New Magnetic Resonance Imaging Sequences for the Female Pelvis in Diagnosing Ovarian Endometrioma an Imaging-Laparoscopic Correlation

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Abstract

Introduction: Radiological detection of pelvic endometriotic lesions would provide a basis for optimal preoperative planning. MRI provides valuable information on deep pelvic and uterine lesions. Susceptibility weighted MRI provides additional information differentiating deep pelvic end uterine endometriotic lesions from other neoplastic and inflammatory lesions depending on detection of hemosiderin laden deposition from bleeding foci.

Aim: Extra-ovarian endometriosis (EOE) usually appears as solid masses mimicking neoplasms, post-inflammatory lesions as well as uterine leiomyomas both clinically and radiologically. Detection of blood products within a lesion may be suggestive of its endometriotic nature. We present a descriptive study of MR imaging findings that include susceptibility-weighted imaging (SWI) for patients with EOE.

Patients and Methods: Prospective study in which twenty patients with suspected pelvic endometriosis underwent laparoscopic evaluation after MRI examination. T1-weighted images, T2-weighted images, Fat-saturated T1-weighted images (fsT1WI) and SWI were obtained using 1.5T MR imaging. Images were reviewed for the presence of signal voids on SWI.

Results: Laparoscopic evaluation revealed 14 out of 20 cases having ovarian endometriomas, conventional MRI detected the same number of cases. However, DWI detected only 11 cases, while SWI detected signal voids of blood byproducts in all 14 cases. Hence, both laparoscopic and MRI evaluation were equal in detection of endometrioma.

Conclusions: SWI is a sensitive MRI technique which demonstrates hemorrhage of varying chronicity in patients with EOE and may improve future MRI characterization of EOE.

Keywords: endometriosis, extra-ovarian endometriosis, susceptibility-weighted imaging, magnetic resonance imaging, female pelvis
Introduction

Endometriosis is a common gynecologic condition occurring in about 5-10% of menstruating women and defined as the presence of functional endometrial glands and stroma outside the uterus [1]. The most common site of endometriosis is ovary [2,3].

Ovarian endometriomas are usually diagnosed by conventional T1- and T2-weighted magnetic resonance (MR) images with high accuracy, and fat-suppressed sequences improve the conspicuity and detection rate of small endometriomas [4].

Susceptibility-weighted imaging (SWI) is a relatively new MR technique that maximizes sensitivity to susceptibility effects and has exquisite sensitivity to blood products such as deoxyhemoglobin and hemosiderin resulting from acute and chronic hemorrhage, respectively [5,6]. Takeuchi et al. reported that SWI was useful in the diagnosis of endometrioma by detecting the hemosiderin deposition within the walls of endometriomas [7].

Diffusion-weighted imaging exploits the random motion of water molecules, because water movement in highly cellular tissues is restricted, the water molecules within such tissue retain their signal even at high \( b \) values (500–1000 s/mm\(^2\)). This explains why highly cellular tissues such as tumors appear persistently bright on diffusion-weighted images, even at high \( b \) values [8]. On a diffusion-weighted image obtained with a low \( b \) value, an endometrioma exhibits low signal intensity resembling the T2 shading. Thus, endometriomas have less signal intensity to lose on images obtained with higher \( b \) values than adnexal masses with higher T2 signal intensity do. Because the ADC value is based on the slope of the signal intensity loss between acquisitions at low \( b \) values and those at higher \( b \) values, endometriomas often have low ADC values [9].

The purpose of this study is to evaluate the role of DWI and SWI in evaluation of pelvic ovarian endometrioma.

Materials and Methods

Patients

This prospective study was approved by ethics committee.

All patients included in the study with history, clinical examination and ultrasound study suggesting pelvic endometriosis such as history of dysmenorrhea and pelvic pain, pelvic tenderness, RVF uterus and frozen pelvis, as well as associated ovarian endometriotic cysts.

