Comparison of two different sites of measurement for transabdominal uterine artery Doppler velocimetry at 11–13 weeks

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ABSTRACT

Objectives To compare the feasibility of two transabdominal approaches for performing first-trimester uterine artery (UtA) Doppler and to evaluate the correlation with pulsatility index (PI) in the second trimester.

Methods This was a prospective longitudinal Doppler study of the uterine arteries at 11–13 and 21–22 weeks’ gestation. Transabdominal ultrasound and color Doppler were used to measure the UtA-PI of the ascending branch of the uterine artery at the level of the internal cervical os (Site A) and at the level of the apparent crossover with the external iliac artery (Site B) at 11–13 weeks, and at Site B only at 21–22 weeks. In all cases the measured left and right PI were converted to a multiple of the median (MoM) for gestational age, and the intercorrelation between the measurements at different sites and gestational ages was calculated using non-parametric analysis (Spearman’s rank correlation).

Results Satisfactory measurements were obtained at 11–13 weeks from both uterine arteries in all 81 women at Site A and in 50 (62%; 95% CI, 50–72%) at Site B (P < 0.01). Measurements were obtained at Site B at 21–22 weeks in all cases. In the 50 cases with measurements from both sites at 11–13 weeks, the correlation of PI-MoMs between Sites A and B at 11–13 weeks was only moderate (ρ = 0.61). The correlation between first-trimester UtA-PI MoMs at Site A and second-trimester UtA-PI MoMs was stronger than that between first-trimester UtA-PI MoMs at Site B and second-trimester UtA-PI MoMs (ρ = 0.73 vs ρ = 0.47, P < 0.01).

Conclusion Evaluation of UtA-PI at 11–13 weeks can be achieved at the level of the internal cervical os in a greater proportion of women than at the level of the apparent crossover with the external iliac vessels, and the measurements obtained correlate better with second-trimester UtA-PI. Copyright © 2012 ISUOG. Published by John Wiley & Sons, Ltd.

INTRODUCTION

Increased impedance to blood flow in the uterine arteries, as assessed by Doppler ultrasound, reflects impaired placentaion, which is associated with high downstream resistance owing to failure of trophoblastic invasion and of transformation of the spiral arteries into low-resistance vessels. Elevated uterine-artery impedance has been found to be associated with several adverse pregnancy outcomes, including pre-eclampsia and intrauterine growth restriction (IUGR). Initial Doppler studies were carried out at 18–24 weeks’ gestation, when the process of placentation is almost complete, but recent studies suggest that increased impedance indices can be present from as early as 11–13 weeks. When combined with biophysical and biochemical markers, it is now possible to predict most cases of pre-eclampsia at 11–13 weeks. These findings coincide with the publication of studies which demonstrate that low-dose aspirin, with or without low-molecular-weight heparin, is effective in reducing the prevalence of pre-eclampsia, IUGR and preterm birth in high-risk women. Consequently, there is growing scientific and clinical interest for a study...
that would evaluate the combination of prediction of pre-eclampsia and adverse pregnancy outcomes and their prevention with low-dose aspirin\textsuperscript{17}.

The heterogeneity of methodologies for first-trimester uterine artery (UtA) Doppler makes the interpretation and comparison of data difficult\textsuperscript{8}. While UtA pulsatility index (PI) at the level of the internal cervical os from its ascending branch has been reported as a strong and reproducible predictor of pre-eclampsia\textsuperscript{18–20}, there are still conflicting results regarding the role of first-trimester PI and which technical approach should be preferred\textsuperscript{9}. We hypothesized that the differences in the site of assessment for UtA Doppler could explain the controversy.

The objective of this study was to compare the measurements of UtA-PI using the two reported transabdominal approaches and to correlate them with mid-trimester findings, with the aim of helping to determine the optimal method of first-trimester screening for pre-eclampsia and IUGR.

**METHODS**

A prospective study was performed at Centre Hospitalier Universitaire de Québec (CHUQ). We consecutively recruited women with a singleton pregnancy and a live fetus at the time of ultrasound screening for Down syndrome, between 11 + 0 and 13 + 6 weeks’ gestation. The project was approved by the Institutional Ethics Committee and written informed consent was obtained from all women before enrollment. Gestational age was calculated from the last menstrual period and was confirmed by the measurement of fetal crown–rump length.

Transabdominal ultrasound examinations were performed using a RAB4-8-D 3D/4D curvilinear array probe (4–8.5 MHz) with the women having a full bladder. Each uterine artery was identified by color Doppler and was visualized from the cervix to its ascent along the uterine body. Each UtA-PI measurement was performed at two different sites: in the ascending branch of the uterine artery at the level of the internal cervical os (Site A) and at the level of the apparent crossover with the ipsilateral external iliac vessels (Site B). The PI was measured for the left and right uterine arteries using three similar consecutive waveforms.

