ANNALS OF TRANSPLANTATION

ORIGINAL PAPER

e-ISSN 2329-0358
© Ann Transplant, 2020; 25: e923211
DOI: 10.12659/AOT.923211

Received: 2019.02.02
Accepted: 2020.05.18
Available online: 2020.06.08
Published: 2020.07.21

Efficacy and Safety of Weight Reduction of the Donor in Hepatic Steatosis for Living Donor Liver Transplantation

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

ACDEF 1 Jae Hun Chung
A 1,2,3 Je Ho Ryu
A 1,2 Kwang Ho Yang
CD 1,2 Byung Hyun Choi
AB 4,5 Youngmok Park
BF 1,2 Tae Beom Lee
C 1,2 Jae Ryong Shim
F 1,2 Hyo Jung Ko
DE 1,6 Sung Hwan Cho

1 Department of Surgery, Pusan National University Yangsan Hospital, Yangsan, South Korea
2 Division of Hepato-Biliary-Pancreatic Surgery and Transplantation, Department of Surgery, Pusan National University Yangsan Hospital, Yangsan, South Korea
3 Research Institute for Convergence of Biomedical Science and Technology, Pusan National University Yangsan Hospital, Yangsan, South Korea
4 Department of Surgery, Pusan National University Hospital, Yangsan, South Korea
5 Division of Hepato-Biliary-Pancreatic Surgery and Transplantation, Department of Surgery, Pusan National University Hospital, Yangsan, South Korea
6 Division of Colorectal Surgery and Transplantation, Department of Surgery, Pusan National University Yangsan Hospital, Yangsan, South Korea

Corresponding Author: Je Ho Ryu, e-mail: ryujhhim@hanmail.net
Source of support: Departmental sources

Background: Use of steatotic livers is a known risk factor for increased primary nonfunction after liver transplantation. This study investigated the efficacy and clinical outcome of simple weight reduction of steatosis for donors undergoing living-donor liver transplantation (LDLT).

Material/Methods: We defined two groups: the reduction group, which included donors with >30% macrovesicular steatosis and body mass index (BMI) >25 kg/m^2, and the conventional group, which included donors with <30% macrovesicular steatosis. Donors in the reduction group were educated about the goal of voluntary weight reduction to lose 5% of body weight, not exceeding 1.6 kg/week, and attempted to maintain weight reduction for at least 8 weeks.

Results: Weight reduction significantly improved steatosis (40.71±14.56 *vs.* 7.867±2.67, p=0.000). Body weight and BMI were reduced in the weight reduction group (85.40±8.254 kg *vs.* 76.27±7.556 kg, p=0.052; and 28.89±2.303 kg/m^2 *vs.* 26.16±1.629 kg/m^2, p=0.025, respectively). The transplanted grafts of recipients and remnant livers of donors showed intact liver function, and there was no difference in liver function tests between the conventional and reduction groups. No significant difference in graft survival was observed.

Conclusions: Simple weight reduction improves steatosis and contributes to safer LDLT for both recipient and donor. Importantly, according to our results, even steatotic livers can be used for LDLT after patients follow a simple weight reduction protocol.

MeSH Keywords: Fatty Liver • Liver Transplantation • Living Donors • Weight Loss

Full-text PDF: https://www.annalsoftransplantation.com/abstract/index/idArt/923211

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

Background

Living-donor liver transplantation (LDLT) has been a successful transplant procedure for many patients and has shown excellent recipient outcomes over the last decade [1]. The shortage of available donors leads to use of marginal liver donors, such as those with steatotic livers, in LDLT [2]. Marginal donors are defined as those with a greater risk of initial poor function or graft failure, and thereby, an increased risk of expected recipient morbidity and mortality [3]. Although LDLT is an important means of addressing the worldwide shortage of liver grafts, it is also the most serious surgery a healthy person can undergo as a living donor; therefore, donor safety is an absolute priority [4].

