Magnetic Resonance Imaging in the Diagnosis of Fetal Pathology

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ABSTRACT

Introduction: Fetal Magnetic Resonance Imaging (MRI) is an imaging method for displaying anatomical structures of the fetus without ionizing radiation and it has been in use since the MRI has been used for the analysis of the adult human body. **Aim:** The aim of our paper is the two-year retrospective analysis of fetal MRI examinations for the purpose of presenting various pathological conditions of the fetuses.

Methods: A total of 59 fetal MRI examinations were performed on pregnant women in the time period 2016 to 2018 at the Radiology Clinic at Sarajevo University Clinical Center, on Siemens and Toshiba 1.5 Tesla scanners. All cases were referred by gynecologists who suspected a fetal pathology. The comparison of the fetal age at which the congenital anomalies are usually detected is performed using the univariate analysis of variance and the Student t test, at the 95% level of confidence. **Results:** Of the total of 59 fetal MRI examinations, 2 fetuses (3,4%) were healthy, while pathology of the head and CNS was found in 26 fetuses (44,2%), thoracic cavity pathology in 5 fetuses (8,5%), abdominal cavity pathology in 18 fetuses (30,6%), pathology of extremities in 2 fetuses (3,4%), spinal cord pathology in one fetus (1,7%), and in 3 fetuses associated anomalies were found (5,1%). The pathology of the uterus and placenta was found in two pregnant women (3,4%). **Conclusion:** Prenatal MRI provides extremely useful information in cases where the ultrasound examination of the fetus is insufficient due to the size and position of the fetus. MRI is a key tool in deciding whether to continue or stop the further development of the fetus.

Keywords: MRI, fetus, pathology.

1. INTRODUCTION

Fetal Magnetic Resonance Imaging (MRI), or prenatal MRI, is a non-invasive imaging method for displaying anatomical structures of the fetus that do not use ionizing radiation. It is used for the purpose of confirming the ultrasound findings of the fetal pathology or as a supplementary method in more complex cases. Magnetic resonance has been in use for the analysis of anatomical structures of the fetus ever since it has been used for the analysis of the adult human body. The first published scientific work on the magnetic resonance of the fetus was published in the US back in 1985, however in today's Europe the number of published scientific papers is double in comparison to the US, and this number is over 200 papers a year. Fetal MRI is not recommended in the first trimester of pregnancy, unless the fetus

is vitally endangered, although the harmful effect is not proven (1). The key task of the fetal MRI examination is, in fact, the early detection of congenital anomalies incompatible with life, which require the termination of pregnancy, or the discovery of life-compatible anomalies in developed countries due to fetal surgery whenever possible. Today, fetal MRI is the method used in everyday practice for the purposes of clinical testing and scientific work.

2. AIM

The aim of our paper is the two-year retrospective analysis of fetal MRI examinations for the purpose of presenting various pathological conditions of the fetuses.

3. MATERIAL AND METHODS

In a retrospective study at Sarajevo University Clinical Center, in the

time period 2016 to 2018, at the Radiology Clinic, a total of 59 fetal MRI examinations were performed on pregnant women. The examinations were performed in non-contrast enhanced T2W sequences in axial, coronal and sagittal planes, as well as in T1W, T1 fat-saturated and DWI sequences. The MRI examinations were performed on Siemens and Toshiba 1.5 Tesla scanners. All cases were referred by gynecologists who suspected a fetal pathology, within 48 hours after gynecological examination. Indications for this modality include abnormal fetal ultrasound findings, infections during pregnancy, family history of genetic diseases, high-risk pregnancy and the presence of fetal anomalies, especially CNS anomalies. The comparison of the fetal age at which the congenital anomalies are usually detected is performed using the univariate analysis of variance and the Student t test, at the 95% level of confidence. Analysis was performed using the statistical software for biomedical research MedCalc v12.3.

Chart 1. The percentage of pathology found on prenatal MRI.

Chart 2. Frequency of detected pathology by prenatal MRI in gestation weeks.

Chart 3. Pathology discovered by prenatal MRI by region of the body and gestation weeks.

4. RESULTS

Of the total number of fetal MRI examinations in pregnant women with suspected fetal pathology, in almost three years, at the University Clinical Center Sarajevo, findings in 2 fetuses (3.4%) were found to be normal, while 57 pregnant women (96.6%) had pathological findings. Both fetuses with normal MRI findings were sent by a gynecologist with a suspicion of the existence of a megacysterna magna.

