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The Importance of Predicting the Differance between Preoperative Estimated Graft Volume and Intraoperative Actual Graft Volume on Donor Selection in Adult Living Donor Liver Transplantation: A Single Center Experience

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Backgrounds: In living donor liver transplantation, a difference between the intraoperative actual right lobe graft weight and the preoperative CT volumetric estimation is frequently seen, which may has an impact on the safety of living donors and the prognosis of recipients.

Objective: Our aim of the study was how to predict the difference between intraoperative actual and preoperative estimated right lobe graft weight and graft-recipient body weight ratio in adult living donor liver transplantation.

Methods: Our study was conducted on 400 donors who involved in adult right lobe liver transplantation at Ain Shams Center for Organ Transplantation (ASCOT) between 2008 and 2020.Preoperative right lobe liver graft volumetry was performed with dynamic hepatic computed tomography (CT) using automatic volume calculating software and compared with actual intraoperative blood free graft weight which obtained after hepatectomy using automated electronic scale.

Results: The Mean donor age was 27.9 ± 6.78 years old, and 292 of the donors were males. The mean preoperatively estimated graft volume was 917.4±156.2 g and the mean intraoperative measured actual graft volume was 798±150 g. There was a statistically significant difference (p=0.0001). A mean±SD of difference between estimated and actual liver volume is 12.8±4.2%.

Conclusion: Surgeons who specialize in liver transplantation should be aware that there is a discrepancy between the estimated and actual graft volume. The weight of the right lobe graft can be predicted preoperatively by reducing the preoperatively estimated liver volume by 12-14%. Also, actual right lobe volume = 249.7 + 0.59 (Estimated right lobe volume).

Key words: Liver, living donor liver transplantation, Actual graft weight, CT volumetric analysis.

Introduction

Living donor Liver transplantation (LDLT) is a complex procedure of surgical skills and decision making. From preoperative period to postoperative follow up, multidisciplinary team involvement is necessary. Starzl performed the first successful liver transplantation in 1967.[1]

Long waiting lists of patients requiring liver transplantation surpassed the number of cadaveric liver donors; Until Strong performed the first successful LDLT in 1989. Adult LDLT using right lobe liver graft was introduced in 1996 overcoming small size grafts (Left lobe graft) with inability to meet the metabolic demands of adult recipients.[2]

Thanks to LDLT, liver transplantation is possible during limited numbers of cadaveric liver or in countries where cadaveric liver transplantation is not yet approved. In Egypt, deceased organ donation is not yet approved thus LDLT is life saving for patients with end stage liver disease.[3]

Unlike cadaveric liver transplantation, LDLT harnesses risks for both the donor and the recipient. Accurate prediction of donor graft volume preoperatively prevents not only postoperative donor liver failure but also prevent graft failure for the recipient due to small graft-recipient body weight ratio (GRBWR). Today, graft size appropriateness for donation is determined using both GRBWR and graft weight as a percentage of standard liver mass. GRBWR should be at least 0.8%, or around 40% of the standard liver volume, with a GRBWR of 1% being roughly similar to 50% of the standard liver mass. These numbers, however, are based on LDLT in individuals who are not critically ill. Donor liver shouldn't be resected for more than 70% of the total liver volume to avoid liver failure requiring urgent liver transplantation.[4,5]

In LDLT, preoperative liver volume assessment using CT volumetry and automatic volume calculation software remains standard method, but variation between preoperative and intraoperative volume measurements exists. Seleem et al evaluated discrepancy between estimated right lobe liver graft volume and actual intraoperative graft volume in 45 LDLT. Seleem et al concluded that actual graft weight could be predicted by multiplying the

estimated graft volume by 0.96.[3]

Our aim is how to predict the difference between intraoperative actual and preoperative estimated right lobe graft weight and graft-recipient body weight ratio in adult living donor liver transplantation.

