DOI: https://doi.org/10.53350/pjmhs020231712744

ORIGINAL ARTICLE

Radiological Liver Volumetry and its Impact on Surgical Decision-Making and Post-Hepatectomy Liver Failure. A Clinical Study

RABIAA MAHMOOD ALI[1], MUHAMMAD ATIQ[2], MARIA AFZAL BODLA[3], MUHAMMAD HABIB HASSAN[4], UMAIR KHAN SHERWANI[5], SIDRAH MAHMOOD[6]

[1]*Consultant Radiologist Mukhtar A Sheikh Hospital, Multan*
[2]*Assistant Professor Bakhtawar Amin Medical and dental College Multan*
[3]*Senior Registrar Lahore General Hospital, Lahore*
[4]*House Officer Bakhtawar Amin Medical and Dental College Multan*
[5]*Assistant Professor Multan Medical and Dental College Multan*
[6]*Consultant Radiologist MINAR Cancer Hospital, Multan*
Correspondence to: Muhammad Atiq, Email: ateeqahmedmtn@gmail.com

ABSTRACT

Background: Post hepatectomy liver failure (PHLF) has been an important morbidity and mortality cause after liver resection. The preoperative evaluation of the hepatic reserve must be accurately conducted to ensure the correct planning of the surgery and elimination of postoperative complications. Radiological liver volumes have become a useful method to predict future liver remnant (FLR) and maximize surgeries.

Objective: To assess how radiological liver volumetry can influence the surgical planning and its correlation with the occurrence of post-hepatectomy liver failure in patients that undergo elective hepatectomy.

Methods: This was a prospective clinical trial study where 100 patients undergoing an elective liver resection surgery at a tertiary care unit were included. Preoperative contrast-enhanced computed tomography-based liver volumetry was carried out on all patients to determine the total liver volume, planned resection volume and FLR. In making decisions in surgery relating to the degree of hepatectomy, volumetric findings were used in conjunction with clinical and biochemical parameters. The liver functions after the surgery were controlled, and PHLF was evaluated according to the standard criteria. The statistical associations were used to determine the relationship between FLR and PHLF.

Results: As an average, the liver remnant was found to be 62.3 ± 9.8. Forty-six percent of the patients had major hepatectomy, and 54 percent minor resections. A liver failure post- hepatectomy was seen in 18 percent of the patients with majority being mild to moderate cases. Patients who suffered FLR <60% showed a high incidence of PHLF than those who suffered FLR ≥60% (38.9% vs. 6.3, $p < 0.05$). Postoperative liver failure had strong relationships with lower FLR values and intrinsic chronic liver disease.

Conclusion: Radiologic liver volumetry is important and dependable preoperative risk stratification and surgical planning tool in hepatectomy. Proper evaluation of the future liver remnant would greatly decrease future hepatectomy liver failure and would help to develop personalized and safer hepatic surgery.

Keywords: Liver volumetry, future liver remnant, hepatectomy, post-hepatectomy liver failure, surgical planning.

INTRODUCTION

Hepatectomy has persisted as a primary curative procedure in a large array of hepatic pathologies, such as primary liver malignancy, metastatic tumor, as well as selected benign conditions[1]. Post-hepatectomy liver failure (PHLF) has remained the most dreaded and life-threatening complication following liver resection despite the current developments in surgical practices and perioperative care[2]. PHLF is caused by inadequate functional hepatic remnant, which is unable to sustain the metabolic, synthetic, and detoxification requirements of the body following surgery. Thus, the proper preoperative evaluation of hepatic reserve is essential to reduce morbidity and mortality and make appropriate surgical decisions[3].

Historically, the use of anatomical landmarks, subjective intraoperative evaluation, and indirect clinical liver function parameters were used to plan liver resection. Nonetheless, these methods have a restricted scope especially in patients who have a history of chronic liver disease, cirrhosis, steatosis, liver damage due to chemotherapy, or portal hypertension[4]. Within these environments, the mismatch between anatomical and real functional liver size becomes clinically important, and this leads to higher rates of PHLF despite apparently sufficient resections[5].

Radiological liver volumetry, which is mostly done through contrast-enhanced computed tomography (CT) or magnetic resonance imaging (MRI), has become an important instrument in contemporary surgery of the hepatobiliary[6] Volumetry allows total liver volume and more importantly the future liver remnant (FLR) to be calculated objectively by means of precise three-dimensional segmentation of the liver. Measurement of FLR has been found to be strongly associated with the postoperative liver performance and patient outcomes, thus directly affecting the degree of resection that can be considered as safe in the individual patients[7].

