

International experience for laparoscopic major liver resection

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Abstract Although minor laparoscopic liver resections (LLRs) appear as standardized procedures, major LLRs are still limited to few expert teams. The aim of this study was to report the combined data of 18 international centers performing major LLR. Variables evaluated were number and type of LLR, surgical indications, number of synchronous colorectal resections, details on technical points, conversion rates, operative time, blood loss and surgical margins. From 1996 to 2014, a total of 5388 LLR were carried out including 1184 major LLRs. The most frequent indication for laparoscopic right hepatectomy (LRH) was colorectal liver metastases (37.0%). Seven centers used hand assistance or hybrid approach selectively for LRH mostly at the beginning of their experience. Seven centers apply Pringle's maneuver routinely. The conversion rate for all major LLRs was 10% and mean operative time was 291 min. Mean estimated blood loss for all major LLR was 327 ml and negative surgical margin rate was 96.5%. Major LLRs still remain challenging procedures requiring important experience in both laparoscopy and liver surgery. Stimulating the younger generation to learn and accomplish these techniques is the better way to guarantee further development of this surgical field.

Keywords Laparoscopy · Left hepatectomy · Major liver resection · Right hepatectomy

Introduction

Despite an initial slow development, laparoscopic liver surgery is now performed worldwide [1, 2]. Several comparative studies suggested that laparoscopic liver resections (LLR) are associated with decreased per and postoperative morbidity [3], quicker return to normal activities [4] and simplification of subsequent surgery [1].

Although minor LLR and particularly laparoscopic left lateral sectionectomy appear as standardized procedures in most centers [5], major LLR are still limited to a few expert teams [4, 6]. The reputed obstacles to this approach included foremost a steep learning curve with the need to learn how to mobilize by laparoscopy large parts of the liver as well as the fear of difficult-to-control bleeding and issues regarding patient selection.

European teams started LLR in the mid-1990s [7] and have made important steps forward in laparoscopic major resections [4]. Ten European centers reported in 2013 their experience of major LLR [6] and suggested that in expert hands those demanding procedures could be feasible and safe.

The extra-European experience of major LLR is constantly increasing with teams that have already performed more than 300 procedures. This worldwide enthusiasm for

major LLR led us to update our data considering the global development of those procedures.

The aim of this study was to report the combined data of 18 international centers performing major laparoscopic liver resections. The evolution of their technical approach and current surgical trends were analyzed.

Methods

All international centers enrolled in this study have more than 5 years of experience in the laparoscopic liver surgery field: four from France, two from Italy, two from Japan, two from South Korea, one from Belgium, one from Australia, one from UK, one from Norway, one from Argentina, one from Taiwan and two from USA. All surgical teams had already significant experience in liver surgery and laparoscopy before moving on to LLR.

As defined by the 2008 international consensus of Louisville [1], patients with solitary lesions of 5 cm or less, located in liver segments II to VI, at distance from the line of transection, the hepatic hilum, and the vena cava were considered as more suitable to LLR. However those criteria were not exclusive and each patient's medical file was discussed in a multidisciplinary meeting in every center. In all centers, exclusion criteria were tumors close to the portal pedicle or hepatic veins, an American Society of Anesthesiologists score (ASA) exceeding 3, a decompensated cirrhosis (Child B or C), esophageal varices grade > 1 and a platelet count < 80 x 10⁹/l.

Questionnaires were sent to all centers in order to gather the most recent data concerning LLR. Variables evaluated were total number of laparoscopic hepatic resections, number and type of major LLR, surgical indications, number of major LLR performed on cirrhotic patients, number of procedures that were associated with a synchronous colorectal resection, details on technical points including their evolution over time (use of hand assistance or hybrid approach, liver mobilization or prior vascular control of inflow and outflow before parenchymal transection), conversion rates, median operative time, median blood loss, surgical margins. An evaluation of the estimated number of open major liver resection and minor LLR required before starting major LLR was also demanded. All data were finally pooled in a table and used for analysis.

