Multidetector CT for Hepatobiliary Tumors

Douglas S. Katz, M.D.

Vice Chair for Research & Education, Dept. of Radiology, & Director of Body Imaging, Winthrop-University Hospital, Mineola, NY
Professor of Clinical Radiology, SUNY at Stony Brook
Deputy Editor, Radiology
Purpose

- To review the current role of multidetector CT (MDCT) in the evaluation of known or suspected primary or secondary hepatobiliary malignancy
- To briefly explain current MDCT technology & imaging protocols
- To review the MDCT findings of various malignant hepatic masses
- To explain the role of MDCT for follow-up after surgery or other treatment
- To briefly overview current controversies in the use of MDCT for imaging hepatobiliary malignancy

Multidetector CT Technology

- Current MDCT: 16 to 64+ detectors or channels
- Acquire 16-64+ data streams simultaneously; leads to very rapid scanning – entire liver with thin sections in several seconds
- Shorter breath hold - advantageous for elderly/ill patients
- Thin sections (1 mm or smaller) can be reconstructed &/or combined to thicker sections
- “Isotropic voxels” – same dimensions in x, y, & z planes – permits high-quality reformations directly from the “raw” CT data: multiplanar (sagittal, coronal) or volumetric (e.g., for CT angiography (CTA))
Multidetector CT Technology

- Other advantages of MDCT technology:
  - decrease or eliminate motion & other artifacts
  - scan entire liver during specific phase(s) of contrast injection:
    - early arterial (e.g., 15-20 seconds from start of injection, but depends on age, cardiac output, weight, etc.) - use for CT angiogram
    - late arterial (e.g., 25-30 seconds) – for hypervascular lesions
    - portal venous (e.g., 50-70+ seconds)
    - delayed (2-15 minutes)
  - can perform advanced applications – e.g., perfusion imaging, fusion with PET data
  - has completely replaced CT arterial portography/CT hepatic arteriography at most centers

Multidetector CT Technology

- Downside of MDCT c/w MR is radiation dose, especially with multiphasic protocols
- Another potential downside - increased identification of small hepatic lesions which may not be clinically relevant
- Some authors advocate “scan thin, review thick” (Dr. Jonas Rydberg, Indiana University)
- Use of arterial + portal venous phase images improves identification and characterization of many liver lesions, both benign & malignant
- Use dose reduction strategies such as “z-axis dose modulation” (based on patient size at each point during scanning), especially in younger patients without proven tumor, e.g., screening for HCC
MDCT versus MR

- “MR is often viewed as the most sensitive and specific technique for evaluating the liver... While there is data in the literature supporting this contention, the evidence is by no means overwhelming, & not surprisingly there is relatively little information available on comparisons between state-of-the-art MR and CT”
  - James Glockner, Mayo Clinic (JMRI 2007)

- MDCT is more readily available, much faster, & somewhat lower in cost
- MDCT has superior spatial resolution
- MR has wide flexibility/range of pulse sequences, & superior contrast resolution

Role of IV Contrast

- In general, IV contrast is critical to the correct identification and characterization of hepatic lesions
- Iodinated contrast is always given for evaluation of known or suspected hepatobiliary malignancy, unless contraindicated: allergy, renal failure, or patient refuses to give consent
- Hepatic contrast dynamics are complex
- Most practices inject a set amount of a fixed concentration at a fixed rate (2.5 – 5 mL/sec) – but vary volume depending on patient weight (Brink JA JCAT 2003)
- Use faster rate for arterial-phase imaging/CTA
Phases of Contrast

- Roles of non-enhanced and delayed CT images are somewhat controversial
- Somewhat easier to see calcium and hemorrhage on initial non-enhanced images
- They add little in most patients, especially non-enhanced images, & adds substantial radiation
- However, persistent washout on delayed images adds specificity for HCC
- It is important to tell the radiologist what type of tumor is known or suspected, so that the protocol can be customized as needed

Phases of Contrast

- Routine portal venous phase imaging alone is adequate for most known or suspected ‘hypovascular’ metastases
- Use arterial phase + portal venous phase imaging for known or suspected HCC or ‘hypervascular’ metastases: islet cell tumor, renal cell CA, melanoma, carcinoid, some sarcomas – improves yield by 10-30%
- Delayed images may add specificity and increased yield, in suspected cholangiocarcinoma, esp. in the Klatskin type
- Portal venous phase images are adequate for evaluation of most hepatobiliary cystic lesions
Hepatocellular Carcinoma

- CT (& MR) - widely used for the diagnosis and follow-up of hepatocellular carcinoma
- CT & MR are both superior for screening for HCC compared with sonography, but are more expensive, and the radiation dose can be substantial especially if CT is used frequently
- Ultrasound contrast agents are STILL NOT approved for body imaging applications in the United States
- MR appears to have **slightly** higher accuracy for identification of HCC, compared with state-of-the-art MDCT; accuracy lower for smaller foci
- Few CT/MDCT studies with explant correlation

