Magnetic resonance imaging for diagnosis of pelvic lesions associated with female infertility

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Abstract Objective: To study the mandatory indications and accuracy of magnetic resonance (MR) imaging for diagnosis of pelvic lesions associated with female infertility.

Design: Prospective cross-sectional study.

Main outcome measures: Indications and accuracy of MR imaging for diagnosis of pelvic lesions. Uterovaginal lesions were excluded as they were studied in a previous article (under publication).

Materials and methods: 423 infertile women were investigated by hysterosalpingography (HSG), transabdominal and transvaginal ultrasonography after thorough clinical examination. Hundred and thirty (30.95%) patients were associated with pelvic lesions not conclusively diagnosed by HSG or/and ultrasonography and were examined by MR imaging to confirm the diagnosis. Fifty-four patients (41.53%) had uterovaginal lesions. They were discussed in a previous article. Seventy-six (58.46%) patients had other pelvic lesions. The present study concerned with these lesions.

Results: The diagnosis by MR imaging was conclusive for 11 cases of pyosalpinx, 3 cases of hematosalpinx, 25 cases of hydrosalpinx, 24 cases of ovarian endometriomas, deep endometriosis of the of rectosigmoid (3 cases), urinary bladder (3 cases), one case of endometriosis of the abdominal wall after repeated cesarean sections and six ovarian tumors, 5 cases of benign cystic teratoma and 1 case of serous cystadenocarcinoma. The diagnosis of these lesions was confirmed by laparoscopy or laparotomy and histopathological examination. Magnetic resonance imaging failed to diagnose peritubal adhesions in 22 out of 39 cases (56.41%) of tubal lesions and peritoneal implants of endometriosis in 12 out of 31 cases (38.70%) of pelvic endometriotic lesions. They were discovered during the surgical treatment of the tubal and ovarian lesions through laparoscopy or laparotomy.

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1. Introduction

Tubal and ovarian disorders are responsible for more than 70% of causes of infertility (1,2). Pelvic lesions are investigated mainly by hysterosalpingography (HSG) and ultrasonography (US). However, with these methods the diagnosis may not be conclusive. These methods are supplemented with laparoscopy and occasionally magnetic resonance (MR) imaging (2). Being an expensive procedure many investigators are reluctant to use MR imaging in this field.

Magnetic resonance imaging has the advantage of nonuse of ionizing radiation which is an important consideration in women of reproductive age. Another advantage is that MR imaging is less invasive than laparoscopy and less observer dependent than the classic imaging techniques as US. Furthermore, recent advances in MR imaging with phased-array coil have created further imaging possibilities resulting in excellent spatial and tissue contrast resolution, multiplanar capability, and relatively fast techniques. The disadvantages of MR imaging is the high cost and the long time of examination (2).

Magnetic resonance imaging is contraindicated in patients with pacemakers, cochlear implants, certain metallic objects and impaired renal function (2).

The aim of the present study was to identify the obligatory indications and assess the accuracy of MR imaging for the pre-operative diagnosis of pelvic lesions (after exclusion of uterovaginal lesions) associated with female infertility. As a rule we resorted to MR imaging if the other imaging modalities did not provide conclusive diagnosis.

2. Materials and methods

Between June 2008 and April 2013, 423 infertile women were investigated by HSG and US in the Department of Obstetrics and Gynecology and Department of Radiodiagnosis, Tanta University Hospitals. Hundred and thirty (30.73%) patients were associated with pelvic lesions not conclusively diagnosed by HSG or/and US and were examined by magnetic resonance (MR) imaging. Fifty-four (30.73%) patients were associated with pelvic lesions other than uterovaginal morbidities. They were presented in a previous article (under publication). Seventy-six (58.46%) patients, discussed in the present study, had pelvic lesions other than uterovaginal morbidities. Before examined by HSG and US each patient was asked about the duration of infertility, whether primary or secondary. A detailed menstrual and obstetric history was taken with emphasis on previous pregnancies or history of any abortion and gynecological history with emphasis on genital tract infections.

