Less than 35% of residual liver volume, is it safe for young donor in living donor liver transplantation? Comparative study

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Received: 13 May 2021
Revised: 27 May 2021
Accepted: 1 June 2021
Published: 11 January 2022

The Egyptian Journal of Surgery 2021, 40:976–984

Background
Most of the studies showed that the residual liver volume (the remaining liver tissue after partial hepatectomy) in living donor liver transplantation (LDLT) should be more than 35%, as it carries the best outcome for the donor after transplantation and the least incidence of complications. In this study, we compared the outcome of LDLT in case of residual volume between 30 and 34.9% versus residual liver volume above 35%, to increase the donor pool without affecting the safety of the donor.

Objective
To compare the outcome of LDLT with donors having residual liver volume between 30 and 34.9% versus residual liver volume above 35% regarding postoperative liver function tests (aspartate aminotransferase, alanine aminotransferase, bilirubin, and international normalized ratio), hospitals stay, and other postoperative complications.

Patients and methods
Type of study: a cohort retrospective study was conducted. Study setting: The study was conducted at Ain Shams University Hospital and Cairo Fatemic Hospital. Study population: A total of 40 donors were divided into two groups. Group A included 20 donors with residual liver volume 30–34.9%, and group B included 20 donors with residual liver volume more than 35%. Inclusion criteria were age between 18 and 35 years, BMI between 18 and 30, no hyperlipidemia, and on liver biopsy, steatosis was less than 10%.
Exclusion criteria were age less than 18 or above 35 years, BMI was below 18 or above 30, presence of hyperlipidemia, and on liver biopsy, steatosis more than 10%.

Results
There was a nonsignificant difference between the groups in our study regarding grading of complications (I–V) according to modified Clavien system. There was a nonsignificant statistical difference between both groups in this study regarding peak aspartate aminotransferase, peak alanine aminotransferase, and peak international normalized ratio (P=0.494, 0.482, and 0.278, respectively). Peak total bilirubin, peak direct bilirubin, and peak creatinine were significantly higher among cases of group A (remnant liver volume 30–34.9%) in the current study. Mean peak total bilirubin, peak direct bilirubin, and peak creatinine were 4.82±3.01, 2.67±2.14, and 0.82±0.16, respectively, versus 2.83±1.60, 1.41±1.58, and 0.77 ±0.16, respectively, in control group (P=0.013, 0.041, and 0.032, respectively). There was a nonsignificant difference between both groups in our study regarding hospital stay.

Conclusion
Overall, 30–34.9% of residual liver volume in selected donors was as safe as above 35% of residual liver volume.

Keywords:
end-stage liver disease, living donor liver transplantation, orthotropic liver transplantation, residual volume

Egyptian J Surgery 40:976–984

1110-1121

Introduction

Liver transplantation is one of the few truly life-saving and life-altering procedures in medicine, but at the same time, it is a highly risky procedure. Although the basic principles of liver transplantation have not changed, the field of liver transplantation is still young, evolving, and dynamic.

Liver transplantation is the only treatment of patients experiencing end-stage liver disease resulting from liver

cirrhosis, decompensated liver disease, acute liver failure, and hepatocellular carcinoma within Milan criteria [1].

During the past four decades, liver transplantation evolved from an experiment with a very high mortality rate to a common procedure with acceptable survival rates on the short and long runs [2].

Orthotropic liver transplantation became a routine procedure, and the 1- and 5-year survival rate had increased to 90 and 80%, respectively [3].

Living donor liver transplantation (LDLT) began in 1989 as a solution to solve the shortage of deceased donor (DD) organs for pediatric recipients. The increasing shortage of DD grafts for adults in North America and Europe gave way to living donation as a potential solution to the shortage of DD organs [4].

