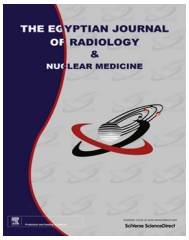
The Egyptian Journal of Radiology and Nuclear Medicine (2013) **44**, 923–936

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

www.elsevier.com/locate/ejrnm
www.sciencedirect.com



ORIGINAL ARTICLE

A two-stage imaging protocol for evaluating women presenting with acute pelvic pain

Amal Amin Abu El Maati [a,*], **Enas Abdel Ghany Ibrahim** [a], **Fatma Zeinhom Mokhtar** [b]

[a] *Department of Radiodiology, Ain Shams University, Egypt*
[b] *Department of Radiodiology, Cairo University, Egypt*

Received 22 April 2013; accepted 26 June 2013
Available online 22 July 2013

KEYWORDS

Pelvic pain;
US;
MRI

Abstract *Purpose:* To evaluate a two-stage imaging protocol for diagnosing women presenting with acute pelvic pain.
Materials and methods: Forty-nine female patients aged 20–49 years (mean 29.5 years) who were presenting with acute pelvic pain underwent US examination of the pelvis. MRI of the pelvis was done for seventeen patients with indeterminate ultrasound findings. Data from both MRI and US were obtained, and the definite diagnosis was established with laparoscopic or surgical findings and results of clinical follow-up as the reference standard.
Results: Positive pelvic US and MRI findings for gynecological causes were seen in thirty-six out of forty-nine cases (36/49). Final diagnoses of our positive cases (36) were as follows: hemorrhagic ovarian cyst seven cases (19%), ovarian torsion five cases (14%), endometriosis five cases (14%), teratodermoid four cases (11%), ectopic pregnancy four cases (11%), tubo-ovarian abscess three cases (8%), degenerating fibroid three cases (8%), adenomyosis two cases (6%), pedunculated prolapsed submucosal fibroid one case (3%), uterine AVM one case (3%) and pelvic hematoma one case (3%), Thirteen cases (13/49) were excluded from the study as they had other non gynecological causes of pelvic pain like appendicitis, lower ureteric stones, crohn's disease and diverticulitis. In 19 cases the diagnosis was established with US alone and so MRI was done for the remaining 17 cases where US was inconclusive.

* Corresponding author. Tel.: +20 1223558198; fax: +20 222687239.
E-mail addresses: amalaminaa@gmail.com, amalamin74@yahoo.com (A.A.A. El Maati).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.ejrnm.2013.06.011

Conclusion: A two-stage protocol for evaluating women presenting with acute pelvic pain with the use of ultrasonography first, and then MRI for cases with inconclusive ultrasound findings, will optimize diagnostic accuracy.

1. Introduction

Acute pelvic pain is generally defined as pain in the lower abdomen or pelvis lasting <3 months. Diagnosis of pelvic pain in women can be challenging because many symptoms and signs are insensitive and nonspecific. As the first priority, urgent life-threatening conditions (e.g., ectopic pregnancy, ruptured and hemorrhagic ovarian cysts) and fertility-threatening conditions (e.g., pelvic inflammatory disease, ovarian torsion) must be considered. A careful history focusing on pain characteristics, review of systems, and gynecologic, sexual, and social history, in addition to physical examination helps narrow the differential diagnosis (1). Specific painful gynecological disorders that were inadequately diagnosed by US and more adequately assessed by MRI are analyzed in this article.

Adnexal torsion is the rotation of at least one turn of the ovaries, adnexa or the fallopian tube around the line of the tubo-ovarian ligament and the infundibulopelvic ligament (2). Symptoms of ovarian torsion are often nonspecific, making it difficult to differentiate from other causes of acute abdominal pain. The classic presentation includes sharp, localized right or left lower abdominal pain and tenderness with a palpable abdominal mass and peritoneal signs. Waves of nausea and vomiting as well as pyrexia have been observed. In some cases, patients experience intermittent pain, making the diagnosis even more challenging (3).

Endometriosis, which is defined, as the presence of ectopic endometrial glands and stroma outside the uterus, is a common cause of pelvic pain and infertility, affecting as many as 10% of premenopausal women (4).

Mature cystic teratoma, also known as dermoid cyst, is the most common neoplasm of the ovary. Most cystic teratomas are asymptomatic but 3% may present as torsion and more rarely as dermoid cyst rupture. Patients present with acute pelvic pain, nausea and/or vomiting (5).

Pelvic inflammatory disease (PID) is one of the most common causes of acute pelvic pain in sexually active women (6). PID should be suspected in all patients presenting with pelvic pain/cervical motion tenderness, fever, and leukocytosis (7).

Fibroids (leiomyoma) are the most common pelvic tumors affecting females in the fertile age group. They occur in 20–40% of females above 30 years of age (8). As fibroids may cause acute pain, patients may present at the emergency department. Acute pain may be caused by the degeneration of a fibroid when it outgrows its blood supply, torsion of a pedunculated fibroid or prolapse of a submucosal fibroid (9).

Adenomyosis occurs in women usually ranging in age between 35 and 55 years and it is due to the abnormal implant of the basal layer of the endometrium within the myometrium. The rate of adenomyosis at pathology after hysterectomy ranges from 5% to 70%. Symptoms are present in approximately 50% of patients, including pain, menorrhagia and dysmenorrhea. Adenomyosis can be diagnosed by means of US. However, US can especially misinterpret focal adenomyosis as a fibroid (10).

Uterine arteriovenous malformation (AVM) can be defined as a tangle of abnormal arterio-venous connections lacking an intervening capillary net-work on histopathologic examination (11,12). Distinguishing between gestational trophoblastic disease and uterine AVMs is critical because the latter can be treated safely and effectively with percutaneous transcatheter embolization but may be complicated by surgical intervention and curettage with heavy, even life-threatening, bleeding (13).

Subacute hematomas are commonly detected in the female pelvis in women after surgery, and in women receiving anticoagulant therapy who present with pelvic pain and/or a palpable mass. Pelvic hematomas tend to have loculations with different rates of clot maturation that result in heterogeneous appearance on MR images. Foci of high signal intensity on T1-weighted images representing methemoglobin may be present within the hematoma (14).

Non-gynecologic conditions may overlap in the presentation of acute pelvic pain and should also be considered. The most important of these is acute appendicitis. (7).

Ultrasound (US) is the primary modality for evaluating lower quadrant pain in young girls and women. However, transabdominal and transvaginal US might be inconclusive, even when combined with color and pulsed Doppler images. Computed tomography (CT) exposes patients to ionizing radiation, which can be problematic, especially in young people and females with suspected pregnancy (10).

With its high contrast resolution, its ability to provide good tissue characterization, and its multiplanar imaging capabilities, magnetic resonance imaging (MRI) is increasingly used to evaluate pelvic pathology (15–18). This technique has superb soft-tissue contrast, particularly of the gynecologic organs, additional benefits include absence of ionizing radiation and exposure to iodinated contrast material (19). There is a significant difference, however, in the inherent costs of MRI and ultrasound. The dilemma for referring physicians and general radiologists is to decide when it is appropriate to refer patients for MRI (18).

The aim of this study is to evaluate a two stage imaging protocol for diagnosing women presenting with acute pelvic pain.

2. Patients and methods

2.1. Patients

Patients presented to the emergency department of Ain Shams University Hospitals during the period from August 2011 to December 2012 with acute pelvic pain associated with or without other symptoms like vaginal bleeding, fever, infertility or dysmenorrhea (Table 2). All patients were subjected to Medical history and clinical examination, pelvic ultrasound was the initial screening investigation done for all patients, and MRI

was done for cases in which US was non –diagnostic or equivocal.

The study group consisted of 49 female patients, their age ranged from 20 to 49 years, (mean age 29.5 years +/−7.5 years SD).

2.2. Ultrasound

Gray-scale US of the entire abdomen and pelvis was performed in all patients by an expert radiologist using a GE, LOGIQ 500, PRO series and a multifrequency 3.5 MHz convex-array transducer for the transabdominal pelvic examination and an endovaginal 7.5 MHz transducer for the endovaginal pelvic ultrasound examination.

For a complete transabdominal pelvic sonogram, the patient was asked to have an adequately distended bladder to act as acoustic window for the pelvic organs and to displace the small bowel from the field of view. For a transvaginal sonogram, the patient was asked to empty her bladder.

During the sonographic examination, the uterine borders, whether regular or irregular, uterine size, myometrial echotexture and the presence of focal solid or cystic abnormalities of the uterus were documented. The endometrium was analyzed for thickness, focal abnormality, and the presence of fluid or masses in the endometrial cavity.

Adnexa including ovaries and fallopian tubes were evaluated; an attempt was made to identify the ovaries first since they served as a major point of reference for assessing the presence of adnexal pathology. Ovarian size was determined by measuring the ovary in 3 dimensions (width, length, and depth), on views obtained in 2 orthogonal planes. Any ovarian abnormalities if present were documented. The normal fallopian tubes are not commonly identified. The adnexal region was examined for any cystic or solid lesions with reporting of its sonographic criteria.

