

Original Article



Variation of Normal Portal Venous Doppler Indices in Post-Operative Period Following Living Donor Liver Transplant

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Author's Contribution

^{1,3}Substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work, manuscript writing.

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Introduction

Orthotopic liver transplantation (OLT) represents a major treatment for end-stage chronic liver disease, as well as selected cases of hepatocellular carcinoma and acute liver failure.¹ Improvements in surgical techniques augmented by the introduction of new immunosuppressive agents have given LT a current 5-year survival rate of approximately 75%.² Living donor liver transplant (LDLT) is the procedure of first choice among transplantation procedures in most Asian countries due to the lack of deceased donors but is less commonly undertaken in Western countries because of the greater

ABSTRACT

Objective: To investigate the variations in normal Doppler indices of the portal vein during the post-operative period following living donor liver transplantation (LDLT).

Methodology: This retrospective cohort study was carried out at Pakistan Kidney and Liver Institute and Research Centre from July 1 to December 31 2021. It included all adult patients over 16 years of age who underwent Living Donor Liver Transplant (LDLT). Triplex Doppler ultrasound of LDLT recipients was performed intraoperatively and postoperatively for 5 consecutive days. Subsequent scans were performed at 2 weeks, 4 months, and 6 months after the transplant. Portal vein velocities were taken at the extrahepatic part, anastomosis, and intrahepatic part. Statistical analysis was performed using SPSS version 20.

Results: The study involved 91 patients, with ages ranging from 17 to 73 years and a mean age of 44.9 years. Among the recipients, 79% were male and 21% were female. The portal venous velocities varied between 31 cm/s and 357 cm/s. All patients had antegrade portal venous flow. The portal venous velocities normalized within 4-6 months following LDLT.

Conclusion: A wide range of portal venous velocities can be encountered following LDLT without clinically significant outcome and these usually normalize within 4-6 months following LDLT.

Keywords: Living donor living transplant (LDLT), Doppler ultrasound.

availability of deceased donors.³ Hepatic vascular complications are the leading cause of morbidity and graft loss in the immediate post-operative period following liver transplantation as they can lead to liver graft ischemia.⁴ The early detection of these complications is critical to initiate prompt treatment so as to reduce liver damage. Therefore, it is regarded as part of standard care to perform a color Doppler ultrasound in the first few days after liver transplantation to detect vascular complications.⁵ However, interpretation of Doppler waveforms can be challenging and at times flawed if one is not familiar with normal variations in waveform patterns that are commonly encountered in absence of complications.⁶ Ultrasound is the primary

imaging modality for evaluating the hepatic vasculature in the early and delayed periods after LT. It is readily accessible, non-invasive, avoids ionizing radiation, can be portably performed at the bedside and its results are highly reliable.⁷ Pulsed and color Doppler examination in tandem help evaluate vessel patency and assess flow spectra. Orthotopic liver transplantation (OLT) represents a major treatment for end-stage chronic liver disease, as well as selected cases of hepatocellular carcinoma and acute liver failure.¹ Improvements in surgical techniques augmented by the introduction of new immunosuppressive agents have given LT a current 5-year survival rate of approximately 75%.² Living donor liver transplant (LDLT) is the procedure of first choice among transplantation procedures in most Asian countries due to the lack of deceased donors but is less commonly undertaken in Western countries because of the greater availability of deceased donors.³ Hepatic vascular complications are the leading cause of morbidity and graft loss in the immediate post-operative period following liver transplantation as they can lead to liver graft ischemia.⁴ The early detection of these complications is critical to initiate prompt treatment so as to reduce liver damage. Therefore, it is regarded as part of standard care to perform a color Doppler ultrasound in the first few days after liver transplantation to detect vascular complications.⁵ However, interpretation of Doppler waveforms can be challenging and at times flawed if one is not familiar with normal variations in waveform patterns that are commonly encountered in absence of complications.⁶ Ultrasound is the primary imaging modality for evaluating the hepatic vasculature in the early and delayed periods after LT. It is readily accessible, non-invasive, avoids ionizing radiation, can be portably performed at the bedside and its results are highly reliable.⁷ Pulsed and color Doppler examination in tandem help evaluate vessel patency and assess flow spectra.

