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REVIEW OF SURGICAL TECHNIQUES FOR PERFORMING LAPAROSCOPIC DONOR HEPATECTOMY

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Living related liver transplantation has proved to be an effective, safe and radical method for treating end-stage liver diseases. In the last decade, a laparoscopic approach to donor hepatectomy has been gradually introduced into clinical practice. According to world literature, there are presently no uniform standards for performing laparoscopic liver resections in living donors. This literature review considers almost all methods for performing this surgery in living donors. These methods are described in transplant centers around the world.

Keywords: liver transplantation, living donation, laparoscopic liver resection.

INTRODUCTION

Laparoscopic hepatectomy in living donors typically consists of several basic stages: trocar placement, liver mobilization, dissection of hepatoduodenal ligament structures, formation of a resection plane, and parenchymal dissection and graft removal.

POSITION OF THE PATIENT ON THE TABLE

The patient was positioned on the operating table in Fowler's position (Reverse Trendelenburg position). According to various literary sources, the angle of the table in relation to the floor ranges from 30° to 45°. The patient's legs are spread apart (French position) [1–3]. Interestingly enough, when performing laparoscopic right hemihepatectomy, the position of the patient on the operating table is slightly different from that for resection of the left lateral segment or left lobe of liver in a related donor. The patient is also placed in the French position in Fowler's position. However, a 10–15 cm diameter roll is placed under the patient's right at the costal arch level [4]. At some transplant centers, the patient is placed on the left side [5].

TROCAR PLACEMENT

All clinics have their own trocar placement approaches. For example, during the first laparoscopic removal of the left lateral section from a living donor [6], the following trocar port placement scheme was described: a 10-mm-diameter optical trocar was placed paraumbilically 2 cm above the navel, two 12-mm-diameter trocars were placed 7–9 cm to the left and to the right, then, a 10-mm-diameter trocar was placed 5 cm proximally to them along the midclavicular line under the costal arch. In most French transplant centers, and at the Shumakov National Medical Research Center of Transplantology and Artificial Organs, when performing laparoscopic left lateral (LL) resection, trocars are placed as follows: an optical 10–12-mm trocar is placed paraumbilically 2–3 cm to the right of the navel, then 10-mm trocar is placed at a 15° angle to the right and 10 cm to the back, and another 12-mm trocar at a 15° angle to the left from the bottom. One 5-mm trocar is placed in the epigastric region, and, if necessary, one more is placed along the anterior axillary line in the right hypochondrium [3, 7–9].

In South Korea, the placement pattern is similar for laparoscopic left lateral sectionectomy, but 12-mm trocars are mostly used [1]. For a more rational port placement, some transplant centers performed ultrasound imaging of the liver [7, 10].

When resecting the left lobe in a living donor, trocar placement is the same as when performing LL resection, except that the main working ports are placed equidistantly upward at an angle of 30° from the paraumbilical optical access [11]. Some transplant centers have a modified version of trocar port placement using 6 trocars [12].

Trocar placement in right-sided hemihepatectomy is shown in Figure 4. Standardized approaches to port placement have been developed using a three-dimensional laparoscope for laparoscopic resection of the right lobe of the liver in living donors [13].

LIVER MOBILIZATION AND HEPATODUODENAL LIGAMENT DISSECTION

Carboxyperitoneum is achieved to target values of 8–13 mm Hg when performing left lateral sectionectomy or left lobar resection [1, 3, 6, 8, 9, 11, 12]. For right-sided hemihepatectomy, the reference intra-abdominal pressure value, according to various literary sources, is 12–15 mm Hg [14, 15]. A 30° optical transducer is mostly used for imaging, although a laparoscope with an

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adjustable viewing angle has been increasingly reported of recent [16, 17].

When resecting the left lateral segment or the left lobe, after revision of the abdominal cavity, the liver is mobilized by intersecting the round, sickle, coronary and left triangular ligaments using a harmonic scalpel and monopolar scissors [3, 6–8]. When mobilizing the left lobe of the liver, namely the gastrohepatic ligament, it is worth noting a possible aberrant artery branching to the left lobe from the left gastric artery.

It should be noted that preliminary circular mobilization of the left hepatic vein during LL resection is not routinely performed in most transplant centers, although there have been recent reports on this maneuver [18].

Next, the hepatoduodenal ligament structures are isolated: the left hepatic artery is mobilized along the length and circularly bypassed with a webbing or its alternatives. After that, the short portal branches are ligated to segment 1, the left branch of the portal vein is also circularly bypassed. Then, using a harmonic scalpel or bipolar coagulation, the venous branches draining segment 4 (Sinus Rexi) are transected.

It should be noted that mobilization of the hepatoduodenal ligament structures is performed using the caudal approach, while, for better visualization, traction is performed for the transected round ligament of the liver [7]. However, in some cases, the left lateral segment is rotated counterclockwise to facilitate its mobilization and isolation of afferent vessels [9].

