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Added Value of Prenatal MRI Over Prenatal US In Detection of Etiology and Type of Ventriculomegaly

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KEYWORDS

Prenatal MRI , Prenatal US, Ventriculomegaly

ABSTRACT:

Aims and Objectives: 1) To evaluate the accuracy of prenatal MRI in detecting fetal etiology and type of ventriculomegaly 2) To compare the diagnostic accuracy between prenatal MRI and prenatal 4D US in evaluating etiology and type of ventriculomegaly by comparing their end results with post natal assessment after delivery in equivocal case when possible. Material and Methods: Prospective hospital-based cohort study was done between january 2019 and March 2024 at Radiology Department . Fifty pregnant women after 20 weeks of pregnancy to 34 weeks who were sonographically suspected or diagnosed to have CNS anomalies. Pregnancy with ultrasound findings of ventriculomegaly anomalies were recruited for prenatal MRI examination, prenatal ultrasound and MRI findings were confirmed in cases of live births with postnatal findings. Results: After conducting aprenatal ultrasound screening in all three trimesters, a total of 22 cases of ventriculomegaly were diagnosed. It was seen that majority of anomalies were detected in 2nd trimester and ventriculomegaly was the most common anomaly. Conclusion: pre and postnatal MRI is the most essential part in detection of etiology and type of ventriculomegaly, prenatal MRI could detect the etilogy and type of most of the cases 18 and 19 cases respectively .

Introduction:

Congenital central nervous system (CNS) anomalies are common and most devastating. They occur in frequency of about 1.4 to 1.6 per 1000 live births but are seen in about 3-6% of stillbirths (Onkar, Onkar et al. 2014). They account for 40% of deaths of all infants in the first year of life. In survivors, they cause a variety of neurological disorders, mental retardation or drug-resistant epilepsy **(Khalil, Elshafey et al. 2016).**

Early detection of congenital CNS anomalies give time available for the clinician and parents to plan about the outcome of pregnancy (Onkar, Onkar et al. 2014).

Prenatal ultrasound has been well established for decades as the primary technique for evaluating the developing fetus in normal as well as in high-risk cases (Bakare, Taori et al. 2013, Khalil, Elshafey et al. 2016). US has many advantages: widespread availability, relatively low cost and quick, and lack of harmful effect to fetus or mother and real time imaging (Bakare, Taori et al. 2013). Although ultrasound can characterize many anomalies accurately, it has many limitations as; operator dependent, small field of view, relatively poor soft-tissue contrast, beam attenuation by maternal adipose tissue and fetal bone, and limited visualization of posterior fossa after 33 weeks gestation because of calvarial calcification. Also, ultrasound relies heavily on fetal positioning and presence of sufficient amniotic fluid to provide an adequate acoustic window . So, US findings are occasionally incomplete or inconclusive to guide treatment choices (Bakare, Taori et al. 2013, Khalil, Elshafey et al. 2016).

Fetal brain MRI became embraced as a clinically important imaging technique useful for fetal assessment, which is helpful in formulating prognosis and perinatal management and can detect occult

Journal of Chemical Health Risks
www.jchr.org
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abnormalities in up to 50% of cases for certain indications (Masselli, Vaccaro Notte et al. 2020). MRI has many advantages includes; it is not limited by maternal obesity, fetal position, or oligohydramnios, it has better soft tissue contrast resolution, as well as the ability to distinguish individual fetal structures such as brain, lung, liver, kidney, and bowel, visualization of the brain is not restricted by the ossified skull, and MRI provides multiplanar imaging as well a larger field of view, facilitating examination of fetuses with large or complex anomalies (Khalil, Elshafey et al. 2016).

Fetal MRI study may give limited diagnostic information in early gestational age due to the small size of the fetus. So, the ideal gestational age to perform MRI is after 18 weeks of gestation (Khalil, Elshafey et al. 2016). Also, CNS develops from 3 to 20 weeks of intrauterine life (Onkar, Onkar et al. 2014).

Our study aimed to evaluate the role of pre-natal MRI over US in detecting etiology and types of ventriculomegaly and comparing theses results with post natal MRI.

Patients and methods:

Prospective hospital-based cohort study was done between january 2019 and March 2024 at Radiology Department . Fifty pregnant women after 20 weeks of pregnancy to 34 weeks who were sonographically suspected or diagnosed to have CNS anomalies, patients referred from the Gynecological and Obstetric Department at Women Reproductive Health Hospital, were included in this study.

Inclusion criteria:

1. All pregnant women with current single or multiple pregnancy with either suspected or detected fetal CNS anomalies on US routine antenatal examination , medically diseased women also involved in the study (DM, HT, etc)
2. Gestional age ranging between 20 to 34 ws
3. Pregnant women with past or family history of congenital fetal abnormality.
4. Accept to participate in the study.

Exclusion criteria:

1. Claustrophobic patients.
2. Pregnant women with contraindication to MRI as cochlear implants and pacemakers.
3. Refused to participate in this study.

