OBJECTIVES

• Understand normal transplant vasculature
• Distinguish abnormal Doppler parameters as predictors of transplant complications.
• Identify situations in which further imaging (i.e., CT, MR, Angiography) may be useful to assess complications.

USA – Liver Transplantation 2009

• OLT – only treatment for irreversible acute liver failure and chronic end-stage liver disease (ESLD)
• Guideline for liver transplant candidacy - based on improved life expectancy with transplantation
• Priority - based on MELD score (bilirubin, creatinine, INR)
• OUTCOMES (Expected per SRTR)
  • Graft survival rates: 85%, 75% (1,3yr)
  • Pt survival rates: 90%, 80% (1,3yr)

Indications

DISCLOSURES

None
LI 4.1 Total adult liver transplants

Liver Transplants: What are the key vascular connections?

- Vascular Anastamoses
  - HA
  - IVC
  - PV
- Direct biliary anastomosis vs choledocho-jejunostomy

NORMAL PIGGYBACK ANASTOMOSIS LIMITS IVC TO ONE CONNECTION

Imaging Protocol

- Grayscale liver and spleen, biliary tree, perihepatic spaces
- Color and spectral Doppler
  - Hepatic arteries: main, right and left
  - Portal vein: main, right and left
  - Hepatic veins: right and middle and left
  - Splenic vein
  - IVC

Post-operative Liver Transplant

- Major complication
  Hepatic artery thrombosis or stenosis
- Less common
  portal vein, hepatic vein or IVC stenosis or thrombosis

HEPATIC ARTERY IMPORTANCE IN LIVER TXP

- Thrombosis or stenosis: 13%
- Leading cause of graft failure, from bile duct necrosis, infarction, abscess formation.*
- Dx in 10% of asx pts with aggressive screening early p/op **
- Rx: a. revision or re-bx

References:
HAS/HAT Disastrous Complication

DX OF HA THROMBOSIS/STENOSIS

- Resistive index (RI) < 5 and/or acc time > .08 sec in any of vessels (M, R, or L)
  - 73-81% sensitivity for HA T/HAS*, **
- False Positives:
  - Small non-vis HA’s p/op
  - Reperfusion injury with shunting (high velocity/normal acc time).
- False negatives:
  - Rapid collateral formation.***


Rising LFT’s Post-op Txp

Abnormal LFT’s –HAS?

Low RI’s- HAS? False Positive: Intraparenchymal Shunting

Adult LRD Right Lobe Allograft HAT with Normal RIs


HA (arrowheads) reconstituted from phrenic artery collaterals (arrows)
Spectral Doppler and RI's First Ten Days Post Op

<table>
<thead>
<tr>
<th>Normal</th>
<th>37.8%</th>
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<tbody>
<tr>
<td>(244/645)</td>
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</tr>
<tr>
<td>RI = 1</td>
<td>32.6%</td>
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<tr>
<td>(210/645)</td>
<td></td>
</tr>
<tr>
<td>RI &lt; 0.5</td>
<td>16.7%</td>
</tr>
<tr>
<td>(108/645)</td>
<td></td>
</tr>
<tr>
<td>Absent HA</td>
<td>12.8%</td>
</tr>
<tr>
<td>(83/645)</td>
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Do High RI’s predict HAT?

Initial study on 10/1 with high RI and normal liver.

Study 11/25 with no hepatic artery and abnormal liver.

Spectral Waveforms of 56 Patients with HAT Days 0-10

<table>
<thead>
<tr>
<th>Nonvisualization of HA</th>
<th>26/83 (31.3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low RI &lt; 0.5</td>
<td>9/108 (8.3%)</td>
</tr>
<tr>
<td>RI = 1</td>
<td>10/210 (4.8%)</td>
</tr>
<tr>
<td>Normal hepatic waveforms</td>
<td>11/244 (4.5%)</td>
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</tbody>
</table>


Management of Non-vis HA: Rescan, CEUS, Angiography or OR?

| Transient Nonvisualization Rescan <24 hours All HA’s present | 4/52 (7.6%) HAT |
| Persistant Nonvisualization One or more HA | 22/31 (71.0%) HAT |

Odds Ratio 30.00 (95% CI 8.15 to 105.65)


ABSENT DIASTOLIC FLOW- USUALLY RETURNS TO NORMAL NO INCREASED INCIDENCE OF HAT

Day 1

Day 3

Day 14


IMPROVED HA VISUALIZATION WITH US CONTRAST

• 8/72 no flow on CDUS
• 6 flow on CEUS (Optison .5ml)
  – confirmed with angio or nl f/u US.
• 2 no flow, angiography confirmed
• US sensitivity rose from .91 to 1.0 (p<.014)

HAS?

