Liver Imaging: A Guide for Medical SpRs

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Core Curriculum in Hepatology
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Acknowledgements

• Ronan Ryan
• Sinead McEvoy
• Lisa Lavelle
• Anne Carroll
Learning Objectives

• How to classify and work up patients with focal liver lesions in non-cirrhotic livers
• To learn something about imaging findings and workup in cirrhosis, PHT, PVT, nodes and nodules in cirrhotic livers
• What imaging tests to use in:
  – Patients with post-OLT complications
  – Suspected cholangiocarcinoma
Imaging patients with focal liver lesions
The Clinician should establish

- Age
- Symptomatic/ asymptomatic lesion?
- Which category of patient -
  - Incidental finding, otherwise well?
  - History of malignant disease?
  - Chronic liver disease?
- Relevant tumour markers
  - AFP, CA-19-9, CEA
Radiologist must establish

• Lesion Characterisation:
  – Benign v. Malignant
  – Benign ‘leave alone’ lesions

• Lesion identification
  – Number of lesions and their site, size
The same imaging findings may represent different lesions in non-cirrhotic and cirrhotic livers.
Incidental lesion, otherwise well

• Typically a female patient aged 20-40 who has had US for abdominal discomfort.
• A focal lesion is seen in the liver.
• Top 3 differential diagnoses:
  1. Cyst (US or CT)
  2. Haemangioma
  3. Focal Nodular Hyperplasia
• Consider adenoma
Key US Features: Hepatic Cyst

- Transonic
- Thin wall
- Bright back wall
- Increased posterior through transmission
Liver cyst: CT
Sub-centimetre cysts on CT
The ‘incidental’ subcentimetre lesion on CT

Managing Incidental Findings on Abdominal CT: White Paper of the ACR Incidental Findings Committee

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As multidetector CT has come to play a more central role in medical care and as CT image quality has improved, there has been an increase in the frequency of detecting “incidental findings,” defined as findings that are unrelated to the clinical indication for the imaging examination performed. These “ incidentalomas,” as they are also called, often confound physicians and patients with how to manage them. Although it is known that most incidental findings are likely benign and often have little or no clinical significance, the inclination to evaluate them is often driven by physician and patient unwillingness to accept uncertainty, even given the rare possibility of an important diagnosis. The evaluation and surveillance of incidental findings have also been cited as among the causes for the increased utilization of cross-sectional imaging. Indeed, incidental findings may be serious, and hence, when and how to evaluate them are unclear. The workup of incidentalomas has varied widely by physician and region, and some standardization is desirable in light of the current need to limit costs and reduce risk to patients. Subjecting a patient with an incidentaloma to unnecessary testing and treatment can result in a potentially injurious and expensive cascade of tests and procedures. With the participation of other radiologic organizations listed herein, the ACR formed the Incidental Findings Committee to derive a practical and medically appropriate approach to managing incidental findings on CT scans of the abdomen and pelvis. The committee has used a consensus method based on repeated reviews and revisions of this document and a collective review and interpretation of relevant literature. This white paper provides guidance developed by this committee for addressing incidental findings in the kidneys, liver, adrenal glands, and pancreas.

Key Words: Incidental findings, incidentaloma, pancreatic cyst, renal cyst, liver lesion, adrenal nodule

Key Imaging Features: Haemangioma

- Nodular peripheral enhancement that tracks the dominant vascular phase
- The lesion fills in from the periphery towards the centre
- The lesion is T2-hyperintense even on very long TE sequences (> 180)
‘Classic’ Haemangioma

T1 IP       T1 OP       T2 SS FSE       T2 FS FSE
‘Classic’ Haemangioma

Gd Art                      Gd Port                      Gd Delayed
Key Imaging Features: FNH

- The lesion is uniformly hyperintense on the arterial phase and becomes almost isodense on the portal venous and delayed phase
- The lesion tracks liver on MR
- The lesion takes up liver-specific contrast medium
FNH

Pre-Contrast

Arterial Phase

Liver-specific CM
Haemangioma / FNH

• Look for typical vascular pattern with most available, lowest radiation method
  – Contrast-enhanced US
  – MRI
  – CT
Adenomas

- Inflammatory – 30% bleed
- HNF 1-alpha mutated – low risk if < 5cm
- Beta-catenin mutated – malignancy risk
- Unclassified
- Hepatic adenomatosis

Radiographics 2011; 31:1529
Known malignant disease

• In a patient with known malignant disease it is important to know if this is a new liver lesion. If so, the differential diagnosis is
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  3. Metastasis from the known primary
Known Malignant Disease

• If this is the first staging workup image all liver lesions aggressively for diagnosis

• MRI with liver-specific contrast medium is better than CT for lesion identification and characterization
? Breast Ca Metastasis
? Breast Ca Metastasis
Chronic Liver Disease

Cirrhosis, Portal Hypertension, Portal vein thrombosis, Nodes and Nodules in cirrhotic liver
What is Cirrhosis?