Methods

Study setting

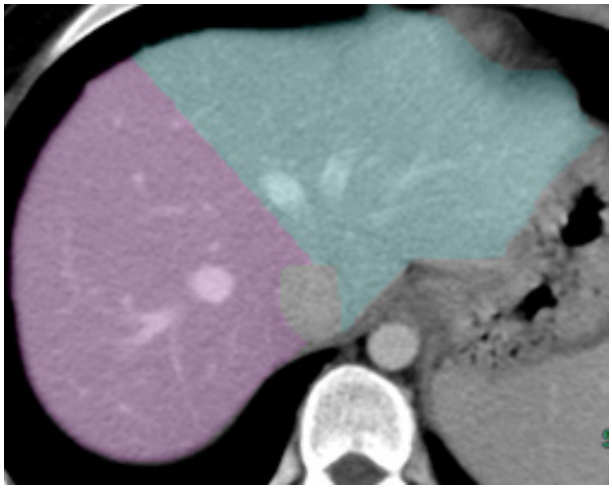
In this retrospective observational study, we evaluated 400 living donors involved in adult-to-adult right lobe liver transplantation from May 2008 to May 2020 at Ain Shams center for organ transplantation (ASCOT) from May 2008 to May 2020. Ethical committee approval was obtained.

Preoperative right lobe graft assessment

Preoperative multi-phasic Post-contrast CT study was performed to our candidates using (Siemens SOMATOMA definition flash 128 slice dual source).

The hepatic venous phase images were used for post-processing on (Syngo Acquisition Workplace), were the hepatic veins seen opacified to be our guide at the volumetric study. A 10 mm slice thickness cuts were recreated followed by tracing the liver boundaries excluding the surrounding organs to calculate the total liver volume. The assumed mean liver density equals 1 gm/ml means that the calculated volumes equal their respective weights.

Using our middle hepatic vein as our guide, virtual plane was drawn dividing the liver into right and left lobes namely according to Couinaud classification (Segments V, VI, VII and VIII as the right lobe) and (Segments II, III and IV) as the left lobe associated with the caudate lobe, this plane runs from the inferior vena cava to the gallbladder fossa as shown in **(Figures 1 a,b,c).**



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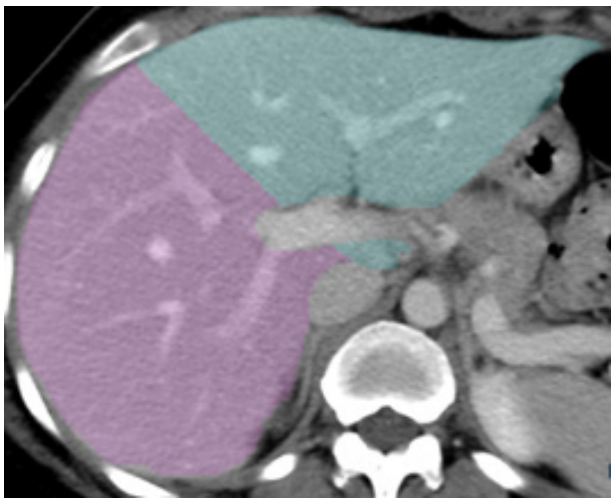

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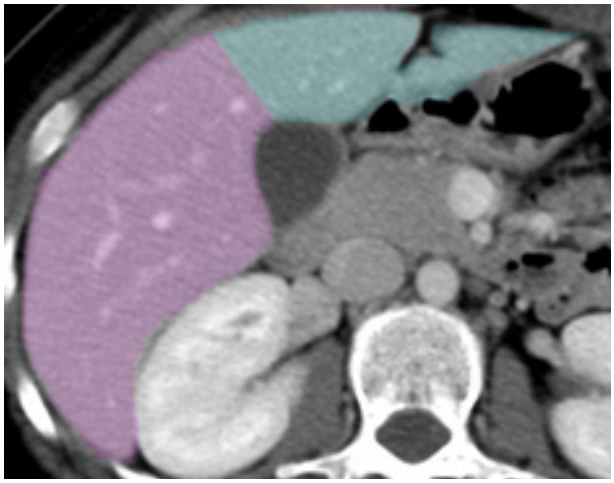

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Fig 1: Shows the virtual line drawn just to the right of the middle hepatic vein (+/- 1 cm) dividing the liver into right lobe without middle hepatic vein (purple shadow) and left lobe with middle hepatic vein (blue shadow) at the level of insertion of hepatic veins into IVC (Fig. 1a), the level of portal bifurcation (Fig. 1b) and at the level of gall bladder fossa (Fig. 1c).