Detailed general, abdominal and pelvic examinations were performed. Husband’s semen analysis was a pre-requisite before any investigation for the female partner.

3. Technique of hysterosalpingography (HSG)

Hysterosalpingography was performed during the early follicular phase of the menstrual cycle, 3–4 days after cessation of menstrual flow.

Fractionated technique under the guidance of an image intensifier screen using iodinated water-soluble contrast medium (Telebrix Hystero) was the method of choice. The initial X-ray was taken after the injection of 3 ml of contrast material to visualize the cavity of the uterus to exclude intrauterine adhesions or a mass forming a filling defect. Further injection of

Conclusion: The following pelvic lesions associated with female infertility were not conclusively diagnosed by HSG or/and US but were precisely diagnosed by MR imaging with 100% accuracy: Pyosalpinx, hydrosalpinx and hematosalpinx, ovarian and deep infiltrating endometriosis and benign and malignant ovarian tumors as benign cystic teratoma and serous cystadenocarcinoma.
contrast medium till the uterus and tubes were filled and dye spilled from the fimbrial ends of the tubes. During this fractionated injection of the contrast medium, 2–3 serial films were taken. Another film was taken 20 min later after removal of the speculum and cannula (1).

4. Technique of pelvic MR imaging (3)

MR imaging was obtained on the available 1.5 T superconducting MRI (Signa, GE Medical System, Milwaukee, Wis) with a surface phased-array coil installed at Department of Radio-diagnosis, Tanta University Hospitals.

It is recommended that an antiperistaltic (e.g., 1 US Pharmacopia unit of glucagon or 20 mg of scopolamine butylbromide) be administered intramuscularly or intravenously before examination to minimize intestinal peristalsis. MR imaging is contraindicated in patients with pacemakers, cochlear implants, jewelry of any kind and certain metallic objects.

4.1. 1-T1-weighted imaging

Repetition time (TR)/echo time msec (TE), 450–650/6.5–17 ms; section thickness/intersection gap, 5/1.5 mm; acquisition time, 2.5 min) and field of view (FOV) ranged from 350 to 400 (depending on the size of the patient). Postcontrast T1-weighted images (0.1 mmol/kg of gadolinium chelate) are useful in selected cases, such as pelvic inflammatory disease, evaluation of vascularity in uterine leiomyoma, and detection of malignancy in an adnexal mass.

4.2. 2-Fat suppressed spin-echo T1-weighted imaging

T1-weighted images obtained with a selective chemical fat-suppression technique are especially useful for detecting hemorrhagic adnexal masses and should be obtained routinely in patients with infertility in the axial and sagittal planes, (repetition time (TR)/echo time (TE) 800/8; number of acquisitions 2 using a multislice technique, FOV: 38 × 38, echo train length (ETL) of 3. Slice thickness varied from 4 to 6 mm with a 0.8 to 1.2 mm interslice gap, matrix 512 × 256, bandwidth 62 KHz.

3-T2-weighted imaging in the axial, coronal and sagittal planes (repetition-time (TR) msec/echo time (TE) msec 4500/80, echo train length (ETL) of 8–18, number of acquisitions 3, FOV: 38 × 38, bandwidth: 41 KHz, matrix: 320 × 224. Some images were obtained in the coronal plane to assess the extent of the tumor.

Diffuse weighted imaging (DWI): in some patients additional DWI was performed, using a single-shot echo-planner imaging (EPI) sequence, TR/TE inversion time (TI): 7000/80 ms; FOV: 38 × 38 cm, matrix 192 × 224, bandwidth: 250 KHz, slice thickness 8 mm, interslice gap 0 mm, b value of 0, 500, 800, and 1000 s/mm².

Apparent diffuse coefficient (ADC) map: ADC maps were generated on the scanner console using the b = 1000, 500, 800 and b = 0 images. For each patient a region of interest (ROI) was 0.6–187; mean 20.2 cm². The ROI was then manually copied to the corresponding ADC map on the display monitor, from which the mean and lowest ADC values were obtained. We investigated ADC values for each region.

