**Name of journal:** **World Journal of Gastroenterology**

**ESPS Manuscript No: 11609**

**Columns: TOPIC HIGHLIGHTS**

WJG 20th Anniversary Special Issues (15): Laparoscopic resection of gastrointestinal

**Laparoscopic liver resection for living donation: where do we stand?**

Cauchy F *et al*. Laparoscopy and living donor hepatectomy

François Cauchy, Lilian Schwarz, Olivier Scatton, Olivier Soubrane

**François Cauchy, Lilian Schwarz, Olivier Scatton, Olivier Soubrane**,Service de Chirurgie Hépato-Bilio-Pancréatique et Transplantation Hépatique, Hôpital Saint-Antoine, Assistance Publique - Hôpitaux de Paris, 75012, Paris, France

**Olivier Soubrane,** Department of HPB Surgery and Liver Transplantation, Hopital Beaujon, 92110 Clichy, France

**Author contributions:** Cauchy F, Schwarz L and Soubrane O designed the research; Cauchy F and Schwarz L performed the research; Cauchy F, Schwarz L and Scatton O analyzed the data; Cauchy F and Schwarz L wrote the paper; Scatton O and Soubrane O gave an important intellectual contribution; Scatton O and Soubrane O supervised.

**Correspondence to: Olivier Soubrane, MD, Professor,** Department of HPB Surgery and Liver Transplantation, Hopital Beaujon, 100 Boulevard du Général Leclerc, 92110 Clichy, France. olivier.soubrane@sat.aphp.fr

**Telephone:** +33-1-40875895

**Received:** May 28, 2014 **Revised:** July 21, 2014

**Accepted:** September 5, 2014

**Published online:**

**Abstract**

In Western countries, living donor liver transplantation (LDLT) may represent a valuable alternative to deceased donor liver transplantation. Yet, after an initial peak of enthusiasm, reports of high rates of complications and of fatalities have led to a certain degree of reluctance towards this procedure especially in Western countries. As for living donor kidney transplantation, the laparoscopic approach could improve patient’s tolerance in order to rehabilitate this strategy and reverse the current trend. In this setting however, initial concerns regarding patient’s safety and graft integrity, need for acquiring surgical expertise in both laparoscopic liver surgery and living donor transplantation and lack of evidence supporting the benefits of laparoscopy have delayed the development of this approach. Similarly to what is performed in classical resectional liver surgery, initial experiences of laparoscopy have therefore begun with left lateral sectionectomy, which is performed for adult to child living donation. In this setting, the laparoscopic technique is now well standardized, is associated with decreased donor blood loss and hospital stays and provides graft of similar quality compared to the open approach. On the other hand laparoscopic major right or left hepatectomies for adult-adult LDLT currently lack standardization and various techniques such as the full laparoscopic approach, the hand assisted approach and the hybrid approach have been reported. Hence, even-though several reports highlight the feasibility of these procedures, the true benefits of laparoscopy over laparotomy remain to be fully assessed. This could be achieved through standardization of the procedures and creation of international registries especially in Eastern countries where LDLT keeps on flourishing.

© 2014 Baishideng Publishing Group Inc. All rights reserved.

**Key words:** Liver transplantation; Laparoscopy; Living donation; Postoperative course

**Core tip:** Initial concerns regarding patient’s safety and graft integrity, need for acquiring surgical expertise in both laparoscopic liver surgery and living donor transplantation (LDLT) and lack of evidence supporting the benefits of laparoscopy have delayed the development of this approach in LDLT. Preliminary experiences of laparoscopic liver resection for LDLT have begun with laparoscopic left lateral sectionectomy for adult-child LDLT, where the procedure is now well standardized and provides satisfactory results. On the other hand, lack of standardization and multiplicity of the techniques currently limit the evaluation of this approach in the setting of major liver resection for adult-adult LDLT.

Cauchy F, Schwarz L, Scatton O, Soubrane O. Laparoscopic liver resection for living donation: where do we stand?. *World J Gastroenterol* 2014; In press

**INTRODUCTION**

Liver transplantation (LT) is the mainstay treatment for patients with end-stage liver disease or early hepatocellular carcinoma occurring on cirrhosis with survival rates reaching up to 80% and 70% at 1 and 5 years respectively[1]. Yet, the long-lasting imbalance between graft availability and an increasing number of patients on the waiting list required development of several other strategies. Living donor liver transplantation (LDLT) has emerged as a valuable alternative to deceased donor liver transplantation[2]. In Eastern countries, where the hesitancy to donate organs after death corroborates with strong cultural and religious beliefs, rates of deceased organ donation of 0.05-6.0 per million[3] are among the lowest observed and have led to successful development of LDLT. In Western countries, after an initial peak of enthusiasm during the late 90’s, reports of fatal complications published in both scientific journals[4,5] and in the public press have led to a marked decrease in the number of procedures. Hence, LDLT now barely account for 4%-5% of the total number of liver transplantations in Europe and in the United States[6,7]. This proportion contrasts with that of living kidney transplant, which has reached almost 40% in the last 10 years in the United States[8,9]. While this large difference is certainly mainly the consequence of the higher risks of complications and death in live liver donors, one should nevertheless bear in mind that the use of the laparoscopic approach in living donor nephrectomy has led to an overall increase in donation rates[10]. In living donor nephrectomy, several meta-analyses and randomized controlled trials have established that laparoscopy was associated with decreased morbidity rates and postoperative pain, shorter in-hospital stay, lower cost, better quality of life and faster return to work[9,10].

In classical resectional liver surgery (*i.e.*, for malignant or benign disease), initial concerns regarding both safety and feasibility of the laparoscopic approach, especially for major hepatectomies have led to delay its development and it’s only recently that this strategy has gained acceptance. Hence, the laparoscopy is now considered as the approach of choice for several procedures such as left lateral sectionectomy[11,12]. Yet, its use in the setting of living donation still raises several concerns about not only donor safety but also graft integrity[13]. The objective of this comprehensive review is therefore to discuss on the past and present limits of the laparoscopic approach for living donation in order to provide relevant insights regarding its current place. To such end, a MEDLINE search was performed for relevant English full-text articles using a combination of the following key words “living donor liver transplantation” with “laparoscopy” and/or ”laparoscopy assisted hepatectomy” and/or “laparoscopic hepatectomy” and/or "left lateral sectionectomy” and/or “left hepatectomy” and/or “right hepatectomy” and/or “right posterior sectionectomy”. The reference lists of the selected papers were also searched in order to obtain additional relevant articles.