Methodology

This retrospective cohort study was carried out at Pakistan Kidney and Liver Institute and Research Centre from July 1 to December 31, 2021. Institutional Review Board approval was obtained before commencing the study. It included all adult patients over 16 years of age who underwent Living Donor Liver Transplant (LDLT). Exclusion criteria included all patients with vascular complications, patients who failed to show up at the 2 weeks, 4 months and 6 months follow up ultrasound and

those having hemodynamic complications like shock and shock-like states. Triplex Doppler ultrasound of LDLT recipients was performed intraoperatively and postoperatively for 5 consecutive days. Subsequent scans were performed at 2 weeks, 4 months, and 6 months after the transplant. These scans were performed on one of two ultrasound machines, the GE Logiq S8 or GE Logiq P7. Portal vein velocities were taken at the extrahepatic part, anastomosis, and intrahepatic part. Statistical analysis was performed using SPSS version 20.

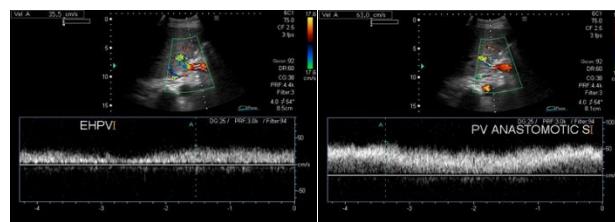
Results

A total of 91 patients were included. The minimum patient age was 17 years. The maximum patient age was 73 years. The mean age was calculated to be 44.9 years. About 79% of the recipients were males and 21% were females. The mean portal venous velocities ranged between 31 cm/s to 357 cm/s. The velocities in the extrahepatic portal vein had a maximum value of 106 cm/s on postoperative day 0 which decreased to 31 cm/s at 6 months. The mean portal vein velocities at anastomotic site on day 0 and at 6 months were 357 cm/s and 45 cm/sec respectively. The post anastomotic intrahepatic mean portal vein velocity was 154 cm/s on day 0 that gradually declined to 40 cm/s at the 6-month follow up Doppler ultrasound scan.

Table I: Velocity normalization with time. Mean velocity measurements taken intraoperatively and then on days 1, 2, 3, 4, 5, 2 weeks, 4 months, and 6 months.

	Mean portal vein velocities (cm/sec)		
	Extrahepatic	At anastomosis	Intrahepatic
Day 0	106	357	154
Day 1	62	290	137
Day 2	56	192	126
Day 3	53	123	118
Day 4	50	120	112
Day 5	48	105	91
2 weeks	42	79	70
4 months	39	53	51
6 months	31	45	40

All patients had antegrade portal venous flow. The portal venous velocities normalized in 4-6 months following LDLT.



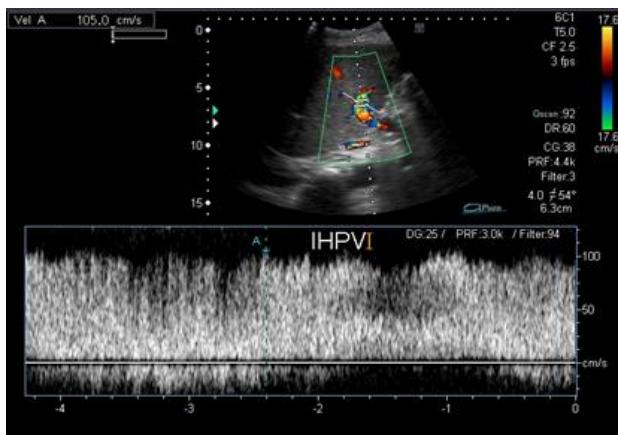


Figure 1. Measurements of portal vein velocities. (a) Extrahepatic antegrade flow with a velocity of 35.5 cm/s at 6-month follow up. **(b)** Antegrade flow with an increase in velocity at the anastomotic site measuring 63 cm/s on the 4-month follow up scan. **(c)** Antegrade flow with intrahepatic velocity measuring 105 cm/s on post-operative day 4.