In the case of Site A, we obtained a sagittal section of the uterus and the cervical canal in order to identify the uterine vessel angle. The probe was then moved laterally, side-to-side until the paracervical vascular plexus was seen, and color flow mapping was used to identify the uterine artery and its ascent along the uterine body (Figure 1)\textsuperscript{5}. Pulsed wave Doppler was used to obtain flow-velocity waveforms from the ascending branch of the uterine artery at the point closest to the internal os. The Doppler gate was set at 2 mm and placed over the vessel, and the smallest possible angle of insonation was sought to obtain the highest systolic peak and end-diastolic velocities. The procedure was repeated on both sides.

In the case of Site B, the probe was placed approximately 2–3 cm inside the iliac crests with the ultrasound beam directed toward the pelvis and the lateral side of the uterus. Each uterine artery was identified by color flow mapping, at the level of the apparent crossover with the external iliac artery. To ensure that Doppler velocities were recorded at the main trunk of the uterine artery before the collateral branches arise, we tried to sample approximately 1 cm distal to the crossover with the external iliac artery (Figure 2). The pulsed Doppler gate was set at 2 mm and placed over the vessels with the smallest possible angle of insonation. Pulsed wave Doppler was used to obtain flow-velocity waveforms. The procedure was repeated on both sides.

Uterine artery Doppler was repeated at 21–22 weeks on both sides of the uterus using the second technique (1 cm above the apparent crossover with the external iliac artery). All first- and second-trimester ultrasound examinations were performed by the same well-trained
sonographer who was blinded to the previous measurements and clinical data. One woman out of five was randomly selected to have a second first-trimester examination performed by another sonographer for assessment of interobserver agreement on whether satisfactory UtA-PI measurements could be obtained. Both sonographers were certified by The Fetal Medicine Foundation for uterine artery Doppler examination.

Correlation analyses were performed using women with available measurements for both sites. Right PI, left PI and mean PI were calculated for each examination. They were reported as multiples of the median (MoM) for gestational age in order to eliminate the gestational age effect\(^2\) and medians for each week of gestation were calculated using our own data. Correlation coefficients (\(\rho\)) between Site A and Site B measurements and between first- and mid-trimester findings were calculated using non-parametric analysis (Spearman’s rank correlation). We planned to recruit 80 women. The differences between correlation coefficients were compared using Fisher’s test (with \(r\)-to-\(Z\) transformation).

RESULTS

During the study, 81 women with live singleton pregnancies were recruited. Satisfactory first-trimester UtA Doppler measurements were achievable for both uterine arteries in 81 patients (100%) at Site A and in 50 patients (62%; 95% CI, 50–72%) at Site B (\(P < 0.01\)). The sonographer was not able to visualize the uterine artery at Site B on either side in 16 (20%; 95% CI, 12–30%) of the cases and on one side in 15 (19%; 95% CI, 11–29%). We found that the values of UtA-PI obtained from Site A were higher than those obtained from Site B (\(P < 0.001\)) on both the left and the right sides (Figure 3) and there was only a moderate correlation between mean UtA-PI measurements obtained using the two approaches (\(\rho = 0.61; n = 50\)).

Among the 50 women with available data for both uterine arteries using both techniques, two women were lost to follow-up and one had a miscarriage at 16 weeks’ gestation. The remaining 47 women had a satisfactory UtA Doppler examination at 21–22 weeks. We found that first-trimester mean UtA-PI at Site A correlated better than mean UtA-PI at Site B (\(\rho = 0.73\) vs \(\rho = 0.47\)) with mid-trimester mean UtA-PI (\(P < 0.01\)) and this was also true for both the left and the right uterine arteries considered separately (\(P < 0.01\) for both). Figure 4 demonstrates the correlation between first- and second-trimester mean UtA-PI according to both approaches. We compared the characteristics of women according to whether UtA Doppler measurement could be obtained at Site B on both sides at 11–13 weeks and we found that maternal weight could be a factor involved in the failure to obtain satisfactory measurements (Table 1).

Interobserver agreement on the feasibility of first-trimester UtA-PI measurements was evaluated in 16 women. For Site B, the two observers were in agreement regarding the feasibility for 29 (91%) of the 32 (left and right) evaluations (kappa = 0.76, \(P < 0.001\)). The small number of women evaluated by the two observers precludes further reproducibility analysis.