The estimated volume of the right and left hepatic lobes were then calculated twice, with and without the middle hepatic vein.

The right lobe of the liver without MHV, residual liver volume for the donor (Left lobe + MHV) as well as the graft recipient weight ratio were then calculated by an expert hepatobiliary consultant radiologist (More than 20 years' experience).

Intraoperative:

Back-table procedure and graft weight measurement:

The line of resection was determined by using intraoperative ultrasound, which visualize the path

of the middle hepatic vein and its tributaries. The course of the main trunk of the middle hepatic vein was marked and line of resection was drawn 1 cm to the right of MHV using surgical electrocutery **(Figure 2)**. During parenchymal transection, any significant accessory hepatic veins were clamped and divided. After parenchymal transection was completed, the right hepatic artery was ligated and divided while right portal vein and the right hepatic vein were clamped and divided. The vascular clamps were released to drain the blood from the graft then the graft was removed and we manually press the liver graft. We routinely measured the right liver graft weight immediately after procurement after the blood was drained (Blood-free graft weight) **(Figure 3)** followed by cannulation of right portal vein and wash by about 3-4 liters of HTK (histidine-tryptophan-ketoglutarate) solution on the back table. Flushing was maintained until the wash became clear and then kept immersed in the HTK (Bretschneider, Germany).

The preoperative estimated GRBWR (Graft to recipient body weight ratio) and estimated graft volume were compared to actual GRWR and actual graft weight.

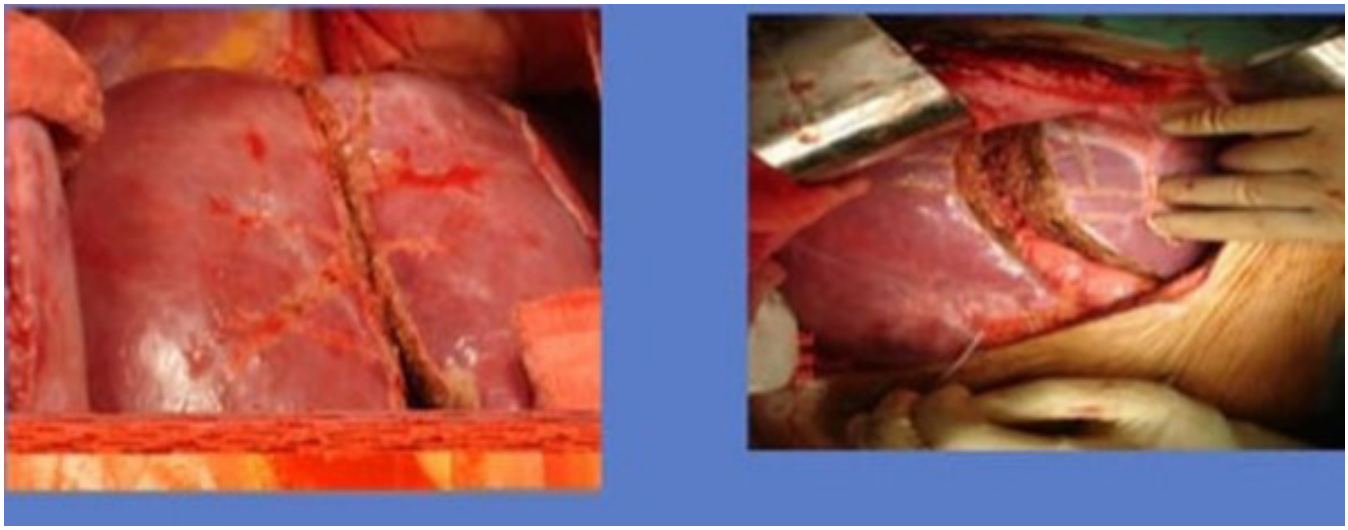

Fig 2: Showed ultrasound guided line of resection of right lobe graft which is marked 1 cm to the right of MHV.