The usual imaging time per patient was approximately 24 min. The added examination time of diffusion-weighted imaging was approximately 4 min.

Short time inversion-recovery (STIR) sequences: is based on the rapid T1 recovery of fat and is, therefore, not substantially affected by field inhomogeneities. Unfortunately, STIR suppresses all short T1 species, including tissues that have absorbed gadolinium. Hence, it is not possible to use STIR fat to improve the detection of contrast medium enhancement (3).

4.3. Interpretation of MR images: (3)

Image interpretation was done according to signal intensity, shape, site, size, pattern of enhancement and their relations to surrounding structures at unenhanced and enhanced T1 and T2 weighted images.

T1-weighted image was used as a localizer of the lesions. It helped to characterize hemorrhage as in hematosalpinx and ovarian endometriomas which were both best demonstrated on T1-weighted images to demonstrate high-signal intensity blood products.

- Contrast-enhanced T1-weighted images were used to measure tumor size and detection of malignancy in an adnexal mass.
- Fat suppressed T1-weighted images were used in suspicious adnexal masses to detect its fatty or hemorrhagic content (3).

DWI and ADC map were used in cases of endometriosis, in which there is no restricted diffusion with higher ADC value and in cases of neoplasm whether benign or malignant to differentiate between them as benign mass shows no restricted diffusion with higher ADC value than malignant one.

The texture of the ovaries was clearly imaged in women of reproductive age. The ovaries displayed hypointense stroma with hyperintense follicles on T2 weighted images. Normal fallopian tubes were not routinely imaged because of their small diameter and tortuous course. On T1-weighted images, the normal pelvic musculature and viscera demonstrated homogeneous low to medium signal intensity (3).

All participants signed a written consent. The study was approved by the ethics committee of Tanta University Hospitals.

5. Statistical analysis

Statistical analysis was performed to evaluate the sensitivity, specificity, positive and negative predictive values and diagnostic accuracy of MRI in correlation to intervention; laparoscopic or traditional operation, abdominal or vaginal and histopathological study of biopsies or excised lesions (4).

6. Results

The study population comprised 76 infertile patients. Twenty-five cases were found to have hydrosalpinx, 11 cases had pyosalpinx, 3 patients had hematosalpinx, 24 patients had ovarian endometriomas (19 bilateral and 5 unilateral), 6 patients had...
deep endometriosis (urinary bladder 3 cases and rectosigmoid 3 cases), endometriosis of the abdominal wall 1 case, 1 patient had cystadenocarcinoma and 5 patients had benign cystic teratomas. The pelvic lesions found in these patients were accurately diagnosed by MR imaging as the diagnosis was confirmed after operative interference and histopathological examination. Laparoscopic surgery was resorted for treatment of tubal lesions and ovarian endometriomas. Traditional surgery was used for treatment of other pelvic lesions.

Magnetic resonance imaging failed to diagnose peritubal adhesions in 22 out of 39 cases (56.41%) of tubal lesions and peritoneal implants of endometriosis in 12 out of 31 cases (38.70%) of pelvic endometriotic lesions. They were discovered during the surgical treatment of the tubal and ovarian lesions through laparoscopy or laparotomy.

Table 1 shows the clinical characteristics of the studied women.

Table 2 shows MR imaging pattern of dilated tubes. MR imaging was able to discriminate hydrosalpinx from ovarian cysts and differentiated between hydrosalpinx and pyosalpinx and hematosalpinx (Figs. 1–3).

Table 3 depicts the features of MR imaging of ovarian endometriomas and endometriosis of abdominal wall, urinary bladder and rectosigmoid (Fig. 4a–c).

Table 4 shows the MRI signal pattern of 6 ovarian neoplasm, 1 serous cystadenocarcinoma and 5 benign cystic teratoma.

