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Added Value of Fetal Magnetic Resonance Imaging in Diagnosis of Central Nervous System Congenital Anomalies in Egyptian Population

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Abstract: CNS anomalies are the second most frequent type of congenital anomalies. It is important to diagnose them as early as possible due to poor outcome. The aim of the study is to assess the role of magnetic resonance imaging in evaluation of congenital anomalies of central nervous system. This study included 80 pregnant women with suspected congenital CNS anomalies. All patients had been examined by 2D ultrasound and MRI. The majority of anomalies in the current study were anencephaly, hydrocephalus with aqueductal stenosis and Chiari malformation . Twenty percentage of brain anomalies was associated with meningioceles. A significant difference was detected in both aqueductal stenosis and dandy walker as regards history of consanguinity. The results were compared with post natal clinical assessment and MRI. It is concluded that fetal MRI is becoming an increasingly important tool in diagnosis of brain abnormalities suspected on the basis of family history or fetal sonography (with equivocal data), with continuing improvements in technology for better improvement of postnatal outcome. BPD = Biparietal diameter, CNS = Central nervous system, EFW = Expected fetal body weight, FL = Femur length, FOV = Field of view, MRI = Magnetic resonance imaging, N= Number, SD = Standard deviation, Ssfp= Steady-state free percession, ST= Slice thickness, TE =time of echo, TR=time of repetition, T2WI=T2 weighted image, US=ultrasound.

Keywords: Fetal MRI, CNS Anomalies, Congenital, Ultrasound, Prenatal

1. Introduction

Congenital CNS anomalies are defined as abnormalities that result from defective embryogenesis and any insult that occur in the developmental process. They may be isolated abnormalities or part of a syndrome that are an important cause of neonatal morbidity and mortality [1].

Ultrasound (US) examination is an effective modality for the prenatal diagnosis of the CNS anomalies. Although US is commonly known as the screening modality of choice in the evaluation of fetus because of the cost-effectiveness and safety, the sonographic findings are occasionally inconclusive or equivocal for choosing the proper management [2].

MRI is a useful adjuvant tool to US in evaluating fetal brain malformations. Superior soft tissue contrast, larger field of view and the ability to depict sulcation and myelination are the strengths of MRI. Subtle or inconclusive US abnormalities can be confirmed or ruled out by MRI as in cases of oligohydraminos, maternal parietal wall edema or obesity and abnormal fetal position [3].

In some cases, additional findings are detected with MRI often help in arriving at a definitive diagnosis, which is necessary for parental counseling and for guiding management [4].

As regards the fetal MRI ethics and safety, The ACR states that it is a noninvasive diagnostic tool with no hazardous ionizing radiation and no known associated side effects or reported delayed hazardous fetal outcome especially if there is cost-benefit ratio to the patient [5].

Fetal MRI is best to be done after 15th weeks of gestation to overcome small fetal size and excessive fetal motion that hinders the proper assessment of fetal brain [6].

Single shot fast spin echo (in 1.5 Tesla unit MRI) is the backbone sequence of fetal MRI with high resolution and rapid acquisition time with no maternal or fetal sedation is required [7].

The main limitation of fetal MRI is motion artifact of excessive fetal motion, refusal to perform fetal MRI and disability to follow up of anomalies throughout time of pregnancy [8].

2. Patient and Methods

This cross sectional prospective study was performed on 80 pregnant patients (in second or third trimester), with clinically and/or ultrasound suspected brain and spinal fetal congenital anomalies, who were referred from fetology unit of Gynecology and Obstetrics Department to Radio diagnosis department, it was done from July 2015 to January 2018. The study was approved by the Research Ethical Committee.

2.1. Inclusion Criteria

1. Congenital anomalies of the central nervous system which were suspected or not adequately assessed by ultrasound (its results were equivocal).
2. Evaluation of complex fetal anomalies that inadequately assessed by ultrasound.
3. Fetuses with a family history of CNS anomalies and high risk pregnancies.
4. When ultrasound was limited as in maternal obesity, oligohydraminos, evaluation of posterior cranial fossa in third trimester, fetal position due to lack of adequate acoustic window.

2.2. Exclusion Criteria

1. Patients with absolute or relative contraindications to perform MRI as patients with cardiac pace makers and MRI non compatible intracranial clips of arterial brain aneurysms.
2. Patients who refused the examination.
3. Patients with gestational age less than 15^{th} week due to small sized fetus with excessive motion artifact of the MRI images.