The cul-de-sac and bowel posterior to the uterus were evaluated for the presence of free fluid or masses. Spectral, color, and/or power Doppler ultrasound was used for evaluation of the vascular characteristics of pelvic lesions especially in suspected cases of ectopic pregnancy and ovarian torsion.

2.3. Pelvic MRI

MRI was performed on a 1.5-T superconducting magnet system (General Electric Corp, Milwaukee, WI, USA), using a phased array body coil. MRI of the pelvis consisted of the following sequences: three-plane localizer; axial, sagittal and coronal T1-weighted fast spin echo (FSE), axial T2 weighted fast recovery fast spin echo (FRFSE) fat sat. Coronal, and sagittal T2-weighted FRFSE, axial, sagittal and coronal short time inversion recovery (STIR), axial T1-weighted fat-suppressed, axial diffusion-weighted images ($b = 0$, $b = 400$ & $b = 800$ sec/mm^2) with fat saturation. MR imaging parameters for female pelvic examination in our study are summarized in (Table 1).

Post contrast axial, coronal and sagittal T1 weighted images with fat saturation were obtained after giving the patient a dose of 0.1 mmol/kg of Gadolinium that was injected automatically at a rate of 2 ml/s.

2.4. Statistical method

Data were expressed as both number and percentage for the categorical data (qualitative variable).

3. Results

The study was conducted on forty-nine female patients aged 20–49 years (mean age 29.5 years +/−7.5 years SD) who presented with acute pelvic pain associated with or without other symptoms like vaginal bleeding, fever, infertility or dysmenorrhea (Table 2). Thirteen cases (13/49) were excluded from the study as they had other non gynecological causes of pelvic pain like appendicitis, lower ureteric stones, crohn's disease and diverticulitis.

Positive pelvic US and MRI findings for gynecological causes were seen in thirty-six out of forty-nine cases (36/49). In nineteen cases (53%) the diagnosis was established with US. Pelvic MRI was done for the remaining seventeen cases (47%) where US was non-diagnostic or equivocal (Table 3). Data from both MRI and US were obtained, and the definite diagnosis was established with laparoscopic, surgical findings and results of clinical follow-up as the reference standard.

Final diagnoses of the positive cases (36) were as follows: hemorrhagic ovarian cyst 7 cases (19%); five of them were diagnosed by US and two by MRI (Fig. 1), ovarian torsion five cases (14%); three of them were conclusive by ultrasound and two needed MRI (Figs. 2,3), endometriosis five cases (14%); two were diagnosed by US and three by MRI (Fig. 4), teratodermoid four cases (11%) where three cases were diagnosed by US and one by MRI, ectopic pregnancy four cases (11%); three cases were diagnosed by US and one by MRI (Fig. 5), tubo-ovarian abscess three cases (8%); one was diagnosed with US and three with MRI (Fig. 6), degenerating fibroid three cases (8%); one case was diagnosed with US and two with MRI, adenomyosis two cases (6%); one was conclusive with US and the other needed MRI, pedunculated prolapsed submucosal fibroid one case (3%) (Fig. 7), uterine AVM one case (3%) (Fig. 8) and pelvic hematoma one case (3%) (Fig. 9); the latter three cases were inconclusive by US and were diagnosed by MRI. (Table 4) and the cases are presented within pie Chart 1.

4. Discussion

Acute abdominal pain related to the gynecological conditions is a common presentation in the emergency department. One of the challenges facing clinicians is the wide range of differential diagnoses that must be considered when assessing abdominal pain. Often it can be difficult to distinguish gynecological from gastrointestinal emergencies. In conjunction with clinical findings, various imaging modalities play an important role in diagnosing the cause of pain. In patients presenting with pain that is thought to originate in the gynecological tract, ultrasound is usually employed as the first imaging modality as it is highly sensitive, fast and easy to access. Computed tomography (CT) is not routinely employed in diagnosing acute gynecological complications. MRI is not usually used in the acute setting but it becomes an important tool in characterization

Table 1 Summary of MR imaging parameters for female pelvic examination.

Plane and pulse sequence	FOV	Thickness (mm)	Spacing (mm)	Matrix	TR	TE
Coronal T2 FRFSE	24	4.0	1.0	288 × 224	3200	108
Axial T2 FEFSE FS	28	4.0	1.0	320 × 224	4016	106
Sagittal T2 FRFSE	24	4.0	1.0	288 × 224	2800	101
Axial STIR	28	4.0	1.0	320 × 256	4366	50
Sagittal STIR	24	4.0	1.0	320 × 256	3700	52
Coronal STIR	24	4.0	1.0	320 × 265	6150	46
Axial T1 FSE	28	4.0	1.0	256 × 160	550	11
Coronal T1 FSE	24	4.0	1.0	256 × 160	400	10
Sagittal T1 FSE	24	4.0	1.0	256 × 160	716	13
Axial T1 SE FS	28	4.0	1.0	256 × 160	780	10
Axial DWI	28	6.0	1.0	128 × 128	7006	86
Axial T1 post FS	28	4.0	1.0	256 × 160	750	11
Sagittal T1 post FS	30	4.0	1.0	256 × 160	650	13
Coronal T1 post FS	30	4.0	1.0	256 × 160	700	15

Table 2 Summary of clinical presentations of 49 patients presenting with acute pelvic pain.

Associated symptoms	Diagnosis	Num of cases
Dysmenorrhea	Endometriosis, uterine fibroid, adenomyosis	6(17%)
Dyspareunia	Endometriosis, ovarian cyst	7(19%)
Fever	PID	3(8%)
Radiation of pain to groin	Ovarian torsion	5(14%)
Nausea and vomiting	Ovarian torsion	5(14%)
Vaginal bleeding	Ectopic pregnancy, Pedunculated prolapsed submucosal fibroid, Uterine AVM	6(17%)
Vaginal discharge	PID	3(8%)

Table 3 The comparative number of patients correctly diagnosed according to the modality.

Diagnosis	Conclusive by US	Inconclusive US: diagnosed by MRI
Hemorrhagic ovarian cyst	5	2
Ovarian torsion	3	2
Pelvic endometriosis	2	3
Teratodermoid	3	1
Ectopic pregnancy	3	1
Tubo ovarian complex	1	2
Degenerated fibroid	1	2
Adenomyosis	1	1
Pedunculated submucosal fibroid	–	1
Uterine AVM	–	1
Pelvic hematoma	–	1
Total No.	19(53%)	17(47%)

and final diagnosis of abnormalities that remain indeterminate following ultrasound examination (9).

According to the recommendation of Seigleman and Oliver (4), a T1-weighted fat-suppressed sequence was included in the MRI protocol for two reasons: First, the loss of signal intensity within a T1-hyperintense adnexal mass at fat-suppressed imaging facilitates characterization of fat containing mass as a mature cystic teratoma, second, saturation of the high signal intensity of fat improves the dynamic range of T1-weighted images by enhancing the differences among non–fat-containing T1-hyperintense structures, thereby enabling more sensitive detection of small endometriomas, hematosalpinx. The addition of this sequence helped in the diagnosis of many cases in our study namely hemorrhagic ovarian cyst, endometriosis, ectopic pregnancy, teratodermoid, and pelvic hematoma.

According to Roche et al. (9) the inclusion of a T1-weighted pulse sequence is helpful in identifying blood products and is recommended as part of any imaging protocol for examination of the pelvis.

Diffusion-weighted imaging has been incorporated into pelvic MR imaging protocols (20). DW imaging allows improvement of characterizing complex adnexal masses. It has a large number of potential clinical applications in the female pelvis, and can easily be added to any routine MR protocol (21,22). In our study it had a confirmatory role in diagnosing a case of tubo-ovarian abscess.

Thirty-six patients complaining of acute pelvic pain were enrolled in our study. In 19 patients out of them, identification of the cause of acute pain was diagnosed by gray scale ultrasound as well as color/power Doppler. MR was requested, often because US was non-diagnostic or inconclusive.

