Int J Clin Exp Med 2016;9(8):15004-15016
www.ijcem.com /ISSN:1940-5901/IJCEM0021495

Review Article

Laparoscopic versus open live donor hepatectomy in liver transplantation: a systemic review and meta-analysis

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Received December 9, 2015; Accepted March 19, 2016; Epub August 15, 2016; Published August 30, 2016

Abstract: Objective: The aim of this study was to compare laparoscopic versus open live donor liver transplantation using meta-analysis. Background: Living donor liver transplantation (LDLT), as an alternative to deceased donor liver transplantation (DDLT), has increasingly performed all around the world. Laparoscopic live donor hepatectomy (LLDH) has been performed increasingly, and is gaining worldwide acceptance. As the studies assessing the safety and efficacy of laparoscopic compared with open techniques is growing, we combined the available data to conduct this meta-analysis to compare the two techniques. Methods: A literature search was performed to identify studies comparing laparoscopic with open live donor hepatectomy (OLDH) published before June 2015. Perioperative outcomes (blood loss, operative time, hospital stay, analgesia use) and postoperative complications (donors and recipients postoperative complications, recipients specific postoperative complications including biliary complications and vascular complications) were the main outcomes evaluated in the meta-analysis. Results: Fourteen studies with a total of 1136 patients were included in this meta-analysis, of which 357 were treated by laparoscopic technique and 779 were treated by the open procedures. Compared with the open group, laparoscopic group was associated with significant less estimated blood loss (P=0.01), shorter duration of operation (P=0.02), length of hospital stay (P=0.003) and duration of PCA use (P=0.04). The laboratory tests such as peak ALT and AST after operation were similar (P=0.72 and P=1.00). There was a significant higher rate of overall donor morbidity (P=0.002) and donor minor complications (Grade I-II) (P=0.02) in the open group. No significant difference was observed in donor major complications (Grade III-V), recipients overal morbidity and recipients complications such as bile complications and vascular complications. Conclusions: LLDH is a excellent alternative to OLDH because it is associated with better perioperative outcomes and similar prognosis.

Keyword: Laparoscopic, live donor hepatectomy, living donor liver transplantation

Introduction

Liver transplantation (LT) has been widely accepted as the standard treatment for patients with end-stage liver disease and unresectable hepatocellular carcinoma (HCC). As the shortage of the grafts for LT has been severer over years, LDLT, as an alternative to DDLT, has increasingly performed all around the world. The several advantages like reduction of pre-transplantation waiting time and a similar overall graft and recipient survival rate compared with DDLT promote the development of this aproach [1-3]. Despite these benefits for the recipients, LDLT donors achieve no medical benefits and are exposed to the risk of complications such as biliary complications and damage of the liver function which may affect the donor postdonation quality of life [4-6].

Nowadays, laparoscopic liver resections are considered to be a safe alternative to the open technique, laparoscopic left lateral sectionectomy (LLS) is now even considered the gold standard for malignant or benign lesions [7, 8]. Since the first report of full laparoscopic LLS for adult-child LDLT in 2002 [9], LLDH has been performed increasingly, and is gaining worldwide acceptance.

Though several meta-analysis and rondomized controlled trials have established that laparos-

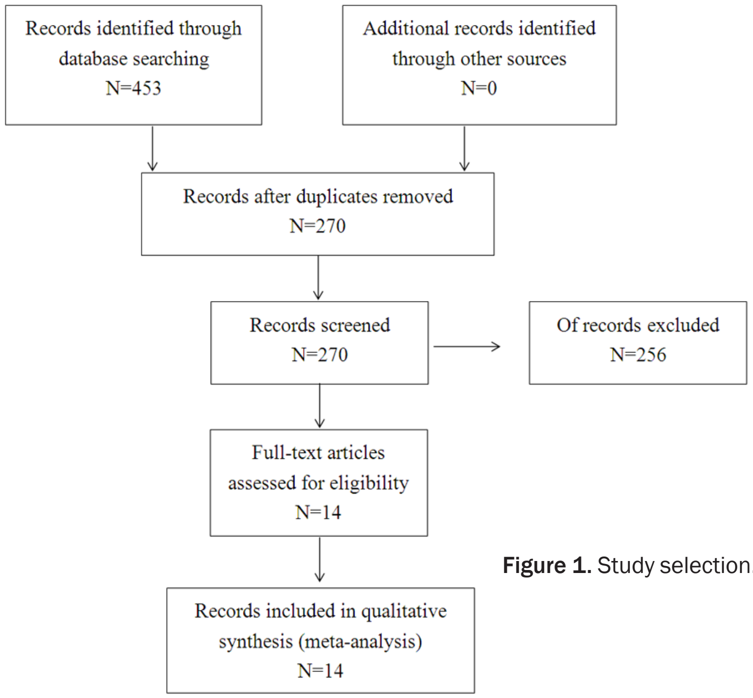

Figure 1. Study selection.

copic live donor nephrectomy was associated with decreased morbidity rates and shorter hospital stay, lower costs, better quality of life and faster return to work [10, 11], there are few reports in LLDH. As the studies assessing the safety and efficacy of laparoscopic compared with open techniques is growing, we therefore combined the available data and sought to compare the perioperative outcomes (blood loss, operative time, hospital stay, analgesia use) and postoperative complications between LLDH versus OLDH by conducting this meta-analysis.

Materials and methods

Literature search and study selection

The publications search was conducted by two authors (DW.X, P.W, Q.X) on the major medical database such as Medline, Embase and Cochrane library for relavant articles published before June 2015. The search headings were composed of the following terms: Laparoscopic, hybrid, hand-assisted, liver resection, living donor liver transplantation, LDLT. Relevant papers were also identified from the reference lists of previous papers. No language or publication type restrictions were used during the search.

Inclusion and exclusion criteria

The inclusion criteria of this meta-analysis were: 1) Clinical studies comparing laparoscopic and open living donor hepatectomy. Laparoscopic, single-port, hand-assisted or hybrid were considered as laporoscopic procedures; 2) Studies with at least one of the outcomes of interest mentioned. Exclusion criteria were: 1) reviews, case reports, editorials and letters; 2) Studies without enough data of interest; 3) Studies with outcomes of either only laparoscopic or only open living donor hepatectomy. What's more, if studies were reported by the same institute, only one with available data and a better quality was used in each synthetic analysis for a single outcome.

