THE EFFECT OF PLACENTAL LOCATION ON UTERINE ARTERY FLOW VELOCITY WAVEFORMS

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The effect of placental location on uterine artery flow velocity waveforms

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We examined the effect of placental location with regard to flow velocity waveforms in the uterine arteries in 84 control and 28 hypertensive women during the third trimester of pregnancy. The ratio of systolic peak to end-diastolic frequency was obtained with a continuous-wave Doppler device and the placental location was determined by real-time ultrasonography. In both normal and hypertensive pregnancies with unilateral placental location the systolic/diastolic ratio of the ipsilateral uterine artery was significantly lower than the contralateral artery ratio [1.73 ± 0.35 (systolic/diastolic ratio) versus 2.46 ± 0.73, $p < 0.001$, and 2.38 ± 1.01 versus 4.04 ± 1.77, $p = 0.0012$, respectively]. The physiologic and clinical significance of this finding is discussed. (Am J Obstet Gynecol 1988;159:1504-8.)

Key words: Uterine artery, hypertension, systolic/diastolic ratio, Doppler ultrasonography, placental location

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Analysis of flow velocity waveform in the uterine arteries performed with continuous-wave Doppler ultrasonography is considerd a clinically useful method for evaluation of high-risk pregnancies, especially in pregnancies complicated by preeclampsia and intrauterine growth retardation.[1-5] The ratio of the systolic peak frequency over the end-diastolic least frequency (sys-