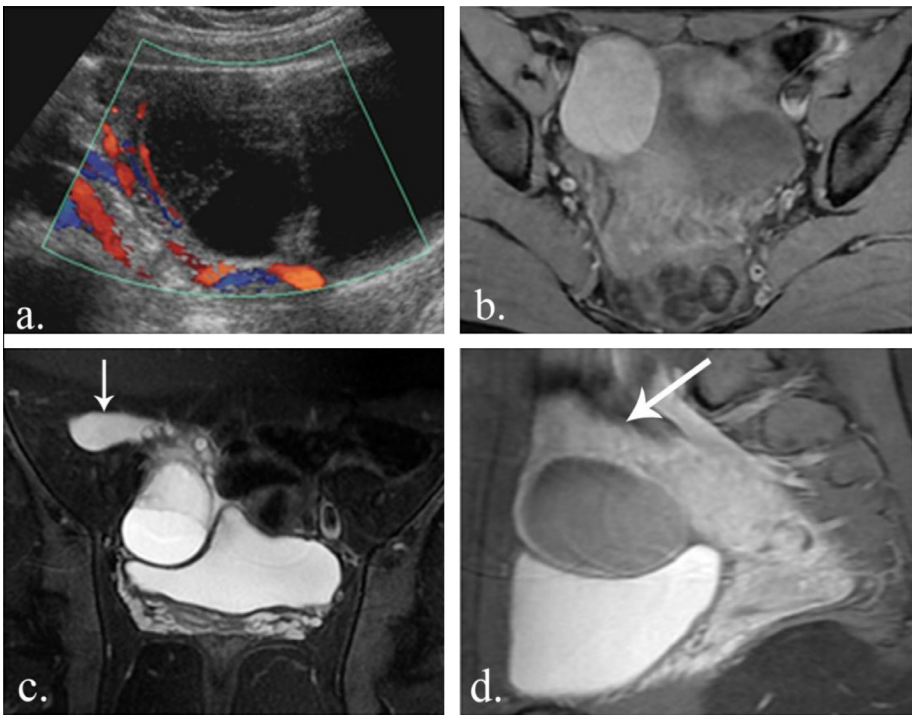


Fig. 1 Leaking hemorrhagic ovarian cyst: a 23 year old female patient presented with right sided pelvic pain. (a) Transabdominal pelvic ultrasound of a hemorrhagic cyst shows the characteristic mesh of fine linear echoes referred to as a ''lacy'' or ''fish net'' appearance. Color Doppler shows perilesional flow with absence of blood flow in the fine septations, however the ovarian stroma was stretched by virtue of the described cyst such that intra ovarian blood flow could not be elicited, so the possibility of ovarian torsion was raised and MRI was recommended. (b) Axial T1 weighted image with fat saturation revealed a right ovarian cystic lesion displaying hyperintense signal denoting its hemorrhagic nature. (c) Axial T2 fat sat. image revealed hyperintense signal intensity of the right ovarian cyst with slight fluid leveling with adjacent mild amount of free fluid (arrow). (d) Sagittal contrast enhanced fat sat T1 weighted image revealed homogenously enhancing ovarian parenchyma (arrow) that is seen stretched by virtue of the described cyst.

There were seven patients with Hemorrhagic ovarian cyst in our study; five of them demonstrated the typical findings of a hemorrhagic cyst at US according to Betel And Glanc (23) who stated that the sonographic appearance of hemorrhagic ovarian cyst is variable, depending on the age of the blood, and most show through transmission. Internal echoes as well as internal strands are often seen and are related to fibrin. Unlike septations, strands are numerous, thin, weak reflectors and do not traverse the entire cyst. An internal clot may mimic a solid component, but clots are avascular and have concave borders or angularity due to clot retraction.

Regarding the other two cases: in one case the hemorrhagic ovarian cyst by gray scale ultrasound appeared as iso to hyperechoic ovarian apparently solid mass lesion that needed further characterization. In the other case gray scale as well as Color Doppler ultrasound revealed an enlarged cystic mass lesion with no evidence of normal ovarian tissue or flow so ovarian torsion could not be excluded according to Yoffe et al. (24), who stated that Hemorrhagic ovarian cysts are called ''the great imitator'' owing to their multiple appearances depending on the age of the blood, so further assessment was recommended.

Hubert and Bergin (25) stated that hemorrhagic ovarian cysts tend to be of relatively high signal intensity on T1W images and of intermediate-to-high signal intensity on T2W images and frequently reveal a fluid–fluid level, and that hemorrhagic cysts should remain of relatively high signal on T1W images with fat suppression, which helps to differentiate them from dermoid cysts in most situations. They also tend to have thicker walls than do simple cysts and may exhibit wall enhancement on post contrast images. However, the internal components of the cysts never enhance.

This goes with the findings in our study where the hemorrhagic ovarian cyst was identified by its preserved high signal intensity on T1 weighted image without and with fat suppression and lack of contrast enhancement. High T2 signal intensity with fluid level were seen in one case, and the homogenous enhancement of the stretched ovarian stroma excluded the possibility of torsion.

Three cases with ovarian torsion were diagnosed, where the US criteria found were similar to Chang et al. (3) who stated that adnexal torsion or Ovarian torsion findings in gray-scale ultrasound include an enlarged ovary, ovarian mass, free fluid, follicles at the periphery of an enlarged ovary, thickening of a cyst wall, and a twisted pedicle. Our findings also agreed with Albaryam et al. (26) who found that unilaterally enlarged ovary with central afollicular stroma and multiple uniform 8–12-mm peripheral follicles is a common ultrasound finding that can be found in up to 74% of cases.

Concerning the other two cases: one case was a 24 year old virgin, known to have hemolytic anemia, who had previous history of left sided oophorectomy for ovarian torsion, so the critical situation mandated urgent MRI to be done to confirm the diagnosis that was suspected by US where the ovary

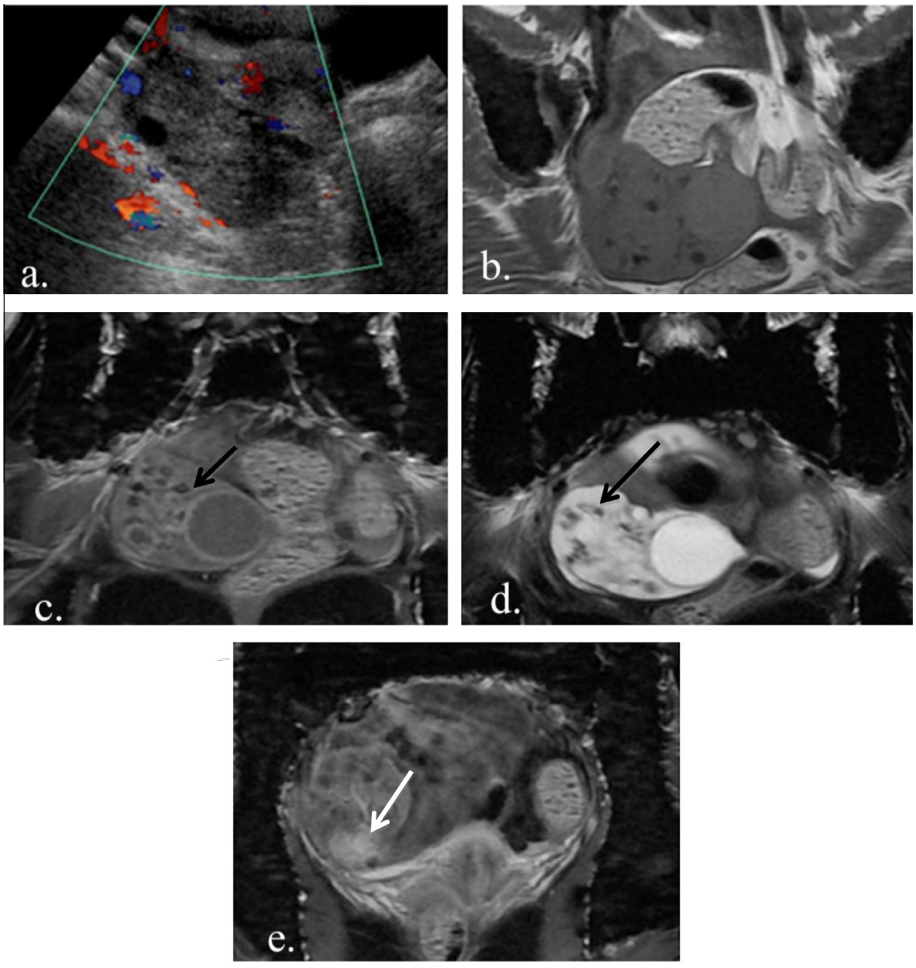


Fig. 2 Ovarian Torsion: a 24 year old female presented with right iliac fossa pain and nausea. (a) Pelvic ultrasound revealed an enlarged right ovary with few peripherally situated follicles. No intra-ovarian vascularity was detected by color Doppler US. The patient had history of previous left sided oophorectomy for left ovarian torsion. (b, c &d) axial T1, axial T1 fat sat and axial T2 weighted images revealed an enlarged right ovary (black arrows) that shows small hypointense foci on both T1 and T2 weighted images most likely hemorrhagic, with a well defined non hemorrhagic cyst seen at its medial aspect. A rim of free fluid is seen surrounding the ovary on T2 weighted image. (e) Axial T1 post contrast image shows minimal enhancement (white arrow) likely minimal supply at its capsular layer. A note was made of the diffuse marrow hypointense signal at all pulse sequences (known hemolytic anemia patient).

was enlarged with estimated volume about 59 cc with peripherally situated follicles and surrounding free fluid and to detect any enhancement for the hope of conservation of the right ovary. By MRI faint peripheral enhancement was detected, the patient was treated with laparoscopic untwisting of the pedicle and did not require oophorectomy. Regarding the other patient the twisted vascular pedicle was misinterpreted as the normal ovary with normal vascularity within, and the enlarged torsed ovary was interpreted as an adnexal mass that was referred for MRI for further characterization. According to Duigenan et al. (27) twisting of the ovarian pedicle is pathognomonic when seen and, hence, is the most specific feature of ovarian torsion; in our study, in addition to ovarian enlargement on MRI, we identified ovarian torsion by the abnormally high T2-signal intensity of the ovarian parenchyma in 2 cases and the twisted vascular pedicle in one case.