- **All Patients underwent the following:**

Thorough medical history taking, two dimension and four dimension Ultrasound examination done using variable ultrasound machines, SAMSUNG medison SAX 8 machine with transducer 2D convex C2-8, 3D convex C2-6, 3D TV EC 4-9 at the fetal care unit of Gynecology and Obstetrics Department, GE voluson E8 BT 20 ultrasound machine with transducer GE - RAB 4-8 D with 2D/3D multi-slice mode from fetal care clinic , we follow aknown basic principles of US examination in previous studies done from 20 weeks of pregnancy till 34 weeks, Prenatal MR imaging was performed using 1.5 Tesla MRI machine (Philips, Achieva & Siemens Sempra Medical System) using a 16- channel abdominal phased array Torso coil in the supine position except at advanced gestational ages, when the patient lies in the left lateral decubitus position, after centering the region of interest (brain stem).It was done immediately after prenatal sonographic examination.

MRI technique:

MR imaging was primarily performed, using initial three plane localizer with single shot fast spin echo (TR 4960-TE 100 band width 50) to visualize the position of the fetus.

Then neuroimaging examination was done for fetal brain imaging (axial, sagittal and coronal plane).

prenatal protocol was as follows:

T2 HASTE (axial, coronal and sagittal with TR:1300ms and TE:93ms ,flip angle 180 degree and slice thickness 5mm ,T1 field sagittal and axial with TR 171 ms, TE 4,76ms flip angle 70 degree and slice thickness 5mm, T2 TRUFI axial ,sagittal and coronal with TR:947ms,TE:2.3ms,flip angle :60 degrees and slice thickness 5mm, Axial DWI at b50_400_800_tra _p2, Axial flair (T2_tse_dark-fluid_tra) with tr:7000m,te98ms,flip angle 150 degree and slice thickness 5mm, and T2 CISS transverse iso with TR:4.68 ms ,TE2ms,flip angle 44 degree and slice sickness 3mm.

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 06-16 | ISSN:2251-6727

The imaging postnatal routine protocol was as follows:

1-Coronal T2WI

2- Sagittal T1WI

3-Axial DWI at b50_400_800_tra _p2

4-Axial FLAIR (t2_tse_dark-fluid_tra)

Data analysis & image interpretation by prenatal MRI

Fetal Biometry Brain volume estimation was performed using the fronto- occipital, cerebral biparietal and bone biparietal diameters as well as the craniocerebral index and the cephalic index, Ventricular size assessment was performed using the transversal diameter of the lateral ventricles measured on the coronal slice at the level of the atria.

Data analysis & image interpretation in prenatal US

Evaluation of ventriculomegaly , Establishing its class of severity is based on the width of the atrium of the lateral ventricle.

Statistical analysis

Data was analyzed using SPSS version 26. Categorical data were presented in the form of frequencies and percentages. Numerical data were checked for normality by Shapiro- walk test and presented by mean and standard deviation according to their distribution.

The degree of agreement between prenatal US, Prenatal MRI and postnatal MRI for diagnosis of different parameters of CNS congenital anomaliess measured by Cohen's kappa (k).

Receiver operating characteristic (ROC) curve analysis was done, area under the curve (AUC), accuracy, sensitivity, specificity, positive and negative predicted value was calculated for prenatal US in comparison to postnatal MRI, Prenatal MRI in comparison to postnatal MRI, and Prenatal MRI in comparison to prenatal MRI. The level of significance was considered at P value < 0.05.

Results

Fifty women, their mean age was 26.82±4.61 and ranged from 17 to40 years, mean gestational age was 26.60±2.24 and ranged from 21 to 34weeks, were enrolled in this study Regarding neonatal outcome of studied women, 90% were lived and 10% died (table 1)

Table (1): Demographic data among patients

Demographic data	N=50	%
Age of mother (years)		
■ Mean ± SD	26.82±4.61	
■ Range	17.0-40.0	
Gestational age (weeks)		
■ Mean ± SD	26.60±2.24	
■ Range	21.00-34.00	
Neonatal outcome		
■ Live	45	90%
■ Died	5	10%

The most common CNS anomalies diagnosed by MRI were ventriculomegaly (48.9%)

1- As regard detection of Ventriculomegaly by different imaging modalities:

Postnatal MRI, prenatal MRI and prenatal ultrasound diagnosed 22 cases (48.9%)

- Prenatal US detected 22 cases and all of them were truly diagnosed postnatally with Ventriculomegaly, the calculated sensitivity and specificity of prenatal US in diagnosis of Ventriculomegaly were 100.0% and 100.0% respectively. p value<0.001.

Prenatal MRI detected 22 cases and all of them were diagnosed postnatally with Ventriculomegaly, the calculated sensitivity and specificity of prenatal MRI in diagnosis of Ventriculomegaly were 100.0% and 100.0% respectively.p value <0.001.

