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Role of 2D/3D Ultrasound in Congenital Fetal Anomalies with MRI Correlation

Dr. Yasmeen Usmani[1], Dr. Mohd Aasif[2]

Abstract: ***Background: Congenital anomalies, which frequently have an unidentified cause and result in serious physical, psychological, and social issues, are said to affect about 2% of newborn kids [1]. Ultrasound (2D/3D) is the most widely used screening technique for foetal imaging, but it has limitations, including a small field of view, limited soft tissue acoustic contrast, beam attenuation by adipose tissue, poor image quality in oligohydramnios, and limited visualisation of the posterior fossa in later stages of pregnancy due to calvarial calcification [1-3]. Therefore, to confirm these results in comprehensive ultrasonography, MRI Correlation is needed. Aims and Objectives: The purpose of the study is the role of 2D/3D Ultrasound in congenital fetal anomalies with MRI correlation. Materials and Method: The study was conducted in Department of Radiodiagnosis, LLRM Medical College, Meerut on 40 pregnant female with strong suspicoius of having congenital fetal anomalies. After ultrasound, MRI was done within one week of USG. Observations and Results: Out of 40 cases of strongly suspected congenital fetal anomalies USG was able to correctly identify 33 cases, in which 11 cases of CNS fetal anomalies out of 15 cases and 22 cases of Non-CNS fetal anomalies out of 25 cases. These cases was confirmed further on MRI. Conclusion: The ultrasonograpy diagnosed correctly 11 cases out of 15 cases of CNS anomalies. Moreover the ultrasound unable to diagnosis of CNS anomalies in the four cases of porencephalic cyst, lissencephaly occipital meningocele and corpus callosum agenesis (one case). Ultrasound was also correctly diagnosed twenty two cases out of twenty five cases. Moreover, it was unable to diagnosis of non CNS anomalies in the three cases of Cleft lip & palate (one case), congenital diaphragmatic hernia and Multicystic dysplastic kidney. The sensitivity of the ultrasonograpy for the diagnosis of the anomalies was 82.5%.***

Keywords: Prenatal 2D/3D USG, Congenital fetal anomalies and MRI

1. Introduction

Congenital anomalies, which frequently have an unidentified cause and result in serious physical, psychological, and social issues, are said to affect about 2% of newborn kids [1]. Ultrasound (US) is the most widely used screening technique for foetal imaging, but it has limitations, including a small field of view, limited soft tissue acoustic contrast, beam attenuation by adipose tissue, poor image quality in oligohydramnios, and limited visualisation of the posterior fossa in later stages of pregnancy due to calvarial calcification [1-3]. Detailed ultrasonography, which encompasses 2D, 3D, colour doppler, power doppler, and colour flow interrogation, forms the basis for foetal assessment and early anomaly identification. Fetal ultrasonography might not catch every birth abnormality or might misidentify one when none is actually present. Therefore, to confirm these results in comprehensive ultrasonography, MRI Correlation is needed.

Aims and Objectives

The purpose of the study is the role of 2D/3D Ultrasound in congenital fetal anomalies with MRI correlation.

2. Materials and Methods

The prospective study was conducted in Department of Radiodiagnosis, LLRM Medical College, Meerut. We included 40 strongly suspected cases for congenital anomalies in the study.

Inclusion Criteria:

- Patients suspected for congenital anomalies included in the study.
- Patients giving written informed consent was taken.
- Maternal Age 18-40 years.
- The gestational age range was 15-38 weeks, singletons or multiple pregnancy.
- Gestational age was calculated according to the date of the last menstrual period or early pregnancy dating scan.

Exclusion Criteria:

Patients not giving consent

Patients contra indicated for MRI

- The cardiac implantable electronic device (CIED) such as pacemakers, implantable cardioverter defibrillators (ICDs) and cardiac resynchronization therapy (CRT) devices.
- Metallic implants within the body.
- Drug infusion pumps (insulin delivery etc).
- Metalic fragments such as bullets, shotgun pellets and metal shrapnel.
- Artificial limb.

Methodology:

All (40) patients data was collected according to a predefined protocol. The data was registered as demographic characteristics, family history, risk factors, neurological examination, and diagnostic data. Full 2D/3D pelvic Ultrasound evaluation was done in all cases using 3.5-5 MHz 2D/3D transducer on logic p-9 General Electric machine. US studies was reviewed and reported by experienced sonographers in prenatal US.

MRI

Studies were performed on a Philips Achieva 1.5 T super conducting magnet using the synergy body coil in supine position. No sedation will be used. After a scout acquisition, a series of fetal images in the axial, sagittal, and coronal planes were obtained with a fast gradient-echo sequence, (balanced FFE) with TR/TE of 3.1/1.6, flip angle 60◦ or

single shot fast spin echo sequences with TR/TE of 1000/80 and matrix of 128-256 × 256, slice thickness of 5 mm and 30-35 cm FOV. Images were reviewed by experienced radiologist in the field of fetal MRI.

Statistical evaluation

The collected data was entered into Microsoft Excel computer program. All the analysis was carried out on SPSS 21.0 version (Meerut India). Values are expressed as mean, median, ±SD, minimum and maximum. The p-value <0.05 was considered significant.

3. Observations and Results

The distribution of cases according to different age group. The percentage of 21-25 years, 26-30 years, 31-35 years, and 35-40 years age group were 45.0%, 40.0%, 12.5%, and 2.5%, respectively.

The distribution of cases according to gestational age at USG and MRI. The percentage of ≤16 weeks, 17-24 weeks, 25-30 weeks, and >30 weeks gestational age by USG and MRI were 7.5%, 57.5%, 15.0%, and 20.0%, respectively.

