The Egyptian Journal of Radiology and Nuclear Medicine 49 (2018) 571–578

Contents lists available at ScienceDirect

The Egyptian Journal of Radiology and Nuclear Medicine

journal homepage: www.elsevier.com/locate/ejrnm

Original Article

MRI is it complementary or mandatory to ultrasound in classification of different congenital anomalies of female reproductive tract?

Yasmin Mounir Tohamey[a,*], Asmaa Mahmoud Abdel Magied[a], Lamia Adel Salah El Din[a], Reham Ashraf Mohamed[b]

[a] Diagnostic and Interventional Radiology Department, Faculty of Medicine, Cairo University, Egypt
[b] Gynecology and Obstetrics Department, Cairo University, Egypt

ARTICLE INFO

Keywords:
US
MRI
Mullerian duct
Anomalies

ABSTRACT

Aim of work: To assess the added value of MRI compared to US in diagnosis of Mullerian duct anomalies and its subtypes thus guiding proper management plans.
Patients and methods: From October 2014 to March 2015 we prospectively evaluated 50 female patients, ranging in age from 15 to 40 years. They were referred for US and MRI assessment of clinically suspected Mullerian duct anomalies.
Results: Final diagnosis of patients includes: 8/50 (16%) cases were classified as **class I**, 10/50 (20%) cases were classified as **class II**, 22/50 (44%) cases were classified as **class III**, 5/50 (10%) cases were classified as **class IV** and 5/50 (10%) cases were not MDA. MRI was superior to US, with reported diagnostic accuracy of 100%.
Conclusion: The use of diverse imaging modalities, in conjunction with clinical information, provided important clues to the diagnosis of MDAs. The imaging work-up for MDAs usually begins with ultrasound. Although it might have been suffice to detect the presence of a uterine abnormality, MRI was generally needed to classify the abnormality into a specific MDA category.

1. Introduction

The Müllerian duct anomalies (MDA) enclose a broad spectrum that ranges from agenesis to duplication varieties to minor uterine cavity anomalies [1].

The mean incidence rate of uterine malformations is 4.3% of the general population and/or for fertile women, about 3.5% in infertile women and about 13% in women with recurrent pregnancy losses [2].

Infertility and repeated first trimester spontaneous abortions register high incidence among MDA patients. The role of imaging is to detect and classify these MDA so that proper treatment is implemented [3].

There are many classification systems for **congenital utero-vaginal anomalies**. The modified Rock and Adam Classification is most common one encountering four classes [4].

Ultrasound (US) still remains the primary radiological assessment tool in evaluation of patients with MDA for being quick, safe, available and economic yet still has some limitations. Magnetic resonance imaging (MRI) with its multiplanar capability and tissue characterization is now considered the best imaging modality for MDA assessment. It lacks radiation and provides clear delineation of both the internal and the external uterine anatomy [5].

Precise differential diagnosis of MDAs based on their characteristic MR imaging findings is crucial owing to the variable rates of gynecologic and obstetric complications among MDAs [5].

MRI should be considered as an adjunct to ultrasound to evaluate Mullerian anomalies [6].

The aim of the study is to assess the added value of MRI compared to US in diagnosis of Mullerian duct anomalies and its subtypes thus guiding proper management plans.

2. Patients and methods

The study was approved by the hospital ethical committee and an informed consent was obtained from all patients. From October 2014 to March 2015 we prospectively evaluated 50 female patients, ranging in age from 15 to 40 years (mean age = 21.78 ± 4.6). Forty-six of them were married with 4 virgins.

Patients with clinically suspected Mullerian duct anomalies were referred from the Gynecology Department to the Radiology Department

Peer review under responsibility of The Egyptian Society of Radiology and Nuclear Medicine.
* Corresponding author.
E-mail address: yasminmounir@gmail.com (Y.M. Tohamey).

https://doi.org/10.1016/j.ejrnm.2018.01.011
Received 26 May 2017; Accepted 15 January 2018
Available online 01 May 2018

Table 1
MRI sequences used in the study.

Sequence	TR (msec.)	TE (msec.)	FOV (mm)	Matrix	Slice thickness (mm)
T2 sagittal	3000	90	290 × 290	208 × 205	4
T2 axial	3700	100	288 × 350	292 × 180	5
T1 axial	500	10	260 × 216	263 × 171	5
T1 SPAIR axial	530	8	240 × 240	240 × 190	5
T2 coronal	5000	90	300 × 300	272 × 200	4.5

(Women's imaging unit) for US and MRI assessment.

Out of the 50 cases, 24/50 (48%) cases presented with primary amenorrhea, 23/50 (46%) cases presented with secondary infertility and 3/50 (6%) cases presented with cyclic pelvic pain.

