

Differentiation between Ovarian Endometriotic Cysts and Functional Hemorrhagic Cysts on Magnetic Resonance Imaging

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ABSTRACT:

BACKGROUND:

Ovarian functional hemorrhagic and endometriotic cysts are frequently seen on ultrasound examinations. Magnetic resonance imaging plays a major role in their differentiation based on different imaging characteristics.

OBJECTIVE:

Investigating magnetic resonance imaging signs to differentiate endometriotic from functional hemorrhagic cysts.

PATIENTS AND METHODS:

A prospective descriptive study of 66 cystic hemorrhagic ovarian lesions, conducted in X-ray Institute, Medical City, Bab Al-Mua'dam, Baghdad/Iraq from September 2018 to December 2019. Lesions were inspected for the presence of T2 shading, dark spot, and dark rim signs. Standard of reference was either histopathological analysis or follow-up ultrasound imaging.

RESULTS:

Of 66 hemorrhagic lesions, 39 were endometriotic cysts and 27 were functional hemorrhagic cysts. T2 dark spots were only seen in 19 of 39 endometriomas. T2 shading was seen in 34 of 39 endometriotic cysts and 8 of 27 functional hemorrhagic cysts. Twenty-four of 39 endometriotic cysts and 12 of 27 hemorrhagic cysts showed the dark rim sign.

CONCLUSION:

High sensitivity of the shading sign for diagnosing endometriomas. Identification of dark spots within endometriomas increases specificity and accuracy for their diagnosis. Dark rim sign is also useful for differentiation between endometriomas and functional hemorrhagic cysts.

KEYWORDS: Ovarian endometriotic cyst, functional hemorrhagic cyst, magnetic resonance imaging.

INTRODUCTION:

Endometriosis is the occurrence of ectopic endometrial tissue outside the cavity of the uterus.⁽¹⁾ These islands of endometriosis are composed of endometrial glands surrounded by endometrial stroma.⁽²⁾ Ovarian endometriotic cysts are one of the variable manifestations of endometriosis; representing a severe stage of the disorder.⁽³⁾ They can be easily detected with non-invasive imaging modalities such as ultrasound or MRI especially when they demonstrate characteristic imaging features.⁽⁴⁾ Magnetic resonance imaging is more specific than ultrasonography for their diagnosis.⁽⁵⁾ Historically, the diagnosis of endometriotic cysts has largely relied upon the shading sign, 'low T2 signal intensity in an adnexal cyst of otherwise

high T1 signal intensity'.^(6, 7) The high T1 signal intensity should not be suppressed on fat-suppressing sequences. Many patterns of T2 shading have been described, it may appear as fluid-fluid level, loss of signal intensity in gradient pattern or the lesion may demonstrate homogeneous and complete loss of signal intensity.⁽⁸⁾ Continuous research on the subject led to recognition of dark spot and dark rim signs on T2 weighted images. Small foci of very low signal intensity were seen within endometriotic cysts and thought to result from very small retracted blood clots containing concentrated amounts of protein and hemosiderin. These foci were given the name "T2 dark spots".⁽⁹⁾ The dark rim sign is seen as linear or curvilinear, very low signal intensity areas in the walls of hemorrhagic lesions and are most likely a result of hemosiderin deposition within the thick fibrous capsule surrounding them.^(10,11) Two patterns have been recognized depending on whether these foci completely or incompletely outline the

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walls of hemorrhagic lesions; which defines the complete and incomplete dark rim signs respectively. Both patterns were recognized in endometriotic cysts but the incomplete form was found to be more indicative of endometriomas.⁽¹²⁾

PATIENTS AND METHODS:

Study group and design: This was a prospective descriptive study conducted in X-ray Institute, Medical City, Bab Al-Mua'dam, Baghdad / Iraq during the time period from September 2018 to December 2019.

Ethical considerations: Approval for the study was taken from the scientific committee of diagnostic radiology in the Iraqi board of medical specialization. Oral informed consent was taken from all the patients included in the study.

