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THE ROLE OF ULTRASOUND AND MRI IN DIAGNOSING FETAL ANOMALIES: A CROSS-SECTIONAL COMPARATIVE STUDY.

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ABSTRACT

Background
Prenatal detection of fetal anomalies is critical for early diagnosis, parental counseling, and clinical management. While ultrasound (USG) is the first-line imaging modality, magnetic resonance imaging (MRI) is increasingly utilized as a complementary tool, especially in complex or ambiguous cases.

Objectives
To compare the diagnostic accuracy of ultrasound and magnetic resonance imaging (MRI) in detecting fetal anomalies and evaluate the concordance of each modality with final postnatal or autopsy-confirmed diagnoses.

Methods
This cross-sectional study included 50 pregnant women with suspected fetal anomalies. All participants underwent detailed ultrasound and fetal MRI between 24 and 34 weeks of gestation. Imaging findings were independently evaluated by experienced radiologists. The final diagnosis was established through postnatal examination or autopsy. Sensitivity, specificity, accuracy, and inter-observer agreement (Kappa statistics) were computed for each modality.

Results
The mean maternal age was 26.4 ± 4.2 years, and the mean gestational age at imaging was 28.1 ± 2.6 weeks. MRI detected 45 of 50 confirmed anomalies, demonstrating higher sensitivity (90.0%), specificity (95.6%), and accuracy (92.0%) compared to ultrasound (76.0%, 91.3%, and 80.0%, respectively). MRI outperformed ultrasound in detecting central nervous system (95% vs. 70%), thoracic (100% vs. 66.7%), and genitourinary anomalies (100% vs. 75%). Inter-observer agreement was greater for MRI ($\kappa = 0.86$) than for USG ($\kappa = 0.74$). MRI required a longer scan time (35 ± 8 min vs. 20 ± 5 min), and 88% of patients tolerated the MRI procedure well.

Conclusion
MRI provides superior diagnostic performance over ultrasound in the prenatal evaluation of fetal anomalies, particularly in central nervous system and thoracic abnormalities. It serves as an effective adjunct in cases where ultrasound findings are inconclusive.

Recommendations
MRI should be considered a complementary imaging modality in prenatal diagnostics, especially when ultrasound results are ambiguous or suggest central nervous system or thoracic anomalies.

Keywords: Fetal anomalies, Ultrasound, Magnetic Resonance Imaging, Prenatal diagnosis, Diagnostic accuracy, Central Nervous System malformations
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INTRODUCTION

Fetal anomalies are a significant cause of perinatal morbidity and mortality worldwide, affecting approximately 2–3% of all pregnancies. Early and accurate prenatal detection of these anomalies is critical for optimal parental counseling, clinical decision-making, and planning of perinatal care[1,2].

The primary imaging modality for routine prenatal screening is ultrasound (USG), which is non-invasive, widely available, and cost-effective. It provides real-time anatomical assessment and plays a vital role in anomaly scans during the second trimester[3].

However, ultrasound has limitations, particularly in cases involving maternal obesity, oligohydramnios,

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late gestational age, or complex anomalies, especially of the central nervous system (CNS). In such scenarios, fetal magnetic resonance imaging (MRI) has emerged as a valuable adjunct tool due to its superior soft tissue contrast, multiplanar imaging capability, and lack of ionizing radiation[4]. Fetal MRI can delineate subtle structural abnormalities and clarify inconclusive or suspicious ultrasound findings, especially involving the brain, thorax, and abdomen[5].

Several studies have highlighted the complementary role of MRI in enhancing diagnostic confidence[5,6]. Nevertheless, comparative data evaluating the diagnostic yield, sensitivity, specificity, and agreement of MRI versus ultrasound in diverse fetal anomalies remains limited, especially in resource-constrained settings. Therefore, this study aims to systematically compare the diagnostic performance of ultrasound and MRI in detecting fetal anomalies, using postnatal examination or autopsy as the reference standard.

METHODOLOGY

Study Design and Study Setting

This was a prospective cross-sectional study conducted to evaluate and compare the diagnostic performance of ultrasound and magnetic resonance imaging (MRI) in detecting fetal anomalies.

The study was carried out in the Department of Radiodiagnosis at Late Smt. Indira Gandhi Memorial Government Medical College, Kanker, Chhattisgarh, India. The institution is a government-run tertiary care teaching hospital that caters to a largely rural and tribal population in central India. It is equipped with advanced diagnostic facilities including ultrasonography and MRI services, making it a referral center for prenatal imaging and fetal medicine in the region.

This prospective cross-sectional study was conducted over an 12-month period, from November 2023 to October 2024

Study Population

A total of 50 pregnant women with clinically or sonographically suspected fetal anomalies were enrolled consecutively from the antenatal outpatient department. All participants were between 24 and 34 weeks of gestation and provided informed written consent.