Residual volume in donors is the liver volume remaining in donor after left or right lobe donation. The preoperative computed tomography (CT) volumetry predicts the estimated residual volume with and without middle hepatic Vein (MHV) that differs according to preoperative venography and surgical technique. Nonadequate graft size had been a limiting factor in adult-to-adult LDLT. Adult-to-adult LDLT has been performed for both acute and chronic liver failure, but the effect of the patient's pretransplantation medical status and cause of disease on graft size requirements has never been quantified. The term 'small-for-size syndrome' is used to refer to clinical consequences of using a graft that is too small [5].

CT volumetry generally is considered the standard method for preoperative estimation of hepatic graft weight. However, the results of previous studies have shown that there is a tendency for considerable overestimation with CT volumetry compared with the intraoperatively measured weight of the right hepatic lobe. One of the major causes of CT volumetric error likely is related to the blood volume circulating in the large hepatic vessels because the blood volume is included at CT volumetry, whereas graft weight usually is measured blood free [6].

The use of donors with more than 35% remnant liver volume (RLV) is safe regarding the postoperative donor outcome. The use of donors with less than 35% RLV is controversial, so it's recommended to do more advanced studies on lower RLV less than 35% to increase the pool of potential donors for LDLT, especially in countries in which DD liver transplantation is still forbidden [7].

In the past, several surgeons have documented that the accepted lower safety margin of donor RLV has to be 30% of the total liver volume in LDLT. Transplant surgeons have to set strict limitation for the safety margin of RLVs [8].

International experience is still limited without jeopardizing donors' lives. In this regard, other donor characteristics, such as age, medical comorbidity, and steatosis in the liver should be taken into consideration separately in each case. Dual donors are an alternative solution to donors with a potential small residual liver volume. It is only possible if the recipient has several donors, each with a potential small RLV after right-lobe graft donation. When the possibility of dual-lobe LDLT is entertained, the cumulative risk to both donors should be justified and discussed with both donors [9].

Aim

The aim of this study was to compare the outcome of LDLT with donors having residual liver volume between 30 and 34.9% versus residual liver volume above 35%, regarding postoperative levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), bilirubin, international normalized ratio (INR), also hospitals stay, and postoperative morbidity in the donor.

Patients and methods

Type of study: This was a cohort retrospective study.

Study setting: The study was conducted at Ain Shams University Hospital and Cairo Fatemic hospital from January 2019 to December 2020.

Study population: A total of 40 donors were included and divided into two groups. Group A included 20 donors with residual liver volume 30–34.9%, and group B included 20 donors with residual liver volume more than 35%.

Inclusion criteria were age between 18 and 35 years, BMI between 18 and 30, no hyperlipidemia, and on liver biopsy, steatosis less than 10%.

Exclusion criteria were age below 18 or above 35 years, BMI below 18 or above 30, presence of hyperlipidemia, and liver biopsy, steatosis more than 10%.

Sampling method: systematic sampling was employed.

Sample size: a total of 40 patients fulfilling the inclusion criteria were divided into two groups equally: group A consisted of 20 donors with residual liver volume from 30 to 34.9%, and group B consisted of 20 donors with residual liver volume more than 35%.

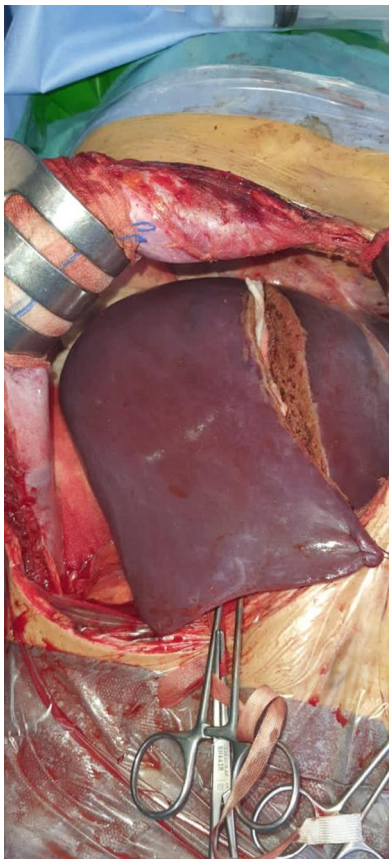
Ethical considerations: the clinical research study was conducted in accordance with the current policies, requirements, and regulations of the Ain Shams University. The investigators made certain that an appropriate information process is in place to ensure that potential research participants or their authorized representatives are fully informed about the nature and objectives of the clinical study, the potential risks and benefits of study participation, and their rights as research participants. The investigators obtained oral agreement and written informed consent from each participant or the patient's authorized representative before performing any study-specific procedures on the patient.

