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Prediction of Liver Volume from Liver Transplant Donor using Biometric Formula compared with Computed Topography Volumetry

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Abstract

Introduction. Liver volume calculation is critical in assessing the compatibility and resectability of the graft in living donor liver transplants (LDLT). An accurate estimation of liver volume is a predictor for successful LDLT. The gold standard of liver volume estimation is CT Volumetry. Despite several limitations in the availability of software, facility, and time consumed, there is still disagreement of biometric formula to predict liver volume in Indonesia.
Methods: A cross-sectional design study was carried out in Dr. Cipto Mangunkusumo General Hospital, enrolling those who underwent liver transplantation from 1st January 2010 – 3rd October 2019. Bodyweight, body height, body mass index, body surface area, and CT volumetry were the variables of interest in the study and were subjected to analysis.
Result. Body weight, body height, and body surface area are found from multivariate analysis in this research. Multivariate logistic regression of body weight with caudal liver volume giving out liver volume estimated equation of estimate liver volume of 479.23 ± 13.95 (bodyweight). The equation in this study proposes a biometric formula to estimate liver volume using bodyweight based on Indonesian anthropometry.
Conclusion: Bodyweight is proposed for equation formation based on a characteristic patient feature in Indonesia. Accuracy testing of the liver estimation equation discovered in this study proposed an entirely satisfactory result in the Indonesian population.

Key words: liver volume, liver transplant, biometric formula, CT volumetry

Introduction

The scarcity of donors must limit liver transplants. Only about 5 % of all liver transplants around the world are using a living donor. In China, about 80% of all liver transplants were using living donors due to the lack of deceased donors.[1,2] Presence of living donor liver transplant (LDLT) lowered the deceased donor liver transplant (DDLT).[3] LDLT were first performed for children in 1989; within ten years, it is performed for adults and brings a breakthrough to Liver transplant development.[4] For this reason, as the national referral hospital, dr. Cipto Mangunkusumo General Hospital decided to study more on LDLT than DDLT. From January 2010 up to May 2018, about 40 liver transplants were performed in dr. Cipto Mangunkusumo General Hospital, 5 out of 40 patients were adults, and the rest were children, with most indications of biliary atresia.

Accurate liver volume calculation acts as one of the predictors for successful LDLT and is required to estimate adequate liver volume, which is essential to determine the suitability of the graft and resectability of the organ for LDLT. About 30% of normal liver parenchymal tissue is enough for the donor to pursue life without symptoms of steatosis.
Small graft size might result in dysfunction of the graft, while larger graft size might result in poor perfusion and threaten the donor's life.[6] Minimum graft size for LDLT, to promote adequate graft function within the recipient body, is called a graft to recipient body weight ratio or GRBWR, the required value of GRBWR ratio must be equal to or above 0.8%. Thus, an accurate liver volume is essential. At least 0.8% and above are the required value of graft to recipient body weight ratio or GRBWR. It is a minimum graft size for LDLT to promote adequate graft function within the recipient body.[7]
CT Volumetry is a non-invasive method in calculating liver volume referred to as a gold standard. Although limited facility as of the availability of software, facility and time-consuming.[8]
Initially, in 1995, Urata et al. propose a liver volume calculation formula based on the biometric of the donor. Other researchers follow his step and introduce their formula for liver volume calculation; each research differs in population. For example, in the USA, Vauthey et al. use body surface area or BSA to create the formula involving 292 patients.[9-13]
To date, Indonesia has not proposed any biometric formula to predict liver volume from transplant donors. With that in mind, this study focused on formulating liver volume estimation using biometric of the donor based on the liver volume of the donor in the Indonesian population.

