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Doppler Ultrasound Assessment of Portal Venous Flow Changes During Pregnancy

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Abstract

Background & Objectives: We aimed to evaluate portal venous flow changes during pregnancy by evaluating flow velocities and patterns in relation to gestational age.

Methods: A total of 130 pregnant comprised (age, 18–45 years [mean, 29.3± 5.31 years]) were recruited. The subjects were divided into: Group 1: thirty four subjects in the 1st trimester; Group 2: fifty five subjects in the 2nd trimester; and Group 3: forty one subjects in the 3rd trimesters. Portal vein diameter and maximum and minimum velocities were measured from the main portal vein. Spectral analysis was performed by calculating the portal vein pulsatility: minimum portal vein velocity divided by its maximum velocity.

Results: The (mean±SD) maximum flow velocities (cm/sec) were higher in group 2 (31.58± 10.33) than those in groups 1 (29.44± 8.97) and 3: (26.8± 6.78), with a significant difference between groups 2 and 3. The mean minimum flow velocities were again higher in group 2: (20.89 ± 5.99) than those in groups 1 (17.71± 5.67) and 3 (18.2± 4.9) with a significant difference between groups 1 and 2. There were no statistically significant differences in mean portal vein diameter among the groups. The portal vein pulsatility value progressively increased with increasing gestational age from 0.60 in the first trimester to 0.68 in the third trimester, with statistical significant differences between groups 1 and 2 and groups 1 and 3.

Conclusion: There is a significant increase in maximum portal vein flow velocity during the second trimester, with decreased waveform pulsatility with advancing gestational age.

Key words: Portal vein, Pregnancy, Doppler ultrasound.

Introduction

Maternal physiological changes are observed during pregnancy. A significant increase in cardiac output and plasma volume is observed during pregnancy, which is essential for its good outcome. In the literature, several articles have been reported on portal vein flow in healthy subjects and maternal blood flow changes in some abdominal organs (specifically the kidneys and uterus). However, investigations assessing hepatic blood flow during pregnancy are still insufficient.[1-4]There are some physiological alterations in the hepatic blood supply during gestation. Changes during pregnancy in portal vein flow patterns and velocity have been reported in few studies.[1-3]Doppler ultrasound is a valuable, well-suited, and reproducible technique for studying the physiology of portal venous blood flow during pregnancy because of its accessibility, lack of ionizing radiation, and non-invasiveness. Considering its portability, low cost, and rapid assessment and accomplishment.[5]it is regarded as one of the most important modalities and cornerstones in suggesting and diagnosing various liver diseases from the

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haemodynamic information that can correlate with disease states.The upper normal limit of the main portal vein diameter is 13–16 mm.[6] The normal waveform morphology of portal venous flow in healthy individuals is described as continuous throughout the cardiac cycle[5,7]. However, normal waveforms show gentle undulations rhythmically with the cardiac cycle.[5, 8] The peak portal velocity corresponds to the systole and the lowest velocity to the end diastole. The feeble pulsatility of the portal vein is influenced by atrial contraction that occurs at the end diastole, in which the pressure is reflected back to the portal circulation and the forwarded portal venous flow is decreased (referred to as the trough). Therefore, the marked pulsatility of the portal vein is regarded as pathologic and has been described in congestive heart failure.[7]Regarding the waveform pattern or morphologic features, the degree of portal vein undulation is variable. Previously, there were some terms used to describe the degree of undulations as pulsatile, phasic, nonphasic, and aphasic. The first three described patterns all have phasicity. Pulsatile flow is exaggerated phasicity, which is a normal finding in arteries but is considered abnormal when observed in veins. The term aphasic is described when no flow is observed.[5] Currently, portal vein undulation is quantified by the pulsatility index (PI). The PI of the portal vein or portal vein pulsatility (PVP) is calculated as the minimum portal vein velocity (V2) divided by its maximum velocity (V1). Normally, PI is greater than 0.5, and a lower PI indicates higher pulsatility. The normal phasicity could range from low to high. When the phasicity is abnormally low, it can cause a nonphasic waveform, while when it is abnormally high, it could lead to a pulsatile waveform.[5-9] Confusing terms such as biphasic should be avoided, and portal vein waves can be briefly described as being antegrade and phasic.[5] The normal portal vein direction is hepatopetal (antegrade).[6]Determining the physiological changes in pregnancy is crucial to establish a baseline of normal portal venous dimension to distinguish physiologic from disease states when these are observed considering that there are some pathologic processes that may occur during gestation, producing changes in the liver similar to that of normal pregnancy causes such as acute fatty liver and viral hepatitis.[10] Doppler ultrasound is sensitive to the diagnosis of these pathologies even before laboratory and clinical findings become evident.[11]Our study aimed to assess portal venous flow changes during pregnancy by evaluating flow velocities and patterns in relation to gestational age.