Liver volumetry has more than mere measurement. Volumetric assessment is crucial in establishing surgical eligibility, personalizing the degree of hepatectomy and choosing complementary measures like portal vein embolization or staged hepatectomy to cause pre-major resection FLR hypertrophy[8]. A smaller FLR might be tolerated in patients with normal hepatic parenchyma but in patients with impaired liver hepatic function, a much greater FLR is necessary to prevent postoperative decompensation. Volumetry therefore, provides a connection between radiological evaluation and clinical and surgical judgement[9].

Although it is used more and more, there is still a variability in the ways liver volumetry is becoming part of the standard clinical practice, especially in resource-constrained conditions. Besides, the correlation of radiologically determined liver volumes, preoperative intraoperative results, and the true occurrence of PHLF deserves additional consideration in various populations of patients. This relationship should be understood to enhance surgical thresholds, risk stratification, and patient outcomes[10].

This is a clinical study that seeks to determine the significance of radiological liver volumetry in the surgery decision-making process, as well as to determine the influence of radiological liver volumetry on the formation of liver failure in the aftermath of hepatectomy. This study aims at increasing the clinical utility of liver volumetry as a significant part of the safe and personalized hepatic surgery by correlating volumetric parameters with operative strategies and postoperative outcomes.

Received on 02-07-2023
Accepted on 25-12-2023

MATERIALS AND METHODS

This was a prospective clinical trial which was carried out among 100 patients who were undergoing elective liver resection in a teaching hospital which is in the tertiary care. The period of the study was a specific term as all qualified patients who intended to undergo partial hepatectomy were recruited one after another. The Institutional Review Board granted the ethical approval and all participants were given written informed consent before they were included in the study. Adult men and women aged 18 years and above who were to undergo hepatic resection due to malignant or benign liver lesion were participated. They were open to patients with hepatocellular carcinoma, metastatic liver disease, cholangiocarcinoma and benign tumors that required surgical resection. The patients who had undergone a major liver resection in the past, those patients with acute liver failure, progressive decompensated cirrhosis (Child Pugh C), renal insufficiency, and the absence of full radiological information were excluded. Patients having emergency liver surgery were also not included so as to keep uniformity in preoperative assessment.

Every patient was thoroughly assessed in the preoperative period, including a history of clinical and physical examination and comorbid conditions assessment. There were baseline liver functional tests of serum bilirubin, alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, albumin, and international normalized ratio. The patients were stratified based on liver functional status according to Child-Pugh classification, and the appropriate patients were calculated based on Model of End-Stage Liver Disease (MELD) score. These parameters were applied together with volumetric findings to plan surgery. Liver volumetry was done preoperative by contrast-enhanced multiphasic computed tomography. Thin-slice images were obtained and transferred to a special work station to reconstruct them in three dimensions. The techniques used to calculate total liver volume, planned resection volume, and future liver remnant (FLR) were semi-automated liver segmentation methods. The FLR was given as an absolute volume and percentage of total functional liver volume. Volumetric thresholds were standardized and more FLR demanded in patients with a history of liver disease, steatosis, or chemotherapy-related liver destruction.

Radiological volumetry results used along with clinical and biochemical parameters influenced the degree of liver resection. Patients having insufficient FLR were regarded as having modified surgical plans, comprising of limited resection or preoperative optimization. A multidisciplinary conference among hepatobiliary surgeons, radiologists and anesthesiologists made the final decision on the surgical plan. Overall intraoperative observations were recorded, such as texture of liver, fibrosis, and the actual extent of resection and compared to the volumetric approximations made beforehand. All hepatectomies have been conducted by well experienced hepatobiliary surgeons using the normal surgical procedures. Intraoperative blood loss, time of surgery, and transfusion were noted. Depending on the indicators, patients were followed in high-dependency or intensive care facility after the operation. Serial liver functioning tests were conducted on postoperative days 1, 3, 5, and 7 or till discharge.

