BENHA MEDICAL JOURNAL bmj

Print ISSN 1110-208X.

Online ISSN 2357-0016

The Added Value of Uterine Artery Doppler in The Evaluation of The Second and Third Trimester Fetal Distress: A Systematic Review

Tasneem M. Badr, Hamada T. Khater, Alaa M. Shalabi

Abstract:

Background: The uterine artery plays a critical role in fetal oxygenation and nutrient delivery during pregnancy. Abnormal uterine artery Doppler (UAD) indices, such as elevated pulsatility index (PI) and diastolic notching, are associated with adverse outcomes like fetal distress (FD), preeclampsia, and fetal growth restriction (FGR). Despite its clinical utility, the predictive accuracy of UAD in the second and third trimesters remains variable. This systematic review aimed to evaluate the diagnostic performance of UAD indices in predicting FD and related perinatal complications during the second and third trimesters of pregnancy. Following PRISMA 2020 guidelines, a comprehensive search of PubMed, Scopus, and Web of Science was conducted (January 2015–May 2025). Studies assessing UAD indices in singleton pregnancies ≥18 weeks were included. Two reviewers independently screened records, extracted data, and appraised study quality using the Newcastle-Ottawa Scale. Of 204 records, 23 studies met inclusion criteria. In the second trimester, elevated PI (>95th percentile multiples of the median) showed moderate sensitivity and high specificity for FD. Bilateral notching improved specificity but not sensitivity. Third-trimester PI (>1.5 multiples of the median) had similar specificity but lower sensitivity for predicting emergency cesarean delivery due to FD. Bilateral notching in late gestation correlated strongly with adverse neonatal outcomes. UAD indices, particularly in the second trimester, offer high specificity for identifying pregnancies at risk of FD and adverse outcomes. However, sensitivity limitations highlight the need for multimodal screening. Standardized protocols and integrated risk models are essential for optimizing clinical utility.

Keywords: uterine artery Doppler; pulsatility index; fetal distress; preeclampsia; FGR

Diagnostic Radiology Department, Faculty of Medicine Benha University, Egypt.

Corresponding to:
Dr. Tasneem M. Badr.
Diagnostic Radiology Department, Faculty of Medicine Benha University, Egypt.
Email: Tassneembadr@gmail.com

Received:
Accepted:

Introduction

The uterine artery plays a crucial role in providing nutrients and oxygen (O_2). to the fetus during pregnancy. In early pregnancy, uteroplacental circulation forms through trophoblast invasion into the uterine decidua and vessels. This allows maternal blood to deliver nutrients and O_2 to the maternal-fetal interface. The uterus and uterine arteries undergo gradual changes throughout pregnancy to support fetal growth and maintain placental function[(1).]

Uteroplacental blood vessel formation occurs in two stages. Before 12-weeks, spiral arteries invaded the boundary between the decidua and myometrium. From 12 to 16 weeks, they penetrate the myometrium, transforming into low resistance uteroplacental vessels. As the fetus grows, uterine artery resistance decreases to enhance blood flow. However, defective placentation increases resistance and risk of complications like preeclampsia, FGR, and small-for-gestational-age (SGA) neonates [(2)].

Blood flow in the uterine artery is now measured noninvasively via Doppler ultrasound, using the anatomical landmark where the artery crosses the external iliac artery. Indices like pulsatility index (PI), resistive index (RI), systolic/diastolic ratio, and diastolic notch are key indicators. Elevated resistance is associated with intrauterine growth restriction (IUGR) and preeclampsia [(3)].

Doppler evaluation is commonly used in high-risk pregnancies, such as those with a history of IUGR, hypertension, autoimmune disease, or fetal distress (FD). FD, often due to acidosis and hypoxia, can result in neurological damage or death. Color Doppler ultrasound is valuable for diagnosing such complications. It assesses umbilical and cerebral arteries and may help distinguish between placental and maternal causes of FD, guiding appropriate management [(4)].

1. Fetal Distress:

Fetal distress (FD) refers to signs suggesting compromised fetal oxygenation, often indicating fetal hypoxia, though no universally standardized definition exists. It encompasses a spectrum of clinical scenarios that can lead to serious neonatal outcomes, including neurological injury, morbidity, and mortality. Prompt recognition and response—typically via emergency cesarean deliver—are essential when fetal cerebral oxygen deprivation is suspected to prevent irreversible damage [(5)].

The pathophysiology of FD often involves impaired uteroplacental perfusion, which may be aggravated by uterine contractions, cord compression, or spiral artery dysfunction. Maternal conditions such as hypertensive disorders, diabetes mellitus, systemic inflammation, chorioamnionitis, preterm labor, and fetal growth restriction (FGR) can further impair oxygen delivery, increasing fetal vulnerability [(6)].

To mitigate the risk of hypoxic–ischemic injury, clinicians rely on the detection of non-reassuring fetal heart rate (FHR) patterns during labor to guide timely intervention. Advances in understanding fetal responses to asphyxia and interpreting FHR evolution have refined the criteria for diagnosing FD. In high-risk pregnancies, antepartum assessments and continuous intrapartum monitoring are key to evaluating fetal oxygenation and guiding obstetric management [(5,6)].

