Chapter 4

Laparoscopic Liver Resection

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Abstract

A few centers start to practice laparoscopic liver resections at the beginning of laparoscopic surgery. Since development new devices and evolution of surgical skills, this area started to gain new perspectives and in more centers this became the standard practice for liver resection. In this chapter are presented indications, limitations and current techniques in laparoscopic liver resection.

Introduction

After laparoscopic cholecystectomy became the standard, other laparoscopic procedures like hernia repair, bariatric surgery, colon surgery, anti reflux surgery had proved their superiority over laparotomy. Despite first laparoscopic liver resection (wedge resection) was published in the early 90’s [1] and first major hepatectomy was reported by Huscher et al. in 1997 [2], this field develop slower than the others that we have mentioned before. Since 2000 – starting with publication of Cherqui et al [3], laparoscopic liver resection (LLR) starts to gain interest and in 2009 Nguyen et al [4] report a review with almost 3000 LLRs performed at that date.

Because of the technical challenges, risks of complications and questioning the patient’s benefit, a small number of centers have taken the time and effort to perform LLRs. Existing data from literature [5-33] confirms the safety, benefits and feasibility of laparoscopic approach when compared to open resection. The number of reported LLR increased from 2009, especially for major and anatomic
LLRs, despite the fact that minor resections remain the majority of LLRs in the clinical practice [34]. On the 2nd International Consensus Conference [35] (2nd ICC) on LLR in Japan is described the progress and dissemination of the method across the world.

**International Consensus and Indications for LLRs**

First International meeting that discuss the position of LLRs was held in Louisville in 2008 [36] and concluded that LLRs results are comparable with open liver resection (OLR) and both symptomatic benign and malign tumors are the main indications. The statement of Louisville concluded that term of “minor resections” should be used for small wedge resections and for resections of the left lateral section (segments 2 and 3) or anterior segments (segments 4b, 5 and 6). Hemihepatectomies, trisectionectomies and resections of the difficult postero-superior segments (segments 1, 4a, 7 and 8) were considered “major resections”.

Since statement of Louisville the number of LLRs has increased steeply worldwide and published conversion rates have gradually decreased. In our days indications for LLR aren’t different from those for open surgery. LLRs can be used for benign and malignant (primary or metastatic) tumors and living donor liver harvesting.

At the 2nd ICC from Morioka, Japan, 2014 the current status of laparoscopic liver surgery was reevaluated and new recommendations were made. The classical definition was used to define minor resection (2 or fewer segments removed) and major resection (3 or more segments removed).

![Figure 1: Differences between open and laparoscopic approach.](image-url)

The following guidelines were suggested as follows:

- Minor LLRs had become standard practice.
- Major LLRs are still innovative procedures in the exploration phase and for their introduction, continues caution was the recommendation.
- A scoring system [37] was proposed for estimating the difficulty of LLR preoperatively. This system evaluates a series of factors like the extent of liver resection, tumor location, tumor size, proximity to major vessels, and the severity of fibrosis.
• The “caudal” approach is the main conceptual change in LLR, in contrast to the “anterior” approach in OLR [35,38,39].

• The “lateral approach” (left lateral decubitus) gives access to right posterior segments.

Limitations of LLRs

Patients with bilateral or central tumors, close to the liver hilum, major hepatic veins or inferior vena cava (IVC) are not standard candidates for a laparoscopic approach. Because of difficult tumor mobilization and risk of rupture, large intrahepatic tumors should be carefully analyzed when are proposed for laparoscopic resection [40]. LLRs are contraindicated in patients that can’t tolerate pneumoperitoneum because of their cardiopulmonary diseases.

The surgeon experience is another important factor that limits laparoscopic approach in liver resections. The training of surgeons is essential in order to perform save and efficiency LLRs. As we mentioned before the classical open frontal view is modified in the laparoscopic approach, where a caudal view put the surgeon in position to see the anatomy from a different perspective. Selection of the cases are essentially in the first years; young or less training surgeons should start with wedge resections or with the resections of appropriate segments: 2,3,4b, 5 and 6). Due to acquiring the necessary skills to perform major resections a learning curve is necessary.

Anesthesia and Intraoperative Care

Maintaining the central venous pressure (CVP) under 5-mm Hg plays an important role in minimizing blood loss. Along with the tamponade effect of pneumoperitoneum, low CVP reduces the venous parenchymal bleeding during parenchymal transection. Some studies suggest [41,42] that a temporary increase in CO₂ pneumoperitoneum pressure (16-20 mmHg) can be used to help control bleeding during LLR. In this case, the surgeon should be careful after decreasing high pneumoperitoneum pressure because the bleeding could restart. Along with increasing the pneumoperitoneum pressure, to control a severe hemorrhage, decreasing the airway pressure [43] by a brief pause in the artificial ventilation is an additionally maneuver that can be used.