**WHY HAS THE DEVELOPMENT OF LAPAROSCOPY BEEN DELAYED IN THE SETTING OF LIVING LIVER DONATION?**

***Long and necessary learning curve***

The most controversial topic in liver surgery is clearly the performance of laparoscopic living donor hepatectomy. In laparoscopic liver resection for LDLT, both expertise in LDLT as well as in laparoscopic liver surgery are required. On one hand, LDLT only represents a small proportion of all liver transplantation annually performed, especially in Western countries[6,7], which clearly limits the possibility of fast development. On the other hand, mastering both liver surgery and laparoscopic techniques should be achieved before attempting laparoscopic liver resections. In this setting, several reports have emphasized that a minimum of 15-60 procedures depending on the extent of the resection was required before optimal results could be obtained[14,15]. As experience with advanced technological support in minimally invasive surgery increased, laparoscopic liver resections have therefore trended from minor wedge resections and left lateral sectionectomy for peripherally located lesions towards major resections[15,16]. Altogether, it is not surprising that the development of laparoscopic liver resection for LDLT has been delayed until initial reports highlighting the safety and feasibility of laparoscopic liver surgery were released.

Interestingly, when it came to performing laparoscopic left lateral sectionectomy for living donation, a learning curve of approximately 20 procedures was also observed before achieving optimal blood loss, warm ischemia times[17], postoperative course and hospital stay[18]. This finding supports that even the most experienced surgeons in both laparoscopic liver surgery and liver transplantation will have to face some kind of difficulties at the beginning of their experience.

***Initial concerns regarding patient safety and graft integrity using the laparoscopic approach***

Donor safety is clearly the main issue of this strategy. Mortality after living donation ranges from 0.05%-0.1% for left lateral section donation to 0.2% for right liver donation[19]. Also, a consistently reported rate of complication of approximately 40%[20,21] including major ones such as biliary fistula, infections or pulmonary complications[22,23] in case of open right liver donation may discourage these healthy donors. These risks, superimposed with elevated rates of psychological difficulties[21] following donation affect both medical teams and general opinion. In Western countries, where deceased liver transplantation is widely available, this has led to a certain degree of reluctance among medical teams and a decrease in living donation is currently observed. In this setting, laparoscopic liver donation could not suffer worse results than the open approach and should at the best reduce these risks in order to rehabilitate this strategy and reverse the current trend.

Several concerns regarding patients safety have long-limited the development of the laparoscopic approach in patients undergoing classical liver resectional surgery. In particular, an important initial reluctance was the risk and management of hemorrhage under laparoscopy. However, with technical refinements and growing expertise during the past two decades, several reports have emphasized decreased blood loss and transfusion rates in patients undergoing laparoscopic liver resection compared to patients operated under laparotomy[24-26]. Possible explanations for this finding include the 30-degree reverse Trendelenburg position reducing hepatic backflow, more effective hemostasis on the cut surface due to laparoscopic magnification and possibly the effects of pneumoperitoneum which could both decrease cut surface bleeding[27] and therefore leave enough time for laparoscopic haemostasis or conversion when required. Another important issue, which has now been sorted out, was the theoretical increased risk of gas embolism as a consequence of the pneumoperitoneum itself. In this setting, one should nevertheless bear in mind that this pneumoperitoneum is made of CO2, which solubility is greater than that of nitrogen[13] and that several experimental studies have clearly established that CO2 was not associated significant hemodynamic instability[13].

In donors undergoing open hepatecomy graft retrieval is generally achieved using large midline or subcostal laparotomies. In case of full laparoscopic approach, the graft has to be placed in a plastic bag and extraction is usually performed using smaller incisions such as supra-pubic incisions. In this setting, several authors have raised some concerns regarding the risk of physical graft integrity and prolonged warm ischemia time (WIT)[28]. First, it has now been established that liver function tests and graft functional recovery were identical in patients operated under laparotomy or laparoscopy. Second, our group has shown that even-though longer WIT were observed in laparoscopically retrieved grafts, this did not impact graft related postoperative complications or survival[29]. Altogether, there is currently no argument supporting that the laparoscopic approach itself could jeopardize the quality of the graft.

***Delayed evidence supporting the benefits of the laparoscopic approach in liver surgery***

Today, laparoscopic minor liver resections are considered to be safe and reproducible techniques and even superior to the open approach. In this setting, laparoscopic left lateral sectionectomy is now considered the gold standard for malignant or benign lesions[11,12]. Apart from obvious cosmetic benefits the reported advantages of laparoscopy over laparotomy are multiple. These include decreased surgical site infections[30] and postoperative ascites[25,26], shorter hospital stay[30,31], and improved cost effectiveness[32]. Still, these benefits mainly arose from the results of retrospective case-control series or meta-analyses of retrospective studies. Hence, even-though laparoscopic surgery has certainly gained global acceptance over the last 20 years, current medical literature clearly lacks strong evidence when it comes to the specific subset of liver surgery. Among the several explanations that may account for this major drawback, ethical concerns clearly limited the feasibility of randomized controlled trials comparing open and laparoscopic approaches.

**INITIAL EXPERIENCE WITH LAPAROSCOPIC LIVER RESECTION FOR LIVING DONATION: THE MODEL OF LAPAROSCOPIC LEFT LATERAL SECTIONECTOMY FOR ADULT-CHILD LDLT**

As for liver resection for malignant or benign lesions, laparoscopic approaches to living donation were initially described for removing an adult left lateral segment graft for transplantation into a child. First described simultaneously in Brazil and Australia in 1989[33,34], open left lateral sectionectomy (LLS) for adult-child LDLT is now a well-standardized procedure and has been shown to provide the best patient survival rates[35,36]. In this setting, the rationale of performing this procedure through laparoscopy was to provide the healthy donors with the advantages of this modern minimal invasive approach and, at the same time, to assure maximal safety of the procedure and the procurement of grafts of optimal quality. Hence, since the first report of full laparoscopic LLS for adult-child LDLT in 2002[37], this approach has progressively gained increased acceptance.

Table 1 summarizes the results of the three most important series focusing on laparoscopic LLS for adult-child LDLT[18,29,38]. Of these, the first two series were small case control studies, which mainly aimed at reporting both safety and feasibility of this approach. From the donor point of view, the laparoscopic approach was associated with decreased blood loss[29,38], improved postoperative course with decreased postoperative complication rates[29], shorter postoperative recovery and hospital stays[38] compared to the open approach. From the recipient point of view, even though the laparoscopic approach was associated with longer WIT[29] compared to the open approach, recipients displayed similar postoperative liver function tests and identical rates of biliary complications, graft loss leading to retransplantation and overall postoperative mortality[29,38]. Interestingly, our recent bicentric report of 70 LLS for adult-child LDLT highlighted an 8% rate of hepatic artery thrombosis (HAT)[18]. This rate, which may seem higher compared to values reported in the literature, may account for several explanations. First, at the beginning of this experience, living donation was dedicated to emergency situations, including acute necrosis in biliary atresia recipients or retransplantation for acute liver graft failure, which are well known to be at higher risk of complications. In that sense, the same series reported a 0% HAT rate in the center where LLS for adult-child LDLT was performed electively. Second, no anticoagulants were given to the donor at the time of vessels division suggesting that a systematic protocol for anticoagulation before retrieval should probably be introduced.