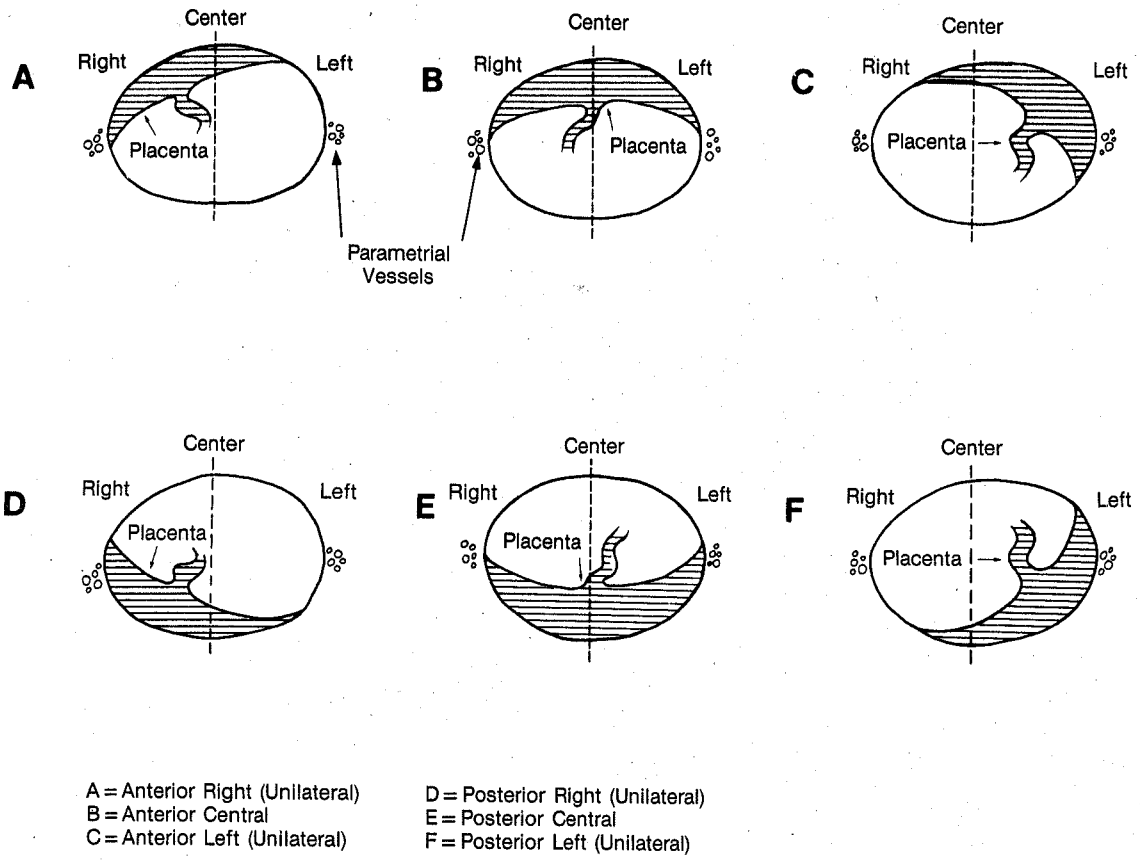

Fig. 1. Representative diagramatic cross sections of uterus to demonstrate classification of placental location.

tolic/diastolic ratio) has been used as an expression of uterine vascular resistance.

Trudinger et al.[1, 5] studied normal pregnant women during the third trimester and reported a mean systolic/diastolic ratio of 1.5 with an upper normal limit of 1.8 (ninety-fifth percentile value). Fleischer et al.[2] and Schulman[3] also studied normal pregnancies in the third trimester and reported a mean systolic/diastolic ratio of 2, with an upper normal limit of 2.7 (ninety-fifth percentile value). Both groups found that systolic/diastolic ratio values higher than the ninety-fifth percentile are associated with poor perinatal outcome although their mean and upper normal values are significantly different. Values considered abnormal by one group fall within the normal range of the values of the other group. This difference might be a result of different methods. Trudinger et al. obtained the flow velocity waveforms from subplacental uterine radial or arcuate arteries overlying or adjacent to the placenta after it was located by real-time ultrasonography, whereas Fleischer et al. and Schulman obtained the flow velocity waveforms from the average of flow velocity waveforms from both the left and right parametrial uterine vessels without consideration of placental location.

Table I. Placental location by ultrasonography

Placental location	*Normal pregnancies*		*Hypertensive pregnancies*		
	n	%	*n*	%	χ_2 *test*
Right	32	38	13	46	NS
Left	16	19	6	21	NS
Central	36	43	9	33	NS
TOTAL	84	100	28	100	

In light of these differences we designed the following study to prospectively evaluate the effect of placental location on the flow velocity waveforms of the uterine vessels.

Material and methods

The study population comprised two groups of pregnant women—84 normal pregnant women and 28 pregnant women with chronic hypertension or preeclampsia. All study participants were examined once during the third trimester of pregnancy (30 to 40 weeks). The study was approved by the Clinical Research Practices Committee and each participant gave written informed consent.

Table II. Right uterine artery and left uterine artery systolic/diastolic ratios according to placental location in normal and hypertensive pregnancies

Placental location	Normal pregnancies				Hypertensive pregnancies			
	n	Right uterine artery (mean ± SD)	Left uterine artery (mean ± SD)	p	n	Right uterine artery (mean ± SD)	Left uterine artery (mean ± SD)	p
Right	32	1.72 ± 0.35	2.59 ± 0.77	<0.001	13	2.32 ± 1.00	3.67 ± 1.67	<0.02
Left	16	2.18 ± 0.57	1.75 ± 0.37	<0.02	6	3.86 ± 1.33	2.52 ± 1.09	<0.02
Central	36	1.94 ± .33	1.94 ± 0.41	NS	9	2.72 ± 1.24	2.32 ± 0.50	NS

Table III. Contralateral and ipsilateral uterine artery systolic/diastolic ratios in normal and hypertensive pregnancies

Uterine arteries	Normal pregnancies		Hypertensive pregnancies		
	(mean ± SD)	n	(mean ± SD)	n	p
Contralateral	2.46 ± 0.73	48	4.04 ± 1.77	19	0.001
Ipsilateral	1.73 ± 0.35	48	2.38 ± 1.01	19	0.01
	$p < 0.001$		$p = 0.001$		