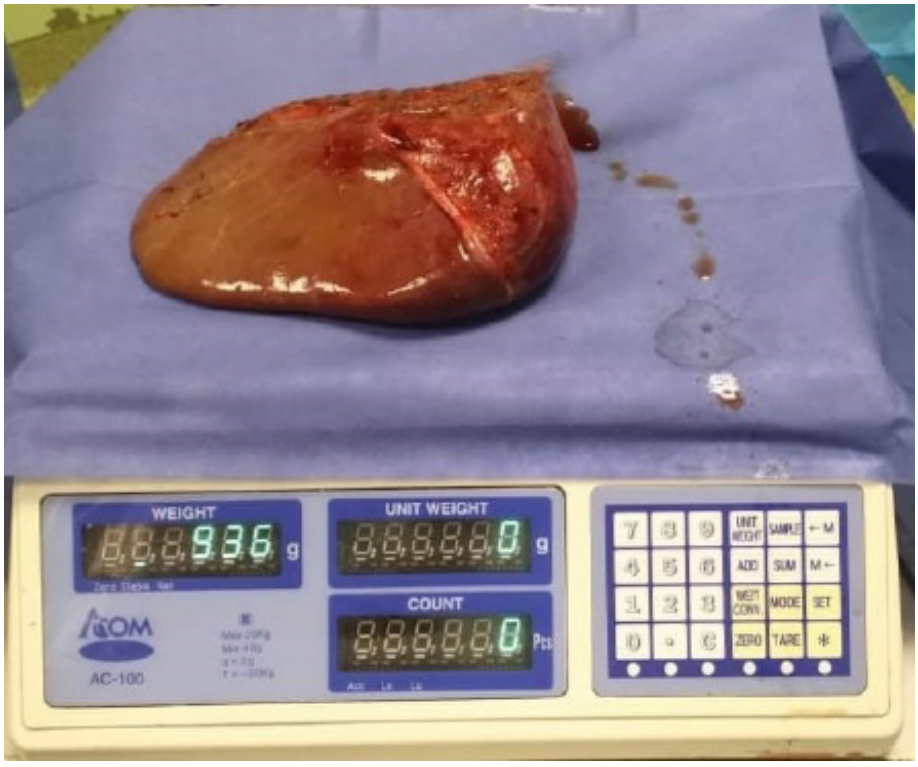

Fig 3: Showed intraoperative right lobe blood free graft weight using automated electronic scale.

Statistical analysis

Data were collected and sorted on Microsoft excel. Statistical analysis was done using IBM SPSS Statistics for Windows, version 26 software. Quantitative data were presented as mean ± standard deviations. Also qualitative variables were presented as number and percentages. Chi-square test, Fisher exact test for categorical data. Independent t-test was used to compare means of continuous data. A linear regression analysis between the estimated GRWR and graft volume versus actual GRWR and graft volume was performed.

Results

400 living donors involved in adult-to-adult right lobe liver transplantation from May 2008 to May 2020. Mean donor age was 27.9 ± 6.78 years old, and 292 of the donor participants were males. Preoperative estimated right lobe graft volume was 917.4 ± 156.2. Other characteristics including donor's BMI and estimated GRWR are presented in **(Table 1)**.

As predicted, mean actual graft volume is significantly lower than preoperative estimated right lobe graft volume (798±150 vs. 917.4±156.2, p=0.0001). As for GRWR%, intraoperative GRWR is lower than estimated GRWR using CT volumetry (1.04±0.23 vs 1.22±0.3, p=0.0001), as shown in **(Table 2).**

(Figure 4) shows linear regression between estimated GRWR of right lobe (X-axis) and actual GRWR of the right lobe (Y- axis). The relationship was highly significantly linear (R = 0.8o, r2 = 0.64, adj. r2 = 0.64, p < 0.0001) with intercept = 0.19 and slope = 0.720. A significant positive correlation between estimated GRWR and actual GRWR (Pearson correlation=0.80, p=0.0001).