Altogether, with almost 100 procedures performed to date, both safety and reproducibility of laparoscopic LLS for adult-child LDLT have now been established. Even-though some minor adjustments are still required, there is no doubt that this approach will become the standard of care in upcoming years.

**LAPAROSCOPIC MAJOR LIVER RESECTION FOR ADULT-ADULT LIVING DONATION**

Adult to adult (AA) LDLT was introduced almost a decade after LDLT for children[39]. AA LDLT is mainly performed using two types of partial grafts *i.e.*, right hemiliver grafts and left hemiliver grafts, both with specific advantages and shortcomings. In this setting, the use of laparoscopy has raised several issues concerning both safety and feasibility but also usefulness. Hence, it’s only very recently that the first reports of laparoscopic major hepatectomy for AA LDLT have been released.

***Laparoscopic right hepatectomy for AA LDLT***

Living donor right hepatectomy, which entrails removal of about two thirds of the donor liver represents the main type of partial liver graft for AA LDLT. While right liver graft donation provides an adequate volume of transplanted functional liver parenchyma and therefore ensures recipients safety, it has raised much concern about donor safety. Indeed, less than 10 years ago, AA LDLT using right liver grafts was still associated with a 30% donor transfusion rate and a 40% postoperative complication rate[20,21] including biliary tract complications and pulmonary complications in 3%-8%[40] and 10%[23] of the donors respectively. To rehabilitate this strategy and reverse the current trend of decreasing AA live donation rates, efforts in reducing these high complication rates were clearly required[41]. In this context, several units have therefore advocated that the laparoscopic approach for AA LDLT living donation could be considered as an option to reduce donor morbidity. Indeed, increasing number of reports have emphasized that laparoscopic right hepatectomy for classical liver resection demonstrated better surgical outcomes than the open approach in terms of reduced intraoperative blood loss and postoperative hospital stay[42-45]. Various techniques of laparoscopic right hepatectomy have been reported[46-50]. Currently, three main techniques of laparoscopic right hepatectomies have been described: (1) the pure “full” or “totally” laparoscopic approach where the whole procedure is performed through laparoscopy; (2) the hand assisted laparoscopic approach where a hand port is used to facilitate the operation; and (3) the laparoscopic assisted approach or “hybrid technique” where pedicular dissection and liver mobilization are performed under laparoscopy when parenchymal transection and specimen extraction are performed using a short (midline or subcostal) incision. Currently, there are no published data indicating the superiority of one technique over the others and the choice of the technique depends on the surgeons’ expertise and preference as well as the indication for surgery. In our experience we believe that the hybrid method may be used as a valuable “salvage” alternative strategy, which offers the possibility for safe conversion in case of bleeding or large tumor with involvement of the hepatocaval confluence.

Some detractors of laparoscopic major hepatectomy for LDLT only consider this approach as a pure technical achievement[28]. On the opposite, several HPB surgeons have focused on developing laparoscopic right hepatectomy using conceptual and standardized techniques[29,51] with the aim to ensure donor safety through decreased intraoperative blood loss, improved postoperative course with decreased morbidity and faster rehabilitation[46].

As shown in Table 2, 167 cases of laparoscopic right hepatectomy for AA LDLT have been reported between 2006 and 2014, mostly through case reports, case series or case match series with low statistical power[51-62]. Of these, two procedures were performed using a full laparoscopic approach, one procedure was performed using a robot-assisted technique, while the 164 other cases were performed using hand assisted or hybrid techniques. In these reports, there was no evidence indicating that the laparoscopic approach for right hepatectomy living donation was superior to conventional open approach. However, it should be emphasized that (1) no death was reported; (2) the rate of severe complications (0% to 17%) was quite low; and (3) the lengths of hospital stay (3 to 12 d) were more than acceptable.

Altogether, currently published results seem to confirm previous assertions regarding the feasibility of the laparoscopic approach for right hepatectomy in the setting of AA LDLT. Whether potential physical and psychological benefits of a smaller incision superimposed on at least similar postoperative results may change the landscape for living liver donors leading to an increased willingness to donate will nevertheless clearly require further investigations.

***Laparoscopic left hepatectomy for AA LDLT***

The rationale of left hemi-liver graft donation for AA LDLT would be to reduce the risk brought on the donor while providing the recipient with a sufficient amount of functional liver parenchyma at the same time. From the donor point of view, left hemi-liver grafts account for approximately 40% of the donors’ total liver volume and this type of hepatectomy is generally associated with decreased rates of postoperative biliary and pulmonary complications[23,63,64]. Yet, some authors advocate that the use of these smaller grafts essentially transfers the risk from the donor to the recipient[65] in the form of small-for-size syndrome (SFSS). Indeed, a graft to recipient weight ratio (GRWR) under 0.8% or a graft volume standard liver volume (GV/SLV) less than 40% is considered as an increased risk factor for graft failure after LT in adult recipients. In this context, the first published series of adult LT using left liver grafts reported worse outcomes as compared to right liver grafts. Nowadays however, improvements in the preoperative planning with tailoring of the type of donor hepatectomy to the recipients’ needs[66] as well as refinements in surgical technique with optimal outflow reconstruction[67,68] and both selective use of splenic artery occlusion[69] or portocaval shunt creation[70] allow patients and grafts survivals to reach those of right grafts for LDLT[71-73]. Altogether, even if these considerations may appear to be beyond the scoop of this review, they largely explain the delayed development of AA LDLT using laparoscopically harvested left hemiliver-grafts, which was not correlated to technical difficulties but rather to inherent limitations related to this type of grafts.

In classical resectional surgery, laparoscopy may indeed be considered a valuable approach with low intraoperative blood loss, overall complications, and mortality rates. This has led some authors to considering this approach as the future standard of care for this procedure[74,75]. This widely contrasts with the small number of series reporting the results of laparoscopic assisted or full laparoscopic left hepatectomy in the setting of LDLT[53,56,76-78] (Table 3). Still, preliminary studies of laparoscopic assisted left hemi-hepatectomies for AA LDLT with or without caudate lobe harvesting have emphasized that this approach was associated with low postoperative morbidity and provided shorter hospital stays than in the open approach. On the other hand, the very limited experience of 6 cases of totally laparoscopically harvested left hemi-liver grafts for L**D**LT arising from two expert centers[77,78] currently do not allow drawing any solid conclusion regarding the safety of this approach.

**FUTURE EXPECTATIONS**

***Need for standardization***

With increasing reports highlighting the safety and feasibility of the laparoscopic approach for both traditional liver resectional surgery and live donor liver hepatectomy, several improvements such as laparoscopic right posterior sectionectomy or full robotic right and left hepatecomies are likely to be expected in upcoming years. However, these refinements may be considered as pure technical achievements and there is a more important need for surgical units to achieve standardization of the existing procedures. Indeed, the technique of major liver resections is not standardized even through laparotomy and countless techniques including those focusing on vascular control strategy of resection with primary mobilization of the right liver or anterior approach without mobilization or parenchymal transection have been reported. In the setting of laparoscopic major liver resection, there is no doubt that standardization would both increase the reproducibility of the techniques and allow overcoming reluctances to promote the widespread development of this approach. The question on how the progression from surgical innovation to more standardized techniques can be achieved is still an open debate. As an example, our group has recently reported a conceptual technique of laparoscopic right hepatectomy based on facts and oncologic principles, the so-called “caudal approach”[49]. Hopefully, this technique, which was developed in order to both decrease morbidity and improve reproducibility regardless of the indication for liver resection will also promote standardization.