Study tools: laboratory tests included liver function tests – INR, and pelvi-abdominal ultrasound and CT volumetry.

Study procedures: the donors and recipients were admitted to the hospital the night before the planned transplantation. A hockey stick incision with an upper midline extension was used. After an intraoperative ultrasound evaluation of the vascular structures and cholecystectomy, cholangiography through the cystic duct stump for evaluation of the biliary tree was performed. A cavitron ultrasonic surgical aspirator (CUSA System 200 macrodissector; Cavitron Surgical Systems, Stamford, Connecticut, USA) was used for parenchymal division, as in Fig. 1. Heparin sodium (2000 U) is given intravenously before the clamping of the vessels after transection of the parenchyma. After removal of the graft, vessel stumps are closed with continuous, nonabsorbable sutures. The stump of the right biliary duct was closed with interrupted, absorbable sutures, as in Fig. 2a, b.

SMOF lipid was then injected gently through the cystic duct stump to check for any leaks in the biliary tree. Before closure of the abdomen, two drains are placed in the right upper quadrant, which was brought out through a stab incision in the right lower quadrant.

Figure 1



The right lobe of the liver after parenchymal division.

Donor follow-up

Donor follow-up for one month was done through the following items

Clinical data included the following: vital data, including pulse, blood pressure, temperature, and respiratory rate to detect any hemodynamic instability and respiratory complications; bowel habits; drain amount and color of the drain (Drain was removed when the amount of the drain fluid was less than 200 ml and serous within 24 h) and wound care (wound discharge would be sent for culture and sensitivity).

Laboratory investigation included the following: complete blood count; liver profile (ALT, AST, bilirubin (total and direct), alkaline phosphatase, and gamma-glutamyl transferase); coagulation profile (INR); and serum electrolytes (Na–K).

Radiological evaluation (abdominal duplex ultrasonography) was done every day for three days and then every other day unless needed to be more frequent.

After discharge: weekly follow up Labs and abdominal ultrasound for 1 month.

Statistical analysis

Data were collected, revised, coded, and entered to the Statistical Package for Social Science (IBM SPSS), version 20 (Armonk, New York, USA). The qualitative

data were presented as number and percentages, whereas quantitative data were presented as mean, SDs, and ranges when their distribution was found parametric. The comparison between two groups with qualitative data was done by using χ^2 test, and Fisher exact test was used instead of χ^2 test when the expected count in any cell was found less than 5. The comparison between two independent groups with quantitative data and parametric distribution was done by using independent *t* test. The confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the *P* value was considered significant as follows: *P* value more than 0.05 = nonsignificant, *P* value less than 0.05 = significant, and *P* value less than 0.001 = highly significant.

