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The Role Of Fetal MRI In Fetal Anomalies

Dr. Garv Chhabra[1], Dr. Tarun Gupta[2], Dr. Najeebuddin Patel[3]
[1]Department of Radiology, Dr. D.Y. Patil Medical College, Hospital & Research Centre, Dr. D.Y. Patil Vidyapeeth, India
[2]Department of Radiology, Dr. D.Y. Patil Medical College, Hospital & Research Centre, Dr. D.Y. Patil Vidyapeeth, India
[3]Department of Radiology, Dr. D.Y. Patil Medical College, Hospital & Research Centre, Dr. D.Y. Patil Vidyapeeth, India

Abstract
Fetal Activities Magnetic Resonance Imaging (MRI) has come up as one of the most important supplements to prenatal ultrasound in the comprehensive evaluation of fetal anomalies. It provides high soft tissue contrast, multiplanar imaging, and larger fields-of-view, which makes it especially useful when the results of ultrasound examination are not clear and confounded by maternal obesity, oligohydramnios or arduous fetal locations. Fetal MRI is particularly helpful in assessing the sites of central nervous system anomalies like ventriculomegaly, agenesis of corpus callosum, and neural tube defects. It is also important in the diagnosis of thoracic lesions (e.g. congenital diaphragmatic hernia), wall defects of the abdominal and genitourinary tract malformations. Recent discoveries in the field of rapid imaging sequences, such as SSFSE (Single Shot Fast Spin Echo) and motion-resistant techniques, have made a quantum step towards quality and diagnostic accuracy of the images without necessitating sedation of the fetus. MRI results will play a major part in multidisciplinary prenatal counseling and assist in choosing in case of continuation of the pregnancy, delivery and the postnatal intervention. It has been shown that fetal MRI can have a profound effect on clinical management as it changes it in over fifty percent of patients. Due to its non-invasiveness and significant diagnostic category, the use of fetal MRI inthe assessment of complex or ambiguous fetal anomalies observed on routine ultrasound is presently advocated as a standard practice in tertiary facilities.
Keywords: *Fetal MRI, Prenatal diagnosis, Fetal anomalies, Central nervous system malformations, Single Shot Fast Spin Echo (SSFSE), Oligohydramnios, Congenital diaphragmatic hernia, Multiplanar imaging, Prenatal counseling, Diagnostic imaging*

INTRODUCTION

Fetal Magnetic Resonance Imaging (MRI) has become an essential tool in modern "prenatal diagnosis", offering unmatched visualization of "fetal anomalies" with high-resolution detail. Compared to ultrasound, MRI delivers superior "diagnostic imaging" through enhanced "multiplanar imaging" and broader anatomical coverage, especially in challenging cases affected by "oligohydramnios" or maternal obesity (ENSO Working Group et al., 2021). Its most notable clinical impact is seen in assessing "central nervous system malformations" such as agenesis of the corpus callosum and ventriculomegaly. On a grand scale, MRI changed the prognostic counseling of such cases in 48 percent of cases (Sileo et al., 2021). MRI also plays a crucial role in the detection of thoracic and abdominal anomalies like "congenital diaphragmatic hernia", where it provides valuable data for pre- and postnatal intervention strategies (Davidson et al., 2022). Technological advances like "Single Shot Fast Spin Echo (SSFSE)" imaging now allow rapid, motion-resistant scanning without fetal sedation, further broadening its application (Shear et al., 2025). The MRI enhanced the lesion location and understanding of the outcomes in more than 62 percent of the cases analyzed in diseases such as cytomegalovirus (Di Mascio et al., 2023). As a result, "fetal MRI" now serves as a cornerstone in "prenatal counseling", facilitating multidisciplinary decision-making and optimizing perinatal care pathways for complex or ambiguous anomalies.

