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ORIGINAL ARTICLE

Variation of Normal Hepatic Artery Doppler Indices Post Living Donor Liver Transplant

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Abstract

Objective: The Research study was design to see Variation of Normal Hepatic Artery Doppler Indices in Post Living Donor Liver Transplant.

Background: Due to the lack of deceased donors, adult-to-adult living donor living transplant (LDLT) has emerged as the procedure of first choice among liver transplantation procedures in most Asian countries. Hepatic artery complications can lead to graft ischemia and are one of the most frequent causes of graft loss in the immediate postoperative period. Ultrasonography, including Doppler evaluation, is the established initial imaging modality of choice for early detection and follow-up screening of vascular complications.

Materials and Methods: This retrospective cohort study was carried out at the Pakistan Kidney and Liver Institute and Research Centre (PKLI) and spanned from 01/07/2021 to 31/12/2021. Patients above 16 years of age who had undergone LDLT were included. Hepatic artery peak systolic velocities (PSV), resistive indices (RI), and acceleration times (AT) were documented intra operatively and then for 5 consecutive days. Follow-up scans were performed at 2 weeks, 4 months, and 6 months after the transplant. SPSS version 20 was used for statistical analysis.

Results: A total of 91 patients were included in the study. The minimum age was 17 years and the maximum age was 73 years with a mean age calculated to be 45 years. Approximately 79% of patients were males and 21% were females. A PSV of as less as 15 cm/s and as high as 267 cm/s was recorded with normal waveforms. A minimum RI of 0.44 and a maximum of 0.89 was observed. A minimum AT of 0.01 seconds and a maximum of 0.07seconds were noted.

Conclusion: A wide range of hepatic arterial velocities can be encountered following LDLT without clinically significant out comes. The hepatic arterial velocities normalized within 4 to 6 months following LDLT. Hepatic artery RI values of 0.44 to 0.89 can be observed without any complications.

Keywords: Living donor living transplant (LDLT), color Doppler ultrasound (CDUS), hepatic artery (HA), peak systolic velocity (PSV), resistive indices (RI), and acceleration times (AT).

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Introduction

The first successful liver transplantation was performed by Dr Thomas Starzl in the 1960s [1]. Recent years have seen a surge in the number of liver transplantation procedures performed for patients with liver dysfunction due to chronic liver disease and acute liver failure.[2] the allograft for liver transplantation can be harvested either from a deceased donor or from a living donor after performing a partial hepatectomy. Deceased donor liver transplantation is more prevalent in the western world. In countries where the procurement of cadaveric organs is difficult due to lack of availability, LDLT is by far more common.[3] Refined surgical technique backed by immunosuppressive therapy has led to improved outcomes, with 1-year patient and graft survival rates of 90% and 88%respectively[4], and a 5-year survival rate of approximately 75%.[5]

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Hepatic artery complications are one of the most common causes of morbidity and graft failure as they can lead to graft ischemia.[6] The early detection of vascular complications is vital to initiate prompt treatment and minimize liver damage.[7] Because the blood supply to the biliary tree is entirely arterial, abnormal liver function tests are often the first manifestation. However, this can be diagnosed at colour Doppler ultrasound (CDUS) in the presymptomatic phase, allowing early reperfusion that avoids the need for retransplantation.[8] Vascular surveillance using CDUS effectively diagnoses vascular complications and is now considered a standard of care.[9] It can be easily performed intra-operatively and at the bedside in the early post-transplantation period. It is readily accessible and non-invasive, Furthermore, it avoids these of ionizing radiation.

The interpretation of Doppler findings in the immediate post-transplantation period can be challenging as the hepatic artery waveforms commonly altered in the absence of complications.[10] However, if performed by expert operators, the results are highly reliable.[11] The advocated timing and frequency of dopplerscreening also varies from a single examination on the postoperative day or every 12 hours daily or alternate-day examinations for 14 d, or daily until discharge.[12]

Material and Method

This retrospective cohort study was carried out at PKLI from 1st February 2021 to 31st December 2021. Before initiating the study, approval from the Institutional Review Board had been obtained. It included all patients over 16 years of age who underwent LDLT.All patients having vascular complications, patients who failed to turn up for their follow-up scans, and those having hemodynamic complications such as shock and shock-like states were excluded. Triplex Doppler ultrasound of the recipients was performed intraoperatively and for 5 consecutive days in the immediate postoperative period. Follow-up scans were carried out at 2 weeks, 4 months, and 6 months after surgery. All scans were undertaken on either the GE Logic S8 or Geologic P7 ultrasound machines. Hepatic artery peak systolic velocities (PSV), resistive indices (RI), and acceleration times (AT) were documented on each scan (Figure 1). Statistical analysis was undertaken on the SPSS version 20 software.

