Contrast Enhanced MR and CT Cholangiography

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Disclosures

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Consultant, Bracco Diagnostics
Acknowledgments

• Ben Yeh MD.
UCSF, San Francisco CA
Biliary imaging

US

Fluoro

MRCP

Routine CT

Scintigraphy

CT Cholangiography
Background - CE-MRC

Hepatobiliary phase of contrast enhancement
T1-shortening effect, bright bile on T1WI
Wide window for imaging (10 min - several hours)
High-resolution/volumetric T1 WI in a breath-hold

Morphologic and functional imaging
CE-MR Cholangiography

T1 MRC
# Hepatobiliary Contrast Agents

<table>
<thead>
<tr>
<th>Properties</th>
<th>MnDPDP (Teslascan)</th>
<th>Gd-BOPTA (Multihance)</th>
<th>Gd-EOB-DTPA (Eovist/Primovist)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>--</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>H-B phase</td>
<td>+++ &gt;10 min-hours</td>
<td>+ &gt; 60 min-2 hrs</td>
<td>+++ &lt;10 min-hrs</td>
</tr>
<tr>
<td>Biliary Excretion</td>
<td>50%</td>
<td>6%</td>
<td>50%</td>
</tr>
<tr>
<td>FDA</td>
<td>Approved Pulled out</td>
<td><strong>Approved in US and EU</strong></td>
<td>Approved in US and EU</td>
</tr>
<tr>
<td>Examples</td>
<td><img src="image1.png" alt="Example Image" /></td>
<td><img src="image2.png" alt="Example Image" /></td>
<td><img src="image3.png" alt="Example Image" /></td>
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</tbody>
</table>
T1-MRC:HB Contrast

Mn-DPDP

Gd-BOPTA

Gd-EOB-DTPA
Gd-EOB-DTPA / Gd-BOPTA

PHARMACOKINETICS

- Uptake by hepatocytes via bilirubin transport system
- Reduced uptake in patients with compromised liver function/advanced cirrhosis and biliary obstruction
- **Early phase**: Extracellular, similar to Gd-DTPA
- **Late Phase**: Hepatobiliary uptake, Sustained liver enhancement due to biliary excretion
Gd-EOB-DTPA / Gd-BOPTA

**Dose & Protocol**

- **Dosage**
  - Gd-EOB-DTPA - 25-100μ mol/kg
  - Gd-BOPTA - 50-500μ mol/kg

**Postcontrast -**

- Dynamic multiphase T1 W (GRE) w/o F/S -
- Hepatobiliary phase T1 W (GRE) with F/S – T1MRC
  - 20-30 min Gd-EOB-DTPA
  - 60-90 min Gd-BOPTA
“All in One Exam”

MRA

MRV

T1 MRC
Gd-DTPA vs. Gd-EOB (Dynamic Imaging)
Gd-EOB-DTPA Dosage and Injection

Dosage and injection
- 0.025mm/kg @ 1cc/sec
- Saline 30 ml at 2cc/sec
- Bolus timing- Dynamic imaging

Hepatobiliary phase
Mean transit times for CM in the various biliary segments
- IBD= 12min
- CBD=13min
- GB= 13min.

Within 20 min Gd-EOB-DTPA can be expected in the IBD and the CBD in patients with normal liver function.

Ringe KI et al. Eur J Radiol. 2010 Mar 26
T2 MRCP Before or After T1 MRCP?

Before

20 Min Post

Gd-EOB-DTPA adversely affects T2-MRCP and should be performed first within 10 minutes.

CT C: Advantages

• High spatial resolution
  – Cross-sectional & cholangiographic display
  – Co-registration with other anatomy

• Minimally invasive

• Physiologic information

• Easy to perform
  – CT scanners readily available
CT C: Advantages

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• Easy to perform
  – CT scanners readily available
  – Minimally invasive
Excretory CT C Protocol

• Preparation
  – No oral contrast
  – Benadryl 25 mg IV, then FLUSH
  – 30 min infusion iodipamide meglumine 52% diluted 20 cc in 100 cc NS

• CT imaging 15 min after infusion completion
  – If serum bilirubin elevated > 1.5, give double dose iodipamide meglumine, longer delay
Excretory CT C Protocol

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  – No oral contrast
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# CTC Protocol: Following CTA

<table>
<thead>
<tr>
<th>Parameters</th>
<th>16-MDCT</th>
<th>64-MDCT</th>
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<tbody>
<tr>
<td>DC (mm)</td>
<td>0.5-0.75</td>
<td>0.5-0.625</td>
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<tr>
<td>Pitch</td>
<td>1-1.5</td>
<td>1-1.5</td>
</tr>
<tr>
<td>kV</td>
<td>80-100</td>
<td>80-100</td>
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<tr>
<td>mA</td>
<td>AutomA (75-440) (NI 25-30)</td>
<td>AutomA (75-440) (NI 25-30)</td>
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<tr>
<td></td>
<td>Dose 1-3 mSv</td>
<td>Dose 1-3 mSv</td>
</tr>
<tr>
<td>Slice venous (mm)</td>
<td>2-3</td>
<td>2-3</td>
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<tr>
<td>Contrast</td>
<td>30 min infusion of Iodipamide meglumine 52% diluted 20 cc in 100 cc NS</td>
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<tr>
<td>Premedication</td>
<td>Benadryl</td>
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</table>
CT Cholangiography
# Liver Vascular/Biliary Anatomy

<table>
<thead>
<tr>
<th>Anatomy</th>
<th>Anomalies</th>
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<tbody>
<tr>
<td>Artery</td>
<td>45%</td>
</tr>
<tr>
<td>Portal Vein</td>
<td>11-30 %</td>
</tr>
<tr>
<td>Hepatic veins</td>
<td>16-33%</td>
</tr>
<tr>
<td>Biliary</td>
<td>6-15%</td>
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</tbody>
</table>