Fatty liver disease or hepatic steatosis is a histological finding that is commonly found in human liver biopsy specimens, and it is estimated that more than 20% of patients who have planned for liver resection have some degree of steatosis [5–7]. Steatosis is a known major risk factor for patient outcomes that affect hepatocellular recovery by impairing hepatic homeostasis and inducing hepatocellular injury after liver resection, owing to lipid accumulation [8]. Donor steatosis is associated with an increased risk of primary nonfunction and initial poor graft function in the recipient [9,10]. Marcos et al. reported a series in which no liver dysfunction was found in living donors or recipients using grafts containing less than 30% steatosis [11].

Previous studies have shown a positive correlation between the degree of hepatic steatosis and body mass index (BMI) [12,13]. Based on this correlation, for several years, donor weight loss has been used as pre-hepatectomy management strategy to improve donor hepatic steatosis and reduce post-hepatectomy risk to the donor. In previous studies, strict weight loss and drug therapy have been used to ensure the safety of marginal donors and successful transplant cases [2,14]. Standardized measurement of the remnant liver volume (RLV) is RLV/sTLV, where total liver volume (TLV) is calculated from patient body surface area (BSA). RLV/body weight ratio (RLV/BWR) has also been used to accurately assess the functional limit of hepatectomy. Three-month overall and severe morbidity (Clavien-Dindo grade IIIb–V) and mortality were significantly increased in groups with RLV/BWR <0.5% and RLV/sTLV <20% [15].

Weight reduction improves steatosis in marginal donors and contributes to safer LDLT for both recipients and donors. However, compared to previous studies, this study differs significantly in the way weight was controlled in marginal donors. Compared to the strict weight control followed in previous studies, such as with restriction of daily caloric intake, exercise control, and drug use, this study set only the upper limit of weight loss within a certain period to prevent deterioration of the general health status of donors due to excessive weight loss. Further, this study employed autonomous weight loss without medication.

Material and Methods

Patients and methods

Between May 2010 and January 2015, volunteers underwent liver donation for 109 cases of LDLT at Pusan National University Yangsan Hospital, Republic of Korea. Percutaneous needle biopsy (PCNB) had been performed in all living donors for preoperative evaluation of hepatic steatosis. We defined the reduction (RD) group as donors with more than 30% macrovesicular steatosis on initial liver biopsy and BMI more than 25 kg/m^2 and the conventional (CV) group as donors with less than 30% macrovesicular steatosis. During the study period of 5 years, seven donors were included in the RD group, of whom five were close relatives of the recipients, whereas the two non-related donors were the brother-in-law and son-in-law of the recipients. Individuals with both BMI less than 25 kg/m^2 and macrovesicular steatosis more than 30% were excluded for incompatibility as living donors. The CV group included 102 donors.

The donors in the RD group were educated about the goal of voluntary weight reduction: to lose 5% of body weight, not exceeding 1.6 kg/week, and attempt to maintain weight reduction for at least 8 weeks. To confirm improvement in hepatic steatosis after weight reduction, we performed PCNB again. These pathologic specimens were collectively reviewed by two pathologists in a blind fashion.

Liver volume was also measured twice by computed tomography using a volumetry program (Dr. Liver, Virtual Liver Surgery Planning System, Humanopia Co. Ltd, Pohang, Korea). Then, RLV/BWR and RLV/sTLV were calculated to predict improvement in donor safety after right liver lobectomy. The equation for sTLV is sTLV=–794.41+1267.28×BSA (m^2) [16]. BSA was calculated using Mosteller's formula, which is $BSA(m^2)=\sqrt{(\text{height [cm]} \times \text{weight [kg]})/3{,}600}$. Um et al. reported nearly all formulas including that for sTLV published by Vauthey et al. and crudely applicable range of sTLV estimation for Korean adults [17]. After donor hepatectomy, we checked surgical complications and classified the grades using the Clavien-Dindo classification [18].