2.1. Methods

1. Pelvic Ultrasound technique for MDA:
   - All patients underwent preliminary ultrasound examination. The examination was done on ultrasound machine GE logic 7.
   - Transabdominal examination was performed through a moderately

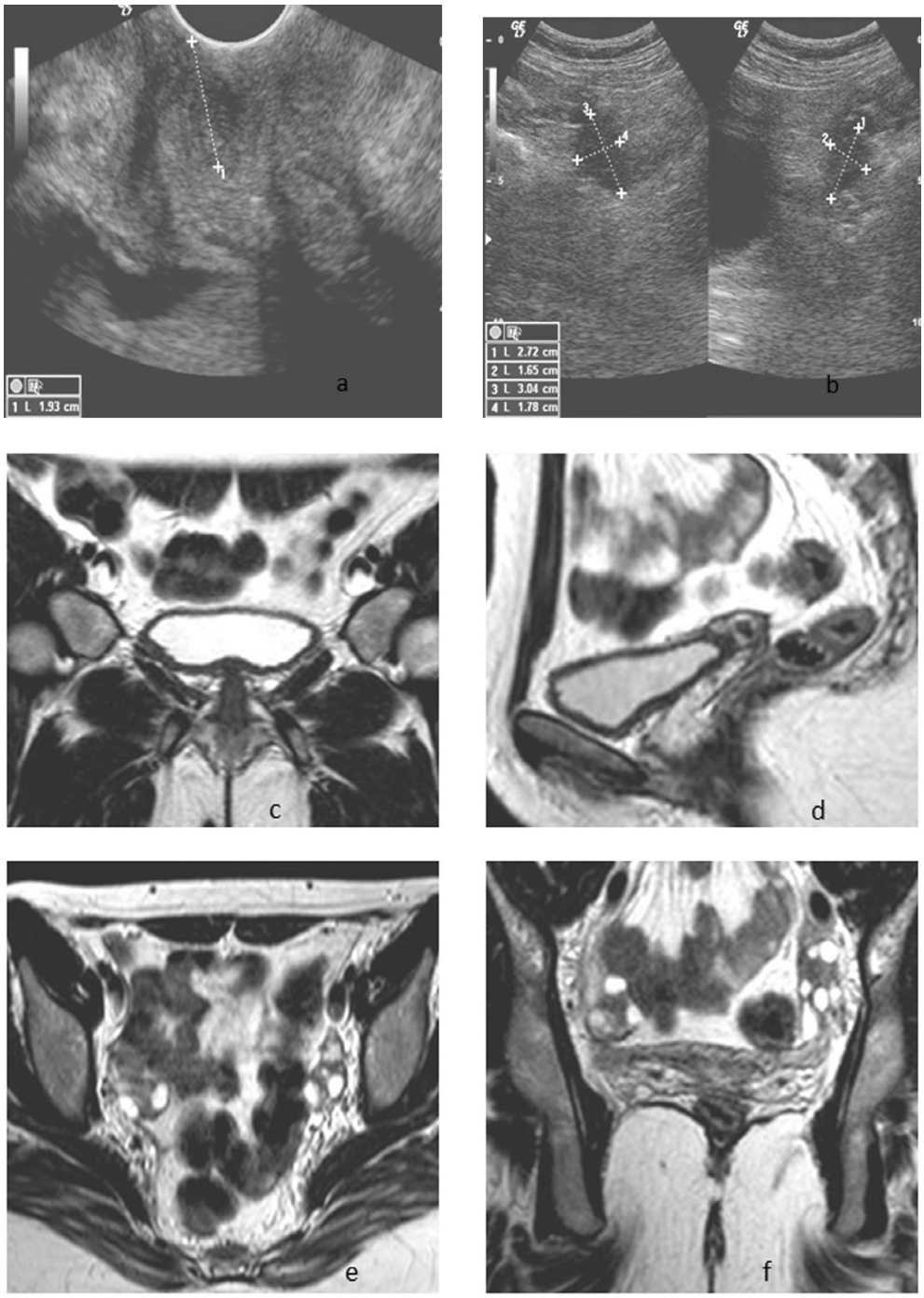
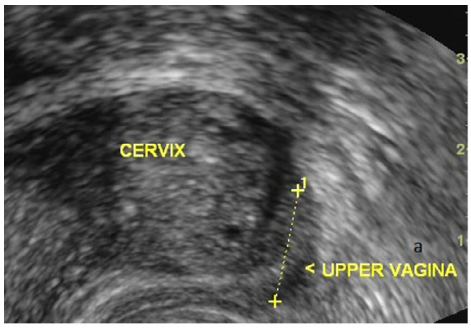
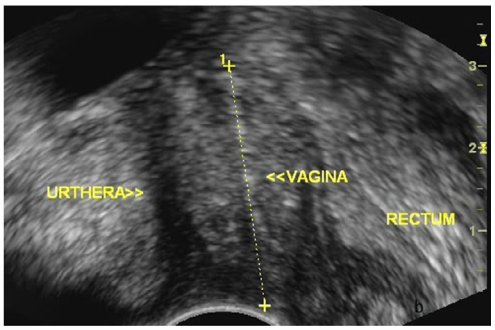
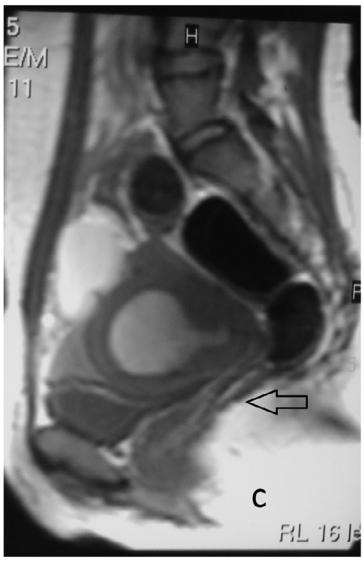


Fig. 1. A female patient, 34 year- old, married, presenting with 1ry amenorrhea. Mayer-Rokitansky-Kuster-Hauser syndrome (MRKH). TVUS showed absent Uterus and cervix. Blind vaginal pouch measuring 1.9 cm (Fig. 1a). Two well developed ovaries were visualized (Fig. 1b). MR Coronal T2 showing complete absence of the uterus and cervix (Fig. 1c). Sagittal T2 shows blind vaginal pouch (Fig. 1d). Axial and coronal T2 showing bilateral ovaries with follicular activity (Fig. 1e and f).