The location of the placenta was determined by real-time ultrasonography. The entire uterine cavity was scanned and the placental location was determined. The placenta was classified as central when it was equally distributed between the right and left sides, irrespective of its anteroposterior and fundal position (Fig. 1). When >75% of the placental mass was to one side of the midline, it was classified as unilateral, irrespective of its anteroposterior and fundal position. When the location was borderline, the right and left parametrial uterine vessels were identified to evaluate possible distortion introduced by uterine rotation. Placental location was evaluated without knowledge of the systolic/diastolic ratio values. In the majority of instances the examiner who obtained the flow velocity waveforms was not aware of the placental location. However, in approximately 40% of the cases both examinations were done by one examiner (A. D. K.), and in these cases the placental location was determined first. The interobserver variation in assignment of placental location was 13%.

The flow velocity waveforms were obtained with the mother lying comfortably in a slight left lateral tilt. A continuous-wave Doppler device was operated at a frequency of 4 MHz and was equipped with a spectrum analyzer (Multigon 500A, Multigon Industries, Inc., Mount Vernon, N.Y.). The transmitted beam power density was 6.5 mW/cm^2. The signal was obtained by placing the Doppler transducer 2 to 3 cm medial to the anterior superior iliac spine. This landmark permitted regional consistency and reproducibility of flow velocity waveforms. We believe the flow velocity waveforms obtained by this method were produced by the arcuate arteries or by the ascending branch of the uterine artery. Hereafter these flow velocity waveforms will be called uterine artery flow velocity waveforms. Two measurements were obtained from each side. The average systolic/diastolic ratio of the two measurements on each side is reported as right uterine artery systolic/diastolic ratio and left uterine artery systolic/diastolic ratio. The average of the left and right uterine arteries is reported as mean uterine artery systolic/diastolic ratio to compare with reported data.

Results were analyzed by the two-tailed Student t test for paired observations. To compare normal and hypertensive pregnancies, the Student t test for independent samples with unequal variances was used. Comparisons of frequencies were performed with the χ^2 test. In comparisons of multiple groups the significance level was adjusted according to Bonferroni's method.[6]

Results

The placenta was located unilaterally 57% of the time in normal pregnancies and 67% of the time in hypertensive pregnancies (Table I). In both normal and hypertensive pregnancies the right and left uterine artery flow velocity waveforms demonstrated significantly different systolic/diastolic ratios when the placenta was located unilaterally. When the placenta was centrally located the difference between right and left uterine arteries was not statistically significant (Table II).

Because the laterality differences were consistent regardless of left or right placental location, all of the women with unilateral placentation were grouped together and the ipsilateral uterine artery was compared with the contralateral artery. In normal and hypertensive pregnancies the ipsilateral and contralateral uterine arteries were significantly different (Table III).

Table IV. Comparison of ipsilateral uterine artery systolic/diastolic ratios with the mean uterine artery S/D ratio in normal and hypertensive pregnancies

	Normal pregnancies		*Hypertensive pregnancies*	
Uterine arteries	*n*	*(mean ± SD)*	*n*	*(mean ± SD)*
Ipsilateral	48	1.73 ± 0.35	19	2.38 ± 1.01
Mean	48	2.09 ± 0.43	19	3.03 ± 1.08
		$p < 0.001$		$p = 0.001$

Table V. Percentage of cases in which ipsilateral, contralateral, and mean uterine artery systolic/diastolic ratios would be classified abnormal according to criteria of Trudinger et al.[1,5] and of Fleischer et al.[2] and Schulman[3] in normal and hypertensive pregnancies