2.3. All Patients Were Subjected to the Following

2.3.1. Proper History Taking

patient data and informed written consents were obtained from all patients after full explanation of benefits. Any expected risks appeared during the course of this study as claustrophobia, will be dealed by reassurance of the patient and informing her about the benefits of MRI examination, privacy of all patients' data were guaranteed and there was a code number for every patient's file.

2.3.2. D Ultrasound Examination

All patients were scanned by two-dimensional trans-abdominal probe using a TOSHIBA Aplio 500 ultrasound equipment with a convex abdominal transducer (3-5MHz.)

The examination protocol included

i. Basic examination of the head in three main axial planes with different measurements (BPD and cisterna magna diameter) in addition to detailed neuro-sonographic examination in axial, sagittal and coronal planes to demonstrate detailed anatomy of fetal brain.

ii. Measurement of AC &FL and calculation of EFBW.

iii. AFI calculation by four quadrant method.

2.3.3. Fetal MRI Study

i. Patient preparation

No maternal sedation was required, the mother was only kept fasting for 4-6 hours. Prior to the MRI examination to decrease the fetal motion.

The patient removed all metal objects like pins & earrings and emptied the bladder prior to examination (to prevent her irritability during examination).

ii. MRI protocol

The study was achieved by using TOSHIBA vantage titan 1.5 Tesla MRI unit, the mother lied supine or in left lateral position, throughout the course of the MR examination, in comfortable position to minimize fetal motion, feet were introduced first (to minimize patient irritability and claustrophobia), the examination time ranged from 15-45 minutes.

Axial, coronal and sagittal planes were taken relative to the fetal head.

Optimal slice thickness (ST) was 2-3mm, with 0 mm interval gap (because of small size of fetal brain).

Body coil was used to allow coverage of the fetal head and to increase signal to noise ratio over the more standard pelvic phased array coils, with small field of view as possible. In certain cases, the coil was in need to be repositioned in the middle of the examination (e.g. when switching from one twin to the other)

Fetal MRI was primarily performed using an initial localizer (3 axis localizer) obtained in 3 orthogonal planes. It took about 18 seconds (sec) to localize the region of interest (mother's pelvis) the localizer was used to visualize the position of the fetus and determine fetal sidedness, as well as to ensure that the coil is centered over the region of interest, while axial shimming took about 13 sec.

Field of view should be tailored to fetal size. Overlap of maternal onto maternal anatomy (wrap- around) is acceptable if fetal structures were well-visualized.

Ultrafast single-shot T2-weighted sequence serves as the backbone sequence of fetal MRI. It allows imaging the fetal anatomy in exquisite detail. In particular, the fetal brain can be well evaluated due to their high water content which displays a strong MR signal and cerebrospinal fluid that surrounds the fetal brain and spinal cord.

Fetal brain imaging parameters included TE =90 milliseconds, TR =4500 milliseconds, bandwidth =25 kHz, matrix =192X160, field of view =24 cm and number of excitations =0.5.

Sagittal T2WI images were taken for the patient's whole

abdomen prescribed from the localizer with no skip, it took about 1 min and 54 sec, followed by coronal Steady-state free precession (Ssfp) sequence which took about 32 sec and finally Axial T2 Fast Advanced Spin Echo (FASE) sequence with breath holding which took about 11 sec (TR = 10309 ms, TE=91ms) using 6 mm thick slices with a 1mm gap and a large field of view (17 cm). For every sequence 20 slices were taken. Multiple sequences were taken predominantly T2 FASE sequence in 3 orthogonal planes (axial, sagittal & coronal).

The reference standard is postnatal clinical evaluation and MRI for all patients.

2.4. Statistical Analysis

Data were analyzed using SPSS software package version 18.0 (SPSS, Chicago, IL, USA). Quantitative data was expressed using Range, mean and standard deviation, while Qualitative data was expressed in frequency and percent. Qualitative data was analyzed using Chi-square test also exact tests such Fisher exact and Monte Carlo was applied to compare different groups. p value was assumed to be significant at ≤.05.

3. Results

In the present study 80 pregnant patients were included, the maternal age ranged from 18 to 45 years with the mean of age were 33.18 ± 7.37 years, 50% of cases ranged between 35-45 years, 20% of cases ranged between18- 25 years. On the other hand, the maternal age ranged from 25-35 years was observed in 30% of cases.

In the current study, there were 58 cases came just for antenatal follow up without any complaint, 20 cases complained from decrease of fetal movements and two cases complained from passage of amniotic fluid.

