Doppler interrogation of the uterine arteries provides information on the physiologic transformation of the spiral arteries during pregnancy. Lack or suboptimal conversion of such arteries by the late second or third trimester of pregnancy is a strong indicator of increased risk for adverse pregnancy outcome, in particular, iatrogenic prematurity due to severe fetal growth restriction or preeclampsia. Uterine artery Doppler can thus play a role in the presence of medical conditions antedating pregnancy, which have greater risk of abnormal placentation, like chronic hypertension, to identify the subgroup with increased pregnancy complications and adverse outcome. In the presence of pregnancy complications related to inadequate placentation, such as fetal growth restriction or preeclampsia, uterine artery Doppler also plays a role, as abnormal findings signal increased severity of the disease and thus greater likelihood of unfavorable perinatal outcome.

KEYWORDS: uterine artery, Doppler velocimetry, fetal growth restriction, preeclampsia, abnormal placentation

In the presence of obstetric complications in the third trimester of pregnancy, UtA Doppler is ideally positioned to provide valuable prognostic information allowing the recognition of complications associated with abnormal placentation. Several maternal pathologies antedating pregnancy, such as chronic hypertension, inherited and acquired thrombophilias, diabetes mellitus, and autoimmune disorders including lupus erythematosus, increase the probability of abnormal development of the placental vasculature with the related risk of obstetric complications. Once again, UtA Doppler at completion of placentation has been used to identify the subset of such high-risk pregnancies, which may benefit from increased surveillance, whereas in the subset with appropriate placentation, normal UtA Doppler findings can provide reassurance to the parents and the health care providers.

Technique

The technique of UtA Doppler interrogation is fairly simple. Using color-flow mapping, each uterine artery is identified where it crosses over the external iliac artery. The range gate should be placed over the entire diameter of the artery distal to the crossover point and before division into branches. The angle of insonation should be minimized and kept at least 60°. Once waveforms are obtained with a clear envelope, at least three waveforms can be averaged and impedance indi-
ces calculated (Figs. 1 and 2) Interobserver variability of UtA Doppler has been reported as approximately 10%, with intraobserver variability of 2.5 to 10.1%.3-5

Uterine Artery Doppler in the Presence of Obstetric Complications

Fetal Growth Restriction

In the presence of ultrasonographic evidence of FGR, abnormal UtA Doppler identifies fetuses at higher risk of preterm delivery and lower birth weight.6,7 Low gestational age at delivery is the most important independent predictor of adverse neonatal outcome in FGR.8 In one study of FGR fetuses with abnormal UtA Doppler, only 20% of those delivered at <34 weeks had uncomplicated neonatal course, compared with 60% of those delivered at >34 weeks.9 In the largest study of 294 FGR fetuses delivered after 34 weeks, adverse neonatal outcome—defined as admission to the neonatal intensive care unit (NICU) for reasons other than low birth weight alone—occurred more frequently in cases with abnormal than normal UtA Doppler waveforms (35% versus 11%, OR = 3.2; 95% CI, 1.9-5.3) (Table 1). Logistic regression analysis demonstrated that abnormal UtA Doppler findings remained a significant predictor of adverse neonatal outcome after controlling for occurrence of preeclampsia (OR = 4.1, 95% CI, 2.2-7.5).10 Umbilical artery Doppler is a major prognosticator among FGR cases, particularly those delivered preterm. In cases with normal umbilical artery Doppler findings, UtA Doppler prognosticates increased risk for emergency cesarean section.11 Not surprisingly, UtA Doppler has been found to be a predictor of perinatal mortality and major neonatal morbidity.9 Finally, abnormal results at UtA Doppler in the presence of FGR identifies women at increased risk for subsequent development of preeclampsia.12

Hypertensive Complications of Pregnancy

Placental vascular lesions due to abnormal placentation are a characteristic finding in the presence of preeclampsia and other hypertensive complications of pregnancy. UtA Doppler obtained on admission for such conditions offers precious information, identifying the majority of pregnancies at higher risk for indicated preterm delivery, and neonates with worse FGR and need for NICU admission.13 For example, in a cohort study of 186 cases of preterm preeclampsia diagnosed on average at 31.3 ± 3.6 weeks and delivered at 32.8 ± 3.3 weeks, those with abnormal UtA Doppler findings on admission had significantly lower gestational age delivery (32.5 versus 35.3 weeks), higher rates of very low birth weight (52% versus 5%), and of FGR (70% versus 23%).14 Of interest, UtA Doppler predictive ability was independent of laboratory indicators of severity of preeclampsia.14 The information provided by UtA Doppler operates along a continuum, so that the risk for such adverse outcomes is directly correlated with the severity of abnormal UtA Doppler findings15 (Table 2).

