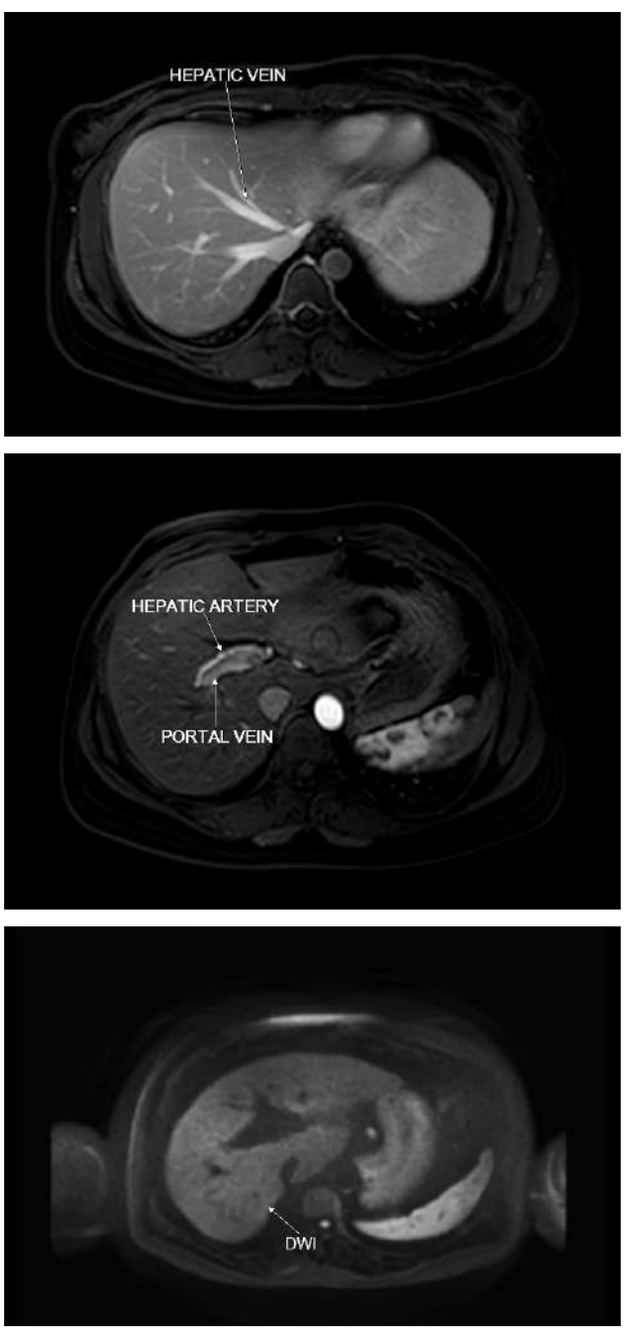


Fig 3. MRI liver (contrast). a) Late arterial phase showing opacified artery and early opacification of the portal veins. b) Portal venous phase c) Delayed phase.

CONTRAST MRI

Extracellular and hepatobiliary contrast agents are commonly used in liver imaging. While extracellular agents are distributed in the interstitial spaces, hepatobiliary agents are taken up by the hepatocytes and excreted in bile. The extracellular agents are used for lesion detection and characterisation based on dynamic imaging and vascular assessment. Hepatobiliary specific agents are used to characterise the lesions as hepatocellular and non-hepatocellular origin and further to specifically characterise the hepatocellular lesions having functioning and non-functioning hepatocytes.

The extracellular paramagnetic contrast agents, Gd-DTPA (Gadopentate dimeglumine, Magnevist) is the commonly used agent. This contrast shortens the T1 relaxation time and appears bright on TIW images and hence contrast is performed in T1W sequence. Acquisition of the images are similar to CT, late arterial (20-30 seconds), portal venous (60 to 80 seconds) and delayed (3-10 minutes) after contrast administration. (Fig.3) It is administered at a dose of 0.1 millimole per kg, at a rate of 2 ml per second followed by saline flush[7].

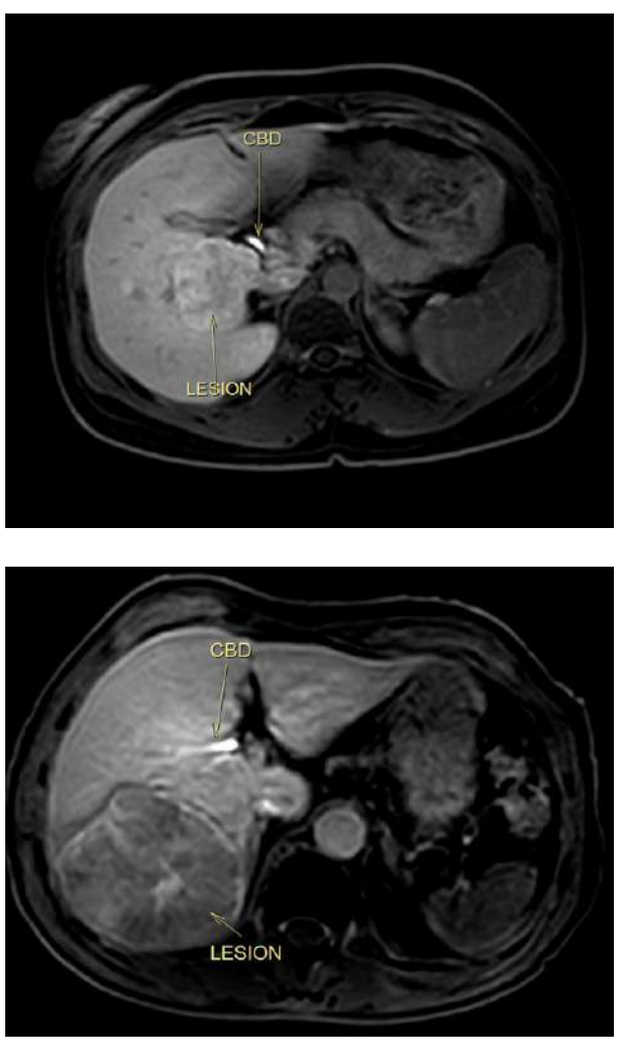


Fig 4. MRI liver (Hepatobiliary contrast) @ 2 hrs – showing the biliary opacification. a) The lesion in posterior segment shows retained contrast thereby representing functioning hepatocytes (FNH). b) The lesion shows washout representing non-functioning hepatocytes (HCC).

Multihance (Gd-BOPTA) and Eovist (Gd-EOB-DTPA) are the two commonly used hepatobiliary specific agents. Lesions having functioning hepatocytes (FNH/Adenoma/well differentiated HCC) retains the contrast and appears bright. Lesion of non-hepatocyte origin (Cyst/Hemangioma/Metastasis) and non-functioning hepatocytes (Poorly Differentiated HCC) will appear dark. Hepatobiliary phase is also used for dynamic evaluation of the biliary tree.[8] (Fig.4)

Further Reading:

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