Biliary Variants
Right hepatic duct draining into Left
Right hepatic duct draining into Left
2nd order biliary findings: Versus intraoperative findings

Percent concordance

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
<th>100</th>
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<tbody>
<tr>
<td>CTC</td>
<td>100%</td>
<td>96%</td>
<td>95%</td>
<td></td>
<td></td>
<td></td>
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</table>

Cheng 1999
Wang 2005
Schroeder 2006

n = 10 24 62
2nd order biliary findings: Versus intraoperative findings

Percent concordance

<table>
<thead>
<tr>
<th>Study</th>
<th>CT</th>
<th>T2w MRCP</th>
<th>T1w MRCP</th>
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<tbody>
<tr>
<td>Cheng 1999</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wang 2005</td>
<td>96%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schroeder 2006</td>
<td>95%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fulcher 2001</td>
<td>88%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limanond 2004</td>
<td>85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee 2004</td>
<td>84%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>An 2006</td>
<td>75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee 2004</td>
<td>91%</td>
<td></td>
<td></td>
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<tr>
<td>An 2006</td>
<td>92%</td>
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</table>
Biliary branch visualization in living liver donors

CT vs MR:

Yeh et al., Radiology 2004

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CT cholangiography
T2w MRC
Excretory T1w MRC
Combined T1 & T2 MRC

Visualization Score

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Common</th>
<th>1st order</th>
<th>2nd order</th>
<th>3rd order</th>
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<tbody>
<tr>
<td>Intrahepatic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Extrahepatic</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

Yeh et al., Radiology 2004
MDCT and MRA/MRC: Hepatic Biliary Anatomy Assessment

CTC (n=266)
- 94-100%
- 4-16 MDCT

MRC (n=151)
- 85-92.5% (n=40)

Schroeder et al 2005
Schroeder et al 2006

Song W et al 2007
Basaran et al 2008
Bilienteric anastomosis

Failed MRCP
Failed ERCP
CT Cholangiogram

Miller, Yeh et al., Liver Transpl. 2004
Hepaticojejunostomy: Anastamosis

T2 MRC

Contrast MRC
Hepaticojejunostomy: Low Grade Stricture

Contrast MRC

Curved Reformat
POST BILIARY-ENTERIC ANASTOMOSIS, OBSTRUCTION OF LEFT BILE DUCT.

HIDA SCAN

FAILED ERC

1. Ratio: 9.8
Post-Whipple Surgery Stricture

T2 MRC

TI MRC
Bile Leak: CE-MRC
Recipient In Living Related Liver Transplant: Bile duct Injury?
Problem Solving: liver cyst?

Routine CT

CT cholang’grm
Bile duct visualization

- CT cholangiogram after inconclusive MRCP (n=31)
  - Better bile duct visualization at CT, p<0.05
  - Additional functional information in 12 of 23 patients

Pearl: Pseudo-narrowing of the CHD (RHA crossing the CHD)

CE-MRC

PTC
Excretory MR-C/CT-C: Limitations

- Excretion of contrast
  - Serum Bilirubin < 2.0
  - Obstruction
  - Metabolic / functional disorder
  - Antibiotics, drug interactions
  - Other

- Non-distention of ducts
  - Physiologic caliber of ducts, no positive pressure

- Contrast reactions
- Ionizing radiation with CT
- Non-interventional
Posterior Biliary Stricture

Miller, Yeh et al., Liver Transpl. 2004
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Agent</th>
<th>% Reactions</th>
<th>n</th>
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<tbody>
<tr>
<td>UCSF</td>
<td>2009</td>
<td>Cholografin</td>
<td>0.6</td>
<td>500</td>
</tr>
<tr>
<td>Cheng</td>
<td>1997</td>
<td>Cholografin</td>
<td>0%</td>
<td>16</td>
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<tr>
<td>Stockberger</td>
<td>1994</td>
<td>Cholografin</td>
<td>0%</td>
<td>18</td>
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<tr>
<td>Maglinte</td>
<td>1993</td>
<td>Cholografin</td>
<td>0.9%</td>
<td>113</td>
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<tr>
<td>Schroeder</td>
<td>2006</td>
<td>Biliscopin</td>
<td>0.7%</td>
<td>250</td>
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<tr>
<td>Persson</td>
<td>2006</td>
<td>Biliscopin</td>
<td>0.7%</td>
<td>153</td>
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<tr>
<td>Breen</td>
<td>2000</td>
<td>Biliscopin</td>
<td>0.7%</td>
<td>300</td>
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<tr>
<td>Kwon</td>
<td>1997</td>
<td>Biloptin &amp; Biliscopin</td>
<td>0.2%</td>
<td>437</td>
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<tr>
<td>Sachiarias</td>
<td>1995</td>
<td>Biliscopin</td>
<td>1%</td>
<td>1061</td>
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<tr>
<td>Nilsson</td>
<td>1987</td>
<td>Biliscopin</td>
<td>1%</td>
<td>196</td>
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<td>Nilsson</td>
<td>1987</td>
<td>Biliscopin</td>
<td>3.5%</td>
<td>2492</td>
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<tr>
<td>Alinder</td>
<td>1986</td>
<td>Biliscopin</td>
<td>1%</td>
<td>200</td>
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</table>
Summary

- CE-MR and CT Cholangiography is now feasible with the availability of HB-CM
  - Opportunities for morphologic and functional biliary imaging
    - Reliably mapping of the biliary anatomy
    - To assess the integrity of the biliary system and biliary-enteric anastomosis
  - Limitations in patients with compromised liver function or biliary obstruction