Results

The inclusion criteria were met by 91 patients. The mean patient age was 45 years, with a minimum age of 17 years and maximum age of 73 years. Of these recipients, 79% were males and 21% were females. Individual PSV values of as less as 15 cm/s and as high as 267 cm/s were recorded with normal waveforms. As a general trend, the mean PSV was highest intra operatively (102 cm/s) and gradually declined onfollow-up to 69 cm/s at 6 months. Individually, a minimum RI of 0.44 and a maximum of 0.89 was observed. However, the mean RI showed a narrow range of fluctuation between 0.65 to 0.69. Individually, a minimum AT of 0.01 seconds and a maximum of 0.07 seconds were noted. The mean AT remained stable throughout at 0.03 and only minimally increased to 0.04 at the 6-month follow-up.

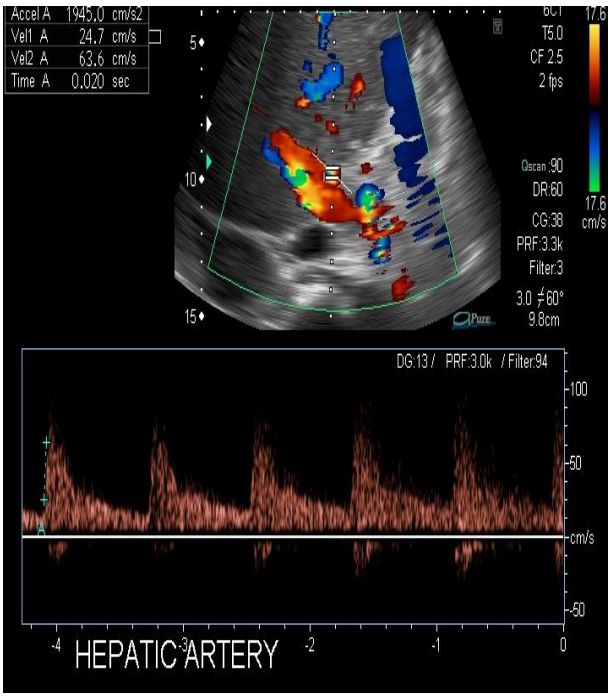
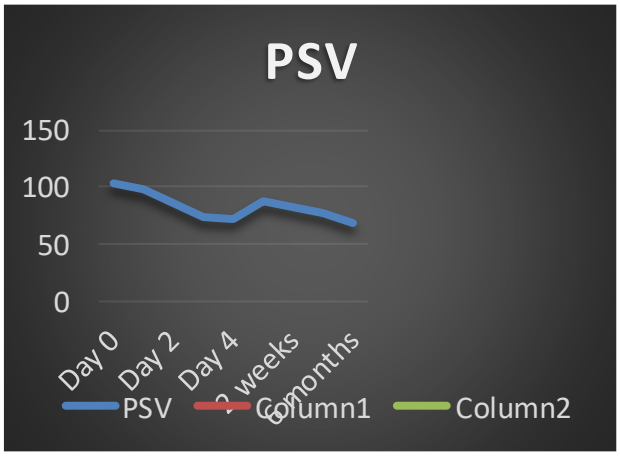


Figure1.Normal hepatic artery waveform with Doppler indices including PSV and AT post-transplant.

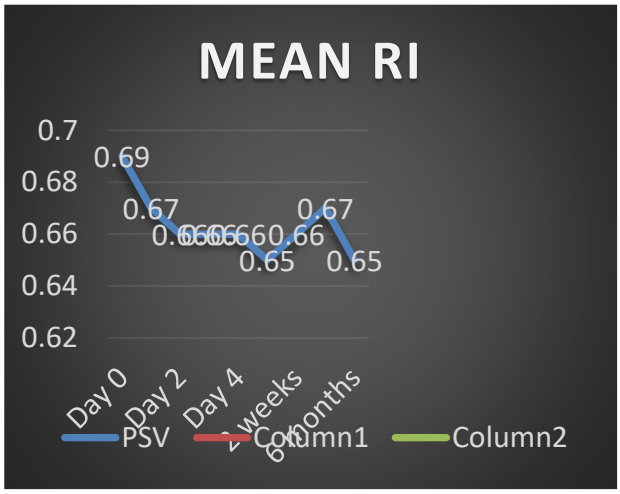
Table 1: Pattern of distribution of hepatic artery Doppler indices including PSV, RI, and AT intraoperatively, days 1, 2, 3, 4, 5, 2 weeks, 4 months, and 6 months.