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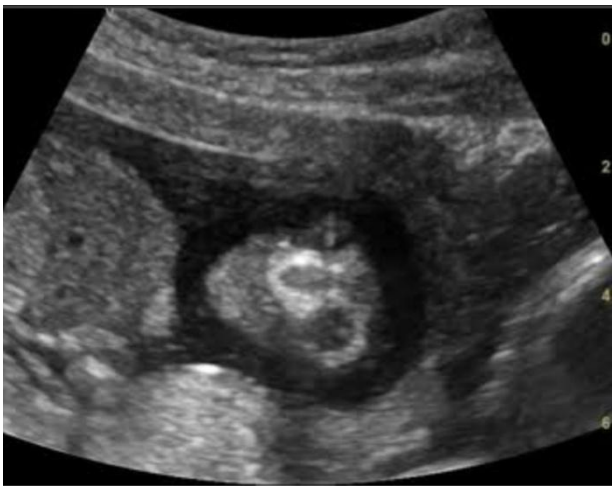
Table 1: Distribution of cases according to types of congensital anomalies by USG

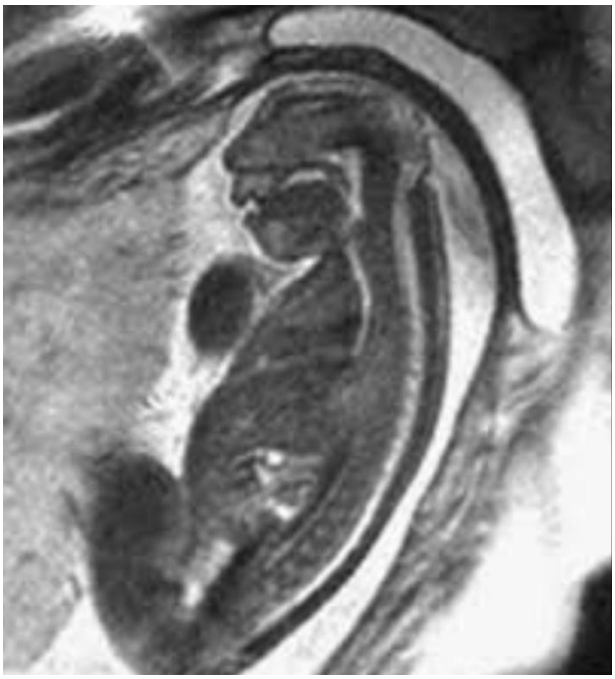
	Number (n)	Percentage (%)
Short femur length	1	2.5
Anencephaly-CNS	3	7.5
Cleft lip & palate-facial	1	5
Pleural effusion lung	2	5
Fetal ascites-abdominal	3	7.5
Gastrochisis-abdomen	1	2.5
Omphalocele= abdomen	1	2.5
Sacrococcygeal teratoma-CNS	3	7.5
Clubfoot (talipes equinovarus)	2	5
Claw hand	1	2.5
Cystic hygroma	1	2.5
Echogenic intracardiac foci in left ventricle-CVS	1	2.5
Long bone of upper and lower limb	1	2.5
Post urethral valve	1	2.5
Hydrocephalus	3	7.5
Congenital diaphragmatic hernia	1	2.5
Single umbilical cord	2	5
Spinal bifida-CNS	1	2.5
Corpus Callosum agenesis	1	2.5
Hydroureteronephrosis-renal	2	5
No	7	17.5

Table 2: Distribution of cases according to types of congenital anomalies diagnosed by MRI

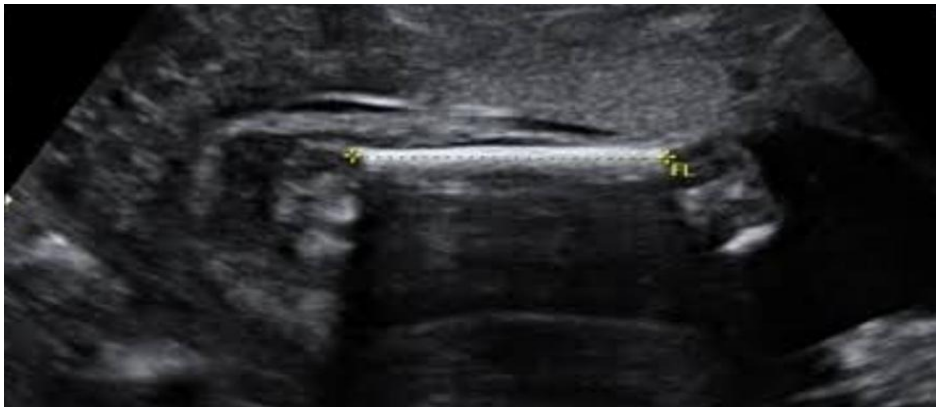
	Number (n)	Percentage (%)
Short femur length	1	2.5
Anencephaly-CNS	3	7.5
Cleft lip & palate-facial	3	7.5
Pleural effusion lung	2	5
Fetal ascites-abdominal	3	7.5
Gastrochisis-abdomen	1	2.5
Omphalocele= abdomen	1	2.5
Sacrococcygeal teratoma-CNS	3	7.5
Clubfoot (talipes equinovarus)	2	5
Claw hand	1	2.5
Cystic hygroma	1	2.5
Occipital meningocele	1	2.5
Echogenic intracardiac foci in left ventricle-CVS	1	2.5
Long bone of upper and lower extrimity-limb	1	2.5
Post urethral valve	1	2.5
Hydrocephalus	3	7.5
Congenital diaphragmatic hernia	2	5
Single umbilical cord	2	5
Corpus callosum agenesis	2	5
Spinal bifida-CNS	1	2.5
Porencephalic cyst-CNS	1	2.5
Lissencephaly-CNS	1	2.5
Hydroureteronephrosis-renal	2	5
Multicystic dysplastic kidney	1	2.5