In the case of hemihepatectomy, it is necessary to take into account the anatomical border of separation into the left and right lobes of the liver, namely, the line running from the bottom of the gallbladder to the suprahepatic part of the inferior vena cava [19]. Cholecystectomy is performed based on the Critical View of Safety principle, a control system based on assessment and registration of three key elements:

– Dissection of the Calot's triangle (cystic duct – hepatic duct – liver);
– Visualization of only two tubular structures leading to the gallbladder;
– Mobilization of the lower part of the gallbladder and visualization of the lower 1/3 of the gallbladder bed before intersecting any tubular structures [20].

As for right-sided hemihepatectomy, some authors believe that cholecystectomy should be performed before mobilizing the hepatoduodenal ligament to achieve more detailed visualization of the arterial blood supply to the right lobe of the liver [4, 14]. In some Asian clinics, for example, in South Korea, the operation begins with mobilization of the right lobe of the liver, and then proceeds to dissection of afferent vessels and cholecystectomy [5, 21].

Intraoperative cholangiography [22] or indocyanine green fluorescent imaging [21–24] is used to visualize the ductal zone. Modified cholangiography is also used. For this purpose, a bulldog forceps is applied on the supposed intersection site of the bile duct, and cholangiography is performed through the cystic duct stump. In this way, the safety of duct intersection is confirmed [15].

LIVER PARENCHYMAL DISSECTION

To determine the optimal plane of resection when performing hemihepatectomy, clamping of afferent blood flow to the left or right lobe of the liver using vascular clamps is performed. A parenchyma dissection line is marked with a harmonic scalpel along the line of demarcation, and then the vascular clamps are removed [25].

In some transplant centers, just before parenchyma dissection is done, the hepatoduodenal ligament structures are taken onto a turnstile to apply the Pringle maneuver – clamping of afferent blood flow to the liver in the event of massive bleeding, although this technique is not routinely used in some transplant centers [60, 62, 84]. It should be noted that the Pringle maneuver was not used in any of the reports described when performing laparoscopic left lateral sectionectomy [1–3, 6, 9, 26].

Parenchymal dissection is performed using an ultrasonic or water-jet dissector, bipolar and monopolar coagulation, or argon [1–3, 6, 9]. Some authors argue that large vessels will never be injured by light maneuvers as long as the vessels are in the surgeon's field of vision. Even during parenchymal dissection, intraparenchymal structures can be visualized using magnification on a laparoscope, and minor bleeding can be controlled by raising the intra-abdominal pressure [27].

When resecting the left lateral segment, the parenchymal resection line is defined towards the medial wall of the left hepatic vein and goes slightly to the right of the falciform ligament. The dissection is also carried out according to the caudal approach, i.e. from the bottom to up. According to a study in Hungary, the optimal parenchymal dividing line for the left lateral segment should be about 1 cm to the right of the falciform ligament, except for deviant biliary anatomy of the left lateral segment, when the level of segmental bile duct fusion according to MR cholangiography is to the right or left of the intended level [6, 28]. This is due to the need to obtain a minimum number of bile ducts on the graft to reduce the number of biliary complications in the recipient. In hemihepatectomy, the resection line follows the demarcation line as previously described.

It is very important to note that in laparoscopic hemihepatectomy, after dividing the caudate lobe, a nylon tube is passed into the anterior part of the Glisson's right posterior foot in order to raise the residual parenchyma. Thus, the hanging maneuver is performed, which helps to complete the parenchymal dissection most safely, although some authors consider this maneuver as optional [21, 23]. A somewhat similar maneuver has been described for laparoscopic resections of the LL and left lobe in living donors. So, for the convenience of paren-

chymal dissection at the junction of the left and median hepatic veins, the following maneuver is applied: this area is circumferentially bypassed with a webbing and pulled upward, thereby improving visualization during dissection, and providing additional vascular safety [29].

In the parenchymal transsection process, the portal plate, in which the bile duct and paraductal vessels pass, is exposed. These elements are crossed with scissors, and a careful hemo- and biliostasis with suturing and clipping is performed on the donor's side. At some transplant centers, the portal plate is clipped with Hem-o-lock clips (TFX Medical Ltd., RTP Durham, NC, USA) and then crossed with scissors between the clips [9, 30, 31].

GRAFT REMOVAL

After the graft remains connected only by afferent vessels and hepatic veins, the Pfannenstiel incision is performed with installation of a port for manual assistance. Then, the graft is removed directly: the afferent vessels of the graft are clipped and transected (in some transplant centers, the portal vein is transected with a stapler [32, 33]), the hepatic veins are transected using a stapler. The obtained graft is removed using manual assistance through the previously installed port and it is then transferred for perfusion with a preservative solution [8].

