

Current value of intraoperative ultrasound of the liver in the era of cross-sectional imaging

Poster No.: C-1498
Congress: ECR 2018
Type: Scientific Exhibit
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Keywords: Liver, Ultrasound, MR, CT, Intraoperative, Neoplasia, Metastases
DOI: 10.1594/ecr2018/C-1498

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Aims and objectives

Intraoperative ultrasound (IOUS) has been an important imaging tool for guiding hepatic surgery since its inception in the early 1980s [1-3]. In fact, it has long been considered as the most sensitive and reliable technique for detecting and localizing hepatic lesions as well as their association with major vascular structures [4,5].

But with modern progresses in preoperative cross-sectional imaging of the liver, especially with the inception of multislice computed tomography and diffusion weighted imaging in MRI [6-9], its role has become controverted [10-13].

The purpose of our study was to determine if IOUS still provides new information about hepatobiliary lesions , locoregional staging and vascular anatomy in comparison with cross-sectional imaging. Our aim was also to evaluate IOUS's impact on surgical strategy.

Methods and materials

Patients

In this prospective study, 24 patients having undergone 25 hepatic resections between September 2016 and September 2017 were included : 11 men and 13 women. Their ages ranged from 36 to 78, with a mean age of 56 years. There were 9 patients with liver metastases, 9 patients with hydatid cysts, 3 patients with cholangiocarcinomas, 3 patients with bile duct injuries and one patient with a hepatocellular carcinoma (HCC). All IOUS and surgeries were performed at the general surgery department of Mahmoud Matri Hospital (Ariana, Tunisia).

Only laparotomic surgeries were included. Patients with incomplete preoperative imaging studies were excluded.

Imaging protocol

For each patient, a preoperative computed tomography and/or magnetic resonance imaging was performed to determine the initial surgical strategy.

CT scans were performed using a 16 slice CT scanner (General Electric BrightSpeed™, GE Healthcare, USA). The protocol consisted of at least 3 series: a non-enhanced CT, an early arterial phase using the automatic bolus tracking technique and a late portal phase (70-80s). In some patients, late arterial and delayed phases were added for a better lesion characterization.

MRI were performed using a 1.5 Tesla system (Philips Ingenia™, Philips Healthcare, Netherland). The protocol consisted of T2-weighted and fat-suppressed T2-weighted fast spin-echo sequences, DIXON sequences, diffusion-weighted images with b-values of 0, 150, 600 and 800 s/mm² and T1 weighted post Gadolinium sequences.

IOUS was performed in all patients by an experimented radiologist competent at hepatobiliary imaging using an Esaote MyLab™ Seven (Esaote, Genova, Italy) ultrasound machine (Figure 1). Two types of dedicated and sterilized probes were used : a standard 1- 8 MHz convex probe and a 3-11 MHz linear T-shaped probe (Figure 2).

Data analysis

Data were analyzed by a senior radiologist competent at hepatobiliary imaging and a radiology resident. The size, location and number of lesions were compared between

IOUS and preoperative imaging as well as their association with the main vascular structures. Vascular and biliary variants have been specified for each patient in both preoperative et intraoperative imaging.

We also compared the initial surgical strategy with the operative report to determine if IOUS changed the surgical plan.

Statistical analysis

Statistical analysis was performed using SPSS 22.0 (SPSS, Inc., Chicago, IL, USA) software. The results were expressed as means, medians and percentages.

Images for this section:



Fig. 1: Esaote MyLab™ Seven ultrasound machine in operating theatre.