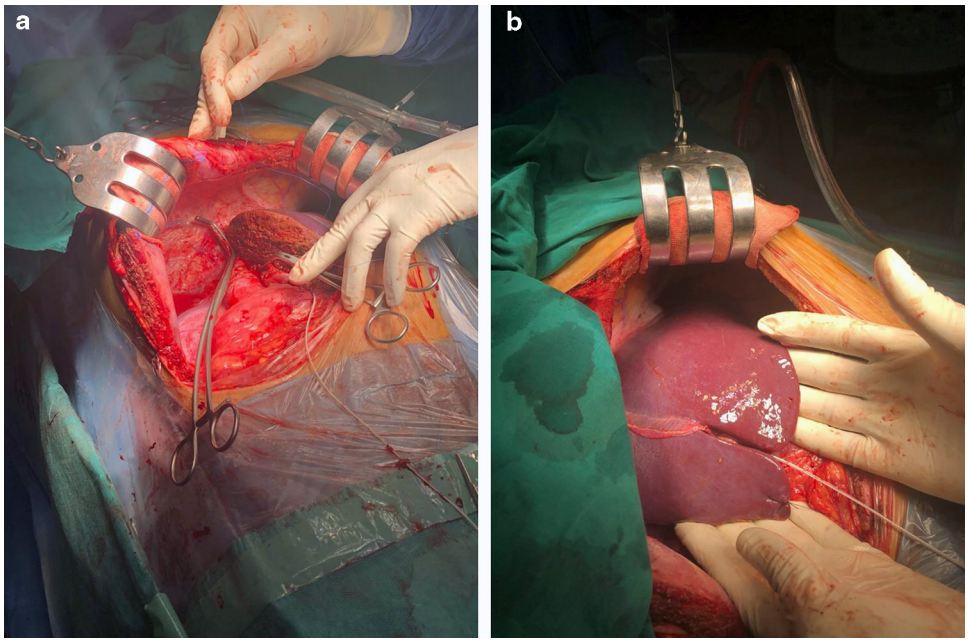
Results

Table 1 shows that there was no statistically significant difference between the two groups regarding age, sex, BMI, and biopsy (% of steatosis).

Table 2 shows that there was no statistically significant difference between two the groups regarding hemoglobin, white blood cell (WBCs), platelets, AST, ALT, INR, albumin, total bilirubin, and direct bilirubin.

There was no statistically significant difference between two the groups regarding intraoperative bleeding, biliary injury, or vascular injury, as there was no case in our study that experienced any of these complications.

Figure 2



(a) The left lobe of the liver representing the residual liver volume after resection. (b) The left lobe of the liver representing the residual liver volume after resection.

Table 1 Comparison between group A (*N*=20) and group B (*N*=20) regarding age, sex, BMI, and biopsy (% of steatosis)

	Group A *N*=20	Group B *N*=20	Test value	*P* value	Significance
Age					
Mean±SD	26.33±7.18	26.65±7.19	–0.143[b]	0.887	NS
Range	18–35	19–35			
Sex [*n* (%)]					
Female	3 (15.0)	7 (35.0)	2.133[a]	0.144	NS
Male	17 (85.0)	13 (65.0)			
BMI					
Mean±SD	24.05±3.44	23.45±3.74	0.530[b]	0.599	NS
Range	17.4–30	17.6–30			
Biopsy (% of steatosis)					
Minimal steatosis less than 5%	2 (10.0)	2 (10.0)	0.000[a]	1.000	NS

[a]χ^2 test. [b]Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

There was no statistically significant difference between two groups regarding blood transfusion, as there was no case in our study that needed blood transfusion.

Table 3 shows that there was no statistically significant found between two groups regarding ICU stay, and also there was no statistically significant difference between the two groups regarding hospital stay.

Table 4 shows that there was no statistically significant difference between the two groups regarding biliary leakage, wound infection, and chest infection and also grading of complications (I–V) according to modified Clavien system.

Grade 1 complications included postoperative pain, vomiting, and neuropraxia that needed physiotherapy, and grade 2 complications included wound infection, chest infection, or biliary leakage.

There were no cases in our study that had bleeding or liver decompensation; thus, there was also no statistically significant difference found between the two groups.