Table 5 shows the accuracy, sensitivity, specificity, positive and negative predictive values of MR imaging for diagnosis of tubal diseases, endometriotic lesions, ovarian neoplasm, peritubal adhesions and peritoneal implants of endometriosis.

7. Discussion

Nondilated fallopian tubes are not usually seen on MR images unless they are outlined by pelvic fluid. Dilated fallopian tubes manifest as fluid-filled tubular structure that arises from the upper lateral margin of the uterine fundus and is separate from the ipsilateral ovary. On MR imaging, they appear as

**Figure 1** Bilateral pyosalpinx. (a)- contrast enhanced axial T1-weighted image showing bilateral intrapelvic multilocular hypointense structures with irregular thick walls showing enhancement. (b)- T1 weighted fat suppressed image showing high signal intensity within the right adnexa which is likely due to high protein content of the fluid.

**Table 1** Clinical characteristics of 76 studied women.

<table>
<thead>
<tr>
<th>Clinical characteristics</th>
<th>Age (years)</th>
<th>Body mass index (kg/m²)</th>
<th>Infertility</th>
<th>Duration of infertility</th>
<th>Gravidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>26.33 (23–37)</td>
<td>26.40 (24–39)</td>
<td>43 (56.5%)</td>
<td>1.2 (1–3)</td>
<td>4.67 (2–7)</td>
</tr>
</tbody>
</table>

**Table 2** Signal pattern of magnetic resonance imaging of fallopian tube disease.

<table>
<thead>
<tr>
<th>Pathology</th>
<th>T1- weighted image</th>
<th>T1- weighted fat suppression</th>
<th>T2- weighted image</th>
<th>Contrast – enhanced axial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyosalpinx N = 11</td>
<td>Hyperintense tubular structure</td>
<td>High signal intensity within the content which is proteinaceous</td>
<td>Irregular thick wall tubular hyperintense mass.</td>
<td>Mild enhancement of the wall.</td>
</tr>
<tr>
<td>Hematosalpinx N = 3</td>
<td>Hyperintense mass with folds</td>
<td>No signal loss which is consistent with hemorrhage</td>
<td>High signal intensity mass with folds</td>
<td>No change</td>
</tr>
<tr>
<td>Hydroosalpinx N = 25</td>
<td>Low signal intensity cystic mass has a folded and tortuous appearance.</td>
<td>No change</td>
<td>No change</td>
<td>No change</td>
</tr>
</tbody>
</table>

**Figure 2** Bilateral pyosalpinx. (a) and (b)- contrast enhanced axial T1-weighted image showing bilateral intrapelvic multilocular hypointense structures with irregular thick walls showing enhancement. (c) - T1 weighted fat suppressed image showing high signal intensity within the right adnexa which is likely due to high protein content of the fluid.
retort-, sausage-, C-, or S-shaped cystic masses on MR imaging. Thin longitudinally oriented folds along the interior of the tube represent incompletely effaced mucosal or submucosal plicae. However, in severe cases, the plicae may be either flattened or absent (5).

If the diameter of the dilated tube reaches 10 cm, not an uncommon finding, hydrosalpinx may mimic a multilocular ovarian tumor such as cystadenoma, the multiplanar capability of MR imaging can help to determine whether a multilocular cystic structure is actually the dilated tube, which may be differentiated from an ovarian cyst or dilated bowel loop by its serpentine appearance. Identifying an ipsilateral ovary that is separate from a lesion also may assist in the differential diagnosis of hydrosalpinx and ovarian cyst (5).

On T2-weighted images, the cystic nature of the lesion with its incomplete internal septa, which have low-signal intensity, may be seen. A thickened wall of a dilated fallopian tube that displays variable or heterogeneous signal intensity may be indicative of pyosalpinx or a component of a tubo-ovarian abscess. The wall and septa demonstrate contrast enhancement, especially when inflammation is present. Presence of an enhancing solid component is suggestive of fallopian tube carcinoma. Enhancement of the dilated tubal wall surrounding a saclike cystic mass may be indicative of a tubal pregnancy. MR imaging may identify the cause of dilatation of the tube (5).