***Need for reports arising from Eastern countries***

Apart from LLS for adult-child living donation, large sided series or studies comparing the results of full laparoscopic right and left major liver resection for living donation to similar open procedures are currently lacking and need to be conducted. Knowing that randomized controlled trials are unlikely to be undertaken, creating an international registry and comparing the results to open cohorts might allow us to evaluate the relevance and risks of the approach. Furthermore, the fact that all four reports focusing on full laparoscopic major hepatectomy for living donation arose from either European or American centers suggests an underdevelopment of this approach in Eastern countries. In France, as in many other Western countries, the number of major liver resection for liver donation is particularly low. This is at least partly due to the continuously decreasing overall number of LDLT. In this setting, there is a crucial need for reports of laparoscopic LDLT arising from Eastern expert centers, which annually perform hundreds of major hepatectomies for LDLT[79-81].

**conclusion**

apart from laparoscopic left lateral sectionectomy for adult-child LDLT, the current place of laparoscopy in living donor hepatectomy still lacks high level of evidence. Creation of international registries especially in Eastern countries should be undertaken in order to assess the relevance of this approach. Even-though preliminary reports tend to support both safety and potential benefits of laparoscopy in the setting of LDLT, future challenges should include standardization of the technique in order to achieve a certain degree of reproducibility and favor widespread development.

**ACKNOWLEDGEMENTS**

The authors would like to thank Clemence Sebag for her precious help in reviewing the manuscript.

**REFERENCES**

1 **Agopian VG**, Petrowsky H, Kaldas FM, Zarrinpar A, Farmer DG, Yersiz H, Holt C, Harlander-Locke M, Hong JC, Rana AR, Venick R, McDiarmid SV, Goldstein LI, Durazo F, Saab S, Han S, Xia V, Hiatt JR, Busuttil RW. The evolution of liver transplantation during 3 decades: analysis of 5347 consecutive liver transplants at a single center. *Ann Surg* 2013; **258**: 409-421 [PMID: 24022434 DOI: 10.1097/SLA.0b013e3182a15db4]

2 **Chen CL**, Kabiling CS, Concejero AM. Why does living donor liver transplantation flourish in Asia? *Nat Rev Gastroenterol Hepatol* 2013; **10**: 746-751 [PMID: 24100300 DOI: 10.1038/nrgastro.2013.194]

3 **Mañalich R**, Paez G, Valero R, Manyalich M. IRODaT: the International Online Registry for Organ Donation and Transplantation 2007. *Transplant Proc* 2009; **41**: 2030-2034 [PMID: 19715825 DOI: 10.1016/j.transproceed.2009.06.035]

4 **Melloul E**, Dondero F, Paugam-Burtz C, Bouadma L, Arnulf B, Belghiti J. Living liver donor death related to complications of myeloma. *Liver Transpl* 2009; **15**: 326-329 [PMID: 19242991 DOI: 10.1002/lt.21685]

5 **Polido W**, Hoe LK, Siang NK, Chah TK. Acute myocardial infarction after live donor liver surgery. *Liver Transpl* 2007; **13**: 154-156 [PMID: 17192856]

6 **Dutkowski P**, De Rougemont O, Müllhaupt B, Clavien PA. Current and future trends in liver transplantation in Europe. *Gastroenterology* 2010; **138**: 802-9.e1-802-9.e4 [PMID: 20096694 DOI: 10.1053/j.gastro.2010.01.030]

7 **Pomfret EA**, Sung RS, Allan J, Kinkhabwala M, Melancon JK, Roberts JP. Solving the organ shortage crisis: the 7th annual American Society of Transplant Surgeons' State-of-the-Art Winter Symposium. *Am J Transplant* 2008; **8**: 745-752 [PMID: 18261169 DOI: 10.1111/j.1600-6143.2007.02146.x]

8 . Organ Procurement and Transplantation Network. Transplants by donor type. Available at: http: //optn.transplant.hrsa.gov/latestData/ rptData.asp

9 **Nanidis TG**, Antcliffe D, Kokkinos C, Borysiewicz CA, Darzi AW, Tekkis PP, Papalois VE. Laparoscopic versus open live donor nephrectomy in renal transplantation: a meta-analysis. *Ann Surg* 2008; **247**: 58-70 [PMID: 18156924]

10 **Schweitzer EJ**, Wilson J, Jacobs S, Machan CH, Philosophe B, Farney A, Colonna J, Jarrell BE, Bartlett ST. Increased rates of donation with laparoscopic donor nephrectomy. *Ann Surg* 2000; **232**: 392-400 [PMID: 10973389]

11 **Chang S**, Laurent A, Tayar C, Karoui M, Cherqui D. Laparoscopy as a routine approach for left lateral sectionectomy. *Br J Surg* 2007; **94**: 58-63 [PMID: 17054316]

12 **Dokmak S**, Raut V, Aussilhou B, Ftériche FS, Farges O, Sauvanet A, Belghiti J. Laparoscopic left lateral resection is the gold standard for benign liver lesions: a case-control study. *HPB* (Oxford) 2014; **16**: 183-187 [PMID: 23600942 DOI: 10.1111/hpb.12108]

13 **Buell JF**, Cherqui D, Geller DA, O'Rourke N, Iannitti D, Dagher I, Koffron AJ, Thomas M, Gayet B, Han HS, Wakabayashi G, Belli G, Kaneko H, Ker CG, Scatton O, Laurent A, Abdalla EK, Chaudhury P, Dutson E, Gamblin C, D'Angelica M, Nagorney D, Testa G, Labow D, Manas D, Poon RT, Nelson H, Martin R, Clary B, Pinson WC, Martinie J, Vauthey JN, Goldstein R, Roayaie S, Barlet D, Espat J, Abecassis M, Rees M, Fong Y, McMasters KM, Broelsch C, Busuttil R, Belghiti J, Strasberg S, Chari RS; World Consensus Conference on Laparoscopic Surgery. The international position on laparoscopic liver surgery: The Louisville Statement, 2008. *Ann Surg* 2009; **250**: 825-830 [PMID: 19916210]

14 **Vigano L**, Laurent A, Tayar C, Tomatis M, Ponti A, Cherqui D. The learning curve in laparoscopic liver resection: improved feasibility and reproducibility. *Ann Surg* 2009; **250**: 772-782 [PMID: 19801926 DOI: 10.1097/SLA.0b013e3181bd93b2]