DISCUSSION

This study has found that first-trimester transabdominal UtA Doppler, performed at the level of the internal cervical os from its ascending branch (Site A), is more easily obtained and correlates better with mid-trimester Doppler than when it is performed at the level of the apparent crossover with the external iliac vessel (Site B). These
Table 1 Characteristics of participants according to whether uterine artery Doppler measurements could be obtained at apparent crossover with external iliac artery (Site B) on both sides at 11–13 weeks

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Doppler achievable on both sides</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age (years)</td>
<td>Yes (n = 50)</td>
<td>No (n = 31)</td>
</tr>
<tr>
<td>Gravidity</td>
<td>29 (26–33)</td>
<td>29 (26–34)</td>
</tr>
<tr>
<td>Parity</td>
<td>2 (2–3)</td>
<td>2 (1–4)</td>
</tr>
<tr>
<td>Gestational age at first ultrasound (weeks)</td>
<td>12.6 (12.1–13.0)</td>
<td>12.3 (12.0–12.9)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>161 (157–165)</td>
<td>162 (159–170)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58 (51–69)</td>
<td>65 (61–74)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>22 (20–26)</td>
<td>24 (21–28)</td>
</tr>
</tbody>
</table>

Results are in agreement with those of Kaminopetros et al., who found a strong correlation between transabdominal first-trimester UtA-PI at the level of the internal cervical os from its ascending branch with mid-trimester UtA-PI ($r = 0.60$ and 0.54 for the left side and the right side, respectively)\textsuperscript{18}. They are also in agreement with previous studies that showed a good predictive value of this approach for placental-related adverse pregnancy outcomes\textsuperscript{3–8}. These combined results suggest that first-trimester UtA Doppler measurements for prediction of pre-eclampsia and IUGR should be taken at the level of the internal cervical os from its ascending branch.

Several studies have reported that evaluation of blood-flow impedance of the mid-trimester uterine artery evaluated at the level of the apparent crossover with the external iliac artery (Site B) is a strong predictor of several adverse pregnancy outcomes. However, this approach seems to be difficult to apply to first-trimester examination. Liao et al. also found that measurement at Site B is not applicable to the first trimester and that different techniques should be employed\textsuperscript{22}. First, the uterus is much smaller during the first trimester and sometimes there is no apparent crossover with the external iliac artery to allow appropriate measurement. Second, the apparent crossover with the external iliac artery could be far from the cervical os of the small uterus. We believe that the differences in PI values between sites of measurements could be explained by the collateral vessels (Figure 5)\textsuperscript{23}.

In the current study, we found a lower median PI at Site B for both left and right uterine arteries in the first trimester. Interestingly, the median values of UtA-PI observed at Site A in the current cohort are comparable with those of Poon et al., using the same technique, while the median values obtained from Site B are comparable with those of Audibert et al. and Kasdaglis et al\textsuperscript{9,10,24}. Our study was limited by the small number of women included. However, the significant differences found between the two measurement sites are sufficient to question the use of Site B (at the level of the apparent crossover with external iliac artery) using the transabdominal approach for first-trimester evaluation of UtA Doppler in any screening program for pre-eclampsia. Our study was also limited by the absence of transvaginal evaluation of UtA Doppler. The transabdominal route was selected for this study because it is a user-friendly approach that could be easily integrated into routine prenatal screening. Kaminopetros et al. also described significant correlations between first-trimester PI obtained using transvaginal and transabdominal techniques and second-trimester PL, but the strength of the correlations were higher when the transvaginal approach was used\textsuperscript{18}. In their study, they used Site A measurements for both transabdominal and transvaginal approaches at first-trimester examination and Site B measurements for the second trimester. Moreover, Plasencia et al. found that first-trimester transvaginal examination of UtA Doppler using measurements at Site A was associated with higher PI values than those obtained transabdominally. However, they did not correlate their findings with mid-trimester values\textsuperscript{25}. Finally, the current study did not evaluate the factors related to the lack of correlation between first- and second-trimester UtA-PI and was not designed to examine adverse pregnancy outcomes.

The findings of this study could explain the contradictory results between studies that evaluated the use of first-trimester UtA Doppler for prediction of pre-eclampsia\textsuperscript{2,9,24}. It demonstrates that first-trimester UtA Doppler at the cross-section with iliac vessels is difficult to obtain and unachievable in a significant proportion of
women, an important limitation for its use as a screening procedure. Moreover, PI values using this approach do not correlate with mid-trimester UtA-PI values as well as do the PI values obtained by UtA Doppler at the level of the cervical os, a marker of impaired placentation process and placental-related adverse pregnancy outcomes.\(^1\)\(^2\)\(^6\)\(^27\). In conclusion, the current study and the literature suggest that first-trimester UtA Doppler for the prediction of pre-eclampsia and IUGR should be performed at the level of the internal cervical os from its ascending branch.

REFERENCES