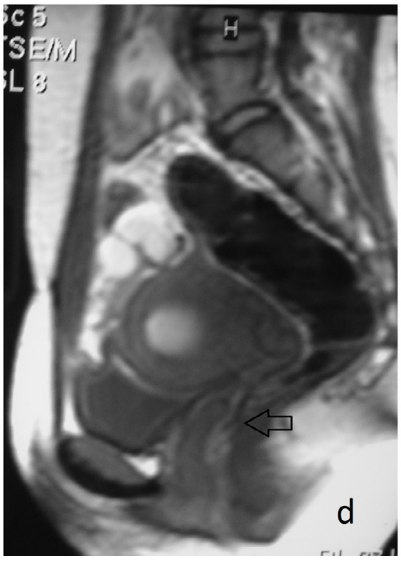
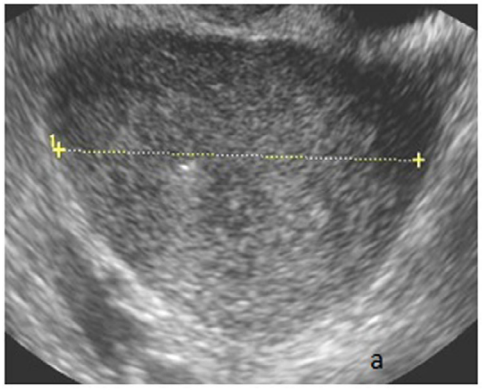
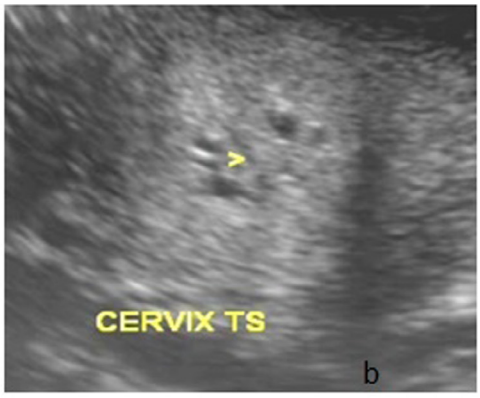
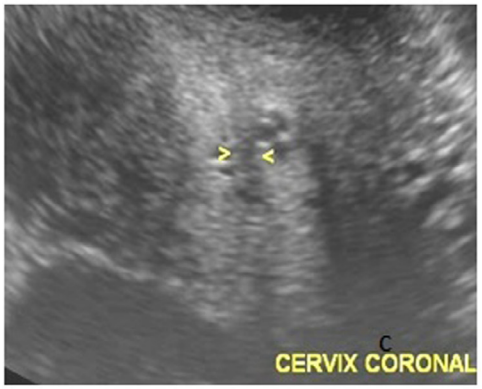


Fig. 2. A female patient, 16 year-old, virgin, presenting with 1ry amenorrhea and cyclic abdominal pain. Vaginal atresia. **U/S** showed atretic upper third of the vagina (1.3 mm) (Fig. 2a), patent well developed lower two thirds of the vagina (Fig. 2b). MRI (T2 Sagittal images) revealed distended uterine cavity with blood signal fluid (hyper intense T2) (Fig. 2c). A non-communicating atretic tract extending between the cervical canal and distal vagina (arrow) (Fig. 2d).







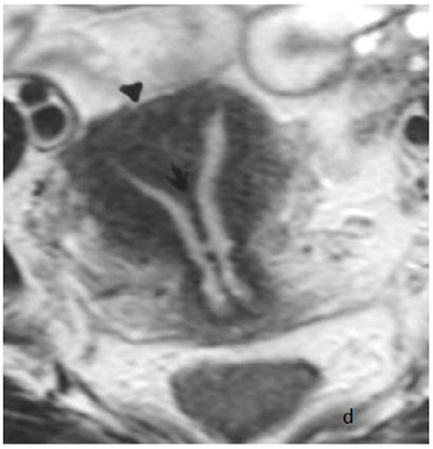


Fig. 3. A female patient, 23 year-old, married, presenting with 2ry infertility for TVUS. Septate uterus. **TVUS** revealed increased transverse diameter (6.2 cm) of the uterus with preserved external fundal contour (Fig. 3a). Two separate endometrial cavities are noted with a thin septum in between reaching down to the cervix (Fig. 3b and c). MRI revealed preserved external fundal contour MRI (T2 Coronal Oblique images) shows duplicated hyper intense endometrial cavities separated by a hypo intense septum reaching down to the cervix (Fig. 3d).