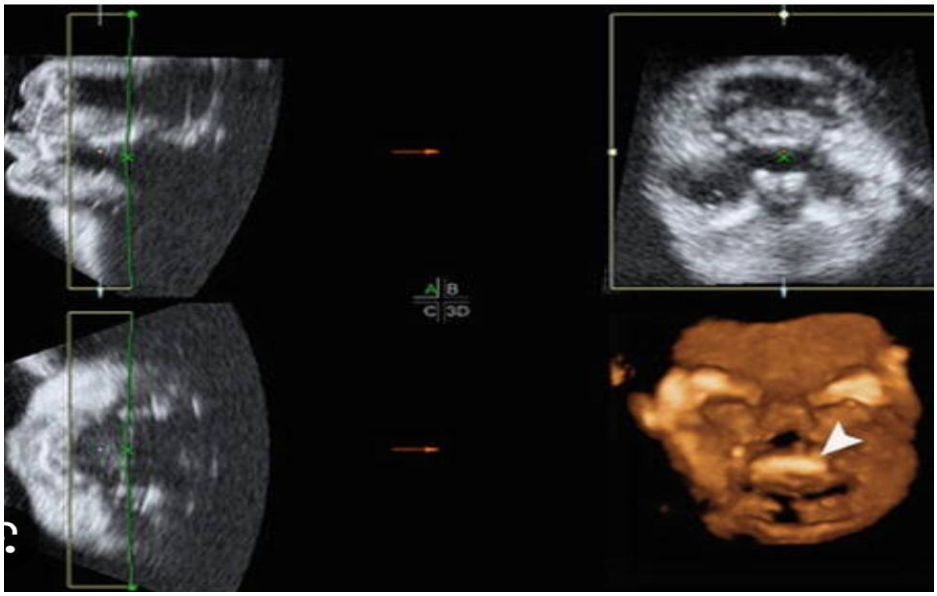
Anencephaly



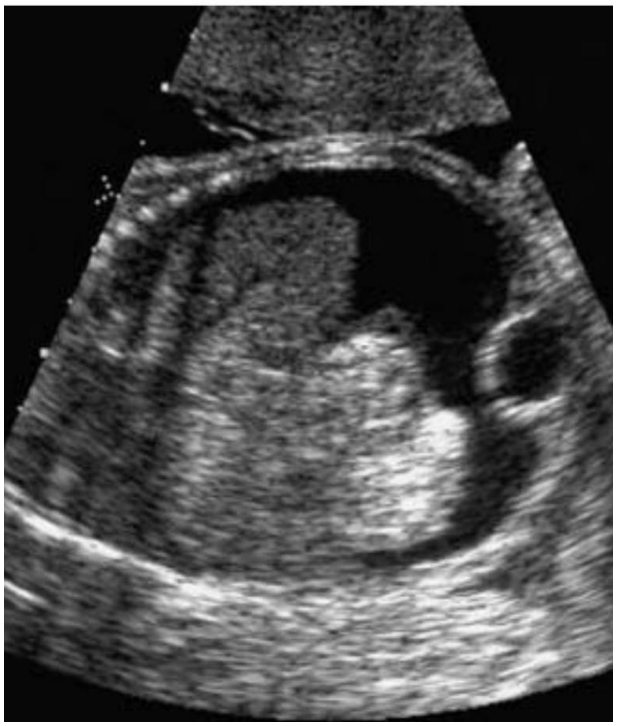
MRI



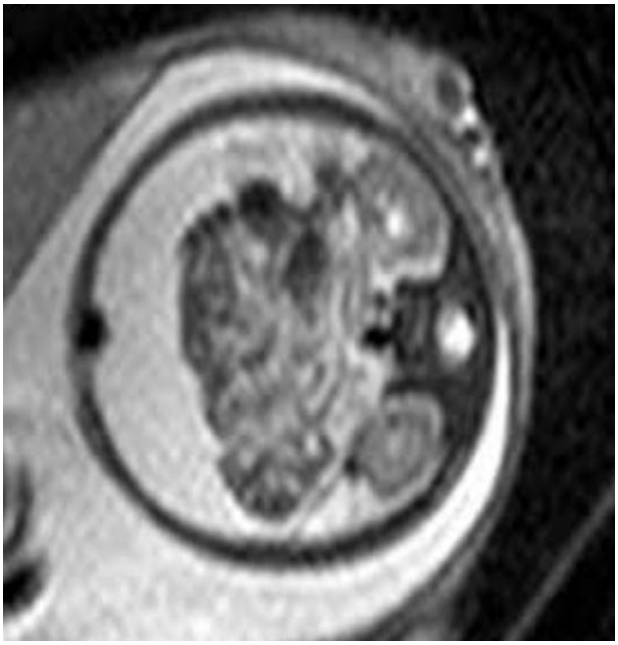
Short femur length usg



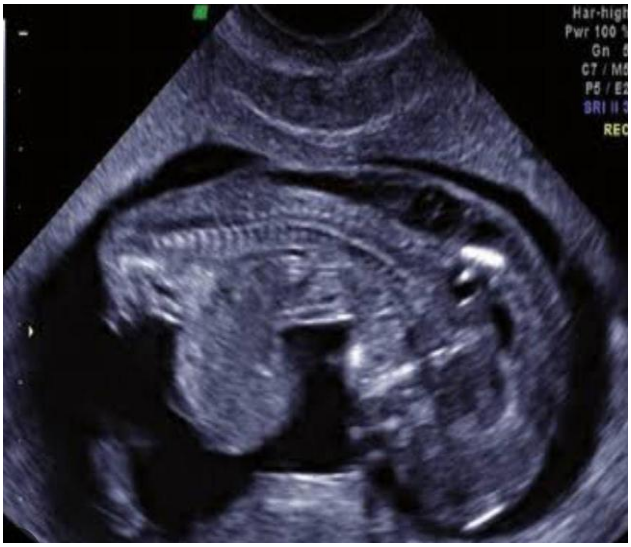
Cleft Lip USG



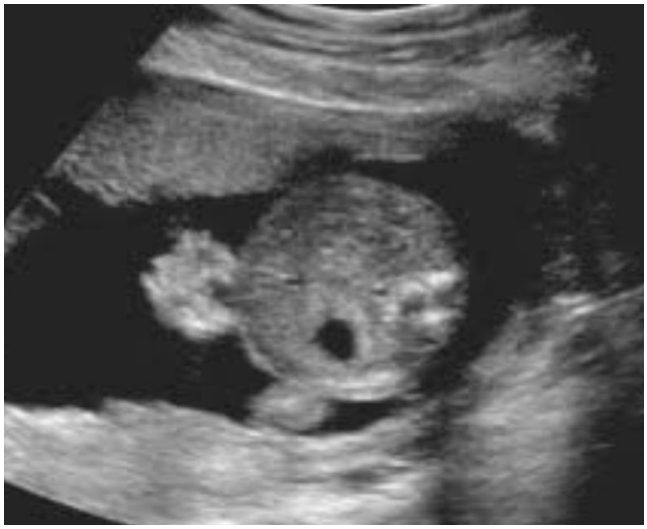
Fetal as cites USG



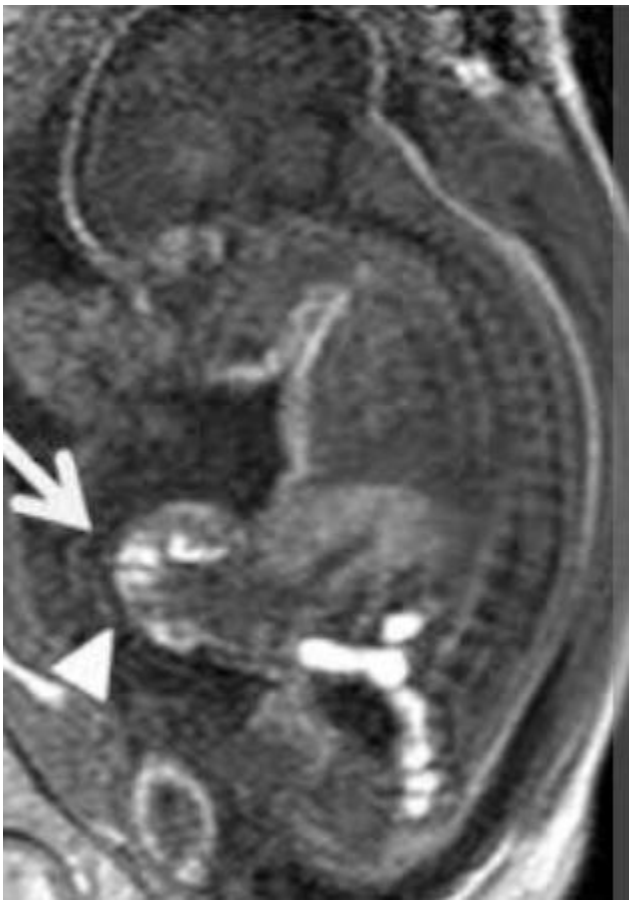
Fetal ascites MRI



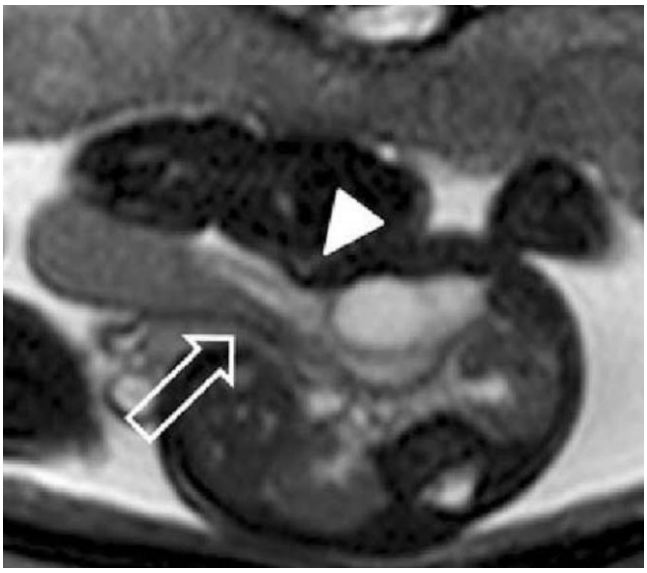
Omphalocele USG



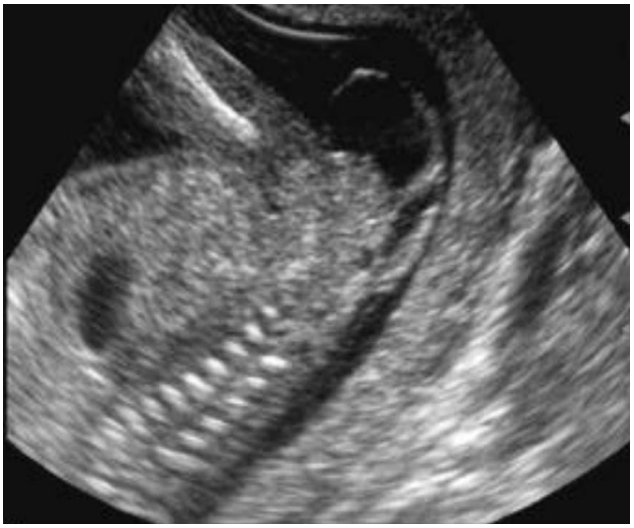
Gastroschisis USG



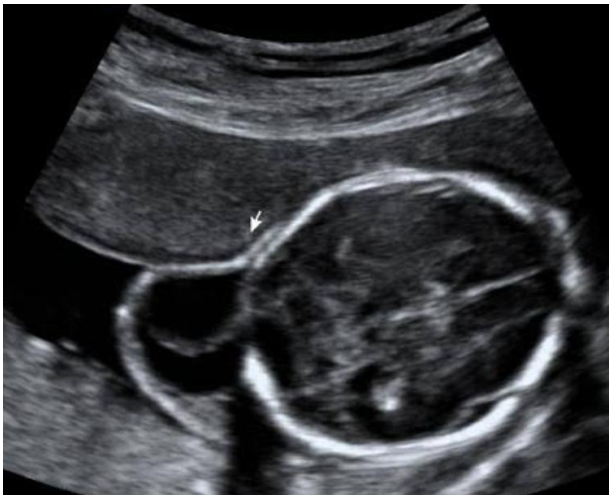
Omphalocele MRI



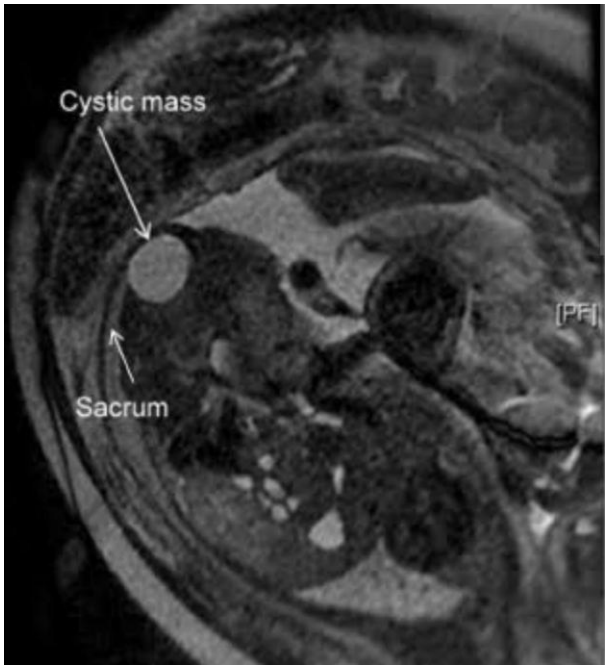
Gastroschisis MRI