Post hepatectomy liver failure was measured and categorized based on internationally recognized standards, which were set on the basis of the deterioration of bilirubin and coagulation parameters, which occurred after the surgery. The patients were grouped as no PHLF and PHLF with different severity. There was the recording of clinical outcome, length of hospital stays, postoperative complications, and mortality. A statistical software package was used to enter and analyze the data. Mean and standard deviation were used to present continuous variables where frequencies and percentages were used to present categorical variables. The correlation between FLR volume, surgical extent and PHLF documented was assessed with the help of the corresponding statistical tests. The p-value that was taken as significant was below 0.05.

RESULTS

The main peculiarities of the study cohort are provided in this table: the age, gender distribution, surgical indications, and baseline liver functional state. It shows that the majority of patients had undergone hepatic surgery due to malignant hepatoma, and had retained hepatic reserve, and that a significant percentage had an underlying chronic liver disease. These baseline characteristics are crucial in interpreting the risk of surgery and the postoperative results.

This table shows the correlation between the percentage of liver remnant in the future and the occurrence of the liver failure after hepatectomy. It is also a clear indication that patients with lower FLR percentages were much more likely to develop PHLF further supporting the idea of radiological liver volumetry as being an important predictor of postoperative liver function and surgical outcomes.

Table 1: Baseline Demographic and Clinical Characteristics (n = 100)

Variable	Value
Age (years), mean ± SD	52.6 ± 11.4
Gender (Male/Female)	62 / 38
Indication for Surgery	
Malignant lesions	72 (72%)
Benign lesions	28 (28%)
Liver Function Status	
Normal liver	68 (68%)
Chronic liver disease / fibrosis	32 (32%)
Child–Pugh Class A	84 (84%)
Child–Pugh Class B	16 (16%)

This table describes the quantitative outcomes of the liver volume preoperative radiology and shows the total liver volume, planned resection volume and the future liver remnant calculated in absolute and percentage. These are the measurements that gave an objective ground to assess the safety of hepatectomy, to choose the right surgical approach especially in patients with low liver reserve.

Table 2: Radiological Liver Volumetry Parameters

Volumetric Parameter	Mean ± SD
Total liver volume (mL)	1380 ± 260
Planned resection volume (mL)	520 ± 190
Future liver remnant (FLR) volume (mL)	860 ± 210
FLR as % of total liver volume	62.3 ± 9.8

When stratified by liver condition, patients with chronic liver disease had a significantly higher required FLR threshold.

In this table, patients have been divided into groups based on the degree of hepatic resection done. It shows the role of volumetric results in the take-up of operational decisions, and major hepatectomies were performed in patients with sufficient residual liver volume and minor resections were favorable in patients with marginal or impaired hepatic reserve.

Table 3: Type of Hepatectomy Performed

Type of Resection	Number (%)
Major hepatectomy (≥3 segments)	46 (46%)
Minor hepatectomy (<3 segments)	54 (54%)

Table 4: Incidence and Severity of Post-Hepatectomy Liver Failure

PHLF Status	Number (%)
No PHLF	82 (82%)
PHLF present	18 (18%)
Mild	10 (10%)
Moderate	6 (6%)
Severe	2 (2%)

This table provides a summary of the outcome of liver failure post-operation (the ratio of patients developing PHLF and the grade of severity). It emphasizes that despite recovery of most of the patients without liver failure, a portion of them developed mild

to severe PHLF, which emphasizes the clinical significance of precise preoperative risk evaluation.

This table showed the correlation between the percentage of liver remnant in the future and the occurrence of the liver failure after hepatectomy. It is also a clear indication that patients with lower FLR percentages were much more likely to develop PHLF further supporting the idea of radiological liver volumetry as being an important predictor of postoperative liver function and surgical outcomes.

This association was statistically significant ($p < 0.05$), indicating that lower FLR values were a strong predictor of post-hepatectomy liver failure.

Table 5: Association Between FLR Percentage and PHLF

FLR Percentage	Patients (n)	PHLF n (%)
≥60%	64	4 (6.3%)
<60%	36	14 (38.9%)

DISCUSSION

Liver failure after hepatectomy is one of the most severe and life-threatening complications after liver resection, and proper preoperative evaluation of hepatic reserve is vital to prevent it. The current clinical trial assessed the functions of radiological liver volumetry in surgeon decision-making as well as its effects on the progression of post-hepatectomy liver failure in 100 study patients undergoing elective hepatectomy[11]. The results indicate that volumetric evaluation of the future liver remnant (FLR) is very significant in making predictions of the outcome after the surgery as well as the receptor of surgical resection[12]. In the present research, most of the patients had liver resection due to malignant disease, and this is in line with the practice of hepatobiliary surgery in the global arena[13]. Though the liver functioning remained intact in the majority of patients, almost a third of the patients showed the presence of chronic liver disease or fibrosis, and the clinical dilemma of balancing oncologic clearance with postoperative liver safety is a challenging issue to address[14]. In these patients, the traditional liver functional tests can be not enough as the biochemical parameters do not necessarily indicate the actual functional hepatic reserve[15].