Hydrosalpinx may be an isolated finding. On MR imaging the signal intensity of the tubal fluid depends on the cause of obstruction (6). On T1-weighted images, the signal intensity of the content of hydrosalpinx usually is that of simple fluid with low signal intensity, but the tubal content may have high signal intensity if it is hemorrhagic (hematosalpinx) or proteinaceous (pyosalpinx) (7). On T2-weighted images fluid content of hydrosalpinx has high signal intensity and slightly hypointense relative to urine in the presence of hemorrhage (hematosalpinx) or pus (pyosalpinx) (8).

Hydrosalpinx may be a component of a complex adnexal lesion. Pelvic inflammatory disease (PID) is one of the most common causes of tubal and peritubal damage. In the acute phase of the disease, the fallopian tubes are swollen, edematous and congested. As acute suppurative salpingitis ensues, the tubal lumen fills with pus and tubal fimbriae may adhere to the ovaries. This may result in salpingo-oophoritis, a condition in which the tubes and ovaries partially adhere to one another but remain largely separate and identifiable on images. If the fimbriae close before the ovary becomes extensively involved, the inflamed tube forms a pyosalpinx. As the inflammation subsides, the pus undergoes slow proteolysis and the tube is filled with a thin serous fluid, the pyosalpinx thus is transformed into hydrosalpinx (9).

The detection of a hydrosalpinx within a complex adnexal mass may aid in the differential diagnosis as malignant tumors are not associated with dilated tubes (10).

Endometriosis may affect the fallopian tube at two separate locations, with different consequences (11). The most common types of tubal endometriosis are serosal and subserosal. Functional serosal and subserosal endometrial implants cause repeated bouts of intraluminal hemorrhage and fibrosis with resultant formation of periluminal adhesions and, thus, hydrosalpinx. A less common type of tubal endometriosis is

Figure 2  Hematosalpinx. (a)- axial T1 weighted image showing hyperintense mass with folds. (b)- axial T2 weighted image showing less hyperintense mass with folds compared to (a). (c)- axial T1 weighted with fat suppressed image showing hyperintense mass consistent with hemorrhage.
intraluminal. In this type, the tubal lumen in the intramural and isthmic segments is filled with endometrial tissue. Repeated intraluminal hemorrhages end in perifimbrial adhesions and hematosalpinx.

Hyperintense tubal fluid seen on T1-weighted images is suggestive of hematosalpinx. On T2-weighted images, the signal intensity within the fallopian tube, with hematosalpinx, generally is very high relative to the typical signal intensity of an endometrioma, which displays moderate to marked T2 shading (12). Hematosalpinx has been reported to be an indication of endometriosis in certain cases and it may be the only imaging finding indicative of endometriosis (4,12).

In the present study we encountered 25 cases of hydrosalpinx due to PID, 3 cases of hematosalpinx due to tubal endometriosis as no cause was detected on MR imaging and 11 cases of pyosalpinx (Table 2, Figs. 1–3). The diagnosis of these lesions was confirmed on laparoscopy together with histopathological examination. Thus, in the present study, the accuracy, sensitivity, specificity, positive and negative predictive values of MR imaging for diagnosis of tubal dilatation, type and cause, were 100%.

Table 3: Signal pattern of magnetic resonance imaging of endometriotic lesions.

