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Do Respiratory Maneuvers Affect Right Hepatic Vein Waveform and Maximum Velocity in Post LDLT Recipients?

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Author`s Contribution

[1,2]Conception, Synthesis and Planning of the research, Review the Study [3]Discussion, [4]Interpretation, Data analysis , [5,6]Active participation in active methodology

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ABSTRACT

Objective: To evaluate the effect of respiratory maneuvers on the right hepatic vein (RHV) Doppler waveform and its maximum velocity in living donor liver transplant (LDLT) recipients.

Methodology: This was a prospective cross-sectional study performed at Pakistan Kidney and Liver Institute and Research Centre (PKLI& RC), Lahore from February 1, 2022, to March 31, 2022. The sample size of the study, calculated according to WHO sample size calculator, was 30 patients after applying the inclusion and exclusion criteria. Most of these patients were analyzed during their first post-operative week while staying in the surgical intensive care unit (SICU). The Doppler waveform and maximum velocity of RHV were recorded during normal gentle breathing, following breath-hold after deep inspiration and then after quiet expiration. The waveforms that were recorded were triphasic, biphasic, or monophasic in the pattern. To assess the RHV flow quantitatively, the damping Index was also calculated during all these three respiratory maneuvers as follows (DI=Minimum velocity/maximum velocity)

Results: The maximum velocities during normal respiration, after quiet expiration, and after breath-holding following deep inspiration were 125 cm/sec, 105 cm/sec and 94 cm/sec. The waveforms observed during gentle breathing were triphasic in 77%, biphasic in 10%, and monophasic in 13% of the patients. After quiet expiration, these were triphasic in 80%, biphasic in 6%, and monophasic in 13% of patients. However, after breath-hold following deep inspiration, the waveforms observed were triphasic in 42%, biphasic in 13%, and monophasic in 45% of the patients. ($P < 0.008$)

Conclusion: The study showed that not only did the RHV waveforms show significant change from triphasic pattern to monophasic pattern, but also the peak velocities were lower following expiration. Therefore, during the Doppler ultrasound assessment of post-LDLT recipient patients, respiratory variations must be taken into consideration.

Keywords: Doppler ultrasonography, hepatic vein, Vascular complications.

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Introduction

Liver transplantation is an valuable therapy in individuals suffering from cirrhosis and hepatocellular carcinoma (HCC).[1] The first case of a human liver transplant was reported in 1963.[2] Living donor liver transplantation prevails in Pakistan due to the extreme shortage of deceased donor organs. The importance of Duplex ultrasound in the evaluation of Liver in post LDLT recipients cannot be denied. Ultrasound is non-invasive, easily available at the bedside, and a cost-effective modality. It is frequently used as a preliminary examination for early diagnosis of complications. It is also an effective instrument to detect graft dysfunction. Post liver transplant vascular complications, especially in the first few days following surgery, are a significant hazard to the survival of recipients.[3] Hepatic artery thrombosis and portal vein thrombosis are the most dreadful consequences which can result in graft failure. The hepatic vein outflow obstruction is relatively unusual but may induce segmental hepatic congestion.[4] Hepatic vein thrombosis is rare but not a diagnostic challenge.

The usual hepatic vein Doppler spectrum is triphasic, depicting the respiratory phasicity and the cardiac cycle. The right atrial pressure, thoracoabdominal pressure, and the compliance of hepatic parenchyma are the determining factors. The triphasic pattern has two peaks above the baseline towards the heart followed by a peak below the baseline during atrial contraction.[5]

The hepatic venous Doppler spectral pattern depends on the balance between the right atrial pressure and the hepatic pressure. The analysis of hepatic vein Doppler during respiration helps us to recognize not only the normal and abnormal flow patterns but also distinguishes between diseases involving the right heart.[6] The respiratory phasicity and even the Valsalva maneuver can alter the pulsatility and thus the waveform of hepatic veins. Other pathological factors to affect the venous waveform are hepatic Cirrhosis, Bud-Chiari syndrome, and in the case of Post LDLT recipients the hepatic venous outflow tract obstruction which could be either due to thrombosis or stenosis.

Therefore, in this study, we aimed at recording the right hepatic vein peak systolic velocities, damping indices, and the spectral waveform during different respiratory maneuvers in LDLT patients and looking for any significant differences.

Methodology

The cross-sectional prospective study was conducted at the Department of Radiology of the Pakistan Kidney and Liver Institute and Research Center in Lahore. After obtaining authorization from the institutional review board (IRB), the study spanned two months, from February 1, 2022, to March 31, 2022, and involved the examination of 30 patients who had undergone liver transplants. The male-to-female ratio in the study group was 5:1. The participants ranged in age from 22 to 62 years, with a mean age of 50 years. Excluded from the study were patients with a left lobe graft, pediatric patients, and those on ventilator support. The inclusion criteria encompassed patients with right lobe hepatic grafts who underwent Doppler ultrasound within the first 10 days following living donor liver transplant.