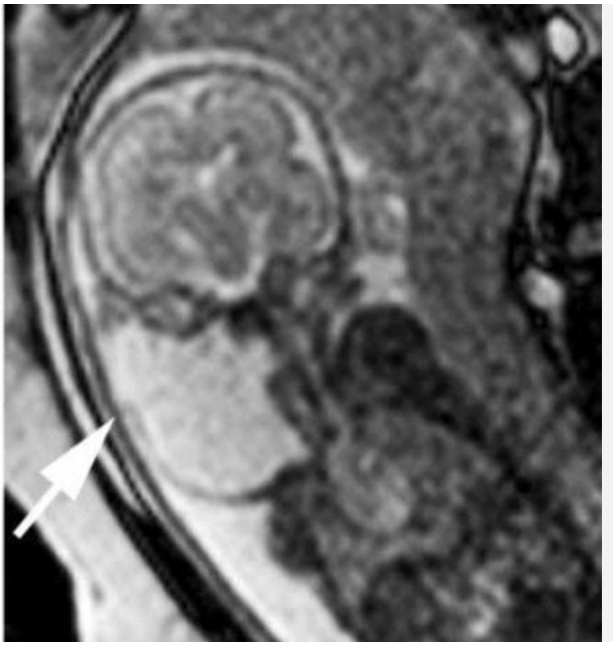
Saccrococcygeal teratoma USG



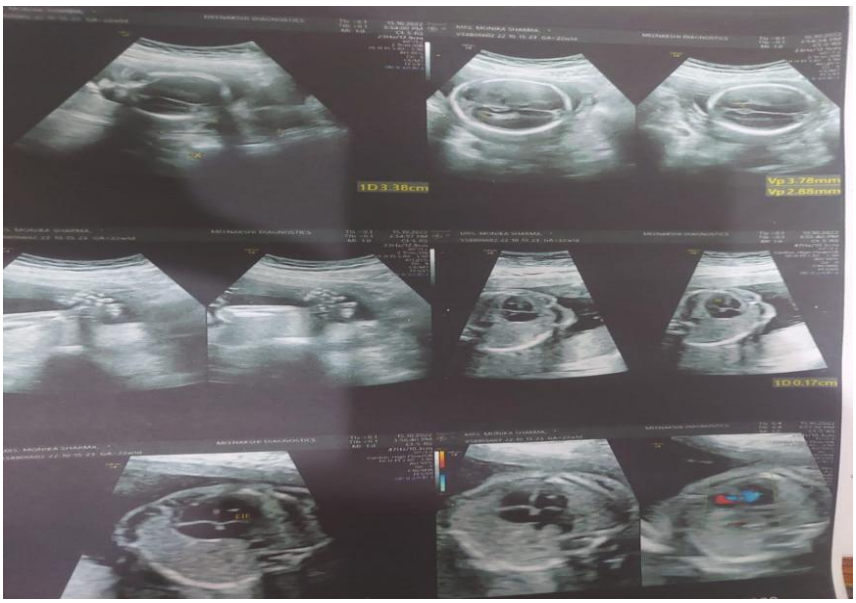
Cystic hygroma USG



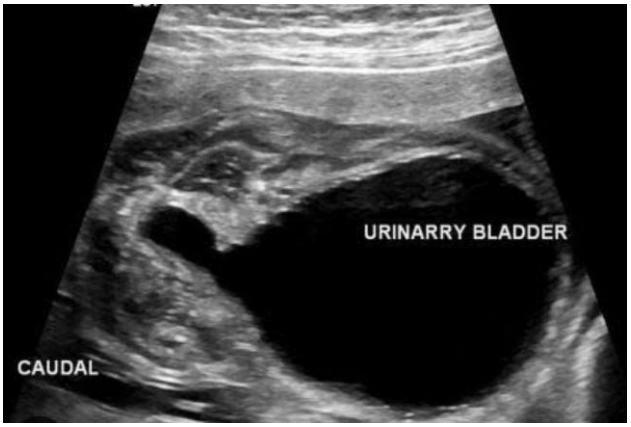
Saccrococcygeal teratoma MRI



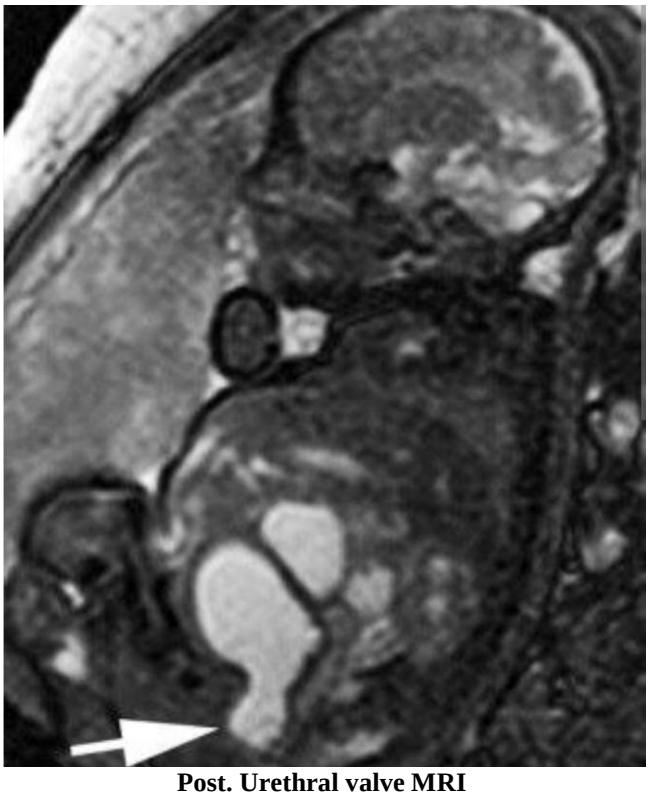
Cystic hygroma MRI



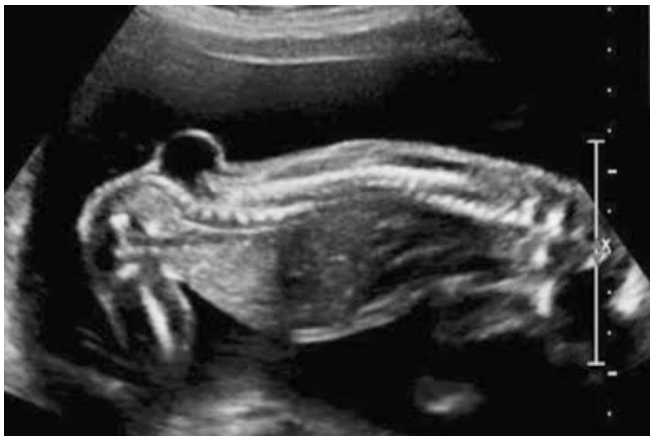
Echogenic intracardiac foci USG



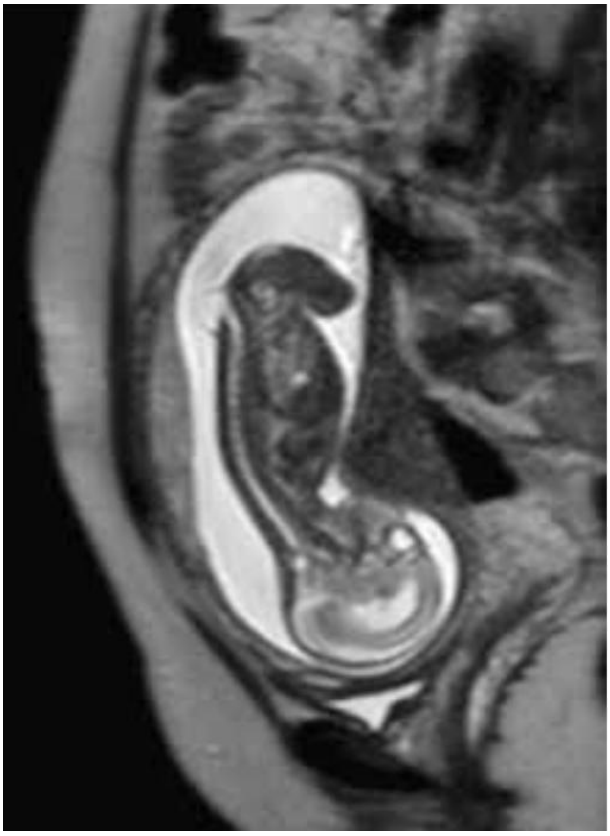
Post. Urethral valve USG



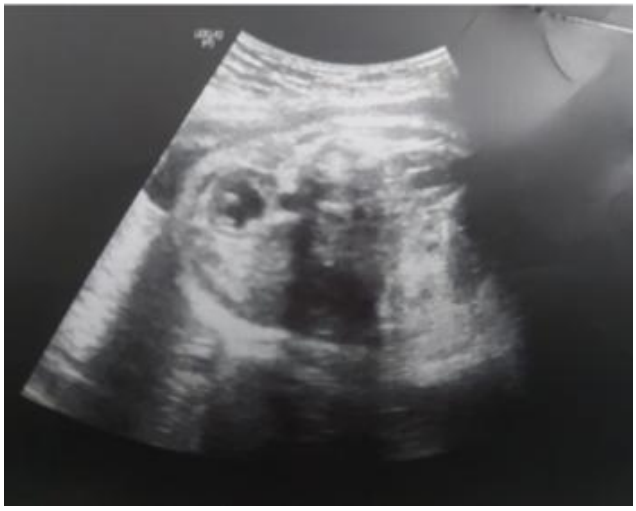
Post. Urethral valve MRI



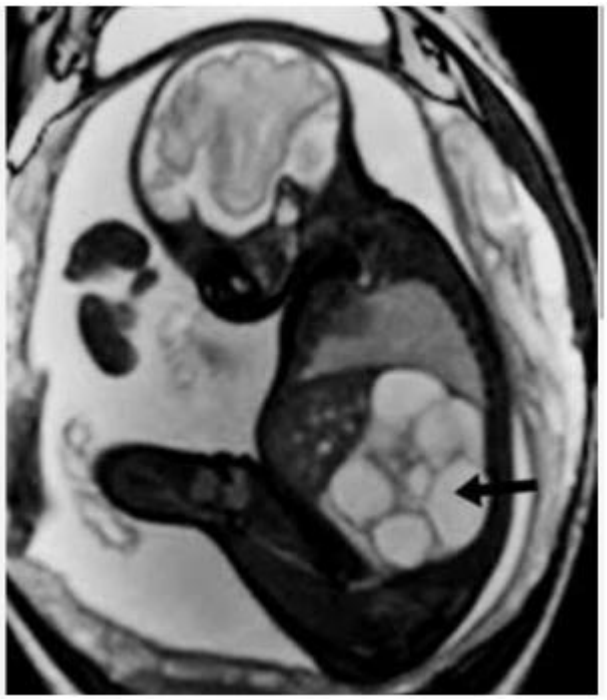
Spina bifida USG



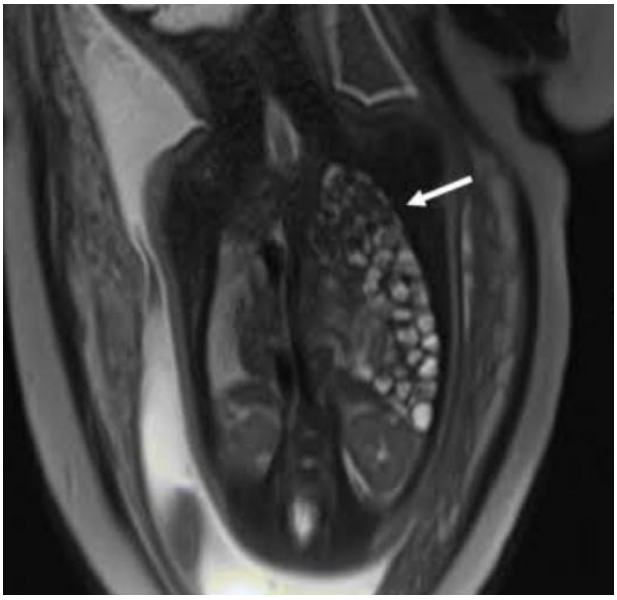
Spina bifida MRI