Regarding the relationship between preoperative estimated graft volume and actual intraoperative right lobe graft volume, A highly significant linear relationship (R = 0.61, r2 = 0.38, adj. r2 = 0.38, p < 0.0001) with intercept = 249.7 and slope = 0.59. A significant positive correlation between estimated graft volume and actual graft volume (pearson correlation=0.61, p=0.0001), **(Figure 5).**

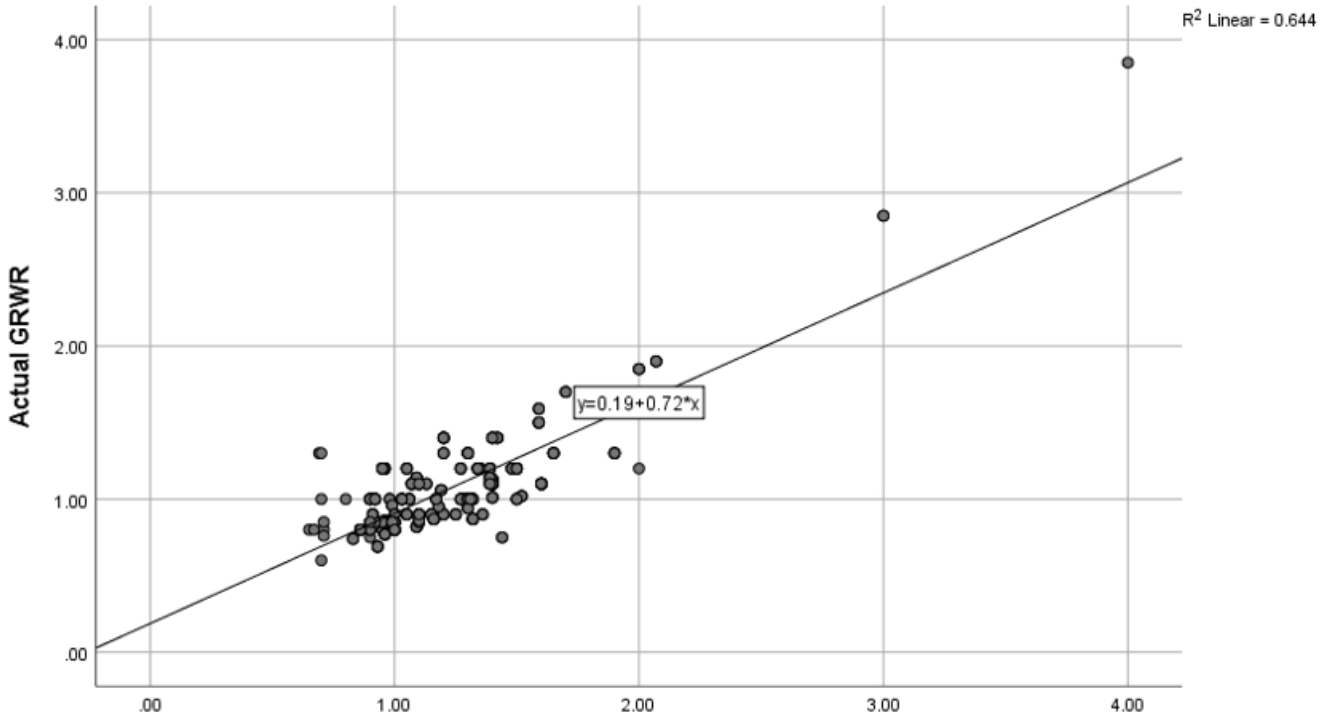

Fig 4: The relationship between preoperative estimated GRWR and actual intraoperative GRWR Of the right lobe.