Outcomes of interest

Perioperative outcomes and postoperative complications were evaluated in the meta-analysis. The blood loss, operative time, hospital stay, analgesia use were the main perioperative outcomes to be assessed. The data about donors and recipients postoperative complications were also extracted in which donors postoperative complications were identified by the Clavien-Dindo classification [12]. Morever, recipients specific postoperative complications including biliary complications and vascular complications were compared between the two procedures.

Data extraction and quality assessment

Three authors (DW. X, P. W, Q. X) independently carried out the data extraction data from each study using standardized forms to ensure the accuracy of the data. The following information were extracted: study characters (first author, year of publication, source journal, study design, study period), population characters (sample, size, age, gender) and outcome parameters (blood loss, operative time, hospital stay, the duration postoperative continuous

Table 1. Characteristics of the included studies

Reference	Country	Year	Study design	Arm	Sample size	M/F	Donor age [years]	Hepatectomy type
Kurosaki [17]	Japan	2006	Comparative	LLDH	13	8/5	39±12	Hybrid
				OLDH	13	9/4	31±10	
Soubrane [18]	France	2006	Comparative	LLDH	16	10/6	29±5	Pure
				OLDH	14	9/5	32±5	Laparoscopic
Baker [19]	USA	2009	Comparative	LLDH	33	15/18	37±10.3	Hybrid
				OLDH	33	13/20	39.1±11.1	
Kim [20]	Korea	2011	Comparative	LLDH	11	1/10	29.6±5.7	Pure
				OLDH	11	6/5	35.2±3.8	Laparoscopic
Thenappan [21]	USA	2011	Case-control	LLDH	15	7/8	33.9±8.9	Hybrid
				OLDH	15	6/9	35.7±8	
Choi [22]	Korea	2012	Comparative	LLDH	60	35/25	31.2±10.3	Hybrid
				OLDH	90	58/32	36.8±12	
Nagai [23]	USA	2012	Comparative	LLDH	4	3/1	43.2±3.7	Hybrid
				OLDH	30	9/21	38.6±9.4	
Ha [24]	Korea	2013	Case-control	LLDH	20	11/9	25±5.5	Hybrid
				OLDH	20	17/3	29±11.1	
Marubashi [25]	Japan	2013	Comparative	LLDH	31	13/18	35.8±8.4	Hybrid
				OLDH	79	54/25	37.8±10.1	
Makki [26]	India	2014	Comparative	LLDH	26	13/13	27.4±9.4	Hybrid
				OLDH	24	18/6	32.4±8.4	
Zhang [27]	China	2014	Case-control	LLDH	25	13/12	27.4±9.4	Hybrid
				OLDH	25	18/6	32.4±8.4	
Samstein [28]	USA	2015	Comparative	LLDH	22	12/10	37.2±8.6	Pure
				OLDH	20	8/12	31.1±8.6	Laparoscopic
Soyama [29]	Japan	2015	Comparative	LLDH	67	33/34	NR	Hybrid
				OLDH	137	57/80	NR	
Suh [30]	Korea	2015	Comparative	LLDH	14	1/13	24.9±8.7	Hybrid
				OLDH	268	206/62	34.0±9.7	

intravenous analgesic use, donors and recipients mobidity and mortality, biliary complications, vascular complications). The quality of the studies was assessed by using the Newcastle-Ottawa quality assessment scale [13], which was also performed by the three observers.

Publication bias assessment

Funnel plots were used to assess the risk of publication bias across series for all outcome measures in which no points fell outside the 95% CI limits for all outcomes (not shown).

Statistical analysis

Meta-analysis was accomplished by RevMan software version 5.0.0 in accordince with the PRISMA guidelines [14]. Odds ratio (OR) with 95% CI was applied to dichotomous variables, while weighted mean difference (WMD) with 95% confidence interval (CI) was applied to continuous variables. Mean and standard deviation (SD) which were used for continiuous variables were required in the statistical analysis. Formulas proposed by Hozo et al [15] were applied to calculating the mean and the SD in the study which only reported the size of the trial. *P* values <0.05 were considered to indicate statistical significance in the meta-analysis. The Q statistic (P<0.10 was considered as statistically significant heterogeneity) and the I^2 statistic (I^2>50% was considered to represent significant heterogeneity) was used in assessing heterogeneity among studies was assessed [16]. If there were no significant

Table 2. Newcastle-ottawa scoring system for cohorts studies

Reference	Selection star	Comparability star	Outcome star	Total star
Kurosaki [17]	3	2	3	8
Soubrane [18]	3	2	3	8
Baker [19]	4	2	3	9
Kim [20]	3	2	3	8
Thenappan [21]	3	2	3	8
Choi [22]	3	2	3	8
Nagai [23]	3	1	3	7
Ha [24]	3	2	3	8
Marubashi [25]	3	1	3	7
Makki [26]	3	2	3	8
Zhang [27]	3	2	3	8
Samstein [28]	3	2	3	8
Soyama [29]	3	1	3	7
Suh [30]	3	2	3	8

heterogeneity, a fixed-effect model was used. Otherwise, a random-effect modle was used and a subgroup analysis was performed to explore the difference in results of different studies. Funnel plots was used in assessing potential publication bias. A sensitivity analysis was also conducted in which each trial was excluded in turn to evaluate the influnce of a single trial on the pooled estimate.

Results

Study characteristics

As shown in **Figure 1**, the systemic literature search identified 453 articles in which 183 duplications were removed, then the remaining 270 relevant references were screened. We excluded 256 ineligible or non-relevant articles according to the exclusion criteria. Finally, 14 published articles (3 case-controled and 11 comparative studies) were included in the meta-analysis [17-30]. Characters of the 14 included studies were presented in **Table 1**. A total of 1136 patients were included in this meta-analysis, of which 357 were treated by laparoscopic technique (including procedures using either pure laparoscopic, the single port or the hand-assisted approach for the mobilization of the liver, then followed by open procedure of the operation) and 779 were treated by the open procedures. Quality assessment of the included studies was shown in **Table 2**.

Perioperative outcomes

Estimated blood loss: Thirteen included studies reported blood loss in both groups. Significant heterogeneity among the 13 studies was found (P=0.0009, I^2=64%). The overall data showed that total blood loss was significant lower in the laparoscopic group than the open group (MD=-58.49, 95% CI=-104.17--12.81, P=0.01) (**Figure 2**).