- Diagnostic accuracy of prenatal US in diagnosis of Ventriculomegaly in comparison to prenatal MRI, will be the same results of prenatal US in comparison to postnatal MRI as the results of prenatal MRI the same of the results of postnatal MRI. Table (2)

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Table (2): Diagnostic accuracy for Prenatal US, prenatal MRI in detection of ventriculomegaly

		Postnatal MRI			Validity measures				
		Positive	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
Prenatal US	**Positive**	22 (48.9%)	0 (0.0%)	22 (48.9%)	100 %	100 %	100 %	100 %	100 %
	Negative	0 (0.0%)	23 (51.1%)	23 (51.1%)					
	Total	22 (48.9%)	23 (51.1%)	45 (100.0%)					
		Positive	**Positive**	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Prenatal MRI	**Positive**	22 (48.9%)	0 (0.0%)	22 (48.9%)	100 %	100 %	100 %	100 %	100 %
	Negative	0 (0.0%)	23 (51.1%)	23 (51.1%)					
	Total	22 (48.9%)	23 (51.1%)	45 (100.0%)					

- ***Kappa agreement: for Prenatal US (=1.000, P value<0.001), for Prenatal MRI (=1.000, P value<0.001)

- **AUC, 95%CI: for Prenatal US (=1.000 {1.000-1.000}, P value<0.001), Prenatal MRI (=1.000 {1.000-1.000}, P value<0.001)

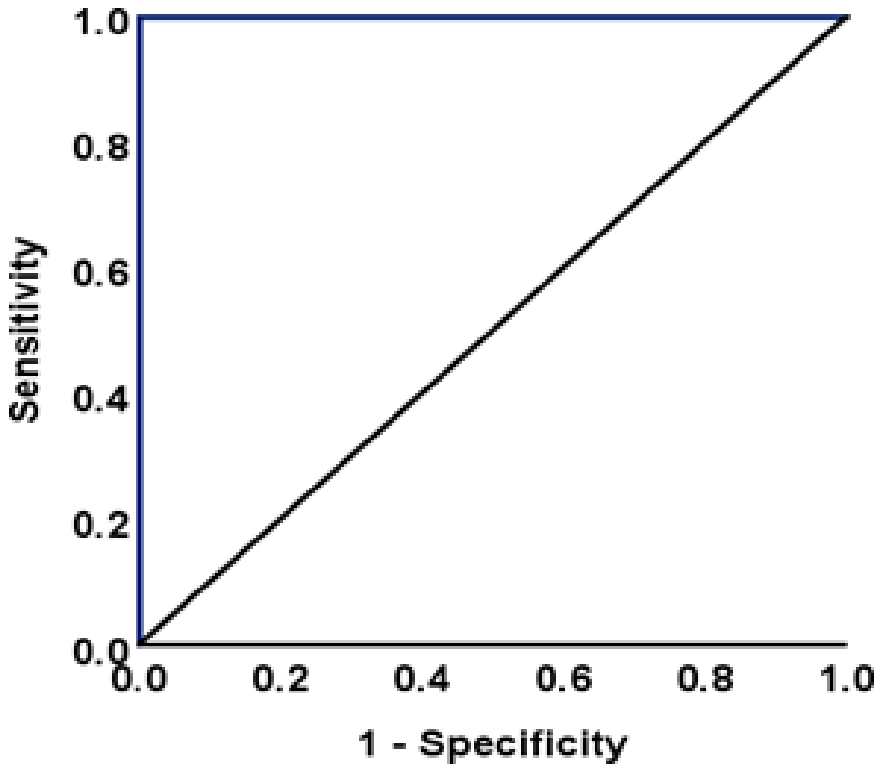

Figure (1): Roc curve for diagnostic accuracy for Prenatal US or prenatal MRI in detection of ventriculomegaly

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 06-16 | ISSN:2251-6727

As regard etiology of Ventriculomegaly, we found that postnatal MRI, prenatal MRI detected etiology in 18 cases (40.0%) and prenatal US detect etiology in 7 case (15.6%). Table (3) and figure (4)

Table (3): Detection of etiology of Ventriculomegaly by different imaging modalities

	Etiology of ventriculomegaly		
	Positive	**Negative**	**Total**
Postnatal MRI	18 (40.0%)	27 (60.0%)	45 (100.0%)
Prenatal US	7 (15.6%)	38 (84.4%)	45 (100.0%)
Prenatal MRI	18 (40.0%)	27 (60.0%)	45 (100.0%)

- Prenatal US detected 7 cases and all of them were true diagnosed postnatally, the calculated sensitivity and specificity of prenatal US in detection of etiology of Ventriculomegaly were 38.9% and 100.0% respectively. p value =0.029.

- Prenatal MRI detected 18 cases and all of them were true diagnosed postnatally, the calculated sensitivity and specificity of prenatal MRI in detection etiology of Ventriculomegaly were 100.0% and 100.0% respectively. p value <0.001.