Concerning to the maternal obstetric history, most of pregnant females, 60 cases were multigravida (75%)**,** while only 20 cases (25%) were primigravida.

According to the risk factors for congenital anomalies, (25%) of cases took drugs during their first and second trimesters, followed by cases suffering from diabetes mellitus (22.5%) and cases exposed to radiation (20%). The hypertensive cases and those exposed to fever and infections represented by (10 %) and (15%) respectively in this study, as well as (7.5%)of cases was not exposed to any risk factors., while there were 4 cases only had more than one risk factor as hypertension and drug intake.

Regarding to consanguinity, 50 cases (62.5%) had a positive history of consanguinity, while only 30 cases (37.5%) had negative history.

Out of the 80 pregnant females, there were 52 (65%) cases with positive family history of congenital anomalies in the offsprings and 28 (35%) with negative family and past history of congenital anomalies in the offspring.

According to amount of amniotic fluid index (AFI) in this study, 40 cases (50%) showed increased aminiotic fluid with AFI more than 25 cm, while 24 cases (30%) showed decreased aminiotic fluid with AFI less than 4 cm. Normal aminiotic fluid index found only in 16 cases (20%) .

Regarding the distribution of the studied cases according to fetal gender, the current study showed that 58 fetuses (72.5%) were males and 22 fetuses (27.5%) were females. The range of gestational age of the studied feti was 15.50 – 37.0 weeks, the mean = 26.66 ± 6.25 (SD).

In this study forty four of the studied pregnant cases (represented by 55%) were in the second trimester, while thirty six of studied cases (45%) were in the third trimester**.**

In the current study, the biparietal diameter couldn't be assessed due to abnormal cranial bone (anencephaly) in 24 cases (30%), while in the remaining 56 cases (70%) the gestational age according to biparietal diameter (BPD) measurements ranged from 17 to 41 weeks with the mean value was 29.56 ± 5.72 weeks. On the other hand, the gestational age according to femur length (FL) ranged from 16 to 39 weeks with the mean value was 27.58 ± 6.37 weeks. Moreover, the fetal body weight (EFW) ranged from 452 to 4100 grams with mean value of 2104.15 ± 979.56 grams.

Encephalocele, holoprosencephaly, chiari malformation, hydro-cephalus with aqueductal stenosis, anencephaly, dandywalker malformation, corpus callosum agensis and obstructive hydrocephalus distal to 4th ventricle were observed in this study as different types of congenital anomalies of the fetuses. The majority of these anomalies were anencephaly, hydrocephalus with aqueductal stenosis, Dandy walker malformations, chiari malformation and holoprosencephaly (30%, 20%, 15%, 10% and 10% respectively). The lowest number of cases (four cases) suffered from encephalocele, corpus callosum agensis and Obstructive hydrocephalus distal to 4th ventricle**.**

Twenty percentage of brain anomalies cases was associated with meningioceles and the remaining percentage of brain anomalies (80%) was not associated with meningioceles.

The fate of pregnancy in the current study was, 36 cases (45%) underwent termination of pregnancy, while 44 cases (55%) continued their pregnancy to 37th weeks of gestational age.

There was a statistically highly significant difference ($p< 0.001$) between diagnostic values of 2D ultrasound compared to MRI in detection of brain abnormalities.

The present study revealed significant differences (p: 0.007) between past medical history of systemic diseases, and amount of amniotic fluid. Out of 32 cases with no past medical history of systemic diseases, 24 cases (75%) showed normal amniotic fluid, 8 cases (25%) showed decreased amniotic fluid. Out of 32 diabetic cases; 24 cases (75%) showed increased amniotic fluid and 8 cases (25 %) showed normal amniotic fluid. Out of 16 hypertensive cases, 8 cases (50%) showed decreased amniotic fluid, 4 cases (25 %) showed normal amniotic fluid and 4 cases (25 %) showed increased amniotic fluid.

Positive history of consanguinity was found in 50 cases; 4 anomalies (8%) were encephalocele, 4 anomalies (8%) were holoprosencephaly, 8 anomalies (16%) were Chiari

malformation, 16 anomalies (32%) were aqueductal stenosis, 12 anomalies (24%) were anencephaly, 4 cases (8%) were corpus callosum agenesis and 2 cases (4%) were obstructive hydrocephalus distal to 4th ventricle. Out of 30 cases with negative history of consanguinity, 4 anomalies (13.3%) were holoprosencephaly, 12 anomalies (40%) were anencephaly, 12 anomalies (40%) were Dandy walker and two cases (6.7%) were obstructive hydrocephalus distal to 4th ventricle.