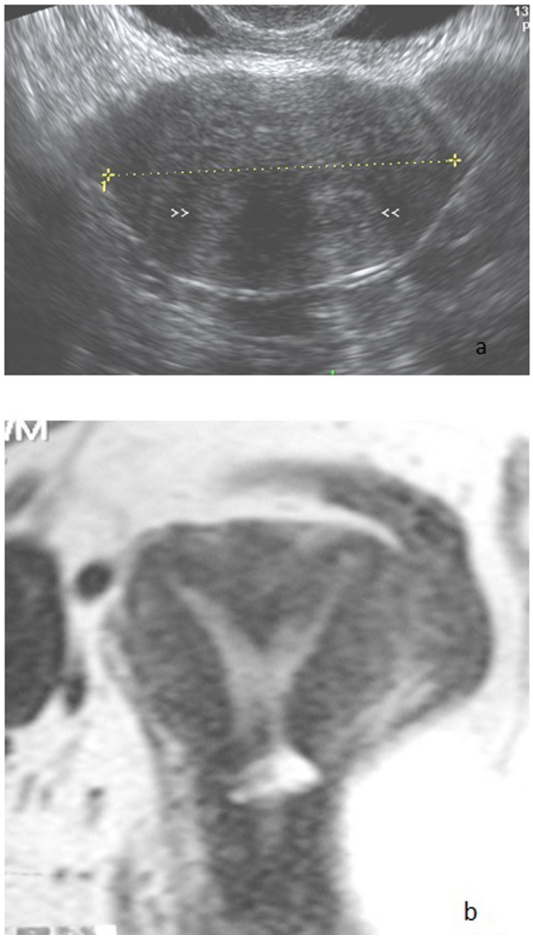


Fig. 4. A female patient, 24 year-old, married, presenting with 1ry infertility. **TVUS** (Fig. 4a) revealed increased transverse diameter (5.7 cm) of the uterus with preserved external fundal contour. Two separate endometrial echoes are noted. **MRI** revealed preserved external fundal contour. (T2 Coronal Oblique images) shows duplicated hyper intense endometrial cavities with a hypo intense septum in between. Both endometrial cavities join to form a single cervical canal (Fig. 4b).

full bladder, using 3–4 MHz transducer.

- Transvaginal ultrasound was performed by introduction of a 7–8 MHz probe in the vagina. Bladder was empty.
- Transperineal in 4 virgin cases for additional illustration.
- Sagittal images were obtained by scanning in the same plane as the uterus, parallel to its long axis together with axial and coronal planes.

2. MR Imaging:

- MR imaging was performed on 1.5 MRI system using two machines (Intera and Achieva, Philips medical system, The Netherlands). All the patients were imaged in the supine position with the aid of pelvic phased-array coil. (SENSE XL Torso coil 16 channels). Patients were instructed to have full bladder prior to examination. Also, before the examination, patients were routinely questioned about any contraindication for MRI examination and instructed to remove any metal objects.

2.2. MR imaging protocol

The following MRI sequences were performed in all patients:

- An inversion-recovery image of the uterus in the sagittal plane was obtained initially to determine uterine lie. Fast spin-echo (FSE) T2-weighted images were then acquired parallel to the long axis of the uterus to characterize the external uterine contour in coronal plane, depending on uterine lie.
- For the purpose of MDA classification, coronal oblique T2-weighted images of the uterus were the most critical, since these were necessary for proper assessment of the uterine fundal contour. Finally, a coronal fast-spoiled-gradient-echo image or a single-shot fast spin-echo T2-weighted image was obtained by using the body coil, with a large field of view to enable assessment of the kidney.
- Imaging parameters are demonstrated in (Table 1).

2.3. Image analysis

Ultrasound through different approaches and MR pelvic images were reviewed to assess anomalies regarding genesis, hypolasia, canalization, duplication, obstruction, fusion anomalies or associated pelvic lesions.

Ultrasound image analysis:

- The cervix and vagina are seen in midline sagittal plane, with the cervix is barrel in shape with central echogenic endocervical canal. The vagina is seen as a collapsed, hypoechoic tubular structure between the urethra anteriorly and the rectum posteriorly. The cervix and vagina were best evaluated by transvaginal scanning. Transabdominal approach was efficient in identifying collections (hematometrocolpos), usually seen as cystic mass with diffuse low level internal echoes.
- The uterus is differentiated from the cervix by thick myometrial wall and mild distention of the cavity of the uterus, as compared with the thin and often imperceptible wall of the vagina.
- Transabdominal scan is also used to check renal anomalies.

MRI image analysis:

o Uterus:

(a) **Size:** Uterine length was measured, it normally measures 6–9 cm and the uterine body to cervix ratio is 2:1 when measured in the sagittal plane.

(b) **Inter-cornual distance:** The distance between the distal ends of the horns was measured in the oblique long-axis images and is normally 2–4 cm.

(c) **External fundal contour:** The external contour of the uterus was normally convex and was best detected in long-axis oblique images.

(d) **Zonal anatomy:** Zonal anatomy is the differentiation between the high-signal-intensity endometrium, the low-intensity junctional zone (inner myometrium), and the intermediate-intensity outer myometrium, as depicted in T2-weighted images. It is normally seen in the reproductive age group.

(e) **Uterine septum:** Evaluating its presence, its signal intensity and extent are assessed.

(f) **Inter-cornual angle**

(g) The inter-cornual angle is the angle between the most medial aspects of the two uterine hemi cavities.

(h) **Obstruction:** Distended blood-filled uterus/cervix and in extreme cases blood-filled fallopian tubes (hematosalpinx) show the characteristic signal pattern of altered blood and blood products. The level of obstruction was determined.

o Vagina

The vagina was normally seen as a tube of intermediate signal intensity between the bladder base and urethra anteriorly and the anal canal posteriorly. The direction and extent of a vaginal septum was assessed if present. The obstruction site of a blood-filled vagina (hematocolpos) was estimated.