Decreased Fetal Movements

Only one study has examined the value of UtA Doppler at the time of nonstress test done for decreased fetal movements at a mean gestational age of 36 weeks. Abnormal UtA Doppler findings were significantly associated with delivery within 2 days of testing, with emergency cesarean delivery and operative delivery for fetal distress, but not with more objective measures of adverse neonatal outcome.16

Obstetric Complications

In a large cohort of pregnancies with a variety of complications, including gestational hypertension with or without proteinuria, oligohydramnios, suspected FGR, vaginal bleeding, preterm labor, postterm pregnancy, decreased fetal movement, or history of adverse outcome, 54% (399/741) developed adverse perinatal outcome, defined as low Apgar score, low arterial or venous pH, preterm delivery, cesarean delivery for fetal distress, admission to NICU, birth weight >2 SD below expected, or perinatal death. UtA Doppler ob-
tained at an average of 38.6 weeks (range: 25.6-43.1) predicted the occurrence of adverse outcome with odds ratios and positive likelihood ratios (LR) directly proportional to the severity of the UtA Doppler abnormality (Table 3). Similarly, in a study of 633 pregnancies at high risk due to hypertensive complications of pregnancy, oligohydramnios, suspected FGR, vaginal bleeding, postterm pregnancy, decreased fetal movement, previous adverse outcome (ie, stillbirth, small for gestational age (SGA) baby, or preeclampsia), UtA Doppler at an average of 35 weeks predicted risk of SGA neonates, need for cesarean delivery, and prematurity, with a predictive ability that was independent and superior to that of umbilical artery Doppler. These findings were confirmed by an independent study of UtA Doppler in 282 women at high risk due to a variety of medical conditions (including chronic hypertension, renal or autoimmune disease, as well as history of adverse obstetric outcome). Compared with normal UtA Doppler findings, abnormal UtA Doppler results at 28 weeks were associated with higher risk for preeclampsia (LR 7.6, 95% CI, 3.7, 7.6), SGA baby (LR 11.2, 95% CI, 6.6-18.7), fetal demise (LR 7.3, 95% CI, 2.4-7.3), or severe complications, defined as the development of preeclampsia, hypertensive disease with a SGA baby, intrauterine demise of a structurally normal fetus, or elective delivery before 34 weeks for maternal or fetal indications (LR 12.5, 95% CI, 8.8-13.6).

Table 1 Perinatal Outcome in Relation to Maternal Uterine Artery Doppler Waveform in Growth-Restricted Fetuses Delivered at >34 weeks

<table>
<thead>
<tr>
<th>Uterine Artery Abnormal (n = 109)</th>
<th>Doppler Waveform Normal (n = 185)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preeclampsia</td>
<td>22%</td>
<td>11%</td>
</tr>
<tr>
<td>Gestational age at delivery (wk)</td>
<td>37.7 ± 2.0</td>
<td>38.8 ± 1.6</td>
</tr>
<tr>
<td>Meconium-stained amniotic fluid</td>
<td>3%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Cesarean delivery (CD)</td>
<td>38%</td>
<td>15%</td>
</tr>
<tr>
<td>CD for non-reassuring fetal testing</td>
<td>27%</td>
<td>10%</td>
</tr>
<tr>
<td>Birth weight (g)</td>
<td>2193 ± 446</td>
<td>2524 ± 379</td>
</tr>
<tr>
<td>Birth weight percentile</td>
<td>4.8 ± 5.1</td>
<td>9.3 ± 10.2</td>
</tr>
<tr>
<td>Umbilical artery pH</td>
<td>7.28 ± 0.07</td>
<td>7.29 ± 0.07</td>
</tr>
<tr>
<td>Admission to NICU</td>
<td>35%</td>
<td>11%</td>
</tr>
<tr>
<td>Length of stay in NICU (days)</td>
<td>20.7 ± 10.2</td>
<td>16.5 ± 10.3</td>
</tr>
</tbody>
</table>

Mean ± SD or (%).