- Diagnostic accuracy of prenatal US in detection etiology of Ventriculomegaly in comparison to prenatal MRI, will be the same results of prenatal US in comparison to postnatal MRI as the results of prenatal MRI the same of the results of postnatal MRI. Table (4)

Table (4): Diagnostic accuracy for Prenatal US, prenatal MRI in detection of etiology of ventriculomegaly

		Postnatal MRI			**Validity measures**				
		Positive	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
Prenatal US	**Positive**	7 (15.6%)	0 (0.0%)	7 (15.6%)	38.9%	100.0%	100 %	71.1%	75.6%
	Negative	11 (24.4%)	27 (60.0%)	38 (84.4%)					
	Total	18 (40.0%)	27 (60.0%)	45 (100.0%)					
		Positive	**Positive**	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Prenatal MRI	**Positive**	18 (40.0%)	0 (0.0%)	18 (40.0%)	100 %	100 %	100 %	100 %	100 %
	Negative	0 (0.0%)	27 (60.0%)	27 (60.0%)					
	Total	18 (40.0%)	27 (60.0%)	45 (100.0%)					

*****Kappa agreement: for Prenatal US (=0.433, P value<0.001), for Prenatal MRI (=1.000, P value<0.001)

**AUC, 95%CI: for Prenatal US (=0.694 {0.526-0.863}, P value=0.029), Prenatal MRI (=1.000 {1.000-1.000}, P value<0.001)

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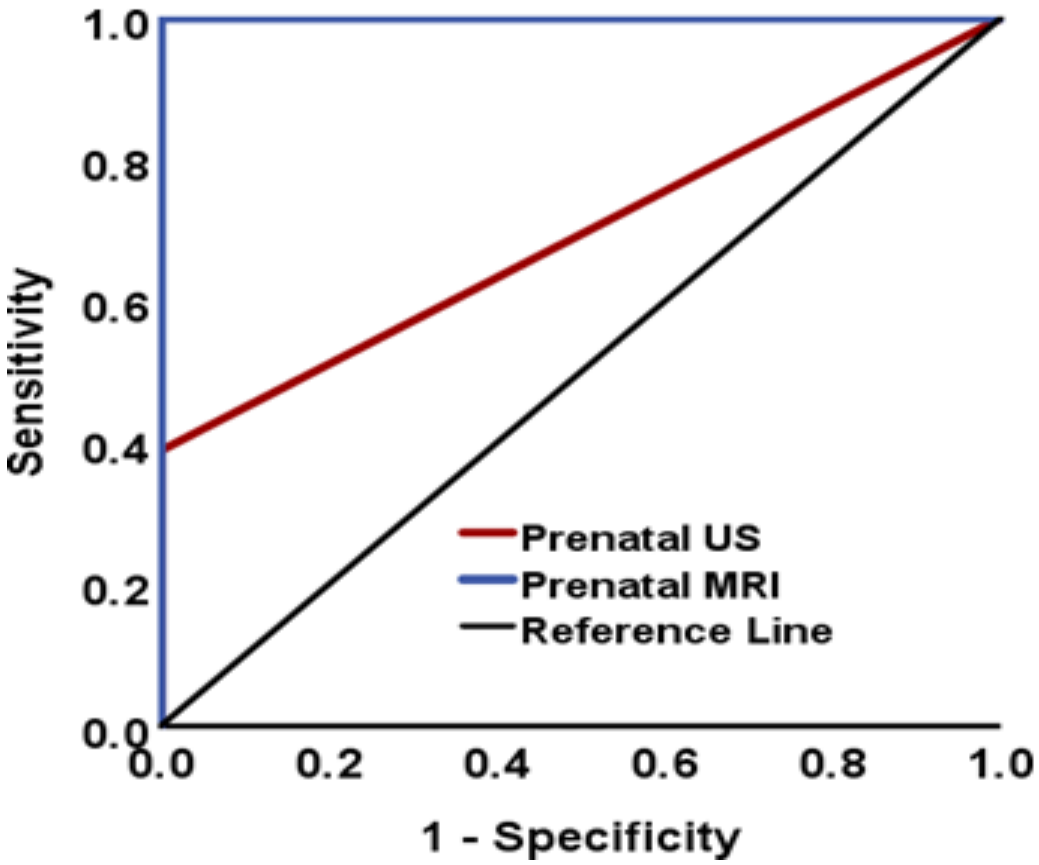

Figure (2): Roc curve for diagnostic accuracy for Prenatal US, prenatal MRI in detection of etiology of ventriculomegaly

As regard type of Ventriculomegaly we found that: postnatal MRI, prenatal MRI detect type in 19 cases (42.2%) and prenatal US detect etiology in 7 case (15.6%). Table (5) and figure (5)

Table (5): Detection of type of Ventriculomegaly of intracranial cysts by different imaging modalities

	Type of ventriculomegaly		
	Positive	**Negative**	**Total**
Postnatal MRI	19 (42.2%)	26 (57.8%)	45 (100.0%)
Prenatal US	7 (15.6%)	38 (84.4%)	45 (100.0%)
Prenatal MRI	19 (42.2%)	26 (57.8%)	45 (100.0%)

- Prenatal US detected 7 cases and all of them were true diagnosed postnatally, the calculated sensitivity and specificity of prenatal US in detection of etiology of Ventriculomegaly were 36.8% and 100.0% respectively. p value =0.037.

Prenatal MRI detected 19 cases and all of them were true diagnosed postnatally, the calculated sensitivity and specificity of prenatal MRI in detection type of Ventriculomegaly were 100.0% and 100.0% respectively. p value <0.001.