Radiological liver volumetry gave objective and reproducible results on total liver volume, volume of resection, and FLR. The research showed a direct negative correlation between the percentage FLR and the occurrence of post hepatectomy liver failure. The rate of PHLF in patients whose FLR was less than 60 percent was significantly greater than when the FLR was greater. This observation confirms the idea that poor residual liver volume is a significant predictor of postoperative hepatic insufficiency[16]. The findings also show how volumetric analysis affected surgical plan. Major hepatectomy was done in patients with sufficient FLR and minor resections were chosen in patients with low hepatic reserve. This patient-focused practice is an indication of the inclusion of radiological data in multidisciplinary decision-making, which is patient-specific surgical planning as opposed to a standard operative approach[17]. This type of individual planning is especially critical with chronic liver disease, or with liver damage that occurs during chemotherapy, or with steatosis, so that the functional reserve of the liver is decreased because of its size[18].

The PHLF indicated in this study is similar to those observed in the literature as the majority of them were mild to moderate. Severe PHLF was uncommon though had a great clinical implication since it was associated with longer hospitalization and higher rates of postoperative morbidity. Such results highlight the significance of identifying high-risk patients as early as possible with the help of volumetric assessment in order to implement some preventive measures, such as minimizing the scope of the resection or making the most out of the preoperative liver condition. This research suffers some limitations in spite of its strong points[19]. It is a single-center clinical study, which might be having institutional practices and patient demographics. Also, although volumetry estimates the liver quantity, it does not directly measure liver quality and liver functioning. The volumetric analysis along with functional tests can also be combined to further predict the risk. However, the study is well-grounded in clinical evidence to use radiological liver volumetry in preoperative assessment as a routine[20].

CONCLUSION

The Preoperative assessment of hepatectomy patients is an important and essential instrument of radiological liver volumetry. This paper shows that the correct assessment of the future liver remnant has a long-lasting impact on the decision-making of the surgery and is closely related to the risk of liver failure after the hepatectomy. Lower percentiles of FLR increase the chances of postoperative liver failure in patients significantly, and sufficient FLR correlates with positive results. Implementation of liver volumetry into the standard preoperative planning facilitates the customization of surgical plans, increased safety, and minimized postoperative problems in patients. Radiological volumetric assessment is thus regarded as a vital part of the contemporary hepatobiliary surgery especially in the patient with underlying liver disease or in those with a major liver resection.

