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3D ultrasound in the diagnosis of uterine anomalies

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ABSTRACT

Congenital uterine malformations are genital tract anomalies that can arise at different stages in the development of the Müllerian ducts. Their exact epidemiology is unclear. Depending on the type of uterine anomaly, they can be asymptomatic or imply adverse reproductive outcomes (infertility, recurrent miscarriages, preterm labor), thus altering the quality of life. The American Society of Reproductive Medicine (ASRM) most common classification system divides uterine malformations into seven categories. The CONUTA (Congenital Uterine Anomalies) working group set up by the European Society of Human Reproduction and Embryology (ESHRE) together with the European Society for Gynecological Endoscopy (ESGE) developed and published in 2013 the new classification system of congenital uterine malformations which are grouped by classes according to common impairment of the primary embryological process, respectively formation, fusion, resorption. To plan their therapeutic management, one must first determine the exact type of uterine anomaly. Several methods can be used for diagnosing uterine anomalies. Three-dimensional ultrasound (3D-US) represents the essential diagnostic tool and should be used as the first line in most cases where the uterine malformation is suspected.

Keywords: uterine anomalies, Müllerian duct, three dimensional ultrasound, sonography, uterine cavity, infertility, recurrent miscarriage, fusion anomalies

INTRODUCTION

Congenital uterine malformations are anomalies in the development of the genital tract that can arise at any point during the Müllerian developmental process. They are not uncommon, but their true prevalence is unclear because many of them are not diagnosed during a routine visit. A recent meta-analysis concluded that uterine malformations affect 5.5-7% of women in an unselected population, 8% of infertile women, 13.3% of women with a history of miscarriages, and 24.5% of women who suffer from infertility and recurrent miscarriages (1).

Although congenital uterine anomalies are present at birth, most adult women fail to manifest noticeable symptoms. The spectrum of clinical manifestations is comprehensive, ranging from asymptomatic to severe symptomatology, usually in the context of miscarriage and/or infertility. In cases where pregnancy is achieved, some uterine anomalies can lead to poor perinatal outcomes (2).

Classification of uterine malformations is important to plan their therapeutic management. The American Society of Reproductive Medicine (ASRM) classification system, established in 1988, is the most frequently used set of criteria to determine uterine anomalies. The system includes seven categories: (a) segmental Müllerian agenesis and hypoplasia, (b) unicornuate uteri, (c) didelphys uteri, (d) bicornuate uteri, (e) septate uteri, (f) arcuate uteri, and (g) Diethylstilbestrol related anomalies (3).

The CONUTA (Congenital Uterine Anomalies) working group set up by the European Society of Human Reproduction and Embryology (ESHRE) together with the European Society for Gynecological Endoscopy (ESGE) developed and published in 2013 the new classification system of congenital uterine malformations which are grouped by classes ac-

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cording to common impairment of the primary embryological process, respectively formation, fusion, resorption:

- U0 class includes the normal uterus with linear or convex interostial contour, but with fundic identification of the cavity on the midline <50% of the thickness of the uterine wall
- U1Class dysmorphic uterus includes uterus with normal contour but with abnormally shaped cavity, exclusively septate: U1a Class uterus with a T-shaped cavity; U1b Class infantile uterus with cervico-uterine ratio 2/3; U1c Class uterus with minor deformity.
- U2 Class - septate uterus, includes cases with normal fusion and abnormal resorption of the common wall of the Müllerian ducts, normal external fundic contour, but with fundic identification of the cavity on the midline > 50% of the thickness of the uterine wall: U2a Class partially septated uterus; U2b Class uterus completely septate;
- U3Class bicorporeal uterus includes defects of fusion of the Müllerian ducts, abnormal external fundic contour with identification on the midline > 50% of the thickness of the uterine wall: U3a Class partially bicorporeal uterus; U3b Class complete bicorporeal uterus; U3c Class septate bicorporeal uterus (resorption defect added to the fusion one) with fundic identification on the midline> 150% of the thickness of the uterine wall;
- U4Class hemiuter defined as unilateral uterine development with incompletely formed or absent contralateral hemiuter: U4a Class hemiuter with rudimentary communicating / non-communicating functional cavity; U4b Class hemiuter without rudimentary functional cavity (non-functional or aplastic horn);
- U5 Class aplastic uterus includes all cases of uterine aplasia due to the failure of development of any type of cavity: U5a Class aplastic uterus with rudimentary functional cavity (uni/bilateral functional horn present); U5b Class aplastic uterus without rudimentary functional cavity;
- U6 Class unclassified cases.