o Gonads

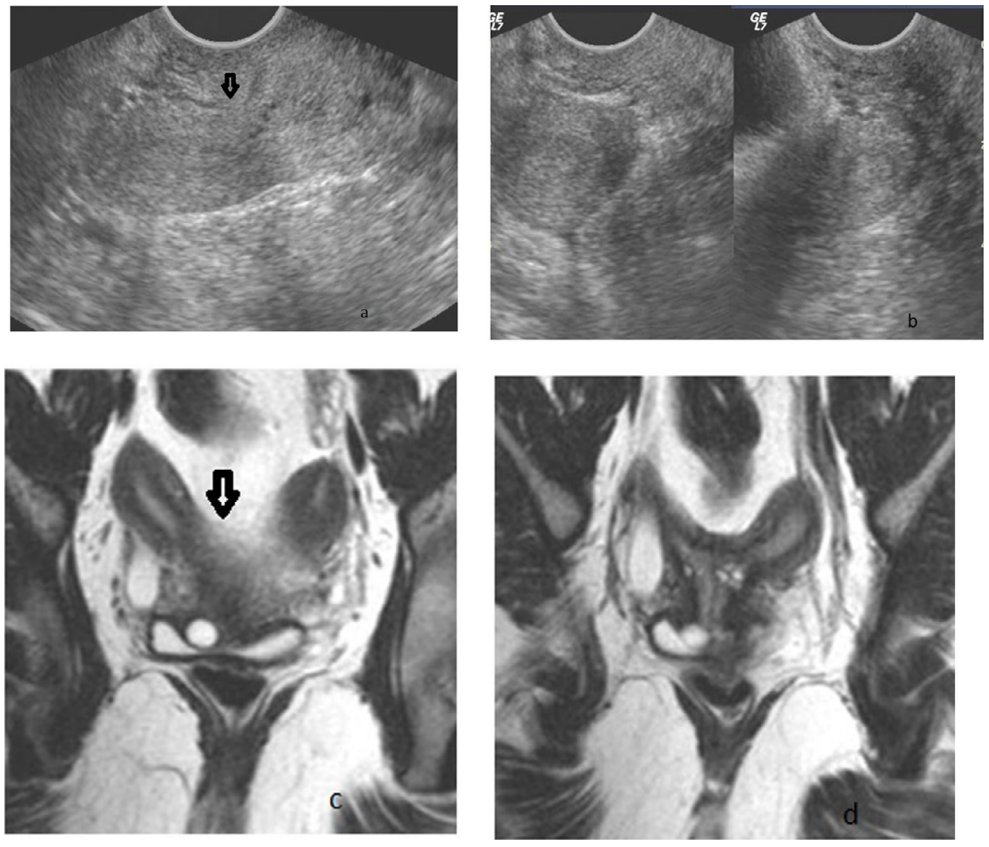


Fig. 5. A female patient, 27 year- old, married, presenting with 2ry infertility for TVUS. Bicornuate unicollis uterus proved by laparoscopy. TVUS revealed disturbed circumferential uterine contour (arrow) (Fig. 5a). Two endometrial cavities. (Fig. 5b) MRI (T2 coronal oblique) revealed deep fundal cleft (arrow) with increased intercornual distance. Both endometrial cavities join to form a single endocervical canal (Fig. 5c and d).

Both ovaries were identified. Any associated lesions such as endometriosis was noted.

o Associated pelvic lesions or renal anomalies

Any associated pelvic lesions or renal anomalies were reported.

Finally patients were classified according to Modified Rock and Adam classification which is divided into 4 classes: Class I dysgenesis of Müllerian ducts that comprises agenesis or hypoplasia of the uterus and upper two-thirds of the vagina with the most common form is Mayer-Rokitansky-Kuster-Hauser syndrome (MRKH). **Class II** disorders of vertical fusion they include cervical dysgenesis and obstructive and non obstructive transverse vaginal septa. **Class III** disorders of lateral fusion describes anomalies that result in a full or partial reproductive tract duplication. **Class IV** unusual combinations of defects such as Herlyn-Werner-Wunderlich (HWW) syndrome a very rare congenital anomaly a triad of uterus didelphys, obstructed hemivagina and ipsilateral renal agenesis [4].

Statistical analysis:

- Data were statistically described in terms of range, mean standard deviation (SD), frequencies (number of cases) and percentages when appropriate.
- Accuracy was represented using the terms sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy.
- Findings of US and MRI were correlated with findings of diagnostic laparoscopy, hysteroscopy and surgical findings in some operated cases.

3. Results

Forty-five out of fifty patients included in the study were diagnosed as follows: 8/50 (16%) cases were classified as **class I**, 10/50 (20%) cases were classified as **class II**, 22/50 (44%) cases were classified as **class III**, 5/50 (10%) cases were classified as **class IV** and 5/50 (10%) cases were not MDA.

- According to imaging findings ***Class I*** included 12 cases: 8 true cases and 4 false cases. 6/12 (50%) cases were pure MRKH (Fig. 1), 2/12 (17%) cases were MRKH with rudimentary horns, 4/12 (33%) cases were not MDA (Androgen insensitivity syndrome). 10/12 (84%) cases were correctly diagnosed on ultrasound, with one FP (testicles mistaken for ovaries) and one FN case (virgin with bad resolution on abdominal and transperineal approaches). All cases were correctly diagnosed on MRI (accuracy 100%). The diagnostic indices of U/S were sensitivity = 87.5%, specificity = 75%, PPV = 87.5%, NPV = 75% while MRI were sensitivity = 100%, specificity = 100%, PPV = 100%, NPV = 100%.
- ***Class II*** included 10 cases: 6 cases of vaginal (Fig. 2) and 4 cases of cervical atresia. Both U/S and MRI showed 100% sensitivity and specificity in the diagnosis of the presence and level of obstruction.
- ***Class III*** included 23 cases: 22 true cases and 1 false case. 22/23 (95.7%) cases were Class III MDA (Figs. 3–6). 1/23 (4.3%) case was not MDA. It was misdiagnosed by US of having double uterine cavities however, pelvic MRI showed single uterine cavity and the false cavity was thick walled endometrioma). 15/23 (65%) cases were correctly diagnosed on ultrasound, with reported sensitivity of 68.2%, PPV = 93.7%. All cases were correctly diagnosed on MRI with sensitivity, specificity, PPV and NPV = 100%.
- **Class *IV*** included 5 cases (10%). 3/5 (60%) cases were diagnosed as didelphys uterus with obstructed hemivagina and absent kidney on the obstructed side (Fig. 7). 1/5 (20%) case was diagnosed as septate uterus with pelvic right kidney. 1/5 (20%) case was diagnosed as MRKH with left rudimentary horn and absent right kidney. Both U/S and MRI correctly diagnosed all cases, with reported accuracy, sensitivity and specificity of 100%.
- Comparison between the diagnostic performance of US and MRI is