Physiology of Fetal Oxygenation

Fetal oxygenation involves the transplacental transfer of molecular oxygen, its binding to fetal hemoglobin (HbF), and distribution via fetal circulation to support aerobic metabolism and tissue development. This metabolic process converts oxygen and glucose into carbon dioxide and water, generating energy critical for fetal growth. In hypoxic conditions, however, the Krebs cycle is inhibited, forcing cells into anaerobic metabolism, where pyruvate is converted to lactic acid, contributing to metabolic acidosis [(7)].

Despite continuous acid production under normal metabolic activity, fetal acid–base homeostasis is tightly regulated. Plasma bicarbonate and hemoglobin serve as primary buffering agents, maintaining extracellular pH within a narrow physiological range to protect vital organs like the CNS and cardiovascular system. Secondary buffers such as inorganic phosphates and erythrocyte bicarbonate provide additional, though limited, acid neutralization.

Crucially, the oxygen–hemoglobin dissociation relationship is non-linear. Factors such as blood pH and 2,3-diphosphoglycerate (2,3-DPG) levels modulate HbF's affinity for oxygen, affecting how readily oxygen is released to fetal tissues [(8)].

Hemodynamic Consequences to Hypoxia

Fetal hypoxia is a pathological condition characterized by insufficient oxygen supply to fetal tissues, impairing aerobic metabolism. When oxygen becomes limited, cells shift to anaerobic metabolism, producing organic acids such as lactic acid. Accumulation of these acids can surpass the fetal buffering capacity, leading to metabolic acidosis, which may compromise organ function and increase the risk of adverse outcomes [(9)].

There are several mechanisms of fetal hypoxia:

1.Hypoxemic hypoxia – caused by reduced maternal placental perfusion, leading to decreased fetal arterial oxygen tension (pO_2).

2.Anemic hypoxia – results from low fetal hemoglobin (HbF) concentration, reducing oxygen-carrying capacity.

3.Ischemic hypoxia – occurs when blood flow to fetal tissues is impaired, regardless of oxygen content.

Based on the placenta's role in oxygen transfer, hypoxia is further classified into:

- Preplacental hypoxia: Systemic hypoxia affecting both mother and fetus (e.g., high altitude, cyanotic heart disease).
- Uteroplacental hypoxia: Normal maternal oxygenation but compromised placental circulation (e.g., preeclampsia, placental insufficiency).
- Post placental hypoxia: Adequate oxygen supply to the placenta, but impaired fetal utilization, leading to localized fetal hypoxia.

These hypoxic states may result from acute or chronic maternal, placental, or fetal conditions, all of which can disrupt acid–base balance and amplify the physiological impact of hypoxia [(10)].

Antenatal Surveillance:

Antenatal surveillance plays a pivotal role in identifying and managing pregnancies at increased risk for adverse outcomes. Modern obstetric care emphasizes the early detection and continuous monitoring of such pregnancies through assessments of fetal growth, placental function, cardiovascular dynamics, and hemodynamic parameters. Accurate evaluation enables timely parental counseling, appropriate diagnostic planning, consideration of in utero interventions, and coordinated perinatal and postnatal care strategies [(11)].

Ultrasound technology has become an indispensable tool in fetal surveillance. Its primary purposes include determining gestational age, identifying multiple gestations, detecting congenital anomalies, and evaluating growth patterns. Fetuses classified as small for gestational age (SGA) or those with fetal growth restriction (FGR) are at higher risk for intrauterine hypoxia and perinatal complications, necessitating heightened clinical attention [(12)].

When FGR is suspected, early biometric assessment via ultrasound is crucial. Continued surveillance, typically every two weeks—helps monitor growth trajectories and assess for worsening growth deviations, enabling evidence-based decisions regarding the timing and mode of delivery to optimize fetal outcomes [(13)].

2. Uterine Artery Doppler:

The uterine arteries, originating from the internal iliac arteries, supply the uterus by ascending along its lateral walls after giving off cervical branches. These arteries anastomose with the ovarian arteries near the uterine cornua. Branches, known as arcuate arteries, run transversely along the uterus and give rise to approximately 100 radial arteries, which penetrate the myometrium and reach the decidual layer. There, they form the spiral arteries, which are responsible for delivering oxygen-rich maternal blood into the intervillous space of the placenta, facilitating fetal oxygenation and nutrient exchange [(2)].

In the non pregnant state, spiral arteries are muscular and have high resistance. During pregnancy, they undergo a critical process known as spiral artery remodeling, essential for establishing effective uteroplacental circulation. This transformation is driven by trophoblastic invasion during the first and early second trimesters—initially after implantation (primary invasion) and again between 12–16 weeks gestation (secondary invasion). The arteries lose their smooth muscle and endothelial lining, becoming dilated, low-resistance vessels. This remodeling shifts the uteroplacental blood supply into a high-capacitance, low-resistance system, optimized for continuous maternal–fetal exchange and independent of maternal blood pressure regulation [(14)].

Failure of spiral artery transformation is a key mechanism in several pregnancy complications, including preeclampsia, fetal growth restriction (FGR), placental abruption, late spontaneous miscarriage, preterm labor, and premature rupture of membranes. Of these, early-onset preeclampsia is most strongly linked to defective remodeling, contributing to adverse perinatal outcomes through sustained uteroplacental hypoperfusion [(4)].

