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Applicability of the Magnetic Resonance Technique during the Gestational Period: a narrative review

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Abstract: Over the last few decades, fetal imaging has led to significant improvements in prenatal counseling and postnatal therapy options, as obstetric MRI examination mainly plays a complementary role to the morphological ultrasound study when there is any diagnostic doubt or even to confirm If there is any abnormal finding in the conventional ultrasound exam. It is worth noting that there is no evidence that MRI causes biological effects in the fetus, the exams should be reserved for patients in the second and third trimester of pregnancy. Here, we performed a literature review to point out the importance of the applicability of gestational Magnetic Resonance for the identification of changes in embryonic development, gestational pathologies, maternal diseases, sequelae of infections, fetal malformations, diagnosis of placental deficiency and creation of three-dimensional prototypes for surgical planning and fetal visualization. From this narrative review it was possible to identify that the applicability of gestational MRI is related to the identification of alterations in embryonic development, gestational pathologies in general, maternal diseases, sequelae of infections, fetal malformations, diagnosis of placental deficiency and creation of prototypes three-dimensional (3D) models for surgical planning and fetal visualization.

Keywords: Paradoxical psoriasis; Adalimumab; Crohn disease; Hidradenitis suppurativa.

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1. Introduction

Gestational Magnetic Resonance (MRI) began to be performed in 1983 and, during its first years, the method was not consolidated, despite its potential, since the image acquisition sequences were slow and, therefore, very impaired by movement fetal. From the 1990s, with the advent of fast sequences, especially the T2 single shot spin echo, the exam became much less susceptible to motion artifacts, starting to be more widespread [1]. Fetal magnetic resonance imaging (MRI) is increasingly used as a complementary imaging technique during prenatal diagnosis [2].

Over the last few decades, fetal imaging has led to significant improvements in prenatal counseling and postnatal therapy options, as obstetric MRI examination mainly plays a complementary role to the morphological ultrasound study when there is any diagnostic doubt or even to confirm If there is any abnormal finding in the conventional ultrasound exam. It is worth noting that there is no evidence that MRI causes biological

effects in the fetus, the exams should be reserved for patients in the second and third trimester of pregnancy [3].

The study on MRI is of great relevance, as it has been increasingly used for the evaluation of complex fetal anomalies detected on ultrasound. The advantages of MRI include high soft-tissue contrast resolution, imaging capability in any plane regardless of fetal positioning, and rapid acquisition with a large field of view. MRI is typically used as a complementary imaging tool when congenital abnormalities are detected during prenatal ultrasound. Fetal MRI facilitates accurate diagnoses, as it provides important anatomical information that may be useful in planning prenatal and early postnatal care, reducing perinatal morbidity and mortality.

Developments and modifications to hardware and software used in MRI have improved its diagnostic accuracy in fetal studies. Several studies have emphasized the benefit of MRI in the evaluation of congenital brain and lung anomalies, as well as complex fetal syndromes [4]. Here, we performed a literature review to point out the importance of the applicability of gestational Magnetic Resonance for the identification of changes in embryonic development, gestational pathologies, maternal diseases, sequelae of infections, fetal malformations, diagnosis of placental deficiency and creation of three-dimensional prototypes for surgical planning and fetal visualization.

2. Results

Here, it was possible to identify that the applicability of gestational magnetic resonance is related to the identification of alterations in embryonic development, gestational pathologies in general, maternal diseases, sequelae of infections, fetal malformations, diagnosis of placental deficiency and creation of three-dimensional (3D) prototypes for surgical planning and fetal visualization (Table 1). The percentage of studies that addressed the use of magnetic resonance imaging for the evaluation of fetal brain alterations was 29.16% and the articles that presented studies specifically on the gestational consequences of Zika Virus infection corresponded to 12.50% of the total number of studies analyzed.

Table 1. Description of articles included in the study.

Item	Clinical target	Reference
1	Placenta Acreta	[7]
2	Congenital Mullerian duct anomaly and infection	[13]
3	Diagnostic Imaging Exams during pregnancy	[5]
4	Assessment of uterine contractility and infertility	[8]
5	United Twins and 3D Models	[14]
6	Brain aneurysm	[10]
7	Lissencephaly	[15]
8	Fetal thyroid disease	[16]
9	Evaluation of the fetal skeleton	[4]
10	Ventriculomegaly	[15]
11	Changes in the development of the spine and spinal cord	[18]
12	COVID-19	[11]
13	Preeclampsia and brain development	[9]
14	Abdominal Malformations (1)	[12]
15	Abdominal Malformations (2)	[21]
16	Oral teratoma	[19]
17	Brain Measurements / Uterine Growth Restriction	[20]
18	Hydatidiform spring	[22]
19	Brain malformations caused by Zika Virus	[14]
20	Placental changes	[6]
21	3D Reconstructions Prototypes	[23]

22	Microcephaly related to congenital Zika virus infection	[24]
23	Changes in the Central Nervous System (microcephaly) related to congenital Zika virus infection	[25]

It was observed that 8.34% of the articles discussed placental problems, malformations and uterine pathologies, abdominal malformations, head, and neck diseases, in addition to 3D prototyping. Still, 4.16% of the studies studied non-obstetric indications for maternal MRI, hydatidiform mole, fetal skeletal structure, in addition to alterations in the development of the fetal spine and spinal cord (Table 2).

Table 2. Description of the main indications for the application of MRI in pregnant women

Description	%
Fetal brain changes	29,16
Gestational consequences of Zika virus infection	12,50
Placental deficiencies	08,34
Uterine malformations and pathologies	08,34
Abdominal malformations	08,34
Head and neck diseases	08,34
3D prototyping	08,34
Non-obstetric maternal indications	04,16
Hydatidiform spring	04,16
Study of fetal skeletal structure	04,16
Developmental disorders of the spine and spinal cord	04,16

3. Discussions

3.1 Use of MRI in pregnant women: current concepts

In recent decades, there has been a significant increase in the number of imaging tests performed on pregnant patients. This increase includes different modalities such as ultrasonography, computed tomography and magnetic resonance imaging. Imaging methods free of ionizing radiation are preferred during pregnancy. Ultrasonography and MRI have advantages over CT. However, CT can provide important data, contributing to the diagnosis in some situations. It is important to remember the fundamental principles of radiation protection, to reduce the risks to which the pregnant woman and the fetus will be exposed.