• A diffuse hepatic parenchymal process with extensive fibrosis and regenerative nodule formation

• There are many causes of cirrhosis
Cirrhosis
Recognising Cirrhosis

- Liver contour
- Lobar morphology
  - Hypertrophy left and caudate
  - Atrophy right lobe
  - Widening of the GB fossa and fissure for FL
  - ‘The C/ RL ratio’
  - PSC / Budd-Chiari variants
  - Fibrous septae
Cirrhotic liver contour
US - Zoomed view
Cirrhotic Liver Contour

Widened fissure for FF

Widened GB Fossa
Caudate-Right Lobe Ratio

C/ RL > 0.65
> 96% CI for Cirrhosis

Harbin et al, Radiology 1980; 135:273
Exceptions

Late PSC

Late Budd-Chiari
Query cirrhotic liver?

• We can rule it in

• We cannot rule it out
Portal Hypertension

Fig. 7.1. Causes of portal hypertension. (a) Pre- and posthepatic. (b) Intrahepatic.
Portal Hypertension: Collaterals

- OG Jxn
- GH ligament
- Umbilical Vein
- Caput Medusae
- Splenorenal shunt
Portal Hypertension: Oesophageal Varices
Portal Hypertension:
Gastrohepatic ligament varices
Portal Hypertension: Recanalisation of the umbilical vein
Portal Hypertension: Caput Medusae
Portal Hypertension: Caput Medusae
Portal Hypertension: Splenic Varices and Splenorenal shunts
Portal Hypertension

GB oedema

Small bowel oedema
Lymphadenopathy in Cirrhotic Patients
Enlarged lymph nodes are common in late cirrhosis

- PBC 86%
- PSC 69%
- Cryptogenic 64%
- Viral 48%
- Alcohol 37%

- Even in HCC 94% of nodes benign

Dodd GD et al, Radiology 1997; 203:127
Portal Vein Thrombosis

- Occlusive or non-occlusive?
- Benign?
- Tumour thrombus?
PVT: Non-occlusive
PVT on Ultrasound
Benign PVT

Arterial Phase Imaging

PVP CT

DWMR b800
Malignant PVT

4-phase dynamic MR: Delayed phase

Arterial Phase Imaging

DWMR b800
Malignant PVT MPR

PVP Coronal MPR

DWMR b800 Coronal MPR
Malignant PVT

- Arterial phase hypervascularity
- PVP isodensity
- Delayed phase washout
- High SI on DWMR
- High AFP
  (may be in 1000s)

If in doubt, FNA under US guidance
Hepatocarcinogenesis

- Regenerative Nodule
- Low grade dysplastic nodule
- High grade dysplastic nodule
- Early HCC
- Overt HCC
Overt HCC does NOT have a portal blood supply Therefore it has a characteristic enhancement pattern This is used for non-invasive radiological diagnosis
American Association for the Study of Liver Disease

Characteristic Imaging Features of HCC

- Four phase contrast enhanced study
  - 4 Phase Multidetector CT (MDCT)
  - Dynamic contrast enhanced MRI

* Arterial hyperenhancement

* Portal venous or delayed phase washout

* ‘Washout’ a misnomer - relative hypoenhancement compared with surrounding parenchyma on portal venous or delayed phase
? HCC: T1W images

TI (IP)

T1 (OP)
HCC: T2W images

T2W Fat Sat

T2W TE 72

T2W TE 480
HCC: Dynamic Vascular Imaging
HCC: Dynamic Vascular Imaging

Arterial Phase
HCC: Dynamic Vascular Imaging

Portal Venous Phase
HCC: Dynamic Vascular Imaging

Equilibrium Phase
HCC: Dynamic Vascular Imaging

Arterial neovascularization

Portal venous destruction
HCC: Liver-Specific MR Contrast

Unenhanced + 20 min

No Hepatocyte Uptake (‘Primovist’)

