

How Far Does Residual Liver Volume Affect Portal Pressure Gradient During Donor Hepatectomy in Living Donor Liver Transplantation

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Abstract

Background: Living donor liver transplantation (LDLT) is now a solution for end stage liver disease. In living donors, up to 70% of the whole liver volume can be donated. Relative portal hypertension (increase of the portal pressure after donor hepatectomy as compared to the preoperative state was observed. Several factors affect portal pressure gradient in LDLT, we evaluate the effect of residual liver volume (RLV) on the portal pressure gradient.

Aim of Study: In this study we aimed to studying the correlation between portal pressure gradient and residual liver volume after donor hepatectomy in living donor liver transplantation.

Patients and Methods: This prospective study included 30 adult living donors who underwent right hepatectomy in Liver Transplantation Unit, Faculty of Medicine, Cairo University during the period between June 2015 to October 2016. Inclusion criteria an age group from 21 to 50 years with a residual liver volume $\geq 35\%$. Computed Tomography volumetry was done to all donors to calculate the graft weight recipient ratio and the residual liver volume of the donor. PVP was measured intra-operatively using wide gauge cannula preclamping and postclamping of portal vein.

Results: The mean portal pressure before and after clamping of right portal vein was 9.9mmHg and 15.23mmHg respectively ($p < 0.001$). The portal venous gradient is negatively correlated with RLV (p -value 0.029).

Conclusion: The study has demonstrated a significant rise in PVP post clamping of right portal vein. Also, the lower the percentage of residual liver volume the higher the changes in portal venous pressure.

Key Words: Liver transplantation – Residual liver volume – Portal pressure – Living donor – CT volumetry.

Introduction

THE only curative treatment for patients with irreversible acute or chronic liver failure is liver transplantation [1].

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Right-lobe grafts are commonly used in LDLT, taking about 60% of liver volume. Although LDLT using right-lobe grafts is rapidly being accepted worldwide, donor safety should be the top priority [2].

The hepatic artery flow/100gm decreases and the portal vein flow increases following liver resection. Also, the portal vein pressure increase following extendenig hepatectomy [3].

Some donors decompensate to a greater extent, inspite of adequate residual volume. The explanation for this probably lies in the variation in portal pressure [4].

It has been well documented that remnant liver regeneration occurs in the postoperative period following partial liver donation. To explain this phenomenon, relative portal hypertension (increase of the portal pressure after donor hepatectomy as compared with the preoperative state was blamed [5].

Current view points believed that the excessive flow of portal vein for the volume of the liver parenchyma leads to overpressure and sinusoidal endothelial damages [6].

RLV lesser than 20-30% of TLV ends in liver failure [7].

The changes in portal hemodynamics that occur during donor hepatectomy and its relation to the residual liver volume have not been studied frequently. This represent the main motive of this study.

Patients and Methods

This prospective study included 30 adult living donors who underwent right hepatectomy in the Liver Transplantation Unit, Faculty of Medicine,

Cairo University during the period between June 2015 to October 2016.

Inclusion criteria were to have an age group from 21 to 50 years with a residual liver volume $\geq 35\%$. Exclusion criteria included donors with major medical disorders, positive viral serology (hepatitis B or C virus, IgM for CMV, herpes simplex, and HIV), a body mass index (BMI) $>30 \text{ kg/m}^2$ and cases with liver pathology (hemangioma, bilharzial fibrosis) or trifurcated portal vein on portal venography.

Preoperative preparations:

Routine preoperative preparations in the form of physical examination, laboratory and radiological investigations were done. These included complete blood count (CBC), coagulation profile, viral serology, liver and kidney function tests. Radiological investigations included abdominal ultrasound (US), triphasic computed tomography (CT) of the abdomen to detect abdominal pathology. MRCP was done to delineate the biliary anatomy and CT angiography to delineate the vascular anatomy of the hepatic artery, hepatic veins and portal vein.

CT volumetry was done to all donors to calculate the graft weight recipient ratio and the residual liver volume of the donor (Fig. 1).

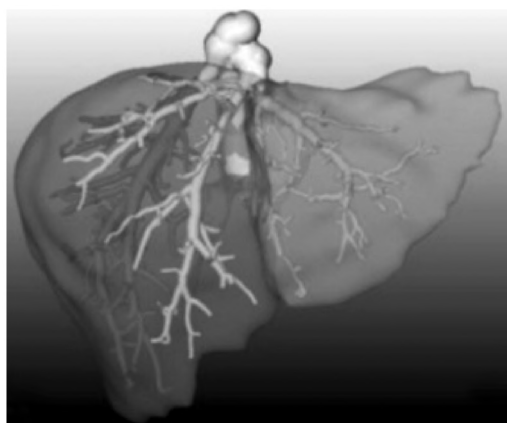


Fig. (1): CT volumetry of liver.