Among the case population we diagnosed five were with pelvic endometriosis. US diagnosed 2 cases without need for further assessment where the sonographic appearance obtained in our study was similar to Kuligowska et al. (28) who found that the typical sonographic appearance of ovarian endometriomas consists of cystic masses that have diffuse low-level homogeneous echoes. The contents of the cyst, however, may vary in appearance because of the age of the hemorrhage. Endometriomas can be multilocular, with thin or thick septations and thick irregular walls, our findings were correlated with clinical history of cyclic pelvic pain and infertility with follow up US, as a follow-up transvaginal US study in 6 weeks, can be helpful in differentiating endometrioma (which will change in size and appearance because of the changing age of the hemorrhage) from other causes (28). In the other three cases US findings were equivocal and further evaluation by MRI was recommended.

The classic endometrioma shows shading, defined as a range of low-signal intensities on T2-weighted images and a corresponding high signal on T1-weighted images. This shading reflects the chronic nature of the endometrioma resulting from repeated episodes of hemorrhage accumulating over

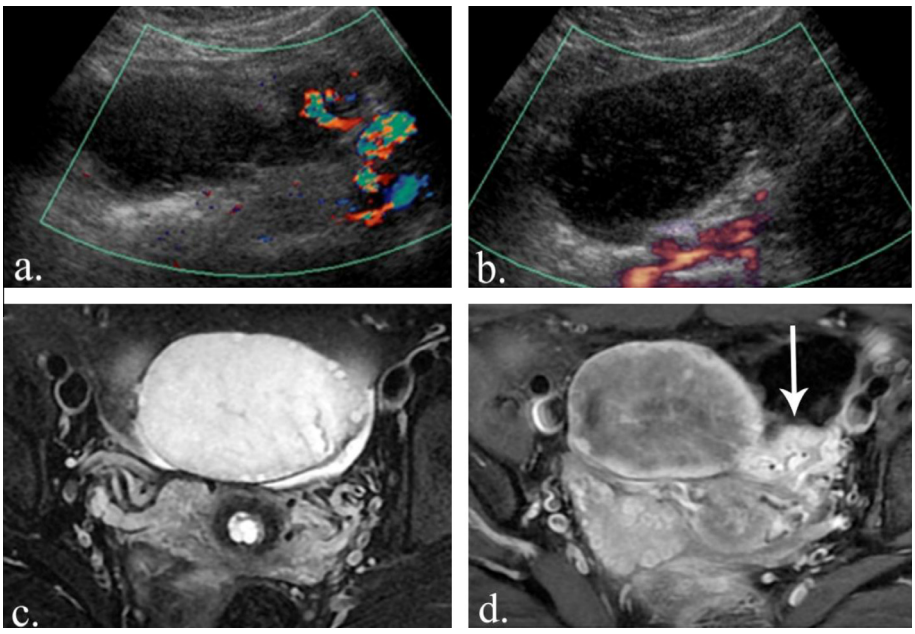


Fig. 3 Ovarian torsion: a 24 year old female patient presented with left iliac fossa pain. (a & b) Pelvic ultrasound revealed a left adnexal mass that was thought to be adjacent to the left ovary that showed internal vascularity by color Doppler and further MRI was recommended for adnexal mass characterization. (c) Axial T2 weighted fat sat images revealed an enlarged left ovary with peripherally situated subcentemetric follicles and minimal surrounding free fluid. (d) Axial post contrast T1 weighted image with fat saturation revealed enlarged left ovary with poor central enhancement and engorgement of its vascular pedicle seen (arrow in d) and this was misinterpreted in ultrasound as the normal ovary yet retrograde, it was known to be the whirlpool sign of the twisted vascular pedicle in ovarian torsion.

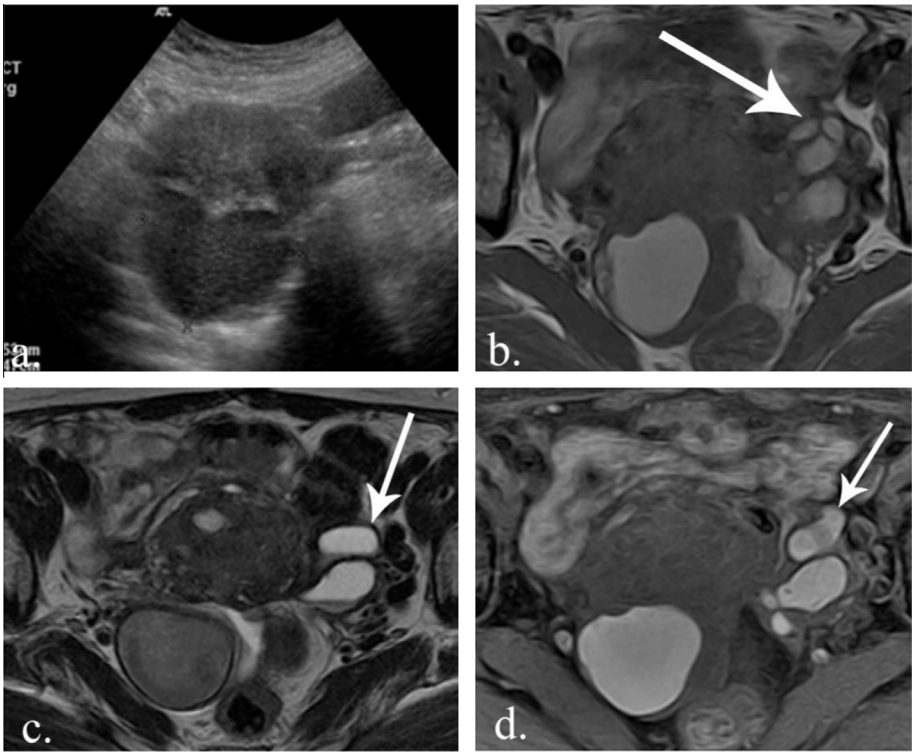


Fig. 4 Endometriosis: a 38 year old female presented with pelvic pain and dysmenorrhea. (a) Pelvic ultrasound revealed cystic mass in the right adnexal region with diffuse low-level internal echoes. (b) Axial T1 fat sat. revealed that this cystic mass is an endometrioma displaying hyperintense signal on T1 weighted images with and without fat suppression (b & d) with hypointense signal on T2 weighted image (c) denoting its hemorrhagic nature. Also noted are multiple left adnexal confluent cystic lesions bright on T1 weighted images with and without fat suppression (b & d). Some fluid levels on T2 weighted image(c) were noted denoting left sided hematosalpinx (arrows).