Results

From 1996 to 2014, a total of 5388 LLR were carried out in these 18 international centers including 1184 major LLR. Left and right hepatectomies represented 51.1% and 43.1% of all major LLR, respectively. The mean percentage of right hepatectomies performed by laparoscopy over all right

Table 1 Types of resection and indications for major laparoscopic liver resections

Variable	Data
Laparoscopic liver resections, <i>n</i>	5388
Laparoscopic major liver resections, <i>n</i> (%)	1184 (21.9)
Right hepatectomy, <i>n</i> (%)	605 (51.1)
Left hepatectomy, <i>n</i> (%)	467 (43.1)
Central hepatectomy, <i>n</i> (%)	70 (5.9)
Trisectionectomy, <i>n</i> (%)	42 (3.5)
Concomitant colorectal resection ^a , <i>n</i> (%)	28 (2.4)
Indications	
Right hepatectomy	
Benign lesions, <i>n</i> (%)	179 (28.9)
Primary malignant tumors, <i>n</i> (%)	202 (33.4)
Metastases, <i>n</i> (%)	224 (37.0)
Left hepatectomy	
Benign lesions, <i>n</i> (%)	241 (51.6)
Primary malignant tumors, <i>n</i> (%)	130 (27.8)
Metastases, <i>n</i> (%)	105 (22.5)

^a 11 centers.

hepatectomies was 31.1% ranging from 1% to 95%. The mean percentage of left hepatectomies performed by laparoscopy over all left hepatectomies was 34.3% ranging from 1.7% to 100%. A concomitant colorectal resection was performed in 2.5% of all laparoscopic right hepatectomies (LRH) including four rectal resections. A concomitant colorectal resection was performed in 1.7% of all LLH including two rectal resections. The most frequent indication for LRH and LLH was colorectal liver metastases (37.0%) and benign lesions (51.6%) respectively. Laparoscopic liver resection was performed for a cirrhotic patient in 21.2% over all LRH and 18.9% over all LLH. Types of resection and indications for major laparoscopic liver resections are described in Table 1.

No center uses routine hand assistance, whereas seven centers used hand assistance or hybrid approach selectively for LRH mostly at the beginning of their experience. In these seven centers hand assistance or hybrid approach was used for LRH and LLH in 19.1% and 16.1% of the procedures, respectively. Seven centers apply Pringle's maneuver routinely. Seventeen teams systematically try to control portal veins and hepatic arteries extraparenchymally before parenchymal transection. Three teams routinely control hepatic veins before parenchymal transection. One team controls hepatic veins before liver transection only during LLH. During the evolution of their experience 11 teams changed their techniques concerning the following specific points: abandoned hand assistance or hybrid approach after preliminary experience (seven teams), abandoned routine portal triad clamping to a selective use (one team), developed routine portal triad clamping (two teams), developed

Table 2 Intraoperative results

Variable	Data
Right hepatectomy	
Mean duration of surgery, min	321
Conversions, <i>n</i> (%)	91 (15)
Mean estimated blood loss, ml	411
Negative surgical margin, <i>n</i> (%)	580 (95.9)
Left hepatectomy	
Mean duration of surgery, min	261
Conversions, <i>n</i> (%)	28 (6)
Mean estimated blood loss, ml	242
Negative surgical margin, <i>n</i> (%)	453 (97.0)

routine portal triad clamping for postero-superior approach (one team), developed portal pedicles control before liver transection (one team), abandoned separate dissection of hepatic artery and portal vein to extra-glissonian pedicle approach (one team), abandoned right liver mobilization switching to anterior approach (two teams), developed hepatic veins' control before transection for posterior-superior approach of lesions close to right or middle hepatic veins (two teams).

The conversion rate for all major LLR was 10% and mean operative time was 291 min. Mean estimated blood loss for all major LLR was 327 ml and negative surgical margin rate was 96.5%. Intraoperative results are described in Table 2.

Eleven centers have established special learning programs for laparoscopic hepatectomies and especially major ones for trainees. The estimated mean number of open major liver resections required before starting major LLR was 30, ranging from a team considering that one can learn major hepatectomies directly from laparoscopy to a team considering that a preliminary experience of 70 open major liver resections was required. The estimated mean number of minor LLR required before starting major LLR was 29, ranging from a team considering major LLR were accessible to any surgeon who learned dissection and transection during minor LLR to a team considering that a preliminary experience of 60 minor LLR was required.

Discussion

Technical refinements have enabled surgical groups to routinely perform laparoscopic minor and major liver resections [1]. However, despite their technical feasibility, major LLRs still remain challenging procedures requiring important experience in both laparoscopy and liver surgery. We report in this series an international multicenter study concerning major LLR.