Among them, the principle of use limitation stands out, always using the lowest dose necessary to obtain the diagnosis, a principle recognized by the International Commission on Radiological Protection as "*As Low As Reasonably Achievable*" (ALARA). A legal aspect that must be considered by obstetricians and radiologists, before performing imaging studies, is the use of the free and informed consent form (TCLE). It is considered good medical practice to obtain these terms signed by the pregnant women, so that the patient's understanding of the diagnostic alternatives is documented, as well as the harm and benefits related to the examination that will be performed. It is suggested to obtain the informed consent form of all pregnant women who undergo sectional examinations, including MRI and CT (ROCHA, 2020).

The main advantages of using MRI involve the absence of the use of ionizing radiation, the multiplanar capacity and the excellent resolution in the evaluation of soft tissues.

Potential risks to the fetus are tissue heating provided by high-frequency pulses, hearing damage from high-intensity noise, and cell migration defects during the first trimester, secondary to the electromagnetic field itself. Despite these theoretical concerns, there are no reports of adverse effects in pregnant women or fetuses undergoing this test [5].

The acquisition of images in MRI devices of up to 1.5 Tesla is considered safe, and the performance of exams in 3.0 Tesla devices is not recommended, due to the greater potential for tissue heating and the lack of adequate studies to date. The use of MRI is recommended in any gestational period when other methods that do not use ionizing radiation do not clarify the clinical situation, provided that the examination is relevant for the diagnostic-therapeutic definition of the pregnant woman and/or the fetus and that its postponement, until the patient is no longer pregnant, be reckless [5].

About gadolinium (paramagnetic contrast medium), there are no reports of adverse mutagenic effects in human fetuses using regularly administered doses. However, there are no well-controlled studies on the teratogenic effects of this contrast medium in human fetuses or cases of systemic nephrogenic fibrosis triggered using gadolinium during pregnancy, although there is a potential risk for the mother and the baby. Due to the uncertain effects of the use of paramagnetic contrast media by children who had intrauterine contact with this drug, it is recommended to use it with caution during pregnancy. According to the recommendations of the American College of Radiology, gadolinium should be used only when the benefits justify the potential risks to the fetus, and it should be administered at the lowest possible dose to reach the diagnosis [5].

The decision on the imaging method to be used in the abdominal evaluation of the pregnant woman is complex and should consider the urgency of diagnostic confirmation, the main clinical hypotheses, the results of previous exams and the risk-benefit for the mother-fetus binomial. The main non-obstetric clinical manifestations requiring abdominal imaging evaluation are those that require urgent attention, such as those causing an acute abdomen (particularly appendicitis and biliary tract diseases), in addition to urinary tract obstructions [5].

Placental analysis is part of routine prenatal evaluation, initially performed by ultrasonography (US) with Doppler. Magnetic resonance imaging (MRI) is reserved for situations that are dubious at US, because it presents good tissue resolution, regardless of maternal biotype or fetal position, in addition to allowing the acquisition of multiplanar images. The growing number of uterine surgical manipulations in recent years has led to an increase in suspected cases of placental adhesive diseases, with a consequent increase in requests for placental MRI. Radiologists need to become familiar with gestational MRI scans, as placental diseases, although rare, have potential maternal-fetal morbidity and mortality. These exams must be carried out in 1.5 to 3.0 T equipment, with a phased-array coil, the patient in the supine position, bladder in small/medium fullness, ideally between 28 and 32 weeks of gestation. The use of gadolinium should be avoided, as it has been associated with an increased risk of rheumatological and inflammatory diseases and cutaneous infiltrative conditions in children with a history of intrauterine contrast exposure, in addition to an increased incidence of stillbirths and neonatal death [6].

The gravid uterus has smooth contours and an inverted pear shape, with a fundus region that is wider than the lower segment. The placenta has a fetal surface (chorionic plate) and maternal surface (basal plate) next to the retroplacental space. In the second trimester of pregnancy, the placenta has a discoid, flattened morphology, a smooth surface and homogeneous signal, there is good visualization of the myometrial-placental interface, and the myometrium has a trilaminar appearance with central hypersignal on T2-weighted images. With placental maturation in the third trimester, there is better definition of the cotyledons, progressive myometrial thinning, lobulations on the fetal face and subplacental vascularization. Placental thickness increases during gestational age and should be measured in its middle portion, close to the insertion of the umbilical cord and perpendicular to the placental long axis, with a normal value of 2 to 4 cm. Hematological and systemic vascular diseases with microinfarcts course with placental thinning, while

hydrops fetalis, prenatal infections, diabetes, and maternal anemia course with placental thickening [6].

Indications for placental evaluation by MRI include low-lying placenta, when implantation occurs in the lower uterine segment, with the placental margin less than two centimeters away from the internal cervical os without covering it. It is associated with an increased risk of bleeding; Premature placental abruption (a rare situation responsible for premature delivery and increased fetal mortality) which on MRI presents a very distinct hematoma of the placenta, diffusion restriction and the behavior of the signal can help to differentiate acute, subacute and chronic phases, collaborating in the prediction of bleeding stability; Placental Adhesive Diseases resulting from excessive trophoblastic invasion and anomalous decidualization representing a spectrum of diseases, from placenta accreta, in which there is direct contact of the placenta with the myometrium (partial invasion), passing through placenta percreta, in which total myometrial invasion occurs, to placenta increta, characterized by placental extension beyond the uterine serosa and eventual invasion of adjacent organs, such as the bladder. This differentiation can be a challenge for imaging methods. The suspicion of PAD is the main indication for MRI, and prenatal diagnosis is extremely important because it allows better planning of delivery with a multidisciplinary team and possible embolization of the uterine artery, avoiding hysterectomy [6].

Placenta accreta is an obstetric condition that can be fatal and often requires a multidisciplinary approach. It is characterized by an abnormal adhesion of the placenta to the uterine wall. Based on the degree of adhesion, placental invasion can be classified as accreta, increta or percreta. The global incidence of placenta accreta has been increasing over the years and this appears in parallel with the increase in the cesarean section rate. The consequences of a late diagnosis of placenta accreta can be serious, emphasizing the importance of early detection during prenatal care. Prenatal diagnosis of placenta previa, placenta accreta and its variants can reduce maternal and fetal morbidity and mortality, allowing the resolution of the pregnancy to be scheduled in tertiary institutions with multidisciplinary teams, neonatal intensive care units, blood banks, among other resources available at the time of surgery. These measures can be effective only if these conditions are created in advance and if the correct diagnosis occurs [7].