Duration of operation: The duration of operation was reported in thirteen articles, and most of them showed that it was longer for laparoscopic group than for open group. The heterogeneity test indicated that there was significant heterogeneity in the results of the thirteen studies (P<0.00001, I^2=79%), the overal trend showed a significant reduction in duration of operation in the open group compared with the laparoscopic group was observed (MD=28.41, 95% CI=4.64-52.18, P=0.02) (**Figure 3**).

Length of hospital stay: Eleven included studies reported length of hospital stay. The random-effect model was used to combine the data due to evident heterogeneity among studies (P<0.00001, I^2=78%). In the data, length of hospital stay in the open group was longer than that in the laparoscopic group (MD=-1.38, 95% CI=-2.28--0.47, P=0.003) (**Figure 4**).

Duration of PCA use: The duration of PCA use was recorded in five articles, all of them suggested that it was significantly longer in the open group than in laparoscopic group. Significant heterogeneity among the five studies was found in duration of PCA use (P=0.02, I^2=64%). Pooled results revealed that duration of PCA use in the open group was longer than that in the laparoscopic group (MD=-0.54, 95% CI=-1.04--0.03, P=0.04) (**Figure 5**).

Peak ALT and AST: Results of the laboratory tests such as peak ALT and AST after operation were reported in eight articles. There was no significant heterogeneity observed in both peak ALT (P=0.12, I^2=39%) and AST (P=0.08, I^2=46%) among the studies. Pooled results in the fixed-

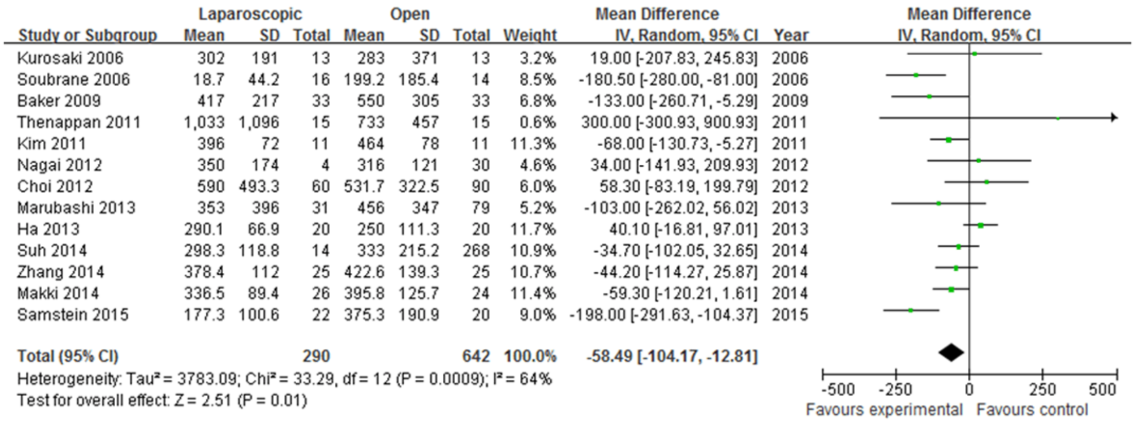

Figure 2. Meta-analysis of controlled trials comparing the blood loss between laparoscopic group and the open group.

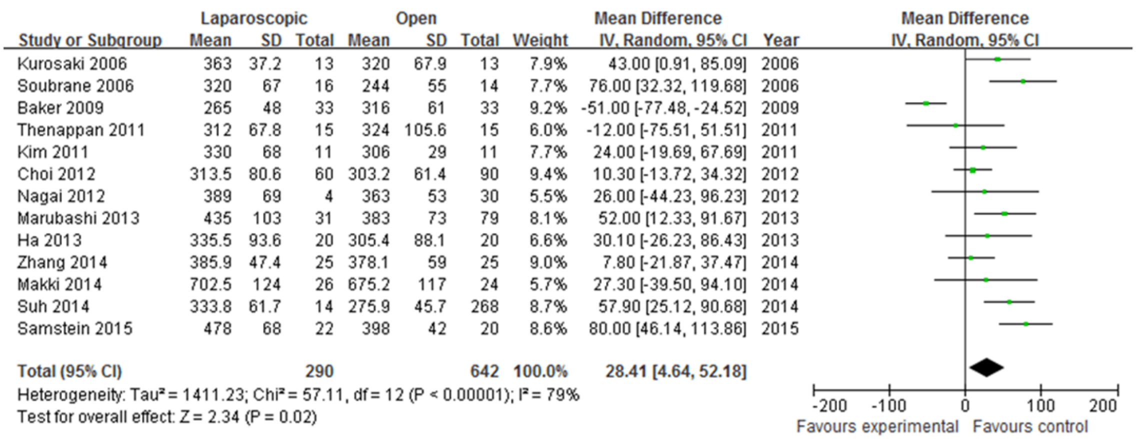

Figure 3. Meta-analysis of controlled trials comparing the operation time between laparoscopic group and the open group.

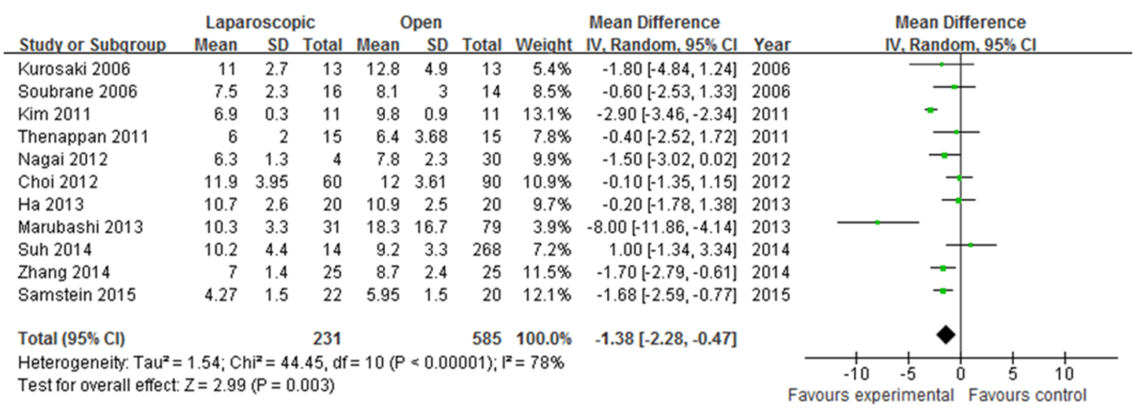

Figure 4. Meta-analysis of controlled trials comparing the length of hospital stay between laparoscopic group and the open group.