Uterine Artery Doppler Screening:

Uterine artery Doppler (UAD) screening is a widely investigated method for predicting preeclampsia and related placental disorders. When used in the first trimester, its standalone predictive accuracy is limited. A key challenge is the frequent presence of diastolic notching in early gestation, even among uncomplicated pregnancies, which reduces specificity. Consequently, resistance indices, especially the pulsatility index (PI), are favored and adjusted for maternal and demographic factors such as gestational age (GA), body mass index (BMI), and ethnicity. However, despite such calibrations, first-trimester UAD remains an insufficient independent predictor of preeclampsia [(15)].

The second trimester offers stronger predictive value. Most evidence supporting UAD screening for preeclampsia stems from this period, with numerous studies showing a strong correlation between elevated PI, diastolic notching, and increased preeclampsia risk, particularly in high-risk populations. Even in low-risk groups, combining abnormal indices with notching enhances detection. These findings are supported by systematic reviews and meta-analyses, emphasizing the utility of second-trimester Doppler ultrasound for identifying pregnancies vulnerable to preeclampsia and adverse outcomes [(16)]. (figure 1)

A sequential screening strategy, involving UAD assessments during both the first and second trimesters, has been evaluated to enhance diagnostic accuracy and reduce false positives. In a study by Gómez et al. of 870 singleton pregnancies assessed at 11–14 and 19–22 weeks, persistently abnormal PI, or bilateral notching in the second trimester were significantly associated with gestational hypertension, preeclampsia, and intrauterine growth restriction (IUGR). Notably, even pregnancies in which second-trimester PI normalized after early elevation still showed increased risk, suggesting that early abnormalities carry prognostic value regardless of subsequent normalization [17].

More recently, multi-parametric screening models integrating first-trimester UAD, maternal history, blood pressure, and biochemical markers (e.g., PlGF, PAPP-A) have demonstrated improved predictive performance. Among these, uterine artery PI has consistently been the most robust standalone predictor for early-onset preeclampsia [18]. For instance, a UK cohort study by Audibert et al. found that while adding UAD to a model incorporating clinical and biochemical markers modestly improved detection, its contribution was constrained by the small number of severe cases and inconsistent Doppler technique—especially when sampling was not conducted near the internal os [19].

Another study focusing on high-risk women reported that PlGF alone offered strong predictive value, with the addition of UAD or sFlt-1 failing to further improve accuracy. The success of multivariate models depends on the quality of Doppler acquisition, the validation of risk algorithms, and their applicability across diverse populations, where maternal characteristics and technical factors can influence screening efficacy [20].

Methods

This systematic review combined a comprehensive evaluation of existing literature with institutional experience from Benha University Hospitals. For the literature review, electronic databases including PubMed, Scopus, and Google Scholar were searched for publications from January 2015 to May 2025 using key words such as “uterine artery Doppler; fetal distress; preeclampsia; FGR”.

The inclusion criteria of the study group involved; a singleton pregnancy, late Second or Third trimester pregnancies, Pregnancies with fetal distress, Patients who had been approved to be included in the study.

While the Exclusion criteria included multiple fetal pregnancies, Pregnancies with IUFD and Patients who refused to take part in the study.

This systematic review was conducted in accordance with the PRISMA 2020 guidelines to ensure transparency and methodological rigor.

Studies were included based on predefined PICO criteria. The population of interest comprised pregnant women with singleton gestations assessed by uterine artery Doppler (UAD) at ≥18 weeks' gestation. The intervention/index tests included Doppler-derived indices such as pulsatility index (PI), resistive index (RI), systolic/diastolic (S/D) ratio, and diastolic notching. Comparators included normal Doppler indices or pregnancies without complications. Eligible outcomes were fetal distress (clinically or Doppler-defined), emergency cesarean for distress, perinatal mortality, low Apgar scores, NICU admission, fetal growth restriction (FGR), and preeclampsia.

Only clinical trials, cohort studies, case–control studies, and systematic reviews/meta-analyses published in English between January 2015, and May 2025 were considered.

A comprehensive search of PubMed, Scopus, and Web of Science databases was performed on June 1, 2025. In addition, the reference lists of included studies were manually searched to identify any potentially relevant articles missing from the database search.

All retrieved references were imported into EndNote (version X9) for reference management. Two independent reviewers screened titles and abstracts against the eligibility criteria. Full texts were obtained for studies deemed potentially relevant. Disagreements during screening or selection were resolved through discussion or adjudicated by a third reviewer when necessary.

A standardized data extraction form was used to collect relevant study details. Data entries were independently verified for consistency and completeness.

The quality of included studies was appraised using the Newcastle–Ottawa Scale (NOS) for observational studies. The NOS evaluates three domains: selection of study groups, comparability, and outcome or exposure assessment. Studies scoring ≥7 was classified as high quality.

Due to significant heterogeneity in UAD protocols, threshold values, and outcome definitions, meta-analysis was not feasible. Therefore, findings were synthesized narratively, with a focus on threshold values, predictive accuracy, and methodological quality.