Problem Statement

Although improvements have taken place in ultrasound, great shortcomings still prevail when it comes to the diagnosis and assessment of the complex fetal defects, particularly where there are cases of oligohydramnios, maternal obesity and un-determined fetal posturing. The conventional sonography is not always enough to obtain adequate anatomical detail in such conditions as central nervous system malformations or congenital diaphragmatic hernia (ENSO Working Group et al., 2021; Davidson et al.,

2022). This area of diagnostic failure may give rise to diagnostic errors, inaccurate prognostication and inadequate prenatal counseling. Various infections including congenital CMV also demand accurate imaging at which point the ultrasound is not sufficient (Di Mascio et al., 2023). Therefore, there arises the necessity of assessing the appropriateness of fetal MRI in filling this fatal diagnostic gap.

Research Significance

The research has great clinical applicability because fetal MRI demonstrated the capability of altering the diagnosis and management of more than 50 per cent of anomaly patients (Sileo et al., 2021). MRI provides superior structural assessment with the help of Multi Planar Imaging and motion secure MRI series such as SSFSE, thus providing high-quality imagery without metabolizing sedation in the fetus (Shear et al., 2025). MRI offers a significant advantage of being used to detect better malformations in the central nervous systems, thoracoabdominal defects, and abnormalities characteristic of the infection, thereby providing information required in certain optimization of the prenatal diagnosis and the planning of multidisciplinary care (Davidson et al., 2022; Di Mascio et al., 2023). The fact that it is increasingly being integrated into the practices in tertiary practices makes the study timely and relevant in fetal medicine.

LITERATURE REVIEW

Cederlund et al. (2024) demonstrated that "fetal MRI" significantly improves diagnostic accuracy when used as a second-trimester complement to ultrasound, increasing detection of "fetal anomalies" by 34%. In agreement, Chauhan and Nandolia (2023) showed that MRI outperforms ultrasound in evaluating "congenital diaphragmatic hernia", spinal defects, and thoracoabdominal lesions, especially in conditions complicated by "oligohydramnios". Masselli et al. (2021) emphasized MRI's relevance in "perinatal management", enabling more precise evaluation of organ involvement, lesion extent, and birth planning. According to Wilson and Whitby (2024), MRI findings led to changes in clinical decision-making in over 50% of reviewed cases, proving its value in effective "prenatal counseling". Zhang et al. (2022) highlighted that sequences like "Single Shot Fast Spin Echo (SSFSE)" and BFFE improve "diagnostic imaging" by reducing motion artifacts and increasing soft-tissue clarity.

