Laparoscopic liver intraoperative ultrasound in liver limited surgery resection.

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Authors: M. Millor Muruzábal, P. Garcia Barquin, F. M. Caballeros, J. M. Madrid, A. Quilez, D. Cano, M. Elorz, F. Rotellar, A. Benito; Pamplona/ES
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Learning objectives

- To review the value of laparoscopic intraoperative ultrasound (LIous) in liver surgery, especially in cases of minimal parenchymal resection.

- To describe some signs, findings and tricks of LIous to be taken into account before, during and after laparoscopic liver resections.
Background

Until now, different studies have highlighted the importance of intraoperative ultrasound in open surgery, delimitating hepatic resection and its utility in the diagnosis of new liver lesions.

However, in recent years, LIOUS has gained greater importance due to the increased widespread of laparoscopy, especially in the liver surgery field.
Findings and procedure details

Along with inspection and palpation, intraoperative ultrasound (IOU) has been considered the "gold standard" in the detection of liver tumor lesions. Although IOU is not globally extended, it allows real-time guided liver surgery, especially in difficult cases, playing an important role when major preservation of parenchyma is necessary, improving safety of the procedure and postoperative outcome [1, 2].

Nowadays it should be an essential tool in any liver surgical procedure, especially in those with oncological purpose, as it provides information on the number, topography and the relationship of known lesions. It also improves the detection of new lesions not previously seen on preoperative evaluation and helps in the characterization of indeterminate lesions.

On the other hand there is a progressive increase in the use of laparoscopic surgery, acquiring more importance, particularly in the field of liver surgery where great benefits over open surgery have been demonstrated: less intraoperative bleeding, better control of postoperative pain, earlier normalization of digestive function, shorter hospital stay and a general decrease in postoperative complications, without adding a higher cost or compromising oncologic staging. So far, studies have highlighted the importance of the laparoscopic intraoperative ultrasound (LIOU) in the same way as in open surgery [3-9].

The experience in the use of EIOL is principally for minor liver resections. Nevertheless, its field of actuation is progressing in the case of major liver resections, both for benign and malignant (primary or metastatic) disease [10].

Prior to EIOL, there are a number of procedures that have to be taken into account.

First of all, the correct preoperative assessment by ordering the appropriate imaging using CT, MRI, PET and/or US depending on the type of tumor and/or condition of the patient.

After a preoperative plan, the surgeon has to imagine the surgical procedure and final result, trying to know in advance other possible technical intraoperative difficulties. This requires the consideration of the patient liver anatomy, possible variants or abnormalities and the number and location of the lesions [3]. Fig. 2 on page 7 Preoperative study can be very useful in combining its findings with those obtained in the LIOU, increasing its efficiency.
Already in operating room, patient positioning depends on the location of the lesion or the type of surgery performed (hepatectomy, sectionectomy or atypical resection).

Usually, the patient is placed in supine Lloyd-Davis position and the surgeon will be usually placed between the patient’s legs [3]. To intervene posterior segments, patient is placed in left lateral decubitus (about 30º) and the surgeon will be on the patient’s left side.

The number and localization of the trocars on the skin will depend on the location of the lesions and the type of intervention. The camera (5mm-30º) and the work clamps are introduced through 3-6 mm trocars. At least, one must be 12 mm for the LIOU transducer (which has a thickness of 10 mm). Fig. 3 on page 8

From a surgical point of view, just before resection, it is crucial to control the hemostasis by the Pringle maneuver with a successful clamping of the hepatic pedicle using an external tourniquet [11].

Prior to performing the LIOU, it is important to effect the mobilization of the liver that allows not only the exposure of the lesions for marking the limits of the transection, but also the complete hepatic exploration, in search of undetected lesions in preoperative test [12-14]. Fig. 4 on page 9 Fig. 5 on page 10

LIOU can be performed with different equipment and transducers. In our institution we used 5-10 MHz on a Ultraview 800, BK, Denmark equipment. The transducer is flexible 90º in all axes so it allows multiple views. The best imaging depends on the field of view, which is established together with the position of the trocar and the transducer angulation.

Finally, B-mode, Doppler and post-contrast imaging can be taken [3].

LIOU shows a high quality thanks to the direct contact of the transducer with the liver capsule, helped by peritoneal fluid [12, 14]. Fig. 6 on page 11

After surgical scrubbing, LIOU must begin with a formal and thorough examination of all accessible hepatic parenchyma, vascular anatomy (hepatic and portal veins) and the hepatic hilum, in order to detect the number, size and location of the hepatic lesions, to established the affected segments and to determine the relationship of these lesions with the vascular and biliary tracts. This fact is mandatory to establish whether the lesions are operable or not and ultimately, to continue the initial surgical plan or to change to another more appropriate one [3,12]. Fig. 7 on page 12
Keep in mind that IOU can detect between 5-30% of hepatic lesions that had not been detected on preoperative imaging, 30-50% of hepatic surgeries would change in varying degrees, depending on the findings of IOU [12].