MRI has been incorporated into obstetric practice for some cases of fetal, maternal, and placental evaluation, as the soft tissues are clearly visible, allowing evaluation of the retroperitoneal space. MRI is mainly indicated for cases of posterior placenta accreta, cases in which ultrasound visualization is impaired due to fetal volume. For the diagnosis of placenta accreta by MRI, criteria such as the presence of uterine bulging, heterogeneous signal intensity within the placenta, dark intraplacental bands on T2-weighted sequences, abnormal placental vascularity, focal interruptions in the myometrial wall, bladder inclination are used. and direct visualization of invasion of adjacent organs. Ultrasonography remains the main imaging modality for screening for abnormal placental implantation, however, MRI is a very useful complementary imaging resource in cases of inconclusive ultrasound or posterior placenta [7].

3.2 Use of MRI for the diagnosis of gestational pathologies

Uterine contractility outside the gestational phase, during the menstrual cycle and the usual functional variation of the organ is one of the mechanisms responsible for reproduction and fertility, due to its direct action on the mechanisms of conduction of spermatozoa to the ovum and in decidual implantation. Pathologies such as uterine leiomyoma, endometriosis, adenomyosis, polycystic ovary syndrome, as well as the use of intrauterine devices and oral contraceptives, can alter the functionality of uterine contractility. In this way, magnetic resonance imaging with ultra-fast sequences can provide a dynamic cinematographic evaluation (Cine-RM) of the uterus, correlating the quality of uterine contractility in patients with infertility or current pathologies [8].

The use of transvaginal videosonography to assess uterine peristalsis, characterizing the waves according to the presented direction is described as: A, if cervico-fundica; B, cervical fundus; and C, limited to the isthmus. In that decade, worldwide radiology was undergoing a revolution, with the advent and unbridled evolution of MRI, especially for pelvic evaluation. Thus, in 2004, researchers from the University of Kyoto found that Cine-MRI was responsible for better delineating peristalsis and was associated with the behavior of the endometrium, junctional zone, and myometrium. It is also worth mentioning the use of Cine-MRI for evaluation of pelvic floor dysfunction, in the case of cystocele, enterocele, rectocele and uterine or vaginal prolapse [8].

Based on the visual concepts of television and cinema, Cine-RM consists of acquiring several images in a short interval of seconds, with subsequent visualization of these images without intervals, with a perceptible and comfortable speed to the human eye, around 12 frames/ second. Cine-RM has two possibilities for application, using T2 sequence single shot fast spin echo (SSFSE) and steady-state free precession (SSFP). Although SSFP has better resolution, its high noise provides greater vulnerability to susceptibility artifacts and distortion. For this reason, SSFSE was considered the best sequence for assessing uterine peristalsis, due to its better contrast and spatial resolution. Therefore, for the evaluation of uterine contractility in infertile women with associated pelvic pathologies, Cine-MRI can provide additional pathophysiological information, without significant temporal and financial repercussions [8].

Preeclampsia (PE) is a significant gestational disorder that causes complications in 3 to 5% of all human pregnancies and is among the leading causes of maternal and fetal morbidity and mortality. In addition to the immediate risks and complications for the mother and fetus, it can pose increased risks throughout life, with specific complications. Children of pregnancies with PE have higher risks of hypertension, stroke and cognitive impairment compared to individuals from uncomplicated pregnancies. PE accounts for up to 12% of global annual maternal gestational deaths and up to 25% of all fetal and neonatal deaths worldwide annually. PE is hypertension of recent onset and may be accompanied by proteinuria (> 300 mg/day), thrombocytopenia (< 10^5/uL), renal failure (serum creatinine >1.1 mg/dL), impaired liver function, pulmonary oedema, headaches, or visual disturbances after the 20th week of pregnancy.

In addition to the immediate gestational complications of PE, numerous long-term maternal complications have been identified. Women who experience PE have significantly increased risks of developing future cardiovascular risk factors such as dyslipidemia, hypertension, and metabolic disease. PE at a minimum double the risk of future heart disease, raising lifetime risks for coronary artery disease, cardiovascular disease, and stroke. DANG ET al. explored the impact of preeclampsia on the brain of offspring of preeclamptic pregnancies. While the impact of PE on brain vascular and neurological development occurs during fetal life, postnatal brain assessments are used to study the legacy of preeclamptic pregnancy in offspring [9].

The vein of Galen aneurysm (AVG) is a rare congenital malformation resulting from the presence of multiple arteriovenous vessels, derivations that drain into a median forebrain vein. It is usually a simple malformation corresponding to 1% of all cerebral vascular malformations. However, it can be associated with congenital heart disease, hydrops and hygroma. Its etiology is unknown, and there is no description of familial inheritance. Heart failure is the most common symptom in the neonatal period, but seizures and other neurological signs can also be observed. AVG has a low incidence rate but high morbidity and mortality, making prenatal diagnosis necessary for proper follow-up, delivery, and parenting counseling. In general, the condition is diagnosed prenatally based on conventional methods [10].

The condition is diagnosed through ultrasonography, when a cystic image confirms the dilation of the vein, located in the mid-region, or slightly deviated from the central region, below the third ventricle in the mid-supratentorial line. Color Doppler images demonstrate turbulent flow within the cyst, which may be associated with secondary

ventriculomegaly. Magnetic resonance imaging (MRI) helps confirm the diagnosis and reveals complications such as a hemorrhagic lesion in the white matter of the brain. Other methods of prenatal diagnosis, such as three-dimensional ultrasound in Power Doppler mode is described, but these do not demonstrate advantages over conventional ultrasound and magnetic resonance imaging [10].

Fetal echocardiography can help detect early signs of heart failure, which, along with hydrops, is the most common consequence of AVG. Magnetic resonance imaging is used to evaluate disease-associated neurological findings that may be of prognostic value. In some cases, magnetic resonance imaging can identify neuronal migration abnormalities that are not detected by ultrasonography. As AVG is associated with high death rates, its prenatal diagnosis based on ultrasound and magnetic resonance imaging is essential for counseling and monitoring of parents in tertiary care institutions [10].