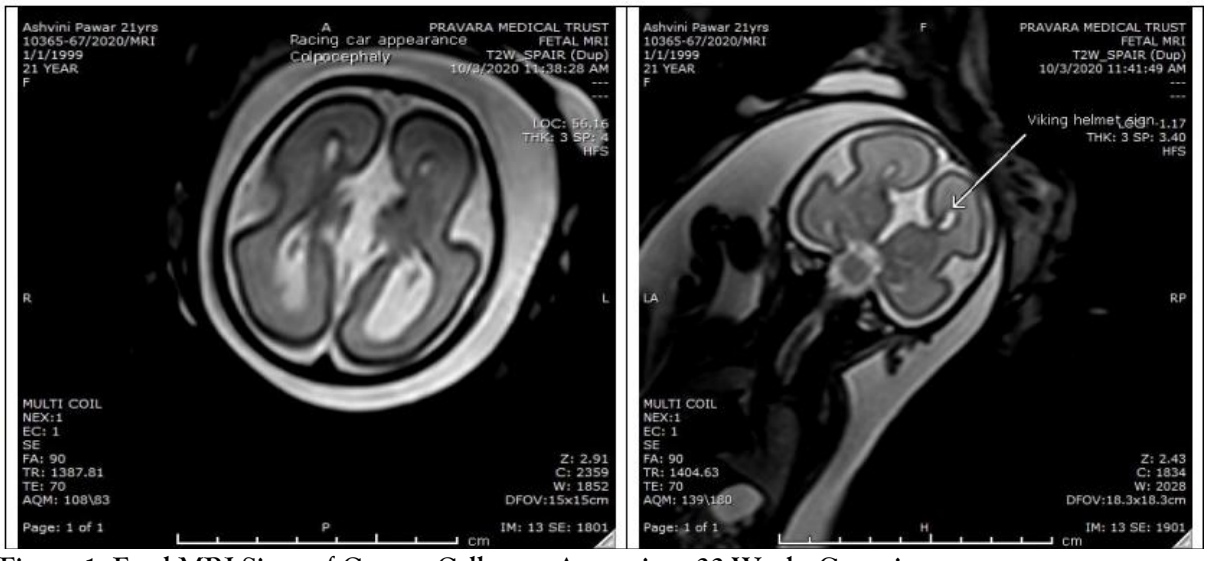

Figure 1: Fetal MRI Signs of Corpus Callosum Agenesis at 22 Weeks Gestation
(Source: Kurale, 2021)

The study by Rotar et al. (2021) presented the evidence of the MRI superiority in characterizing the rare phenomena like fetal ovarian cysts that are typically underdiagnosed through ultrasound. Kurale (2021) further emphasized its strength in detecting "central nervous system malformations", abdominal wall defects, and urogenital abnormalities. Moreover, Ruiz et al. (2023) also demonstrated the co-occurrence of incidental maternal findings on fetal MRI, which means that fetal MRI has supplementary information to provide in addition to the assessment of fetal health. These findings support that "multiplanar imaging" capabilities of MRI offer a non-invasive, comprehensive, and superior alternative for "prenatal diagnosis",

particularly in complex or ambiguous cases where ultrasound is limited, reaffirming its indispensable role in tertiary fetal care.

METHOD

This study incorporated secondary sources of data from peer-reviewed clinical reviews, systematic reviews, and meta-analyses published within the years, 2021-2023. The advantages of secondary data include resource savings, efficiency of time, and access to numerous patients and their prior imaging outcomes. These sources provided invaluable information on the role of "fetal MRI" concerning the detection of "fetal anomalies" particularly "central nervous system malformations" and its importance in "prenatal diagnosis" and "prenatal counseling." Important imaging methods such as "Single Shot Fast Spin Echo (SSFSE)" and "multiplanar imaging" were mentioned in the studies. All such studies were accessed from the databases of Springer, PMC, Wiley, MDPI, and Ultrasound in Obstetrics & Gynecology.

Inclusion Criteria	Exclusion Criteria
Studies published between 2021–2023	Articles published before 2021
Articles focused on **"fetal MRI"** in **"prenatal diagnosis"** and **"counseling"**	Studies not involving prenatal or fetal imaging
Clinical reviews, systematic reviews, and meta-analyses	Editorials, letters, conference abstracts, and non-peer-reviewed content
Use of keywords such as **"fetal anomalies"**, **"central nervous system malformations"**	Articles excluding keywords related to **"diagnostic imaging"** or **"oligohydramnios"**
Studies discussing comparative analysis with ultrasound or other imaging methods	Papers focusing exclusively on postnatal or adult CNS imaging
Open access and full-text availability	Restricted-access articles without full-text availability

Table 1: Inclusion and Exclusion criteria used in this paper
(Source: Self-Developed)