15 **Cai X**, Li Z, Zhang Y, Yu H, Liang X, Jin R, Luo F. Laparoscopic liver resection and the learning curve: a 14-year, single-center experience. *Surg Endosc* 2014; **28**: 1334-1341 [PMID: 24399518 DOI: 10.1007/s00464-013-3333-5]

16 **Kluger MD**, Vigano L, Barroso R, Cherqui D. The learning curve in laparoscopic major liver resection. *J Hepatobiliary Pancreat Sci* 2013; **20**: 131-136 [PMID: 23064988 DOI: 10.1007/s00534-012-0571-1]

17 **Troisi RI**. Open or laparoscopic living donor liver hepatectomy: still a challenging operation! *Am J Transplant* 2014; **14**: 736 [PMID: 24447688 DOI: 10.1111/ajt.12611]

18 **Scatton O**, Katsanos G, Boillot O, Goumard C, Bernard D, Stenard F, Perdigao F, Soubrane O. Pure Laparoscopic Left Lateral Sectionectomy in Living Donors: From Innovation to Development in France. *Ann Surg* 2014; Epub ahead of print [PMID: 24646560]

19 **Cheah YL**, Simpson MA, Pomposelli JJ, Pomfret EA. Incidence of death and potentially life-threatening near-miss events in living donor hepatic lobectomy: a world-wide survey. *Liver Transpl* 2013; **19**: 499-506 [PMID: 23172840 DOI: 10.1002/lt.23575]

20 **Ghobrial RM**, Freise CE, Trotter JF, Tong L, Ojo AO, Fair JH, Fisher RA, Emond JC, Koffron AJ, Pruett TL, Olthoff KM. Donor morbidity after living donation for liver transplantation. *Gastroenterology* 2008; **135**: 468-476 [PMID: 18505689 DOI: 10.1053/j.gastro.2008.04.018]

21 **Abecassis MM**, Fisher RA, Olthoff KM, Freise CE, Rodrigo DR, Samstein B, Kam I, Merion RM. Complications of living donor hepatic lobectomy--a comprehensive report. *Am J Transplant* 2012; **12**: 1208-1217 [PMID: 22335782 DOI: 10.1111/j.1600-6143.2011.03972.x]

22 **Belghiti J**, Liddo G, Raut V, Zappa M, Dokmak S, Vilgrain V, Durand F, Dondéro F. "Inherent limitations" in donors: control matched study of consequences following a right hepatectomy for living donation and benign liver lesions. *Ann Surg* 2012; **255**: 528-533 [PMID: 22311131 DOI: 10.1097/SLA.0b013e3182472152]

23 **Dondero F**, Taillé C, Mal H, Sommacale D, Sauvanet A, Farges O, Francoz C, Durand F, Delefosse D, Denninger MH, Vilgrain V, Marrash-Chahla R, Fournier M, Belghiti J. Respiratory complications: a major concern after right hepatectomy in living liver donors. *Transplantation* 2006; **81**: 181-186 [PMID: 16436960]

24 **Fancellu A**, Rosman AS, Sanna V, Nigri GR, Zorcolo L, Pisano M, Melis M. Meta-analysis of trials comparing minimally-invasive and open liver resections for hepatocellular carcinoma. *J Surg Res* 2011; **171**: e33-e45 [PMID: 21920552 DOI: 10.1016/j.jss.2011.07.008]

25 **Tranchart H**, Di Giuro G, Lainas P, Roudie J, Agostini H, Franco D, Dagher I. Laparoscopic resection for hepatocellular carcinoma: a matched-pair comparative study. *Surg Endosc* 2010; **24**: 1170-1176 [PMID: 19915908 DOI: 10.1007/s00464-009-0745-3]

26 **Xiong JJ**, Altaf K, Javed MA, Huang W, Mukherjee R, Mai G, Sutton R, Liu XB, Hu WM. Meta-analysis of laparoscopic vs open liver resection for hepatocellular carcinoma. *World J Gastroenterol* 2012; **18**: 6657-6668 [PMID: 23236242 DOI: 10.3748/wjg.v18.i45.6657]

27 **Costi R**, Scatton O, Haddad L, Randone B, Andraus W, Massault PP, Soubrane O. Lessons learned from the first 100 laparoscopic liver resections: not delaying conversion may allow reduced blood loss and operative time. *J Laparoendosc Adv Surg Tech A* 2012; **22**: 425-431 [PMID: 22670635 DOI: 10.1089/lap.2011.0334]

28 **Borle DP**, Bharathy KG, Kumar S, Pamecha V. Laparoscopic living donor left hepatectomy: donor safety remains the overriding concern. *Am J Transplant* 2014; **14**: 735 [PMID: 24397484 DOI: 10.1111/ajt.12612]

29 **Soubrane O**, Cherqui D, Scatton O, Stenard F, Bernard D, Branchereau S, Martelli H, Gauthier F. Laparoscopic left lateral sectionectomy in living donors: safety and reproducibility of the technique in a single center. *Ann Surg* 2006; **244**: 815-820 [PMID: 17060776]

30 **López-Ben S**, Palacios O, Codina-Barreras A, Albiol MT, Falgueras L, Castro E, Figueras J. Pure laparoscopic liver resection reduces surgical site infections and hospital stay. Results of a case-matched control study in 50 patients. *Langenbecks Arch Surg* 2014; **399**: 307-314 [PMID: 24526221 DOI: 10.1007/s00423-014-1169-7]

31 **Truant S**, Bouras AF, Hebbar M, Boleslawski E, Fromont G, Dharancy S, Leteurtre E, Zerbib P, Pruvot FR. Laparoscopic resection vs. open liver resection for peripheral hepatocellular carcinoma in patients with chronic liver disease: a case-matched study. *Surg Endosc* 2011; **25**: 3668-3677 [PMID: 21688080 DOI: 10.1007/s00464-011-1775-1]

32 **Medbery RL**, Chadid TS, Sweeney JF, Knechtle SJ, Kooby DA, Maithel SK, Lin E, Sarmiento JM. Laparoscopic vs open right hepatectomy: a value-based analysis. *J Am Coll Surg* 2014; **218**: 929-939 [PMID: 24680574 DOI: 10.1016/j.jamcollsurg.2014.01.045]

33 **Raia S**, Nery JR, Mies S. Liver transplantation from live donors. *Lancet* 1989; **2**: 497 [PMID: 2570198]

34 **Strong RW**, Lynch SV, Ong TH, Matsunami H, Koido Y, Balderson GA. Successful liver transplantation from a living donor to her son. *N Engl J Med* 1990; **322**: 1505-1507 [PMID: 2336076]

35 **Bourdeaux C**, Darwish A, Jamart J, Tri TT, Janssen M, Lerut J, Otte JB, Sokal E, de Ville de Goyet J, Reding R. Living-related versus deceased donor pediatric liver transplantation: a multivariate analysis of technical and immunological complications in 235 recipients. *Am J Transplant* 2007; **7**: 440-447 [PMID: 17173657]