Diagnostic accuracy of prenatal US in detection type of Ventriculomegaly in comparison to prenatal MRI, will be the same results of prenatal US in comparison to postnatal MRI as the results of prenatal MRI the same of the results of postnatal MRI.table (6)

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(6), 06-16 | ISSN:2251-6727

Table (6): Diagnostic accuracy for Prenatal US, prenatal MRI in detection of type of ventriculomegaly

		Postnatal MRI			Validity measures				
		Positive	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**	**Accuracy**
Prenatal US	**Positive**	7 (15.6%)	0 (0.0%)	7 (15.6%)	36.8%	100.0%	100 %	68.4%	73.3%
	Negative	12 (26.7%)	26 (57.8%)	38 (84.4%)					
	Total	19 (42.2%)	26 (57.8%)	45 (100.0%)					
		Positive	**Positive**	**Negative**	**Total**	**Sensitivity**	**Specificity**	**PPV**	**NPV**
Prenatal MRI	**Positive**	19 (42.2%)	0 (0.0%)	19 (42.2%)	100 %	100 %	100 %	100 %	100 %
	Negative	0 (0.0%)	26 (57.8%)	26 (57.8%)					
	Total	19 (42.2%)	26 (57.8%)	45 (100.0%)					

***Kappa agreement: for Prenatal US (=0.403, P value=0.001), for Prenatal MRI (=1.000, P value<0.001)**
****AUC, 95%CI: for Prenatal US (=0.684 {0.517-0.851}, P value=0.037), Prenatal MRI (=1.000 {1.000-1.000}, P value<0.001)**

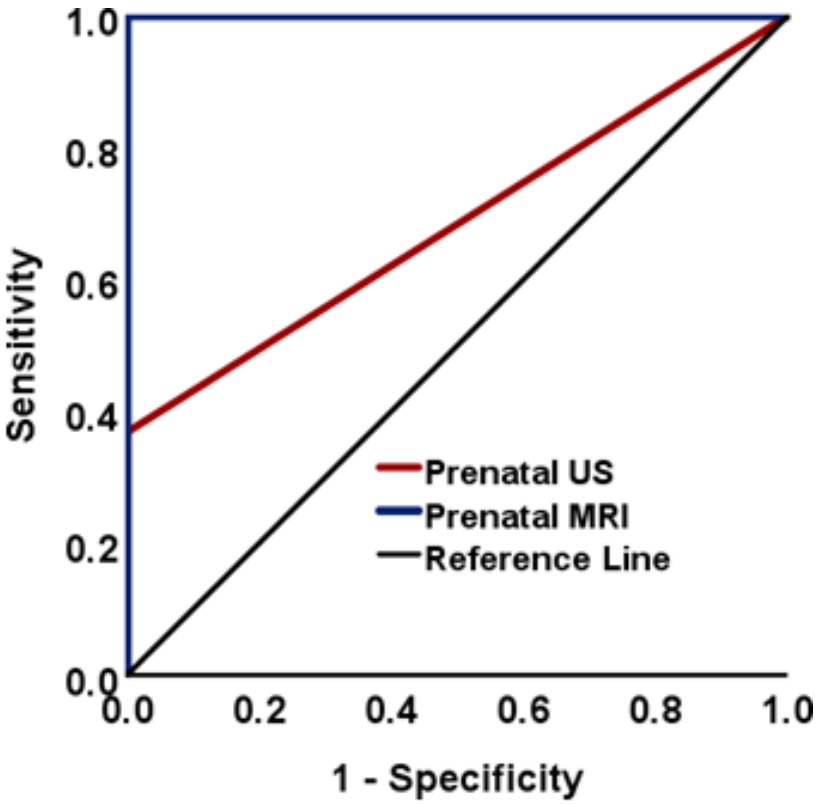

Figure (3): Roc curve for diagnostic accuracy for Prenatal US, prenatal MRI in detection of type of ventriculomegaly