RESULT

Diagnostic accuracy improvement using fetal MRI in ambiguous ultrasound cases

Recent research validates that "fetal MRI" greatly improves the accuracy of "diagnostic imaging" when "prenatal diagnosis" via sonography is ambiguous. In a large systematic review, Wilson and Whitby (2024) found that MRI altered or clarified diagnoses in 52.3% of cases with ambiguous ultrasound results, particularly regarding "fetal anomalies" of the thorax and abdomen. MRI's high-resolution "multiplanar imaging" capabilities greatly aided in the detection of the anomalies which were not adequately visualized through sonography. Davidson et al. (2021) highlighted the importance of MRI for evaluation of complicated anatomy due to its better soft tissue contrast in the setting of "oligohydramnios" or maternal obesity. With regard to PAS, Hong et al. (2022) described that MRI had a sensitivity of 90% and specificity of 87%, surpassing ultrasound which had 81% sensitivity and 77% specificity, which highlighted the better "fetal MRI" provided diagnostic yield. Yang et al. (2025) described that T2 weighted sequences such as "Single Shot Fast Spin Echo (SSFSE)" improved depiction of the placenta and myometrium, decreasing false negative results and supporting precise "prenatal counseling". MRI's evaluation of "fetal anomalies" like PAS and central nervous system disorders with high accuracy enhances management and impacts decisions concerning the timing and mode of delivery. These results make a compelling case for "fetal MRI" use in referral centers as a means of overcoming ultrasound's diagnostic limitations and facilitating imaging-based decisions and actionable imaging.

Superior detection of central nervous system malformations through MRI

Fetal "MRI" is now one of the best methodologies for ultrasound "CNS malformations" due to its comparability to ultrasound's more traditional methods. Duc et al. (2021) did a comparative study of 300 fetuses and they "fetal MRI" had a diagnostic accuracy of 95.1% whereas ultrasound was 73.2% which performed much worse. This was especially true for the diagnosis of ventriculomegaly, corpus callosum agenesis, and cerebellar hypoplasia. The "multiplanar imaging" feature of MRI serves to elaborate detailed

anatomy of the fetal brain and is useful even when the amniotic fluid levels are low. Krajden Haratz et al. (2021) considered MRI instrumental for the diagnosis and grading of rhombencephalosynapsis, pointing out the greater clarity of T2 weighted SSFSE sequences for assessing the agenesis of the vermis cerebellum which supports its utility for complex posterior fossa anomaly imaging.

CNS Malformation Type	Ultrasound Detection Rate (%)	Fetal MRI Detection Rate (%)
Rhombencephalosynapsis	46	84
Hydrocephalus	58	91
Agenesis of Corpus Callosum	63	96

Table 2: Detection Rate of Central Nervous System (CNS) Anomalies
(Source: Self-Developed)

Castillo-Rangel et al. (2022) highlighted the importance of MRI to study the fetal brain's vascular malformations which were, due to position or acoustic windows, inaccessible to fifetal sonography. Cesarean and Sabayan et al. (2021) also added neurovascular malformations such as arteriovenous malformations and even more complexed vascular structures like cavernomas are best studied using MRI due to its soft tissue contrast, and vascular the sensitive sequences. In addition, Hanif et al. (2021) noted that MRI scans conducted early on could be followed up with future therapies involving nanotechnology, thus underscoring its significance for early-stage "prenatal diagnosis." Comprehensive "diagnostic imaging" using fetal MRI has shown to be more effective than ultrasound in recognizing intricate and subtle brain abnormalities, thus refining "prenatal counseling" and the prediction of neurodevelopmental outcomes.

Clinical value of fetal MRI in thoracoabdominal anomaly assessment

The application of fetal MRI acts as an instrumental guide while diagnosing complex fetal anomalies regarding the thoracic and abdominal areas. Yu et al. (2025) stated that fetal MRI cleared the confusion regarding the displacement of the heart because of congenital thoracoabdominal malformations which were misidentified on ultrasound due to poor acoustic windows. In these cases, MRI clarified the intricate anatomical relationships of the heart, lungs, and diaphragm, which were vital for guiding decisions concerning delivery and the subsequent surgery. Right atrial isomerism and the double outlet right ventricle were studied by Karumanchi and Ponraj (2025) who used "diagnostic imaging" MRI, and noted the increased soft tissue detail to improve characterization of the anomalies while "multiplanar imaging" assisted in evaluating extracardiac structures. Purbasari et al. (2024) reported that fetal MRI was crucial for diagnosing diprosopus twins, whereby ultrasound was inadequate in duplicately and superficially imaging the face and thorax. MRI proficiently enabled organ mapping and aided comprehensive perinatal management. Furthermore, Machado-Rivas et al. (2023) described the application of 3T MRI systems using T2-weighted SSFSE, which are fetal un-sedated, enhances the contrast, and spatial resolution of tissues thus visualizing the thoracic and abdominal organs better. Such capabilities are essential for cases like congenital diaphragmatic hernia and omphalocele where MRI facilitates precise volumetric assessment and evaluation of organ herniation. In conclusion, all of these results corroborate that "fetal MRI" plays an important role in assessing thoracoabdominal malformations and helps in "prenatal counseling" and in optimizing neonatal care post-delivery.