56-year-old man with HCC – CT & MR
Hepatocellular Carcinoma

- Larger HCC foci – hypervascular, heterogeneous (“mosaic” pattern); smaller HCC foci may be uniformly hypervascular
- Higher grade HCC often washes out on portal venous & delayed images - becomes relatively hypovascular, & see capsule – gets blood supply from hepatic artery (Doyle DJ et al. JCAT 2007)
- Look for portal venous invasion/arterialization
- Problems in cirrhotic patients with overlap of small (often lower grade) HCC grade lesions, & dysplastic nodules, residual benign lesions (hemangioma, FNH), & non-tumoral shunts

Hepatocellular Carcinoma

- Arteriportal shunts are common in HCC (up to 60%), and in cirrhosis alone (Kim HJ et al. AJR 2005)
- Lower-grade HCC foci may not be hypervascular; also watch for diffuse infiltration
- Small (< 2 cm) hypervascular foci seen ONLY on hepatic arterial phase images are particularly problematic:
  -10 to 30% are HCC
  - further evaluate with MR and/or get 3-6 month follow-up (Taouli B et al. Liver Transpl 2006)
  - correlate with alpha-fetoprotein level
62-year-old man with HCC

Hepatocellular Carcinoma

- Controversy over what phases to obtain on MDCT when imaging for HCC
- No utility of ‘dual phase’ arterial imaging (early and late) (Ichikawa I et al. AJR 2002; Laghi A et al. Radiology 2002)
- Initial non-enhanced images also have no utility (Doyle DJ et al. JCAT 2007; Iannaccone R et al. Radiology 2005)
- Delayed phase does slightly improve sensitivity – from 89% to 93% in one study - but increased the overall diagnosis of HCC by only 2 out of 190 patients (Iannaccone R et al. Radiology 2005)
- Number of phases of MDCT is NOT an issue with MR – no ionizing radiation – ALWAYS do multiple phases & pre-contrast imaging
Cholangiocarcinoma

- Peripheral hepatic cholangiocarcinomas are usually large, heterogenous, relatively hypovascular, non-specific masses
- Suspect diagnosis if the lesion has the appearance of a metastasis from a bowel primary, but none is found
- Klatskin tumors – lesion itself may be difficult to identify unless invading one or both adjacent hepatic lobes
  - intrahepatic biliary dilatation, ending at the junction of right & left ducts
  - thin sections & delayed images/multiplanar images are helpful (Kamel IR et al. Radiol Clin North Am 2005)
  - look for intrahepatic metastases, vascular encasement, lymphadenopathy, & distant metastases

74-year-old woman with cholangiocarcinoma
75-year-old man with cholangiocarcinoma – four-phase CT

Cholangiocarcinoma

- Recent MDCT reports – more promising c/w earlier literature for more accurate staging (Lee HY et al. Radiology 2006; Cho ES et al. JCAT 2007; Kim HJ et al. Radiology 2005)
- Common bile duct cholangiocarcinoma – variable appearance – stricture, polypoid lesion, invasive mass
- MR is complementary, especially for suspected Klastkin tumors – do MRCP + gadolinium-enhanced sequences, including delays
- No risk of inducing cholangitis/pancreatitis with CT/MR, unlike with ERCP
Cholangiocarcinoma & Biliary Cystic Tumors

- Gallbladder carcinoma – findings of advanced invasive tumor: hypodense mass centered on gallbladder, gallstones, direct invasion of liver, omental tumor
- Less advanced gallbladder cancers are usually identified at cholecystectomy and not at CT prospectively
- Biliary cystadenoma/cystadenocarcinoma – cystic, usually intrahepatic lesion; may have complex appearance – septae, nodules

Hepatic Metastases

- MDCT: imaging test of choice for identification, characterization, and follow-up of hepatic metastases in most patients
- Most metastases are hypovascular relative to normal hepatic parenchyma, on portal venous phase images – e.g., colon, lung, pancreatic CA
- Need to distinguish from benign hypovascular lesions – cysts, hamartomas, abscesses
- Purely cystic metastases - difficult to diagnose
- “TSTC” – “too small to characterize” lesions - remain somewhat problematic, are difficult to biopsy, & may require follow-up imaging
Typical TSTC hepatic lesion

Hepatic Metastases

- 80% of hepatic lesions < 1 cm, in patients with known primary tumors, are benign (cyst, hamartoma, hemangioma) (Schwartz LH et al. Radiology 1999)

- Thinner slice collimation leads to detection of more smaller hepatic lesions (Weg N et al. Radiology 1998) – 18% increase from 5 versus 2.5 mm image reconstruction