	Hepatic artery doppler indices (mean)		
	PSV	RI	AT
Day 0	102	0.69	0.03
Day 1	97	0.67	0.03
Day 2	82	0.66	0.03
Day 3	75	0.66	0.03
Day 4	72	0.66	0.03
Day 5	88	0.65	0.03
2 weeks	82	0.66	0.03
4 months	77	0.67	0.03

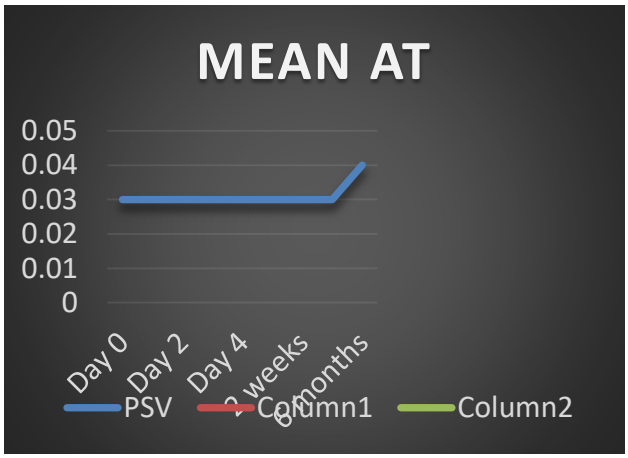
6 months	69	0.67	0.04



Hepatic Artery Mean PSV



Hepatic Artery Mean RI



Hepatic Artery Mean acceleration time

Discussion

The interpretation of hepatic Doppler ultrasound can be a source of anxiety for those with limited experience [13]. Normal hepatic arterial waveform is pulsatile. Its peak height corresponds to peak systolic velocity, and its trough corresponds to end-diastolic velocity. The flow is ante grade throughout the entire cardiac cycle and therefore lies above the baseline. Since the liver requires continuous blood flow, the hepatic artery is a low-resistance vessel [14].

When the flow of blood encounters a reduced cross-sectional diameter, its velocity increases to maintain the continuity of flow. Elevated hepatic arterial velocity is a normal transient postoperative phenomenon. Stell et al[15] have documented segments of increased velocity in all patients with normal allograft function on their first postoperative images and these peak systolic velocities ranged widely from 13.2-367 cm/s. Our variation of velocities was also confined within this range and measured from 15 - 267 cm/s.A probable cause for this transient occurrence in the immediate postoperative period may be due to the fleeting persistence of the preoperative high-arterial-inflow state, which is caused by portal hypertension.[15] At the site of arterial anatomises, edema can result in luminal narrowing, mimicking steno sis and this too results in elevated velocity at the anatomises site. As postoperative edema resolves, the elevated arterial velocity reduces within a few days and we experienced a similar pattern.

Resistive index (RI), the most commonly used Doppler parameter in hepatic artery evaluation, permits asemi quantitative estimation of the resistance to arterial flow into the liver. The resistive index, which represents the ratio of (peak systolic velocity - peak diastolic velocity)/peak systolic velocity, should be> 0.5.[16] A normal value, both in normal healthy individuals and those with transplants, ranges from 0.55 to 0.80.[17]

Most of our patients fell into this range and on average hovered close to 0.67. Decreased RI is a good indicator for hepatic arterial complications, and it is an even better indicator combined with a prolonged systolic acceleration time (a tardusparvus waveform). One of our patients dipped below this cut-off to 0.44, however, the absence of a tardusparvus pattern was reassuring and the patient had an uneventful recovery.

Almost half of the patients in the immediate post-transplant phase have a transient high RIthat returns to normal in a few days if there are no complications.[10] We observed a similar pattern and a maximum RI of 0.89 was recorded without complications and subsequently returned to normal limits.Transient increased arterial

resistance has been attributed to various causes including hepatic arterial spasm, increased portal flow inhibiting the release of arterial vasodilators, tissue enema, increased cold ischemia time, and older age in liver donors.[10] HighRI has been classified by García-Criado et al[10] into four types. Type 1: RI > 0.80 with continuous flow in the diastolic phase. Type 2: RI = 1, complete absence of diastolic flow with preserved systolic velocity. Type 3: absence of diastolic flow and diminished systolic velocity. Type 4: undetectable flow. The last two types of spectral waveforms are indistinguishable from arterial hypo perfusion secondary to arterial complications. Therefore, when these patterns appear in the immediate postoperative period, it is mandatory to perform daily CDUS, suspecting complication when the waveform does not become normal within 4 days. In these cases,CT angiography (CTA), MR angiography (MRA), or arteriography is indicated. If a patent artery is seen, a daily CDUS examination is mandatory until the flow becomes normal. Early and transient high RI, related to an older donor and prolonged period of ischemia, lacks clinical repercussions and long-term prognostic implications.[10]

The acceleration time, which represents the time from end-diastole to the first systolic peak, should be less than 0.08 sec.[1] All our patients remained within this limit.

Conclusion

Knowledge of normal postoperative changes in velocity and Doppler indices is vital for competent interpretation of doppler assessment. A wide range of hepatic artery velocities is noted following LDLT without a clinically significant impact. These elevated velocities usually normalize within 4 to 6 months following LDLT.Hepatic artery RI values of 0.44 to 0.89 can be observed without any complications.

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