Statistically significant differences were found between positive and negative history of consanguinity in both aqueductal stenosis and dandy walker (p: 0.016 &0.001 respectively). A significant difference was detected between brain anomalies and past history of consanguinity.

There were significant differences between continuation of pregnancy and termination of pregnancy as a fate in cases of all brain anomalies of this study. A significant difference (p: 0.005) was found between continuation of pregnancy and termination of pregnancy in fetus suffering from anencephaly. In this study 36 cases who underwent termination, two cases (5.5%) were encephalocele, two cases (5.5%) were holoprosencephaly, twenty four anomalies (42.86%) were anencephaly, two cases (5.5%) were aqueductal stenosis, two cases (5.5%) were Chiari malformation, four anomalies (11.11%) were Dandy walker.

Out of 44 cases who continued pregnancy & underwent delivery, two cases (4.5%) were encephalocele, six anomalies (13.6%) were holoprosencephaly, fourteen anomalies (31.8%) were aquductal stenosis, six anomalies (13.6%) were Chiari malformation, eight anomalies (18.18%) were Dandy walker, four anomalies (9.09%) were obstructive hydrocephalus distal to 4th ventricle and four anomalies (9.09%) were corpus callosum agenesis**.**

Prenatal ultrasound has 82.2% sensitivity, however fetal MRI sensitivity 93.6% (as 6.4% of cases improperly assessed due to motion artifact of the fetus).

Positive predictive values of fetal MRI and ultrasound 97.2% & 85.4% respectively.

Table 1. *Distribution of the studied cases according to maternal age, risk factors, consanguinity and family history: (N=80).*

Maternal age	**N**	**%**	**Mean ± SD.**
18 - < 25	16	20%	21.44 ± 2.35
25 - < 35	24	30%	31.07 ± 2.85
18 - < 45	40	50%	39.10 ± 2.58
Total	80	100%	33.18 ± 7.37
Risk factors			
-Drugs	20	25%	
-DM	18	22.5%	
-Radiation exposure	16	20%	
-Exposure to fever and infections	12	15%	
-Hypertension	8	10%	
-No exposure to any risk factor	6	7.5%	
(3)Consanguinity			
-Yes	50	62.5%	
-No	30	37.5%%	
(4)Family history			
-Yes	52	65%	
-No	28	35%	

Table 2. *Distribution of the studied cases according to fetal data (N=80).*

Fetal gestational age(weeks)	**N**	**%**
15 -< 17 weeks	10	12.5
17 - < 21 weeks	14	17.5
21 - < 27weeks	20	25
27 - < 30 weeks	16	20
30 - < 34 weeks	8	10
34 - < 37 weeks	12	15
Min. – Max	15.50 – 37.0	
Mean ± SD	26.66 ± 6.25	
(2) Trimester		
2nd trimester	44	55
3rd trimester	36	45
(3) Gender		
-Male	58	72.5
-Female	22	27.5
(4) Fetal body measurements		
-Bpd (Week)		
*Couldn't be measured	24	30%
*Measured	56	70%
Min. – Max	17 – 41	
Mean ± SD	29.56 ± 5.72	
-FL (Week)		
Min. – Max	16.0 – 39.0	
Mean ± SD	27.58 ± 6.37	

Fetal gestational age(weeks)	N	%
-EFBW (gram)		
Min. – Max	420.0 – 4100.0	
Mean ± SD	2104.15 ± 979.56	

Table 3. *Distribution of the studied cases according to type of congenital anomalies (N= 80).*

Types of congenital anomalies	N	%
Encephalocele	4	5%
Holoprosencephaly	8	10%
Chiari malformation	8	10%
Hydrocephalus with aqueductal stenosis	16	20%
Anencephaly	24	30%
Dandywalker malformation	12	15%
Corpus callosum agensis	4	5%
Obstructive hydrocephalus distal to 4th ventricle	4	5%
Total	80	100%

Table 4. *Comparison of 2D US and MRI accuracy for detection of brain abnormalities.*

2D US (n= 80)	MRI (n= 80)	χ^2	^{MC}p
82.2%	93.6 %	21.926*	<0.001*

χ^2, p: χ^2 and p values for Chi square test.
^{MC}p: p value for Monte Carlo for Chi square test.
*: Statistically significant at $p \leq 0.05$.