effect model were found to be equivalent between laparoscopic group and open group for peak ALT (MD=5.60, 95% CI=-25.42-36.62, P=0.72) (**Figure 6**) and AST (MD=-0.03, 95%

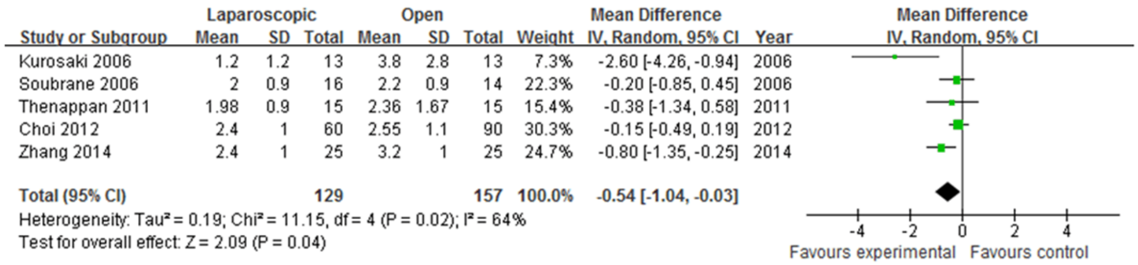

Figure 5. Meta-analysis of controlled trials comparing the analgesia use between laparoscopic group and the open group.

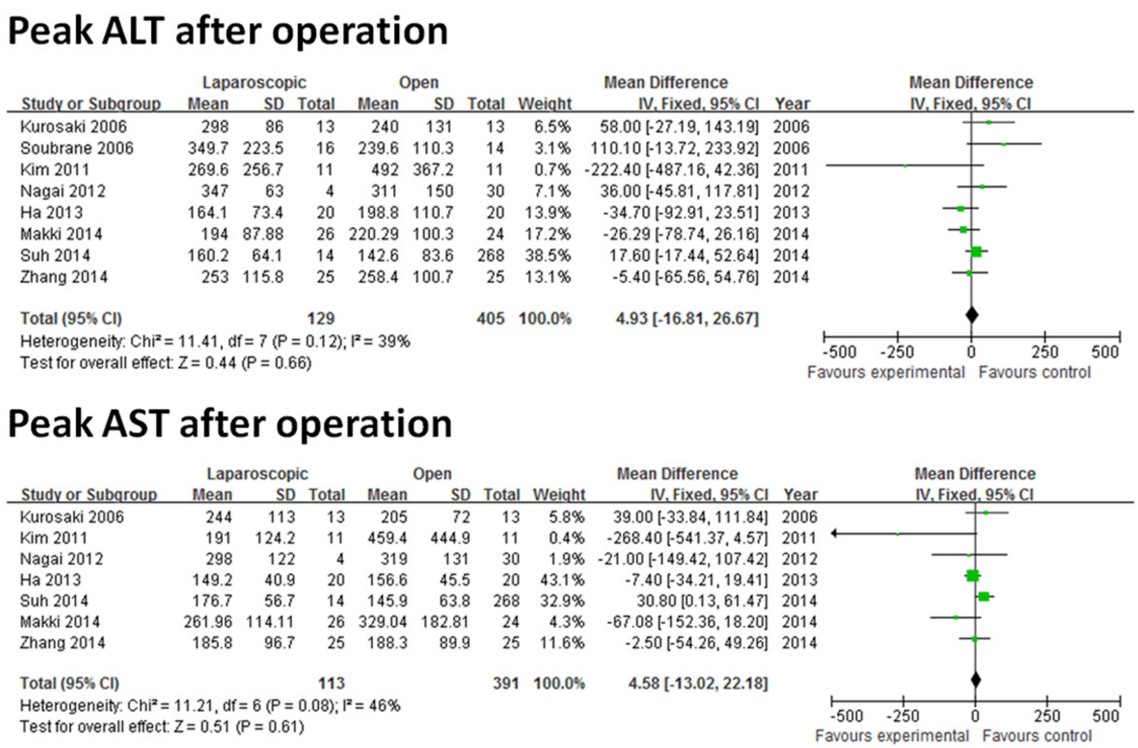

Figure 6. Meta-analysis of controlled trials comparing the peak ALT and AST between laparoscopic group and the open group.

CI=-29.79-29.73, P=1.00) (**Figure 6**) after the operation.

Donor mortality and morbidity

No perioperative mortality in the donor was reported in the studies included in this meta-analysis. The overall donor morbidity was reported in thirteen of the included studies. The heterogeneity test showed no significant heterogeneity observed in perioperative morbidities of the thirteen studies (P=0.95, I^2=0%), and a fixed-effect model showed that donor morbidity in the laparoscopic group was lower than the open group (OR=0.55, 95% CI=0.37-0.80, P=0.002) (**Figure 7**).

Furthermore, donor morbidity according to Clavien-Dinido classification was also reported in eleven of the included studies. Results of the eleven studies showed no heterogeneity (P=0.98, I^2=0%), and pooled results in the fixed-effect model revealed that a significant reduction of minor complications (Grade I-II) was observed in the laparoscopic group (OR= 0.55, 95% CI=0.33-0.91, P=0.02) (**Figure 8**). However, there was no statistically significant difference between the two groups for

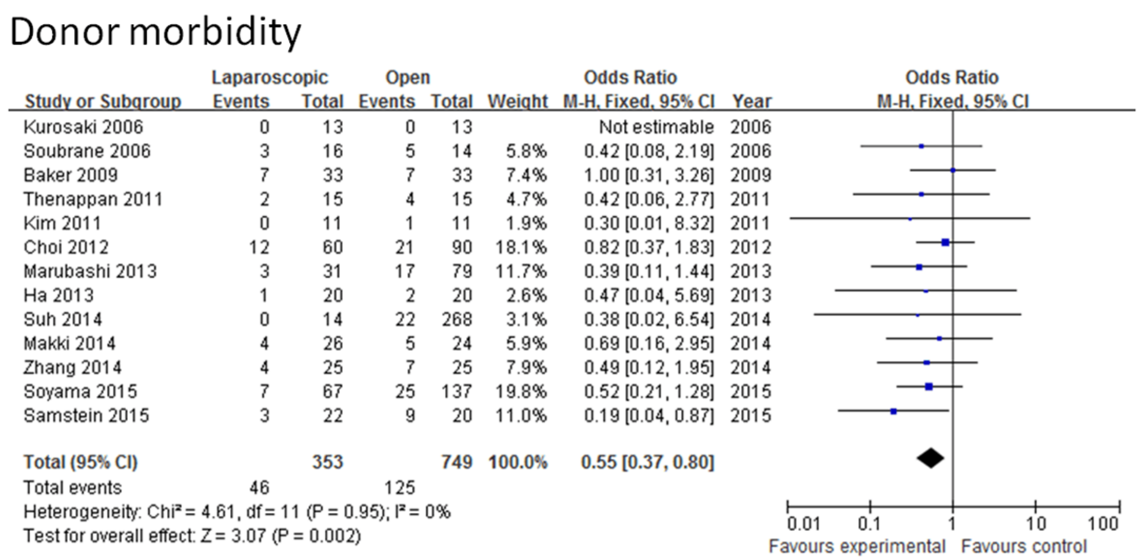

Figure 7. Meta-analysis of controlled trials comparing donor mortality and morbidity between laparoscopic group and the open group.