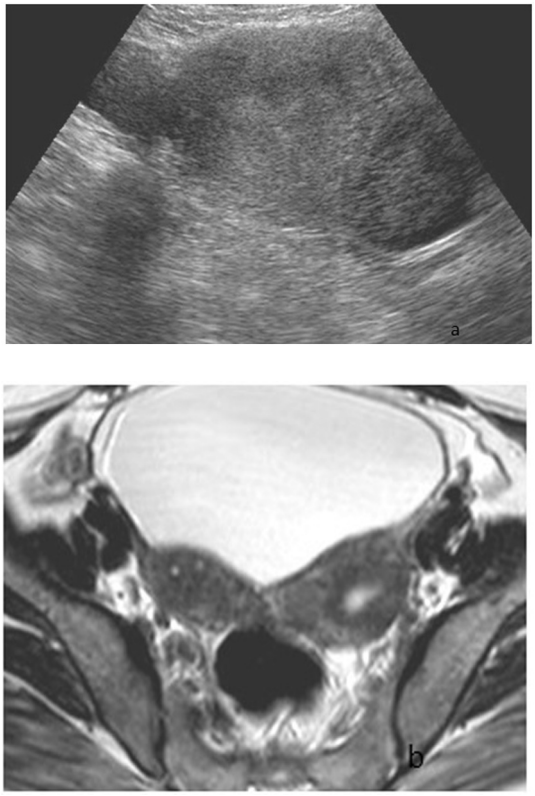


Fig. 6. A female patient, 39 year-old, married, presenting with 2ry in fertility for TVUS. Unicornuate Uterus with right rudimentary horn. **TAUS** revealed double uterine cavities, the right one is rudimentary horn while the left is functioning. (Fig. 6a). **MRI** coronal T2 revealed double uterine cavities, non-communicating. MRI shows unilateral left functioning uterine cavity with right rudimentary horn (Fig. 6b).

demonstrated in Tables 2 and 3. MRI was superior to US regarding the diagnosis and classification of MDA.

4. Discussion

Müllerian duct anomalies (MDAs) represent a broad spectrum of developmental abnormalities related to various gynecologic and obstetric complications, including primary amenorrhea, infertility, and endometriosis. The integration of both clinical information and use of diverse imaging modalities, provides important clues to the diagnosis of MDAs [6]. The role of imaging is to help detect, diagnose, and distinguish surgically correctable forms of müllerian duct anomalies from inoperable forms [7].

In this study we evaluated the added value of MRI to initial ultrasound evaluation of different Mullerian duct anomalies.

Among 50 cases with initial diagnosis of MDA only 45 cases were finally diagnosed as so, whereas 5 cases were not, 4 cases on clinical and hormonal evaluation were assorted as Androgen sensitivity syndrome and one case was normal cavity with adjacent thick wall endometrioma misdiagnosed as class III.

The most common anomaly encountered in our study was the septate uterus which represents 12/45 (26.6%) of our study population. Thus was in agreement of Robins et al. [1], who reported that septate uterus is the most prevalent one among MDA anomalies.

Ultrasonography findings can add support to the clinical findings suggesting the absence of uterus and fallopian tubes in the presence of normal ovaries [8]. In our study, 8 cases were finally diagnosed as C***lass I***, 6 cases were pure MRKH with complete absence of uterus and cervix correctly seen by ultrasound.

Complete androgen insensitivity syndrome is caused by complete end-organ resistance to androgens. These patients have a female phenotype yet 46XY karyotype with functioning testes. They are often raised as female until investigation for primary amenorrhoea uncovers the true diagnosis [9]. Robins 2015 [1] stated that the hormonal profile is that of a normal female with age-appropriate luteinizing hormone, follicle-stimulating hormone, estradiol, and testosterone levels. This profile helps distinguish the MRKH syndrome from androgen insensitivity syndromes in which postpubertal testosterone is elevated which was the scenario in our study, where four cases presented with 1ry amenorrhea initially suspected as class I were not MDA on final diagnosis where hormonal profile revision confirmed (Androgen insensitivity syndrome). One case was missed by US, whereas MRI showed undescended testes in all four cases.

MRI is extremely useful in detecting absence of the vagina and uterus on an adequate technical image that confirms the diagnosis of agenesis or hypoplasia. This modality can also depict a rudimentary uterus and any coexisting renal abnormalities [8]. Two cases MRKH with rudimentary horns were seen in our study one of which was missed by ultrasound and both were seen on MRI.