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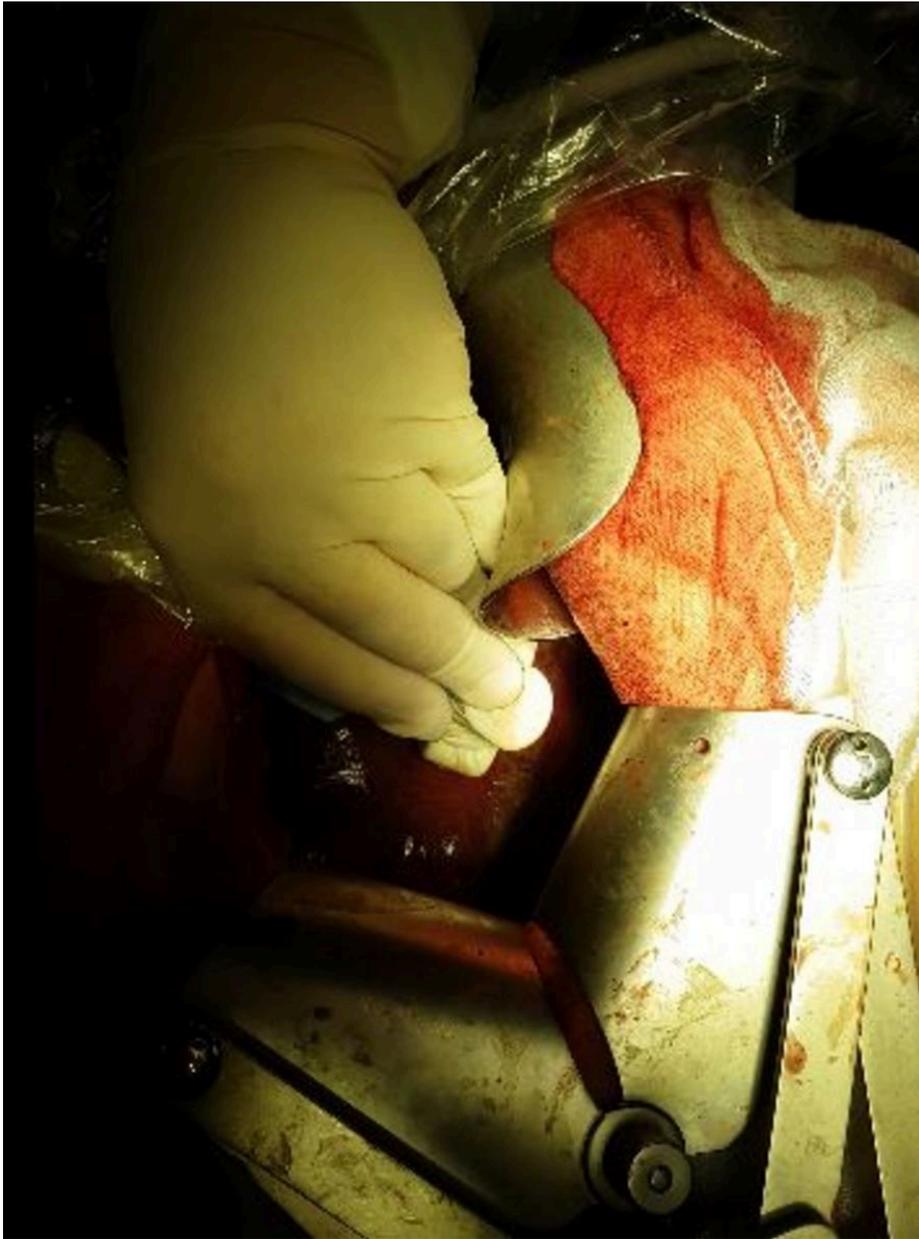


Fig. 2: Intraoperative ultrasound of the liver using a T-shaped transducer.

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Results

Preoperative imaging identified 20 liver metastases in 9 patients ,15 hydatid cysts in 9 patients ,3 cholangiocarcinomas ,3 bile duct injuries and one hepatocellular carcinoma.

The medium delay between the last preoperative imaging and the operation was 11 days.

Lesion detection

Compared with preoperative imaging, three additional liver metastases (15%) were detected in two patients intraoperatively. One of these metastases was superficial and could only be detected by inspection. The two others were detected by IOUS.

IOUS also detected a nodule associated with HCC in cirrhotic liver that turned out to be a nodular regenerative hyperplasia in histopathological analysis.

In one patient with intrahepatic cholangiocarcinoma, two additional lesions were detected by inspection: a retroperitoneal nodule and a superficial hepatic nodule. In this case, the discordance can be explained by the long delay between preoperative imaging and IOUS.

Staging and vascular anatomy

IOUS was found to play a primary role in tumor staging. In our study the association with main vascular and biliary structures was more accurately assessed in 12 cases (48%) (Figure 3 and 4).

Moreover, IOUS provides a real-time imaging of the liver which is a valuable tool to ensure vascular permeability before, during and after hepatic resection.

In our study, this was especially helpful in patients with hydatid cysts compressing hepatic or portal veins.

Compared with hepatic malignancies, hydatid cysts cause much more vascular distortion either by compression, destruction or displacement.

After evacuating the cysts' content, the assessment of vascular permeability was easier leading to a better choice of the radical treatment to be performed: perikystectomy or hepatectomy (Figure 5, 6 and 7).