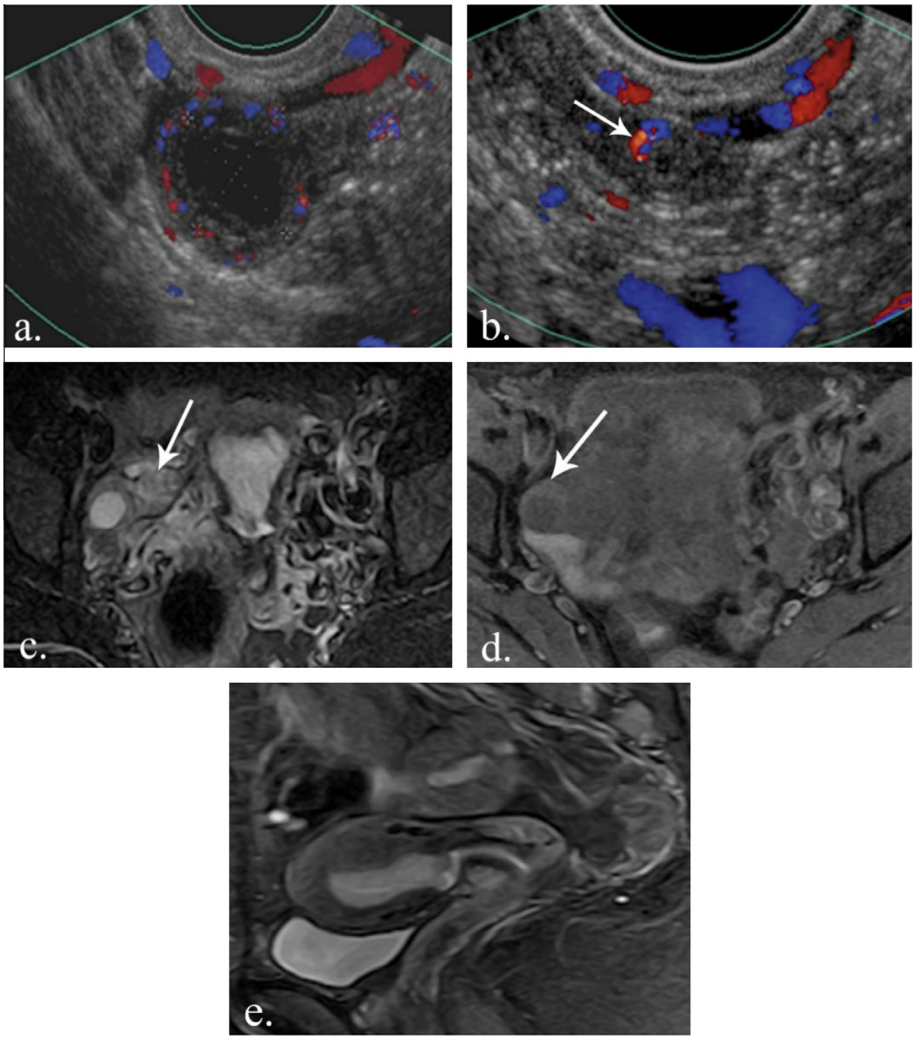


Fig. 5 Ectopic pregnancy: a 26 year old patient presented with right iliac fossa pain. The patient had positive pregnancy test yet serum beta HCG was <1000 mIU/ml. Tranvaginal ultrasound (a & b) revealed a right adnexal cystic lesion showing fine linear internal echoes, with surrounding vascular ring as shown by color Doppler examination, it was interpreted as hemorrhagic corpus luteum cyst. Another suspected small right adnexal mass was seen with internal vascularity (arrow in b) (c & d). Axial STIR and T1 fat sat images revealed a single right adnexal heterogeneous soft tissue shadow (arrow on c) with a well defined cystic component seen in its lateral aspect that shows minimal hemorrhagic changes apparent on T1 fat sat image (arrow on d). (e) Sagittal STIR revealed thickening of the endometrium (decidual reaction), so it was diagnosed by MRI as ectopic pregnancy that was proven latter by laparoscopy.

months and years with extremely high concentrations of iron, protein, and intracellular methemoglobin (29). In our study the shading effect on T2 weighted image was identified in three cases diagnosed by MRI. The presence of T1-weighted hyperintensity within a dilated fallopian tube is suggestive of endometriosis, and may be the only finding at MR imaging in some women. (30) This was identified in two of the three cases of endometriosis diagnosed in our study.

Regarding the four patients who were proven to have dermoid cyst, three of them were straightforward by US according to the criteria found by Outwater et al. (26) who stated that Cystic teratomas may appear cystic with hyperechoic areas or hyperechoic densities on ultrasound with loss of through transmission. In the fourth case the mass lesion was complex appearing attaining a large size and an associated ovarian cyst on the same side was also seen, so it was confusing and interpreted as complex left adnexal mass for further characterization by MRI. On MRI It was identified, according to Outwater et al. (26) by its very high signal intensity on T1-weighted images due to the sebaceous component, which is characteristic of dermoid cyst. Fat suppression differentiated fat from other hemorrhagic lesions, such as hemorrhagic cysts and endometriomas, which also appear hyperintense on T1-weighted images but remain high in signal intensity on fat-saturated images (26). The associated cystic lesion displayed a low signal on T1WI and a high signal on T2WI was not suppressed on fat sat T2WI and with no post contrast enhancement denoting its simple nature.

In the setting of suspected ectopic pregnancy, US, in combination with clinical and laboratory values, has been studied extensively, and numerous signs and criteria are described in the literature. The most specific US criterion of ectopic pregnancy is the presence of an extra uterine gestational sac with either a yolk sac or embryo, with a specificity of 100%. If

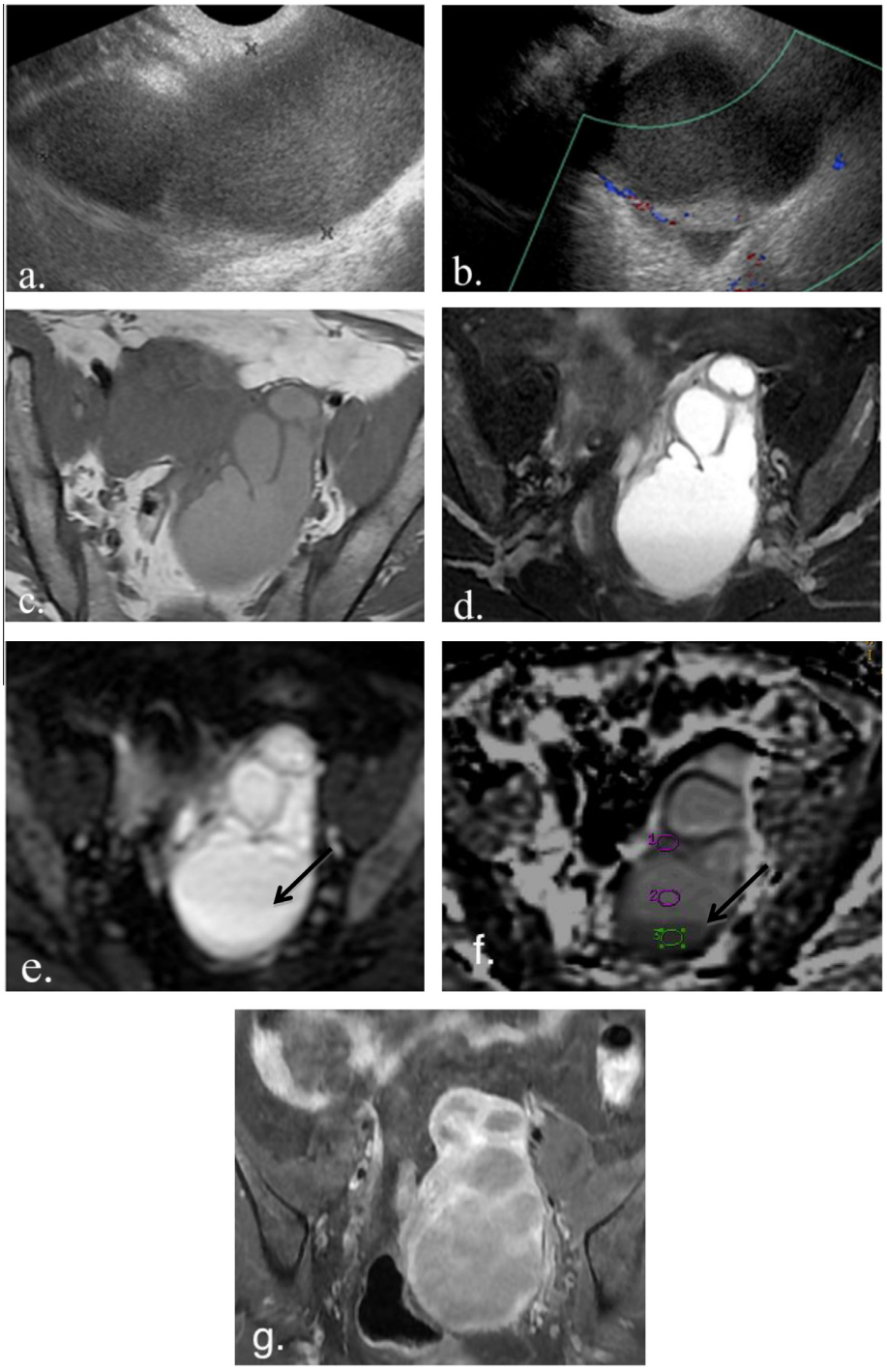


Fig. 6 Tubo ovarian abscess: a 36 year old female patient presented with pelvic pain and fever. Pelvic ultrasound (a & b) revealed a left adnexal multiloculated cystic lesion with low-level internal echoes and minimal amount of free fluid. It was interpreted as an ovarian cystic mass for differential diagnosis. (c & d) Axial T1 and T2 fat sat weighted image revealed a left adenexal multilocular cystic lesion that reflects bright signal on T1 and T2 fat sat weighted images. (e & f) Axial diffusion weighted image and the corresponding ADC map revealed significant diffusion restriction with low ADC value, subtle fluid- fluid level was seen (arrows) denoting abscess formation; mean ADC value measured was 2.8×10^{-3}. (g) This was confirmed in the axial post contrast T1 weighted images with fat saturation that revealed thick marginal moderate contrast uptake.

less-stringent criteria are used, then the specificity decreases. For instance, when the only findings are free pelvic fluid and the lack of an intrauterine pregnancy, the sensitivity and specificity decrease to 63% and 69%, respectively. Ectopic pregnancy cannot, therefore, be definitively excluded with US in a number of cases (27). In our study we had four cases of ectopic pregnancy. In three cases US was sufficient for final diagnosis while in the last case US was inconclusive as hemorrhagic