All selected patients were subjected to MRI examination, nineteen of them underwent laparoscopy, while one underwent open laparotomy.

All the MRI studies were reviewed by two radiologists of 12 and 8 years of experience in consensus.

All selected patients were informed of the procedures and a written consent was taken from them.

Inclusion criteria: Females with history, clinical examination and ultrasound features suggesting of pelvic endometriosis at reproductive age.

Exclusion criteria: Relative and absolute contraindications to MRI examination such as patients with metallic implants and pregnant females.

Methods

Magnetic resonance imaging (MRI)

MRI was performed on a Philips Achieva 1.5 Tesla closed-configuration, in supine positioning, using body coil. The following MRI sequences were used:

Starting with Sagittal T2 weighted turbo spin echo (T2 TSE) using repetition time (TR) of 3000 msec, an echo time (TE) of 100 msec, a field of view (FOV) of 120 x 270 mm, and a slice thickness of 3 mm. Followed by
Axial T2 weighted turbo spin echo (T2 TSE) using repetition time (TR) of 3600 msec, an echo time (TE) of 120 msec, a field of view (FOV) of 180 x 180 mm, and a slice thickness of 3 mm.

Axial T1 weighted spin echo (T1 SE) using repetition time (TR) of 450 msec, an echo time (TE) of 15 msec, a field of view (FOV) of 180 x 180 mm, and a slice thickness of 3 mm.

Axial T1 fat sat using repetition time (TR) of 1200 msec, an echo time (TE) of 7 msec, a field of view (FOV) of 180 x 180 mm, and a slice thickness of 3 mm.

Coronal T2 weighted turbo spin echo (T2 TSE) using repetition time (TR) of 7900 msec, an echo time (TE) of 100 msec, a field of view (FOV) of 180 x 180 mm, and a slice thickness of 3 mm.

Then, Diffusion weighted image using repetition time (TR) of 1215 msec, an echo time (TE) of 58 msec, a slice thickness of 3 mm, and b-values of 0, 300, and 600 sec/mm².

And Lastly, Susceptibility weighted image: using repetition time (TR) of 32.8 msec, an echo time (TE) of 47.8 msec, and a slice thickness of 3 mm.

Analysis

An overview for detection of any adnexal lesion, is best seen in Sagittal T2WI sequence.

Both axial T2WI and axial T1WI are used to detect blood signals, they appear hyperintense in T1WI and display hypointense signal on T2WI sequence termed “shading sign”.

Axial T1 fat sat sequence is used to exclude fat-containing lesions, which would otherwise suppress on fat suppression lesions. And the Coronal T2WI is used for multiplanar purposes.

However, this signal was to be further confirmed by DWI and SWI to differentiate it from otherwise, high protein content cysts.

DWI is used to detect restricted lesions as blood signals restrict in benign hemorrhagic ovarian cysts [10] and endometriomas [11] and it usually gives restriction in the acute and early subacute phases of bleeding.

SWI depends on the detection of hemosiderin deposition along the cyst wall reflecting blood signals by signal voids (blooming), and may be diagnostic for endometriomas, especially in the endometriomas with atypical MR findings [9].

Laparoscopy

Diagnostic laparoscopy was done to all patients and compared to MRI results.

Diagnostic laparoscopy was done using Carl Storz machine, Insufflator Storz 264 320 20, Electronic laparoflator 264 300 20, and Light source WISAP.

Laparoscopy was done during the post menstrual period, with empty urinary bladder, using of general anesthesia with complete aseptic three puncture techniques.

Assessment of the pelvic structures involves the evaluation of the ovaries to confirm the presence of chocolate cyst if any. Evaluation of the ovaries for size, shape, surface and ovulation. Also, evaluation of tubes for shape, patency and presence of adhesions.