To compare post-hepatectomy safety of donors between the CV (n=102) and RD (n=7) groups, we defined initial residual liver dysfunction as peak bilirubin level more than 3 mg/dL or prothrombin time (PT) more than 18 seconds on postoperative Day 5 [19,20]. To compare outcomes between recipients of the CV and RD groups, we measured serial changes in liver function tests of LDLT recipients for 1 month after LDLT.

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

Transplanted liver function was measured by aspartate aminotransferase (AST), alanine aminotransferase (ALT), and peak total bilirubin levels and PT on postoperative Days 1, 3, 7, and 28.

Statistical analysis

Quantitative variables were written in mean and standard deviation. Student's *t*-test was utilized to analyze the results of quantitative variables such as change of hepatic steatosis, RLV/BWR, and RLV/s-TLV before and after weight loss. The chi-squared test was applied to analyze categorical variables. Repeated measures analysis of variance (repeated ANOVA) was used to compare changes in serial laboratory results, such as AST, ALT, and total bilirubin levels and PT, in the same recipients. Statistical differences were considered significant when $p<0.05$. Recipient survival was analyzed by the Kaplan-Meier method. Statistical calculations were performed with PASW statistics, version 20 for Windows (SPSS Inc., Chicago, Illinois, USA).

Results

Clinical features of the CV and RD groups are summarized in Table 1. The mean age of donors (years) was 27.99±9.31 in the CV group and, 32.14±7.31 in the RD group. BMI and steatosis were significantly different between the groups. Before LDLT, there was no statistical difference in the Model for End-Stage Liver Disease (MELD) score and Child-Turcotte-Pugh (CTP) scores between the recipients in the CV and RD groups. From preoperative anesthesiological evaluation, American Society of Anesthesiologists (ASA) classification, we found that the preoperative condition of recipients in both groups was similar. In preoperative evaluation, six patients with BMI >25 kg/m^2 and steatosis >30% achieved weight loss of over 5%; their average weight reduction (kg) was from 85.40±8.25 to 76.27±7.56 (p=0.052). The mean value of percentage (%) of weight loss was 10.63±3.77. As body weights changed, BMI also improved from 28.89±2.30 to 26.16±1.63 (p=0.025). After weight reduction, fatty changes during the second biopsy also improved from 40.71±14.56% to 7.87±2.67% ($p<0.001$), and RD donors were now in a transplantable state (Table 2).

RLV/BWR increased from 0.59±0.15 to 0.65±0.14 ($p<0.001$), and RLV/sTLV increased from 28.29±7.11 to 30.71±6.36. ($p<0.001$). Three categories reflect improved safety for donor hepatectomy in the RD group (Table 2).

All seven donors in the RD group had no initial residual liver dysfunction (peak bilirubin level over 3 mg/dL or PT over 18 seconds) on postoperative Day 5 (Table 3). Compared to results from donors in the CV group, there were no significant differences on postoperative Day 5. In addition, there was only one major complication, which was bile leakage (Clavien-Dindo classification IIIa). Endoscopic retrograde biliary drainage and percutaneous drainage of biloma were performed for this complication and the donor was discharged in 15 days without any sequelae from bile leakage. There was another case of pleural effusion (Clavien-Dindo classification I). There were also some complications of donor hepatectomy in the CV group: three portal vein thromboses, two bile leaks, one postoperative bleed, and one bleeding duodenal ulcer (Clavien-Dindo classification IIIa).

Postoperative outcomes of recipients from the two groups were determined using four results: AST, ALT, and total bilirubin levels and PT (Table 3). There was no statistically significant difference between the CV and RD groups ($p>0.05$) or in survival rates ($p>0.05$) (Figure 1). As a result, marginal donors with BMI >25 and steatosis >30% became normal donors through simple weight reduction. Further, the outcomes of LDLT from donors in the RD group did not differ from those in the CV group.