On the other hand, at patients with cardiopulmonary diseases, increased pneumoperitoneum pressure isn’t an option, considering the fact that higher pressure reduces liver, renal, lower limb and mesenteric blood flow. Also cardiac output and arterial pressures increase after high pressure in the abdominal cavity. In case of an obese patient all these are exacerbated. As we know using portal clamping along with prolonged pneumoperitoneum can cause a significant reduction in hepatic oxygen tensions,
tissue hypoxia, with higher transaminase and increased tissue necrosis [44].

Theoretical low CVP and high pneumoperitoneum pressure increase the risk of CO₂ embolism. Despite this theoretical idea there is no clinical data to demonstrate that hypothesis. In an recent meta-analysis Mirnezami et al [45] reported 0.1% incidence of gas embolism. Moreover it seems that there are no differences regarding gas embolism comparing major hepatectomies and minor hepatectomies. On a study effectuated on 477 major hepatectomies [46], from high-volume centers, gas embolism occurred in 0.2%.

Using argon beam coagulation increases incidence of gas embolism. The explication could be that argon is not diffusible as CO₂ [47-49]. At the 2nd ICC [35] on LLR the recommendation was to avoid argon beam coagulator (if used, it requires precaution) during parenchymal transection.

**Techniques of LLRs**

There are 3 techniques:

- Pure laparoscopic liver resection (PLLR), when the entire resection is made through the laparoscopic trocars and for extracting the specimen a separate incision is made.

- Hand-assisted laparoscopy surgery (HALS): an auxiliary hand-port is place along with the laparo-scopic ports, serving also to extract the specimen. Hand-assisted laparoscopic surgery can be used at any time of the operation to aid the dissection.

- Hybrid hepatectomy (also termed laparoscopic assisted hepatectomy): after laparoscopic liver mobilization (hand-assisted can be used) an elective mini-laparotomy is made for parenchymal dissection and to secure the vascular pedicles.

**Patient Position**

In laparoscopic liver resection there are three commonly used patient positions:

- Supine (Figure 2) - used for resection of the left hepatic segments (2, 3) or the right anterior sector of the liver (4b, 5).

- Left lateral decubitus (Figure 3) - used for tumors placed in the posterior segments (6, 7).

- French position (Figure 2) - the patient is supine with the legs spread and bent at the knees, with the surgeon between patient’s legs.

According to the position of the tumor, the appropriate position is chosen. When is necessary, a hand-port can be placed, usually in the right flank of the abdomen. Appropriate site selection for hand-port is mandatory: if is placed too close to the liver, the hand will be over the liver and if is placed too low, the surgeon has to stop for pro-
longed periods which can become uncomfortable.

Figure 2: Supine and French position (patients with the legs spread).

Figure 3: Left lateral decubitus.

In supine and French position five ports are positioned: three 12 mm ports and two 5 (or 10) mm ports. The 12 mm ports are placed: one at the umbilicus (or higher if the distance between umbilicus and xiphoid is greater) and two working ports in the right and left mid clavicular line. The 5 (or 10) mm ports are placed in the right and left anterior axillary line.

To tackle segments IVa and VIII, a 10mm port is placed in epigastric for lifting the right diaphragm to cre-
ate the necessary space for parenchymal dissection.

In the left lateral decubitus we have 4 trocars: two of 12 mm place at the umbilicus and in the right mid clavicular line; two of 5 (or 10) mm placed on the right anterior axillary line and epigastric.

Intra-Operative Ultrasound

For a correct evaluation of the tumor and the relation with major hepatic structure an intra-operative ultrasound should be performed prior to start liver resection. By using it a correct plane of the dissection is achieved. For keeping R1 rates as low as possible, intra-operative ultrasound should be used before, during and at the end of the dissection.

Pringle’s Maneuver

To perform Pringle’s maneuver we need to lift the liver. We can do that by two methods:

- Using a retractor like Nathanson hook, diamond flex or gold finger. In this way we lift the left lobe and hepato-duodenal ligament from inferior caval vein ensuring good access through the Winslow’s hiatus and giving fixed retraction for the hilar dissection.
- Retracting the falciform ligament. In this case we need to divide the falciform ligament and to suture the teres ligament near to the liver. In that way we can hold the suture and keep the liver on the anterior abdominal wall. In cases that gallbladder wasn’t removed we can use this for retraction, but first we need to dissect the Calot’s triangle and the infundibulum.

After the liver is retracted, the pars flaccid of lesser omentum is divided (attention should be paid for a left hepatic accessory artery) and a tourniquet around the hepato-duodenal ligament is placed. Using the tourniquet, a nylon tape can be placed around hepatic pedicle to perform portal triad clamping.

Despite the advantage of reducing blood loss, not all the centers [50-52] that perform LLRs totally agree the Pringle’s maneuver.