Cytomegalovirus (CMV) is the congenital viral infection that most commonly causes hearing, visual and psychomotor impairment. Preexisting maternal immunity to the disease substantially reduces the risk but does not eliminate the likelihood of infection and fetal affectation. Rodrigues et al. reported a case of maternal non-primary CMV infection during pregnancy, with vertical transmission, resulting in severe fetal involvement. Preconception analyzes indicated past CMV infection. The pregnancy was uneventful until the ultrasound performed at the 20th week, which revealed brain alterations such as a thin and hyperechogenic cerebral cortex with prominent lateral ventricles, bilateral periventricular hyperechogenicity, hypoplasia of the cerebellar vermis and absence of the corpus callosum. Magnetic resonance imaging at 22 weeks of gestation confirmed the US findings and raised the hypothesis of fetal infection based on an increase in the circulation spaces of the cerebrospinal fluid at the expense of a marked reduction in the thickness of the cerebral parenchyma of both hemispheres with a lissencephalic appearance, suggesting sequelae brain infection rather than a primary malformative lesion of the central nervous system. The fetal karyotype was normal. The CMV IgG antibody titer had tripled since the first trimester measurement. PCR for CMV DNA in amniotic fluid was negative. The pregnancy was terminated at the 23rd week. Neuropathological findings at autopsy showed severe brain lesions associated with CMV infection.

The number of children infected with SARS-CoV-2 is small, perhaps due to the lower expression of Angiotensin Converting Enzyme 2 (ACE2) in children compared to adults. However, little is known about fetal impairment in mothers infected with SARS-CoV-2. The consequences of the maternal and fetal inflammatory response, with the production of potentially cytotoxic substances, cytokines, as well as the effect of the use of antiviral drugs have not been studied so far. There are studies reporting infected adults who developed neurological diseases, such as mental confusion, stroke, seizures, or loss of smell, due to a direct or indirect effect on the central nervous system. Acute hemorrhagic encephalopathy, diagnosed by magnetic resonance imaging, has also been reported in patients affected by COVID-19. The prevalence of neurological impairment from COVID-19 is still being investigated, but Japanese studies have demonstrated clinical findings related to the nervous system. There are insufficient data related to fetal or newborn vulnerability to neurological sequelae from COVID-19 infection. SARS-COV-2 infection can cause an exaggerated immune reaction that is manifested by the excessive activation of immune system cells and the production of large amounts of interferons and cytokines that can affect fetal development and increase the risk of neurological diseases in the period. neonatal [11].

3.3 Use of MRI for the diagnosis of fetal abnormalities

Although ultrasonography (US) remains the main method in the evaluation of fetal disorders due to its low cost and wide availability, fetal MRI has been frequently used as an adjuvant method in recent years. The improvement in image resolution, the formation

of multiple contrasts between different tissues and the wide field of view and acquisition of images generated by equipment and software led to the growing use of fetal MRI facilitated by technological advances such as the ultra-fast T2-weighted sequence and diffusion images. Fetal MRI can achieve superior or similar results to those of US, especially in cases of maternal obesity, oligohydramnios or anomalous fetal position. Fetal MRI is capable of evaluating large-volume fetal organs such as lungs, liver, colon and kidneys. Furthermore, fetal MRI allows the examination of large or complex malformations, facilitating the understanding of the malformation in the context of the entire fetal body. Initially, the studies were directed to the central nervous system. With the advancement of software and hardware, fetal MRI has gained importance in the evaluation of the fetal abdomen cavity, as well as malformations in the abdominal cavity, including esophageal atresia and duodenal obstruction, as well as effusions in the abdominal cavity, such as meconium peritonitis and abdominal cysts including ovarian cysts which are the main cause of abdominal mass in female fetuses and mesenteric cysts [12].

Mullerian duct anomalies (MDAs) are birth defects of the female genital system that arise from abnormal embryologic development. These abnormalities include a wide range of anomalies resulting from developmental failure, faulty fusion, or septal regression defects during fetal development. Herlyn-Werner-Wunderlich syndrome (HWWS), also known as obstructed hemivagina and ipsilateral renal anomaly, was first described in the 1970s. It is a rare congenital anomaly of the female genital tract characterized by ipsilateral uterine didelphy, renal agenesis and blind hemivagina. Congenital developmental anomalies of Müller's ducts are a significant etiologic factor in infertility and are associated with an increase in obstetric complications. SHWW is extremely rare and is commonly diagnosed at the time of menarche [13].

The vaginal septum is usually longitudinal and can be of variable thickness. Delay in diagnosis is common, mainly due to communication between the two cavities, incomplete hemivaginal obstruction, elasticity of the septum, and the use of medications such as oral contraceptives and non-steroidal anti-inflammatory drugs that can minimize symptoms and therefore further delay the onset. frame recognition. A high index of suspicion is necessary to diagnose these cases early, avoiding complications such as retrograde tubal reflux and consequent endometriosis and infertility. When clinical signs and symptoms are present, ultrasonography is usually the initial imaging test performed, but it is highly dependent on operator experience. Magnetic resonance imaging is considered the gold standard for diagnosis and preoperative planning for the treatment of HWWS. Treatment must be individualized according to the complaints and the main objective is to alleviate the obstruction by remodeling the vagina. Some vaginal septa can be easily displaced to the side and others can be thick enough to cause symptoms, requiring surgical excision [13].

Conjoined twins are a rare complication of monochorionic and monoamniotic twin pregnancies. 3D images of the fetal surface are generated by software during imaging tests for spatial understanding of the relationship between the fetal parts. 3D technologies are an important tool for counseling parents and preparing the multidisciplinary team for childbirth and neonatal care, as well as possible surgical planning for postnatal separation in these cases [14]. Conjoined twins (SG) represent a rare complication of monochorionic and monoamniotic twin pregnancies with an incidence ranging from 1:50,000 to 1:100,000 live births. The uniqueness of the anatomy of the GS may increase the risk of fetal disease and neonatal death. Recognition of anatomical features is crucial in the prenatal assessment and postnatal care of the GS, and prenatal and postnatal imaging studies are essential. In recent decades, virtual 3D techniques and 3D physical models have been described as emerging technologies for SG care and parental counseling [14].

Conjoined twins are a rare occurrence, and the anatomical classification is based on the site of anatomical fusion which may be associated with a high mortality rate. The thoracopagus has an 80% mortality rate, due to the presence of severe cardiopulmonary abnormalities, while the omphalopagus may have a 20% mortality rate. The anatomical

presentation of GS is extremely variable and each anatomical feature leads to the association of multiple major malformations, which are present in more than a quarter of cases and contribute to the high rate of neonatal mortality. In these cases, prenatal imaging is critical for parental counseling, individualized prenatal care, and preparation for the delivery of multidisciplinary specialty care and, postnatally, for clinical assessment of the anatomy in cases where separation is not indicated. and in case of surgical separation to provide accurate information to parents and multidisciplinary care [14].