Discussion

In the current study, all seven donors had a successful result in terms of improving steatosis. In Case 4, weight loss was slightly short of the goal, but the improvement in hepatic steatosis was sufficient for liver transplantation. After weight reduction, steatosis in Case 3 had improved to 5% from 70%. This result was considered abnormal; however, we could not account for this difference from the other donors. Given these two cases, we believe that further studies are necessary on the correlation between the degree of weight loss and degree of improvement in hepatic steatosis.

Previous studies have suggested that weight loss of more than 1.6 kg/week may worsen hepatic inflammation and portal fibrosis because of increase in free fatty acids and proinflammatory cytokines released by visceral fat [21]. Therefore, we recommend, as a simple guideline, that voluntary weight reduction not exceed 1.6 kg/week and an attempt should be made to maintain weight reduction for at least 8 weeks. However, a recent study by Choudhary et al. suggests that steatosis can be reversed in a short time (28±10 days) with aggressive lifestyle modifications in highly-motivated liver donors [22]. The proper duration for weight reduction should be investigated in future studies.

The Kaplan-Meier survival curve shows that there was no statistically significant difference between the CV and RD groups. This result indicates that the RD group recipients can expect the same survival rate for liver transplantation as that of the CV group recipients. However, because the number of samples in the RD group in this study was not large, additional studies are needed.

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

Table 1. Clinical characteristics of conventional group and reduction group.

	Conventional group (n=102)	Weight reduction group (n=7)	*p*-Value
Donor			
Sex	M=76/F=26	M=7	0.126
Age	27.99±9.31	32.14±7.31	0.251
BW (kg)	65.77±11.27	85.4±8.25	0.052
BMI (BMI, kg/m^2)	23.13±3.27	28.89±2.30	0.025
Steatsosis (%)	6.19±5.68	40.71±14.56	<0.001
Relation			
Related	95	5	0.466
Non-related	7	2	
Recipient			
Sex	M=78/F=24	M=4/F=3	0.252
Age	51.39±9.94	53.86±5.15	0.142
CTP	1.66±0.84	1.71±0.95	0.862
MELD	12.71±7.56	8.43±4.47	0.518
Etiology			
HCC	69	6	0.989
Alcoholic LC	10	–	
Viral LC (B or C)	16	1	
Others	7	–	

BW – body weight; BMI – body mass index; MELD – Model For End-Stage Liver Disease. CTP – Child-Turcotte-Pugh; HCC – hepatocellular carcinoma; LC – liver cirrhosis.

Table 2. Results of post weight reduction of donors in the reduction group.

Case No.	Sex /Age	Weight(kg)		Weight Reduction (%)	Interval (wks)	BMI		RLV/BWR		RLV/*s*TLV		Steatosis	
		1st	2nd			1st	2nd	1st	2nd	1st	2nd	1st	2nd
1	M/33	94	81	13.83	8	33.1	27.5	0.49	0.56	24.6	28.9	35	5
2	M/43	70	65	7.14	8	26.0	25.5	0.84	0.90	39.8	41.6	30	10
3	M/33	86	77	10.47	10	27.8	24.9	0.56	0.62	26.6	28.8	70	5
4	M/24	90	86.3	4.11	9	29.6	28.8	0.76	0.79	37.0	37.4	50	10
5	M/39	84	73.2	12.86	12	27.1	26.2	0.52	0.59	24.4	26.7	35	10
6	M/23	92.8	82.1	11.53	16	29.8	26.3	0.44	0.50	21.6	23.8	35	10
7	M/30	81	69.3	14.44	10	28.8	23.9	0.49	0.58	24.0	27.8	30	5
AVG (SD)	32.14 (7.31)	85.40 (8.25)	76.27 (7.56)	10.63 (3.77)	10.43 (2.82)	28.89 (2.30)	26.16 (1.63)	0.59 (0.15)	0.65 (0.14)	28.29 (7.11)	30.71 (6.36)	40.71 (14.56)	7.86 (2.67)
p	-	0.052		-	-	0.025		<0.001		<0.001		<0.001	

BMI – body mass index; PCNB – percutaneous needle biopsy; SD – standard deviation; RLV – remnant liver volume; BWR – body weight ratio; sTLV – standardized total liver volume. sTLV=–794.41+1267.28×BSA (m^2). Interval means the intervening period between the first and second percutaneous liver biopsies.