A total of 204 records were identified from PubMed, Scopus, and Embase using the defined search strategy. After removing 93 duplicates, 111 records remained for title and abstract screening. Of these, 56 records were excluded based on irrelevance or non-eligibility. Subsequently, 55 full-text articles were assessed for eligibility. 32 studies were excluded at this stage due to reasons including non-English language, lack of UAD-related outcomes, incorrect population, or insufficient methodological detail. 23 studies met all inclusion criteria and were included in the final synthesis.

The study selection process is depicted in the PRISMA flow diagram (Figure 2), which provides a transparent account of article identification, screening, and exclusion. This structured approach reinforces the rigor and reproducibility of the review.

Results

A total of 204 records were retrieved through systematic searches across PubMed, Scopus, and Embase. After removing 93 duplicate entries, 111 unique articles were screened by title and abstract. Of these, 56 studies were excluded based on irrelevance or failure to meet inclusion criteria. The remaining 55 full-text articles were assessed in detail, resulting in the exclusion of 32 studies for reasons including incorrect population, inadequate UAD data, non-English language, or methodological deficiencies. 23 studies met all eligibility criteria and were included in the final synthesis. The full selection process is illustrated in the PRISMA flow diagram **(Figure 1)**.

The 23 included studies represented a range of designs, primarily prospective cohort, and case–control studies, with sample sizes ranging from 80 to 2,500 pregnancies. UAD assessments were conducted during the second and/or third trimesters, with varying protocols for artery sampling sites (internal os vs. crossover points). Studies reported diverse thresholds for abnormal Doppler indices, particularly for PI, which ranged from 1.3 to 1.8 multiples of the median (MoM). Several studies also evaluated bilateral notching and other resistance indices such as RI and S/D ratio. A full overview of study characteristics is provided in **(Table 1).**

Diagnostic Performance

1. Second Trimester

In the second trimester, an elevated uterine artery PI (typically >95th percentile MoM) was associated with moderate sensitivity (45–68%) and good specificity (70–90%) for predicting fetal distress (FD). The presence of bilateral diastolic notching improved specificity (85–92%) but did not significantly increase sensitivity.

2. Third Trimester

In the third trimester, persistent elevation of PI (>1.5 MoM) showed moderate sensitivity (50–60%) and high specificity (88–95%) for predicting emergency cesarean delivery due to fetal distress. Notably, the presence of bilateral notching in late gestation correlated strongly with adverse neonatal outcomes such as low Apgar scores (<5 at 5 minutes), showing specificity rates of 92–98%, though sensitivity remained low (30–40%).

Quality appraisal using the Newcastle–Ottawa Scale indicated that 15 of the 23 studies achieved a score of ≥7, qualifying as high quality. Common limitations across studies included variability in Doppler sampling technique, inconsistencies in defining thresholds, and lack of blinding in outcome assessments.

Table 1: Studies on Uterine Artery Doppler Indices in Second and Third Trimester Fetal Distress

Title (Shortened)	Year	Journal	Volume
The predictive value of uterine artery ultrasound examination during early pregnancy for gestational hypertension [21]	2023	Chinese Journal of Primary Medicine and Pharmacy	30.0
Diagnostic and prognostic power of the first biometric measurements and doppler examination in fetal growth restriction [22]	2019	Journal of Clinical Obstetrics and Gynecology	29.0
Prediction of Uterine Artery Doppler for Preeclampsia [23]	2020	Chinese Journal of General Practice	18.0
Preeclampsia: Risk factors, diagnosis, management, and the cardiovascular impact on the offspring [24]	2019	Journal of Clinical Medicine	8.0
Fetal Doppler velocimetry and bronchopulmonary dysplasia risk among growth-restricted preterm infants [25]	2017	BMJ open	7.0
Effect of maternal dexamethasone administration on fetal and uteroplacenatal hemodynamics [26]	2022	Voprosy Ginekologii, Akusherstva i Perinatologii	21.0
Placental abnormalities in congenital heart disease [27]	2021	Translational pediatrics	10.0
Perinatal outcomes of two consecutive strategies for the management of fetal growth restriction: a before–after study [28]	2023	Archives of Gynecology and Obstetrics	307.0
Outcome-based comparison of SMFM and ISUOG definitions of fetal growth restriction [29]	2021	Ultrasound in Obstetrics & Gynecology	57.0
Prognostic accuracy of antenatal Doppler ultrasound for adverse perinatal outcomes in low-income and middle-income countries: A systematic review [30]	2021	BMJ Open	11.0
Fetal growth restriction and intra-uterine growth restriction: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians [31]	2015	European journal of obstetrics & gynecology and reproductive biology	193.0
Maternal Infection with Listeria monocytogenes in Twin Pregnancy [32]	2023	Infection and Drug Resistance	16.0
Integrated 2D Doppler indices of uteroplacental and fetal blood flow in diagnosis of intrauterine hypoxia [33]	2021	RUDN Journal of Medicine	25.0
Lysteria Monocytogenes Infection during Monochorionic Twin Pregnancy: Case Report and Review of the Literature [34]	2024	Journal of Clinical Medicine	13.0
Two Cases of True Uterine Artery Aneurysms Diagnosed during Pregnancy [35]	2017	Gynecologic and Obstetric Investigation	82.0
Uterine artery pulsatility index at 30-34 weeks' gestation in the prediction of adverse perinatal outcome [36]	2016	ULTRASOUND IN OBSTETRICS & GYNECOLOGY	47.0
Third trimester uterine artery Doppler for prediction of adverse perinatal outcomes [37]	2022	CURRENT OPINION IN OBSTETRICS & GYNECOLOGY	34.0
Effect of combination of uterine artery doppler and vitamin D level on perinatal outcomes in second trimester pregnant women [38]	2025	Journal of perinatal medicine	53.0
Uterine artery Doppler in early labor and perinatal outcome in low-risk term pregnancy: prospective multicenter study [39]	2023	Ultrasound in obstetrics & gynecology: the official journal of the International Society of Ultrasound in Obstetrics and Gynecology	62.0
Third trimester uterine artery Doppler indices as predictors of preeclampsia and neonatal small for gestational age [40]	2020	Journal of Maternal-Fetal and Neonatal Medicine	33.0
Assessment of relationship between Doppler flows in pregnancies after 41 weeks and the incidence of cesarean sections with induced labour [41]	2017	Polski Merkuriusz Lekarski	43.0
Role of ultrasonography and color Doppler in the assessment of high-risk pregnancies and their accuracy in predicting fetal outcome [42]	2023	Cureus	15.0
A Second Trimester Prediction Algorithm for Early-Onset Hypertensive Disorders of Pregnancy Occurrence and Severity Based on Soluble fms-like Tyrosine Kinase 1 (sFlt-1)/Placental Growth Factor (PlGF) Ratio and Uterine Doppler Ultrasound in Women at Risk [43]	2024	CHILDREN-BASEL	11.0