Many technological advances are being applied and customized to improve understanding of GS anatomy, including 3D imaging, virtual reality, and printing 3D models. The formation of a 3D image is the first step after image acquisition. The presence of several contrasts allows adequate segmentation of the anatomy to be studied. The first description of CT using 3D physical models was reported in 2000, when magnetic resonance imaging was used for prenatal planning and providing information to the specialist in multidisciplinary care after birth when separation surgery was required. Physical 3D models are useful for surgical guidance, providing spatial relationship between tissues and organs, providing detailed anatomical information that is not visible in 2D images. The identification of the vascular connection is one of the key factors for the success of the surgical separation and there are many cases reporting the use of these models in the postnatal care of twins conjoined at the skull that can provide the physical characteristics in real scale of the relationship between structures. 3D technologies can be useful in the prenatal evaluation of GS and are an important tool for counseling and planning postnatal surgical separation [14].

Lissencephaly is a heterogeneous autosomal recessive genetic disorder characterized by the classic triad: brain malformations, ocular anomalies and congenital muscle lesions, dystrophy. Three-dimensional ultrasound was introduced into obstetric clinical practice in the mid-1990s and has been applied adjunctively to conventional ultrasonography as well as magnetic resonance imaging (MRI) for the evaluation of various fetal brain malformations. However, the application of three-dimensional ultrasound in rendering mode to assess the development of fetal sulci and gyri during pregnancy is still of limited application. The prenatal diagnosis of lissencephaly and superimposed syndromes has been described since the mid-1980s by conventional ultrasonography and thus, lissencephaly is usually detected late in pregnancy and ventriculomegaly is described in almost all cases diagnosed prenatally. Although the neuronal migration process peaks around 20 weeks of gestation, the sensitivity of ultrasound in the prenatal diagnosis of abnormal cortical development is low [15].

Fetal MRI improved prenatal ultrasound diagnosis of lissencephaly accurately, showing a "Z" shaped fold in the brainstem, with bifid pons and medulla oblongata. These anatomical details are not diagnosed through ultrasound images, confirming the role of prenatal MRI as a tool for complementary diagnosis in all cases of brain pathology detected by ultrasound. As cortical and sulcal formation reflects brain maturation, MRI provides more accurate information about the development of sulci and gyri compared to ultrasound, since visibility in the method is not affected by cranial bones or reverberation artifacts or fetal position. Magnetic resonance imaging increases the accuracy of ultrasound by detecting abnormalities involving the brainstem, improving the accuracy of counseling, and aiding in the decision-making process. Magnetic resonance imaging is a very useful imaging modality that contributes to the accurate detection of cortical disorders in the fetus, even in early stages of development [15].

Fetal thyroid complications in pregnancy are uncommon and are commonly related to the passage of substances through the placenta. Excessive iodine intake during pregnancy is a well-known mechanism that causes fetal thyroid enlargement or goiter, and invasive procedures have been proposed for the treatment of fetal thyroid pathologies. The thyroid gland is essential for the neurodevelopment of the embryo and fetus. Fetal thyroid pathologies can cause perinatal complications ranging from premature birth and airway obstruction to severe psychomotor impairment in childhood. Excess maternal

iodine intake during pregnancy is a well-known mechanism of fetal thyroid disease. High exposure to iodine can lead to the development of fetal hypothyroidism and fetal goiter. Among fetuses with congenital hypothyroidism, only 3% manifest fetal goiter, with a prevalence of 1 per 40,000 live births. Fetal thyroid enlargement or goiter can be diagnosed based on measurements of thyroid circumference related to gestational age or its diameter biparietal. With different etiologies, including congenital dyshormonogenesis, iodine excess or deficiency, among others, fetal goiter is a less frequent consequence of fetal hypothyroidism, but it increases fetal and neonatal morbidity due to congenital thyroid dysfunctions [16].

The direct impact of thyroid masses can lead to obstruction of the airways and esophagus, increasing the risk of premature delivery due to polyhydramnios, requiring intervention by a multidisciplinary team to guarantee the neonatal airway through extrauterine intrapartum treatment. This compressive effect on the airway and esophagus is a predictable complication, with magnetic resonance imaging playing an important role in the evaluation of soft tissues and characterization of airway permeability. Identification of the possible cause of fetal goiter and interruption of supplemental iodine intake represent conservative treatment with subsequent goiter regression, both in singleton and twin pregnancies [16].

Few studies have investigated the contribution of MRI to the diagnosis of fetal skeletal abnormalities. Skeletal dysplasia has an incidence of approximately 2 cases per 10,000 live births and is fatal in approximately 50% of affected infants. The condition can occur alone or in combination with genetic syndromes. Prenatal (fetal) diagnosis is essential for proper genetic counseling, prognosis, and postnatal management. Substantial advances have been made in the use of MRI to assess the fetal skeleton. While not a substitute, MRI complements ultrasound because it is not limited by fetal position, maternal obesity, or oligohydramnios. However, the accuracy of both methods may be slightly reduced if there is marked fetal movement or severe oligohydramnios. The multiplanar reconstruction of the MR images allows a complete evaluation of the fetus and contributes to the characterization of the fetal skeleton. Skeletal reconstruction allows the identification of defects in the long bones of the fetus and this technique provides good resolution, thus allowing the definitive diagnosis [4].

Fetal skeleton using MR techniques with acquisition of echoplanar images, T2-weighted sequences, in addition to modified gradient-echo sequences with short acquisition times (Volume Interpolated Breath Hold Examination - VIBE), the latter being more useful than 3D ultrasound because it does not depend on the fetal position. The proposal of new MRI sequences for the diagnosis of skeletal dysplasia in fetuses, particularly the modified VIBE sequence in MRI scans, allows the reconstruction of 3D images for the complete characterization of the fetal skeleton. The modified VIBE sequence performs a true three-dimensional analysis and has some advantages over computed tomography and ultrasound in characterizing the entire skeleton. Compared to ultrasound, MRI is not limited by excess adipose tissue, oligohydramnios, or fetal movements. Compared to computed tomography, modified VIBE sequence MRI does not involve exposure to ionizing radiation. The presence or absence of fetal MRI findings can help determine whether the skeletal anomaly is independent of or associated with other anomalies. This ability to detect fetal anomalies is a major contribution of MRI [4].