Ethical committee approval

This study was approved by the local ethical committee of the Faculty of medicine, University of Alexandria, Egypt.
Results

Twenty patients with history suggestive of endometriosis, and ultrasound results of complex pelvic cystic lesions were subjected to MRI evaluation, among these twenty patients nineteen were confirmed by laparoscopic assessment, and one was confirmed by open laparotomy.

The age of the patients in this study ranged between 21-47 years old, and the mean age was 29.65 years.

MRI findings:

Regarding MRI findings of the studied patients, 14 out of 20 cases showed endometrioma representing 70% of the cases (4 bilateral endometriomas, 5 right endometriomas and 5 left endometriomas), as shown in Table 1.

Regarding the appearance of endometrioma on MRI examination, all 14 cases of endometriomas demonstrated signal intensity of blood which classically appeared as hyperintense signal on T1WI sequence not suppressed on fat suppression sequence, and as hypointense signal or shading on T2WI. However, only 11 cases were restricted in DWI representing 78.57%, still all 14 cases again revealed signal voids or blooming on SWI (Figures 1-4, Table 2)

Laparoscopic findings:

Regarding the laparoscopic and open laparotomy evaluation, out of twenty patients, 14 patients showed endometrioma representing 70% of cases (4 bilateral endometriomas, 5 right endometriomas and 5 left endometriomas)

Comparing the MRI findings and laparoscopic evaluation of the twenty cases, both studies were equal in detection of 14 cases of endometriomas.

Table 1: MRI and laparoscopic findings

<table>
<thead>
<tr>
<th>Findings</th>
<th>MRI</th>
<th>Laparoscopy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endometrioma</td>
<td>Total=14</td>
<td>Total=14</td>
</tr>
<tr>
<td>Bilateral</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Right</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Left</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 2: MRI picture of endometrioma

<table>
<thead>
<tr>
<th>MRI sequences</th>
<th>MRI features</th>
<th>Number of patients</th>
<th>percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Hyperintense</td>
<td>14</td>
<td>100%</td>
</tr>
<tr>
<td>T2</td>
<td>Hypointense (shading)</td>
<td>14</td>
<td>100%</td>
</tr>
<tr>
<td>T1 fat sat</td>
<td>Hyperintense (not suppressed)</td>
<td>14</td>
<td>100%</td>
</tr>
<tr>
<td>DWI</td>
<td>Restricted</td>
<td>11 (0.1 -1.1)</td>
<td>78.57%</td>
</tr>
<tr>
<td></td>
<td>Not restricted</td>
<td>3</td>
<td>21.42%</td>
</tr>
<tr>
<td>SWI</td>
<td>Signal voids (Blooming)</td>
<td>14</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>14</td>
<td>100%</td>
</tr>
</tbody>
</table>
Figure 1: Pelvic MRI examination revealed left ovarian cyst with hemorrhagic contents displayed as hyperintense signal in axial T1WI (A), persistence of hyperintense signal in axial T1 fat suppression (B), hypointense (shading) in axial T2WI (C), peripheral patches of signal void (blooming) in SWI (D) fluid in the cyst demonstrate high signal intensity in DWI (E), and low signal intensity (low value) on the ADC map (F) findings indicative of restricted diffusion.

Figure 2: Pelvic MRI examination revealed left ovarian cyst with hemorrhagic contents displayed as hyperintense signal in axial T1WI (A), persistence of hyperintense signal in axial T1 fat suppression (B), hypointense (shading) in axial T2WI (C), peripheral patches of signal void (blooming) in SWI (D) fluid in the cyst demonstrate high signal intensity in DWI (E), and low signal intensity (low value) on the ADC map (F) findings indicative of restricted diffusion.
Figure 3: Pelvic MRI examination revealed right ovarian cyst with hemorrhagic contents displayed as hyper intense signal in axial T1 fat suppression (A), hypointense signal (shading) in axial T2WI (B), peripheral patches of signal void (blooming) in SWI (C), fluid in the cyst demonstrate high signal intensity in DWI (D) and low signal intensity (low value) on the ADC map (E), findings indicative of restricted diffusion.