<table>
<thead>
<tr>
<th>Location</th>
<th>T2-Weighted Image</th>
<th>Fat Suppressed T1-Weighted Image</th>
<th>ADC Value</th>
<th>ADC Map</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ovarian Endometriomas</td>
<td>N = 24</td>
<td>Low signal intensity cyst</td>
<td>High signal intensity cyst</td>
<td>0.85 – 1.16 × 10^{-3} mm²/s</td>
</tr>
<tr>
<td>Abdominal wall endometriosis</td>
<td>N = 1</td>
<td>Isointense signal of the lesion to the muscle</td>
<td>Hypointense mass located dorsally to the rectus muscle</td>
<td>0.93 × 10^{-3} mm²/s</td>
</tr>
<tr>
<td>Bladder endometriosis</td>
<td>N = 3</td>
<td>Hypointense mass in the posterior wall of the bladder</td>
<td>Hyperintense mass of the posterior wall of the rectosigmoid</td>
<td>0.93 × 10^{-3} mm²/s</td>
</tr>
<tr>
<td>Rectosigmoid endometriosis</td>
<td>N = 3</td>
<td>Hyperintense mass of the rectosigmoid</td>
<td>Hyperintense mass of the posterior wall of the rectosigmoid</td>
<td>0.93 × 10^{-3} mm²/s</td>
</tr>
</tbody>
</table>

ADC = apparent diffusion coefficient.
Endometriosis affects about 4–13% of all women in reproductive age and 25–50% of women with infertility problem. It commonly occurs in pelvis, ovaries, ovarian fossa, pouch of Douglas and tubes. Deep infiltrating endometriosis may affect urinary bladder, ureters and bowel (13).

The appearance of ovarian endometriomas on MR images is variable and depends on the concentration of iron and protein in the fluid, products of blood degeneration. Most ovarian endometriomas have the growth appearance of chocolate cysts represents highly concentrated blood products (13–15). In the present study 24 cases of ovarian endometriomas were discovered, 19 bilateral and 5 unilateral (Table 2, Fig. 4a–c). In the present study on T1-weighted MR image ovarian endometrioma had high signal intensity similar to that of fat. On fat suppressed T1-weighted image the high signal intensity of endometrioma did not decrease (Fig. 4a). This signal characteristic differentiates endometriomas from fatty adnexal masses such as benign cystic teratomas (14). In the present study on T2-weighted image ovarian endometriomas had low signal intensity (Fig. 4b). This low signal intensity on T2-weighted images is called shading and occasionally occurs in a gradient from higher to lower signal intensities (15). This pattern of signal intensities results from the high content of iron concentration in the endometrioma and is rarely seen in other masses of any type (15).

The findings in the present study matched with the findings in other studies (13–15). Imaoka et al. (16) found that endometriomas on MR imaging were high signal intensity cysts on T1- and T2- weighted imaging or high signal intensity on T1-weighted imaging with or without fat suppression and low signal intensity on T2-weighted imaging (shading). The dense concentration of cyclic hemorrhage and the viscosity of the contents in the endometrioma caused T2 shortening and produced shading.

MR imaging showed a sensitivity of 92% and specificity of 98% for diagnosis of endometrioma (17). In the present study the histopathological examination after operative treatment through laparoscopy denoted that the accuracy, sensitivity, specificity, positive and negative predictive values of MR imaging for diagnosis of endometriomas were 100% (Table 5).

MR imaging is not sensitive for superficial peritoneal implants of endometriosis; therefore MR imaging should not be relied on to rule endometriosis, laparoscopy is the gold standard for diagnosis of pelvic endometriosis but sometimes the endometrial implants are concealed by dense adhesions (18).

According to the definition of Bazot et al. (19) deep infiltrating endometriosis (DIE) is defined as an endometriotic lesion penetrating into the retroperitoneal space or the wall of pelvic organs to a depth of at least 5 mm. The lesions of DIE can present as nodules, masses, cysts or adhesions between organs. Signal characteristics vary as a function of the distribution of stromal tissue versus glandular elements, the presence of hemorrhage, and the extent of an inflammatory reaction. Pure fibrous lesions have hypointense signal intensity on T1- and T2- weighted imaging whereas lesions with a strong glandular component having hyperintense signals on both T1 and T2. The most frequently encountered lesions, however, are mixed with the fibrous component manifesting hypointense signals on T1 and hemorrhagic foci demonstrating hyperintense signals on T2 (13).