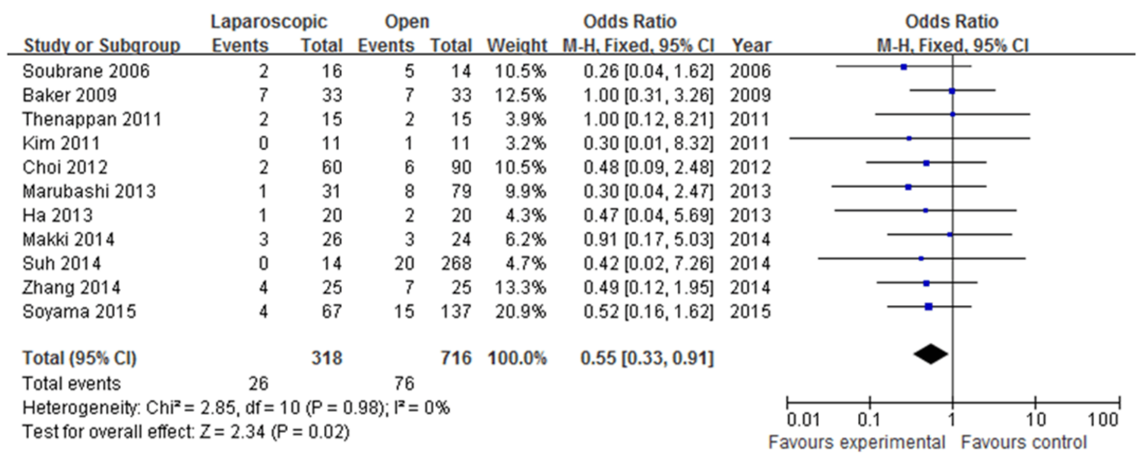

Figure 8. Meta-analysis of controlled trials comparing donor minor complications between laparoscopic group and the open group.

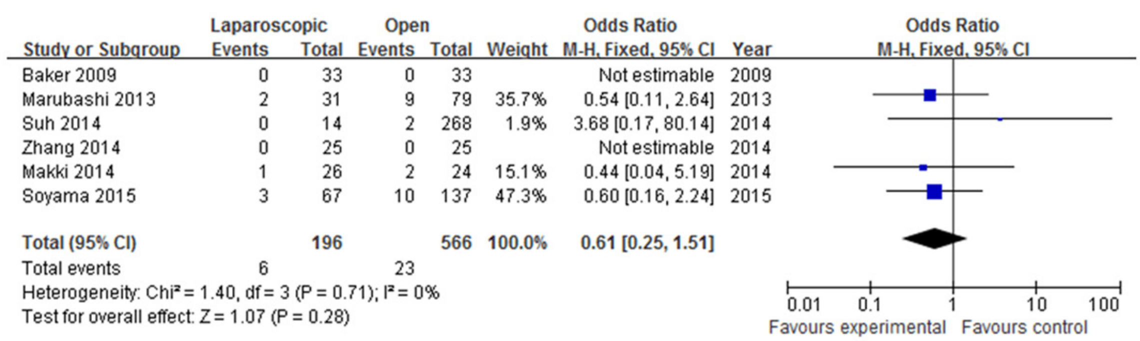

Figure 9. Meta-analysis of controlled trials comparing donor major complications between laparoscopic group and the open group.

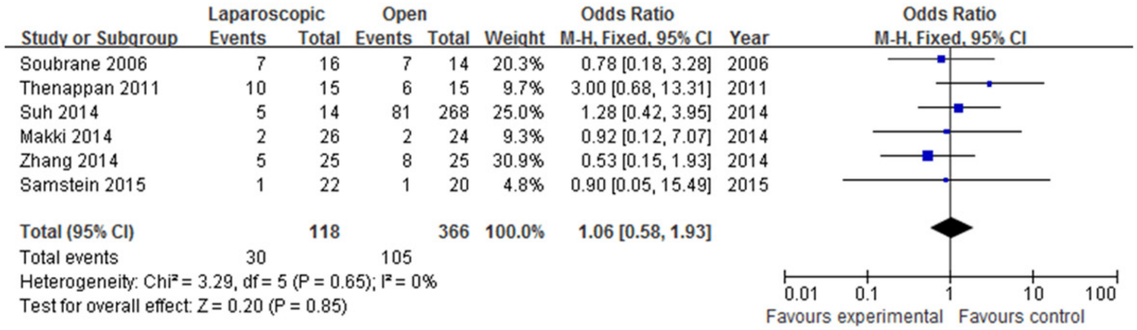

Figure 10. Meta-analysis of controlled trials comparing recipients complications between laparoscopic group and the open group.

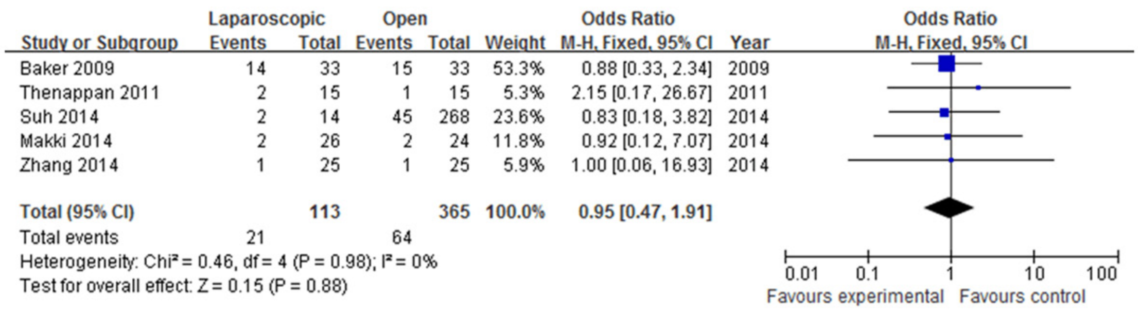

Figure 11. Meta-analysis of controlled trials comparing recipients bile complications between laparoscopic group and the open group.