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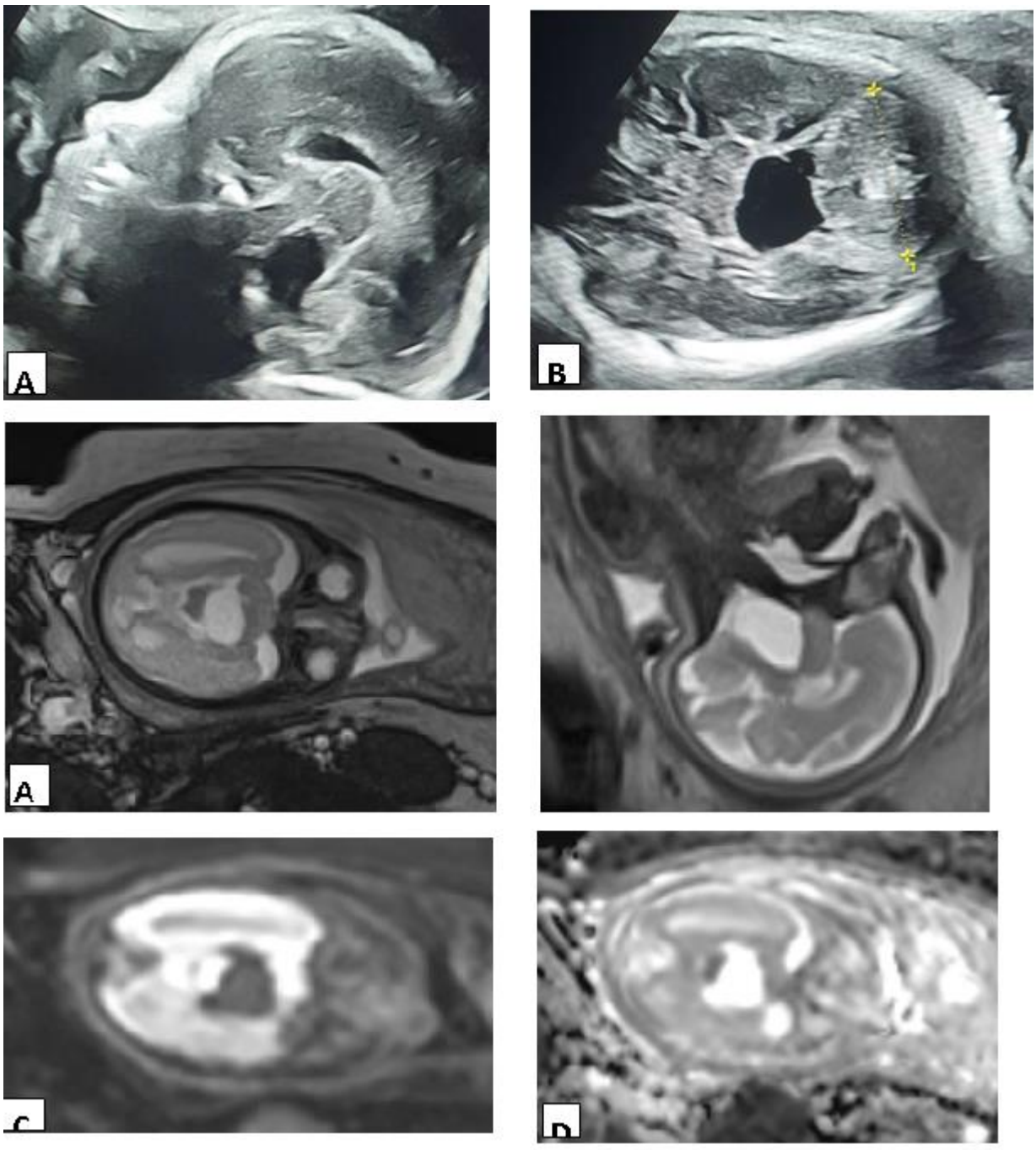

Figure (4) Fetus of 32 ws gestional age with prenatal US (A and B images) referred as 4th ventricular cystic lesion for differential diagnosis, Prenatal MRI imaging (A=axial T2 HASTE, B= sagittal T2 HASTE shows well defined extra axial pre-pontine cystic lesion measuring +/- 23x29x19mm, it exhibits hypointense signal at TIWI hyperintense at T2WI , hypointense at FLAIR, (C and D images) show facilitated diffusion suggestive of arachnoid cyst it cause indentation of brain stem posteriorly and cause mild dilatation of ventricular system.

Journal of Chemical Health Risks
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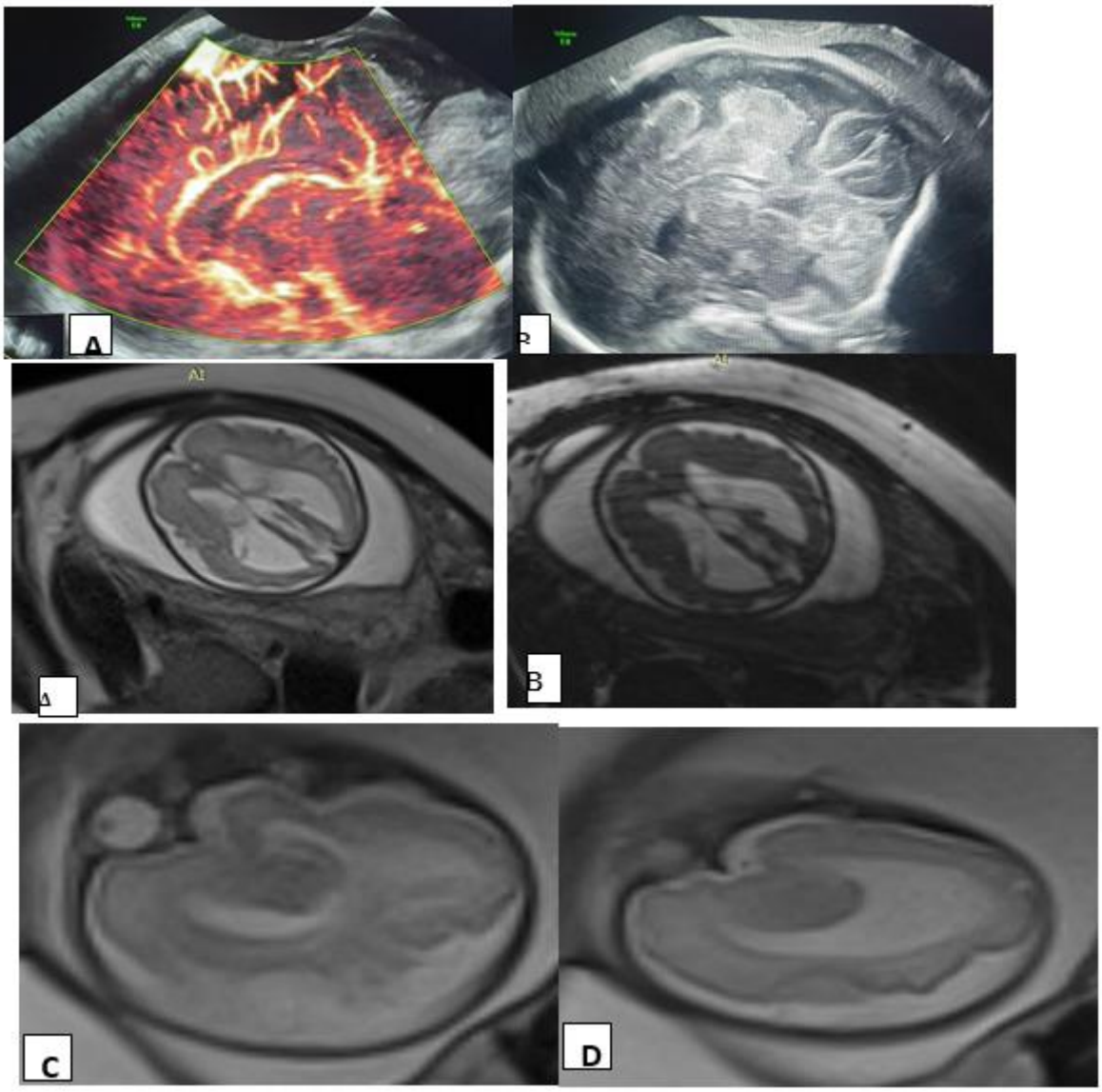