Concerning **Class III** 23 cases were included; 12 cases (52.2%) were septate, 4/23 (17.4%) cases unicornuate, 1/23 (4.3%) case didelphys, 5/23 (21.7%) cases bicornuate. 1/23 (4.3%) case was a thick walled endometrioma and was mis-diagnosed as a double uterine cavity by pelvic U/S. MRI was superior to US in the diagnosis of class III MDA, with reported accuracy of US is 65% compared to 100% of MRI.

The sensitivity of ultrasound examination in Mullerian diagnosis has been reported to be as low as 44% [10]. The limited ultrasound sensitivity in our study was encountered in **class III** (68.2%) owing to the limited diagnostic accuracy in determination of the rudimentay horns in cases of unicornuate uterus (3cases), wrongly interpreting septate for arcuate uterus (1 case) and differentiating bicornuate from septate entity (3cases). We attributed this to the patients' body type, poor resolution of images to see the rudimentary horn and poor operator interpretation.

MR imaging by far supersedes ultrasound in delineating the external uterine fundal contour, allowing for definite differentiation between a fusion anomaly (didelphys or a bicornuate uterus) showing fundal cleft and a resorption anomaly like a septate uterus without a fundal cleft.

This differentiation is also clinically relevant, as the septate uterus has the worst obstetric outcome of all müllerian duct anomalies, with high abortion and pregnancy complication rates compared with bicornuate uterus [11]. These complications are related to the abscence of blood supply to the fibrous septum. The septum can be removed at hysteroscopy, significantly increasing the chance of full term pregnancy [12]. In 4 cases out of 12 septate uterus transvaginal hysteroscopic septal resection was done 5 months later these four cases were able to conceive.

Another value for MRI is revealing the type of the septum whether muscular or fibrous [13] displaying different signal intensity of each where the muscular type shows signal similar to myometrium whereas the fibrous type shows hypointense signal on T2. Each entity has different surgical approach. Of total 12 cases septate uterus the fibrous type was seen in our study.

Another limited diagnostic efficiency of ultrasound is the proper assessment of the septum extent whether partial or complete reaching down to the external os level, a feature supreme assessed by MRI in our study where 11 cases were complete and 1 partial.

Regarding the unicornuate category MRI revealed a unicornuate uterus as a slender curved, laterally deviated banana-shaped cavity [14,15] which was demonstrated in four cases in our study conforming to Brown et al. [14] description.

MRI was superior in this study to US in better classification of different MDA anomalies where US had sensitivity of 82.2%, specificity of 60%, PPV of 94.8%, NPV of 27.3% and accuracy of 80%. While MRI had sensitivity of 100%, Specificity of 100%, PPV of 100%, NPV of 100% and accuracy of 100%.

Our results were comparable with another prospective study conducted by (Console, 2001) [16] 22 patients were investigated with MRI

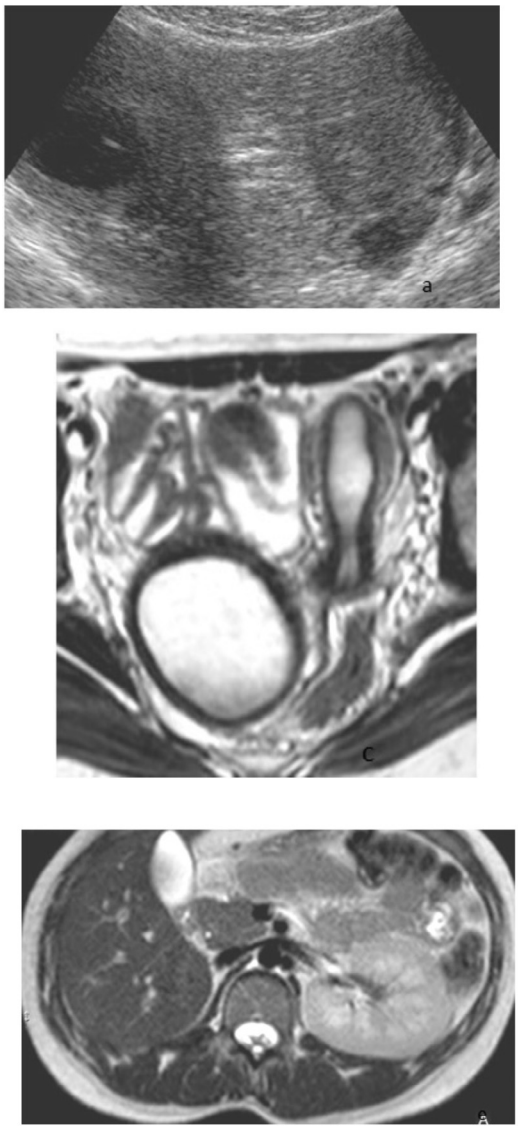


Fig. 7. A female patient, 28 year-old, married, presenting with 1ry infertility and cyclic abdominal pain. Didelphys Uterus with obstructed right hemi-vagina and left cervical atresia. **TVUS** revealed double endometrial cavities with distended right horn (Fig. 7a). **MRI** Coronal and Axial T2WI show duplicated uterine cavity showing two separate widely apart non-communicating uterine horns of apparently different sizes, The largest horn (right one) is an enclosed cavity with no cervical canal and the smallest horn (left one) is seen communicating with an atretic cervical canal (Fig. 7b–d). Also, the patient had absent right kidney (possible Herlyn-Werner-Wunderlich (HWW) syndrome (Fig. 7e).

Table 2
Distribution of final diagnosis cases by U/S and MRI.