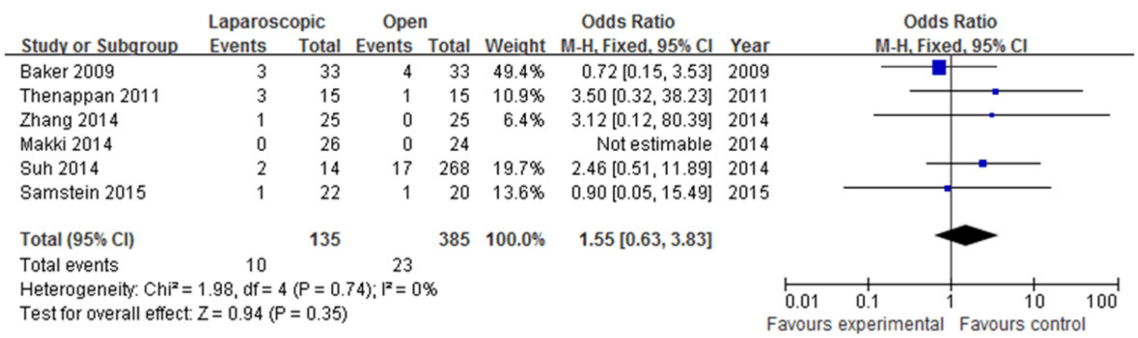

Figure 12. Meta-analysis of controlled trials comparing recipients vascular complications between laparoscopic group and the open group.

major complications (Grade III-V) (OR=0.61, 95% CI=0.25-1.51, P=0.28) (**Figure 9**).

Recipient outcomes

Six studies had data of recipients outcomes after living donor liver transplantation, and all of them showed there was no significant difference between laparoscopic group and the open group recipients. The heterogeneity test showed no significant heterogeneity observed in recipients morbidities of the six studies (P=0.65, I^2=0%). Pooled results in the fixed-effect model were found to be comparable between laparoscopic group and open group recipients (OR=1.06, 95% CI=0.58-1.93, P=0.85) (**Figure 10**).

What's more, recipients complications such as biliary complications and vascular complications were compared separately. There was no significant heterogeneity observed in the two

Table 3. Subgroup analysis

Outcomes	Subgroup	No. of studies	Effect estimate [95% CI]	*P* value	Heterogeneity
Blood loss	Western	5	-151.04 [-207.70, -94.37]	P<0.00001	I^2=49%
	Eastern	8	-28.07 [-55.13, -1.01]	P=0.04	I^2=35%
	Overall	13	-58.49 [-104.17, -12.81]	P=0.01	I^2=64%
Duration of operation	Western	5	23.92 [-40.46, 88.30]	P=0.47	I^2=91%
	Eastern	8	27.39 [14.55, 40.23]	P<0.0001	I^2=22%
	Overall	13	28.41 [4.64, 52.18]	P=0.02	I^2=79%
Length of hospital stay	Western	4	-1.37 [-2.06, -0.69]	P<0.0001	I^2=0%
	Eastern	7	-1.59 [-2.99, -0.18]	P=0.03	I^2=85%
	Overall	11	-1.38 [-2.28, -0.47]	P=0.03	I^2=78%

comparation (P=0.98, I^2=0% and P=0.74, I^2=0%), and no significant difference was found between the two groups for both bile complicantions (OR=0.95, 95% CI=0.47-1.91, P=0.88) (**Figure 11**) and vascular complications (OR=1.55, 95% CI=0.63-3.83, P=0.35) (**Figure 12**).

Subgroup analysis

In order to investigate the source of heterogeneity among the studies, a subgroup analysis was carried out in those syntheses with significant heterogeneity (estimated blood loss, duration of operation, length of hospital stay, duration of PCA use). We stratified the syntheses according to three important factors that might be related to the heterogeneity among studies, including: study design (comparative or case-control studies), transplant area (Western country or Eastern country) and LDLT group's patient number (<50 or ≥50). In the subgroup analysis, we found heterogenrity among studies decreased largely when stratifying the syntheses of estimated blood loss, duration of operation, length of hospital stay and duration of PCA use with transplant area (**Table 3**).

Discussion

As the shortage of the grafts for LT has been severer over years, LDLT as an alternative to DDLT, has increasingly performed all around the world. Nowadays, about 70% of LDLT recipients are from Asian countries because the various social, cultural, and historic reasons limited the development of deceased organ donation. The advantage of reduction of pre-transplantation waiting time in LDLT may lessen the number of patients who died of disease progression on the waiting list. Especially for emergency patients with acute hepatic failure, LDLT is often proved to be an optimal selection and can provide a timely graft to save their lives [31, 32]. What's more, a similar overall graft and recipient survival rate was found in LDLT when compared with DDLT [1, 3]. Donor safety is always the main issue in LDLT because donors achieve no medical benefits and are exposed to the risk of complications, and even death in this procedure [4, 5, 33]. Mortality after living donation ranges from 0.05%-0.1% for left lateral section donation to 0.2% for right liver donation [33]. The morbidity of LDLT donors ranges from 8.6% to 59% [33-36], in which complications including biliary leak and biliary stricture are the most common complication with an incidence of 9% [37].

As the laparoscopic approach was widely used in classical liver resection for malignant or benign lesions, its application on living donation to provide the healthy donors with the similar advantages of a smaller incidence of complications, a shorter duration of hospital stay and less post-operative pain was also paid attention to. Therefore, since the first description of full laparoscopic LLS for adult-child LDLT in 2002 [9], this approach has progressively gained increased acceptance. With the publications of a series of case reports and comparative studies, due to some results among the studies were different, it's necessary to combine the available data and to seek to compare the perioperative outcomes and postoperative complications between LLDH versus OLDH by conducting this meta-analysis.

Our meta-analysis covered 14 studies with a total of 1136 patients included. The present stuy demonstrated that the less total blood loss, the shorter length of hospital stay and duration of PCA use were found in the laparoscopic group compared with the open group. While the duration of operation in the open group was shorter than that in the laparoscopic group. Peak ALT and AST seemed to be equivalent between the two groups.