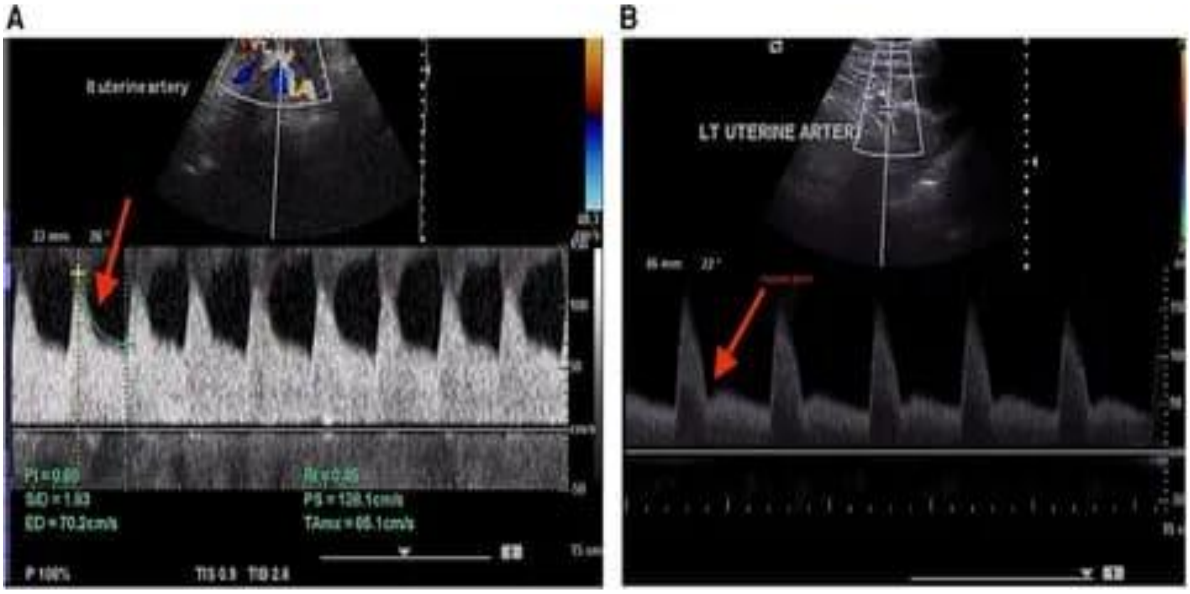

Figure 1. (A) Normal Doppler indices in the uterine artery. (B) Abnormal uterine artery spectral waveform indicating the presence of a diastolic notch.