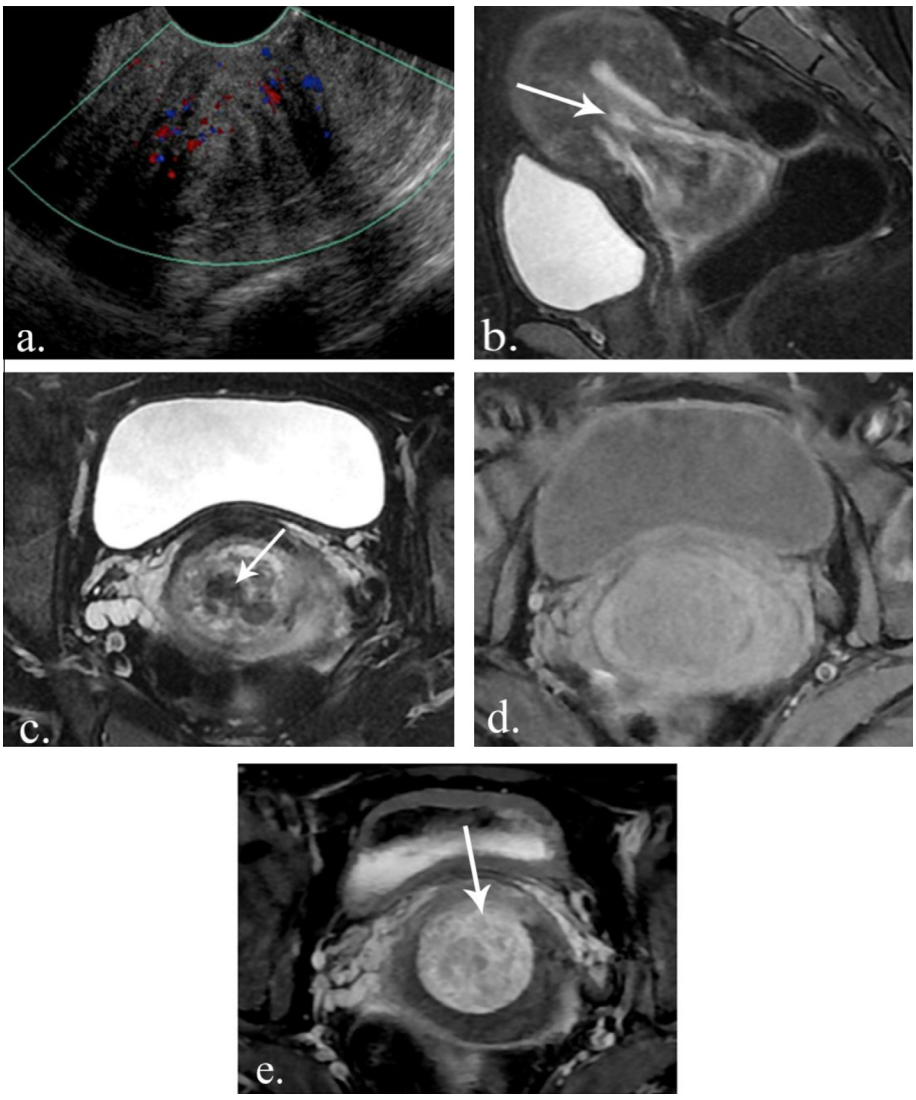


Fig. 7 Pedunculated submucosal fibroid with prolapse and torsion. The patient presented to the emergency department with acute pelvic pain and vaginal bleeding. (a) Transvaginal ultrasound revealed a mass lesion that is seen filling and expanding the cervical canal and protruding into the upper vagina, was interpreted as cervical polyp. (b) Sagittal T2 fat sat. image demonstrates a fibroid arising on a stalk (white arrow) that originates in the lower endometrial cavity. (c) Axial T2 image demonstrates the fibroid has prolapsed into the endocervical canal and demonstrates areas of low signal at T2 (black arrow) suggestive of hemorrhage. (d) Axial T1 fat saturated image demonstrates high signal intensity within the fibroid indicating hemorrhage. Axial T1 fat-saturated image following gadolinium administration demonstrates inhomogeneous enhancement with areas of low signal intensity consistent with torsion (white arrow).

corpus luteum cyst was interpreted and a small adnexal mass lesion was only suspected, so further pelvic MRI was recommended, ectopic pregnancy was identified on T2-weighted MR images that showed a heterogeneous mass with predominantly intermediate to high T2 signal intensity in the right fallopian tube. The mass had an associated cystic component. The findings at laparoscopy confirmed a right tubal ectopic pregnancy.

With MR imaging, there is limited experience with ectopic pregnancy, and it is unclear at what point an intrauterine pregnancy should be seen. Thus, it is prudent to systematically evaluate for ectopic at any time when (a) a patient has positive results of a pregnancy test and (b) an intrauterine pregnancy is not definitively seen (28).

Three patients were diagnosed with tubo-ovarian abscess'' (TOA)''. One patient was conclusive by US correlated with the clinical and laboratory data. In US, the diagnosis was made according to the findings described by Vandermeer et al. (7) which comprises tubular, ovoid, or pear-shaped configuration with wall thickening (> 5 mm) and anechoic or layering echogenic fluid with debris with or without intrapelvic free fluid. In the other two patients Transvaginal sonography was indeterminate. It revealed heterogeneous cystic masses with an irregular contour in the adnexal region and free pelvic fluid in the pouch of Douglas. On MRI TOA was identified as a multiloculated cystic lesion, the contents of the abscess usually showed slightly high signal intensity on TlWI denoting high protein content Post contrast images showed intense

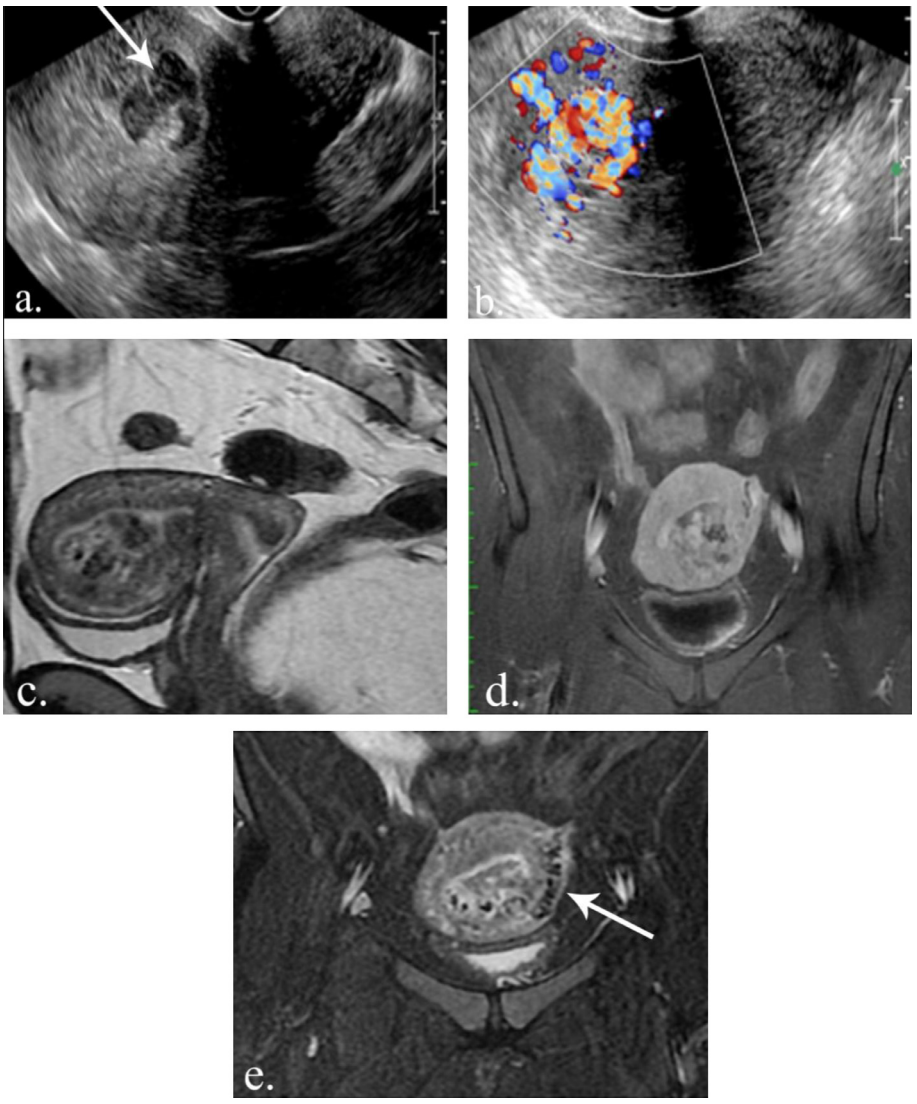


Fig. 8 Uterine AVM: A 21 year old patient presented with vague pelvic pain and vaginal bleeding. (a) Gray Scale Transvaginal ultrasound revealed several interspersed sonolucent spaces of varying sizes close to the uterine fundus (arrow). (b) Endovaginal color Doppler sonogram reveals hypervascular nature of sonolucent spaces. Gestational trophoblastic disease was the ultrasound suggestion however pregnancy test was negative so further MRI examination was recommended. (c) Sagittal T2 weighted image revealed multiple serpiginous flow-related intense contrast enhancement in anterior myometrium corresponding to sonographic findings. (d) Contrast-enhanced fat-suppressed coronal fast spin-echo T1-weighted image during arterial phase also shows multiple serpiginous flow-related signal voids in myometrium (e) coronal STIR image better shows associated asymmetric prominence of contiguous signal void vessels on left (arrow) consistent with uterine AVM.

enhancement of the abscess wall and septa. On DWI, the content of the mass showed significant diffusion restriction.