Table 5. *Association between maternal diseases and amount of Amniotic fluid (N=80).*

AF	Maternal diseases						χ^2	MCp
	Not present (n=32)		DM (n= 32)		HTN (n= 16)			
	N	%	N	%	N	%		
Decreased	8	25	0	0	8	50		
Normal	24	75	8	25	4	25	11.828*	0.007*
Increased	0	0	24	75	4	25		

χ^2, p: χ^2 and p values for Chi square test.
^{MC}p: p value for Monte Carlo for Chi square test
*: Statistically significant at $p \leq 0.05$.

Table 6. *Association between consanguinity and brain anomalies (N=80).*

Brain anomalies	Consanguinity				χ^2	^{FE}p
	N (n= 30)		Yes (n= 50)			
	No	%	No	%		
Encephalocele	0	0	4	8	1.263	0.519
Holoprosencephaly	4	13.3	4	8	0.296	0.622
Chiari malformation	0	0	8	16	2.667	0.278
Aqueductal stenosis	0	0	16	32	6.000	0.016*
Anencephaly	12	40	12	24	1.143	0.311
Dandy walker	12	40	0	0	11.765	0.001*
Corpus callosum agenesis	0	0	4	8	1.263	0.519
Obstructive hydrocephalus distal to 4th ventricle	2	6.7	2	4	0.140	1.000
χ^2(^{MC}p)	19.980 (<0.001*)					

χ^2, p: χ^2 and p values for Chi square test.
^{MC}p: p value for Monte Carlo for Chi square test.
*: Statistically significant at $p \leq 0.05$.

Table 7. *Association between fate of pregnancy and brain anomalies (N=80).*

Brain anomalies	Fate				χ^2	^{FE}p
	Continuation (n= 44)		Termination (n= 36)			
	n	%	N	%		
Encephalocele	2	4.5	2	5.5	0.401	0.515
Holoprosencephaly	6	13.6	2	5.5	0.053	1.000
Chiari malformation	6	13.6	2	5.5	0.053	1.000
Aqueductal stenosis	14	31.8	2	5.5	1.458	0.396
Anencephaly	0	0.0	24	42.86	10.370*	0.005*

Brain anomalies	Fate				χ^2	^{FE}p
	Continuation (n= 44)		Termination (n= 36)			
	n	%	N	%		
Dandy walker	8	18.18	4	11.11	0.037	1.000
Corpus callosum agenesis	4	9.09	0	0.0	0.902	1.000
Obstructive hydrocephalus distal to 4th ventricle	4	9.09	0	0.0	0.902	1.000
$\chi^2(^{MC}p)$	16.724*(0.003*)					

χ^2, p: χ^2 and p values for Chi square test.
^{MC}p: p value for Monte Carlo for Chi square test.
^{FE}p: p value for Fisher Exact for Chi square test.
*: Statistically significant at $p \leq 0.05$.

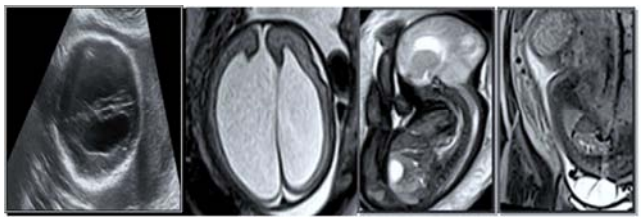

Figure 1. *39 years old lady, G4P2L2 presented at 35 weeks of gestation, for follow up with no previous checkups, no history of any congenital anomalies, positive history of consanguinity, hypertensive, with history of drug intake in first trimester.*

2D US images show dilatation of both lateral ventricles with remaining cerebral mantle about 20mm in thickness

MRI findings:

Axial images show dilatation of both lateral ventricles (occipital horns) .Sagittal images show additional information which is downwards descent of cerebellar tonsil through foramen magnum (changing the diagnosis to Chiari II malformation), associated with myelomemningocele

Diagnosis: Chiari II malformation.