Inclusion criteria: Cystic looking hemorrhagic ovarian lesions larger than 2cm in diameter showing high signal intensity on T1-weighted images before and after application of fat-suppressing sequences were included.

Exclusion criteria: Hemorrhagic lesions with solid looking components and those without histopathological proof or follow-up imaging results were excluded.

Sampling: A sample of 52 female patients (having 66 cystic hemorrhagic ovarian lesions) referred to X-ray Institute of Medical City in Bab Al-Mua'dam was selected after application of inclusion and exclusion criteria.

Reference standard: Final diagnoses were based on either histopathological analysis following surgical removal or follow-up ultrasound examinations. Total resolution of the lesion or reduction of at least 50% in its size on follow-up imaging was considered definitive for functional hemorrhagic cyst. Those lesions that remained stable, did not considerably decrease in size or showed progressive enlargement were considered endometriotic cysts. The mean time from MRI examinations to surgery was 25 days (range, 14-55 days). The mean time between the initial MRI and follow-up ultrasound examinations was 40 days (range, 30-60 days).

MRI technique: All examinations were conducted using a 1.5-T MRI system (Siemens, MAGNETOM Avanto MRI machine) with a body-array torso coil in supine position. Patients were instructed to have adequately distended urinary bladder with no further preparation. Table 1 summarizes the imaging sequences and their parameters.

Table 1

| Sequences Parameters | Sagittal T2 | Coronal T2 | Axial T2 without and with fat suppression | Axial T1 without and with fat suppression |
|-------------------------|----------------|---------------|--|--|
| TR (ms) | 8620 | 8620 | 8811 | 682 |
| TE (ms) | 104 | 104 | 104 | 11 |
| Matrix | 320 × 256 | 320 × 256 | 320 × 200 | 320 × 200 |
| FOV (mm) | 250 | 250 | 250 | 200 |
| Slice thickness (mm) | 4 | 4 | 4 | 4 |
| Section gap (mm) | 1 | 1 | 1 | 1 |

Ultrasound: All ultrasound examinations were performed using a modern system (Philips HD 11XE machine) equipped with a curvilinear probe (5-2MHz).

Trans-abdominal ultrasound examination of the pelvis was done on the same day of MRI examination after identifying a hemorrhagic lesion with heterogeneous signal intensity, to confirm its true cystic nature and exclude the presence of any solid tissue within it. Hemorrhagic lesions containing T2 dark spots were also evaluated with ultrasound aiming to find an ultrasonic correlate for the dark spots and exclude the presence of calcifications within

these lesions. Additionally, follow-up ultrasound examinations within a two-month period was performed to assess the size of hemorrhagic lesions for which surgery was not done. Eight hemorrhagic lesions were examined with ultrasound for suspicion of solid component inside them. Thin septa and low-level debris were seen but no solid component could be detected. Nineteen hemorrhagic cysts containing dark spots on MRI were examined with ultrasound but no ultrasonic equivalent could be found.

Image analysis: Images were viewed on a Syngovia, Siemens Healthcare workstation.

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On T1-weighted images, any lesion showing bright signal intensity similar to or close to that of fat on non-fat suppressed images and remained bright after application of fat-suppression sequences was considered hemorrhagic. Hemorrhagic lesions larger than 2cm in diameter were evaluated on T2-weighted images for the presence of shading, dark spot, and dark rim signs. Shading was defined as hypointense signal within hemorrhagic lesions that is lower than the high T1 signal intensity. Dark spots were defined as small foci of markedly low signal intensity (signal intensity less than that of muscle) inside hemorrhagic lesions that are separated from the walls. The dark rim is seen as very low signal intensity curvilinear foci either completely or incompletely surrounding hemorrhagic lesions.

Statistical Analysis: Collected data was analysed using Pearson chi-squared test. Calculations were made using Microsoft Excel 2013 software. Sensitivity, specificity, positive and negative predictive values were calculated for each of the imaging signs. *P* values were also

calculated and considered statistically significant if less than 0.05.

RESULTS:

The mean age of the participants in the study was 35.6 years \pm 9.2 (standard deviation), and the range was 15-47 years. Of 66 cystic endometriotic ovarian lesions, there were 39 endometriotic cysts and 27 functional hemorrhagic cysts.