Inclusion Criteria

- Pregnant women with suspected fetal anomalies on routine anomaly scan
- Singleton pregnancies between 24 and 34 weeks of gestation
- Willingness to undergo both USG and MRI evaluation

Exclusion Criteria

- Multiple gestations
- Contraindications to MRI (e.g., presence of metallic implants, claustrophobia)
- Incomplete follow-up or withdrawal of consent

Bias Control

To minimize potential sources of bias:
Blinding was implemented during image interpretation. Two radiologists independently reviewed the ultrasound and MRI scans without knowledge of each other's findings.
Selection bias was reduced by enrolling consecutive eligible pregnant women who met the inclusion criteria during the study period.
Information bias was minimized through standardized imaging protocols and interpretation criteria for both modalities.

Imaging Procedure

All patients underwent a detailed ultrasound examination using a high-resolution machine with transabdominal probes by an experienced radiologist. This was followed by fetal MRI, performed on a 1.5 Tesla scanner without sedation, utilizing T2-weighted sequences in axial, sagittal, and coronal planes. Both imaging modalities were interpreted independently by two radiologists blinded to each other's findings.

Outcome Assessment

The final diagnosis was established through postnatal clinical examination, postnatal imaging, or autopsy wherever applicable. Diagnostic accuracy parameters—sensitivity, specificity, and overall accuracy—were calculated for each modality. Inter-observer agreement was assessed using Kappa statistics.

Statistical Analysis

Data were analyzed using SPSS software. Sensitivity, specificity, and overall accuracy were calculated for both ultrasound and MRI. Inter-observer agreement was evaluated using Kappa statistics, with a significance level set at $p < 0.05$.

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Ethical Considerations

The study was approved by the Institutional Ethics Committee of *Late Smt. Indira Gandhi Memorial Government Medical College, Kanker, Chhattisgarh, India.* . Informed written consent was obtained from all participants. Confidentiality and anonymity were maintained throughout the study, and participants had the right to withdraw at any time without any consequence.

RESULTS

A total of 50 pregnant women with suspected fetal anomalies underwent detailed imaging assessment using both ultrasound (USG) and magnetic resonance imaging (MRI). Each modality's diagnostic performance was compared against final diagnoses confirmed by postnatal follow-up or autopsy findings.

Participant Flow

A total of 56 pregnant women with suspected fetal anomalies were initially screened for eligibility. Out of these, 52 met the inclusion criteria and were invited to participate. Two women declined participation due to anxiety regarding MRI. The remaining 50 participants provided written informed consent and were enrolled in the study. All 50 participants completed both ultrasound and MRI examinations, and their cases were included in the final analysis.

Participant Characteristics

The mean maternal age was 26.4 ± 4.2 years (range 19–35 years), and the mean gestational age at imaging was 28.1 ± 2.6 weeks. The majority of participants (64%) were in the third trimester of pregnancy. Most women were from rural areas (72%) and belonged to middle or lower socioeconomic groups. The most common clinical indication for referral was suspected central nervous system anomaly (40%), followed by thoracic or genitourinary abnormalities.

Detection of Anomalies

Out of 50 confirmed fetal anomalies, MRI identified 45 cases, demonstrating superior diagnostic sensitivity (90.0%) and specificity (95.6%) compared to ultrasound, which detected 38 anomalies with a sensitivity of 76.0% and specificity of 91.3%. The overall diagnostic accuracy was higher for MRI (92.0%) than for ultrasound (80.0%) (Table 1).

Table 1: Detection of Anomalies by Imaging Modality

Imaging Modality	Total Detected Anomalies	Sensitivity (%)	Specificity (%)	Accuracy (%)
Ultrasound	38	76.0	91.3	80.0
MRI	45	90.0	95.6	92.0

Type-wise Distribution of Detected Anomalies

Table 2 outlines the distribution of anomaly types and the detection capabilities of each imaging modality. MRI showed better performance across nearly all anomaly categories. For instance, in cases involving central nervous system (CNS) anomalies, MRI detected 95% (19 out of 20), whereas USG identified only 70% (14 cases). In thoracic and genitourinary anomalies, MRI achieved 100% detection rates, outperforming ultrasound, which showed detection rates of 66.7% and 75%, respectively. Both modalities showed equal efficacy in identifying abdominal wall defects and miscellaneous anomalies.

Table 2: Distribution of Anomaly Types Detected

Type of Anomaly	No. of Cases Confirmed	Detected by USG	Detected by MRI
CNS (e.g., ventriculomegaly, agenesis of corpus callosum)	20	14	19
Skeletal anomalies	10	7	9
Thoracic anomalies	6	4	6
Abdominal wall defects	5	5	5
Genitourinary anomalies	4	3	4
Miscellaneous	5	5	5

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Inter-observer Agreement

The inter-observer reliability, measured using Kappa statistics, revealed substantial agreement for ultrasound (κ = 0.74) and almost perfect agreement for MRI (κ = 0.86), indicating greater interpretative consistency among observers with MRI (Table 3).