Cervical and vaginal malformations are considered additional independent subclasses: C0 Class normal cervix; C1 Class septet cervix; C2 Class normal double cervix; C3 Class unilateral cervical apalzia; C4 Class cervical apalasia; V0Class normal vagina; V1 Class non-obstructive longitudinal vaginal septum; V2 Class obstructive longitudinal vaginal septum; V3 Class transverse vaginal septum and / or hymenal imperforation; V4 Class vaginal aplasia (4).

Several methods can be used for diagnosing uterine malformations. The most common method is conventional two-dimensional transvaginal ultrasound. The hysteroscopy could be performed to evaluate the uterine cavity, while laparoscopy is conducted to assess the external uterine contour. However, magnetic resonance imaging (MRI) and 3D-US are more advantageous, offering concomitant information about the outer contour and the uterine cavity. As an imaging technique, MRI has been considered for a long time the gold standard (5). Nevertheless, 3D-US offers significant advantages, such as being a non-invasive low-cost, and a reproducible method. Moreover, this technique also helps obtain the third coronal plane, therefore achieving the volumetric reconstruction of the uterus and offering highly valuable images of the uterine anomalies (Figures 1-4). For this reason, 3D-US could represent an alternative, viable method to MRI.

FIGURE 1. 3D Static ultrasound reconstruction of partial septate uterus (U2a)

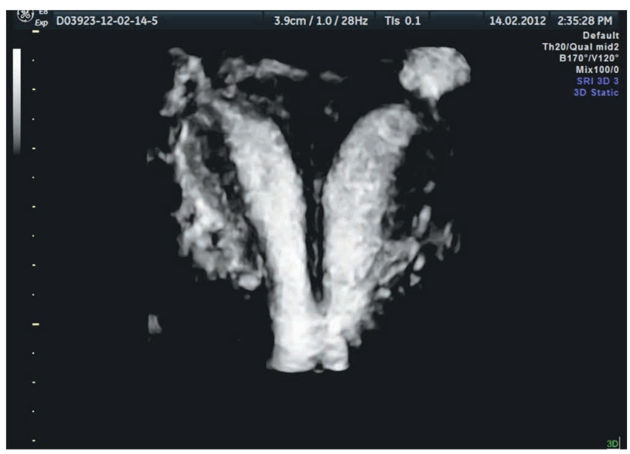

FIGURE 2. 3D Static ultrasound reconstruction of complet septate uterus (U2b)

In this article, we wanted to summarize current data on the usefulness of 3D-US imaging compared to other techniques in diagnosing uterine anomalies.

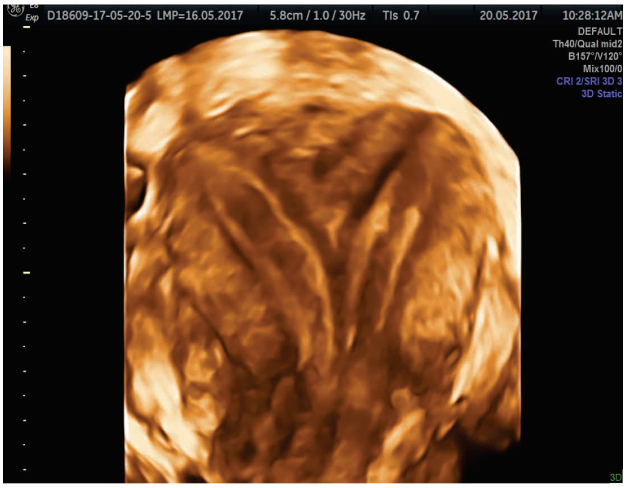

FIGURE 3. 3D Static ultrasound reconstruction of complete septet uterus including cervix (U2b, C1)

FIGURE 4. 3D Static ultrasound reconstruction of complete bicorporeal uterus (U3b)

Several studies have been conducted to highlight various aspects of 3D-US and compare these techniques to other methods. In the case of a uterine anomaly, an exact evaluation of both internal and external contours of the uterus is vital to confirm the diagnosis and classify the uterine malformation correctly.