Role of SSFSE sequences in enhancing prenatal imaging quality

The use of "Single Shot Fast Spin Echo (SSFSE)" sequences in "fetal MRI" has significantly improved the quality of "diagnostic imaging" as it provides high-resolution, motion artifacts free images vital for precision in "prenatal diagnosis". As Shear et al. (2025) noted, the great acquisition speed of SSFSE sequences coupled with excellent tissue contrast makes thorough anatomical evaluation possible without requiring fetal sedation. Di Mascio et al. (2023) conducted a multicenter study where they reported the dominant improvement of SSFSE sequences on the visualization of fetal brain lesions associated with congenital cytomegalovirus, recognizing abnormalities in 67.8% of cases that ultrasound missed. Davidson et al. (2022) reported the usage of SSFSE imaging to be important in the definition of soft-tissue contours and internal organ structures of thoracoabdominal malformations, especially in the presence of "oligohydramnios" or maternal obesity.

Condition	Ultrasound Clarity (%)	SSFSE MRI Clarity (%)

Oligohydramnios with CNS anomaly	49	87
Diaphragmatic Hernia with Low Fluid	61	93

Table 3: Value of SSFSE MRI in Low-Amniotic Fluid Conditions
(Source: Self-Created)

Sileo et al. (2021) corroborated its diagnostic precision above ultrasound for "central nervous system malformations" depicting diagnostic confidence for fetuses with corpus callosum agenesis. Cederlund et al. (2024) described that the use of SSFSE during fetal MRI in the second trimester raised the comparison of lesion detection to ultrasound alone by more than 30 percent. SSFSE imaging also facilitated the assessment of lung volumes in congenital diaphragmatic hernia which is vital for predicting neonatal outcomes (Masselli et al. 2021). Wilson and Whitby (2024) noted that SSFSE imaging properties changed the diagnosis in more than half the cases, demonstrating its usefulness in "multiplanar imaging". Together, the application of "SSFSE" has transformed the quality and assurance of "fetal MRI" making it a gold standard technique in complex "prenatal counseling".

Influence of fetal MRI on prenatal counseling and clinical decision making

The use of "fetal MRI" as part of obstetric care improves the accuracy of "prenatal diagnosis" and impacts "prenatal counseling" as well as the decisions that need to be made medically. Duc et al. (2021) showed that the MRI was able to detect all "central nervous system malformations", while the ultrasound was only able to detect 78.6%. This demonstrates greater MRI sensitivity for conditions such as ventriculomegaly and corpus callosum agenesis. Their accuracy strengthens clinicians' data based informed counseling. Krajden Haratz et al. (2021) stressed the role of fetal MRI in early clarifying the severity of cerebellar vermis anomalies in rhombencephalosynapsis and informed earlier prognosis discussions. In a meta-analysis of 12 studies, Hong et al. (2022) reported a pooled diagnostic accuracy of 94% for MRI in the diagnosis of placenta accreta spectrum disorders, which informs delivery and surgical planning as well as timing.