Portal pressure measurement:

We followed the routine surgical steps of right lobe donation including mobilization of liver, hilar dissection to identify right portal vein, hepatic artery and bile duct.

Portal venous pressure (PVP) was measured using a 16, 18 or 20-gauge antithrombotic catheter inserted into the main portal vein. The other end was connected through an extension-arterial line to a pressure transducer. Then the right portal vein was clamped and the pressure was measured again.

The normal range for directly measured PVP values was considered to be 7 to 12mmHg.

Results

This prospective study included 30 adult living donors. The demographic data is shown in Table (1).

Portal pressure (mmHg)

In this study the mean portal pressure before and after clamping of right portal vein was 9.9mm Hg and 15.23mmHg respectively. The mean changes in portal pressure were significant ($p<0.001$) as shown in Table (2).

Relation between the PVP changes and residual liver volume:

The residual volume of the cases ranged from 36 to 44 % with mean \pm SD 40.17 ± 1.72 .

The lower the percentage of residual liver volume the higher the changes in portal venous pressure (p -value 0.029) as shown in Fig. (3).

Table (1): Demographic data of living donors.

Total number of cases	Range of age	Mean age	Male	Female	Mean BMI (kg/m^2)
30	21–45 years old	29.67 years old	24	6	24.37

Table (2): Portal pressure pre, post clamping and changes in portal pressure and significance of portal pressure changes

Portal venous pressure(PVP)	Minimum (mmHg)	Maximum (mmHg)	Mean (mmHg)	Standard Deviation	p -value
Portal pressure pre clamping	7.00	11.00	9.90	1.16	
Portal pressure post clamping	11.00	19.00	15.23	2.49	<0.001
Changes in portal pressure	2.00	8.00	5.33	1.69	

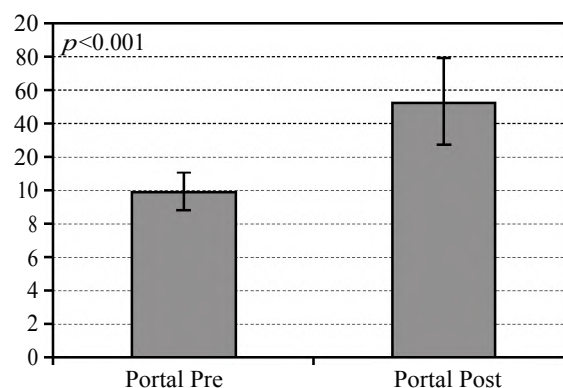


Fig. (2): The mean difference in PVP pre & post clamping of portal vein.

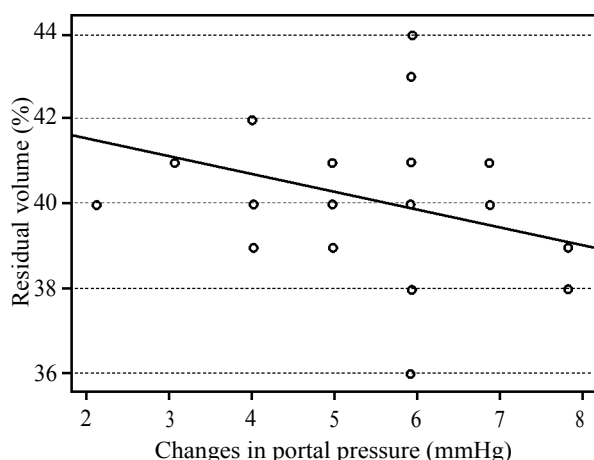


Fig. (3): Correlation between changes in portal pressure and residual volume.

Discussion

Living donor liver transplantation has now become an accepted alternative for any patient waiting for cadaveric liver transplantation, especially in countries like Egypt where there is no cadaveric organ harvesting. After expansion of the indication of LDLT for adult populations by using left lobe grafts, small-for-size grafts with relatively high morbidity remained a significant barrier to more widespread use [8].

Liver regeneration will be initiated immediately after the liver donation surgery. This process involves numerous molecular events and gene expressions. Hemodynamic changes in pressure and shear stress, for example, are also known as two of the most influential factors [9].

It has been hypothesized that an increase in PVP is necessary for liver regeneration to occur after hepatectomy. On the other hand, several reports have hypothesized that excessive portal hypertension and over perfusion can injure the remnant liver and lead to dysfunction [10].