HCC: Diffusion-Weighted Imaging
Nodules

Stepwise Development of HCC in cirrhosis

Radiographics
LI-RADS (Liver Imaging Reporting and Data System)

Category 1: Definitely Benign

Criteria
- Imaging features diagnostic of a benign entity (see Table 1 for examples) OR
- Definite disappearance in absence of treatment

Category 2: Probably Benign

Criteria
- Imaging features suggestive of a benign entity (see Table 2 for examples) OR
- Stable imaging features ≥ 2 years AND no increase in diameter for ≥ 2 years AND does not meet criteria for LI-RADS 1 or 4 or 5 OR
- Probable disappearance in absence of treatment OR

Note: Do not classify as LI-RADS 1 or 2 observations that have one or more ancillary features that favor the diagnosis of HCC. Table 5 lists ancillary features that favor the diagnosis of HCC.

Category 3: Intermediate Probability for Hepatocellular Carcinoma

Criteria
- An observation that does not meet unequivocal criteria for LI-RADS 1, 2, 4, or 5 (see Table 3 for specific criteria) OR
- An observation that meets criteria for LI-RADS 4 or 5 with stable imaging features for ≥ 2 years AND no increase in diameter for ≥ 2 years

Category 4: Probably Hepatocellular Carcinoma

Criteria
A. <20mm
- Masslike, arterial-phase hyperenhancement, with only one Additional Major Feature (see below*) OR
- Masslike, arterial-phase isoenhancement or hypoenhancement, with two Additional Major Features (see below*) OR
- Probable tumor within lumen of vein (see Table 6)

B. 20mm or greater
- Masslike, arterial-phase hyperenhancement, with no Additional Major Feature (see below*) OR
- Masslike, arterial-phase isoenhancement or hypoenhancement, with one or two Additional Major Features (see below*) OR
- Probable tumor within lumen of vein (see Table 6)

Category 5: Definitely Hepatocellular Carcinoma

Criteria
A. ≥ 10 & <20 mm
- Masslike, arterial-phase hyperenhancement, with 2 Additional Major Features (see below*) OR
- Definite tumor within lumen of vein (see Table 6)
LI-RADS

Observation

Benign entity?

Definite

Probable

Neither definite nor probable

No

Mass?

Yes

Non-HCC malignancy?

Yes

OM

No

Tumor in vein?

No

Diameter (mm):

<table>
<thead>
<tr>
<th>Arterial phase hypo- or iso-enhancement</th>
<th>Arterial phase hyper-enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 20</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>≥ 20</td>
<td>10-19</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>≥ 20</td>
</tr>
</tbody>
</table>

LR1

LR2

LR3

LR4A

LR4B

LR5A

LR5B

LR6

Apply Ancillary Features and then Tie-Breaking Rules to Adjust Category

Acknowledgments

Feedback? Email ndrd@acr.org
American Association for the Study of Liver Disease
Imaging Guidelines for Focal Liver Lesions in Cirrhosis

Focal lesion in a cirrhotic liver

- **<1cm**
  - Follow up ultrasound at 3 month interval
  - Stable over 2 years: return to 6 monthly surveillance
  - Interval growth: investigate as below

- **>1cm**
  - 4 Phase Multidetector CT or Dynamic Contrast Enhanced MRI
  - Characteristic imaging features: HCC
  - Non characteristic features: Second contrast enhanced study or biopsy

HCC on US can be hypoechoic, hyperechoic or of mixed echogenicity
Case Example

• 45 yr old male with hepatitis C cirrhosis

Image from US showing a 3cm lesion in the left lobe of liver

Images from subsequent 4 phase MDCT; arterial and delayed phases. Both arterial hyperenhancement and delayed washout are demonstrated confirming HCC.

Images from contrast enhanced MRI; T1 weighted arterial and delayed sequences. A solitary 4.1cm mass is demonstrated in segment 4a. It is hyperenhancing on the arterial phase but no definite washout is identified on venous or delayed phases. Therefore the diagnosis of HCC cannot be made. Second study or biopsy advised.

How will we stage this?