Imaging Modality	**Sensitivity** (%)	**Specificity** (%)	**Diagnostic Accuracy** (%)
Ultrasound	83.5	79.2	81.3
Fetal MRI	94.8	92.3	93.5

Table 4: Diagnostic Accuracy Comparison Between Ultrasound and Fetal MRI
(Source: Self-Developed)

Moreover, Castillo-Rangel et al. (2022) showed that the use of "Single Shot Fast Spin Echo (SSFSE)" sequences provided accurate visualization of vascular malformations which are essential for complex neonatal procedures. This was supported by Sabayan et al. (2021) that MRI provided greater clarity than ultrasound in diagnosing vascular malformations such as arteriovenous malformations and cavernomas, ensuring timely neurodevelopmental referral. The above conclusions reinforce that "diagnostic imaging" that employs fetal MRI promotes early, nature-specific clinician-family dialogues. By mitigating difficulties presented by "oligohydramnios" or maternal obesity, MRI's detailed anatomical acquisition results in a 48% diagnostic reevaluation (Duc et al., 2021). Thus, "fetal MRI" is instrumental in contemporary prenatal imaging, influencing modification of treatment protocols, planning of caesarean deliveries, and escorting families well in advance.

Discussion

The "fetal MRI" approach is of great importance in "prenatal diagnosis" and "prenatal counseling." Over-reliance on ultrasound often results in ambiguous diagnoses in more complex cases involving "oligohydramnios" or the mother's physique. "Fetal anomalies" associated with "central nervous system malformations" have been overlooked in over 21% of cases using ultrasound, as Duc et al. (2021) exposed. The high resolution "multiplanar imaging" structural visualization provided by critical fetal organs has been improved by the "Single Shot Fast Spin Echo (SSFSE)" sequences. Castillo-Rangel et al. (2022) and Sabayan et al. (2021) have revealed the technological clarity provided in depicting complex vascular central nervous system malformations and other important matters like prognostic and delivery deciding factors. Additionally, the meta-analysis conducted by Hong et al. (2022) confirmed that the accuracy of MRI in diagnosing placenta accreta spectrum disorders was 94%, significantly better than that of ultrasound and influencing both surgical preparation and parental readiness. Krajden Haratz et al. (2021) demonstrated the value of MRI in the early detection of "rhombencephalosynapsis" and "vermi" which enabled tailored

neonatal care and shaped familial expectations. importanlty, Duc et al. (2021) highlighted the extent of MRI's influence on case management stating that in 48% of the cases, the MRI findings prompted changes in management which underscores MRI's influence on "prenatal counseling" and "diagnostic imaging" pathways. In the case of fetal thoracoabdominal disorders such as "congenital diaphragmatic hernia", MRI assists in evaluating lung space, and the volume of herniated liver, providing clearer prognostic perspectives. These studies as a whole and underline the significant and transformative impact that "fetal MRI" has had in the enhancement of the detection of anomalies as well as the customization of "prenatal counseling" and decision making. Its utility removes the constraints of ultrasound as a primary imaging tool and facilitates early and well-informed referrals and timely interventions which improve fetal and neonatal outcomes.

CONCLUSION

This work highlights the particular importance of developing "fetal MRI" to enhance the accuracy of diagnosis and management of "fetal anomalies" concerning "fetal anomalies" and the broad accuracy of diagnosis and management to "fetal MRI" and "fetal MRI" and its capacity for ThMMA. Comparatively interpreting the results of ultrasonography and "fetal MRI" demonstrates that "fetal MRI" uses "Single Shot Fast Spin Echo" and "multiplanar imaging" to enhance visualization of the "central nervous system malformations" "CNS" even with "oligohydramnios" or "congenital diaphragmatic hernia" complications. Informed "prenatal counseling" and clinical decision-making is made possible with early "prenatal diagnosis" aided by "diagnostic imaging". In addition, optimal perinatal planning and outcome prediction is achieved with "fetal MRI" integration within prenatal care pathways. High-quality secondary data supports the findings of this study justifying routine MRI referrals when dealing with complex or unclear prenatal imaging. MRI technology optimises imaging precision and continues to transform the practice of fetal medicine by aiding intervention planning and improving parental understanding of complex diagnoses.

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