Surgical strategy and resection guidance

Surgical plans changed owing to IOUS findings in 10 cases (40%). These changes were motivated by additional lesions in one case, vascular proximity or invasion in 8 cases and biliary invasion in one case.

In all cases IOUS was a valuable tool to resection guidance by helping surgeons to define surgical planes. One of the methods used to demarcate the resection area in our study was methylene injection into the portal branch feeding the segments to be resected after its puncture under IOUS guidance (Figure 8).

In patients with malignant hepatic tumors, post-operative ultrasound was helpful to ensure negative margin resection (Figure 9).

Images for this section:

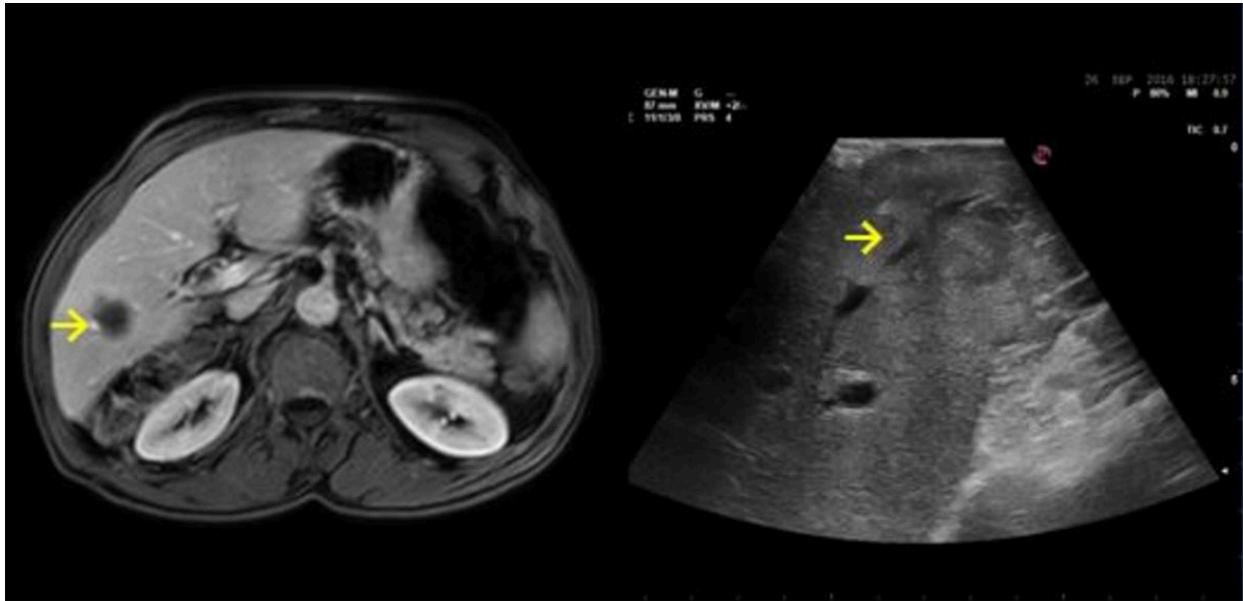


Fig. 3: Colic liver metastasis of segment 7 in contact with the right hepatic vein (yellow arrow) on MRI. This vein has proved to be invaded by the tumor in IOUS examination.