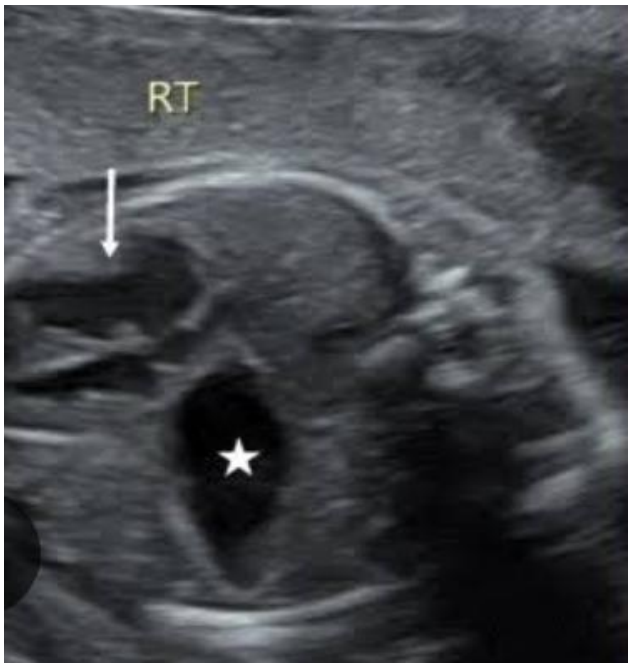
Fetal hydronephrosis USG



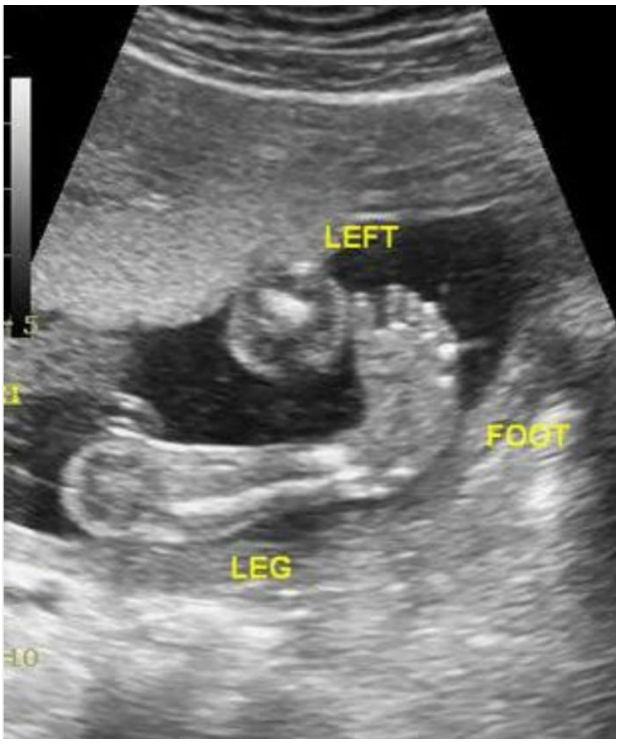
Fetal hydronephrosis MRI



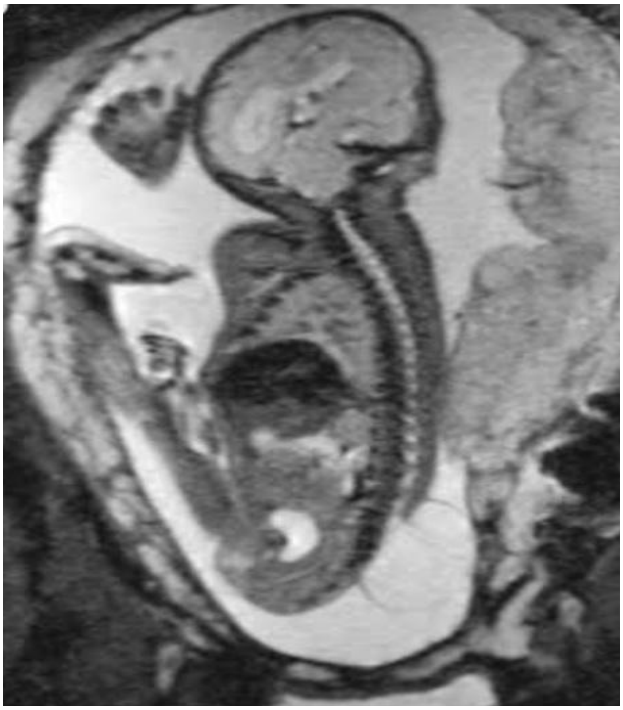
Congenital diaphragmatic hernia MRI



Congenital diaphragmatic hernia USG



Club Foot (Talipes equinovarus) USG



Club Foot (Talipes equinovarus) MRI

4. Discussion

Prenatal birth defect detection is typically seen as advantageous and desired since caring for the handicapped and disabled places a significant load on local healthcare systems. Due to its established utility, cheap cost, and ubiquitous availability, ultrasonography is accepted as the dominant imaging modality for foetal evaluation. Sometimes US results are ambiguous or insufficient to inform treatment decisions. Complementary imaging approaches are preferred in these circumstances [104]. The origin and extent of an anomaly may be ascertained using the multiplanar capabilities of MR imaging. Unlike ultrasound, MR imaging is not as constrained by the foetal position or the mother's body habitus, especially during the third trimester [87]. Because of the nonspecific nature of some defects, technical issues that make it challenging to see the brain near the transducer, and late-gestational difficulties in seeing the posterior fossa, the evaluation of the foetal CNS by US is constrained [105, 106]. The recent advancement of fast sequences has increased the use of MRI for prenatal diagnosis. This circumstance has been utilised to demonstrate that MRI is a useful technique for assessing murky foetal sonographic results [93]. Therefore in this study we aim to evaluate the role of 2D/3D ultrasound in congenital fetal anomalies with MRI correlation. For this purpose, a prospective study was carried out that included a total 40 individuals are enrolled in this study.

