Practical course / Liver
How I do it

OPERATIVE US IN LIVER SURGERY

Stavros Spiliopoulos  MD, PhD, EBIR

Consultant Interventional Radiologist
“OLYMPION” Private Hospital, Patras, Greece
Research Associate, Department of Radiology
Patras University Hospital, Greece
Liver IOUS allows:

- **Focal lesion detection (>2mm) (sensitivity>90%, PPV: 90%, NPP: 78%)**
- **25-35% more lesions compared with standard percutaneous US**

Leads to:

- Changes of the initial surgical plan in 15% of the cases
- Modification of the overall clinical management in up to 50% of the cases
Intraoperative Liver Ultrasound Indications

- Staging of primary/metastatic tumours
- Guidance to resection/ablation of primary or secondary tumours
- Vessel patency/anatomic variations
- Detailed depiction of endoluminal biliary pathology
- Design of partial resection, lobectomy, metastascietomy, transplant interventions

Intraoperative Ultrasound Equipment

- Dedicated intraoperative transducers
- T-shaped linear or curvilinear high frequency probes: 5-10 MHz (higher spatial resolution)
- 3.5-5 MHz probes are useful for initial exploration (better panoramic view)
- Doppler flow and pulsed Doppler imaging capabilities
Intraoperative Ultrasound Equipment
Intraoperative Ultrasound Sterilization

- **Sterile condom sheath**

- **Low-temperature hydrogen peroxide gas plasma sterilization (2-3 hours)**

- Ethylene oxide gas sterilization with high-temperature aeration (16–24 hours, might damage the skin of the transducer tip)

- Glutaraldehyde or dialdehyde solution (4 hours/inflammatory visceral reaction)

Intraoperative Ultrasound Technique

No coupling gel required → Sufficient acoustic coupling from the surface of the liver

Intraoperative Ultrasound Technique

Pre-operative imaging must be available in theatre
Intraoperative Ultrasound Technique

Couinaud segmental anatomy

Intraoperative Ultrasound Technique

- Lights should be dimmed
- Incision of ligaments and hepatic mobilization
- Most challenging portions: posterior portion of the high dome and the blind areas of the liver

Intraoperative Ultrasound Technique

Blind areas of the liver

- High dome of the lateral right lobe: usually requires dissection of the falciform and triangular ligaments
- Posterior sub-diaphragmatic bare area of the liver
- Surface lesions: consider washing with saline or scan from the contralateral liver surface
Intraoperative Ultrasound

Lesion Characterization

Mainly similar characteristics with trans-abdominal US

<table>
<thead>
<tr>
<th>Differential diagnosis of hepatic lesions based on echogenicity</th>
<th>Hyperechoic lesions</th>
<th>Anechoic lesions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoechoic lesions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hepatocellular carcinoma</td>
<td>Most commonly benign</td>
<td>Biliary cyst</td>
</tr>
<tr>
<td>Metastases of extra-abdominal origin</td>
<td>Gastrointestinal metastases</td>
<td>Hydatid cysts</td>
</tr>
<tr>
<td>Hyperplastic nodule</td>
<td>Hepatocellular carcinoma</td>
<td></td>
</tr>
<tr>
<td>Regenerative nodule</td>
<td>Hemangioma</td>
<td></td>
</tr>
<tr>
<td>Adenomatous hyperplasia</td>
<td>Fatty metamorphosis</td>
<td></td>
</tr>
<tr>
<td>Small cysts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Areas without fatty infiltration in a fatty liver</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lesion Characterization:

CEUS: the anaesthesiologist can inject CM

- Small hemangiomas not detected preoperatively are frequently identified intraoperatively
- Fibrosed hemangiomas present peripheral echogenic rim
Lesion Characterization

- Benign and malignant lesions might coexist

- If two lesions have different US features, it is likely that one represents the neoplasm and the other something else

Surgery-specific features

Cautery produces bandlike artifacts

Palpation during liver mobilization produces acoustic shadowing mimicking colorectal mucinous metastases

IOUS-guided surgery
IOUS-guided surgery

1. Evaluation of tumour resectability
2. Type and extent of resection

- Vascular patency
- Vascular invasion
- Anatomical variations
Ischemic demarcation

US-guided precise anatomical resection of a sub-segment or segment of the liver

Ischemic demarcation of segment 6 using the probe on one side and fingertip on the opposite side

Intraoperative IOUS
Biliary disease

- **Exclude metastases** in patients who are undergoing a trisegmental resection for cholangiocarcinoma
- Define ductal anatomy and locate the **confluence of the hepatic ducts** in patients with resectable cholangiocarcinoma
- Locate/characterize **bile duct strictures**
- Define the extent of segmental involvement in chronic inflammatory changes, Caroli disease, or recurrent pyogenic cholangiohepatitis.
- **Color Doppler** to distinguish dilated ducts from vessels and intrabiliary sludge from tumors

Intraoperative IOUS
Liver transplant

- Documentation of vessel patency
- Evaluation of anastomoses
- IOUS-guided thrombectomy
- Identify the avascular resection plane 1–2 cm to the right of the middle hepatic vein in right lobe split-liver transplantation

Intraoperative US-guided thermoablation
Intraoperative IOUS + RFA

Target-shaped colon metastasis

IOUS-guided RFA

Final result: multiple bubbles producing the characteristic posterior acoustic shadow
Intraoperative radiofrequency ablation (RFA)

1. Unresectable, but ablatable lesions

2. Concomitant resection + ablation for curative intent

Results variable with intent-to-cure use of RFA
5-year overall survival for RFA: 14-55% (about 20-25%)
Local recurrence: 3.6-60%

Intraoperative RFA
Intraoperative RFA set-up
Intraoperative RF

5 cm sub-diaphragmatic metastasis (glucagonoma)

Immediately after 2 RF sessions

After 1h (central lesion necrosis)
Intraoperative microwave ablation (MWA)

An applied microwave field causes water molecules to rotate billions of times per second, which leads to heat generation.

Intraoperative MWA

- Larger ablation volume than RFA
- Faster (<10min)
- Reduced Heat Sink effect
- Independent from the variation of the electrical resistance of the tissue (no carbonization - vaporization)

Take home messages

- IOUS allows a higher rate of intrahepatic lesions detection than routine cross-sectional imaging

- Accurate staging

- Safe and precise hepatic resection

- Modification of surgical planning due to real-time accurate lesion localization in relation to vascular structures
Take home messages

- Study the pre-operative imaging
- Perform methodical scanning
- Blind areas/superficial lesions
- Close and continuous collaboration with the surgical team