The first main finding of this study was the important rate of right (31.1%) and left (34.3%) hepatectomies performed by laparoscopy. However, percentages of major liver resections performed by laparoscopy varied widely, depending mostly upon the different types of surgical activity and recruitment of each center. We generally recognized two types of activity: hepatic surgery centers doing all types of liver surgery including liver transplantation and which perform major liver resections by laparoscopy selectively (1–15%) and centers known for minimally invasive surgery with a selected activity performing most major liver resections by laparoscopy (40–100%). Limits between these two types of activity are not always strict with surgical teams evolving in both directions.

In spite of technical improvements and the worldwide expansion of LLR, a combination of laparoscopic major hepatic and extra-hepatic resections, mostly colorectal, is still rather rarely reported [8]. Although the important advantages of laparoscopy make it a reliable choice for concomitant procedures, they still remain very demanding. This is also reflected in the rarity of such combinations even by laparotomy. Moreover, an important number of these patients had probably already been treated in other centers before being addressed for hepatic surgery.

The development of laparoscopy has pushed certain teams toward a more aggressive surgical approach to benign lesions [9]. In our analysis, benign lesions represented more than 50% of surgical indications for LLH. On the contrary, they represented less than 30% of indications for LRH. From a theoretical point of view, laparoscopy is associated with decreased intra- and postoperative morbidity and is particularly suited to surgical management in this frequently young population [10]. However, authors deeply believe that the decision whether or not to operate must be based on the symptomatic character of the benign lesion or, for certain adenomas, on the risk of malignant degeneration or bleeding.

Concerning technical aspects, hand assistance is clearly tending to become obsolete as it is being abandoned by centers that had adopted it in the past, even outside Europe. This technique has been considered to be advantageous for liver mobilization while in fact decreases operative field visualization. However, in the special indication of living donors it still represents the most widely reported technique [11]. On the other hand, few surgical teams have successfully developed a technique of hybrid surgery including anterior approach with hanging maneuver for major LLR. This technique could be useful for resections in cirrhotic livers, tumors in unfavorable locations and living donor hepatectomies [12].

Seven surgical teams are routinely using portal triad clamping. Among these, interestingly enough, three teams have decided to use it on purpose after an initial experience

of selective clamping. These teams share the conviction that the theoretical risk of liver ischemia because of clamping is less important than the benefits of reduced blood loss. This important rate of Pringle's maneuver also underlines the necessity for non-hemorrhagic transection. Image magnification by laparoscopic view undoubtedly facilitates prior vascular control of inflow before liver transection [13]; 17 teams systematically try to control portal and arterial selective branches. The prior vascular control of outflow still remains infrequent with a growing tendency to abandon liver mobilization in favor of an anterior approach. Indeed, right liver mobilization, which is rather difficult during LLR, is avoided. Furthermore, the position of the laparoscope, parallel to the vena cava, provides an excellent view of the retrohepatic space and the hepatocaval confluence and renders the anterior approach safer.

The training of fellows in LLR is a crucial point. The majority of expert centers in this field have started teaching programs including video discussions, courses on cadavers and laparoscopic surgery in animal models. An initial experience of LLR under the supervision of an experienced senior surgeon appears indispensable. Viganò et al. suggested that 60 LLR are required to get beyond the learner's stage [14]. Several centers in our study estimate that, given a good knowledge of anatomy, advanced skills in laparoscopy and a limited experience of minor LLR, trainees can learn major liver resections directly by laparoscopy. This may appear avant-gardist but we think that it reflects everyday practice in these expert centers where one could not imagine performing an open procedure in a patient suitable for laparoscopy only to form a trainee. Starting by letting trainees perform different parts of the procedure might be a fruitful method. Stimulating the younger generation to learn and accomplish these techniques is the better way to guarantee further development of this surgical field.

Two future technical improvements may facilitate the realization of major LLR. Imaging guidance (augmented reality) during liver transection could simplify the control of vessels and biliary branches and overcome the problems related to the limited tactile sensation during LLR [15, 16]. Robotics will also be an inevitable part of the future of liver surgery. Da Vinci system (Intuitive Surgical, Sunnyvale, CA, USA) has not proven any advantages for the moment compared to classical LLR [17] but more innovative systems might offer novel perspectives that could be applied to major LLR.

Conflict of interest None declared.

Author contribution Study design: GW, ID. Acquisition of data: BG, DF, OS, HSH, HKK, DC, NO, RT, LA, EB, MAH, GB, HK, WJ, CL, JP, JB, HT. Analysis and interpretation: HT, DT. Manuscript drafted by: HT, DT. Revision: ID, GW.

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