According to Takeshita et al. (33), who stated that as in the brain abscess, DWI may be a useful noninvasive imaging technique in the diagnosis of PID including TOA, it played a confirmatory role in the diagnosis in our cases.

Four cases were diagnosed as having degenerated myomas, one out of which was diagnosed by ultrasound which according to Roche et al. (9) was identified by its complex appearance and areas of cystic degeneration, with absence of flow on Doppler US. One case was misinterpreted by ultrasound as a cervical polyp yet MRI revealed it was a prolapsed leiomyoma. Sagittal T2-weighted images demonstrated the prolapsing leiomyoma extending into the endocervical canal, and showed the stalk and its uterine attachment. The stalk extends into the endometrial cavity and typically has multiple linear structures running through it. The other two cases had features of degeneration that were described by Singh et al. (8) including interstitial edema, the initial sign of degeneration, that causes high signal intensity on T2-weighted images. On contrast MR imaging, degenerated leiomyomas showed slight or irregular enhancement. Leiomyomas with cystic degeneration show a high-signal intensity on T2-weighted images, and the cystic areas do not enhance.

We had two cases with final diagnosis of adenomyosis. One case was diagnosed by US according to the criteria described

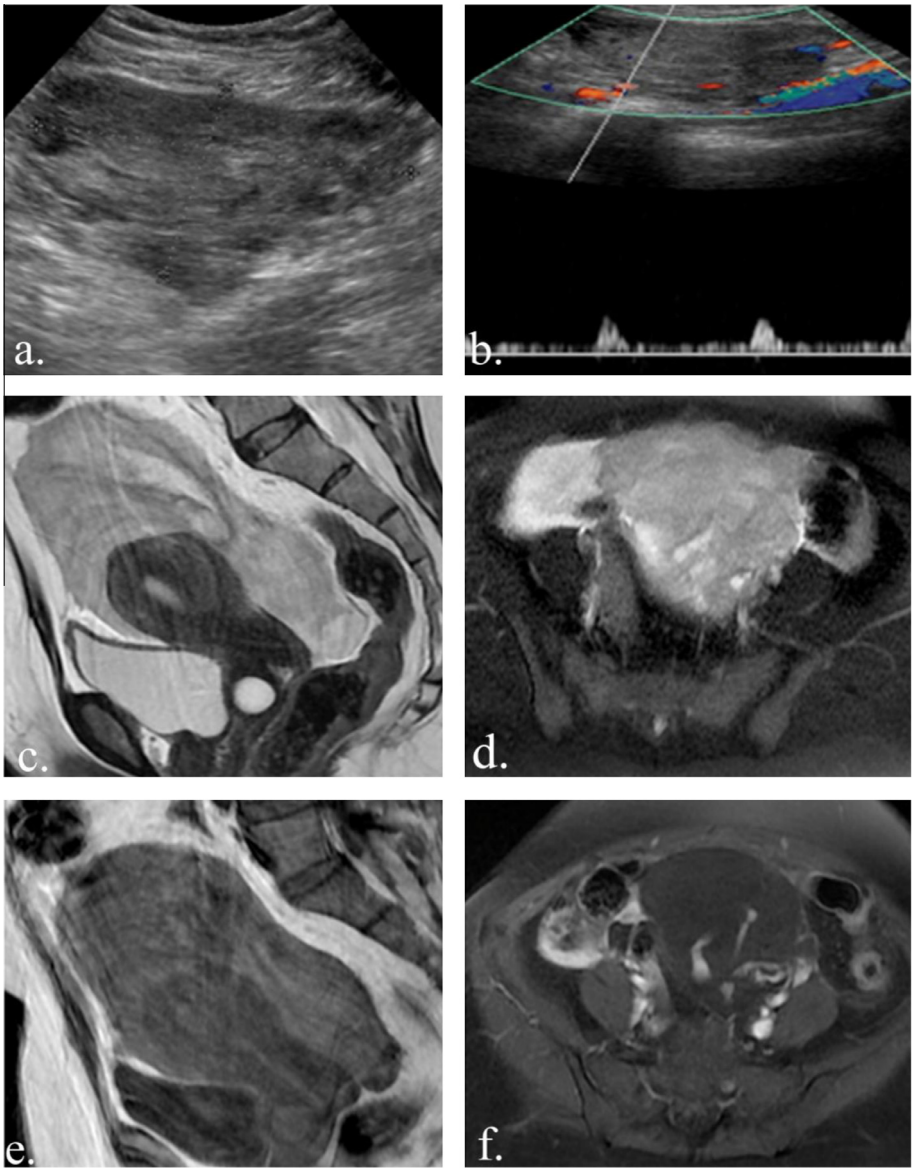


Fig. 9 Pelvic hematoma: a 49 year old female patient presented to the emergency department with acute pelvic pain. Patient gave history of previous cardiac valve replacement and receiving anticoagulant therapy. Pelviabdomial ultrasound was done for the patient. (a & b) Gray scale pelvic ultrasound (a) as well as color Doppler examination (b) revealed a sizeable pelvic mass with inhomogeneous echotexture, blood vessels were seen traversing it. There was also mild amount of perihepatic and perisplenic free fluid seen on abdominal ultrasound (not shown). It was interpreted as an ovarian origin vascular mass lesion with associated ascites, for further MRI characterization. Sagittal T2 and axial T2 fat sat revealed a large pelvic mass seen insinuating the uterus displaying intermediate signal intensity with hyperintense foci. (e) Sagittal T1 weighted image revealed hyperintense foci denoting blood in the subacute stage. (f) Axial T1 weighted image post contrast administration revealed lack of enhancement with blood vessel seen traversing the hematoma. Pelvic hematoma was confirmed at surgery.

by Lyons (34) namely the presence of an echogenic mass with ill-defined borders together with Color and power Doppler US that demonstrated the penetrating vascular pattern within the mass; the other case was interpreted as a fibroid, and was diagnosed by MRI according to the diagnostic features of focal adenomyosis described by Outwater et al. (31) which are the presence of oval, ill-defined, low-signal-intensity masses (i.e., adenomyomas) on T2-weighted MR images. According to Nakai et al. (32) bright, tiny foci, either linear or round, within the masses are often noticed on T1- or T2-weighted images. High-signal-intensity foci on T1-weighted images represent hemorrhages, whereas high signal- intensity foci on T2-weighted images correspond to dilated endometrial glands in the secretory phase. Our findings concerning differentiating fibroid from focal adenomyosis also agreed with Valentini et al. (10) who stated that the differential diagnosis is better achieved by means of MRI: focal lesions caused by adenomyosis (i.e. focal thickening of junctional zone or ''pseudowidening'') tend

Table 4 Final diagnosis of 36/49 (73%) positive cases diagnosed by ultrasound alone or combined with MRI.

Diagnosis	No. of cases	
Hemorrhagic ovarian cyst (Fig. 1)	7	19%
Ovarian torsion (Figs. 2 and 3)	5	14%
Pelvic endometriosis (Fig. 4)	5	14%
Teratodermoid	4	11%
Ectopic pregnancy (Fig. 5)	4	11%
Tubo ovarian complex (Fig. 6)	3	8%
Degenerated fibroid	3	8%
Adenomyosis	2	6%
Pedunculated submucosal fibroid (Fig. 7)	1	3%
Uterine AVM (Fig. 8)	1	3%
Pelvic hematoma (Fig. 9)	1	3%
Total No.	36	100%

to be ovoid and show poor defined margins and poor mass effect on the endometrium whereas fibroids tend to be round, showing well defined margins and a mass effect on the endometrium especially when are submucosal.

Among the cases examined we had one case of uterine AVM: Transvaginal ultrasound revealed fundal parenchymal inhomogeneity with several interspersed sonolucent spaces of varying size. Color Doppler sonography revealed the hypervascular nature of the lesion. It was interpreted as gestational trophoblastic disease but serum hCG was negative. On MRI it was identified according to the diagnostic features described by Maldonado et al. (13) who stated that Serpiginous flow-related signal voids, corresponding to the myometrial hypervascular areas on color Doppler sonography are characteristic of uterine AVMs. Prominent parametrial vessels and disruption of the junctional zones may also be present.

One case of pelvic hematoma was identified. A 49-year-old patient presented to the emergency department with acute pelvic pain. She gave history of cardiac valve replacement 10 years before receiving anticoagulant therapy. US done for the patient revealed a heterogeneous appearing pelvic mass lesion with blood vessels seen traversing through it, with associated mild amount of perihepatic as well as perisplenic ascites. It was interpreted as a vascular adnexal mass likely of ovarian origin for further MRI assessment. MRI revealed a large pelvic mass seen insinuating the uterus displaying intermediate signal intensity on T2 weighted images with hyperintense foci. On T1 weighted images hyperintense foci were identified denoting blood in the subacute stage. Post contrast administration revealed lack of enhancement with blood vessel seen traversing it. Pelvic hematoma was confirmed at surgery.

The limitations of this study include the small study population. Although the study population had a high rate of acute pathologies, they were heterogeneous, thereby limiting the usefulness with regard to a single acute pathology. Also multiple pathologies included in the study prohibited against obtaining significant results.