Discussion

The normal portal vein Doppler waveform shows a continuous flow towards the liver i.e., it is hepatopetal.⁸ Flow is mildly undulating, laminar, and has respiratory variation. Pulsatility is typically absent unless there is right heart failure, but periodicity can occur due to normal variations in velocity caused by cardiac motion. The normal velocity of portal vein flow ranges from 20 to 30 cm/s.⁹ Post-transplant, portal vein stenosis can occur, especially in pediatric and living donor populations, resulting in elevated velocity and aliasing artifact on Doppler evaluation.¹⁰

However, it is important to consider that apparent anastomotic narrowing may simply be a size discrepancy between the recipient and donor portal veins. Thrombosis is a relatively common complication, manifesting as an echogenic filling defect and a lack of flow on Doppler evaluation.¹¹ Portal vein thrombosis and stenosis occur in approximately 1 to 2% of transplant recipients, with causes including surgical technique issues, misalignment or excessive vessel length, hypercoagulable states, and previous portal vein surgery.¹²

The normal antegrade portal vein flow is preserved post-transplant. However, the reduced portal venous resistance in the presence of increased splanchnic flow immediately after transplant can increase portal venous flow and this often manifests as elevated velocity on doppler evaluation. This is further influenced by the compressive

effects of resolving post-operative edema and collections. As the body adapts to the new hemodynamics, the elevated velocities gradually taper to normal and a transient increase in portal vein velocity should not be falsely diagnosed as portal vein stenosis.¹³ Increased portal venous velocity can also result in turbulent flow on Doppler evaluation, which improves with the normalization of velocity. Additionally, transient pulsatile flow may be observed in the postoperative period. In the immediate post-operative period without associated vascular complications, a wide range of portal venous velocities ranging from 15 to 400 cm/s have been documented¹⁴

Therefore, surgeons should not be trigger-happy in labeling patients as having portal venous stenosis on the basis of increased velocity. The wide range of portal venous velocities that we encountered, ranging from 31 cm/s to 357 cm/s is comparable with the study of Stell et al investigating the quantitative Doppler indices following liver transplant.¹⁴ We observed a steep decrease in portal vein velocities at the anastomotic site from day 0 to day 3, representing a 66% decrease. This decrease reflects the reduction in post-operative anastomotic site edema and the recovery of graft function during the first postoperative week, consistent with observations made by Stell et al.¹⁴

From there onwards, further decline was more gradual over the next 6 months, with a further 61% decrease between post-operative day 3 and the 6-month follow up Doppler ultrasound, returning to almost normal. The decline in the intrahepatic velocities was smooth and gradual, slowly returning to normal from day 0 to 6 months. For the extrahepatic segment of the portal vein, a rapid drop of 42% was observed from day 0 to day 1. From there onwards, the reduction in velocities was quite gradual, showing a further 62% reduction at the 6-month follow up scan.

Overall, our findings were consistent with those of Stell et al. and Bolognesi et al.^{14, 15} However, there were a few limitations in our study, including the lack of consideration for postprandial effects and the challenge of accounting for interobserver variations.

Conclusion

The option of LDLT increases the availability of organs for transplantation. It is a radiology-intensive procedure and Doppler ultrasound is the modality of choice for assessing vascular complications. Knowledge of normal

postoperative changes in velocity is essential as a wide range of portal venous velocities is encountered following LDLT without a clinically significant impact. These elevated portal venous velocities usually normalize within 4 to 6 months following LDLT.

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