Among the pathological findings, the youngest fetus was in the 13th week of gestation with congenital ascites, and the oldest fetus was in the 38th week of gestation, in which bilateral ureterohydronephrosis was detected as a consequence of the posterior urethral valve. The placenta and uterus pathology were found in 2 pregnant women (3.4%). 0-1.8% of fetal pathology was detected in the first trimester of pregnancy, 32.4% in the second trimester of pregnancy, and 65.8% in the third trimester of pregnancy.

Pathology of the head and CNS is the most common fetal pathology and was found in 26 fetuses (44.2%). The youngest fetus in which the described pathology was found was in the 20th week of gestation, and the oldest in the 35th week of gestation. The average fetal age for the pathology of the head and CNS is 29.6 ± 9.3 gestation week. The most frequent pathology of the head and CNS in the fetus, and at the same time the most common fetal pathology, is colpocephaly (Figure 1), which occurs in a percentage of 30.7% of all pathologies of the head and CNS, and in the percentage of 13.6% of all pathologies of the fetus. Other head and CNS pathologies found included Bud Chiari malformation, Dandy-Walker syndrome, hydrocephalus internus, corpus callosumagenesis, ventriculomegaly, megacisterna magna, arachnoid cyst, congenital Varicella syndrome, hypoplasia of vermis and pharyngeal teratoma (Figure 2). Furthermore, in our study among pregnant women, there were 3 twin pregnancies. In all 3 twin pregnancies, the head and CNS pathology was found to be present at one of the fetuses, in 2 cases a megacisterna magna was found, whereas in one case it was arachnoid cyst (Figure 3).

The pathology of the thoracic cavity of the fetus was found in 5 fetuses (8.5%). The youngest fetus with found pathology of the thoracic cavity was in the 23rd week of gestation, and the oldest in the 36th week of gestation. The average fetal age for detecting the pathology of the thoracic cavity is 26.4 ± 6.8 gestation week. The most common pathology was CCAM (congenital cystic adenomatoid malformation), followed by herniation of abdominal organs in the thoracic cavity and prominent left thymus lobe.

Pathology of the abdominal cavity of the fetus was found in 18 fetuses (30.6%). The youngest fetus with found abdominal cavity pathology was in the 13th week of gestation, and the oldest in the 38th week of gestation. The average age for detecting the pathology of the abdominal cavity of the fetus is 27.3 ± 15.2 gestation week. The most frequent pathology of the abdominal cavity of the fetus was unilateral and bilateral ureterohydronephrosis, followed by polycystic kidney, congenital ascites, kidney agenesis, gastroschisis, jejunal atresia, ovarian cyst and

Figure 1. Colpocephaly—axial scan, 26th week of gestation.

Figure 2. Pharyngeal teratoma—sagittal scan, 19th week of gestation.

Figure 3. Arachnoid cyst of a fetus—axial scan, 18th week of gestation.

Figure 4. Unilateral CCAM—coronal scan, 22nd week of gestation.

Figure 5. Rear urethral valve (bladder display)—axial scan, 38th week of gestation.

Figure 6. Jejunal atresia—coronal scan, 36th week of gestation.

Figure 7. Dandy-Walker syndrome—axial scan, 20th week of gestation.

Figure 8. Extralobar subdiaphragmatic pulmonary sequestration—coronal scan, 24th week of gestation.

immature gastric teratoma (Figures 4, 5, 6).

Fetal extremities pathology was found in 2 fetuses (3.4%). The pathology of the extremities in one fetus was diagnosed in the 36th week of gestation and it was about the atypical position and asymmetry of the lower extremities, and in the second fetus at the 37th week of gestation, the tumor mass of the lower limb was found. The average fetal age for the detection of pathology of the extremities was 36.5 ± 0.5 gestation week. Pathology of the spinal cord was found in one fetus (1.7%) and it was a spina bifida aperta. The described pathology of the fetus was detected at the 19th week of gestation. The associated anomalies were found in 3 fetuses (5.1%). One case was detected at the 20th week of gestation and was a Dandy-Walker syn-

drome and a bilateral equinovarus (Figure 7). The second case was detected at the 24th week of gestation and was an extralobar subdiaphragmatic pulmonary sequestration and unilateral ureterohydronephrosis (Figure 8). The third case was discovered at the 25th week of gestation where the dextroposition of the heart and the diaphragmatic hernia were diagnosed. The average fetal age for the detection of associated anomalies is 23.0 ± 4.2 week of gestation.