	Normal pregnancies (% of cases with abnormal S/D ratio)		*Hypertensive pregnancies (% of cases with abnormal S/D ratio)*	
Uterine arteries	*According to Trudinger et al.*	*According to Fleischer et al. and Schulman*	*According to Trudinger et al.*	*According to Fleischer et al. and Schulman*
Ipsilateral	38	0	53	26
Contralateral	79	27	89	74
Mean	67	9	82	50

The mean uterine artery systolic/diastolic ratio in normal and hypertensive pregnancies was 2.02 ± 0.40 (systolic/diastolic ratio) and 2.87 ± 1.01, respectively ($p = 0.0002$). The difference between the mean and the ipsilateral uterine artery systolic/diastolic ratios in normal and hypertensive pregnancies also was significant (Table IV).

Neither of the uterine arteries had notching in the normal group. In the hypertensive group 18 (65%) study participants demonstrated notching in one or both uterine arteries. When notching was present in only one of the uterine arteries in women with unilateral placentas, it always involved the contralateral artery. Table V shows the percentage of cases in which the systolic/diastolic ratios of the left, contralateral, and mean uterine arteries would be classified abnormal if the criteria of Trudinger et al.[1,5] or Fleischer et al.[2] and Schulman[3] were used.

Comment

This report demonstrates a significant relationship between placental location and uterine artery resistance expressed by the systolic/diastolic ratio of the uterine artery flow velocity waveforms in both normal and hypertensive pregnancies. When the placenta is located unilaterally, the ipsilateral uterine artery has a lower systolic/diastolic ratio than the contralateral artery. When the placenta is located cenrally both sides demonstrate similar systolic/diastolic ratios.

Campbell et al.[7,8] used duplex-pulsed Doppler to evaluate uterine flow velocity waveforms and found that the vessels on the placental side have a lower pulsatility index. However, it is not clear from their report whether the flow velocity waveforms were obtained from the right or the left sides or simply away from the placenta. In addition, their description indicates the measurements may have been obtained from the parametrial area anywhere between the cervix and the cornu of the uterus. This is important with regard to comparisons because we found that even on the placental side the systolic/diastolic ratio increased as the distance from the placenta increased (unpublished data). Although it is clear from the present data that the systolic/diastolic ratio of the ipsilateral uterine artery is significantly lower than the mean systolic/diastolic ratio, it is not clear whether one is a better indicator of uterine vascular compromise than the other.

In normal pregnancies the spiral arterioles that supply the placental bed undergo trophoblast-induced conversion to uteroplacental arterioles, whereas in pregnancies complicated by preeclampsia or intrauterine growth retardation, conversion of the spiral arterioles is incomplete. This conversion of the spiral arterioles involves only the subplacental vessels.[9-11] If there were no functional anastomoses between right and left uterine arteries, in cases with unilaterally located placentas, one would expect the ipsilateral uterine artery systolic/diastolic ratios to change more than the contralateral ratios in hypertensive pregnancies. On the basis of our findings one could speculate about the existence of functional anastomoses between the two

uterine arteries and a dynamic interaction between right and left uterine artery networks in hypertensive patients.

It is not known whether both uterine arteries contribute equally to uteroplacental blood flow in human pregnancy, although there is evidence of arterial anastomoses between left and right human uterine arteries.[12] In primates evidence exists that this contribution is not equal with one of the uterine arteries supplying more spiral arterioles than the other.[13] The need is obvious for longitudinal studies to address the issue of uterine artery blood flow contributions and to explore the response of the two uterine arteries in preeclampsia. Such studies may also help to determine whether the flow velocity waveforms of the ipsilateral or the contralateral uterine artery are a more sensitive and specific indicator of uteroplacental blood flow compromise.

In conclusion, this report has demonstrated a significant relationship between placental location and uterine artery systolic/diastolic ratios. It has yet to be shown whether evaluation of flow velocity waveforms of uterine arteries may enable us to understand the complex physiologic changes of the uteroplacental vasculature during normal and abnormal human pregnancy and to improve our ability to provide optimal care.

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