- But sensitivity for hepatic metastases does not necessarily improve with thinner slice thickness (Haider MA et al. Radiology 2002)

- Rather than performing CT follow-up in several months, consider MR for < 10 mm lesions: 98% specificity on MR c/w 77% specificity on MDCT (in 59 patients with 178 lesions) (Holalkere NS et al. JCAT 2006)
Hepatic Metastases

- Rim-enhancing lesions, in the correct clinical setting, are metastases until proven otherwise (ddx.: abscesses)
- Larger ‘hypovascular’ metastases may be heterogenous especially at their periphery; may have shunting in adjacent liver on late arterial/early portal venous images (“THAD”) (Kim HJ et al. AJR 2005)
- Perform biphasic CT for known or suspected hypervascular metastases; become either isodense or hypodense on portal venous phase
- Distinguishing small hypervascular metastases from benign lesions – hemangioma, adenoma, shunt - remains problematic, as with HCC, even with thin-section MDCT; get follow-up imaging

Small hypervascular focus in a 59-year-old with cirrhosis
60-year-old woman with metastatic lung cancer

77-year-old woman with metastatic pancreatic islet cell carcinoma
Hepatic Metastases

- Some tumors are variable – e.g., subset of breast carcinoma metastases are relatively hypervascular.
- Selected tumors have specific or relatively specific appearances:
  - low density - mucin and/or necrosis, in colorectal/other metastases from the GI tract
  - calcification in mucin-producing neoplasms (although any treated lesions may calcify)
  - fat in metastatic liposarcoma (rare)
  - some metastases may look identical to the primary tumor – e.g. renal cell carcinoma, islet cell tumor

94-year-old woman with mucinous/necrotic metastases from colon cancer
59-year-old man with stable treated colon cancer metastases on non-enhanced CT (done for unrelated reasons)

46-year-old man with calcified metastases from esophageal cancer; non-enhanced CT
Pre-surgical/Pre-procedural Planning

- MDCT of hepatobiliary tumors assists in surgical planning:
  - resection of hepatic metastases
  - resection of HCC
  - transplantation
- MDCT - highly useful for determination of: number of lesions, location in lobes/segments, vascularity, relationship to central vessels/bile ducts, & for CTA (vascular variants in 45%)
- Determine suitability or non-suitability for these procedures

Pre-surgical/Pre-procedural Planning

- MDCT images very useful for guiding biopsy & non-surgical therapies:
  - embolization (for therapy; also pre-resection, to hypertrophy non-involved liver)
  - chemoembolization
  - radiofrequency ablation (RFA)
  - cryoablation/laser ablation

- Entire data set can be used for:
  - identification of extra-hepatic metastases
  - evaluation of portal hypertension in cirrhotics
  - planning for transplantation
MDCT for Follow-up Imaging

- MDCT: usual imaging test of choice for follow-up of hepatic malignancy after chemotherapy, surgery, embolization, & RFA
- Similar considerations for MR in lieu of MDCT, as with initial imaging
- Similar CT protocol considerations as with initial imaging; assess for:
  - change in lesion size & **vascularity** - the latter has become increasingly important with newer therapies (WHO/RECIST criteria for tumor response have substantial limitations)
  - new lesions/extrahepatic disease

51-year-old woman with stable appearance of liver following chemotherapy for breast cancer
43-year-old man pre- and post-embolization for HCC

26-year-old woman with cholangiocarcinoma, history of right Wilms tumor in childhood, pre- & post-embolization
58-year-old man with HCC, s/p chemoembolization, with residual focus & lumbar spine metastasis

MDCT for Follow-up Imaging

- MDCT (usually biphasic) - typically performed very shortly after RFA & then several times within next year
- With colorectal hepatic metastases/HCC, may see initial hypervascular rim which should resolve in 3-6 months (Choi H et al. RadioGraphics 2001)
- Ill-defined margins, increasing thickness of rim/hypervascularity, new peripheral nodularity, or increased size on serial imaging is consistent with incompletely treated tumor/recurrence on f/u CT after RFA (Liamond P et al. AJR 2003; Filippone A et al. JCAT 2007)
- MDCT - demonstrates complications of surgery/therapy – infection, bleeding, bile leak
54-year-old woman s/p RFA, with new metastasis from breast CA

“Good news!!! Your CT scan was completely unnecessary! We will just need a few more imaging tests before I examine you”
Conclusions

- In most circumstances, MDCT is the imaging test of choice for the evaluation and follow-up of known or suspected hepatobiliary malignancy.
- Although some controversies persist, in general there is consensus on most aspects of MDCT technique.
- MR has a major supplemental role, and is preferred to MDCT in selected situations.
- It is important to provide history to the radiologist, to permit customization of the appropriate MDCT protocol as needed.