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Uterine Artery Doppler in the Presence of Preexisting Medical Complications

Chronic Hypertension

Superimposed preeclampsia and FGR are the two most common obstetric complications in women with chronic hypertension and can be predicted by Doppler interrogation of UtA at completion of placentation. In an initial study, 78 women with chronic hypertension underwent UtA Doppler at 24 weeks gestation. The screen positive rate was 32% when abnormal findings were defined by elevated resistance indices, and 17% when defined by presence of bilateral notching. The rates of preeclampsia (12% versus 0%) and FGR (52% versus 2%) were significantly different between those with versus without increased impedance to flow using resistance indices, as well as between those with versus without notching (preeclampsia: 23% versus 0%; FGR: 85% versus 2%, respectively). In another study of 182 women with chronic hypertension undergoing UtA Doppler at 29 ± 4 weeks gestation, the screen positive rate was 32% when abnormal findings were defined by elevated resistance indices, and 17% when defined by presence of bilateral notching. The rates of preeclampsia (12% versus 0%) and FGR (52% versus 2%) were significantly different between those with versus without increased impedance to flow using resistance indices, as well as between those with versus without notching (preeclampsia: 23% versus 0%; FGR: 85% versus 2%, respectively). In another study of 182 women with chronic hypertension undergoing UtA Doppler at 29 ± 4 weeks, 36% had increased resistance to flow. Rates of superimposed preeclampsia (28% versus 5%), SGA fetuses (46% versus 14%), and severe complications (60% versus 18%) were significantly higher among cases with increased impedance to flow.

Table 2 Effect of Severity of Uterine Artery Doppler Results on Probability of Adverse Outcome in Preeclampsia

<table>
<thead>
<tr>
<th>Score 0</th>
<th>Score 1</th>
<th>Score 2</th>
<th>Score 3</th>
<th>Score 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>363</td>
<td>76</td>
<td>79</td>
<td>35</td>
</tr>
<tr>
<td>Severe preeclampsia</td>
<td>13%</td>
<td>26%</td>
<td>25%</td>
<td>34%</td>
</tr>
<tr>
<td>Weeks at delivery</td>
<td>38 ± 2</td>
<td>37 ± 3</td>
<td>37 ± 4</td>
<td>36 ± 4</td>
</tr>
<tr>
<td>Delivery &lt;34 weeks</td>
<td>2%</td>
<td>16%</td>
<td>16%</td>
<td>17%</td>
</tr>
<tr>
<td>Birth weight &lt;10th centile</td>
<td>2%</td>
<td>3%</td>
<td>10%</td>
<td>17%</td>
</tr>
</tbody>
</table>

Uterine Artery Score definition: Score 0: normal flow in both arteries; Score 1: one abnormal parameter (high Pulsatility Index >1.2 or notch present); Score 2: two abnormal parameters; Score 3: three abnormal parameters; Score 4: four abnormal parameters.

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Moreover, gestational age at delivery (36.6 ± 3.1 versus 38.7 ± 1.7 weeks) and birth weight (2409 ± 698 versus 3146 ± 517 g) were significantly different between the two groups.²¹

**Antiphospholipid Syndrome (APS)**

A study with over 100 cases of APS showed that abnormal UtA Doppler at completion of placentation was present in 20 to 30% of cases and it was independently associated with subsequent occurrence of adverse outcome (defined as FGR, preeclampsia, or stillbirth).²² Similarly, a smaller study of 43 women with APS showed that abnormal UtA Doppler was associated with increased risk of preterm preeclampsia or abortion (LR = 5.6, 95% CI, 2.4-5.6).²³ At variance with these findings, a large study on 170 women with APS (all with history of habitual abortion) showed that abnormal UtA Doppler at 24 weeks was not predictive of subsequent occurrence of preeclampsia or birth weight <10th centile.²⁴ However, a subanalysis suggested that presence of bilateral notch at UtA Doppler was a powerful predictor of preeclampsia (LR = 12.8, 95% CI, 2.2-75) or SGA neonates (LR = 13.6, 95% CI, 1.9-96) among the 45 women with lupus anticoagulant.