Table 2 Comparison between group A (*N*=20) and group B (*N*=20) regarding preoperative laboratory data

	Group A *N*=20	Group B *N*=20	Test value[b]	*P* value	Significance
Hb					
Mean±SD	14.53±1.18	13.80±1.82	1.503	0.141	NS
Range	12–17	10.9–16.8			
WBCs					
Mean±SD	6.21±1.58	6.30±1.96	–0.151	0.881	NS
Range	3.3–8.7	3.5–11.2			
Platelets					
Mean±SD	233350.00±63121.67	271350.00±87916.39	–1.570	0.125	NS
Range	152000–425000	157000–455000			
AST					
Mean±SD	23.10±5.78	24.05±10.95	–0.343	0.733	NS
Range	15–37	10–62			
ALT					
Mean±SD	21.90±9.73	23.90±11.03	–0.608	0.547	NS
Range	5–46	9–46			
INR					
Mean±SD	1.13±0.16	1.07±0.11	1.515	0.138	NS
Range	0.9–1.48	0.9–1.32			
Albumin					
Mean±SD	4.60±0.35	4.52±0.42	0.701	0.488	NS
Range	4–5.4	3.8–5.3			
Total bilirubin					
Mean±SD	0.59±0.25	0.55±0.29	0.489	0.627	NS
Range	0.3–1	0.15–1.4			
Direct bilirubin					
Mean±SD	0.21±0.14	0.18±0.11	0.570	0.572	NS
Range	0.1–0.7	0.09–0.5			

ALT, alanine aminotransferase; AST, aspartate aminotransferase; Hb, hemoglobin; INR, international normalized ratio; WBC, white blood cell. χ^2 test. [b]Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant(S); *P* value less than 0.01: highly significant (HS).

Table 3 Comparison between group A (*N*=20) and group B (*N*=20) regarding ICU stay, hospital stay

	Group A *N*=20	Group B *N*=20	Test value[b]	*P* value	Significance
ICU stay (days)					
Mean±SD	2.90±0.85	2.30±0.80	2.294	0.027	NS
Range	2–4	1–3			
Hospital stay (days)					
Mean±SD	5.85±0.81	7.05±0.69	3.363	0.002	NS
Range	5–7	6–9			

[a]χ^2 test. [b]Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant (S); *P* value less than 0.01: highly significant (HS).

There was no statistically significant difference found between the two groups regarding the time of drain removal, as the mean time for removal in group A was 7 days, whereas in group B was 6 days; thus, there was no statistically significant difference found between the two groups regarding time for drain removal.

Table 5 shows that there was no statistically significant difference found between the two groups regarding peak AST, peak ALT, and peak INR, and there was a statistically significant difference found between the two groups regarding peak bilirubin total, peak bilirubin direct, and peak creatinine.

Table 6 shows that there was no statistically significant difference found between the two groups regarding lowest hemoglobin, lowest albumin, and highest WBCs (Fig. 3).

Discussion

LDLT has become a possible solution for the growing discrepancy between the number of patients listed for liver transplantation and the availability of cadaveric organs. The most important development in recent years has been the extension of LDLT to adults [10].

Table 4 Comparison between group A (*N*=20) and group B (*N*=20) regarding postoperative complications (Fig. 3)

	Group A [*n* (%)] *N*=20	Group B [*n* (%)] *N*=20	Test value[a]	*P* value	Significance
Biliary leakage					
Positive	4 (20.0)	2 (10.0)	0.784	0.376	NS
Wound infection					
Yes	4 (20.0)	1 (5.0)	2.057	0.151	NS
Chest infection					
Yes	4 (20.0)	1 (5.0)	2.057	0.151	NS
Grading (1—5)					
Grade 1	12 (60.0)	13 (65.0)	0.107[a]	0.744	NS
According to modified Clavien system					
Grade 2	4 (20.0)	2 (10.0)			

[a]χ^2 test. Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant(S); *P* value less than 0.01: highly significant (HS).