The mean size of endometriotic cysts was 32.5 \pm 5.2 mm (range, 28-70 mm) while hemorrhagic cysts had a mean size of 43.6 \pm 18.8 mm (range, 26-75 mm). No statistically significant difference was found between the sizes of the two types.

Forty-two lesions were diagnosed by histopathological analysis following surgical resection (*n* = 30 endometriotic cysts and *n* = 12 hemorrhagic cysts). Twenty-four lesions were diagnosed by follow-up imaging (*n* = 9 endometriotic cysts and *n* = 15 hemorrhagic cysts).

The distribution of the shading, dark spot and dark rim signs according to the type of hemorrhagic cyst is presented in tables 2, 3, and 4 respectively.

Table 2: Distribution of the shading sign according to the type of hemorrhagic cyst.

| Pathology Shading sign | Endometriotic Cyst | Functional Hemorrhagic Cyst | Total |
|---------------------------|--------------------|-----------------------------|-------|
| Positive | 34 | 8 | 42 |
| Negative | 5 | 19 | 24 |
| Total | 39 | 27 | 66 |

Table 3: Distribution of the dark spot sign according to the type of hemorrhagic cyst.

| Pathology Dark spot sign | Endometriotic Cyst | Functional Hemorrhagic Cyst | Total |
|-----------------------------|--------------------|-----------------------------|-------|
| Positive | 19 | 0 | 19 |
| Negative | 20 | 27 | 47 |
| Total | 39 | 27 | 66 |

Table 4: Distribution of the dark rim sign according to the type of hemorrhagic cyst.

| Pathology Dark rim sign | Endometriotic Cyst | Functional Hemorrhagic Cyst | Total |
|----------------------------|--------------------|-----------------------------|-------|
| Positive | 24 | 12 | 36 |
| Negative | 15 | 15 | 30 |
| Total | 39 | 27 | 66 |

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Twenty-nine dark spots were seen in 19 endometriotic cysts. The average size of dark spots was 4.5 mm (range 3–10 mm).

Table 5 shows the distribution of the incomplete and complete forms of the dark rim sign. There was a statistically significant difference between the two forms ($P = 0.03$).

Table 5: Distribution of the incomplete and complete dark rim signs according to the type of hemorrhagic cyst.

| Pathology | Endometriotic Cyst | Functional Hemorrhagic Cyst | Total |
|----------------|--------------------|-----------------------------|-------|
| Dark rim sign | | | |
| Incomplete rim | 15 | 3 | 18 |
| Complete rim | 9 | 9 | 18 |
| Total | 24 | 12 | 36 |

Statistical analysis of T2 shading, T2 dark spot, and T2 dark rim signs for differentiating endometriotic cysts from functional hemorrhagic cysts is presented in table 6.

Table 6: Statistical analysis of T2 shading, T2 dark spots, and T2 dark rim in distinguishing endometriotic cysts from functional hemorrhagic cysts.

| MRI Finding | Sensitivity (%) | Specificity (%) | PPV* (%) | NPV** (%) | P value |
|--------------|-----------------|-----------------|----------|-----------|-------------|
| T2 shading | 87 | 70 | 81 | 79 | $P < 0.001$ |
| T2 dark spot | 48 | 100 | 100 | 57 | $P < 0.001$ |
| T2 dark rim | 62 | 75 | 83 | 50 | $P = 0.03$ |