Ultrasound examinations were performed using GE Logic P8 machines equipped with a curvilinear transducer, and patients were positioned comfortably on their backs. The examination involved recording RHV waveforms, including their maximum and minimum velocities, during gentle breathing, breath-hold after deep inspiration, and subsequent expiration. Measurements were taken over a minimum of four respiratory cycles, with Doppler assessment conducted at 1.5 cm from the inferior vena cava. Waveforms were categorized as triphasic, biphasic, or monophasic.

Data analysis was performed using SPSS version 20. The Kruskal-Wallis H test was employed to assess the impact of respiratory maneuvers on the Doppler spectrum of the hepatic veins. A p-value less than 0.05 was considered statistically significant.

Results

The highest velocities during normal respiration, post expiration and following breath-holding after deep inspiration were 125 cm/sec, 105 cm/sec, and 94 cm/sec. The waveforms showed a significant transition from triphasic during gentle breathing to monophasic after breath-hold following deep inspiration, as displayed in Table 1.

Table I: Impact of respiratory maneuvers on the waveform of RHV in post LDLT recipients showing a significant number of patients having monophasic waveform following breath-hold after inspiration.

Respiratory maneuver	Waveform Triphasic	Waveform Biphasic	Waveform Monophasic
Normal Gentle breathing	77%	10%	13%
Expiration	80%	6%	13%
Breath-hold after inspiration	42%	13%	45%

Discussion

Awareness of the living donor liver transplant surgical technique as well as knowing the usual ultrasound appearance of the transplanted liver allows early diagnosis of complications.[7] In adults undergoing liver transplant with a right lobe graft, the liver is transected along the right lateral aspect of the middle hepatic vein (MHV).[8] This right lobe graft includes the RHV, right portal vein, right hepatic artery, and right bile duct. The segment IV artery and MHV are left with the donor the survival of the segment IV. This is crucial in preventing vascular complications in the donor. Reconstruction of branches of MHV, like the larger segment V (V5) and segment VIII (V8) veins, is crucial to evade congestion in these segments. There are several techniques for the reconstruction like the great saphenous vein, left PV

(LPV) and the para-umbilical vein grafts. Cryo-preserved veins or arteries, synthetic grafts are now immensely utilized in many institutions. In PKLI, synthetic grafts are usually used for this purpose.

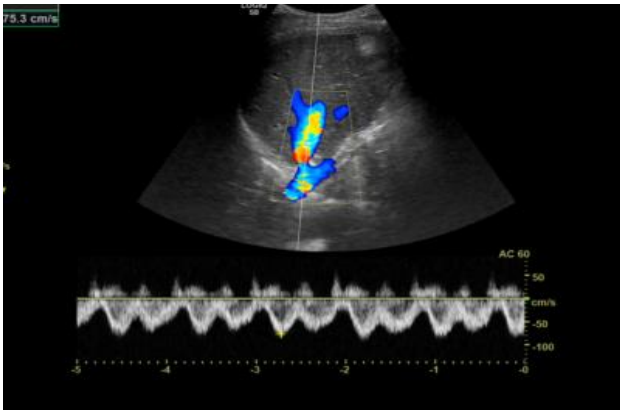

Figure 1. Triphasic waveform of RHV during gentle breathing.

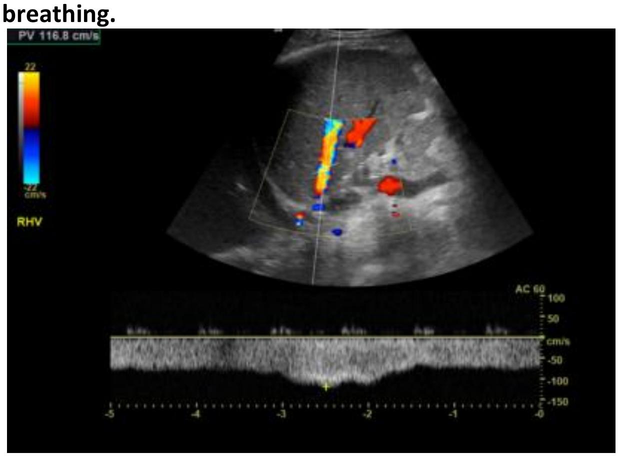

Figure 2. Biphasic waveform of RHV in a patient holding their breath following deep inspiration.