The lower blood loss in this analysis was in accordance with previous published experience with laparoscopic liver resection for benign and malignant lesions [38, 39]. Several explanations may account for these findings: first, the use of pneumoperitoneum could both reduce cut surface bleeding and therefore leave enough time and space for laparoscopic haemostasis; second, the laparoscopic magnification of the transection combined with meticulously coagulation of microvessel, and third, reasons such as the 30-degree reverse Trendelenburg position reducing hepatic backflow may also contribute to the reduction of the blood loss. In Thenappan et al's experience [21], the most recent laparoscopic donors minus the outlier shows a trend toward a more pronounced decrease in blood loss. Soubrane et al [18] found that their acquired knowledge of liver resection performed without pedicle clamping could minimize bleeding which was worth learning in other centers.

The duration of operation in the laparoscopic group was longer than that in the open group, the following reasons may explain this effect. Laparoscopic surgery required frequent installation and removal of laparoscopic devices for mobilization of the liver. The extraction of the graft also lengthened the operation time because surgeon has to place the graft in a plastic bag and perform this procedure using another incision. What's more, the duration of this procedure has decreased in the recent studies refleccted the initial learning curve. The final extraction procedure may lead to possibility of prolonged warm ischemia time (WIT) and physical graft integrity. Actually, however, there was no difference in WIT between the two groups in Kim et al's [20] study. And that donors and recipients laboratory tests including ALT and AST after surgery [18, 20], recipients postoperative complications were also comparable between laparoscopic group and open group [21, 23].

Concerning donor postoperative outcomes, no perioperative mortality in the donor was reported in the studies included, and that donor overall morbidity in the laparoscopic group was significant lower than that in the open group. Furthermore, when sorting donor postoperative complications according to Clavien-Dinido classification, pooled results in the fixed-effect model revealed that a significant reduction of minor complications (Grade I-II) in the laparoscopic group. However, no statistically significant difference was found between the two groups for major complications (Grade III-V). The small incision of laparoscopic donors may present the potential benefit of reducing postoperative pain and the rate of infection compared with the conventional subcostal muscle-cutting incision. In a word, laparoscopic donors may have the advantage over open donors in allowing lower donor overall morbidity and minor complications.

Liver donation is reported to have a negative effect on donor quality of life (QOL), with throbbing, itching, or numbness around the wound being the most common physical symptoms [40]. In Ishizaki et al's research, 24% of donors after LDLT had wound-related physical symptoms, and 19% experienced anxiety concerning their future state of health [41]. Two of the included studies reported donor QOL in both groups [26, 30], with similar conclusion that laparoscopic donors were more satisfied with minimal incisions. Of course, further studies with larger number of donors are necessary to confirm these promising results.

Two studies compared donor procedure costs and both of them seemed comparable between the two groups. As has been reported in classical liver resection that laparoscopic approach also had fiscally important cost advantages [42]. Shorter length of hospital stay, shorter duration of PCA use, fewer days taken off work and lower morbidity rate are factors not only related to high QOL but also with reduced in-hospital costs. If this is consistent with donor procedure, LLDH might also be associated with personal and societal cost benefits.

With respect to recipients' outcomes after LDLT, overall results showed there was no significant difference between laparoscopic group and the open group recipients. Furthermore, recipients special complications such as biliary complications and vascular complications were compared separately. And no significant difference was found between the two groups for both biliary complicantions and vascular complications. These findings, combined with donor postoperative outcomes, verified that compared with grafts obtained from open hepatectomy, those procured from laparoscopic hepatectomy are also suitable for transplantation.

We conducted a subgroup analysis to investigate the source of heterogeneity among the studies. After stratifying the syntheses according to factors that might be related to the heterogeneity among studies, we found heterogenrity among studies decreased largely when stratifying the syntheses of estimated blood loss, duration of operation, length of hospital stay and duration of PCA use with transplant area.

Several limitations may exist in this meta-analysis: first, most studies were retrospective studies, only three of which were case-controlled, and that no randomized controlled trials were identified in the meta-analysis. This may make the extracting data from the medical records retrospectively incomplete. More case-controlled researches with larger patient number were needed to be conducted to avoid this bias. Second, donor selection may be a possible bias since in some studies that younger and female donors were more willing to perform laparoscopic procedure for less scarring and earlier recovery. To lessen donor selection bias, it's necessary to conduct standardized selection criteria according to donor body type and vascular and/or biliary anatomy. Third, surgeons' technical experience and the medical management during perioperative period in different regions differed far from each other which may affect the postoperative complications.

Another limitation within this meta-analysis was the presence of heterogeneity detected within several outcomes, such as estimated blood loss, operative time, hospital stay and analgesia use. Although some degree of heterogeneity was inevitable in a medical meta-analysis due to the reality of clinical practice, heterogeneity present among studies might undermine the quality of the results obtained. Therefore, we performed a subgroup analysis in the syntheses with significant heterogeneity, which showed better homogeneity in the subgroups and similar results with the primary findings. Besides, sensitivity analysis indicated that the results in our meta-analysis could be regarded with a high degree of certainty. In a word, our results provided a systematic and comprehensive evaluation of the operative outcomes after LLDH versus OLDH despite existence of some limitations in the study.

In conclusion, the less total blood loss, the shorter length of hospital stay and duration of PCA use were found in the LLDH compared with the OLDH, while the duration of operation was shorter in the OLDH. Donor overall morbidity was significant lower in the LLDH which was in accord with minor complications. There was no difference in recipients overall complications, and that recipients special complications such as biliary complications and vascular complications were also comparable between the two groups.

Acknowledgements

This study was supported by the National Natural Science Foundation of China (No. 81472243), the Key Joint Research Program of Shanghai Health Bureau (2013ZYJB0001), and the Multicenter Clinical Research of Chinese Citizen Donation after Cardiac Death (15411950400).

Disclosure of conflict of interest

None.

Authors' contribution

Dong-Wei Xu and Ping Wan equally contributed to this paper with conception and design of the study, literature review and analysis, drafting and critical revision and editing; and Qiang Xia coordinated the research and approved the final manuscript for publication.

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References

[1] Reichman TW, Katchman H, Tanaka T, Greig PD, McGilvray ID, Cattral MS, Renner EL, Selzner M, Ghanekar A, Levy G, Grant DR. Living donor versus deceased donor liver transplantation: a surgeon-matched comparison of recipient morbidity and outcomes. Transpl Int 2013; 26: 780-787.