Parenchymal and Hilar Dissections Techniques

In the literature are described many number of parenchymal and hilar dissections techniques without clear superiority of specific-one. The surgeon experience is mandatory in chosen the type of parenchymal and hilar dissections.

Hilar Dissection

There are three major techniques for hilar dissections:

- At the site of hepatic pedicle.
• Posterior approach or Glissonian approach describe by Launois and Jamieson [53].

• Anterior approach.

Regarding the type of the hilar dissection, this is the surgeon choice. Next we describe the differences, advantages and disadvantages of them:

• When the dissection is made at the site of hepatic pedicle the risk of hemorrhages and injury of important elements is bigger; extensive dissection can cause devascularization of the main biliary duct; in cases with extensive adhesions hilar dissection can be tedious and difficult.

• One of the major advantage of posterior approach is that avoids hilar dissection; inflow to the rest of the liver parenchyma is possible because there is no need of Pringle maneuver due to the fact that only the pedicle of the resected area of the liver is ligated; blood loss is reduced by using this technique.

• Hilar dissection and inflow control, complete parenchymal transection and division of the right hepatic vein are necessary at the anterior approach.

Parenchymal Transection

Hemorrhage appears mostly during parenchymal transection and contributes most to the overall blood loss. For this reason, choosing the right instrument for parenchymal dissection is very important. A variety of techniques and surgical instruments can be used for parenchymal transection with none of them showing clear superiority over the others. Among them and most used are: cavitational ultrasonic aspirator (CUSA), bipolar sealing device Tissue Link, Enseal, Habib4X radiofrequency device, Ligasure, water dissector or the Harmonic ACE. We should have prudence when are securing the bile ducts, identifying and ligating the medium and larger vascular structures. For vessels of 2 mm or less hemostasis should be achieve with bipolar cautery, while for vessels of 3-7 mm vessel sealing devices or clips is recommended. In case of vessels of more than 7 mm staplers or locked clips is the preferred method.

Another technique used for parenchymal dissection is stapler hepatectomy. In this situation we have the advantage of more rapid parenchymal transection, without the need for prior control of individual hepatic vessels.

The Caudal Approach

This technique was considered the main conceptual change in LLR, in contrast to the “anterior” approach in OLR at the 2nd ICC from Morioka, Japan, 2014 [35, 38,
Parenchymal transection prior to mobilization of the liver under the laparoscopic-specific view in the left lateral position is the main idea of this concept. In this way facilitates the exposure of the cutting plane in pure laparoscopic posterior right hepatectomy (Figure 4). The cutting plane of posterior right hepatectomy is horizontal in supine position while using caudal approach when the patient is in left lateral position the cutting plane turns to be vertical.

Figure 4: Caudal approach.

Efficacy of Laparoscopic Liver Resection

A mortality rate of 0-2.4% [6,7,9,11-13,15-29,31-33,54-60] was reported in a series of large volume centers after LLR. In a meta-analysis [61] comprising 40 studies there were no differences regarding mortality rates in-hospital and postoperative within 30 days of discharge, between LLR and OLR. On a series of 2804 [4] patients operated by LLR the overall mortality rate was 0.3%.

When we are compared LLR with OLR regarding postoperative outcomes, there are 20 meta-analysis [45,61-79] published, and majority of them have demonstrated a significantly lower length of stay of LLR compared to OLR. Earlier return of bowel activity and lesser requirement of analgesics are mentioned in some studies on LLR [45,62,70,73].

When we are talking about oncological results on LLR, comparative studies and meta-analysis [45,62-65,71,72,74,76-79] have concluded that LLR have no increased risk of positive surgical margins.

Long-Term Outcomes

Despite resistance of LLR in colorectal liver metastasis at the beginning, it is demonstrated that results on selected patients are equally good for LLR compared to OLR [65,72]. Reducing adhesions using laparoscopic approach future interventions are facilitated [26].
Survival rates of LLR and long-term outcomes are superior over OLR when we are dealing with liver resections in hepatocellular carcinoma [63,64,74,76,77].

In some centers robotic surgery and NOTES (Natural Orifices Transluminal Endoscopic Surgery) surgery gained new perspective in the field of liver resections. Augmented reality is enhancements that help the surgeons to project in the operatory field the inner vessels structure allowing them to avoid its lesions. LLRs is used now also for living related liver transplantation to harvest the left lobe from the donor.

Conclusion

LLRs became a safer surgery along with development specific devices and surgical skills. New approaches are used to facilitate liver resections. The results of LLRs are at least as good as OLRs, but this type of surgery should be practiced only in well-equipped centers and by well trained surgeons. LLRs evolves nowadays toward NOTES surgery and robotic surgery but technology hasn’t reached the final touch in liver resections.

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