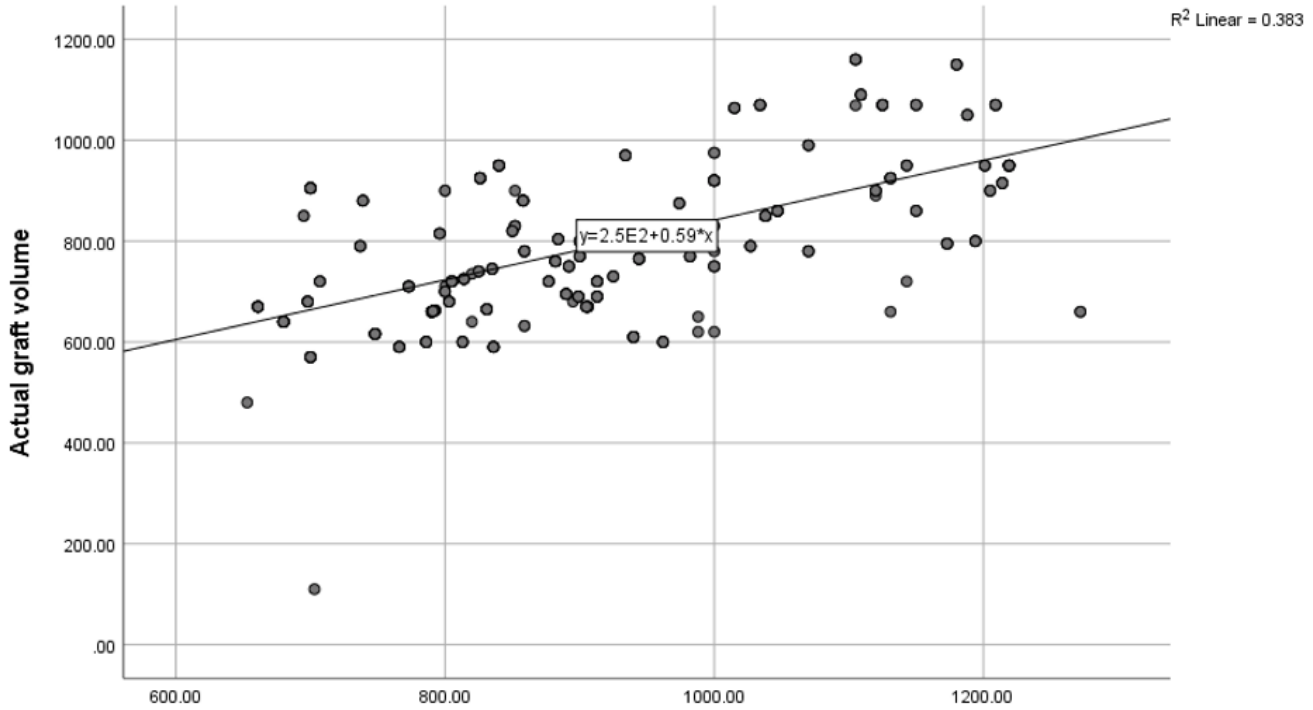

Fig 5: The relationship between preoperative estimated graft volume and actual intraoperative right lobe graft volume.

Table 1: Baseline characteristics

		No. = 400
Donor Age (years)	Mean ± SD	27.9 ± 6.78
	Range	18 – 48
Donor gender	Females	108 (27%)
	Males	292 (73%)
Donor BMI (kg/m2)	Mean ± SD	24.27 ± 3.43
	Range	15.8 – 38
Donor Estimated graft volume (g)	Mean ± SD	917.4 ± 156.2
	Range	653 – 1272
Donor Estimated GRWR %	Mean ± SD	1.22 ± 0.31
	Range	0.83 – 4

Table 2: Comparison between estimated and actual graft volume and GRWR

	Preoperative (Estimated)	Intraoperative (actual)	P-value
Graft volume	917.4±156.2	798±150	0.0001
GRWR %	1.22±0.3	1.04±0.23	0.0001