Figure (5)Fetus 24 ws GA with prenatal US (A and B images) referred as mild ventriculomegaly with suspected corpus callosum abnormality with abnormality of the course of pericallosal artery and referred to MRI unit for confirmation

Prenatal MRI (A=axial T2 HASTE, B=axial CISS and D images= saggital T2 HASTE) detect corpus callosum dysgenesis, unfortunately the fetus died at 32 ws gestional age intrauterine

DISCUSSION

4D Ultrasound is an effective modality in detection of CNS anomalies and their management. However, Ultrasound evaluation of the fetal central nervous system is limited by the non specific ultrasound appearance of some anomalies and technical factors that make visualization of the brain near the transducer is difficult **(Sefidbakht, Dehghani et al. 2016) .**

The most common CNS anomaly in our study was ventriculomegaly that represented 22/50 cases(48.9%) which was in concordance with screening anomalies study of (Mufti, Sacco et al. 2022).

Both US and MRI showed equal diagnostic validity measures in detection of ventriculomegally (100%), this was in agreement with results of (Araujo Júnior, Nakano et al. 2013) who confirmed concordance between ultrasound and MRI in the assessment of the

Journal of Chemical Health Risks
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JCHR (2024) 14(6), 06-16 | ISSN:2251-6727

size of the atrium of the lateral ventricle (Cardoen, De Catte et al. 2011) who also were nearly similar to our study and stated that fetal MRI has a limited role over ultrasound in assessing the size of the cerebral ventricles, except for cases where fetal position and calvarial ossification cause problems.

However, we found that prenatal MRI exhibiting much higher accuracy in detection of etiology and type of ventriculomegaly than prenatal US with kappa agreement between prenatal MRI and prenatal US equal to 0.433 and 0.403 regarding etiology and type respectively, denoting fair agreement

The causes of ventriculomegaly are very heterogeneous and include developmental, destructive, and obstructive processes.

In our study we conducted 22 /50 cases (40%) of ventriculomegaly, prenatal MRI detected the etiology of ventriculomegaly in 18/22 cases and type of hydrocephalus in 19/22 cases, while 6 cases (27%) were due to aqueductal stenosis , that is more in percentage than (Raafat, Hosny et al. 2022) who reported 4 cases (13.3%) with obstructive ventriculomegaly due to aqueduct and that due to the larger sample size of (Raafat, Hosny et al. 2022) who conducted study on thirty pregnancies with ventriculomegaly.

The other causes were, one case due to arnold chiari malformation, another case due to dandy walker variant , and case due to prepontine arachnoid cystic lesion compressing brain stem that are confirmed by post natal MRI.

In our study there was 8/22 (36.3%) cases were associated with posterior fossa anomalies and that is nearly close to what is conducted in (Raafat, Hosny et al. 2022) who found that posterior fossa anomalies constituted (33.3%) of cases, all could be detected on prenatal MRI and missed in prenatal US (only referred by ventriculomegaly).

There is one case typed communicating non obstructing hydrocephalus and MRI couldn't visualize the cause.

There are 9 cases (40.9%) of ventriculomegaly were with dysgenetic causes due to corpus callosum agenesis or dysgenesis, on the other hand prenatal US detected the cause in only 7/22 cases .

Prenatal MRI fails to detect the cause in 4/22 cases, while prenatal US fails to detect the cause in 15/22 cases.