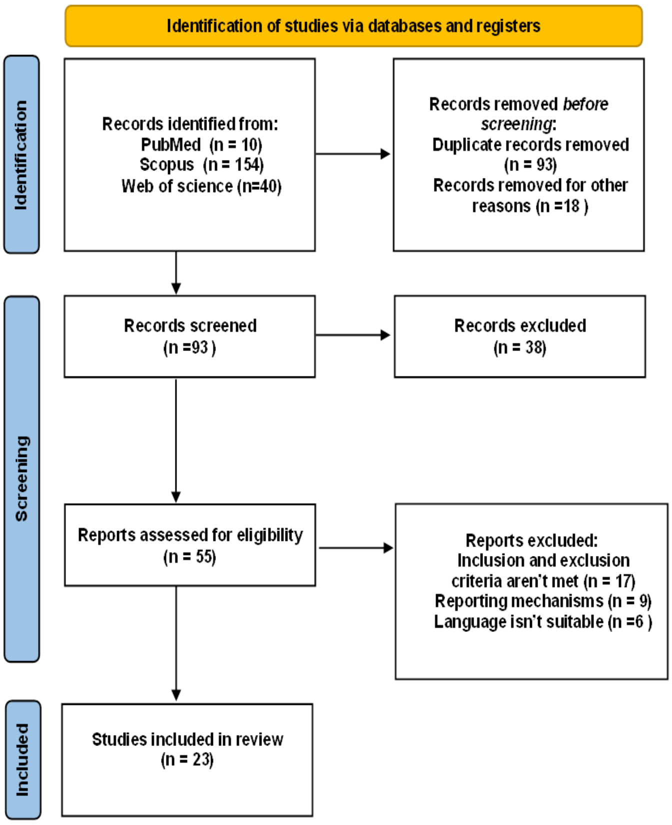

Figure 2: PRISMA Flowchart of the Studies on Uterine Artery Doppler Indices in Second and Third Trimester Fetal Distress.

Discussion

This systematic review evaluated the diagnostic performance of uterine artery Doppler (UAD) indices—specifically pulsatility index (PI) and diastolic notching—in predicting fetal distress and related perinatal complications in the second and third trimesters. The findings demonstrate moderate predictive accuracy, with consistently high specificity for identifying pregnancies at risk, particularly when Doppler abnormalities persist in the third trimester. However, sensitivity remained limited, highlighting the need for multimodal screening strategies.

A key strength of this review is the application of a rigorous and transparent methodology, including duplicate screening, standardized data extraction, and formal quality assessment using the Newcastle–Ottawa Scale. The systematic approach, as illustrated by the PRISMA diagram, ensured the inclusion of only relevant and methodologically sound studies.

Nevertheless, several limitations must be acknowledged. First, the included studies showed substantial heterogeneity in Doppler acquisition protocols, threshold definitions, and outcome measures, precluding formal meta-analysis. Second, sampling site variation—especially in earlier gestation—may have contributed to inconsistent results across studies. Finally, the lack of standardized MoM cutoffs for UAD indices across gestational ages presents a challenge for clinical interpretation and generalizability.

From a clinical standpoint, UAD screening—particularly in the second trimester—offers valuable prognostic information when integrated with maternal risk factors, biochemical markers, and clinical history. Although not sufficient as a standalone test, its high specificity supports its use in risk stratification and guiding surveillance intensity. The prognostic value of early Doppler abnormalities, even when indices normalize later in pregnancy, further underscores the importance of early screening in high-risk populations.

Future research should focus on standardizing UAD protocols, establishing gestation-specific reference ranges, and validating multivariate risk prediction models across diverse populations. Additionally, large, multicenter prospective studies are needed to assess the clinical impact of UAD-guided surveillance strategies on maternal and neonatal outcomes.

Conclusion

UAD indices offer valuable, noninvasive insights into placental hemodynamics in high-risk pregnancies. Future multicenter studies should establish standardized reference ranges, sampling techniques, and integrated risk algorithms for personalized obstetric surveillance.

References

1. Hu X, Zhang L. Uteroplacental Circulation in Normal Pregnancy and Preeclampsia: Functional Adaptation and Maladaptation. Int J Mol Sci. 2021 Aug 11;22(16):8622.
2. Degner K, Magness RR, Shah DM. Establishment of the Human Uteroplacental Circulation: A Historical Perspective. Reprod Sci. 20161012th ed. 2017 May;24(5):753–61.
3. Rosner M, Dar P, Reimers LL, McAndrew T, Gebb J. 1st-trimester 3D power Doppler of the uteroplacental circulation space and FGR. Am J Obstet Gynecol. 2014 Nov;211(5):521.e1-8.
4. Gonçalves LF, Abramowicz JS. Uterine Artery Doppler. In: Fleischer AC, Abramowicz JS, Gonçalves LF, Manning FA, Monteagudo A, Timor IE, and co-authors, editors. Fleischer’s Sonography in Obstetrics and Gynecology: Textbook and Teaching Cases, 8e [Internet]. New York, NY: McGraw-Hill Education; 2017. Available from: obgyn.mhmedical.com/content.aspx?aid=1151031908 % [2025/04/27
5. Vannuccini S, Bocchi C, Severi FM, Petraglia F. Diagnosis of Fetal Distress [Internet]. Buonocore G, Bracci R, Weindling M, editors. Neonatology: A Practical Approach to Neonatal Diseases. Cham: Springer International Publishing; 2016. p. 1–23. Available from: https://doi.org/10.1007/978-3-319-18159-2_156-1