Figure 4: Pelvic MRI examination revealed right ovarian cyst with hemorrhagic contents displayed as hyperintense signal in axial T1WI (A), persistence of hyperintense signal in axial T1 fat suppression (B), hypointense (shading) in axial T2WI (C), peripheral patches of signal void (blooming) in SWI (D) fluid in the cyst demonstrate high signal intensity in DWI (E), and low signal intensity (high value) on the ADC map (F) findings indicative of no restricted diffusion.
Discussion

Among women with pelvic pain the prevalence of endometriosis ranges from 30-80% [2,3]. The estimated prevalence of endometriosis in the general population of women is 10% [3]. As can be seen from its prevalence, endometriosis is a disease which has a considerable impact on women's health.

The aim of this study was to evaluate the role of both conventional and new MRI sequences in diagnosing pelvic endometrioma compared to the laparoscopic role.

The patients' ages ranged between 21-47 years, half of them (50%) were in the 20-29 age group.

In the current study the diagnostic accuracy of MRI as compared to laparoscopy in detecting endometrioma was 100%.

This agreed with Ayida G et al. [12] study which found that accuracy of MRI compared to laparoscopy in detecting endometrioma was 100%, the same diagnostic accuracy as in our study.

In the current study, the MRI picture of the endometrioma was found to be almost typical in all cases. T1WI showed hyperintense signals, not suppressed in fat suppression sequences. T2WI showed hypointense signals (shading).

SWI showed signal void (blooming) in all cases (100%), while DWI showed restriction in 11 cases with low ADC values ranging from 0.1 to $1.1 \times 10^{-3}$ mm$^2$/second, representing 78.57%, and 3 cases are not restricted representing 21.42%.

These results agreed with Kinkel. K et al. [13], who concluded typical features of endometriomas, include high signal intensity at both T1- and T2-weighted sequences persisting at subsequent fat-suppressed T1-weighted images. Fat suppression is mandatory, as it helps to differentiate endometriomas from cystic teratomas and to visualize smaller endometriomas than without fat-suppression techniques. Gradual variation of signal intensity at T2-weighted images has been described as “shading” and is due to chronic bleeding with accumulation of high concentrations of iron and protein in endometriomas. This specific feature helps differential diagnosis with functional hemorrhagic cysts that do not demonstrate shading and that disappear at follow-up imaging.

Also agreed with the study by Dogheim OY, Abdel Hamid AM, Barakat MS, et al. [14] that showed 11 cases (100%) of endometriomas that displayed blooming in SWI.

Moreover, agreed with Takeuchi M et al. [7] study that showed all cases of endometriomas displaying signal voids along the cyst wall on susceptibility weighted images (SWI). According to Takeuchi M et al. [7] to diagnose endometrioma with MRI, visualization of hemosiderin deposition in the cyst wall may be helpful, especially in the diagnosis of endometriomas that do not exhibit typical MRI findings.

It also agreed with Nakayama. T et al. [15] study that included 35 cases of endometriomas and stated that the low ADC value of endometrial cysts has been reported, and thick proteinaceous or bloody products have been considered the cause of this low ADC value. Our data in accordance with these previous observations, showing low ADC value around $1.37 \pm 0.66 \times 10^{-3}$ mm$^2$/second. However, the diagnosis of endometrial cysts may readily be made with conventional T1- and T2-weighted images. In our series, all the 35 endometrial cysts were correctly diagnosed without ADC information. Therefore, the usefulness of the ADC evaluation in the diagnosis of endometrial cysts may be controversial.

Conclusions

Susceptibility-weighted imaging contributes to the diagnosis of endometrioma by depicting hemosiderin deposition in the cyst wall.

Endometrioma usually shows restriction diffusion in DWI, still its role is controversial and other sequences are helpful in diagnosing it.
Conflict of interest:
Authors declare there is no conflict of interest regarding publication of this article.

References