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

Table 3. The serial LFT changes in post LDLT.

		Conventional group	Reduction group	*p*-Value
Donor				
AST (IU/L)	POD#1	195.73±120.20	232.00±146.91	0.454
	POD#3	101.78±36.86	74.57±13.85	
	POD#5	69.80±26.06	48.14±15.80	
ALT (IU/L)	POD#1	203.48±127.75	248.14±124.14	0.253
	POD#3	116.99±55.57	126.86±37.81	
	POD#5	83.81±29.05	81.14±31.66	
PT time (second)	POD#1	16.15±1.62	15.63±0.99	0.454
	POD#3	14.76±1.24	14.73±1.25	
	POD#5	12.99±0.89	12.73±0.43	
T-bil (mg/dL)	POD#1	2.71±1.01	3.04±1.60	0.253
	POD#3	2.01±1.28	2.40±2.09	
	POD#5	1.48±0.87	1.34±0.28	
Recipient				
AST (IU/L)	POD#1	376.5±298.0	236.8±115.9	0.307
	POD#3	105.0±71.6	49.4±13.4	
	POD#7	69.4±47.8	49.2±31.4	
	POD#28	36.0±31.0	34.2±24.5	
ALT (IU/L)	POD#1	376.7±288.6	255.7±121.1	0.545
	POD#3	185.1±127.2	111.2±39.7	
	POD#7	155.6±154.6	108.5±71.4	
	POD#28	69.7±95.5	68.5±73.8	
T-bil (mg/dL)	POD#1	5.1±4.9	2.3±1.2	0.367
	POD#3	3.2±3.7	1.2±0.3	
	POD#7	2.8±2.6	1.0±0.2	
	POD#28	1.1±1.4	0.6±0.2	
PT (INR)	POD#1	1.6±0.2	1.4±0.1	0.192
	POD#3	1.3±0.1	1.1±0.0	
	POD#7	1.2±0.1	1.1±0.0	
	POD#28	1.0±0.1	1.0±0.0	

AST – aspartate aminotransferase; ALT – alanine aminotransferase; T-bil – total bilirubin; PT – prothrombin; POD – post operation day.

Hepatic steatosis is very common; more than 20% of patients planned for liver resection have some degree of steatosis [5]. Marsman et al. showed that livers with up to 30% steatosis used for LDLT could result in a decreased rate of 4-month graft and 2-year patient survival rates [23]. Rinella et al. reported that a donor with BMI less than 25 has a low risk of hepatic steatosis [24]. Consequently, some institutions have tried to improve hepatic steatosis with weight reduction. For example, Hwang et al. educated their donors to adhere to a low-calorie balanced diet (25–30 calories×ideal body weight [kg] per day), aerobic exercise, and total abstinence from alcohol [14]. Nakamuta et al. treated donors with hepatic steatosis more strictly, with an initial oral diet intake of 1,400 kcal per day for 2 days, an then intake of 1,200 kcal per day orally for 2 days. The last-step maintenance oral diet intake was 1,000 kcal per day containing 131 g per day of carbohydrate, 92 g per day of protein, and 13 g per day of fat. Simultaneously, they educated donors to adhere to an exercise program with the goal of burning 600 kcal per day (200 kcal×3 exercise sessions), mainly with a stationary bike. For medication, donors were administered bezafibrate (400 mg/day) until the day of surgery [2]. Both studies showed improvement in hepatic steatosis in