6. Turner JM, Mitchell MD, Kumar SS. The physiology of intrapartum fetal compromises in term. 20190724th ed. Vol. 222, Am J Obstet Gynecol. 2020. p. 17–26.
7. Ochoa JH, Cafici D. Fetal Doppler assessment in pregnancy. Best Pract Res Clin Obstet Gynaecol. 2025 Jun; 100:102594.
8. Dhugga G, Sankaran D, Lakshminrusimha S. ABCs of base therapy in neonatology: role of acetate, bicarbonate, citrate, and lactate. Vol. 45, Journal of Perinatology. 2025. p. 298–304.
9. Yaremenko AV, Pechnikova NA, Porpodis K, Damdoumis S, Aggeli A, Theodora P, and co-authors Association of Fetal Lung Development Disorders with Adult Diseases: A Comprehensive Review. J Pers Med. 2024 Mar 29;14(4):368.
10. Ahrens S, Singer D. Placental Adaptation to Hypoxia: The Case of High-Altitude Pregnancies. International Journal of Environmental Research and Public Health. 2025;22(2):214.
11. Braverman-Poyastro A, Suárez-Rico BV, Borboa-Olivares H, Espino y Sosa S, Torres-Torres J, Arce-Sánchez L, and co-authors Antepartum Fetal Surveillance and Optimal Timing of Delivery in Diabetic Women: A Narrative Review. Journal of Clinical Medicine. 2024;13(2):313.
12. Khalil A, Sotiriadis A, D'Antonio F, Da Silva Costa F, Odibo A, Prefumo F, and co-authors ISUOG Practice Guidelines: performance of third-trimester obstetric ultrasound scan. Vol. 63, Ultrasound in Obstetrics & Gynecology. 2024. p. 131–47.
13. Lees CC, Romero R, Stampalija T, Dall'Asta A, DeVore GA, Prefumo F, and co-authors Clinical Opinion: The diagnosis and management of suspected FGR: an evidence-based approach. Am J Obstet Gynecol. 2022 Mar;226(3):366–78.
14. Gusella A, Martignoni G, Giacometti C. Behind the Curtain of Abnormal Placentation in Pre-Eclampsia: From Molecular Mechanisms to Histological Hallmarks. International Journal of Molecular Sciences. 2024;25(14):7886.
15. Velauthar L, Plana MN, Kalidindi M, Zamora J, Thilaganathan B, Illanes SE, and co-authors 1st-trimester uterine artery Doppler and adverse pregnancy outcome: a meta-analysis involving 55,974 women. 20140404th ed. Vol. 43, Ultrasound Obstet Gynecol. 2014. p. 500–7.
16. Cnossen JS, Morris RK, ter Riet G, Mol BWJ, van der Post JAM, Coomarasamy A, and co-authors Use of uterine artery Doppler ultrasonography to predict pre-eclampsia and IUGR: a systematic review and bivariable meta-analysis. CMAJ. 2008 Mar 11;178(6):701–11.
17. Buijtendijk MF, Bet BB, Leeflang MM, Shah H, Reuvekamp T, Goring T, and co-authors Diagnostic accuracy of ultrasound screening for fetal structural abnormalities during the 1st and second trimester of pregnancy in low-risk and unselected populations. Cochrane Database Syst Rev. 2024 May 9;5(5):CD014715.
18. Crovetto F, Triunfo S, Crispi F, Rodriguez-Sureda V, Roma E, Dominguez C, and co-authors 1st-trimester screening with specific algorithms for early- and late-onset FGR. Vol. 48, Ultrasound Obstet Gynecol. 2016. p. 340–8.
19. Poon LC, Stratieva V, Piras S, Piri S, Nicolaides KH. Hypertensive disorders in pregnancy: combined screening by uterine artery Doppler, blood pressure, and serum PAPP-A at 11-13 weeks. Vol. 30, Prenat Diagn. 2010. p. 216–23.
20. Huang T, Rashid S, Priston M, Rasasakaram E, Mak-Tam E, Gibbons C, and co-authors Prenatal screening for preeclampsia: the roles of placental growth factor and pregnancy–associated plasma protein A in the 1st trimester and placental growth factor and soluble fms-like tyrosine kinase 1–placental growth factor ratio in the early second trimester. AJOG Glob Rep. 2023 Mar 11;3(2):100193.
21. FENG, F., JIN, B., & LUO, Y. The predictive value of uterine artery ultrasound examination during early pregnancy for gestational hypertension. *Chinese Journal of Primary Medicine and Pharmacy*. 2023; 30: 1550-1554.
22. Semir, K. Ö. S. E. Diagnostic and prognostic power of the first biometric measurements and doppler examination in fetal growth restriction. *Journal of Clinical Obstetrics & Gynecology*. 2019; *29*(3): 100-109.
23. DENG Chen-chen, TAO Feng, CHEN Hong-bo. Prediction of Uterine Artery Doppler for Preeclampsia[J]. Chinese Journal of General Practice. 2020; 18(6): 1002-1005.
24. Fox, R., Kitt, J., Leeson, P., Aye, C. Y., & Lewandowski, A. J. Preeclampsia: risk factors, diagnosis, management, and the cardiovascular impact on the offspring. *Journal of clinical medicine*. 2019; *8*(10): 1625.
25. Lio, A., Rosati, P., Pastorino, R., Cota, F., Tana, M., Tirone, C., ... & Vento, G. Fetal Doppler velocimetry and bronchopulmonary dysplasia risk among growth-restricted preterm infants: an observational study. *BMJ open*. 2017; *7*(7): e015232.
26. Abdelrahim, A. M., Moussa, K. S., Ibrahim, A. K., & Farid, L. A. Effect of maternal

dexamethasone administration on fetal and uteroplacenatal hemodynamics. *Вопросы гинекологии*. 2022; *21*(5): 54-61.