Statistical analysis of the mean gestational age in which certain anomalies occurs indicate that there is a significant difference ($F=5.685$; $p=0.0385$) and for which the post hoc analysis revealed that is reflected in younger gestation age for the occurrence of anomalies of the thoracic

cavity and associated anomalies. There was no significant difference in gestational age of detection between the anomalies of the CNS, abdominal cavity. Pathology of the extremities was significantly detected more in the older gestational age compared to the others (Charts 1-3).

5. DISCUSSION

Colpocephaly is the most frequent pathology of the head and CNS in the fetus. It was first described in 1941 by American psychiatrist Clemens E. Benda and represents a dilatation of the lateral or occipital horns of the lateral brain ventricles, and may be the cause of the congenital stroke (1, 2). On fetal MRI it is diagnosed as the diameter of the rear horns of lateral brain chambers exceeds 10 mm on axial scans (3). The most common pathology of the thoracic cavity in the fetus is CCAM (congenital cystic adenomatoid malformation). According to literature, CCAM is a rare congenital anomaly that occurs in 25% of all congenital lung anomalies, and among all cystic lung abnormalities, 95% comprise of it. It is usually unilateral and involves one lung lobe (4). The MRI diagnosis of CCAM is based on the multiple, round zone of hypersignal in T2W within the pulmonary parenchyma of the fetus (Figure 4).

Ureterohydronephrosis is the most frequent pathology of the abdominal cavity of the fetus. The most common cause of bilateral ureterohydronephrosis in male fetuses is the presence of the posterior urethral valve, and in the case of female fetuses, bilateral stenosis is in the area of uretero-vesical junction obstruction (5). For the MRI diagnosis of the posterior urethral valve, an important parameter is the thick and trabecular wall of the bladder, indicating that it suffers from distal stenosis (Figure 5). It is very important to note that for the diagnosis of jejunal atresia, control fetal MRI should be done before the end of pregnancy due to maturation of the gastrointestinal tract; otherwise the finding may imitate a cystic lesion of dense content (Figure 6). Ovary cysts are most commonly cystic lesions of the abdominal cavity of female fetuses and are detected in the third trimester of pregnancy due to elevated values of beta HCG, fetal gonadotrophins and maternal estrogen. They are often associated with congenital hypoparathyroidism and adrenal hyperplasia (6).

According to literature data, the prevalence of pathology of the extremities is 6:10,000 live births, and the upper extremities are affected more often than the lower extremities, which does not coincide with our cases. The pathological process of the extremity is more often unilateral than bilateral and usually involves the right side (7). Spina bifida often occurs and is associated with other anomalies of the musculoskeletal system, in 4.4% of cases it is associated with equinovarus (8). The Dandy-Walker complex is a spectrum of malformations of the rear cranial cavity, which consists of hypoplasia of the vermis, and the communication of the cystically dilated IV cerebral ventricle and subarachnoidal liquor space of the rear cranial fossa. It is most often associated with the agenesis of the corpus callosum. It is important to note that agenesis / hypoplasia of the vermis can also occur within the Joubert syndrome, characterized by a "molar tooth" sign visible on axial MRI scans of the brain (9). With ex-

tralobar subdiafragmatic pulmonary sequestration differential diagnostics should take into account neuroblastoma and adrenal haemorrhage. Extralobar subdiafragmatic pulmonary sequestration is usually detected in the second trimester of pregnancy and is located parasagittal left, with neuroblastoma usually detected in the third trimester of pregnancy, located parasagittal to the right, whereas adrenal haemorrhage is usually detected in the second trimester of pregnancy and in most cases, it is bilateral or located parasagittal right (10). The importance of prenatal MRI examination is to provide a timely diagnosis of fetal disorders in order for further therapy to be carried out adequately. In modern medical centers, prenatal diagnosis leads to prenatal surgical intervention, which impose a need to spread our experiences in this field.

6. CONCLUSION

Prenatal MRI provides extremely useful information in cases where the ultrasound examination of the fetus is insufficient due to the size and position of the fetus, as well as due to oligohydramnion. The advantage of prenatal MRI examination is that the analysis of intracranial structures is not affected by the bones of the calvary, hence a clear analysis of the cortex, subarachnoidal space and the rear cranial fossa is enabled. In case of inability of prenatal surgery, MRI is a key tool in deciding whether to continue or stop the further development of the fetus.

- Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms
- Author's Contribution: Each author gave substantial contribution to the conception or design of the work and in the acquisition, analysis and interpretation of data for the work. Each author had role in drafting the work and revising it critically for important intellectual content. Each author gave final approval of the version to be published and they agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.
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