[2] Hoehn RS, Wilson GC, Wima K, Hohmann SF, Midura EF, Woodle ES, Abbott DE, Singhal A, Shah SA. Comparing living donor and deceased donor liver transplant: A matched national analysis from 2007-2012. Liver Transpl 2014; 20: 1347-55.

[3] Wan P, Yu X, Xia Q. Operative outcomes of adult living donor liver transplantation and deceased donor liver transplantation: a systematic review and meta-analysis. Liver Transpl 2014; 20: 425-436.

[4] Ozgor D, Dirican A, Ates M, Gonultas F, Ara C, Yilmaz S. Donor complications among 500 living donor liver transplantations at a single center. Transpl Proc 2012; 44: 1604-1607.

[5] Lauterio A, Poli C, Cusumano C, Di Sandro S, Tripepi M, Mangoni I, Mihaylov P, Concone G, Giacomoni A, De Carlis LG. Living-donor liver transplantation: donor selection criteria and postoperative outcomes. A single-center experience with a 10-year follow-up. Transpl Proc 2013; 45: 2680-2683.

[6] Xu DW, Long XD, Xia Q. A review of life quality in living donors after liver transplantation. Int J Clin Exp Med 2015; 8: 20-26.

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

[8] Dokmak S, Raut V, Aussilhou B, Fteriche 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.

[9] 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.

[10] 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.

[11] 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.

[12] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 2004; 240: 205-213.

[13] Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol 2010; 25: 603-605.

[14] Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009; 6: e1000097.

[15] Hozo SP, Djulbegovic B, Hozo I. Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol 2005; 5: 13.

[16] Higgins JP, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ 2003; 327: 557-560.

[17] 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.

[18] 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.

[19] 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 23-25.

[20] 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.

[21] Thenappan A, Jha RC, Fishbein T, Matsumoto C, Melancon JK, Girlanda R, Shetty K, Laurin J, Plotkin J, Johnson L. Liver allograft outcomes after laparoscopic-assisted and minimal access live donor hepatectomy for transplantation. Am J Surg 2011; 201: 450-455.

[22] 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? Transpl Proc 2012; 44: 347-352.

[23] 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.

[24] Ha TY, Hwang S, Ahn CS, Kim KH, Moon DB, Song GW, Jung DH, Park GC, Namgoong JM, Park CS, Park YH, Park HW, Kang SH, Jung BH, Lee SG. Role of hand-assisted laparoscopic surgery in living-donor right liver harvest. Transpl Proc 2013; 45: 2997-2999.

[25] 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.

[26] Makki K, Chorasiya VK, Sood G, Srivastava PK, Dargan P, Vij V. Laparoscopy-assisted hepatectomy versus conventional [open] hepatectomy for living donors: when you know better, you do better. Liver Transpl 2014; 20: 1229-1236.
[27] 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.
[28] Samstein B, Griesemer A, Cherqui D, Mansour T, Pisa J, Yegiants A, Fox AN, Guarrera JV, Kato T, Halazun KJ, Emond J. Fully laparoscopic left-sided donor hepatectomy is safe and associated with shorter hospital stay and earlier return to work: A comparative study. Liver Transpl 2015; 21: 768-73.
[29] Soyama A, Takatsuki M, Hidaka M, Adachi T, Kitasato A, Kinoshita A, Natsuda K, Baimakhanov Z, Kuroki T, Eguchi S. Hybrid procedure in living donor liver transplantation. Transpl Proc 2015; 47: 679-682.
[30] Suh SW, Lee KW, Lee JM, Choi Y, Yi NJ, Suh KS. Clinical outcomes of and patient satisfaction with different incision methods for donor hepatectomy in living donor liver transplantation. Liver Transpl 2015; 21: 72-78.
[31] Goldaracena N, Spetzler VN, Marquez M, Selzner N, Cattral MS, Greig PD, Lilly L, McGilvray ID, Levy GA, Ghanekar A, Renner EL, Grant DR, Selzner M. Live donor liver transplantation: a valid alternative for critically ill patients suffering from acute liver failure. Am J Transpl 2015; 15: 1591-1597.
[32] Yamashiki N, Sugawara Y, Tamura S, Nakayama N, Oketani M, Umeshita K, Uemoto S, Mochida S, Tsubouchi H, Kokudo N. Outcomes after living donor liver transplantation for acute liver failure in Japan: results of a nationwide survey. Liver Transpl 2012; 18: 1069-1077.
[33] 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.
[34] Sevmis S, Diken T, Boyvat F, Torgay A, Haberal M. Right hepatic lobe donation: impact on donor quality of life. Transpl Proc 2007; 39: 826-828.
[35] Coelho JC, Parolin MB, Baretta GA, Pimentel SK, de Freitas AC, Colman D. Donor quality of life after living donor liver transplantation. Arqu Gastroenterol 2005; 42: 83-88.
[36] Parolin MB, Lazzaretti CT, Lima JH, Freitas AC, Matias JE, Coelho JC. Donor quality of life after living donor liver transplantation. Transpl Proc 2004; 36: 912-913.
[37] Lei J, Yan L, Wang W. Donor safety in living donor liver transplantation: a single-center analysis of 300 cases. PLoS One 2013; 8: e61769.
[38] Koffron AJ, Auffenberg G, Kung R, Abecassis M. Evaluation of 300 minimally invasive liver resections at a single institution: less is more. Ann Surg 2007; 246: 385-92; discussion 92-94.
[39] Simillis C, Constantinides VA, Tekkis PP, Darzi A, Lovegrove R, Jiao L, Antoniou A. Laparoscopic versus open hepatic resections for benign and malignant neoplasms--a meta-analysis. Surgery 2007; 141: 203-211.
[40] Hsu HT, Hwang SL, Lee PH, Chen SC. Impact of liver donation on quality of life and physical and psychological distress. Transpl Proc 2006; 38: 2102-2105.
[41] Ishizaki M, Kaibori M, Matsui K, Kwon AH. Change in donor quality of life after living donor liver transplantation surgery: a single-institution experience. Transpl Proc 2012; 44: 344-346.
[42] Vanounou T, Steel JL, Nguyen KT, Tsung A, Marsh JW, Geller DA, Gamblin TC. Comparing the clinical and economic impact of laparoscopic versus open liver resection. Ann Surg Oncol 2010; 17: 998-1009.