Mh anastomotic stenosis → balloon angioplasty

6 WEEKS POST ANGIOPLASTY

SELECTIVE HA ARTERIOGRAM STENT PLACED

ONE MONTH LATER

ONE MONTH LATER

SIX MONTHS LATER
IVC AND HEPATIC VENOUS OUTFLOW OBSTRUCTION

- Rare in cadaveric transplants (1.3%) due to direct IVC-IVC anastomosis (1)
- Increased (6.7-16.6%) in live donors; small hepatic veins anastomoses (2)
- Presentation: abd pain, ascites, poor liver fx
- Doppler dx: monophasic waveform (1,2)
- 10mm pressure gradient across stenosis considered clinically significant (2,3)


POST TRANSPLANT COMPLICATIONS IVC

Post Transplant Complications: IVC

IVC Thrombosis and Stenosis

Symptomatic HV Stenosis
Elevated Hepatic Wedge Pressures
Required IVC Revision

Note 4:1 ratio of HV velocity at narrowed area vs proximal intrahepatic velocity.

IVC STENOSIS RELATED DONOR

Leg and abdomen swelling 3 years post txp. Treated over 15 months with multiple trials of angioplasty, eventually successfully stented.
PORTAL VEIN COMPLICATIONS
- Stenosis - common, usually asymptomatic.
- Thrombosis, relatively rare.
- HA-PV fistulæ - common
  - post traumatic, (liver biopsy)
  - Doppler: low RI in feeding h a, arterialized
    shunt flow in enlarged pv
  - require embolization for sx (cardiac failure)

PORTAL VEIN THROMBOSIS
POST LIVER TRANSPLANT
INITIAL EXAMS NORMAL

3 mo later
Rapidly deteriorating liver fx, required
retransplantation
Redundant portal vein predisposed to PV thrombosis.

PORTAL VEIN STENOSIS
- Usually at anastomosis
- Angiographically: stenosis = 8mm gradient
- Stenotic velocity 155 cm/sec (nl= 58cm/sec)*
- 3:1 ratio yields 73% sensitivity for stenosis*
- Many resolve spontaneously over time
  – (Grant et al 2009 RSNA)

*Chong, WK, Beland, JC, Winkes SM. Sonographic Evaluation of Venous
Obstruction in Liver Transplants AJR, June 1, 2007; 188(6): W515 - W521

PORTAL VEIN STENOSIS?
Patient asymptomatic and ratio normal, so no rx.

PV Stenosis?
3 months later
PORTAL VEIN
STENOSIS
Peak PV Vel >155 and ratio of 5:1

Post Transplant Hepatic CT

PORTAL VEIN THROMBOSIS?
No detectable flow in the MPV with reversed flow in R and LPVs? Doesn’t make sense. What to do? Get a CT.

HEMATOMA COMPRESSES MPV

FOLLOWING DECOMPRESSION
HA- PV Fistula
- Common Complication
- Most Asymptomatic
- Seen in up to 50% of patients within 1 week post biopsy
- Less than 10% persist beyond a week
- Most close spontaneously


Arterial Steal Syndromes
- ?Consequence of excess PV flow
- Dx by arteriography-low flow into allograft
- US shows elevated RI’s with low velocity or loss of HA flow signal, loss of diastolic flow most specific
- Angiography demonstrates increased flow to the splenic a. or gastroduodenal a.
- Rx includes splenic artery embolization


HA Pseudoaneurysms
- Extrahepatic
- Occur at anastomosis
- Often missed at US
- US 13% sensitivity
- CTA 78%

Post Coiling

PV Steal
- Residual varices divert inflow from PV
- Cases C/O Mindy Horrow

Poor portal vein flow post-operatively
Patient returned to OR

Day 1
Day 2

Despite revising anastomosis, intraoperative flow is very poor

Large splenorenal varices shunted flow from PV
Ligation of varix improved PV flow

5 months post transplant - Portal Vein Thrombosis

Embolization of varices and thrombectomy of portal vein re-establishes flow
Conclusions

- Doppler US central to management of hepatic transplants
- Critical for diagnosis of arterial and venous thromboses and stenoses as well as abnormal flow patterns
- Identifies post interventional sequelae including arteriovenous fistulae and pseudoaneurysms.

THANK YOU