Ventriculomegaly (VM) is one of the most common brain diseases seen on prenatal ultrasound. The prevalence of MV varies between 0.3 and 10 per 1,000 births, depending on the technique used for the assessment. Mild and moderate MV, defined as an atrial width of 10-15 mm between 15 and 40 weeks of gestation, may be associated with neural and extraneural alterations, malformations, fetal infections and chromosomal anomalies. Traditionally, the diagnosis of MV is based on prenatal exams, brain scans during the second and third trimesters of pregnancy. MV can be isolated or associated with cranial and/or extracranial malformations, resulting in a worse prognosis in these cases. The

introduction of fetal MRI as a prenatal diagnosis of brain VM provides a more accurate prediction of fetal neurodevelopment [17].

Fetal MRI demonstrates superiority in the diagnosis of cases of MV associated with CNS anomalies, when compared to ultrasound. Magnetic resonance provides additional information and one of the main advantages of the method over ultrasound is the analysis of gyri. Therefore, the magnetic resonance study should be performed between the 30th and 32nd weeks of gestation, the most appropriate developmental period for carrying out the investigation. Fetuses with mild and isolated MV have a good prognosis, although there is an overall risk of 11% of neurodevelopmental delay in these fetuses with. Ultrasonography and magnetic resonance imaging are substantially in agreement in defining the degree of MV (isolated or associated). Magnetic resonance imaging may also represent a complementary diagnostic investigation, useful in detecting hemorrhagic foci, porencephaly, cortical and subependymal tubercles, midline anomalies and callosal dysgenesis, as well as abnormalities of the posterior fossa. From the 25th week of gestation, MRI can add additional information about cortical development and maturation and is more accurate in detecting white matter pathologies compared to other techniques [17].

Compared to prenatal brain ultrasound, fetal MRI allows detection of CNS pathologies such as microcephaly and microlissencephaly; suspected intertricolar septum; brachycephaly; impaired cortical gyrus; thalamocaudate sulcus cyst; abnormal periventricular neuronal migration; increased temporal white matter signal with increased apparent diffusion coefficient; abnormal white matter migration; septum in the left occipital horn and abnormal hippocampal gyrus. Magnetic resonance imaging can complement other brain scans, especially when performed in the third trimester of pregnancy, allowing prenatal counseling and prenatal care management by a multi-specialist team. In addition, postnatal MRI may also allow the diagnosis of associated brain abnormalities that were previously unknown prenatally. The clinical limitations of magnetic resonance imaging are represented by high costs, technical availability, and sensitivity at a gestational age of less than 25 weeks [17].

The development of magnetic resonance imaging has significantly improved the accuracy of intrauterine diagnosis of neural tube defects. Filum hypertrophy and shortening, also known as Filum Disease, is a simple spinal dysraphism without subcutaneous masses that can cause tethered spinal cord syndrome by preventing normal ascension of the conus medullaris. This condition can give rise to symptoms in childhood or even in adulthood, linked to neurological deficit due to spinal cord traction, as well as repeated episodes of meningitis or spinal abscesses. Structural defects of this type arise from an error in the normal morphogenesis of the filum terminale and medullary cone, during the phase of "regressive differentiation", in which the caudal medulla atrophies forming the filum, the coccygeal ligament and the ascending cone. The spinal cord extends from the foramen magnum to the sacrum in the human fetus and through ultrasound studies or magnetic resonance imaging during pregnancy, one can identify the irregular positioning of the spinal cord (medullary cone below L2-L3) suggesting some caudal malformation after 35 weeks of gestation [18].

Oropharyngeal Teratoma (*Epignathus*) is an extremely rare form of teratoma that protrudes through the mouth. It is believed that this tumor originates in pluripotent cells derived from the three germ layers, originating in the maxilla, palate, or sphenoid, and grow in a disorganized way, filling the entire oropharyngeal cavity, exteriorizing through the oral cavity. This tumor can lead to asphyxia and severe obstructive respiratory failure in the newborn. Cervical teratomas are well-circumscribed, voluminous masses with a solid and cystic component, which may vary from 5 to 12 cm in their largest diameters, and may cause mandibular hypoplasia, being considered benign in 95% of cases, however, the probability of recurrence is high, and surgical resection is indicated. Mortality due to cervical teratomas without extrauterine intrapartum treatment is around 80 to 100%, decreasing to 9 to 17% after definitive treatment, which consists of surgical resection of the tumor. Congenital teratomas are rare, the most common being sacrococcygeal

(45%), followed by those of the gonads, anterior mediastinum, retroperitoneum and oropharynx. The cervical location accounts for only 3% of childhood teratomas. Clinical manifestations depend on the involvement of adjacent structures, such as the trachea and esophagus, triggering potentially fatal respiratory and swallowing symptoms. When the teratoma is diagnosed during the gestational period, a cesarean section is recommended. Preoperative planning with a multidisciplinary team is essential, aiming at the immediate stabilization of the newborn in the delivery room. Oral teratoma can be diagnosed during prenatal care, by performing an ultrasound and/or magnetic resonance imaging, and a cesarean section is recommended [19].

Intrauterine growth restriction (IUGR), which occurs in 5 to 10% of pregnancies, is a major cause of perinatal mortality and morbidity, resulting in disorders of psychomotor function and neuromotor development, as well as cardiovascular diseases and endocrine disorders in adults. The variety of etiologies and the lack of prenatal interventions to prevent stunting make the management of IUGR a challenge. The main cause of IUGR is placental insufficiency, which results in progressive and relatively predictable fetal compromise. The neurological deficits associated with IUGR appear to be the result of brain reorganization, as suggested by studies showing differences between babies with and without IUGR in terms of brain metabolism, morphology, and connections, as well as neurological microstructure. Although ultrasonography is the primary modality for evaluating the fetus, ultrasound scans have limited ability to detect these types of abnormalities [20].

Fetal magnetic resonance imaging adds information to ultrasound examinations and is a highly accurate method for early diagnosis, detection, confirmation, or exclusion of suspicious changes. It has been used to estimate fetal cerebral oxygenation or to assess brain changes resulting from IUGR. Some magnetic resonance-based studies have shown that newborns with IUGR have reduced gray matter and hippocampal volumes, as well as significant delays in cortical development, with specific gyrus and sulcation patterns. In a recent study, it was quantified the brain growth of normal fetuses during the second half of pregnancy using two-dimensional and three-dimensional biometric parameters in magnetic resonance imaging. Thus, cranial magnetic resonance imaging of fetuses with IUGR can be compared with those of normal fetuses, which improves knowledge of neurodevelopmental patterns associated with fetal malnutrition. Therefore, MRI can be an auxiliary method for the diagnosis of neurological injuries associated with chronic fetal hypoxia and for the early identification of fetuses at high risk of future neurological impairment [20].