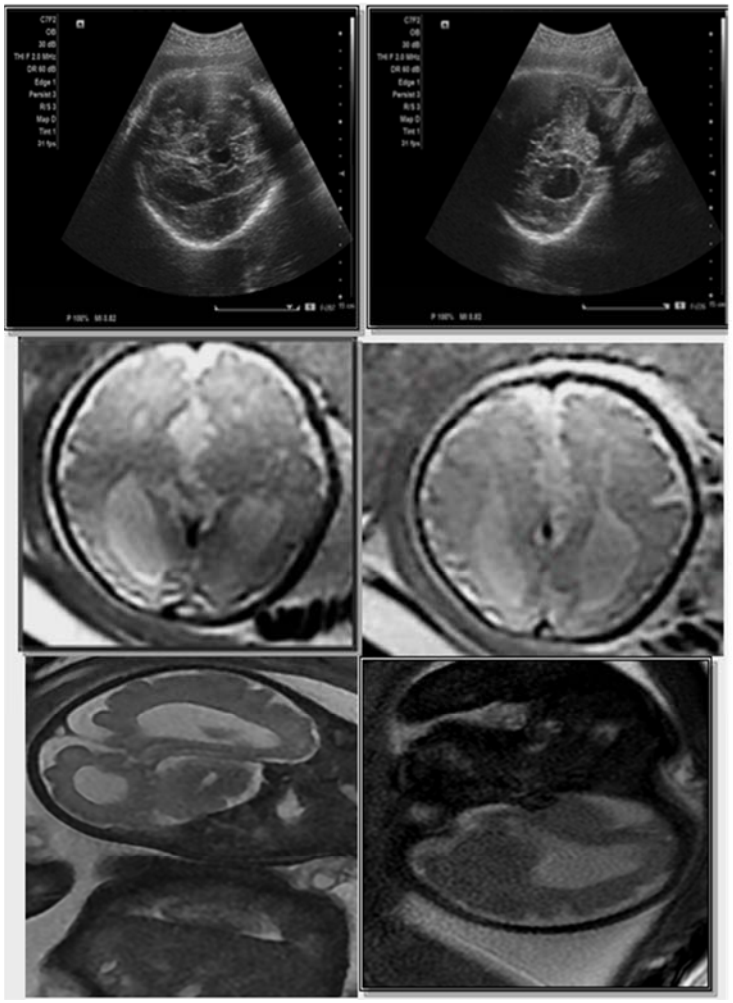

Figure 2. *34 years old lady, G5P4L3, presented at 33 weeks of gestation, for checkup, no history of any congenital anomalies, positive history of consanguinity, diabetic on insulin therapy.*

2D US images show dilatation of occipital horns of both lateral ventricles with parallel orientation to each other, associated with small cystic lesion in midline not connected to ventricular system.

MRI findings:

Axial and coronal images show dilatation of occipital horns of both lateral ventricles with parallel orientation to each other (colpocephaly), associated with small midline arachnoid cyst.

Sagittal images show additional information which is agenesis of corpus callosum.

Diagnosis: Agenesis of corpus callosum, colpocephaly and midline small arachnoid cyst.