Images from subsequent 4 phase MDCT; arterial and delayed phases. Both arterial hyperenhancement and delayed washout are demonstrated confirming HCC.
Staging Systems

- Multiple staging systems have been proposed for HCC, including TNM, BCLC, GRETCH, Okuda, CUPI, CLIP, JIS
- No worldwide consensus on which to use
- Performance status, tumor extent and liver function are independent predictors of survival*
- Thus preferable to use a system which incorporates all 3 factors

Barcelona Clinic Liver Cancer staging system has best predictive power for survival when compared with other prognostic systems*

* Marrero et al, Hepatology 2005
Barcelona Clinic Liver Cancer

- Takes into account:
  - Radiological tumor extent
  - Liver function using the Child Turcotte Pugh scoring system (CTP)
  - Eastern Cooperative Oncology Group performance status (ECOG)*

- Links staging with treatment
- Externally and prospectively validated
- Used in most major trials of HCC therapy – reference staging system
- Continuously updated to incorporate emerging changes

* Oken et al, Am J Clin Oncol 1982
BCLC Staging System*

* AASLD, Bruix et al, Hepatology 2010
'First-pass’ pre-OLT Imaging

- 4-phase liver MDCT, extending portal venous phase to the full abdomen and pelvis
  - HCC?
  - Status of portal venous system
  - Status of hepatic veins and arteries
  - Liver volume
Post-OLT Complications

• ‘Ducts and Dopplers’
• Suspected biliary dilatation
  – MRCP
  – ERCP/ PBD
• Suspected vascular complication
  – Triphasic MDCT and CTA
The Role of Hepatic Arterial Doppler Ultrasound after Liver Transplantation: an ‘Audit Cycle’ Evaluation


Department of Radiology and *The Irish National Liver Transplant Unit, St. Vincent’s University Hospital, Elm Park, Dublin 4, Republic of Ireland

Received: 10 March 1999  Revised: 7 December 1999  Accepted: 16 December 1999

AIMS: To compare the diagnostic performance of hepatic arterial (HA) Doppler ultrasound post-liver transplantation for hepatic artery thrombosis and stenosis in our unit with the literature. To evaluate the role of the technique in clinical practice.

MATERIALS AND METHODS: In a two-phase ‘audit cycle’ study, adult OLT patients had Doppler studies comprising detection of HA flow and measurements of peak systolic velocity, resistive index and systolic acceleration time. In phase I, patients had Doppler examinations ‘routinely’ and for any hepatic biochemical abnormality. In phase II, Doppler ultrasound was performed early post-OLT and later only if a senior transplant clinician suspected graft ischaemia. In addition to HA measurements the waveform was visually assessed. Clinical outcome was the ‘gold standard’.

RESULTS: Phase 1: 38 patients, 40 OLT operations, 125 Doppler studies; 14 arteriograms. Phase 2: 35 patients, 42 OLT operations, two HA angioplasties, one HA revision, one non-occlusive thrombus, 140 studies; 17 arteriograms. Results: Phase 1 [Phase 2]: sensitivity 80% [100%]; specificity 71% [81%]; PPV 28% [56%]; NPV 96% [100%]; incidence of HA abnormality 12.5% [19.5%]; likelihood ratio of negative result 0.28 [0]; of positive result 2.8 [5.3].

CONCLUSION: Previously reported results are reproducible. Normal HA waveform should also be a criterion of normality. The technique is very sensitive but relatively non-specific. Predictive values improve with discriminate use. MacEnaney, P. M. et al. (2000). Clinical Radiology 55, 517–524.

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GRAPH OF CONDITIONAL PROBABILITIES: HA Doppler in patients suspected of graft ischaemia
(MacEneaney et al, 2000 Clin Rad; 55:517-524)
Triphasic CT and CTA
3D - CTA
CHOLANGIOCARCINOMA
Cholangiocarcinoma

• Extrahepatic/ Central
  – 90% of tumours
  – Subclassified by location and behaviour

• Intrahepatic/ Peripheral
  – 10% of tumours
  – Incidence increasing in Western nations

• Mean age of presentation > 65 yo
  (except in PSC, where it is < 40 yo)
The 3 types of ‘extrahepatic’ cholangiocarcinoma according to the morphologic classification system proposed by the Liver Cancer Study Group of Japan.

Chung Y E et al. Radiographics 2009;29:683-700
4-Phase MDCT

NC

AP

PVP

+4 min
4-Phase MDCT
MRCP
Gallbladder Carcinoma
Intrahepatic/ Peripheral CCa
Diagnosis of CCa in PSC

- Dominant Stricture

- CA-19-9 > 129 U/ml
  - Sens 79%
  - Spec 98%

- Cytological Brushings

- PET/CT

Walker & McCormick, Abdo Im 2008; 33:14
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