In conclusion, the results of this study suggest that a two-stage protocol for evaluating women presenting with acute pelvic pain where ultrasound (US) is the primary imaging modality of choice and magnetic resonance (MR) imaging has proved to be a valuable adjunct, that can accurately diagnose or rule out a wide spectrum of pelvic pathologies.

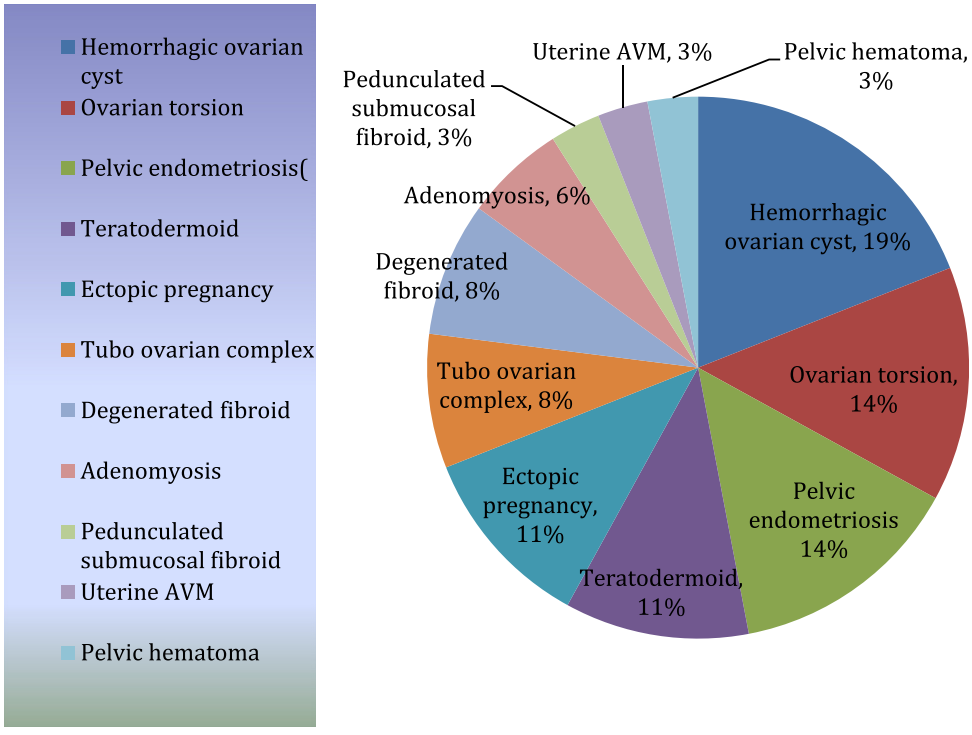


Chart 1 Representing the final diagnosis in the 36/49 (73%) positive cases diagnosed by US alone or combined with MRI.

Conflict of interest

The authors have no conflict of interest to declare.

References

(1) Kruszka PS, Kruszka SJ. Evaluation of acute pelvic pain in women. American Family Physician 2010;82(2):141–7.
(2) Huchon C. Fauconnier a adnexal torsion: a literature review. Eur J Obstet Gynecol Reprod Biol 2010;150:8–12.
(3) Chang HC, Bhatt S, Dogra VS. Pearls and pitfalls in diagnosis of ovarian torsion. Radiographics 2008;28:1355–68.
(4) Seigelman ES, Oliver ER. MR imaging of endometriosis: ten imaging pearls. RadioGraphics 2012;32:1675–91.
(5) Kalish GM, Patel MD, Gunn ML, Dubinsky TJ. Computed tomographic and magnetic resonance features of gynecologic abnormalities in women presenting with acute or chronic abdominal pain. Ultrasound Q 2007;23:167–75.
(6) Sam JW, Jacobs JE, Birnbaum BA. Spectrum of CT findings in acute pyogenic pelvic inflammatory disease. Radiographics 2002;22:1327–34.
(7) Vandermeerm FQ, Wong-You-Cheong JJ. Imaging of acute pelvic pain. Top Magn Reson Imaging 2010;21(4):201–11.
(8) Singh AK, Desai H, Novelline RA. Emergency MRI of acute pelvic pain: MR protocol with no oral contrast. Emerg Radiol 2009;16:133–41.
(9) Roche O, Chavan N, Aquilina J, Rockall A. Radiological appearances of gynaecological emergencies. Insights Imaging 2012;3:265–75.
(10) Valentini AL, Gui1 B, Basilico R, Di Molfetta1 IV, Miccò M, Bonomo L. Magnetic resonance imaging in women with pelvic pain from gynaecological causes: a pictorial review. Radiol Med 2012;117:575–92.
(11) Ghai S, Rajan DK, Asch MR, Muradali D, Simons ME, TerBrugge KG. Efficacy of embolization in traumatic uterine vascular malformations. J Vasc Interv Radiol 2003;14:1401–8.
(12) Timmerman D, Wauters J, Van Calenbergh S, et al. Color Doppler imaging is avaluable tool for the diagnosis and management of uterine vascular malformations. Ultrasound Obstet Gynecol 2003;21:570–7.
(13) Maldonado J, Perez C, Rodriguez W. Teaching file: profuse vaginal bleeding seven weeks following induced abortion AJR teaching file. AJR 2008;191:79–82.
(14) Siegelman ES, Outwater EK. Tissue characterization in the female pelvis by means of MR imaging. Radiology 1999;212:5–18.
(15) ACR Practice Guideline for the Performance of Magnetic Resonance Imaging (MRI) of the Soft Tissue Components of the Pelvis. Reston, VA: American College of Radiology; 2006 (Amended).
(16) Hricak H, Chen M, Coakley F, et al. Complex adnexal masses: detection and characterization with MR imaging-multivariate analysis. Radiology 2000;214:39–46.
(17) Sohaib SA, Sahdev A, Van Trappen P, et al. Characterization of adnexal mass lesions on MR imaging. AJR Am J Roentgenol 2003;180:1297–304.
(18) Schwartz LB, Panageas E, Lange R, et al. Female pelvis: impact of MR imaging on treatment decisions and net cost analysis. Radiology 1994;192:55–60.
(19) ACR Practice Guideline for the Performance of Magnetic Resonance Imaging (MRI) of the Soft Tissue Components of the Pelvis. Reston, VA: American College of Radiology; 2006 (Revised).
(20) Coutinho Jr AC, Krishnaraj A, Pires CE, Bitten court LK, Guimarães AR. Pelvic applications of diffusion magnetic resonance images. Magn Reson Imaging Clin N Am 2011;19(1):133–57.
(21) Qayyum A. Diffusion weighted imaging in the abdomen and pelvis: concepts and applications. Radiographics 2009;29(6):1797–810.
(22) Whittaker CS, Coady A, Culver L, Rustin G, Padwick M, Padhani AR. Diffusion weighted MR imaging of female pelvic tumors: a pictorial review. Radiographics 2009;29(3):759–74.
(23) Betel CB, Glanc P. Demystifying ovarian cysts. Ultrasound Clinics 2012;7:75–91.
(24) Yoffe N, Bronshtein M, Brandes J, Blumenfeld Z. Hemorrhagic ovarian cyst detection by transvaginal sonography: the great imitator. Gynecol Endocrinol 1991;5(2):123–9.
(25) Hubert J, Bergin D. Imaging the female pelvis: when should MRI be considered? Appl Radiol 2008;37(1):9–24.
(26) Albayram F, Hamper UM. Ovarian and adnexal torsion: spectrum of sonographic findings with pathologic correlation. J Ultrasound Med 2001;20:1083–9.
(27) Duigenan S, Oliva E, Lee SI. Ovarian torsion: diagnostic features on CT and MRI with pathologic correlation. AJR 2012;198:122–31.
(28) Kuligowska E, Lu K, Deeds L. Pelvic pain: overlooked and underdiagnosed gynecologic conditions. Radiographics 2005;25:3–20.
(29) Choudhary S, Fasih N, Papadatos D, Surabhi VR. Unusual appearance of endometriosis. AJR 2009;192(6):1632–44.
(30) Outwater EK, Siegelman ES, Chiowanich P, Kilger AM, Dunton CJ, Talerman A. Dilated fallopian tubes: MR imaging characteristics. Radiology 1998;208(2):463–9.
(31) Outwater EK, Siegelman ES, Van Deerlin V. Adenomyosis: current concepts and imaging considerations. AJR Am J Roentgenol 1998;170:437–41.
(32) Nakai A, Togashi K, Koyama T, Yamaoka T, Fujii S, Konishi J. Atypical magnetic resonance appearance of adenomyosis. J Womens Imaging 2001;3:158–63.
(33) Takeshita T, Ninoi T, Doh K, Hashimoto S, Inoue Y. Diffusion-weighted magnetic resonance imaging in tubo-ovarian abscess: a case report. Osaka City Med J 2009;55(2):109–14.
(34) Lyons EA. Ultrasound evaluation of bleeding in the non-pregnant patient. In: Presented at the 102nd Annual Meeting of the American Roentgen Ray Society, Atlanta, Ga, April 28–May 3, 2002.