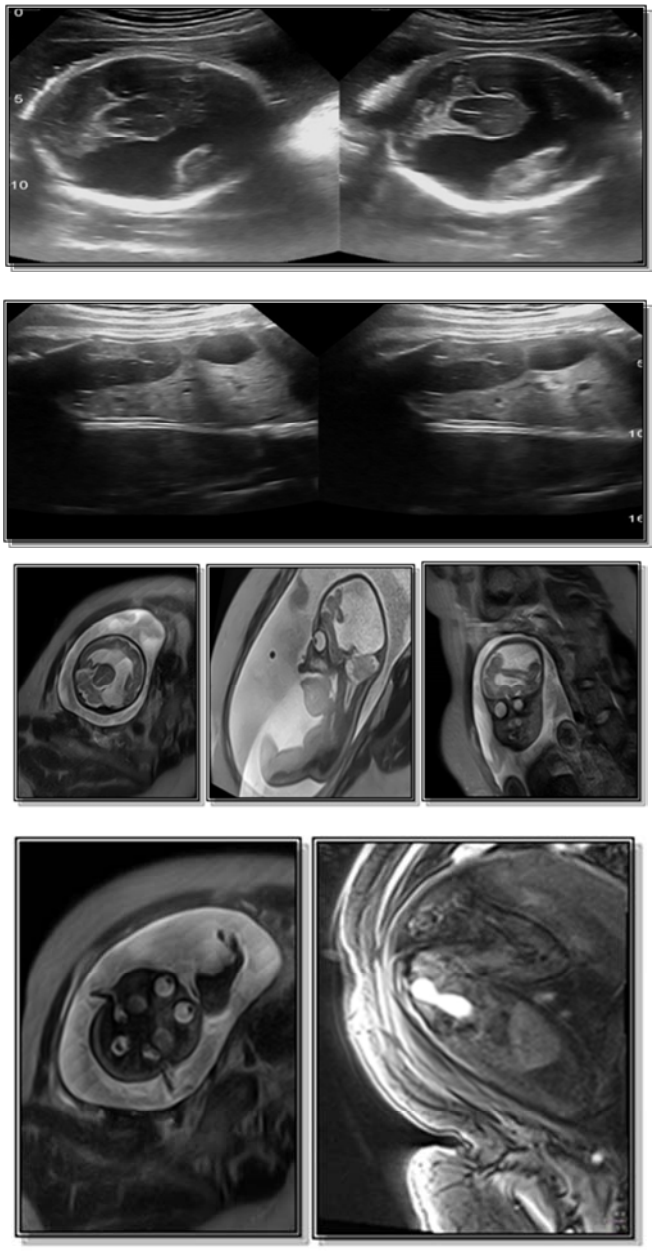

Figure 3. *31 years old lady, G4P3L2, presented at 25 weeks of gestation, complaining for passage of fluid per vagina, positive history of congenital anomalies, positive history of consanguinity, with history of fever in first trimester.*

2D US of the brain shows of the brain demonstrated single monoventricle, absent falx and fused thalami.

Ultrasound of the abdomen demonstrated dilated bowel loop.

MRI findings:

Axial and sagittal views of fetal brain shows a large single monoventricle containing CSF like signal intensity, absent midline structures (including falx cerebri, corpus callosum third ventricle) and fused thalami, coronal and axial views of fetal face shows hypotelorism .Sagittal view of the fetal body showing dilated large bowel loops denoting anal atresia.

Diagnosis: Alobar holoprosenceohaly with hypotolerism & anal atresia.

4. Discussion

The occurrence of congenital anomalies is directly proportional to the maternal age. In this study, The maternal age ranged from 18 to 45 years with Mean of 33.18 ± 7.37 years and median of 35.75 years with the age of about 50 % of cases were above 35 years, this was parallel to the results obtained by AL-Najjar, 2016 [9] where the mean age was 36.8± 5.1 years.

On contrary, Van Gelder et al., 2015 [10] found that teenager pregnancies were significantly associated with increased risk of central nervous system anomalies.

In this study, 60 cases out of 80 were multigravida (75%) which were matched with the results of Nasri et al., 2014 [11] who found that 65% of cases, were multi gravida. On the other hand, Liu et al., 2015 [12] found that the incidence of neural tube defects was increased in offsprings of primigravida.

In the current study, 44 fetuses (55%) were males. This is in agreement with the study carried out by El Hamid et al., 2015 [13] who stated that the congenital anomalies had affected a significant proportion of male fetuses more than female. On the other hand the study done by Eman and Abd-Manaf, 2013 [14] found no significant difference in the frequency of congenital anomalies among male and female babies. Nasri et al., 2014 and Laharwal et al., 2016 [11,15] stated that incidence of neural tube defects increased in females more than males.

The present study showed that 44 cases were performed in the second trimester that agreed with Gedikbaşı et al., 2010 [16] with the mean gestational age (26.66 ± 6.25) weeks ranged between (15 – 37) weeks.

As regards to family history, 52 cases (65%) had a positive family history of congenital anomalies. However, Feriha et al., 2008 [17] found that only 6% of cases showed a positive history of birth defects in some members of the family.

Consanguinity is an important risk factor for the occurrence of congenital anomalies, in the current study 50 cases out of 80 cases (62.5%) had a history of consanguinity that was statistically significant of p value (<0.001*), and distributed as follows (eight cases had Chiari malformation, 16 cases of aqueductal stensosis, 6 cases anencephaly, 4

cases encephalocele, 4 cases corpus callosum agenesis, 4 cases were holoprosencephaly, 2 cases of hydrocphalus distal to fourth ventricle). This finding is in agreement with the study by El Hamid et al., 2015 and Nasri et al., 2014 [13,11] on the presence of congenital anomalies in children of consanguineous marriages where a significant association was found between first degree consanguinity and CNS anomalies especially neural tube defects.

On contrary Sarkar et al., 2013 [18] found that (40%) of consanguineous couples showed some congenital anomalies in their babies which was highly significant, whereas in non consanguineous couples, the prevalence was only 2.2%.

Out of the 16 hypertensive cases, 8 cases had decreased amniotic fluid (with AFI less than 4), 4 cases had adequate amniotic fluid and 4 cases had increased amniotic fluid which is statistically significant for presence of hypertension and abnormal amount of amniotic fluid (p value=0.005), this agreed with Dashe, et al., 2006 [19].

Diabetes mellitus is also an important risk factor for congenital anomalies occurrence that is in agreement with Aberg et al., 2001 [20] stated that specific abnormalities associated with diabetic pregnancies are central nervous system (such as anencephaly, encephalocele, meningomyelocele and holoprosencephaly).