Table 5 Comparison between group A (*N*=20) and group B (*N*=20) regarding peak aspartate aminotransferase, peak alanine aminotransferase, peak total bilirubin, peak direct bilirubin, peak international normalized ratio, and peak creatinine and lowest hemoglobin and lowest albumin and highest white blood cells

	Group A *N*=20	Group B *N*=20	Test value[b]	*P* value	Significance
Peak AST					
Mean±SD	289.75±114.38	262.25±136.60	0.690	0.494	NS
Range	66–506	138–750			
Peak ALT					
Mean±SD	294.90±181.74	255.85±165.35	0.711	0.482	NS
Range	57–780	73–756			
Peak total bilirubin					
Mean±SD	4.82±3.01	2.83±1.60	2.601	0.013	S
Range	0.7–11.9	1.2–8.3			
Peak direct bilirubin					
Mean±SD	2.67±2.14	1.41±1.58	2.116	0.041	S
Range	0.3–7	0.2–6.8			
Peak INR					
Mean±SD	1.96±0.74	1.77±0.32	1.099	0.278	NS
Range	1.27–2.8	1.2–2.35			
Peak creatinine					
Mean±SD	0.82±0.16	0.77±0.16	0.999	0.324	S
Range	0.57–1.2	0.5–1			

ALT, alanine aminotransferase; AST, aspartate aminotransferase; INR, international normalized ratio. χ^2 test. [b]Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant(S); *P* value less than 0.01: highly significant (HS).

Table 6 Comparison between group A (*N*=20) and group B (*N*=20) regarding lowest hemoglobin, lowest albumin and highest white blood cells

	Group A *N*=20	Group B *N*=20	Test value[b]	*P* value	Significance
Lowest Hb					
Mean±SD	10.42±1.50	9.98±1.64	0.885	0.382	NS
Range	8.2–13.3	6.5–13.1			
Lowest albumin					
Mean±SD	2.64±0.49	2.70±0.35	–0.445	0.659	NS
Range	1.2–3.2	2.2–3.5			
Highest WBCs					
Mean±SD	18.99±4.70	18.75±5.84	0.143	0.887	NS
Range	9.8–28.5	9.9–33			

Hb, hemoglobin; WBC, white blood cell. χ^2 test. [b]Independent *t* test. *P* value more than 0.05: nonsignificant (NS); *P* value less than 0.05: significant(S); *P* value less than 0.01: highly significant (HS).

Figure 3

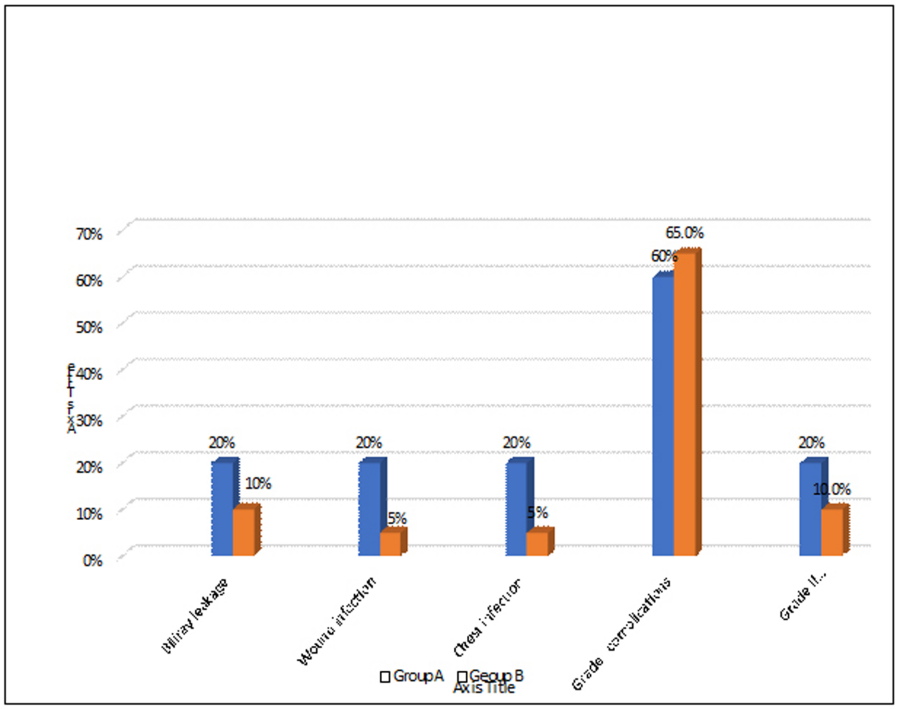


Diagram showing comparison between complications in both group A and group B.