Materials and methods

This cross-sectional study was conducted on 130 pregnant women visiting the outpatient clinic in a tertiary care hospital from April to October 2019. The subjects were divided into three groups according to gestational age: Group 1: First trimester up to completed 14 weeks. Group 2: Second trimester up to completed 28 weeks. Group 3: Third trimester (from 29 weeks through to 42 weeks). The study was approved by the ethical committee of Kurdistan Higher Council of Medical Specialties. Verbal consent was obtained from each subject beforehand.Women with singleton pregnancy were included in the study. Those with any known acute or chronic systemic diseases were excluded. The subjects selected were instructed to fast for 6 hours. Portal vein assessment was performed using colour and pulsed Doppler sonography. All scans were performed by the same examiner using a 3.5-MHz convex-type transducer (GE Logiq p6, USA). The sample volume of the Doppler system was placed in the "site of the portal vein with a size of

approximately half the lumen.[12] The velocity scale was adjusted manually to its lowest value without aliasing; hence, the Doppler waveform fills much of the scale as possible. A low wall filter (50 Hz) was used. Doppler angle for the velocity waveform measurements was always less than 60°, and examinations were performed with the subjects assuming the supine position at the end of normal unforced expiration.[1-2,7,13] The right intercostal approach was used to obtain the acute insonation angle and scan the portal vein longitudinally at a point where it crosses the hepatic artery.Portal vein diameter was measured from inner-to-inner wall at the crossing of the common hepatic artery, and the wall was excluded from measurement. Maximum and minimum velocities were obtained from the main portal vein. Spectral analysis (waveform pattern) was performed by calculating the portal vein pulsatility (PVP) from the measured maximum and minimum velocity values. The flow patterns of the portal vein were classified into both PVP values for every subject and to those > 0.5 and ≤ 0.5, and the correlation between trimesters was investigated in both situations. The Statistical Package for the Social Sciences version 25 program was used for data analysis. The results were assessed for normality using the Smirnov–Kolmogorov test and subsequently analysed using frequency distribution, t-test, and chi-squared or Fisher's exact tests if necessary. A p-values ≤ 0.05 were considered statistically significant.

Results

The age range of the subjects was 18–45 years (mean, 29.3± 5.31 years). Moreover, 34 (20–43 years), 55 (18–45 years), and 41 (19–40 years) subjects were assigned in the first, second, and third trimesters, respectively. There was no significant difference in the mean age and parity of subjects between the groups. The mean values of the maximum and minimum flow velocities and the diameter of the portal vein of the study subjects are shown in Table (1).

Table (1): Portal vein maximum and minimum flow velocities (cm/sec) and mean portal vein diameter (mm).

Flow velocities (cm/sec)	Trimester			
	First	Second	Third	p- value
PV Vmax (mean ±SD)	29.44 (± 8.97)	31.58 (± 10.33)	26.8 (± 6.78)	* < 0.030
PV Vmin (mean ±SD)	17.71 (± 5.67)	20.89 (± 5.99)	18.2 (± 4.9)	**< 0.027
PVD (mm)	10.37 (± 1.27)	10.40 (± 1.57)	10.24(± 1.40)	*** 0.850

* Groups 2 and 3
** Groups 1 and 2
*** Among the groups

PV Vmax = maximum portal vein velocity, PV Vmin = minimum portal vein velocity, PVD = portal vein diameter The maximum PV flow velocities were higher in group 2 than those in groups 1 and 3, with a significant difference between groups 2 and 3 ($p < 0.030$). The minimum PV flow velocities were again higher in group 2 than those in groups 1 and 3, with a significant difference between groups 1 and 2 ($p < 0.027$). There was no statistically significant difference in mean PVD among the groups ($p = 0.850$). The PV flow patterns according to the mean PVP value and those > 0.5 and ≤ 0.5 are presented in Table (2). It shows a progressive increase in PVP value with increasing gestational age

from 0.60 in the first trimester to 0.68 in the third trimester. This suggests a progressively increased minimal velocity relative to the maximum velocity with a significant difference between groups 1 and 2 (p = 0.013) and groups 1 and 3 (p = 0.011). No significant difference was noted between groups 2 and 3 (0.956).