After the liver fragment has been extracted, a thorough revision for hemo- and biliostasis is carried out, and, if necessary, electrocoagulation, stitching or clipping of suspicious areas is performed. A silicon drainage is placed to the wound surface of the liver [11, 14], though some authors believe that with "ideal" liver resection, there are no indications for safety drainage [34].

CONCLUSION

Donor safety is of paramount importance in donor liver surgery. This very important aspect is still the main obstacle to the spread of minimally invasive approaches in living liver donation.

This is probably why the approach to laparoscopic liver resection in living donors is significantly different among different transplant centers. Nevertheless, further evaluation of the standardization of methods is needed to improve intermediate surgical outcomes for these surgical procedures.

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REFERENCES

1. *Kim KH, Jung DH, Park KM, Lee YJ, Kim DY, Kim KM, Lee SG*. Comparison of open and laparoscopic live donor left lateral sectionectomy. *British Journal of Surgery.* 2011; 98 (9).
2. *Troisi RI, Wojcicki M, Tomassini F, Houtmeyers P, Vanlander A, Berrevoet F et al*. Pure Laparoscopic Full-Left Living Donor Hepatectomy for Calculated Small-for-Size LDLT in Adults: Proof of Concept. *American Journal of Transplantation*. 2013; 13 (9): 2472–2478.
3. *Broering DC, Elsheikh Y, Shagrani M, Abaalkhail F, Troisi RI*. Pure Laparoscopic Living Donor Left Lateral Sectionectomy in Pediatric Transplantation: A Propensity Score Analysis on 220 Consecutive Patients. *Liver Transplantation*. 2018; 24 (8).
4. *Goumard C, Soubrane O, Brustia R, Scatton O*. Laparoscopic right hepatectomy for living donation. *Annals of Laparoscopic and Endoscopic Surgery.* 2017; 2: 81–81.
5. *Han HS, Cho JY, Yoon YS, Hwang DW, Kim YK, Shin HK, Lee W*. Total laparoscopic living donor right hepatectomy. *Surgical Endoscopy.* 2015; 29 (1).
6. *Cherqui D, Soubrane O, Husson E, Barshasz E, Vignaux O, Ghimouz M et al*. Laparoscopic living donor hepatectomy for liver transplantation in children. *Lancet*. 2002; 359 (9304): 392–396.
7. *Soubrane O, Cherqui D, Scatton O, Stenard F, Bernard D, Branchereau S et al*. Laparoscopic left lateral sectionectomy in living donors: Safety and reproducibility of the technique in a single center. *Annals of Surgery*. 2006; 244 (5).
8. *Troisi R, Debruyne R, Rogiers X*. Laparoscopic Living Donor Hepatectomy for Pediatric Liver Transplantation. *Acta Chirurgica Belgica*. 2009; 109 (4): 559–562.
9. *Gautier S, Monakhov A, Gallyamov E, Tsirulnikova O, Zagaynov E, Dzhanbekov T et al*. Laparoscopic left lateral section procurement in living liver donors: A single center propensity score-matched study. *Clinical Transplantation*. 2018; 32 (9).
10. *Troisi RI, Elsheikh YM, Shagrani MA, Broering D*. First fully laparoscopic donor hepatectomy for pediatric liver transplantation using the indocyanine green near-infrared fluorescence imaging in the Middle East: a case report. *Annals of Saudi Medicine*. 2014; 34 (4): 354–357.
11. *Samstein B, Cherqui D, Rotellar F, Griesemer A, Halazun KJ, Kato T et al*. Totally laparoscopic full left hepatectomy for living donor liver transplantation in adolescents and adults. *American Journal of Transplantation*. 2013; 13 (9).
12. *Zhu X, Shen Z, Zhang Y, You B, Dong J*. Laparoscopic or abdominal left extrahepatic lobectomy of donor liver in pediatric living donor liver transplantation: a report of 17 cases. *International Journal of Clinical and Experimental Medicine*. 2019; 12 (4): 4116–4123.
13. *Lee J, Shehta A, Suh K, Hong SK, Yoon KC, Cho J et al*. Guidance for Optimal Port Placement in Pure 3-Dimensional Laparoscopic Donor Right Hepatectomy. *Liver Transplantation*. 2019; 25 (11): 1714–1722.
14. *Wakabayashi G, Cherqui D, Geller DA, Buell JF, Kaneko H, Han HS et al*. Recommendations for laparoscopic liver resection: A report from the second international consensus conference held in morioka. *Annals of Surgery*. 2015; 261 (4).
15. *Samstein B, Klair T*. Living Donor Liver Transplantation: Donor Selection and Living Donor Hepatectomy. *Current Surgery Reports*. 2015; 3 (9).
16. *Kwon C.H.D., Choi G.-S., Joh J.-W*. Laparoscopic right hepatectomy for living donor. *Current Opinion in Organ Transplantation*. 2019; 24 (2): 167–174.