In the present study when the diagnosis of deep endometriotic lesions was not conclusive by transvaginal US. MR imaging was performed and the diagnosis was conclusive and was confirmed by laparoscopic or conventional surgery and

Figure 4  Endometrioma of the ovary. (a)- Fat suppressed axial T1-weighted image shows high signal intensity cysts, indicating their hemorrhagic content. (b)- Axial T2-weighted image showing two endometrial cysts of low signal intensity. (c)- Apparent diffusion coefficient (ADC) maps showing two endometrial cysts of high signal intensity. ADC value was 1.16 × 10.32/s.
histopathological examination. The following varieties of deep endometriosis were encountered in the present study:

a. Three cases of endometriosis of the rectosigmoid colon. MR features showed that infiltrating endometriosis was hyperintense on T2-weighted imaging and isointense or hypointense with no fat suppression on T1-weighted imaging (Table 2; Fig. 5). They presented with rectal bleeding and dyschezia. Rectosigmoid endometriosis was associated with ovarian endometriosis in the three cases.

The rectosigmoid colon was the second most commonly affected site of DIE in the study of Chamie et al. (20) the incidence was 19%. In rectosigmoid assessment, the degree of rectal wall infiltration, the size of the rectal lesion, and the distance from the anal border can influence the surgical management (21). All these factors were accurately identified by MR imaging. The diagnosis was confirmed after endoscopically directed biopsy and histopathological examination with accuracy of 100% (20) and 89.1% (21).

In the present study, the accuracy, sensitivity, specificity, positive and negative predictive values of MR imaging for diagnosis of endometriosis of the rectosigmoid colon were 100% (Table 5), the same as that of Chamie et al. (20).

b. Three cases of urinary bladder endometriosis manifested as a mass on the posterior aspect of the bladder, the mass was hypointense on T2-weighted imaging and isointense with no fat suppression on T1-weighted imaging (Table 3; Fig. 6).

The patients were complaining of infertility and urge incontinence that was marked in the premenstrual and menstrual periods. Cystoscopic examination (inter-menstrual) did not reveal any abnormalities. MR imaging discovered the condition. Cystoscopy, during menses, demonstrated the mass that did not invade the bladder mucosa. The mass, in one case, was excised through laparoscopy and the other two cases were submitted to laparotomy. Histopathological examination confirmed the diagnosis. The accuracy, sensitivity, specificity, positive and negative predictive values of MR imaging for diagnosis of this lesion were 100% in the present study.

Bladder endometriosis defined as bladder wall involvement with invasion of the detrusor muscle, is a rare condition constituting roughly 6% of all endometriosis cases (22).

In 40% of cases the urinary symptoms (urgency, frequency, hematuria, or urge incontinence) are cyclic related to menses, 60% will present with non-cyclic symptoms. Typical MR features include localized or diffuse bladder wall thickening involving the dome/posterior wall and heterogeneous T2-isointensity with occasional T1 hyperintense foci. MR also evaluates the distal ureters which may become obstructed, more often by associated mass effect rather than by direct invasion by endometriosis. This is pertinent to surgical planning as re-implantation of the ureter may be required (23). The accuracy of MR imaging for diagnosis endometriosis of the urinary bladder was 98.6% (22) and 99.2% (23).

c. One case of abdominal wall endometriosis, consequent to repeated cesarean section, the lesion was located dorsally to the rectal muscle. It showed heterogeneous
Table 5  Accuracy of MR imaging for diagnosis of pelvic lesions associated with infertility.

<table>
<thead>
<tr>
<th>Lesion</th>
<th>Accuracy (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrosalpinx</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Pyosalpinx</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Hematosalpinx</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Peritubal adhesions</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Endometriosis:</strong></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>-endometriomas</td>
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<tr>
<td>-urinary bladder</td>
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<td>-abdominal wall</td>
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<td><strong>Ovarian neoplasm:</strong></td>
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<td>-benign</td>
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<tr>
<td>-malignant</td>
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</table>

**Figure 5**  Endometriosis of the rectosigmoid. Axial T1-weighted image showing bilateral adnexal cysts displaying high signal intensity, one cyst is infiltrating the rectosigmoid and producing rectal bleeding.