Table (2): Association between trimesters and portal vein pulsatility

Trimester	Mean PVP (mean ±SD)	PVP		Total	p-value
		≤ 0.5	> 0.5		
First	0.60 (± 0.11)	8	26	34	* 0.013
		23.50%	76.50%	100%	
Second	0.67 (± 0.10)	5	50	55	** 0.956
		9.10%	90.90%	100%	
Third	0.68 (± 0.10)	2	39	41	*** 0.011
		4.90%	95.10%	100%	
Total		15 11.50%	115 88.50%	130 100%	**** 0.04

* Between groups 1 and 2
** Between groups 2 and 3
*** Between groups 1 and 3
**** Among all groups
PVP = portal vein pulsatility

Discussion

Doppler ultrasound has been widely used in the evaluation of major abdominal vessel haemodynamics as a simple non-invasive method. In our project, we were able to evaluate a sample of pregnant women stratified according to gestational age in the three trimesters.We found that the maximum and minimum flow velocities of the portal vein were higher in the second trimester of pregnancy than those in the other trimesters. Our study also showed increased PVP values with increasing gestational age. At the level of trimesters, maximum PV velocity was higher in the second trimester than those in the other trimesters, and this result is consistent with the result of the earlier work by Erkoc et al.[14] who made a comparison between third and second trimesters Nakai et al[2] also reported a higher maximum velocity in the second trimester than in the other trimesters, but with no significant difference between the groups, a result consistent with the result in the present study. Nakai et al. claimed the decreased maximum PV velocity in the third trimester to increased diameter "There was no statistically significant difference in mean PVD among the groups (p = 0.850)". Similarly, Clapp et al[3] in their study showed the effect of pregnancy and other factors on portal vein blood flow, and they demonstrated a significant increase in portal blood flow in early and mid-pregnancy values. They attributed the increase in PV blood flow primarily to a significant (p < 0.05) increase in flow velocity without a change in cross-sectional area. They also found a significant decrease in portal blood flow in late pregnancy, which they attributed to a decrease in flow velocity. Therefore, they

found no significant change in PVD in comparison to pre-pregnancy values and between trimesters, although again PVD was higher in the second trimester than in the other trimesters.Bozgeyik et al.[1]who studied PV Doppler parameters in pregnancy, found a significant decrease in the maximum PV velocity in the second and third trimesters. Our study shows some differences from this study. As mentioned, our results show that the maximum PV velocity is higher in the second trimester than that in the third trimester. There was no statistically significant difference in mean PVD among the groups ($p = 0.850$)". As mentioned above, in our study, PV waveform characteristics were assessed using the PVP value. Our results showed a progressively significant increase in PVP value with advancing gestational age ($p < 0.03$ between the first and third trimesters). Among the subjects, 88.5% showed PVP values greater than 0.5, and 11.5% of subjects showed PVP values less than 0.5. This indicates a decrease in the relative difference between the maximum and minimum PV flow velocities with increasing gestational age.To the best of our knowledge, our work is distinct in its type as we could not find similar previous studies to compare stratifying PV waveform characterization using PVP. Bozgeyik et al[1] evaluated the PV waveform, classifying it into monophasic, biphasic, and triphasic patterns. Their results showed only monophasic (17%) and biphasic (83%) patterns, with no significant difference between trimesters. There were no triphasic waveforms in their study. Erkoc et al[13] showed predominant biphasic and monophasic waveforms in the second and third trimesters, respectively, indicating increased PVP value with advancing gestational age, a result consistent with the result of our study. One of the limitations of this study might be the fact that scanning for each patient at each trimester to observe the changes in every individual case was not performed.

Conclusion

There is a significant increase in portal vein maximum flow velocity during the second trimester. Moreover, a decreased waveform pulsatility with advancing gestational age is observed in our study. However, considering that our study is novel since it uses the PVP value for waveform characterization, further large-scale studies should be conducted to establish a nationwide reference.

Conflicts of interest

The author reports no conflicts of interest.

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