Table 3: Details of diagnosis of anomalies by USG and MRI

	USG	MRI
	n	
Short femur length	1	1
Anencephaly-CNS	3	3
Cleft lip & palate-facial	2	3
Pleural effusion lung	2	2
Fetal ascites-abdominal	3	3
Gastrochisis-abdomen	1	1
Omphalocele= abdomen	1	1
Sacrococcygeal teratoma-CNS	3	3
Clubfoot (talipes equinovarus)	2	2
Claw hand	1	1
Cystic hygroma	1	1
Occipital meningocele	0	1
Echogenic intracardiac foci in left ventricle-CVS	1	1
Long bone of upper and lower extrimity-limb	1	1
Post urethral valve	1	1
Hydrocephalus	3	3
Congenital diaphragmatic hernia	1	2
Single umbilical cord	2	2
Corpus callosum agenesis-CNS	1	2
Spinal bifida-CNS	1	1
Porencephalic cyst-CNS	0	1
Lissencephaly-CNS	0	1
Hydroureteronephrosis-renal	2	2
Multicystic dysplastic kidney	0	1

Behairy et al. (2010) [88] showed that Six of the eight isolated CNS anomalies seen on MRI that were accurately detected by ultrasonography. Additionally, in the two cases of Meckel Gruber syndrome, the link of CNS defects was overlooked by the US. This was in line with Glenn and Barkovich's findings [13], particularly given that posterior fossa anomalies were present in three of the four cases that the US missed.

In one case, MRI eliminated the diagnosis of Chiari II and confirmed aqueductal stenosis, which sped up the postnatal insertion of the shunt tube and improved the foetal prognosis.

The genitourinary system is frequently abnormal, making up 14-40% of all malformations found during prenatal sonography [108, 109]. In the study done by Caire et al. [110], oligohydramnios or anhydramnios did not impede MRI diagnosis. He claimed that MRI offered the anatomic detail necessary for an accurate assessment of the renal, bladder, and amniotic fluid areas in all foetuses at any gestational stage (his study included gestational age range of 17-35 weeks). However, Behairy et al. (2010) [88] reported that In two cases, the MRI was unable to determine whether the kidneys and urine bladder were present or absent, most likely as a result of the combination of anhydramnios and a short gestational period (15 and 16 weeks of gestational age).

When it comes to identifying CNS anomalies, a number of studies have found that MRI is more accurate than ultrasonography. [20, 89, 117-122] Others have demonstrated that additional MRI anomalies may result in a change in management and/or counselling. [89, 117-122] The study by Malinger et al. [123] is an exception to this rule, reporting that foetal neurosonography had higher accuracy in 7/39 (17.9%) cases compared to higher accuracy in MRI in 3/39 (7.7%) cases. According to a recent systematic review 43 of 13 articles and 710 foetuses, MRI provided additional information in 22.1% of cases (primarily midline anomalies), had a 2.5% false-positive rate (including ventriculomegaly, haemorrhage, midline anomalies, neuronal migration anomalies, and cell-proliferation disorders), and was more accurate than MRI in 2.0% of cases. [89] In 30.2% of the cases in three articles that were

part of the systematic review, the MRI diagnoses were different enough to need a change in management. [19, 119, 120] In a lower number of cases, more recent investigations found new diagnostic information from MRI. [120] In two (7.7%) of the 26 foetuses with CNS abnormalities detected after delivery that Peruzzi et al. [120] documented, MRI changed the diagnosis and therapy. According to Paladini et al. [124] 126 foetuses had MRI, 2D-US, and 3D-US examinations.12.7% (16/126) of the cases in which MRI and ultrasound results disagreed were also cases in which MRI gave extra diagnostic information (7.9%/10/126). Gonçalves et al. (2016) [93] reported that there were more false-positive diagnoses, such as dubious cortical dysplasia and intracranial haemorrhage, as a result of prenatal MRI's increased sensitivity in detecting CNS defects. By applying objective criteria, other erroneous diagnoses, such as hypoplastic cerebellum, could have been prevented (transverse cerebellar diameter measurement). These findings highlight the significance of having clinical information available at the time of examination (e. g. gestational age, which would have allowed the use of objective criteria) and the need for caution when prospectively diagnosing intracranial haemorrhage or malformations of the cortical development when subtle cortical mantle irregularities or abnormal signal intensities in the brain are not consistently and confidently identified in all sequences and/or planes. The sensitivities of fetal MRI, 2D-US and 3D-US for the diagnosis of other anomalies were not significantly different (80.0%, 77.8% and 75.6%, respectively). For the diagnosis of skeletal defects, ultrasonography performed better than MRI, . One unilateral cleft lip and palate condition that was successfully identified by 2D-US and 3D-US was overlooked by MRI. Cleft lip were appropriately identified by MRI but overlooked by 2D-US and 3D-US. Recent research from Arangio et al. [125] on the diagnosis of facial clefts reveals that MRI can supplement 2D-US and 3D-US results in cases of face clefts. In their investigation, some individuals with facial clefts had the ultrasonographic diagnosis corrected by MRI.

5. Conclusion

This study was carried out to evaluate the role of 2D/3D ultrasound in congenital fetal anomalies with MRI correlation. For this purpose, a prospective study was carried out that included a total 40 individuals are enrolled in this study. The following findings from the study were drawn:

- Total 57% cases were diagnosed by USG/MRI at 17-24 weeks (second trimester).
- The ultrasonograpy diagnosed correctly 11 cases out of 15 cases of CNS anomalies.
- Moreover the ultrasound unable to diagnosis of CNS anomalies in the four cases of porencephalic cyst, lissencephaly occipital meningocele and corpus callosum agenesis (one case).
- Ultrasound was also correctly diagnosed twenty two cases out of twenty five cases.
- Moreover, it was unable to diagnosis of non CNS anomalies in the three cases of Cleft lip & palate (one case), congenital diaphragmatic hernia and Multicystic dysplastic kidney.
- The sensitivity of the ultrasonograpy for the diagnosis of the anomalies was 82.5%.

Compared to 2D-US and 3D-US, foetal MRI demonstrated a better sensitivity for identifying CNS abnormalities. The increased sensitivity of MRI was at the expense of an increase in false-positive diagnoses, which were typically for minor CNS abnormalities that were doubtful or only mildly confidently characterised. In foetuses with urinary tract malformations, there is good agreement between 2D/3D-US and MRI. To increase sensitivity and reduce false-positive diagnoses, ultrasonography and MRI should be used in combined in clinical practise.

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