Magnetic resonance imaging has been applied in obstetrics in situations where US has sensitivity limitations such as abdominal scars and decreased amniotic fluid volume, showing advantages in the evaluation of some malformations, such as cortical maturation disorders. However, ultrasonography (US) remains the method of choice for the evaluation of fetal malformations, due to its good acceptance, low price, and absence of risks for the maternal-fetal binomial. Regarding malformations of the fetal abdominal wall, MRI is usual in the prognostic evaluation of intestinal atresia in gastroschisis or complications of omphalocele, allowing better perinatal management and parental counseling. Likewise, MRI is a more accurate method than US in characterizing the intrapelvic and abdominal extension of sacrococcygeal tumors, in addition to providing more information about the compression of adjacent organs. MRI examination adds anatomical detail in the evaluation of omphalocele. Shows the defined images of the hernial sac, possible central defect of the abdominal wall, separating the abdominal contents from the amniotic fluid, the volume, and its contents (liver, stomach, spleen, colon) which are of great importance for a careful fetal morphological evaluation and counseling maternal. In Gastrochisis, the correct assessment of intestinal integrity is essential for the analysis of neonatal prognosis. In Sacrocygeal Teratoma, MRI helps to assess the extent of the teratoma, the involvement of adjacent organs and the compressive effect of the lesion. During prenatal care, MRI also

evaluates the volumetric growth of the teratoma, which, together with the Doppler flowmetry evaluation, classifies the disease as high or low risk [21].

Gestational Trophoblastic Disease (GTD) is an anomaly in pregnancy that encompasses a group of trophoblast-derived diseases, different from each other by their propensity for regression, invasion, metastasis, and recurrence. In the past, it was common for a patient with a molar pregnancy to present exuberant symptoms such as copious hemorrhage, thecalutein cysts, an enlarged uterus for gestational age, early preeclampsia, hyperemesis, and hyperthyroidism. Currently, early diagnosis is performed through ultrasonography and most patients are diagnosed while still in the asymptomatic phase. In cases in which there is progression to gestational trophoblastic neoplasia, staging is performed with pelvic Doppler flowmetry, and magnetic resonance imaging is fundamental in evaluating the choice of antineoplastic treatment [6].

Magnetic resonance imaging may still be indicated in cases of GTD, a relatively uncommon disease, with a spectrum of benign and malignant presentations, ranging from partial or complete hydatidiform mole to persistent trophoblastic neoplasia, including invasive mole, choriocarcinoma and trophoblastic site tumor. Persistent trophoblastic neoplasia has an incidence of up to 29% after the occurrence of a mole, and MRI is useful in the evaluation of myometrial invasion and local staging. MRI images are also useful in evaluating retained products of conception, which occurs when there is incomplete delivery of the placenta or persistent vaginal bleeding after delivery or abortion, usually diagnosed by US. On MRI, it appears as an eccentric and heterogeneous intracavitary image on T1 and T2-weighted sequences (generally with hypersignal on T1 and low or intermediate signal on T2), with obliteration of the junctional zone and myometrial thinning, hyper or hypovascularized, with intracavitary blood [6].

Placental MRI assessment should include cervical length in a descriptive manner. In exams performed between 18 and 24 weeks, a cervical length of less than 3 centimeters can help define the risk of premature birth. From 24 weeks onwards, this measure will be evaluated by the obstetrician in correlation with previous exams and the clinical picture. It is also important to describe any additional findings, such as uterine fibroids, ovarian masses, gross fetal anomalies, or oligo/polyhydramnios. Placental MRI has limitations inherent to the patient, such as uterine contractions, fetal and maternal movement, claustrophobia, difficulty remaining in the decubitus position in the third trimester, in addition to limitations related to the method, such as the relatively long examination time, high cost, and the need for experienced radiologists. with placental diseases. In the past, exams only informed the placental location. Currently, it is believed that placental imaging is vital for understanding placental physiology and efficiency, with a likely future contribution to understanding premature births, fetal growth restriction and preeclampsia [6].

Gestational trophoblastic neoplasia (GNT), which includes mole invasive, is almost always curable. For this favorable result, the radiologist must play an important role both in the early diagnosis, reducing the morbidity and mortality of molar pregnancy. Ultrasonography is the initial test used for the diagnosis of mole, associated with serum dosage of the beta subunit of human chorionic gonadotropin (β-hCG). Although chest radiography was initially recommended for screening for metastases, computed tomography and magnetic resonance imaging have been globally incorporated in the evaluation of metastatic disease, notably in more complex clinical cases. In the first trimester, MRI shows little or no abnormalities. Changes are best seen in the second quarter. On contrast-enhanced T1-weighted images, a mass can be seen, with a signal equal to or slightly more intense than that of the adjacent myometrium, containing small cystic spaces diffusely distributed in its interior, reflecting the vesicular nature of the tumor. The presence of foci with hyperintense signals is probably due to hemorrhage sites within the lesion. On T2-weighted images, the tumor appears as a mass with a hyperintense, heterogeneous signal, with the appearance of a "bunch of grapes", which distends the uterus and endometrial cavity. Myometrial invasion can be suspected when the lesion crosses the myoendometrial limit and the junctional zone becomes undefined [22].

Due to the high degree of vascularization, it is possible to visualize, both on T1 and T2-weighted images, spaces with tortuous flows compatible with vessels that cross the tumor mass, myometrium, parametrium and annexes, and engorgement of iliac vessels. Hemorrhage foci usually have a high signal intensity on T1 and can be better differentiated on contrast-enhanced images. MRI also plays a role in the metastatic evaluation of NTG. It is superior for identifying parametrial and vaginal invasion compared to US. In the parametrial tissue, a mass with hypersignal can be seen on T2-weighted images, and the vaginal involvement appears as a bulging fornix of hyperintense signal with undefined margins. MRI is used, above all, for the evaluation of complicated cases in which it is desired to assess the extent of the neoplasm [22].

3.4 Use of MRI for the advent of virtual and physical models in 3D

The creation of virtual and physical models based on 3D US, MRI and CT performed separately or together are feasible and the postnatal appearance of the stillborn fetus or newborn closely resembles physical models, particularly in cases of malformations. The use of 3D US, MRI and CT can help to better understand the physical characteristics of the fetus. These techniques can be used for teaching purposes, contributing to a multidisciplinary approach and a better understanding of parents. Images acquired through radiological methods can be segmented and applied to build 3D virtual and physical models [23].