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

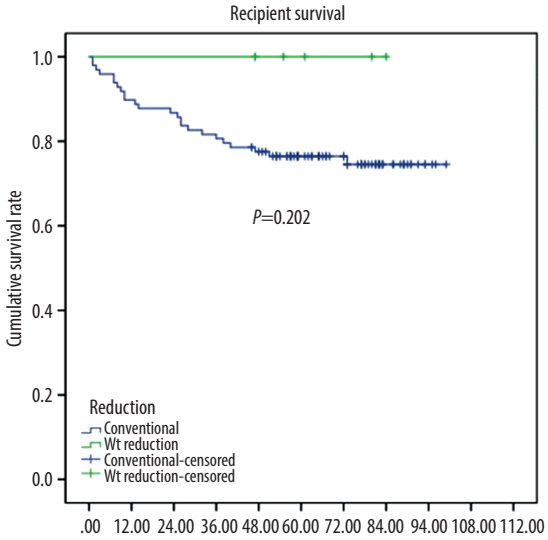

Figure 1. Rate of recipient survival between the C and RD groups. Recipient survival in both the CV and RD groups was analyzed by the Kaplan-Meier method. Statistical differences were considered significant when $p<0.05$. There was no statistically significant difference between the CV and RD groups in survival rates ($p=0.202$).

donors. LDLT was then performed without any adverse events in either donors or recipients. In addition to these studies, various combination therapies for steatosis with restricted diet and exercise have been reported [25–29].

The same results were obtained with the simple treatment of weight reduction in the current study. Because this method is more efficient and simpler to comply with, it is a promising way to ensure the safety of donors and expand the pool of available liver transplant donors.

The Asian population tends to have a higher percentage of non-obese patients with nonalcoholic fatty liver disease (NAFLD) than the Western population [30]. Therefore, prevalence of low BMI and hepatic steatosis may be high. For example, prevalence of NAFLD in non-obese patients was 16.14% in Korea [31]. Our study excluded donors with hepatic steatosis but with low BMI from the RD group. Therefore, further studies are required of donors with hepatic steatosis and low BMI, with the goal of expanding the donor pool.

This study should be interpreted with certain limitations in mind. It was retrospective and conducted at a single center with a small number of subjects.

Conclusions

Simple weight reduction improves steatosis and contributes to safer LDLT for both recipients and donors. Importantly, our findings indicate that even steatotic livers can be used for LDLT after the donors adhere to a simple weight reduction protocol.

References:

1. Porret PM, Olthoff KM: Current state of living donor liver transplantation. Clin Liver Dis, 2013; 2: 160–64
2. Nakamuta M, Morizono S, Soejima Y et al: Short-term intensive treatment for donors with hepatic steatosis in living-donor liver transplantation. Transplantation, 2005; 80: 608–12
3. Park PJ, Yu YD, Yoon YI et al: Single-center experience using marginal liver grafts in Korea. Transplant Proc, 2018; 50: 1147–52
4. Meng H, Yang J, Yan: Donor safety in adult-adult living donor liver transplantation: A single-center experience of 356 cases. Med Sci Monit, 2016; 22: 1623–29
5. Bernuau J, Rueff B, Benhamou JP: Fulminant and subfulminant liver failure: Definitions and causes. Semin Liver Dis, 1986; 6: 97–106
6. Loinaz C, Gonzáles EM: Marginal donors in liver transplantation. Hepatogastroenterology, 2000; 47: 256–63
7. D'Alessandro AM, Kalayoglu M, Sollinger HW et al: The predictive value of donor liver biopsies for the development of primary nonfunction after orthotopic liver transplantation. Transplanatation, 1991; 51: 157–63
8. Vetelainen R, van Vliet A, Gouma DJ, van Gulik TM: Steatosis as a risk factor in liver surgery. Ann Surg, 2007; 245: 20–30
9. Imber CJ, St Peter SD, Handa A, Friend PJ: Hepatic steatosis and its relationship to transplantation. Liver Transpl, 2002; 8: 415–23
10. Busuttil RW, Tanaka K: The utility of marginal donors in liver transplantation. Liver Transpl, 2003; 9: 651–63
11. Marcos A, Fisher RA, Ham JM et al: Liver regeneration and function in donor and recipient after right lobe adult to adult living donor liver transplantation. Transplantation, 2000; 69: 1375–79
12. Monsour HP Jr., Wood RP, Ozaki C et al: Utility of preoperative liver biopsy in live-related donor patients for liver transplantation. Transplant Proc, 1994; 26: 138–39
13. Guzzaloni G, Grugni G, Minocci A et al: Liver steatosis in juvenile obesity: Correlations with lipid profile, hepatic biochemical parameters and glycemic and insulinemic responses to an oral glucose tolerance test. Int J Obes Relat Metab Disord, 2000; 24: 772–76
14. Hwang S, Lee SG, Jang SJ et al: The effect of donor weight reduction on hepatic steatosis for living donor liver transplantation. Liver Transpl, 2004; 10: 721–25
15. Truant S, Boleslawski E, Sergent G et al: Liver function following extended hepatectomy can be accurately predicted using remnant liver volume to body weight ratio. World J Surg, 2015; 39: 1193–201
16. Vauthey JN, Abdalla EK, Doherty DA et al: Body surface area and body weight predict total liver volume in Western adults. Liver Transpl, 2002; 8: 233–40
17. Um EH, Hwang S, Song GW et al: Calculation of standard liver volume in Korean adults with analysis of confounding variables. Korean J Hepatobiliary Pancreat Surg, 2015; 19: 133–38
18. Dindo D, Demartines N, Clavien P-A: Classification of surgical complications. Ann Surg, 2004; 240: 205–13
19. Vauthey J-N, Pawlik TM, Abdalla EK et al: Is extended hepatectomy for hepatobiliary malignancy justified? Ann Surg, 2004; 239: 722–32