There is a strong association between maternal diabetes and polyhydramnios. As a result of maternal hyperglycemia which, in turn, produces fetal hyperglycemia and osmotic diuresis. Liu et al., 2015 [12] stated that rates of central nervous system anomalies were 3 times higher among women with pre-pregnancy DM compared with those without pre-pregnancy DM.

Exposure to radiation is a major risk factor, in the present study 16 cases (20%) were exposed to radiation in their first trimester, this matches with Eman and Abd-Manaf, 2013 [14] who stated that ionizing radiation is significantly association with congenital anomalies occurrence.

Moreover, taking medications in the first trimester (especially folic acid antagonists) is directly proportional to congenital CNS anomalies (especially neural tube defects), in the present study 20 cases (25%) of 80 cases exposed to this risk factor, this was consistent with study by Eman and Abd-Manaf, 2013 [14].

In the current study, out of 80 anomalies about 24 anomalies (30%) were anencephaly, that in agreement with the study by Behairy and Talaat, 2012 who found that anencephaly accounted for the commonest anomaly in that study [21].

The current study showed that about 36 of 80 cases (45%) underwent termination (therapeutic abortion), 24 cases were Anencephaly, which is in agreement with Gedikbaşı et al., 2010 [16] who found that the main reason for termination of pregnancy is CNS abnormalities, the CNS anomalies were responsible for more than one-half of the cases who terminated pregnancy. Neural tube defects, especially anencephaly, constituted a substantial cause in the termination group.

Anencephaly was the commonest anomaly type in the present study that accounted for 24 cases (30%) that in agreement with the results of Feriha et al., 2008 [17] who stated that 38.6% of cases were anencephaly then hydrocephalus accounting for 26.8% of cases.

According to the present study, association of spinal meningioceles were in 16 out of 80 cases (20%), that consistent with Bosemani, et al., 2015 [22] that reported about of 30% of cases were associated with meningioceles.

In the present study, the fetal ages ranged from 15.5 to 37 weeks of gestations, with Mean± SD.= 26.66 ± 6.25 and the Mean ± SD. Of expected fetal body weight (EFBW) was 2104.15 ± 979.56 grams it was mismatched with Feriha et al., 2008 [17] whose results were Mean of gestational age was 39 weeks. Moreover, the Mean of EFBW was 2982.28 grams.

In the present study the ultrasound examination represented a sensitive screening method for detection of CNS anomalies but MRI was better in assessment of anomalies, there were 60 cases (75%) showed agreement of both ultrasound and MRI results, in 18 cases (22.5) MRI added more information to ultrasound findings (due to maternal obesity, abdominal wall edema of severe hypertension and pre-eclapmsia and low lying of fetal head in mother pelvis that hinder the proper assessment of fetal head), as in case of holoprosencephaly MRI detected associated anal atresia and hypotolerism that couldn't be detected in ultrasound study due to low lying of fetal head .Moreover, in two cases (2.5%) the MRI change the diagnosis that was diagnosed by ultrasound as hydrocephalus only, but by MRI there was small cerebellar herniation through foramen magnum and was diagnosed by MRI as Chiari malformation. That in agreement with Hosny et al., 2010 [23] examined 25 pregnant women where MRI findings altered the diagnosis of 2 of 25 cases, MRI added additional findings in 5 cases and in the remaining 18 cases MRI confirmed the US diagnosis.

Limitations of this study were:

Excessive fetal motion that presented in some cases due to polyhdraminos, small sized fetus and maternal motion.

Refusal of many cases to perform MRI examination due to long time and claustrophobia.

Unawareness of clinicians and patients of the MRI importance for diagnosis of anomalies.

Limited number of cases.

Relatively high cost examination compared to ultrasonography.

Difficulty to perform multiple pre-natal and post-natal MRI follow ups.

5. Conclusion

From this study, it can be concluded that fetal MRI from 15th weeks of gestation is becoming an increasingly important tool in evaluating fetuses who have suspected brain anomalies with high sensitivity and positive predictive value measuring 93.6% and 97.2% respectively compared to prenatal ultrasound that has 82.2% sensitivity and positive predictive value 85.4%, with continuing improvements in

technology, this will continue to be a rapidly growing field in future years for better improvement of postnatal outcome, from the current study it is recommended to continue in advancing sequences of fetal MRI as diffusion weighted imaging, MR spectroscopy, diffusion tensor imaging and tractography for proper assessment of fetal brain hypoxia and fiber tracts with more reliable early antenatal diagnosis and management.

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