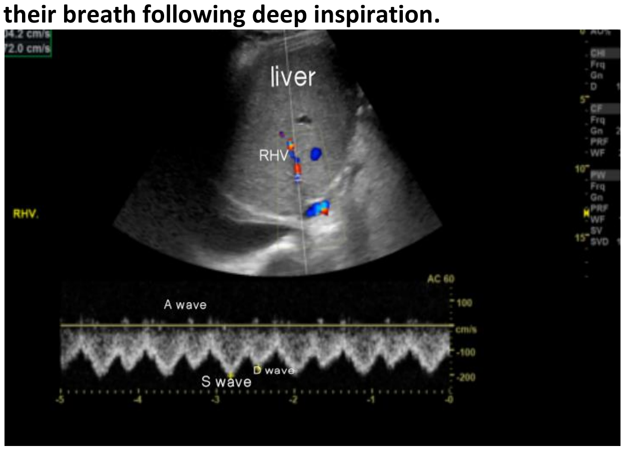

Figure 3.: The usual triphasic waveform of RHV.

The LDLT recipients need to be closely followed up after surgery to evaluate possible graft rejection and complications. Vascular complications are complicit to morbidity and mortality in these transplant recipients.[9] Doppler ultrasound of liver graft is a noninvasive, portable, and sensitive modality to assess post-op LDLT recipient patients. The usual Doppler pattern of hepatic veins is triphasic, consisting of a retrograde wave and two antegrade waves. The biphasic pattern means there is no flow reversal with or without decreased phasicity. The monophasic pattern lacks any phasicity. The factors which affect the hepatic venous flow have been mentioned earlier.

Normally, the hepatic veins depict a triphasic, anterograde flow (below the baseline). There are four waves; “a”, “s”, “v” and “d”, corresponding to the various phases of the cardiac cycle.[5] The “a” wave represents the end-diastolic atrial contraction, that results in a maximum retrograde flow. The “s” wave characterizes the forward flow during ventricular systole and is the lowest/fastest point in the cycle. The “v” wave peak depicts the transition between systole and diastole. This peak can be either above or below the baseline but below the “a” wave. Finally, the “d” wave represents early diastolic ventricular filling and is above the baseline.[10]

Seung Soo Lee performed an identical study in 2007 to determine the influence of respiration on the waveform of the RHV in right-lobe grafts. The RHV flow pattern was acquired from 23 consecutive uncomplicated right lobe grafts and from 26 healthy individuals during normal breathing, and while holding breath at expiration and inspiration. This research inferred that breath hold following inspiration decreases the periodicity of RHV flow remarkably.[11] This conclusion is comparable to our findings.

According to a study by Altinkaya et al[5], the hepatic vein velocities were the highest while breathing gently, followed by end expiration velocities which were second highest. The values were lowest at end inspiration. Thus, these were similar to our study results.

The results of a study conducted by Tiechgraber[12] analyzing hepatic venous flow in healthy people during different phases of breathing in hepatic veins showed the hepatic venous velocity to rise after inspiration with a simultaneous transition from triphasic to the biphasic or monophasic waveform. These are also similar to the results of our study.

Meir H. Scheinfeld studied patient factors on RHV waveform and velocity. According to his study, peritonitis and tense ascites alter the hepatic vein spectrum to a monophasic waveform due to the creation of the pseudo-Valsalva maneuver. Similarly, upon breath-holding the recipients may involuntarily execute a Valsalva maneuver, resulting in a dampened waveform. After exercise, the hepatic vein velocity increases with an unchanged spectral pattern. Moreover, the fasting state does not significantly affect the hepatic vein waveform. During pregnancy, the hepatic vein flow pattern dampened, returning to a normal appearance in majority of women by 8 weeks post-partum. However, it persisted in very few patients.[13]

Kemal Ada MD and Murat Ofelli included 30 diffuse chronic liver disease patients (Child-Pugh class A) and 30 healthy individuals. The triphasic waveform was found in (26.66%) of patients while dampened waveform was observed in about 73%.[14] Cirrhotic livers, steatotic livers, and livers containing metastases also caused a monophasic hepatic vein waveform according to a study by von Herbay et al.[15] A study was conducted by Karabulut et al, to analyze the effect of obesity and hepatosteatosis on the hepatic vein spectrum. Steatosis was graded as being mild, moderate, or severe. The degree of blunting of hepatic vein pulsatility was directly proportional to the increasing grade of steatosis.[16] However, he did not analyze the alteration in the velocity of hepatic veins affected by steatosis. According to his study, the body habitus did not independently influence the hepatic vein flow spectrum. Han et al[2] observed all three hepatic venous flow patterns in uncomplicated grafts. Hence, the hepatic vein spectral variability does not necessarily imply hepatic vein complications since graft edema and changes in cardiac contractility can alter the hepatic vein Doppler pattern. However, this study did not include an analysis of waveform variation in different breathing patterns as a study conducted by our department.

Conclusion

The different respiratory maneuvers affect the RHV waveform patterns as well as velocities in post LDLT recipients. -The peak velocities were lower following deep inspiration as compared to gentle breathing or after quiet expiration. Moreover, the pattern considerably deviated from triphasic to monophasic. Therefore, during the Doppler ultrasound assessment of post-LDLT recipient patients, respiratory variations must be taken into consideration.

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