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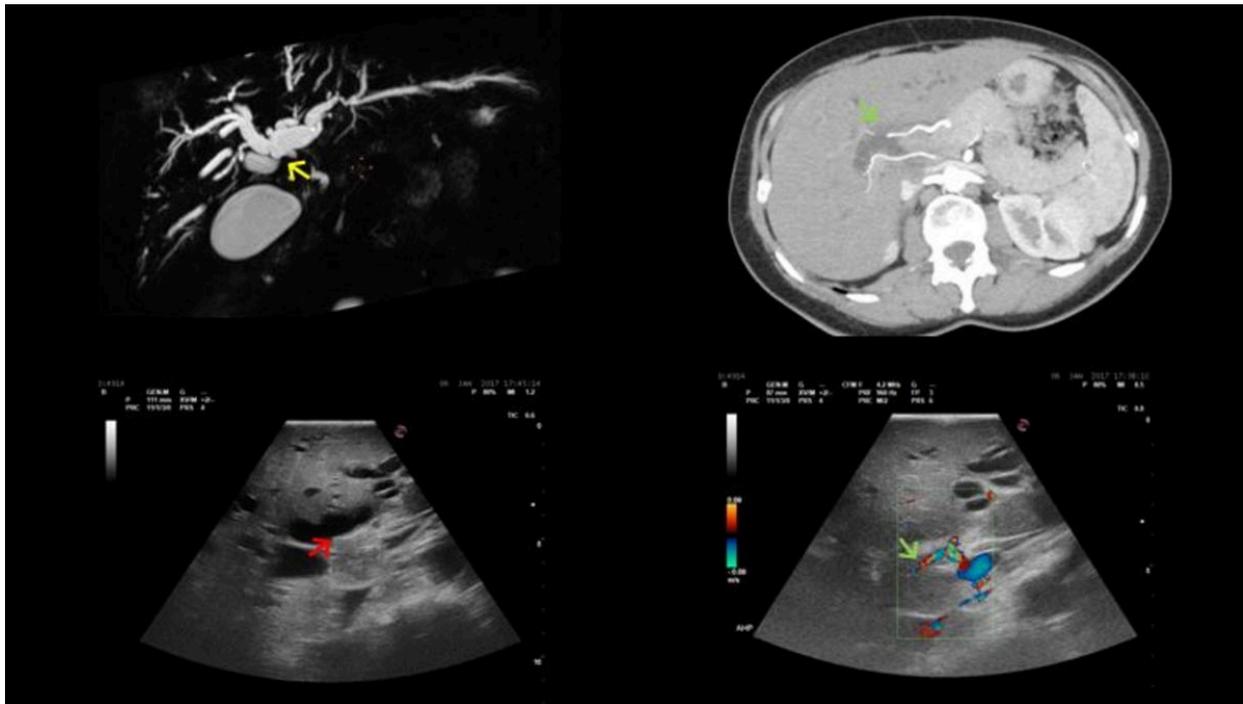


Fig. 4: Hilar cholangiocarcinoma invading the right hepatic artery (green arrow) and the main biliary confluence (red arrow). The invasion of the main biliary confluence could be

assessed more precisely using intraoperative ultrasound and led to a change in surgical strategy.

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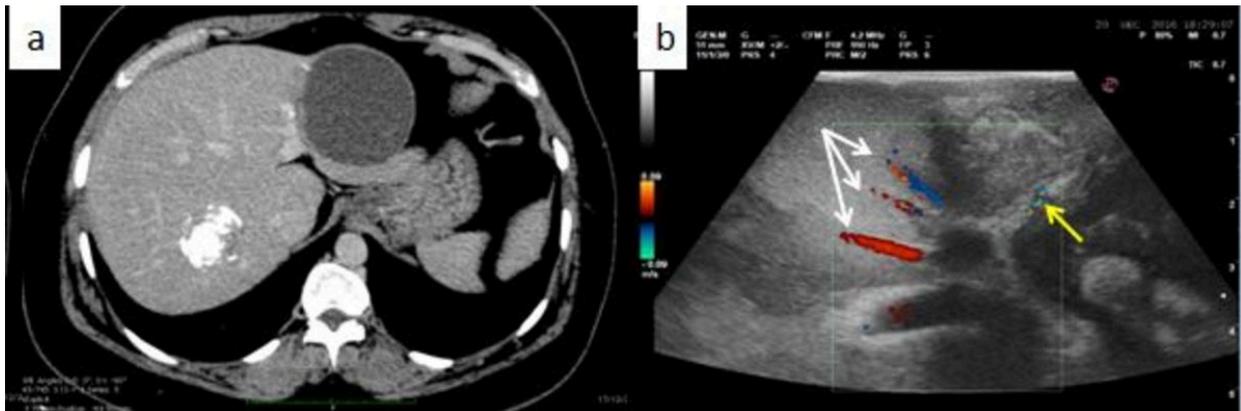


Fig. 5: a- Hydatid cyst of the left liver compressing the vascular pedicles in CT-scan. b- IOUS allowed the visualization of the vascular pedicles of segment 2 (yellow arrow) and segment 4 (white arrows) from either side of the cyst.