* Positive predictive value

** Negative predictive value

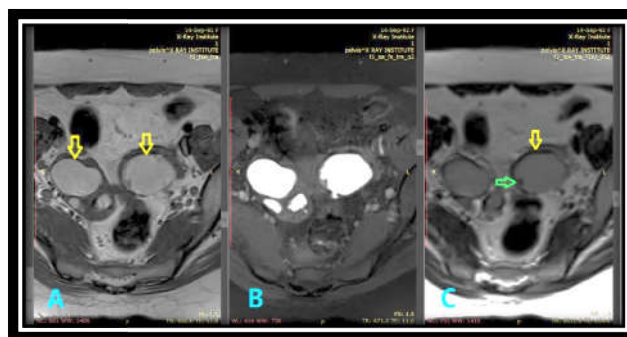


Figure 1: Two pathologically proven endometriotic cysts in a 27-year-old woman:
A, Axial T1-weighted MR image showing bilateral hyperintense adnexal lesions (yellow arrows).
B, Axial fat suppressed T1-weighted MR image showing non-suppression of the high signal.
C, Axial T2-weighted MR image showing relative hypo-intensity in both endometriomas (shading), dark rim (yellow arrow), and dark spot (green arrow).

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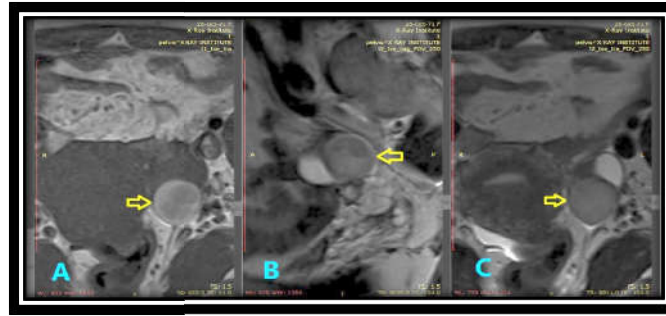


Figure 2: Left ovarian hemorrhagic cyst in a 47-year-old woman:
A, Axial T1-weighted MR image showing mixed signal intensity lesion (yellow arrow).
B, Sagittal and;
C, Axial T2-weighted MR images demonstrating the shading sign (yellow arrows)

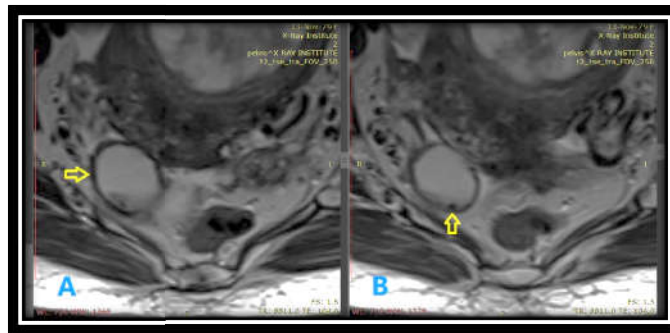


Figure 3: Right ovarian endometriotic cyst in a 39-year-old woman:
A, Axial T2-weighted MR image showing complete dark rim sign (yellow arrow).
B, The same lesion in A showing a dark spot in its dependent part (yellow arrow)

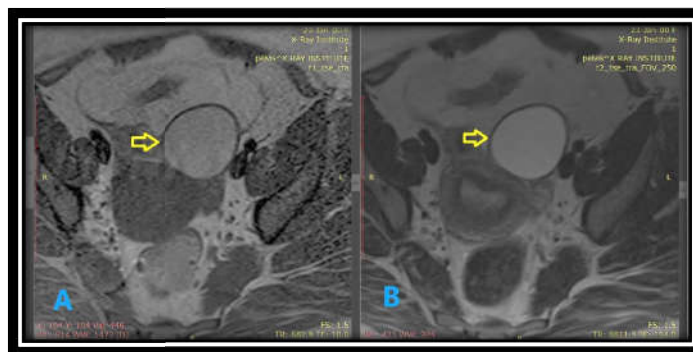


Figure 4: Left ovarian hemorrhagic cyst in a 19-year-old woman:
A, Axial T1-weighted MR image showing a high signal intensity lesion (yellow arrow).
B, Axial T2-weighted image showing the same lesion (yellow arrow) to have a high signal intensity and is completely surrounded by a dark rim (complete dark rim sign).