**Figure 6**  Urinary bladder endometriosis: axial T2-weighted images showing a hypointense mass at the posterior aspect of the urinary bladder.

**Figure 7**  Endometriosis of the lower abdominal wall. Axial T2-weighted image shows a hypointense lesion located dorsally to rectus muscle.

**Figure 8**  Benign cystic teratoma: axial T2 showing heterogeneous high-signal intensity lesion.
The patient with abdominal wall endometriosis presented with a palpable mass in the scar. The mass was cyclic. Endometriosis of the abdominal wall may be difficult to diagnose; it is often mistaken clinically and with diagnostic imaging for other abnormal conditions such as a suture granuloma, an incisional hernia or primary or metastatic cancer. Accuracy of diagnosis with MR imaging approached 100% (24), the same degree of accuracy in the present study.

Certain features of MR imaging predominate for each type of ovarian tumor. Knowledge of these key features of ovarian tumors may allow a specific diagnosis or substantial narrowing of the differential diagnosis. Characterization of ovarian tumors can aid to surgical planning, whether exploration or laparoscopic excision, and may help distinguish benign from malignant tumors and thus avoid inappropriate management (25).

In the present study conclusive diagnosis, with 100% accuracy, of 5 cases of benign cystic teratomas, and 1 case of cystadenocarcinoma was obtained as they showed the characteristic MR imaging features of these tumors (Table 4; Figs. 8 and 9a–c).

Other studies reported similar features on MR imaging for the two types of ovarian tumors. They found that manifestations of malignant adnexal mass on MR imaging included the presence of both solid and cystic areas within the mass; necrosis (hyperintense on T1- and T2-weighted MR imaging) within a solid lesion; papillary projections from the wall or septum of a cystic lesion; an irregular septum or wall; multiple thickened (>3 mm) septations; a large size (>6 cm); bilateral lesions; ascites and enlarged pelvic and para-aortic lymph nodes which can be easily detected on MR imaging and thus assist in staging a malignant ovarian tumor (25). On exploration the surgical staging of cystadenocarcinoma, in the present study, was 1a. The early stage may explain the absence of many features of malignancy on MR imaging of this malignant tumor.

After excision by laparotomy and histopathologic study of the six ovarian tumors included in the present study the accuracy, sensitivity, positive and negative predictive values of MR imaging for diagnosis of these ovarian tumors were 100%. The accuracy of MR imaging for diagnosis of the specific type of ovarian tumors both benign and malignant by Jung et al. (25) was 98.7%.

In the present study magnetic resonance imaging failed to diagnose peritubal adhesions in 22 out of 39 cases (56.41%) of tubal lesions and peritoneal implants of endometriosis in 12 out of 31 cases (38.70%) of pelvic endometriotic lesions. They were discovered during the surgical treatment of the tubal and ovarian lesions through laparoscopy or laparotomy.

The accuracy of MR imaging for diagnosis of pelvic lesions associated with infertility was 100%, This may be explained by

Figure 9  cystadenocarcinoma: a- Axial T1-weighted image showing hypointense pelvic complex predominantly cystic mass with a hypointense intracystic component. b and c- Axial and sagittal T2-weighted images showing hyperintense pelvic complex mass predominantly cystic with heterogeneous intermediate to bright intracystic solid component and evidence of a septum is seen at its inferoposterior aspect.
the small number of women studied and the use of all modes of MR imaging and of the phased array coil with spatial and tissue contrast resolution and multiphase capability.

The limitation of this work was the small number of cases enrolled in the study.

8. Conclusion

The following pelvic lesions associated with female infertility were not conclusively diagnosed by HSG or/and US but were precisely diagnosed by MR imaging with 100% accuracy: Pyosalpinx, hydrosalpinx and hematosalpinx, ovarian and deep infiltrating endometriosis and benign and malignant ovarian tumors as benign cystic teratoma and serous cystadenocarcinoma.

Conflict of interest

No conflict of interest declared.

References