Table 3: Inter-observer Concordance (Kappa Statistics)

Imaging Modality	Kappa Value (κ)	Interpretation
Ultrasound	0.74	Substantial agreement
MRI	0.86	Almost perfect agreement

Scan Duration and Patient Tolerability

The average scan duration was longer for MRI (35 ± 8 minutes) compared to ultrasound (20 ± 5 minutes). In terms of tolerability, ultrasound was better accepted, with 94% of participants reporting no discomfort, whereas 88% tolerated MRI well, with a small proportion (6%) experiencing mild anxiety (Table 4).

Table 4: Time Taken & Patient Tolerability

Parameter	Ultrasound	MRI
Average Scan Time (mins)	20 ± 5	35 ± 8
Patient Tolerability (%)	94% reported no discomfort	88% tolerated well (mild anxiety in 6%)

DISCUSSION

The accurate prenatal identification of fetal anomalies plays a vital role in informed clinical decision-making, effective parental counseling, and optimized perinatal care strategies. This study assessed and compared the diagnostic efficacy of ultrasound (USG) and magnetic resonance imaging (MRI) in 50 pregnant women with suspected fetal anomalies, with postnatal outcomes or autopsy findings serving as the reference standard.

MRI demonstrated higher sensitivity (90.0%), specificity (95.6%), and diagnostic accuracy (92.0%) compared to ultrasound, which showed sensitivity of 76.0%, specificity of 91.3%, and accuracy of 80.0%. These observations align with prior research emphasizing the usefulness of MRI as a complementary tool to ultrasound, particularly in challenging cases or when acoustic limitations compromise image quality [6,7]. Additionally, MRI identified 95% of central nervous system (CNS) anomalies, whereas ultrasound detected 70%.

The enhanced diagnostic capacity of MRI, particularly for anomalies involving the CNS, thorax, and genitourinary system, can be attributed to superior soft tissue contrast, multiplanar reconstruction capabilities, and reduced reliance on operator skill. These features enable MRI to visualize subtle or complex fetal structures more effectively, especially in scenarios where ultrasound imaging is suboptimal due to factors such as oligohydramnios, maternal obesity, or unfavorable fetal positioning. The elevated detection rates reinforce MRI's role as a valuable adjunct when initial sonographic results are uncertain or inconclusive [8,9].

In terms of diagnostic reliability, MRI showed stronger inter-observer agreement (κ = 0.86) compared to ultrasound (κ = 0.74), indicating improved consistency among radiologists. However, MRI required longer scanning durations (average 35 minutes) and was less well tolerated compared to ultrasound, making the latter more practical for initial routine screenings due to its accessibility, affordability, and real-time imaging benefits [10,11].

Although MRI demonstrated diagnostic superiority, it should not replace ultrasound as the primary screening modality. Instead, its use is best reserved for cases where additional anatomical clarity is necessary or ultrasound findings are indeterminate, thereby facilitating better prognostic evaluation and clinical planning [12].

Generalizability:

The findings of this study, while informative, may have limited external applicability. Conducted at a single tertiary care center in a semi-rural region, the results may not fully represent diagnostic capabilities or patient populations in urban or private healthcare environments. Moreover, the relatively small sample size and restriction to singleton pregnancies further constrain broad extrapolation. Nonetheless, as the imaging protocols used were standardized and reproducible, similar diagnostic trends are likely achievable in comparable clinical contexts with access to fetal MRI services.

CONCLUSION

This comparative observational study highlights the superior diagnostic performance of MRI over ultrasound in the prenatal detection of fetal anomalies, particularly involving the central nervous system, thoracic, and genitourinary systems. MRI demonstrated higher sensitivity, specificity, and diagnostic accuracy, along with better inter-observer agreement. However, ultrasound remains indispensable as the primary screening tool due to its wide availability, cost-effectiveness, and real-time capability. MRI should be considered a valuable complementary modality, especially in cases with inconclusive ultrasound findings or complex anomalies. Integrating both imaging techniques enhances diagnostic confidence, guides clinical decision-making, and improves perinatal outcome

STRENGTHS AND LIMITATIONS

One of the strengths of this study is the direct comparison of both modalities in the same patient cohort, minimizing inter-subject variability. However, the study's limitations include a relatively small sample size and single-center setting, which may affect generalizability. Additionally, certain anomalies could only be confirmed postnatally, potentially introducing diagnostic delay or bias.

Recommendations: Based on the findings, MRI should be considered a valuable adjunct to ultrasound in the prenatal diagnosis of fetal anomalies, especially for complex cases or when ultrasound results are inconclusive. Given its higher sensitivity, specificity, and accuracy, MRI is particularly useful for detecting central nervous system, thoracic, and genitourinary anomalies. While MRI requires a longer scan time and may not be feasible in all settings, its diagnostic superiority in certain cases justifies its use in targeted prenatal assessments. Future studies should explore ways to optimize MRI protocols for broader clinical application.

LIST OF ABBREVIATIONS:

USG – Ultrasound
MRI – Magnetic Resonance Imaging
CNS – Central Nervous System
Kappa (κ) – Kappa Statistics

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

KKS-Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript. Statistical analysis and interpretation, revision of manuscript.UKM-Concept and design of the study, results interpretation, review of literature and preparing first draft of manuscript.

DATA AVAILABILITY

Data Available up on request

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