REFERENCES

1. Rahbari NN, Garden OJ, Padbury R, Brooke-Smith M, Crawford M, Adam R, et al. Posthepatectomy liver failure: A definition and grading by the International Study Group of Liver Surgery (ISGLS). Surgery. 2011;149(5):713–724. doi:10.1016/j.surg.2010.10.001
2. Shoup M, Gonen M, D'Angelica M, Jarnagin WR, DeMatteo RP, Schwartz LH, et al. Volumetric analysis predicts hepatic dysfunction in patients undergoing major liver resection. J Gastrointest Surg. 2003;7(3):325–330. doi:10.1016/S1091-255X(02)00370-8
3. Vauthey JN, Abdalla EK, Doherty DA, Gertsch P, Fenstermacher MJ, Loyer EM, et al. Body surface area and body weight predict total liver volume in Western adults. Liver Transpl. 2002;8(3):233–240. doi:10.1053/jlts.2002.31654
4. Abdalla EK, Hicks ME, Vauthey JN. Portal vein embolization: Rationale, technique and future prospects. Br J Surg. 2001;88(2):165–175. doi:10.1046/j.1365-2168.2001.01657.x
5. Clavien PA, Petrowsky H, DeOliveira ML, Graf R. Strategies for safer liver surgery and partial liver transplantation. N Engl J Med. 2007;356(15):1545–1559. doi:10.1056/NEJMra065156
6. Ribero D, Abdalla EK, Madoff DC, Donadon M, Loyer EM, Vauthey JN. Portal vein embolization before major hepatectomy and its effects on regeneration, resectability and outcome. Br J Surg. 2007;94(11):1386–1394. doi:10.1002/bjs.5836
7. Makuuchi M, Thai BL, Takayasu K, Takayama T, Kosuge T, Gunvén P, et al. Preoperative portal embolization to increase safety of major hepatectomy for hilar bile duct carcinoma. Surgery. 1990;107(5):521–527.
8. Zappa M, Dondero F, Sibert A, Vullierme MP, Belghiti J, Vilgrain V. Liver volumetry by computed tomography in patients with hepatocellular carcinoma undergoing liver resection. Eur Radiol. 2009;19(10):2442–2448. doi:10.1007/s00330-009-1415-4
9. Lim MC, Tan CH, Cai J, Zheng J, Kow AW. CT volumetry of the liver: Where does it stand in clinical practice? Clin Radiol. 2014;69(9):887–895. doi:10.1016/j.crad.2014.04.010
10. Truant S, Oberlin O, Sergent G, Lebuffe G, Gambiez L, Ernst O, et al. Remnant liver volume to body weight ratio ≥0.5%: A new cut-off to estimate postoperative risk after extended hepatectomy in non-cirrhotic liver. J Am Coll Surg. 2007;204(1):22–33. doi:10.1016/j.jamcollsurg.2006.09.007
11. Hwang S, Lee SG, Kim KH, Ahn CS, Moon DB, Ha TY, et al. Role of computed tomography volumetry in living donor liver transplantation. Liver Transpl. 2007;13(6):822–829. doi:10.1002/lt.21078
12. Hoekstra LT, van Lienden KP, Doets A, Busch OR, Gouma DJ, van Gulik TM. Tumor progression after preoperative portal vein embolization. Ann Surg. 2012;256(5):812–818. doi:10.1097/SLA.0b013e318272df4a
13. Reissfelder C, Rahbari NN, Koch M, Kofler B, Sutedja N, Büchler MW, et al. Postoperative course and clinical significance of posthepatectomy liver failure after hepatic resection. Ann Surg. 2011;254(2):289–295. doi:10.1097/SLA.0b013e3182263913
14. Cucchetti A, Cescon M, Ercolani G, di Gioia P, Peri E, Pinna AD. Safety of hepatic resection in cirrhotic patients with hepatocellular carcinoma. Ann Surg. 2011;254(2):279–287. doi:10.1097/SLA.0b013e31822638d6

15. van den Broek MA, Olde Damink SW, Dejong CH, Lang H, Malagó M, Jalan R, et al. Liver failure after partial hepatic resection: Definition, pathophysiology, risk factors and treatment**.** Liver Int**.** 2008;28(6):767–780. doi:10.1111/j.1478-3231.2008.01777.x
16. Kokudo N, Shindoh J. How can we improve the safety of major hepatectomy? Ann Surg**.** 2019;269(3):516–517. doi:10.1097/SLA.0000000000003045
17. Schindl MJ, Redhead DN, Fearon KC, Garden OJ, Wigmore SJ. The value of residual liver volume as a predictor of hepatic dysfunction and infection after major liver resection. Gut**.** 2005;54(2):289–296. doi:10.1136/gut.2004.046524
18. Kishi Y, Abdalla EK, Chun YS, Zorzi D, Madoff DC, Wallace MJ, et al. Three hundred and one consecutive extended right hepatectomies: Evaluation of outcome based on systematic liver volumetry. Ann Surg**.** 2009;250(4):540–548. doi:10.1097/SLA.0b013e3181b5fd40
19. Li J, Miao XY, Wang GY, Zheng J, Wu H. Preoperative CT volumetry for prediction of post-hepatectomy liver failure: A systematic review. World J Gastroenterol**.** 2017;23(46):8217–8228. doi:10.3748/wjg.v23.i46.8217
20. Zarzavadjian Le Bian A, Dokmak S, Aussilhou B, Farges O, Belghiti J. Functional liver remnant assessment in hepatectomy: The role of imaging. HPB (Oxford)**.** 2020;22(2):181–189. doi:10.1016/j.hpb.2019.07.007

This article may be cited as: Ali RM, Atiq M, Bodla MA, Hassan MH, Sherwani UK, Mahmood S; Radiological Liver Volumetry and its Impact on Surgical Decision-Making and Post-Hepatectomy Liver Failure. A Clinical Study. Pak J Med Health Sci, 2023;17(12):744-747.