The growing technological development in obtaining and viewing images through non-invasive techniques has brought great advances in medicine, especially in the diagnosis of fetal anomalies. In general, two examination modalities are used to obtain images of the uterine cavity during pregnancy: ultrasonography and magnetic resonance imaging. Computed tomography (CT) also offers detailed images of the fetus, especially its skeleton, from the 30th week of pregnancy, but its use is restricted due to the use of ionizing radiation. Virtual three-dimensional modeling has had a great boost in recent years, due to the high performance of software applied in the areas of engineering, architecture and design and has been taking increasingly more friendly forms, facilitating the visualization of 3D images. MR images demonstrate high contrast between organs and external surface. The physical models obtained by 3D US resulted in excellent impressions of the face, ears, hands, and feet. A combination of methods is also possible for building physical models. The technique of adding materials allows the conversion of a virtual 3D model to a physical model in a quick, easy, and dimensionally accurate process. The construction process transfers a 3D data file, resulting from the overlapping of individually segmented layers to an additive manufacturing or 3D printing equipment, which builds physical models through the overlapping of thin layers of raw materials [23].

Werner et al. [23] introduced the use of physical models in the research of fetal diseases, an area in which studies in digital modeling (3D) are scarce. The results suggest a new possibility in the interaction between the parents and the fetus during prenatal care, physically recreating the interior of the uterus during pregnancy, demonstrating the real size of the fetus, as well as its anatomy. One of the main concerns of this study was to obtain high quality images that could be manipulated with 3D software, without loss of precision. Fetal movements during image acquisition were one of the main difficulties, especially in MRI evaluation. This problem is less in US, because the image is acquired in real time and can be frozen during movement. However, the lower US contrast resolution caused, in some cases, difficulties in the limits of the gray scale. The quality of the process is directly associated with the accuracy of the mathematical data that will be used to generate the physical model. The images are acquired by slices that are superimposed for the realization of the model [23].

Physical models have an impact on the planning of medical interventions. They can also be used in fetal medicine for teaching purposes. The grayscale contrast between organs obtained by MRI is higher. This greater sharpness allowed an easy visual separation of the relevant areas. On CT, only the skeleton was easily identified. However, despite the better contrast obtained by MRI, there was initially a limitation in the number of cuts

obtained (about 30 to 40 cuts), making the result less precise. These printed models also allow tactile and interactive study of complex abnormalities in different disciplines. These techniques are also useful in relation to future parents, by recreating a 3D model with physical characteristics of the fetus, allowing a more direct emotional connection with the unborn child [23].

4. Conclusions

In recent decades fetal medical imaging has led to significant improvements in prenatal counseling and postnatal therapy options. Ultrasonography continues to be the exam of choice due to its availability, safety, and reasonable cost, but it has some limitations such as a small field of view, limited resolution of soft tissue contrast and low acoustic penetration in bone and fat. Magnetic resonance imaging (MRI) has been increasingly used for the evaluation of complex fetal anomalies and its advantages include high resolution of soft tissue contrast, imaging capability in any plane regardless of fetal positioning, and rapid acquisition with a large field of view.

Obstetric MRI mainly plays a role in complementing the morphological ultrasound study when there is any diagnostic doubt or even to confirm an abnormal finding on ultrasound examination. It is very useful mainly in studies of congenital alterations or of the Central Nervous System (CNS) and the spine. Fetal MRI facilitates accurate diagnoses, as it provides important anatomical information that may be useful in planning prenatal and early postnatal care, reducing perinatal morbidity and mortality. Developments and modifications to hardware and software used in MRI have improved its diagnostic accuracy in fetal studies. Several studies have emphasized the benefit of MRI in the evaluation of congenital brain and lung anomalies, as well as complex fetal syndromes.

The combination of certain placental abnormalities and fetal growth aberrations can result in an increased risk of fetal death, and a clearer view of placental findings and characteristics of these abnormalities can provide greater understanding, significantly contributing to the determination of clinical management. MRI provides a fetal and placental field of view with excellent resolution, providing volumetric and functional data. It can also achieve superior results when compared to ultrasound because the modality does not offer limitations related to the maternal-fetal axis, bone overlaps, amniotic fluid volume, obesity, or anomalous fetal position.

We identified that ultra-fast T2-weighted sequences correspond to the most used pattern and T1-weighted sequences demonstrate fat, calcifications, hemorrhages, meconium, placental displacement. The gestational study through MRI includes evaluation of the placenta, umbilical cord, and amniotic cavity. An accurate interpretation of all these structures can provide valuable information that helps prenatal counseling, facilitating therapeutic decisions. The most important indications for performing fetal magnetic resonance imaging include central nervous system anomalies such as corpus callosum anomalies (agenesia), holoprosencephalon, neural tube defects (meningoceles, meningomyelocele), anencephaly and iniencephaly, Chiari malformation, hydrocephalus; anomalies of the genitourinary tract represented by hydronephrosis, megaureter, multicystic renal dysplasia; chest anomalies, such as congenital diaphragmatic hernias, congenital malformation of the pulmonary airways (bronchogenic cysts), cystic hygromas (anomalies of vasculolymphatic origin - multilobed sacs filled with lymph) and other anomalies including amniotic band syndrome, congenital vascular malformations and conjoined twins . MRI still has an important indication in the evaluation of placental anomalies (placenta previa, placenta accreta and placenta increta), in addition to molar pregnancy (hydatidiform mole).

Although ultrasonography (US) remains the main method in the evaluation of fetal disorders due to its low cost and wide availability, fetal magnetic resonance imaging (MRI) has been frequently used as an adjuvant method in recent years. The improvement in image resolution, the formation of multiple contrasts between different tissues and the wide field of view and acquisition of images generated by equipment and software led to the growing use of fetal MRI facilitated by technological advances such as the ultra-fast

T2-weighted sequence and diffusion images. Fetal MRI can achieve superior or similar results to those of US, especially in cases of maternal obesity, oligohydramnios, or anomalous fetal position. Fetal MRI can evaluate large-volume fetal organs such as lungs, liver, colon, and kidneys. Fetal MRI also allows the examination of large or complex malformations, facilitating the understanding of the malformation in the context of the entire fetal body. Initially, the studies were directed to the central nervous system. With the advancement of software and hardware, fetal MRI has gained importance in the evaluation of the fetal abdomen cavity, as well as malformations in the abdominal cavity, including esophageal atresia and duodenal obstruction, as well as effusions in the abdominal cavity, such as meconium peritonitis and abdominal cysts including ovarian cysts which are the main cause of abdominal mass in female fetuses and mesenteric cysts.

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