THE USE OF 3D-ULTRASOUND IN CONGENITAL MALFORMATIONS

3D-US offers great sensitivity and specificity in uterine anomalies, having the following advantages: it can achieve the frontal (coronal) view of the uterus, which can not be obtained with 2D vaginal ultrasound and which is key for the diagnosis of Müllerian anomalies; orthogonal planes allow to view in the same image 3 spacial planes; the vocal mode permits semi-automatic volumetric calculation; the magic scissors cutting mode offers the possibility to remove the non interesting sonographic areas which are not wanted, leaving just the image of the organ that sonographer is studying; the TUI mode does serial images of the structure desired for studying, separated only by few millimeters (6).

3D-US imaging offers valuable information regarding almost each category of uterine anomalies.

Congenital aplasia

Congenital aplasia (U5 Class) or severe hypoplasia of structures derived from the Müllerian duct is the Mayer-Rokitansky-Kuster-Hauser (MRKH) syndrome. It represents 5% to 10% of all Müllerian anomalies (7). In this case, females lack a uterus, cervix, and upper third of the vagina, while having normal ovaries and the lower two-thirds of the vagina. MRKH sometimes associates subtle abnormalities in other organs, in which case sonography is not as reliable as MRI (8,9). The role of 3D-US in this particular case is limited because usually there is no uterine structure to reproduce (9). When a rudimentary uterus accompanies this Müllerian anomaly, it is usually located on the lateral pelvic walls, sometimes containing functioning endometrium. In these cases, ultrasound is also less reliable than magnetic resonance imaging in detecting the internal lining of the uterus. When the rudimentary uterus appears as small buds of less than 2 cm, laparoscopy prevails over both MRI and sonography (2,10).

Unicornuate uterus

Unicornuate uterus (U4 class) result from just one of the Müller`s ducts development, while the other one is either not developed or might be just partially developed and connected or not to the uterus (6). The unicornuate uterus accounts for 5% to 20% of all uterine malformations (7). In this case, 3D-US shows the uterine endometrial cavity with its reduced volume, indicating if the rudimentary horn has functional endometrium and if there is a communication or not. A large review on the management of uterine anomalies indicated that 3D-US has a high level of concordance to MRI in identifying U4 class malformations; it also concluded that the former can obtain high-resolution images while also being more cost-effective and not altered by bowel peristalsis (11).

Didelphys uterus

The third group of uterine anomalies consists of the didelphys or bicorporeal uterus, a fusion anomaly representing 5% of all uterine malformations (7). In this case, both Müllerian ducts fail to fuse at the midline, leading to the complete but independent development of two hemiuteri and thus of two genital hemi systems. A vaginal septum is usually present in three-quarters of cases (6). 3D-US has a high value in cases of didelphys uterus, since it can evaluate the external contour of the uterus. This element is the distinguishing feature of fusion anomalies. 3D-US shows two hemiuteri, appearing as two uterine horns widely divergent, separated by an external deep cleft. In addition, two cervices can be documented by sonography (12). In a prospective study published by Bermejo et al. in 2013, the authors investigated the accuracy of 3D-US in the diagnosis of uterine anomalies, which involve also the cervix and the vagina. They concluded that 3D-US and MRI are highly efficient in assessing anomalies of cervix and vagina, with 3D-US being slightly inferior to MRI (13).