27. Andescavage, N. N., & Limperopoulos, C. Placental abnormalities in congenital heart disease. *Translational pediatrics*. 2021; *10*(8): 2148.
28. Demirdjian, S. P., Meller, C. H., Berruet, M. C., Dosdoglirian, G., & Etchegaray, A. Perinatal outcomes of two consecutive strategies for the management of fetal growth restriction: a before–after study. *Archives of Gynecology and Obstetrics*. 2023; *307*(1): 319-326.
29. Roeckner, J. T., Pressman, K., Odibo, L., Duncan, J. R., & Odibo, A. O. Outcome-based comparison of SMFM and ISUOG definitions of fetal growth restriction. *Ultrasound in Obstetrics & Gynecology*. 2021; *57*(6): 925-930.
30. Ali, S., Heuving, S., Kawooya, M. G., Byamugisha, J., Grobbee, D. E., Papageorghiou, A. T., ... & Rijken, M. J. Prognostic accuracy of antenatal Doppler ultrasound for adverse perinatal outcomes in low-income and middle-income countries: a systematic review. *BMJ open*. 2021; *11*(12): e049799.
31. Vayssière, C., Sentilhes, L., Ego, A., Bernard, C., Cambourieu, D., Flamant, C., ... & Carbonne, B. Fetal growth restriction and intra-uterine growth restriction: guidelines for clinical practice from the French College of Gynaecologists and Obstetricians. *European journal of obstetrics & gynecology and reproductive biology*. 2015; *193*: 10-18.
32. Huang, P., Guo, X., Duan, M., Li, H., Han, C., & Xue, F. Maternal infection with Listeria monocytogenes in twin pregnancy. *Infection and Drug Resistance*. 2023; 2511-2518.
33. Matskevich, N. V., & Famina, M. P. Integrated 2D Doppler indices of uteroplacental and fetal blood flow in diagnosis of intrauterine hypoxia. *RUDN Journal of Medicine*. 2021; *25*(4): 290-297.
34. Roero, S., Peila, C., Arduino, S., Deantoni, S., Coscia, A., & Revelli, A. Lysteria Monocytogenes Infection during Monochorionic Twin Pregnancy: Case Report and Review of Literature. *Journal of Clinical Medicine*. 2024; *13*(20): 6061.
35. Schlütter, J. M., Johansen, G., Helmig, R. B., & Petersen, O. B. Two cases of true uterine artery aneurysms diagnosed during pregnancy. *Gynecologic and Obstetric Investigation*. 2017; *82*(1): 102-104.
36. Valiño, N., Giunta, G., Gallo, D. M., Akolekar, R., & Nicolaides, K. H. Uterine artery pulsatility index at 30–34 weeks' gestation in the prediction of adverse perinatal outcome. *Ultrasound in Obstetrics & Gynecology*. 2016; *47*(3): 308-315.
37. Duncan, J. R., Schenone, C. V., & Običan, S. G. Third trimester uterine artery Doppler for prediction of adverse perinatal outcomes. *Current Opinion in Obstetrics and Gynecology*. 2022; *34*(5): 292-299.
38. Tosun, G., Akar, A. N., Burkankulu, D., Ceyhan, V., & Aydin, E. Effect of combination of uterine artery doppler and vitamin D level on perinatal outcomes in second trimester pregnant women. *Journal of Perinatal Medicine*. 2025; *53*(1): 48-57.
39. Dall'Asta, A., Figueras, F., Rizzo, G., Ramirez Zegarra, R., Morganelli, G., Giannone, M., ... & Ghi, T. Uterine artery Doppler in early labor and perinatal outcome in low-risk term pregnancy: prospective multicenter study. *Ultrasound in Obstetrics & Gynecology*. 2023; *62*(2): 219-225.
40. Običan, S. G., Odibo, L., Tuuli, M. G., Rodriguez, A., & Odibo, A. O. Third trimester uterine artery Doppler indices as predictors of preeclampsia and neonatal small for gestational age. *The Journal of Maternal-Fetal & Neonatal Medicine*. 2020; *33*(20): 3484-3489.
41. Makles, H., & Wilczyński, J. R. Assessment of relationship between Doppler flows in pregnancies after 41 week and the incidence of cesarean sections with induced labour. *Polski Merkuriusz Lekarski: Organ Polskiego Towarzystwa Lekarskiego*. 2017; *43*(258): 258-263.
42. Kale, R. M., Tirupathi, R. G., Sheela, S. R., & Kale, M. Role of ultrasonography and color Doppler in the assessment of high-risk pregnancies and their accuracy in predicting fetal outcome. Cureus. 2023; 15(5).
43. Chirilă, C. N., Mărginean, C., Ghiga, D. V., Voidăzan, S., Chirilă, P. M., & Gliga, M. L. A second trimester prediction algorithm for early-onset hypertensive disorders of pregnancy occurrence and severity based on soluble fms-like tyrosine kinase 1 (sFlt-1)/placental growth factor (PlGF) ratio and uterine doppler ultrasound in women at risk. *Children*. 2024; *11*(4): 468.

To cite this article: Tasneem M. Badr, Hamada T. Khater, Alaa M. Shalabi. The Added Value of Uterine Artery Doppler in The Evaluation of The Second and Third Trimester Fetal Distress: A Systematic Review. BMFJ XXX, DOI: 10.21608/bmfj.2025.414211.2618.