Method

We carried out a cross-sectional stud to discover the new formula to predict Indonesian liver volume in adult liver transplant donors close to its original volume. This research takes place in Dr. Cipto Mangunkusumo General Hospital, from 1 January 2010 - 3 October 2019. Liver transplant donor is the target population of this research,

accessible population should be, the scheduled LDLT patient in dr. Cipto Mangunkusumo General Hospital, from 1 January 2010 – 3 October 2018. This research includes all patients within an accessible population that meet inclusion criteria with no exclusion criteria. We were using the total population sampling method, which includes scheduled LDLT donors in dr. Cipto Mangunkusumo General Hospital patient within a period of 1 January 2010 – 3 October 2018, complete measurement of the donor including complete patient data, body weight, height, body surface area (BSA), and CT Volumetry result are required, even then, to meet sample quantity to calculate their correlation, subject undergoing LDLT without complete data are also counted.

Collected data processed and presented in tabular form, followed by the description of liver volume prediction comparing CT Volumetry and biometric formula. The analytical study was processed using SPSS version 20. The analysis is then conducted using a correlation study between the independent variable and dependent variable. Data analyzed using Bland – Altman to understand the correlation gap and mean and spot any outliers in this research.
The study approved by the Committee of ethics, Faculty of Medicine, Universitas Indonesia.

Results

In the study, of 57 subjects were enrolled, only 49 subjects met the inclusion criteria. The most donor was female (59.2%). Age was distributed unevenly, with a median of 32(21–50) year. The mean height is about 163.45cm $\pm$ 9.90, while the mean weight is about 59.4 kg $\pm$ 11.4. Body mass index and body surface area were unevenly distributed, with the mean of 22.17 kg/m2 $\pm$ 3.14), and the median of 1.61m^2 (1.25–2.07), respectively.

Bivariate analysis on anthropometry variables, age, body weight, height BMI, and BSA was done, and the Spearman correlation analysis performed between anthropometry variables with CLV is as follows. The coefficient correlations of age, body weight, height, body mass index, and body surface area were 0.218 with a p-value of 0.133, 0.589, with a p-value of 0.000, 0.350, with a p-value of 0.014, and. 0.607 with a p-value of 0.000, respectively. Those variables with a p-value of <0.25 underwent multivariate analysis. The analysis included the body weight, body height, and BSA (Table 1). On multivariate logistic regression, height and BSA were excluded. In further analysis, we found body weight was a substantial variable (table 2).

Table 1. Multivariate logistic regression analysis anthropometry variable with CLV

Variables	Enter Method			Backward Method		
	B	SE	p value	B	SE	p value
Constant	-4468.2	3117.5	0.159	-5054.7	3125.2	0.113
Age	5.70	4.02	0.163			
Body weight	150.5	49.6	0.004	144.7	50.1	0.006
Body height	94.9	36.9	0.014	99.2	37.2	0.011
BMI	127.4	76.3	0.102	147.2	75.9	0.059
BSA	-13249.1	4493.9	0.005	-13266	4545.2	0.006

Value R^2 for enter method is 0.586, Value R^2 for backward method are 0.567. B: beta (coefficient of correlation); SE: standard error, BMI: body mass index, BSA: body surface area

Table 2. Multivariate logistic regression analysis between body weight variable and CLV

Factor	Enter Method		
	B	S.E.	p value
Constant	479.23	130.13	0.001
Body Weight	13.95	2.14	0.000

R2 = 0.473, B: beta (coefficient of correlation), SE: standard error

Table 3. Multivariate analysis on the formula from proposed biometric formula

Formula analysis	Value
Range ELV	1009-1734 mL
Intra-class correlation	0.782
Mean ELV	1309.1 ±159.6 mL
Median ELV-CTV	7.13 (-582 – 367) mL
Mean % error	0.03 (±0.11)

In this study, multivariate logistic regression analysis between body weight variable and CLV give out an equation believed to be the formula to estimate liver volume. The equation are as follows: Estimated Liver Volume (ELV) = 479.23 + 13.95 (body weight).