Consequently our study ensured that prenatal MRI has the superiority in detection the etiology and type of ventriculomegaly either obstructive, destructive or dysgenetic .

Our study showed 2 cases with severe ventriculomegaly (9.09%) and two cases with moderate ventriculomegaly(9.09%) and 18 cases with mild ventriculomegaly (81.8%).This result was different from that conducted on (Raafat, Hosny et al. 2022) that reported severe ventriculomegaly detected in (56.7%), while mild and moderate ventriculomegaly comprised (23.3%)and(6.7%) of the cases, respectively, In the study of sonographically isolated ventriculomegaly, (Gupta, Bryce et al. 1994) reported that the incidence of developmental delay was (37%) in children with isolated ventriculomegaly, compared with(84%)in whom additional abnormalities were identified at birth.

In our study prenatal US detected 14/22 cases of isolated ventriculomegaly while prenatal MRI was more superior than prenatal US which could depicted 10 cases out of 14 with associated CNS abnormalities .

According to ventriculomegaly associated with corpus callosal abnormalities, in our study 9/22 (40.9 %)cases of ventriculomegaly are associated with corpus callosal anomalies ,prenatal US diagnosed primitively 7 cases of them while MRI could detect the 9 cases confirmed by post natal MRI , thus MRI has added more value in terms of diagnosis, prognosis and treatment planning to sonographically isolated ventriculomegaly.

Conclusion

Ultrasound is the standard way of recording anomalies specially in the second and third trimesters. MRI using T2W SSFSE sequences in 3 planes, T1W and DWI in the axial plane, is a complementary modality to prenatal ultrasound in making an accurate diagnosis and assessment of CNS anomalies offering a significant percentage of change cases or complete exclusion of

previously established ultrasound suspicion. The incidence of additional detected CNS anomalies on magnetic resonance imaging, which were previously missed on ultrasound, indicates the benefit of performing the same in cases when ultrasound examination is unclear or incomplete and when these additional anomalies are far beyond the range and ability of ultrasound to diagnose them. Finally, prenatal MRI with the diagnosis of associated / additional CNS abnormalities may influence clinical decision-making the continuation or termination of pregnancy and, finally, the preparation of family and clinicians for in utero fetal intervention and postnatal care depending on the presence or absence of abnormal neurodevelopmental outcomes.

and we concluded from this current study as regard sonographic prenatally diagnosed ventriculomegaly, we shift to MRI study an Cases with ventriculomegally to detect etiology and associated anomalie

References

1. Araujo Júnior, E., M. L. Nakano, L. M. M. Nardozza, K. K. Haratz, P. S. Oliveira, W. P. Martins, S. A. Ajzen and A. F. Moron (2013). "Comparison between 2D ultrasonography and magnetic resonance imaging for assessing brain and spine parameters in fetuses with spina bifida." Archives of Gynecology and Obstetrics 287(5): 845-849
2. Bakare, V., K. Taori, A. Disawal, J. Rathod, S. DHAKATE and P. Wavare (2013). Role of MRI in suspected cases of congenital fetal anomalies on ultrasound, European Congress of Radiology-ECR 2013.
3. Cardoen, L., L. De Catte, P. Demaerel, R. Devlieger, L. Lewi, J. Deprest and F. Claus (2011). "The role of magnetic resonance imaging in the diagnostic work-up of fetal ventriculomegaly." Facts Views Vis Obgyn 3(3): 159-163.
4. Gupta, J. K., F. C. Bryce and R. J. Lilford (1994). "Management of apparently isolated fetal ventriculomegaly." Obstet Gynecol Surv 49(10): 716-721.
5. Khalil, A., K. Elshafey, R.-E.-D. Mohamed and H. Salem (2016). Role of magnetic resonance imaging in diagnosis of fetal central nervous system congenital anomalies, European Congress of Radiology-ECR 2016.
6. Masselli, G., M. R. Vaccaro Notte, A. Zacharzewska-Gondek, F. Laghi, L. Manganaro and R. Brunelli (2020). "Fetal MRI of CNS abnormalities." Clin Radiol 75(8): 640.e641-640.e611.
7. Mufti, N., A. Sacco, M. Aertsen, F. Ushakov, S. Ourselin, D. Thomson, J. Deprest, A. Melbourne and A. L. David (2022). "What brain abnormalities can magnetic resonance imaging detect in foetal and early neonatal spina bifida: a systematic review." Neuroradiology 64(2): 233-245.
8. Onkar, D., P. Onkar and K. Mitra (2014). "Evaluation of fetal central nervous system anomalies by ultrasound and its anatomical co-relation." Journal of clinical and diagnostic research: JCDR 8(6): AC05.
9. Raafat, M., S. M. Hosny, G. A. Sheta, S. H. Talaat and E. A. Ali (2022). "Role of fetal MRI to diagnose abnormal cerebral ventricular system and associated fetal brain anomalies." Egyptian Journal of Radiology and Nuclear Medicine 53(1): 85
10. Sefidbakht, S., S. Dehghani, M. Safari, H. Vafaei and M. Kasraeian (2016). "Fetal Central Nervous System Anomalies Detected by Magnetic Resonance Imaging: A Two-Year Experience." Iran J Pediatr 26(4): e4589.