36 **Müller SA**, Mehrabi A, Schmied BM, Welsch T, Fonouni H, Engelmann G, Schemmer P, Weitz J, Schmidt J. Partial liver transplantation-living donor liver transplantation and split liver transplantation. *Nephrol Dial Transplant* 2007; **22** Suppl 8: viii13-viii22 [PMID: 17890257]

37 **Cherqui D**, Soubrane O, Husson E, Barshasz E, Vignaux O, Ghimouz M, Branchereau S, Chardot C, Gauthier F, Fagniez PL, Houssin D. Laparoscopic living donor hepatectomy for liver transplantation in children. *Lancet* 2002; **359**: 392-396 [PMID: 11844509]

38 **Kim KH**, Jung DH, Park KM, Lee YJ, Kim DY, Kim KM, Lee SG. Comparison of open and laparoscopic live donor left lateral sectionectomy. *Br J Surg* 2011; **98**: 1302-1308 [PMID: 21717424 DOI: 10.1002/bjs.7601]

39 **Lo CM**, Fan ST, Liu CL, Wei WI, Lo RJ, Lai CL, Chan JK, Ng IO, Fung A, Wong J. Adult-to-adult living donor liver transplantation using extended right lobe grafts. *Ann Surg* 1997; **226**: 261-29; discussion 261-29; [PMID: 9339932]

40 **Humar A**. Donor and recipient outcomes after adult living donor liver transplantation. *Liver Transpl* 2003; **9**: S42-S44 [PMID: 14528427]

41 **Kim SH**, Kim YK. Improving outcomes of living-donor right hepatectomy. *Br J Surg* 2013; **100**: 528-534 [PMID: 23288584 DOI: 10.1002/bjs.9022]

42 **Topal B**, Fieuws S, Aerts R, Vandeweyer H, Penninckx F. Laparoscopic versus open liver resection of hepatic neoplasms: comparative analysis of short-term results. *Surg Endosc* 2008; **22**: 2208-2213 [PMID: 18622562 DOI: 10.1007/s00464-008-0023-9]

43 **Martin RC**, Scoggins CR, McMasters KM. Laparoscopic hepatic lobectomy: advantages of a minimally invasive approach. *J Am Coll Surg* 2010; **210**: 627-34, 634-6 [PMID: 20421019 DOI: 10.1016/j.jamcollsurg.2009.12.022]

44 **Dagher I**, Di Giuro G, Dubrez J, Lainas P, Smadja C, Franco D. Laparoscopic versus open right hepatectomy: a comparative study. *Am J Surg* 2009; **198**: 173-177 [PMID: 19268902 DOI: 10.1016/j.amjsurg.2008.09.015]

45 **Abu Hilal M**, Di Fabio F, Teng MJ, Lykoudis P, Primrose JN, Pearce NW. Single-centre comparative study of laparoscopic versus open right hepatectomy. *J Gastrointest Surg* 2011; **15**: 818-823 [PMID: 21380633 DOI: 10.1007/s11605-011-1468-z]

46 **Lin NC**, Nitta H, Wakabayashi G. Laparoscopic major hepatectomy: a systematic literature review and comparison of 3 techniques. *Ann Surg* 2013; **257**: 205-213 [PMID: 23263192 DOI: 10.1097/SLA.0b013e31827da7fe]

47 **Dagher I**, Caillard C, Proske JM, Carloni A, Lainas P, Franco D. Laparoscopic right hepatectomy: original technique and results. *J Am Coll Surg* 2008; **206**: 756-760 [PMID: 18387485 DOI: 10.1016/j.jamcollsurg.2007.09.012]

48 **Gayet B**, Cavaliere D, Vibert E, Perniceni T, Levard H, Denet C, Christidis C, Blain A, Mal F. Totally laparoscopic right hepatectomy. *Am J Surg* 2007; **194**: 685-689 [PMID: 17936436]

49 **Soubrane O**, Schwarz L, Cauchy F, Perotto LO, Brustia R, Bernard D, Scatton O. A Conceptual Technique for Laparoscopic Right Hepatectomy Based on Facts and Oncologic Principles: The Caudal Approach. *Ann Surg* 2014; Epub ahead of print [PMID: 24854453]

50 **Nitta H**, Sasaki A, Fujita T, Itabashi H, Hoshikawa K, Takahara T, Takahashi M, Nishizuka S, Wakabayashi G. Laparoscopy-assisted major liver resections employing a hanging technique: the original procedure. *Ann Surg* 2010; **251**: 450-453 [PMID: 20083994 DOI: 10.1097/SLA.0b013e3181cf87da]

51 **Soubrane O**, Perdigao Cotta F, Scatton O. Pure laparoscopic right hepatectomy in a living donor. *Am J Transplant* 2013; **13**: 2467-2471 [PMID: 23865716 DOI: 10.1111/ajt.12361]

52 **Koffron AJ**, Kung R, Baker T, Fryer J, Clark L, Abecassis M. Laparoscopic-assisted right lobe donor hepatectomy. *Am J Transplant* 2006; **6**: 2522-2525 [PMID: 16889605]

53 **Kurosaki I**, Yamamoto S, Kitami C, Yokoyama N, Nakatsuka H, Kobayashi T, Watanabe T, Oya H, Sato Y, Hatakeyama K. Video-assisted living donor hemihepatectomy through a 12-cm incision for adult-to-adult liver transplantation. *Surgery* 2006; **139**: 695-703 [PMID: 16701104]

54 **Baker TB**, Jay CL, Ladner DP, Preczewski LB, Clark L, Holl J, Abecassis MM. Laparoscopy-assisted and open living donor right hepatectomy: a comparative study of outcomes. *Surgery* 2009; **146**: 817-23; discussion 823-5 [PMID: 19789043 DOI: 10.1016/j.surg.2009.05.022]

55 **Nagai S**, Brown L, Yoshida A, Kim D, Kazimi M, Abouljoud MS. Mini-incision right hepatic lobectomy with or without laparoscopic assistance for living donor hepatectomy. *Liver Transpl* 2012; **18**: 1188-1197 [PMID: 22685084 DOI: 10.1002/lt.23488]

56 **Soyama A**, Takatsuki M, Hidaka M, Muraoka I, Tanaka T, Yamaguchi I, Kinoshita A, Hara T, Eguchi S. Standardized less invasive living donor hemihepatectomy using the hybrid method through a short upper midline incision. *Transplant Proc* 2012; **44**: 353-355 [PMID: 22410014 DOI: 10.1016/j.transproceed.2012.01.050]

57 **Zhang X**, Yang J, Yan L, Li B, Wen T, Xu M, Wang W, Zhao J, Wei Y. Comparison of laparoscopy-assisted and open donor right hepatectomy: a prospective case-matched study from china. *J Gastrointest Surg* 2014; **18**: 744-750 [PMID: 24307217 DOI: 10.1007/s11605-013-2425-9]