Having identified the lesions to be resected, the next step is to proceed to the topography and measuring of the area and depth to the liver surface. Fig. 8 on page 13

The surgical region must be prepared for the surgical resection type that has been decided to perform Fig. 9 on page 14 Fig. 10 on page 15 and once again we localise the lesion to be resected. Fig. 11 on page 16

With an electric scalpel, surface limits on liver capsule are marked, being the lesion delimited within a polygonal or round area of resection. Fig. 12 on page 17 Fig. 13 on page 18 Fig. 14 on page 19 Fig. 15 on page 20

It is important not to forget to leave a theoretical safety margin of healthy parenchyma of about 1 cm [12].

Subsequently, marked margins can be checked with LIOU, so that the shadow caused by cauterization in the hepatic surface has enough margin from the edge of the lesion and the theoretical surgical limit. Fig. 16 on page 21 Fig. 17 on page 22 Fig. 18 on page 23 Fig. 19 on page 24

Afterwards the lesion must be included in the resection área so resection can be started superficially. Fig. 20 on page 25

Alternating LIOU allows the insurance of every surgical step in order to maintain safe margins, depth of the incision or presence of vessels. Fig. 21 on page 26 Fig. 22 on page 27 Fig. 23 on page 28 Fig. 24 on page 29 Fig. 25 on page 30 Fig. 26 on page 31 Fig. 27 on page 32 Fig. 28 on page 33 Fig. 29 on page 34 Fig. 30 on page 35 Fig. 31 on page 36

Postoperative imaging tests will show the final result. Fig. 32 on page 37 Fig. 33 on page 38
Fig. 1

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Fig. 2: Preoperative CT: 11 mm colorectal metastasis is identified in segment VII

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Fig. 3: Placement of trocars in the patient with the metástasis in segment VII. A 12 mm trocar, will be needed for laparoscopic transducer. Others thinner trocars will be also necessary

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Fig. 4: Hepatic mobilization that prepares the field to achieve a correct LIOU and posterior surgery

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Fig. 5: Section of the falciform ligament helps in the preparation of the working area

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Fig. 6: Initial LIOU. Transducer is placed easily on the soft liver surface

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Fig. 7: Sonographic identification of a metastatic lesion seen in the preoperative CT, located in segment VII (blue arrow)

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**Fig. 8:** Measuring the depth of the lesion from the liver capsule

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Fig. 9: Advancing in the preparation of the right lobe and the area to be resected

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Fig. 10: Releasing adhesions

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Fig. 11: Once adhesions have been released it is time to confirm the lesion

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Fig. 12: The resection margins are marked with electric scalpel. In this case it will be a square area. On one side...

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**Fig. 13:** On the other side…

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Fig. 14: Inferior ... and ...

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**Fig. 15:** at the end, the upper margin

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Fig. 16: The theoretical limits of resection are marked and checked with LIOU

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**Fig. 17:** The limits of resection are identified as a thin hyperechoic area with or without a tiny dirty shadow on the surface with a soft back shade (pink arrow). The "upper" ...
Fig. 18: The bottom…

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Fig. 19: The lateral margins …

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Fig. 20: Starting the laparoscopic resection

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Fig. 21: Initiated by the lateral margins

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**Fig. 22:** When the resection is going on, the lateral margin are better identified as thicker hypoechoic areas (pink arrow)

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Fig. 23: The resection of the lateral margins continues…

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Fig. 24: Also, ultrasound can check the side margins, depending on the size, depth, vessels or surgeon's demands

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**Fig. 25:** We continue resecting the edges of the lesion, which are becoming increasingly deep, until we overcome the lesion with 1 cm deep

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Fig. 26: Once the four limits are resected, the deeper resection is started. At the bottom right of the ultrasound (pink arrow) we can observe an echogenic area corresponding to the dissector which is inserted into the deep margin of the surgical piece (green arrow). This is a very important moment to suggest the surgeon to deepen or not a little bit more to ensure the deep margin.

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Fig. 27: After a small advance in surgery, the lesion (blue arrow) is identified deep in the liver parenchyma (green arrow). This is observed on ultrasound as a hyperechoic area in the lower right margin (pink arrow).

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Fig. 28: Viewing the dissector (the green arrow on the laparoscopic monitor and the pink arrow on ultrasound), which is located almost directly below the lesion and approximately 1 cm deep of the lesion bottom edge (remember that the lesion measures 11 mm), we can conclude that the margin of the background becomes horizontal and parallel to the capsule.

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Fig. 29: The surgeon continues resecting the deep limit of the piece

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**Fig. 30:** The deeper margin is safe and correct and the resection has surpassed the lesion

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Fig. 31: Deep margin almost completed

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Fig. 32: Post-surgical CT in coronal and axial views, two months later after surgery where surgical bed is observed

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Fig. 33: Comparing both the previous and the post-operative CTs.

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Fig. 34

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Conclusion

LIOU is an essential tool in any liver surgical procedure, especially for oncological purposes, not only providing information about the topography and the relationship of known lesions, but also improving the detection of new tumors, allowing better or greater selection of patients for liver surgery. Apart from this, it also helps to ensure the section margins and the oncological safety, guiding the resection and reducing some of the technical limitations of laparoscopy.
Fig. 34

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Images for this section:

Fig. 34

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References