A prospective study was done by Gupta S et al., In 2012 to study the effect of portal hemodynamic changes on liver functions in 50 donors donating their right lobe with residual liver volume ≥ 30 . The mean rise in pressure during the procedure was 3.24mmHg ($p < 0.05$) [4].

In 2013 a prospective study conducted by Marc-Antoine Allard et al., on 81 living donors who donated their right lobe, from which they concluded that the post hepatectomy PVP significantly increased with a mean of 15.4mmHg [11].

It was reported by D. Mohammed G et al., in 2016 following liver resections in dogs, where he

observed a rise in pressure after 60% hepatectomy up to 16.5 mmHg which is a 33% rise in comparison to base line value with mean rise 6.5mmHg [3].

In our series conducted on 30 living donors donating their right lobe with residual volume at least 35%, a significant rise in portal pressure after clamping of the right portal vein was observed (mean rise 5.33mmHg, $p < 0.001$). Table (3) showing the changes in portal pressure in different studies including ours.

Table (3): Showing changes in portal pressures in different studies including ours.

Study	Total number of cases	Change in PVP	<i>p</i> -value
Marc-Antoine Allard et al., 2013	81 living donors	Increased with mean 15.4mmHg	0.001
Gupta et al., 2012	50 living donors	Mean rise 3.24 mmHg	0.05
Our series	30 living donors	Mean rise 5.33 mmHg	0.001

Although different hypotheses have been proposed to explain this result, many questions remain not answered, extended hepatectomy results in parenchymal loss, a reduced intra hepatic vascular bed, increased hepatic portal resistance due to transient sinusoidal narrowing with higher portal flow per gram of remnant liver [3].

A study conducted by D.Takashi et al., in 1985 on 8 patients undergoing minor hepatic resection (less than 3 segments), observed no change in portal pressure in patients with minor hepatic resections in contrary to major resections in his same study. This supports our results regarding the relation between residual liver volume and changes in portal pressure [11].

A study conducted by Mohamed G et al., on dogs in 2015 revealed a similar correlation was found between the percent of liver resected and the portal pressure. Eight percent rise in portal pressure was observed post 25% hepatectomy, compared to a 33% rise following resection of 60% of the liver volume. He explained this result by the fact that a decrease in residual volume decreases the hepatic arterial flow and increases the PVP. As a consequence, the liver goes under more poor oxygenated blood supply and higher pressure. This is may be one of the most important mechanisms of post hepatectomy liver failure in case of extended liver resection [3].

Similarly, in a study conducted by shoichiro et al., on dogs in 1991, a significant correlation between rise in portal pressure and residual volume

thus suggesting that the extensive hepatectomy may result in more increase in portal venous pressure [12].

In our study, a significant correlation was found between the preoperatively measured residual volume and the rise in portal pressure (p -value 0.029).

It should be noted that we excluded patients with residual volume of less than 35%. However, these results are a motive to expand our patients selection to a residual volume of 30% without compromising the donor safety as the highest portal pressure was 19 mmHg and no decompensation has been reported.

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إلى أي مدى قد تؤثر نسبة المتبقى من الكبد في المتبرع الحي على ضغط الوريد البابي الكبدي

زراعة الفص الأيمن من الكبد الآن تستخدم على نطاق واسع في برنامج زراعة الكبد الحي لأن الفص الأيمن يمثل ٦٠٪ من الكبد ويقدم خلايا كافية للمستقبل، وعلى الرغم من استخدامه بنطاق واسع على مستوى العالم إلا أن الأولوية لأمان المتبرع.

وقد قمنا في الدراسة الحالية بدراسة العلاقة بين المتبقى من الكبد في المتبرع الحي ونسبة ارتفاع ضغط الوريد البابي الكبدي.

وقد تم إجراء أشعة مقطعية قبل العملية لتبيان حجم المتبقى من الكبد وتم إجراء العملية لـ ٣٠ متبرع بالفص الأيمن وتم قياس ضغط الوريد البابي الكبدي أثناء العملية قبل وبعد غلق الوريد البابي الأيمن.

وقد تبين أنه كلما قلت نسبة المتبقى من الكبد كلما زاد ضغط الوريد البابي الكبدي ولكن على الرغم من الزيادة لم يكن هناك خطورة ملحوظة على المتبرع الحي مما قد يدفعنا في المستقبل لتوسيع دائرة اختيار الكبد المتبقى في المتبرع الحي إلى نسبة ٣٠٪ بدلا من ٣٥٪.