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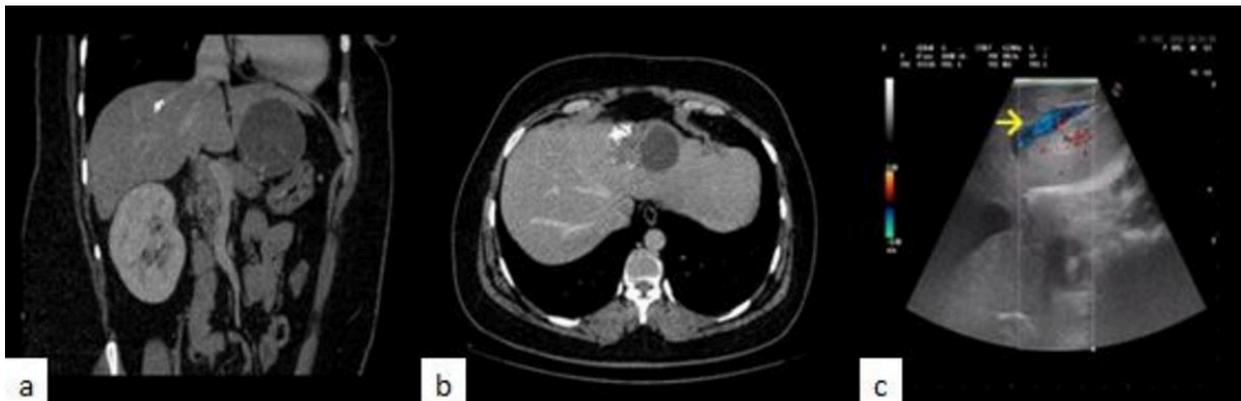


Fig. 6: a-b:CT-scan coronal and axial images showing a hydatid cyst of the left liver. Left hepatic vein has not been visualized. c : IOUS was performed after evacuating the content of the cyst and showed a permeable left hepatic vein.

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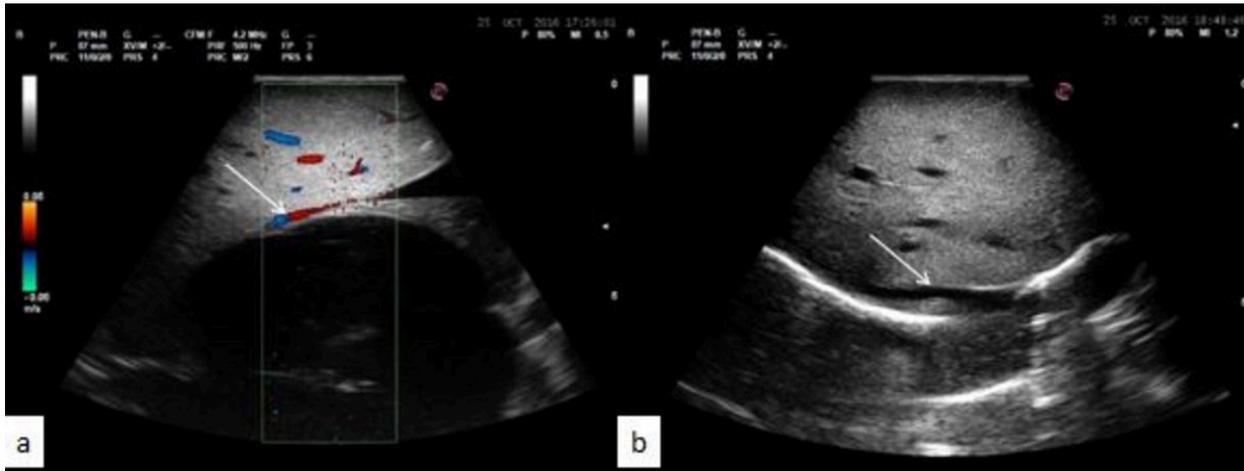


Fig. 7: a- IOUS image showing a hydatid cyst of segment 7 compressing the right hepatic vein (arrow). b- After evacuating the cyst's content, the permeability of the right hepatic vein could be assessed.

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Fig. 8: Methylene blue injection under IOUS guidance after puncture of the left portal branch feeding a HCC of segment 3.

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Fig. 9: Post-operative ultrasound of the resected left liver in patient with HCC -showing negative resection margin.

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Conclusion

Due to its high spatial resolution and by offering a real-time imaging, IOUS continues to be a valuable tool during hepatic surgery.

Although its role in tumor detection has been reduced due to recent advances in preoperative imaging techniques, IOUS still provides additional information for tumor restaging and determining resectability.

In this series it altered surgical plan in 40% of the cases and facilitated the hepatic resection for the surgeon in all patients.

Personal information

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