Bicornuate uterus

The bicornuate uterus, a subclass of the U3 bicorporeal uterus class previously discussed, results also from the incomplete fusion of the two Müllerian ducts, but the separation has a variable degree (6). The bicornuate uterus represents 10% of all uterine malformations (7). On 3D-US, the anomaly is characterized by two well-formed, divergent endometrial cavities within a single uterine body with an external cleft ≥ 1cm by old classification, or > 50% of the thickness of the uterine wall by the new one. In the (ASRM)'s classification system, the element differentiating the didelphys uterus from the bicornuate uterus is the presence of fundal soft tissue, which creates the separations between the two endometrial cavities (12). When it comes to comparing 3D-US to other imaging techniques, the former has several advantages. First, 3D-US creates the possibility to differentiate the bicornuate uterus from the septate uterus without the need to perform a diagnostic laparoscopy, supplementary using its innovative tools such as TUI or the Doppler angiography. In the case of a bicornuate uterus, the two endometrial cavities are not separated by a sept, thus there is no vascularization seen between them on Doppler angiography as is the case of a septate uterus (6). Second, it has been reported that 3D-US is at least as accurate as MRI in diagnosing a bicornuate uterus, reaching an accuracy of 77% to 100% (14).

In a large study done by Bermejo et al. in 2010, including 286 women diagnosed with uterine anomalies, the authors concluded that 3D-US and MRI have a high degree of concordance in assessing uterine anomalies. With both methods, the relationship between uterine cavity and fundus is pictured equally well, being mostly advantageous in the cases of bicornuate, septate, and arcuate uteri (15). Another study comparing 3D-US to other imaging techniques in patients with suspected septate or bicornuate uterus concluded that three-dimensional transvaginal ultrasound is highly accurate to diagnose and differentiate between the two uterine anomalies and that it should be recommended as the first and only tool in the assessment of uterine structure in patients with the suspected anomalies, especially before surgery is planned. The authors suggested that MRI should be used for patients who cannot undergo 3D transvaginal sonography, like virgins (16).

Septate uterus

The septate uterus represents U2 class of uterine anomalies. In this case, the uterine septum fails to reabsorb, resulting in partial or complete septate uterus (6). It is the most frequent uterine anomaly, accounting for 55% of Müllerian malformations (7). As mentioned above, 3D-US offers valuable information, differentiating this anomaly from the bicornuate uterus (6,15). The 3D-US's sensitivity, specificity, positive predictive value, and negative predictive value reaches a near-perfect level (17,18). The sensitivity of 3D-US is 98% to 100%, while specificity reaches 100% in assessing septate uteri (19). Tools of 3D-US such as VOCAL, TUI, and magic cut to improve the technique (6). In a study investigating whether 3D-US is a valid replacement method to hystero-laparoscopy in differentiating between fusion and resorption uterine anomalies, Ahmed et al. found absolute concordance between 3D-US and the later method (20). Septate uteri need to be differentiated from fusion anomalies, since the former can be managed in most cases by hysteroscopic septoplasty, while the later need more complex interventions (21).

Arcuate uterus

The arcuate uterus represents a minor anomaly, accounting for 5-10% of all uterine malformations (7). The characteristic finding on ultrasound is the arched inner contour of the fundus. The external contour of the fundus is normal. While the arcuate uterus is generally considered a normal variant, limited evidence suggests that it can be associated with recurrent miscarriages (22). Several studies show that 3D-US identified the anomaly in cases where conventional sonography failed to diagnose it (23).

The U1a class consists in uterine anomalies mainly but not always related to the *in utero* exposure to dietilestilbestrol (DES), a drug used before the 1970's to treat an obstetric complication such as bleeding in the first trimester, spontaneous abortions, premature delivery, or hypertension-related disorders in pregnancy. After vaginal cancer was detected in adolescents exposed in utero to DES, the drug was banned. On ultrasound, this anomaly consists of a T-shaped uterine cavity. This phenomenon results from uterine constriction produced by the hypertrophic myometrium adjacent to the atrophic areas (6).

CONCLUSIONS

Uterine malformations are fairly prevalent anomalies and can cause gynecological and obstetric complications, altering the quality of life, mostly by causing infertility, recurrent pregnancy loss, or poor pregnancy outcomes.

Along the time, several classification systems have been proposed in order to group and facilitate the management of uterine anomalies, the 1988 American Society of Reproductive Medicine classification system remaining the most commonly used by now.

There is increasing evidence supporting the use of three-dimensional sonography in the assessment of uterine anomalies, except for uterine agenesis or hypoplasia, where MRI prevails.

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