17. *Hong SK, Shin E, Lee K-W, Yoon KC, Lee J-M, Cho J-H et al*. Pure laparoscopic donor right hepatectomy: perspectives in manipulating a flexible scope. *Surgical Endoscopy*. 2019; 33 (5): 1667–1673.
18. *Lu L, Wang Z, Zhu W, Shen C, Tao Y, Ma Z et al*. Left Hepatic Vein Preferential Approach Based on Anatomy Is Safe and Feasible for Laparoscopic Living Donor Left Lateral Sectionectomy. *Liver Transplantation*. 2020. C.lt.25793.
19. *Pereskokov SV, Dmitriev AV, Groshilin VS, Tareeva DA, Kozyrevskiy MA*. Khirurgiya pecheni: ot istokov razvitiya do sovremennykh vozmozhnostey. *Sovremennye problemy nauki i obrazovaniya*. 2017; 5.
20. *Vettoretto N, Saronni C, Harbi A, Balestra L, Taglietti L, Giovanetti M*. Critical View of Safety During Laparoscopic Cholecystectomy. *JSLS: Journal of the Society of Laparoendoscopic Surgeons*. 2011; 15 (3): 322–325.
21. *Hong KSSSK, Yi KWLNJ, Ahn HSKSW, Choi KCYJY, Kim DOH*. Pure laparoscopic living donor hepatectomy: Focus on 55 donors undergoingright hepatectomy. 2018; April 2017: 434–443.
22. *Chen K, Siow TF, Chio U, Wu J, Jeng K*. Laparoscopic donor hepatectomy. 2018; 11: 112–117.
23. *Lee KW, Hong SK, Suh KS, Kim HS, Ahn SW, Yoon KC et al*. One Hundred Fifteen Cases of Pure Laparoscopic Living Donor Right Hepatectomy at a Single Center. 2018: 1878–1884.
24. *Han JR, Han YS, Chun JM, Hwang YJ*. Indocyanine green near-infrared fluorescence cholangiogram during pure laparoscopic living donor hepatectomy for optimal bile duct division. *Transplantation*. 2020; 104 (S3): S498–S498.
25. *Au KP, Siu K, Chok H*. Minimally invasive donor hepatectomy, are we ready for prime time? 2018.
26. *Hong SK, Suh K, Kim KA, Lee J, Cho J, Yi N, Lee K*. Pure laparoscopic versus open left hepatectomy including the middle hepatic vein for living donor liver transplantation. *Liver Transplantation*. 2020; 26 (3): 370–378.
27. *Takahara T, Wakabayashi G, Beppu T, Aihara A, Hasegawa K, Gotohda N et al*. Long-term and perioperative outcomes of laparoscopic versus open liver resection for hepatocellular carcinoma with propensity score matching: A multi-institutional Japanese study. *Journal of Hepato-Biliary-Pancreatic Sciences*. 2015; 22 (10).
28. *Kiss M, Deshpande RR, Nemeskéri Á, Nguyen TT, Kürti Z, Kovács S et al*. Optimal line of hepatotomy for left lateral living donor liver transplantation according to the anatomical variations of left hepatic duct system. *Pediatric Transplantation*. 2015; 19 (5).
29. *Wing K, Cheung TT*. Standardizing Laparoscopic Left Lateral Sectionectomy for Hepatocellular Carcinoma. 2016.
30. *Monakhov A, Semash K, Tsiroulnikova O, Djanbekov T, Khizroev K, Kurtak N, Gautier SV*. Laparoscopic left lateral sectionectomy in living liver donors: from the first experience to routine usage. *Transplantation*. 2020; 104 (S3): S241–S241.
31. *Gautier SV, Monakhov AR, Miloserdov IA, Arzumanov S, Tsirulnikova OM, Semash KO, Dzhanbekov TA*. Simultaneous laparoscopic left lateral sectionectomy and nephrectomy in the same living donor: The first case report. *American Journal of Transplantation*. 2019; 19 (6).
32. *Kim JM, Ha SY, Joh JW, Sinn DH, Jeong WK, Choi GS et al*. Predicting hepatic steatosis in living liver donors via noninvasive methods. *Medicine (United States)*. 2016; 95 (7).
33. *Hong Q, Wang J, Wang Y, Fu B, Fang Y, Tong Q et al*. Clinical outcomes of laparoscopic versus open right hepatectomy for liver tumors: A meta-analysis. *Medicine (United States)*. 2020; 99 (1).
34. *Gavriilidis P*. Re-appraisal of prophylactic drainage in uncomplicated liver resections: a systematic review and meta-analysis. *HPB*. 2017; 19 (1).

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