Discussion

Liver transplantation is a lifesaving option for end-stage liver disease. Thanks to LDLT, a safe and effective alternative to cadaveric transplantation, we were able to reduce waiting lists of patients demanding liver transplantation.[6]

The main principle in LDLT is to provide enough graft (At least GRWR 0.8%) to the recipient while leaving enough (At least 30%) liver remnant to the donor. Failure to provide enough graft volume to the recipient might not meet patient's metabolic demands resulting in small for size syndrome (SFSS).[7] SFSS is characterized by presence of ascites, prolonged coagulopathy, prolonged hyperbilirubinemia, and grade 3 or 4 encephalopathy leading to worse graft survival. Therefore, adequate pre-operative prediction of actual graft volume and GRBWR might

increase donor safety and decrease incidence of SFSS and improve grafts and patients survival.[2,8]

Preoperative CT volumetry is currently used for estimating right lobe graft volume. In our study of 400 donors, There was significant positive correlation between estimated graft volume and actual graft volume and between estimated GRWR and actual GRWR (Pearson correlation=0.80, p=0.0001) and (Pearson correlation=0.61, p=0.0001) respectively. Besides, it showed equation for predicting actual right lobe volume = 249.7 + 0.59 (estimated right lobe volume) while actual GRWR% = 0.19 + 0.72 (Estimated GRWR).

Similar to our study, LATIF et al. estimated preoperative graft volume in LDLT using a cohort of 115 patients. Using liner regression model, authors found a significant linear relation between estimated right lobe volume and actual right lobe weight. Authors proposed the following model: Actual right lobe (g) = 134.004 + 0.796 (Estimated right lobe volume). Results of spearman correlation showed a highly significant positive association between estimated volume of right lobe and actual weight of the right lobe ($\rho = 0.808$, $p < 0.0001$).[9]

Baskiran et al evaluated preoperative liver volume in LDLT. One hundred seventy-four donor right liver lobe patients were included. A significant difference between preoperative and postoperative graft volume is measured. BMI and age had significantly impacted difference between estimated and actual graft volume. In our study, we found actual graft volume and GRWR are significantly lower than estimated graft volume and GRWR, p=0.0001. Baskiran reported mean±SD of difference between estimated and actual liver volume as 5±2.5%. A deviation of 10%, according to literature, is expected. In our study, a mean±SD of difference between estimated and actual liver volume is 12.8±4.2%.[10]

In two small studies by Seleem et al and Pinheiro et al, authors predicted preoperative graft weight needed using liner regression models. Seleem et al., studied 45 right lobe liver graft donors. Actual weight can be predicted by multiplying estimated graft volume by 0.96. Similarly, Pinheiro reviewed 28 donors for right lobe LDLT. A significant positive correlation (0.65,p=0.0001) is seen between estimated graft volume and actual graft weight where actual graft weight= 0.82 (Estimated graft volume).[3,11] While in our study, A highly significant linear relationship between preoperative (Estimated) graft volume and actual right lobe graft volume with slope=0.59.

Several investigations are being done to determine the actual weight of living donor right lobe liver transplants. In those investigations, the graft weight is predicted using a number of formulas. In addition to the preoperative predicted transplant volume, these various algorithms take into account a wide range of variables, including body weight, body surface area (BSA), portal vein, donor age, donor sex, and entire liver volumes.[12,13] In our study, we considered the weight of the right lobe graft after the blood was drained (Blood-free graft weight) after hepatectomy.

Conclusion

Proper preoperative evaluation and prediction of the donor graft volume should be performed in order to ensure done safety and prevent morbidity and mortality, as well as improve recipients' prognosis as regard small-for-size syndrome. The weight of the right lobe of the liver graft can be predicted preoperatively by reducing the preoperatively estimated liver volume by 12-14%. Also, through an equation actual right lobe volume = 249.7 + 0.59 (estimated right lobe volume). More researches should be applied to clarify the time at which the graft is weighed.

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