58 **Suh KS**, Yi NJ, Kim T, Kim J, Shin WY, Lee HW, Han HS, Lee KU. Laparoscopy-assisted donor right hepatectomy using a hand port system preserving the middle hepatic vein branches. *World J Surg* 2009; **33**: 526-533 [PMID: 19115031 DOI: 10.1007/s00268-008-9842-z]

59 **Choi HJ**, You YK, Na GH, Hong TH, Shetty GS, Kim DG. Single-port laparoscopy-assisted donor right hepatectomy in living donor liver transplantation: sensible approach or unnecessary hindrance? *Transplant Proc* 2012; **44**: 347-352 [PMID: 22410013 DOI: 10.1016/j.transproceed.2012.01.018]

60 **Hwang S**, Ahn CS, Kim KH, Moon DB, Ha TY, Song GW, Jung DH, Park GC, Namgoong JM, Yoon SY, Jung SW, Lee SG. Standardization of modified right lobe grafts to minimize vascular outflow complications for adult living donor liver transplantation. *Transplant Proc* 2012; **44**: 457-459 [PMID: 22410043 DOI: 10.1016/j.transproceed.2012.01.072]

61 **Giulianotti PC**, Tzvetanov I, Jeon H, Bianco F, Spaggiari M, Oberholzer J, Benedetti E. Robot-assisted right lobe donor hepatectomy. *Transpl Int* 2012; **25**: e5-e9 [PMID: 22029717 DOI: 10.1111/j.1432-2277.2011.01373.x]

62 **Rotellar F**, Pardo F, Benito A, Martí-Cruchaga P, Zozaya G, Lopez L, Hidalgo F, Sangro B, Herrero I. Totally laparoscopic right-lobe hepatectomy for adult living donor liver transplantation: useful strategies to enhance safety. *Am J Transplant* 2013; **13**: 3269-3273 [PMID: 24266975 DOI: 10.1111/ajt.12471]

63 **Taketomi A**, Kayashima H, Soejima Y, Yoshizumi T, Uchiyama H, Ikegami T, Yamashita Y, Harada N, Shimada M, Maehara Y. Donor risk in adult-to-adult living donor liver transplantation: impact of left lobe graft. *Transplantation* 2009; **87**: 445-450 [PMID: 19202452 DOI: 10.1097/TP.0b013e3181943d46]

64 **Iida T**, Ogura Y, Oike F, Hatano E, Kaido T, Egawa H, Takada Y, Uemoto S. Surgery-related morbidity in living donors for liver transplantation. *Transplantation* 2010; **89**: 1276-1282 [PMID: 20216482 DOI: 10.1097/TP.0b013e3181d66c55]

65 **Roll GR**, Parekh JR, Parker WF, Siegler M, Pomfret EA, Ascher NL, Roberts JP. Left hepatectomy versus right hepatectomy for living donor liver transplantation: shifting the risk from the donor to the recipient. *Liver Transpl* 2013; **19**: 472-481 [PMID: 23447523 DOI: 10.1002/lt.23608]

66 **Kokudo N**, Sugawara Y, Imamura H, Sano K, Makuuchi M. Tailoring the type of donor hepatectomy for adult living donor liver transplantation. *Am J Transplant* 2005; **5**: 1694-1703 [PMID: 15943628]

67 **Concejero A**, Chen CL, Wang CC, Wang SH, Lin CC, Liu YW, Yang CH, Yong CC, Lin TS, Ibrahim S, Jawan B, Cheng YF, Huang TL. Donor graft outflow venoplasty in living donor liver transplantation. *Liver Transpl* 2006; **12**: 264-268 [PMID: 16447205]

68 **Hashimoto T**, Sugawara Y, Tamura S, Kaneko J, Motomura N, Takamoto S, Makuuchi M. One orifice vein reconstruction in left liver plus caudate lobe grafts. *Transplantation* 2007; **83**: 225-227 [PMID: 17264820]

69 **Umeda Y**, Yagi T, Sadamori H, Matsukawa H, Matsuda H, Shinoura S, Mizuno K, Yoshida R, Iwamoto T, Satoh D, Tanaka N. Effects of prophylactic splenic artery modulation on portal overperfusion and liver regeneration in small-for-size graft. *Transplantation* 2008; **86**: 673-680 [PMID: 18791439 DOI: 10.1097/TP.0b013e318181e02d]

70 **Botha JF**, Langnas AN, Campos BD, Grant WJ, Freise CE, Ascher NL, Mercer DF, Roberts JP. Left lobe adult-to-adult living donor liver transplantation: small grafts and hemiportocaval shunts in the prevention of small-for-size syndrome. *Liver Transpl* 2010; **16**: 649-657 [PMID: 20440774 DOI: 10.1002/lt.22043]

71 **Ogura Y**, Hori T, El Moghazy WM, Yoshizawa A, Oike F, Mori A, Kaido T, Takada Y, Uemoto S. Portal pressure & lt; 15 mm Hg is a key for successful adult living donor liver transplantation utilizing smaller grafts than before. *Liver Transpl* 2010; **16**: 718-728 [PMID: 20517905 DOI: 10.1002/lt.22059]

72 **Soejima Y**, Shirabe K, Taketomi A, Yoshizumi T, Uchiyama H, Ikegami T, Ninomiya M, Harada N, Ijichi H, Maehara Y. Left lobe living donor liver transplantation in adults. *Am J Transplant* 2012; **12**: 1877-1885 [PMID: 22429497 DOI: 10.1111/j.1600-6143.2012.04022.x]

73 **Boillot O**, Sagnard P, Guillaud O, Ber CE, Pouyet M, Dumortier J. Adult left liver transplantation from split livers and living donors: a 14-year single-center experience. *Clin Transplant* 2013; **27**: 571-581 [PMID: 23786409 DOI: 10.1111/ctr.12162]

74 **Cai XJ**, Wang YF, Liang YL, Yu H, Liang X. Laparoscopic left hemihepatectomy: a safety and feasibility study of 19 cases. *Surg Endosc* 2009; **23**: 2556-2562 [PMID: 19347401]

75 **Belli G**, Gayet B, Han HS, Wakabayashi G, Kim KH, Cannon R, Kaneko H, Gamblin T, Koffron A, Dagher I, Buell JF. Laparoscopic left hemihepatectomy a consideration for acceptance as standard of care. *Surg Endosc* 2013; **27**: 2721-2726 [PMID: 23436090 DOI: 10.1007/s00464-013-2840-8]

76 **Marubashi S**, Wada H, Kawamoto K, Kobayashi S, Eguchi H, Doki Y, Mori M, Nagano H. Laparoscopy-assisted hybrid left-side donor hepatectomy. *World J Surg* 2013; **37**: 2202-2210 [PMID: 23736986 DOI: 10.1007/s00268-013-2117-3]