**Diabetes Mellitus**

UtA Doppler in the third trimester independently identifies among pregnancies with diabetes mellitus and vasculopathy, those at increased risk of preeclampsia and greater risk of cesarean delivery for non-reassuring fetal status.²⁵ Once again, the information provided by UtA Doppler operates along a continuum, so that in women with diabetes mellitus antedating pregnancy the risk for adverse perinatal outcome (defined as operative delivery for fetal distress, preterm delivery, 5-minute Apgar score <5, low umbilical artery pH, and SGA infants) is directly correlated with the severity of the abnormal UtA Doppler findings.²⁶ Finally, among women with gestational diabetes, abnormal UtA Doppler findings are significantly associated with greater risk of subsequent pre-eclampsia (positive LR of 10.4, 95% CI, 6.6-10.4).²⁷

**Conclusions**

UtA Doppler can identify women with obstetrical complications related to abnormal placentation. Such predictive ability is often independent of other demographic, obstetric, or laboratory characteristics. UtA Doppler has the potential to be incorporated in the routine evaluation of women with preexisting medical conditions associated with increased risk of abnormal placentation, as well as in the evaluation of healthy women who experience obstetric complications related to placental vascular pathology. One of the appealing features of UtA Doppler is that the evaluation needs to be made only once in the late second or third trimester, as abnormal values are unlikely to improve after placental implantation is completed. UtA Doppler is also an ideal tool to establish or rule out placental vascular origin of pathologic processes affecting the fetus, for example, in the presence of FGR.

Screening of high-risk patients has also potential benefits for those with normal results, including reassurance to the patient and benefit in quality of life, less need for unnecessary testing in the third trimester, and reduced time lost from employment while undergoing evaluations and rest. For example, a retrospective study on 170 women at high risk for preeclampsia due to history of preeclampsia, preterm delivery, FGR, fetal demise, abruption, chronic hypertension, diabetes mellitus, or renal disease showed that normal UtA Doppler at 24 weeks, which was found in 69% of cases, had a negative-predictive value of 99% for subsequent occurrence of preeclampsia.³ Prospective studies are needed to confirm these potential benefits.

The time is ripe for larger and better designed studies to evaluate the independent predictive ability of UtA Doppler using multivariate analysis and defining unfavorable pregnancy outcome with objective criteria. Confirmation of UtA Doppler as prognosticator of outcome could herald widespread implementation of this simple technique. It should be remembered that UtA Doppler is of little use for obstetric complications in which fetal risk is not due to impaired placentation, eg, postterm pregnancy or premature rupture of membranes.²⁸,²⁹ More studies are also needed to establish how UtA Doppler identification of patients at increased risk of adverse outcome can affect their management. It is currently unproven whether increased frequency of monitoring of fetal wellbeing, closer ultrasonographic surveillance of fetal growth, more frequent monitoring of maternal blood pressure or proteinuria, and administration of corticosteroid prophylaxis for fetal lung maturity may affect the outcome of patients with abnormal UtA Doppler findings. Finally, the cost–benefit analysis of implementation of UtA Doppler still needs to be tested.

**References**


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**Table 3 Predictive Ability of Uterine Artery Score for Adverse Perinatal Outcome in Pregnancies with Obstetric Complications**

<table>
<thead>
<tr>
<th>UtA Doppler Score</th>
<th>Adverse Outcome (n)</th>
<th>Odds Ratio (95% CI)</th>
<th>Likelihood Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>37% (142/389)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>1</td>
<td>68% (128/188)</td>
<td>1.64 (1.00 to 2.70)</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>74% (76/103)</td>
<td>1.86 (1.00 to 3.54)</td>
<td>3.5</td>
</tr>
<tr>
<td>3</td>
<td>84% (42/50)</td>
<td>4.03 (1.77 to 10.32)</td>
<td>7.3</td>
</tr>
<tr>
<td>4</td>
<td>100% (11/11)</td>
<td>∞ (3.20 to ∞)</td>
<td>∞</td>
</tr>
</tbody>
</table>

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