DISCUSSION:

For nearly 25 years, the diagnosis of endometriotic cysts on MRI has largely depended on the criteria set by Togashi et al.⁽⁷⁾ Identification of either a single hyperintense T1 lesion that demonstrates relative hypointensity on T2 sequences (shading) or multiple hyperintense T1 lesions regardless of T2 signal intensity is highly sensitive (90%) and specific (98%) for diagnosing endometriomas.⁽⁷⁾ Findings of high T1/low T2 signal intensities in endometriotic cysts is attributed to repeated haemorrhage inside them leading to highly viscous fluid containing protein, iron, and methaemoglobin; collectively causing shortening of both T1 and T2 of the fluid.⁽¹³⁾ Subsequent studies done by Outwater et al.⁽¹⁴⁾, Corwin et al.⁽⁹⁾, Lee et al.⁽¹⁵⁾, and Cansu et al.⁽¹²⁾ yielded high sensitivity of the shading sign (approaching 90%) and low specificity. In the present study, the sensitivity and specificity of the shading sign were found to be 87% and 70%, respectively for differentiating endometriotic cysts from hemorrhagic cysts.

The dark spots within endometriotic cysts were first defined by Corwin et al.⁽⁹⁾ In their study, 35% of endometriotic cysts showed very small, well-defined, markedly hypointense foci on T2-weighted images. Oftentimes these spots were seen adjacent to the cyst wall but separate from it. No similar foci were seen in functional hemorrhagic cysts. These small foci may represent small old retracted blood clots having high concentrations of protein and/or hemosiderin which causes significant T2 shortening; ultimately resulting in very low signal intensity of these foci. Their small size (mean, 6.3 mm) may be supporting evidence that these are truly small retracted blood clots. The reported sensitivity and specificity for this sign were 36% and 93%, respectively.⁽⁹⁾ Cansu et al.⁽¹¹⁾ found higher sensitivity (52%) and specificity (100%) values for the dark spots sign. In the present study, the mean size of the dark spots was 4.5mm. No pathological explanation could be found following sectioning of the cyst wall; confirming that these spots do not originate from the wall and are more likely to be blood clots. The sensitivity and specificity values for the dark spots sign were 41% and 100% respectively.

Cansu et al.⁽¹²⁾ noticed T2 linear/curvilinear hypointense signal along the walls of some hemorrhagic cystic lesions and named it the 'dark rim' sign. However, the first description of wall hypointensity was made by Nishimura et al.⁽¹⁶⁾ as a highly-suggestive finding of

an endometriotic cyst. They described it as a "distinct low intensity zone around a cyst loculus on T1- and T2-weighted images" and thought it was produced by the thick fibrous capsule surrounding endometriotic cysts. Indeed, one of the characteristic pathological features of endometriotic cysts is the presence of thick capsule around them that contains hemosiderin-laden macrophages; a result of chronic repetitive bleeding.⁽¹⁷⁾ Takeuchi et al.⁽¹⁸⁾ used susceptibility-weighted imaging and found signal voids in the walls of endometriotic cysts; reporting that these are due to hemosiderin-laden macrophages. Signal voids were not seen in the walls of non-endometriotic cysts. According to Cansu et al.⁽¹²⁾, the reported sensitivity and specificity values for the dark rim sign were 67% and 79%, respectively. The incomplete form was mainly seen in endometriotic cysts while the complete form was more prevalent in hemorrhagic cysts; the difference was found to be statistically significant.⁽¹²⁾ In the present study, the sensitivity and specificity results for the dark rim sign were 62% and 75%, respectively; these are slightly lower than those of Cansu et al. which may have occurred a result of the use of lower magnetic field strength and different imaging parameters. However, the findings of the predominant pattern comply with those of Cansu et al.; the incomplete form is mostly seen in endometriotic cysts while the complete form is more suggestive of hemorrhagic cysts.

CONCLUSION:

T2 shading is highly sensitive for endometriotic cysts but it is also seen frequently in functional hemorrhagic cysts; as a result, it has low specificity. T2 dark spots are new MRI findings most likely resulting from chronic hemorrhage that can be used to differentiate endometriotic cysts from functional hemorrhagic cysts and increase diagnostic efficacy of MRI. The dark rim sign is useful in differentiating the two most common types of hemorrhagic ovarian cystic lesions.

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