77 **Samstein B**, Cherqui D, Rotellar F, Griesemer A, Halazun KJ, Kato T, Guarrera J, Emond JC. Totally laparoscopic full left hepatectomy for living donor liver transplantation in adolescents and adults. *Am J Transplant* 2013; **13**: 2462-2466 [PMID: 24034709 DOI: 10.1111/ajt.12360]

78 **Troisi RI**, Wojcicki M, Tomassini F, Houtmeyers P, Vanlander A, Berrevoet F, Smeets P, Van Vlierberghe H, Rogiers X. Pure laparoscopic full-left living donor hepatectomy for calculated small-for-size LDLT in adults: proof of concept. *Am J Transplant* 2013; **13**: 2472-2478 [PMID: 23914734 DOI: 10.1111/ajt.12362]

79 **Moon DB**, Lee SG, Hwang S, Kim KH, Ahn CS, Ha TY, Song GW, Jung DH, Park GC, Namkoong JM, Park HW, Park YH, Park CS. Toward more than 400 liver transplantations a year at a single center. *Transplant Proc* 2013; **45**: 1937-1941 [PMID: 23769078 DOI: 10.1016/j.transproceed.2012.12.015]

80 **Lee SG**, Hwang S, Kim KH, Ahn CS, Moon DB, Ha TY, Song KW, Chung DH. Toward 300 liver transplants a year. *Surg Today* 2009; **39**: 367-373 [PMID: 19408072 DOI: 10.1007/s00595-008-3917-1]

81 **Soin AS**, Mohanka R, Singla P, Piplani T, Menon B, Kakodkar R, Rastogi A, Goja S, Kumaran V, Nundy S. Segment IV preserving middle hepatic vein retrieval in right lobe living donor liver transplantation. *J Am Coll Surg* 2011; **213**: e5-16 [PMID: 21641832 DOI: 10.1016/j.jamcollsurg.2011.04.027]

**P-Reviewer:** Kang KJ, Yokoyama N **S-Editor:** Ma YJ **L-Editor:** **E-Editor:**

**Table 1** **Summary of the studies reporting the results of full laparoscopic left lateral sectionectomy for adult-child living donor liver transplantation**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Ref.** | **Study**  **type** | ***n*** | **Major**  **complication** | **Blood loss**  **(ml)** | **Transfusion** | **Hospital stay**  **(d)** | **Warm ischemia time (mn)** | **Recipient**  **HAT** | **Retransplantation** |
| Soubrane *et al***[29]**, 2006 | Case control | 30 | 6% | 19+/-44 | 0% | 7.5 +/- 2.3 | 10 (6-12) | 12.5% | 6% |
| Kim *et al***[38]**,  2011 | Case control | 22 | 0% | 396+/-72 | NR | 6.9 +/- 0.3 | 6 +/- 2 | 0% | 0% |
| Scatton *et al***[18]**, 2014 | Case series | 70 | 1.4% | 82+/-79 | 0%1 | 6 (3-18) | 9 +/- 4.1 | 8% | 9% |

1for allogenic transfusion, 6 (8.6%) donors underwent autogenic transfusion. HAT: hepatic artery thrombosis.

**Table 2 Summary of the studies reporting the results of laparoscopic assisted, hand assisted, robot assisted or full laparoscopic right hepatectomy for living donor liver transplantation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Ref.** | **Study**  **type** | ***n*** | **Major**  **complication** | **Blood loss**  **(ml)** | **Transfusion** | **Hospital stay**  **(d)** |
| **Laparoscopic right hepatectomy using midline incision “Hybrid Method”** | Koffron *et al*[52], 2006 | Case series | 4 | 0% | 150 | 0% | 3 +/-1 |
| Kurosaki *et al*[53], 2006 | Case series | 3 | 0%1 | 300+/-1901 | 0%1 | 11 +/-31 |
| Baker *et al*[54],  2009 | Case control | 33 | 0% | 420+/-220 | 0% | 4.3 |
|  | Nagai *et al*[55],  2012 | Case series | 4 | - | 350+/-174 | - | 6.3+/-1.3 |
|  | Soyama *et al*[56], 2012 | Case series | 6 | 6%1 | 520+/-2901 | 0%1 | NR |
|  | Zhang *et al*[57],  2014 | Case control | 25 | 0% | 380+/-110 | 0% | 7+/-1.4 |
| **Laparoscopic hand-assisted right hepatectomy using a transverse or subcostal incision** | Suh *et al*[58],  2009 | Case series | 7 | 14% | - | - | 10+/-7 |
|  | Choi *et al*[59],  2012 | Case control | 20 | - | 870+/-653 | - | 12.1+/-2.8 |
|  | Hwang *et al*[60], 2012 | Case control | 20 | 0% | 290+/-67 | 0% | 10.7+/-2.6 |
| **Single port laparoscopic hand-assisted right hepatectomy using a transverse or subcostal incision** | Choi *et al*[59],  2012 | Case control | 40 | - | 450+/-316 | - | 11.8+/-4.4 |
| **Hand assisted laparoscopic right-Lobe Hepatectomy** | Suh *et al*[58],  2009 | Case series | 2 | 0% | - | - | 12+/-2 |
| **Robot-assisted right lobe donor hepatectomy** | Giulianotti *et al*[61], 2012 | Case report | 1 | 0% | 350 | 0 | 5 |
| **Totally Laparoscopic right-Lobe Hepatectomy** | Soubrane *et al*[51], 2013 | Case report | 1 | 0% | 100 | 0 | 7 |
|  | Rotellar *et al*[62], 2013 | Case report | 1 | 0% | 100 | 0 | 4 |

1specific results of right hepatectomy were not detailed, and separated from left hepatectomy.

**Table 3 Summary of the studies reporting the results of laparoscopic assisted or full laparoscopic left hepatectomy for living donor liver transplantation**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Ref.** | **Study**  **type** | ***n*** | **Major complication** | **Blood loss**  **(ml)** | **Transfusion** | **Hospital stay**  **(d)** |
| **Laparoscopic assisted left hemli-hepatectomy using midline incision “Hybrid Method”** | Kurosaki *et al*[53], 2006 | Case series | 10 | 0%1 | 300+/-1901 | 0%1 | 11+/-31 |
| Soyama *et al*[56], 2012 | Case series | 9 | 6%1 | 520+/-2901 | 0%1 | - |
|  | Murabashi *et al*[76], 2013 | Case control | 14 | 6.5%2 | 353+/-3962 | 0% | 11.5+/-3.6 |
| **Totally laparoscopic left hemi-hepatectomy** | Samstein *et al*[77], 2013 | Case series | 2 | 0% | 125 | 0% | 4+/-1 |
| Troisi *et al*[78],  2013 | Case series | 4 | 25%3 | 50-80 | 0% | 5+/-1 |

1specific results of left hepatcetomy were not detailed, and separated from right hepatectomy; 2specific results of left hep were not detailed, and separated from left lateral sectionectomy; 3one out of four patient required roux-y hepaticojejunostomy for right posterior duct stenosis.