In the early stages of LDLT, small-sized grafts, such as a left lateral section and left lobe, were used. However, liver transplantation surgeons have since discovered that graft size is one of the most important factors in successful LDLT because of the association between graft size and patient survival. Recently, right lobe grafting in LDLT has been safely undertaken in experienced liver transplantation centers [11].

Regarding preoperative laboratory data of patients in the current study, there was no significant statistical difference between groups A and group B regarding hemoglobin, WBCs, platelets, AST, ALT, INR, albumin, and total and direct bilirubin.

The results of Shi *et al.* [12] also suggested that the conditions of the three groups (group 1 RLV below 35, group 2 from 35 to 40, and group 3 RLV above 40) of donors were well matched in terms of the preoperative ALT, AST, total bilirubin, and hemoglobin.

No differences were observed between group 1 (RLV below 35) and group 2 (above 35%) in terms of mean preoperative serum liver enzymes, including AST, in the study by Cho *et al.* [10] (AST=21.7±5.5 vs. 16.6 ±4.2 IU/l; *P*=0.875), (ALT=27.4±12.0 vs. 17.8±9.7 IU/l; *P*=0.653), or in terms of total serum bilirubin levels (0.83±0.29 vs. 1.02±0.39 mg/dl; *P*=0.321) or

hemoglobin levels (14.9±1.7 vs. 14.4±1.4 g/dl; *P*=0.375).

Ikegami *et al.* [14], in contrary to our study, reported that the mean preoperative PT-INR in group S (RLV below 35) was significantly higher than that in group L (RLV above 35) (*P*=0.0307).

There was also no significant statistical difference between both the groups in our study regarding % of steatosis in liver biopsy. Minimal steatosis less than 5% was detected in 10% of patients in both group A and group B, and it did not affect donor safety or complications.

Similar to our study, Kim *et al.* [13] reported that there was no significant difference in overall complication between RLV less than 30% and RLV more than or equal to 30% in liver donor with age less than 50 years, and no or mild fatty changes.

None of the patients of both groups (A and B) in the present study received blood transfusion intraoperatively, and also there was no history of intraoperative bleeding, biliary injury, or vascular injury in patients of both groups in our study.

Ikegami *et al.* [14] in their study reported that one donor in group L (RLV above 35%) required blood transfusion. However, in the study by Cho *et al.* [10], the mean intraoperative blood losses were 697.4±396.0 and 626.3±386.8 ml (*P*=0.281).

Mean hospital stay in the present study was significantly higher among group A patients when compared with group B (5.85±0.81 vs. 5.05±0.69 days; *P*=0.002). However, there was no significant statistical difference between both the groups regarding ICU stay (2.90±0.85 vs. 2.30±0.80; *P*=0.027).

In discordance with our study, Shi *et al.* [12] reported that the ICU time for group 1 (RLV below 35%) was 6.93±2.13 days, which was significantly longer than that for group 2 and group 3 (5.10±1.62 vs. 5.33±1.63 days, respectively). There was no statistical difference in ICU stay between groups 2 and group 3. The three groups of patients exhibited no significant difference in hospitalization time.

Ikegami *et al.* [14] in their study reported that the mean postoperative hospital stay in group S (RLV below 35) and group L (RLV above 35) was 23.2±9.2 and 22.0 ±10.4 days, respectively.

There was nonsignificant difference between both the groups in our study regarding incidence of postoperative bleeding, biliary leakage, liver decompensation, wound infection, and chest infection. Bleeding and liver decompensation were not reported in any patient of both groups in our study. Both wound infection and chest infection were reported in 20% and 5% of patients in group A and group B, respectively. Biliary leakage was reported in 20% and 10% of patients in group A and group B, respectively.

In contrary to our study, R and C correlation analysis done by Shi *et al.* [12] revealed that the complication grade had a significant relationship with RLC ($P<0.05$).