The subject data were used to perform accurate studies from the formulated equation in this research. ELV ranges from 1009 – 1734 mL from the proposed formula. ELV mean was about 1309 mL ±159.6 mL. The difference between ELC and CLV was not evenly distributed, with a median value of 7.13 mL (-582 – 367) and a mean error of about 0.03%. Reliability analysis was performed, and ICC values were of 0.782, classified as entirely satisfactory. The accuracy result is shown in table 3.

Discussion

The total subjects in this study were 49, and all subjects were healthy people that meet all the condition as a liver transplant donor. The donor's age ranges from the youngest 21 years old to the eldest 50 years, with a median age of about 32 years old. Liver transplant donor selection in this study follows previous study recommendations. Previous studies conducted by Brown et al. in 2008 stated that liver transplant donors are recommended to be around 21–55 years old, with the maximum allowed age are 60 years old. In several other studies, age contributed to liver volume estimation calculation.[15] Even though age was not a substantial factor in the equation proposed in this study, the median age obtained was about middle age and so did not affect the liver transplant

equation proposed in this result. The gender variable in this research has a normal distribution with 20 male subjects or about 40.8% and 29 female subjects or about 59.2%. Gender is also one of the factors calculated in the ELV equation. Since the gender variable in this research has a normal distribution, it is counted as no significant substantial effect in the calculated result. We found the mean body height in this study to be 163.5 cm, with a mean bodyweight of about 59.5 kg. Data collected in this research goes according to the distribution of body weight and height in Indonesian population by the age of 21–55 years old, and bodyweight about 58–62 kg and height between 163–165 cm.[16] This shows that collected data in this research can represent Indonesian population that might be the potential donor for a liver transplant. Living donor liver transplants are said to be having complicated preparation methods for a liver transplant. ELV calculation was one of the critical yet complex pre-operative preparation before LDLT. ELV calculation accuracy significantly affects donor-recipient by the minor for size phenomenon (cellular lesion, lowered functional capacity, and ascites) and considerable size phenomenon (poor perfusion, increased abdominal pressure).[17] Liver volume calculations, in general, were conducted using digital software to calculate liver. In general, liver volume calculation required digital software to calculate. In the present time, CT Volumetry is widely accepted as a universal method for liver volume calculation.

Even then, liver volume estimation calculation using CT Volumetry is minimal, and so other alternative methods are demanded, which then propose the use of biometric formula. Liver volume estimation formula anthropometric variables include age, gender, body weight, height, BMI, BSA, and thoracic circumference. We can use the biometric formula to calculate liver volume estimation in a limited facility environment. The study found a new biometric formula based on Indonesian characteristics. The liver volume estimation equation formulated in this research was the first to estimate liver volume in Indonesia. Even then, this equation requires further validation tests to be valid in estimating Indonesian liver volume.

In the multivariate analysis, substantial variables found include body weight, height, and BSA. Based on multivariate logistic regression analysis height, and BSA shows less significance, and the variable was excluded. The linear regression resulted on body weight with CLV shows the following equation: 479.23 $\pm$ 13.95 (bodyweight). The estimated liver volume accuracy test of this equation ranging from 1009 – 1734 mL, with a mean ELV of 1309 mL ±159.6. The mean difference between estimated liver volume and caudal liver volume was not distributed normally with a median of 7.13 mL (–582–367) and a mean error of 0.03%. The result of the reliability test shows an interclass correlation of about 0.782. This show result of the ELV formula in predicting liver volume based on subject data in this study was satisfactory. However, the results need to be validated

Conclusion

Univariate analysis of this study show correlation between BSA and body weight. Linear regression analysis showed a more significant relation was presented by bodyweight variable, and thus proposed for equation formation based on patient characteristics in Indonesia. Accuracy testing of the liver volume estimation equation discovered in this study propose a satisfactory result to be used in the Indonesian population. However, this finding requires a validation test externally.

Disclosure

Authors declare no conflict of interest

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