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]

20. Shoup M: Volumetric analysis predicts hepatic dysfunction in patients undergoing major liver resection. J Gastrointest Surg, 2003; 7: 325–30
21. Rafiq N, Younossi ZM: Effects of weight loss on nonalcoholic fatty liver disease. Semin Liver Dis, 2008; 28: 427–33
22. Choudhary NS, Saraf N, Saigal S et al: Rapid reversal of liver steatosis with life style modification in highly motivated liver donors. J Clin Exp Hepatol, 2015; 5: 123–26
23. Marsman WA, Wiesner RH, Rodriguez L et al: Use of fatty donor liver is associated with diminished early patient and graft survival. Transplantation, 1996; 62: 1246–51
24. Rinella ME, Alonso E, Rao S et al: Body mass index as a predictor of hepatic steatosis in living liver donors. Liver Transpl, 2001; 7: 409–14
25. Keeffe EB, Adesman PW, Stenzel P, Palmer RM: Steatosis and cirrhosis in an obese diabetic. Digest Dis Sci, 1987; 32: 441–45
26. Palmer M, Schaffner F: Effect of weight reduction on hepatic abnormalities in overweight patients. Gastroenterology, 1990; 99: 1408–13
27. Ueno T, Sugawara H, Sujaku K et al: Therapeutic effects of restricted diet and exercise in obese patients with fatty liver. J Hepatol, 1997; 27: 103–7
28. Festi D, Colecchia A, Sacco T et al: Hepatic steatosis in obese patients: Clinical aspects and prognostic significance. Obesity Rev, 2004; 5: 27–42
29. Chalasani N, Younossi Z, Lavine JE et al: The diagnosis and management of nonalcoholic fatty liver disease: Practice guidance from the American Association for the Study of Liver Diseases. Hepatology, 2018; 67: 328–57
30. Lee HW, Kim KJ, Jung KS et al: The relationship between visceral obesity and hepatic steatosis measured by controlled attenuation parameter. PLoS One, 2017; 12: e0187066
31. Kim HJ, Kim HJ, Lee KE et al: Metabolic significance of nonalcoholic fatty liver disease in nonobese, nondiabetic adults. Arch Intern Med, 2004; 164: 2169–75

Indexed in: [Science Citation Index Expanded] [Index Medicus/MEDLINE] [Chemical Abstracts] [Scopus]