Gastric volvulus was the most common complication in Ikegami *et al.* [14] series, and it was corrected endoscopically, followed by peripheral nerve palsy, incisional hernia, and sepsis.

Major complications reported by Cho *et al.* [10] included bleeding, ileus, biliary leakage, and pneumonia, whereas minor complications included pleural effusion, hyperbilirubinemia, wound problems, depression, prolonged ascites, and fluid collection, with nonsignificant differences between both groups regarding their incidence.

There was a nonsignificant difference between both the groups in our study regarding grading of complications (I–V). Grade 2 complications were reported in 20% and 10% of the patients in group A and group B, respectively, whereas grade 2 complications were reported in 60% and 65% of the patients in group A and group B, respectively.

Shi *et al.* [12] reported that 50 donors who exhibited 151 complications. According to the Clavien grading system, 28 cases had grade 1 complications, nine cases had grade 2 complications, eight cases had grade 3a complications, and five cases had grade 3b complications. No serious grade 4 or 5 complications were observed.

There was a nonsignificant statistical difference between the two groups in this study regarding peak AST, peak ALT, and peak INR (*P*=0.494, 0.482, and 0.278, respectively).

This was not in correspondence with the results of Shi *et al.* [12], as the ALT peak in the smallest RLV in group A of the study by Shi *et al.* [12] was 325.64

±202.33 U/l; this value was significantly higher than that in the other two groups (196.85±130.62 and 200.70±150.94 U/l, respectively). The AST peak of 339.79±172.91 U/l was also significantly higher than that in group 2 and group 3 (P=0.010 and 0.003, respectively). The ALT peak and AST peak in group 2 and group 3 showed no significant difference (P=0.915 and 0.893, respectively). However, in the study by Shi *et al.* [12], differences in INR peak among the three groups of donors were observed, but no statistical difference was found, similar to our result.

In contrary to our result, Cho *et al.* [10] reported that peak postoperative AST levels were 219.5±79.9 IU/l (115–539) in group 1 and 210.3±81.6 IU/l (range, 118–588) in group 2 (P=0.497), and mean peak postoperative ALT levels were 231.5±83.3 IU/l (range, 87–591) and 225.8±93.0 IU/l (range, 50–500), respectively (P=0.699).Peak total bilirubin, peak direct bilirubin, and peak creatinine were significantly higher among the case group in the current study. Mean peak total bilirubin, peak direct bilirubin, and peak creatinine were 4.82±3.01, 2.67 ±2.14, and 0.82±0.16, respectively versus 2.83±1.60, 1.41±1.58, and 0.77±0.16 in the control group (P=0.013, 0.041, and 0.032, respectively).

This was in concordance with Cho *et al.* [10], who observed that the mean serum level of total bilirubin in group 1 (3.4±1.6 mg/dl) was slightly higher than in group 2 (2.8±1.4 mg/dl) on the first postoperative day (P=0.023).

In contrary to our result, the study by Shi *et al.* [12] reported that a difference in the total bilirubin peak among the three groups of donors was observed, but no statistical differences was found.

There was a nonsignificant statistical difference between the two groups in this study regarding lowest hemoglobin, lowest albumin, and highest WBCs. Mean lowest hemoglobin was 10.42±1.50 and 9.98±1.64 in group A and group B, respectively; mean lowest albumin was 2.64±0.49 and 2.70±0.35 in group A and group B, respectively; and mean highest WBCs were 18.99±4.70 and 18.75±5.84 in group A and group B, respectively.

Similar to our study, Shi *et al.* [12] reported that a difference in the hemoglobin value among the three groups of donors was observed, but no statistical differences was found. Moreover, Cho *et al.* [10] observed no difference between the two groups in terms of mean hemoglobin level on the first, third, fifth, seventh, 30th, and 90th postoperative days (P>0.05).

Conclusion

Residual liver volume down to 30% in young donor (≤35 years old) in selected cases with no or minimal steatosis or fibrosis is safe.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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