	TP	*FP*	*TN*	*FN*
U/S	37	2	3	8
MRI	45	0	5	0

Table 3
Comparison of diagnostic indices of U/S and MRI.

	Sensitivity	Specificity	PPV	NPV	Accuracy
U/S	81.25%	60%	92.86%	33.33%	78%
MRI	100%	100%	100%	100%	100%

and U/S and correlated with laparoscopic and hysteroscopic findings. MRI allowed correct diagnosis of 21 uterine anomalies (accuracy, 95%) whereas U.S. was correct in 20 of 22 cases (accuracy, 92%).

Another study (Woelfer, 2002) [17] comprised of subgroup of 19 patients clinically diagnosed as ***Class I*** who underwent pelvic MRI to evaluate for the presence of a uterus or uterine remnants, the accuracy reported was (16/19 patients [84%]) is less than the excellent accuracy (100%) reported in our study .

Ultrasound remains the modality of choice for the initial study of patients suspected to have MDAs [13]. MRI should not be systematically used but reserved for particularly complex cases, although its sensitivity is reported to approach 100% [18]. This study proposed, in accordance with many authors in the literature, to reserve MRI imaging for patients with a technically inadequate or indefinitive ultrasound examination.

5. Conclusion

The use of diverse imaging modalities, in conjunction with clinical information, provided important clues to the diagnosis of MDAs. The imaging work-up for MDAs usually begins with ultrasound. Although it might have been suffice to detect the presence of a uterine abnormality, MRI was generally needed to classify the abnormality into a specific MDA category.

Accurate imaging evaluation of MDAs should decrease the need for invasive diagnostic techniques, such as laparoscopy and hysteroscopy which can hopefully be reserved for those women requiring therapeutic intervention.

Conflict of interest

We have no conflict of interest to declare.

References

[1] Robbins JB, Broadwell C, Chow LC, Parry JP, Sadowski EA. Müllerian duct anomalies: Embryological development, classification, and MRI assessment. J Magn Reson Imaging 2015;41:1–12. http://dx.doi.org/10.1002/jmri.24771.

[2] Grimbizis GF, Tsalikis T, Mikos T, Papadopoulos N, Tarlatzis BC, Bontis JN. Successful end-to-end cervico-cervical anastomosis in a patient with congenital cervical fragmentation: case report. Hum Reprod 2004;19:1204–10.

[3] Chandler TM, Machan LS, Cooperberg PL, Harris AC, Chang SD. Müllerian duct anomalies: from diagnosis to intervention. Br J Radiol 2009;82:1034–42.

[4] Amesse LS, Pfaff-Amesse T. Congenital anomalies of the reproductive tract. In: Falcone T, Hurd WW, editors. Clinical Reproductive Medicine and Surgery. 21(2). ed. New York: Elsevier; 2007, 171:235–9.

[5] Yoo RE, Cho JY, Kim SY, Kim SH. Magnetic resonance evaluation of Müllerian remnants in Mayer–Rokitansky–Küster–Hauser syndrome. Korean J Radiol 2013;14:233–9.

[6] Yoo RE, Cho JY, Kim SY, Kim SH. A systematic approach to the magnetic resonance imaging-based differential diagnosis of congenital Müllerian duct anomalies and their mimics. Abdom Imaging 2015 Jan;40(1):192–206.

[7] Olpin JD, Heilbrun M. Imaging of müllerian duct anomalies. Clin Obstet Gynecol 2009;52(1):40–56.

[8] Imaoka I, Wada A, Matsuo M, Yoshida M, Kitagaki H, Sugimura K. MR imaging of disorders associated with female infertility: use in diagnosis, treatment, and management. Radiographics 2003;23(6):1401–21.

[9] Oakes MB, Eyvazzadeh AD, Quint E, Smith YR. Complete androgen insensitivity syndrome – a review. J Pediatr Adolesc Gynecol 2008;21:305–10.

[10] Troiano RN, McCarthy SM. Müllerian duct anomalies: imaging and clinical issues. Radiology 2004;233:19–34.

[11] El Jack AK, Siegelman ES. 'Pseudoseptum' of the uterine cervix on MRI. J Magn Reson Imaging 2007;26:963–5.

[12] Spitzer RF, Caccia N, Kives S, Allen LM. Hysteroscopic unification of a complete obstructing uterine septum: case report and review of the literature. Fertil Steril 2008;90:2016–20.

[13] Deutch TD, Abuhamad AZ. The role of 3-dimensional ultrasonography and magnetic resonance imaging in the diagnosis of Müllerian duct anomalies. J Ultrasound Med 2008;27:413–23.

[14] Brown MA. MR imaging of benign uterine disease. Magn Reson Imaging Clin N Am 2006;14:439–53.

[15] Kuligowska E, Deeds 3rd. L, Lu 3rd. K. Pelvic pain: overlooked and underdiagnosed gynecologic conditions. Radiographics 2005;25:3–20.

[16] Console D, Tamburrini S, Barresi D, Notarangelo L, Tamburrini O. The value of the MR imaging in the evaluation of Müllerian duct anomalies. La radiologia medica 2001;102(4):226–32.

[17] Woelfer B, Salim R, Banerjee S, Elson J, Regan L, Jurkovic D. Reproductive outcomes in women with congenital uterine anomalies detected by three-dimensional ultrasound screening. Obstet Gynecol 2001;98:1099–103.

[18] Garcia-Enguidanos A, Calle ME, Valero J, Luna S, Dominguez-Rojas V. Risk factors in miscarriage: a review. Eur J Obstet Gynecol Reprod Biol 2002;102:111–9.