Corpus luteum with ovarian stromal edema is associated with pelvic pain and confusion for ovarian torsion

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Abstract

Purpose: To distinguish the corpus luteum with adjacent ovarian stromal edema as an entity associated with pelvic pain, with confounding ultrasound features that may lead to false-positive diagnosis of ovarian torsion.
Methods: This is a blinded, retrospective study of 243 corpora lutea on transvaginal ultrasound. Imaging parameters included ovarian and corpus luteum volumes, central cystic space within the corpus luteum, vascularity around the corpus luteum, peripherally displaced follicles, and complex free fluid. Residual volume (ovarian volume minus corpus luteum volume) was used as a surrogate for ovarian stromal edema. Clinical parameters included age, pregnancy, and location/acuity of pain if present. Concern for ovarian torsion in radiology reports was documented.
Results: 51.0% (124/243) of patients presented with pain. Multivariate regression analysis of factors significantly associated with pain (including age, $p = 0.001$; larger corpus luteum volume, $p = 0.002$; larger residual volume, $p < 0.001$; complex free fluid, $p = 0.002$; and peripherally displaced follicles, $p < 0.001$) left only increased residual volume as significantly associated with pain [OR 1.02–1.16; $p = 0.01$]. False-positive concern for ovarian torsion on ultrasound was present in 12.9% (16/124) of patients with pain, associated with enlarged ovaries ($p < 0.001$) and peripherally displaced follicles ($p < 0.001$). High correlation between location of pain and side of the corpus luteum was demonstrated in patients with pain < 14 days duration ($p < 0.001$).
Conclusion: Corpus luteum with ovarian stromal edema is associated with pelvic pain and can mimic ovarian torsion on ultrasound. Further research should explore diagnostically useful differences between cases of ovarian torsion and cases of ovarian edema related to corpora lutea.

Key words: Corpus luteum—Ovarian torsion—Adnexal torsion—Ovarian edema—Pelvic pain

A corpus luteum is a physiologic ovarian secretory structure that develops from a follicle after it undergoes ovulation. It produces progesterone and lesser amounts of other hormones, which decidualize the endometrium prior to implantation of a fertilized ovum, and spontaneously involutes if pregnancy does not occur [1]. Corpora lutea typically form after ovulation during each menstrual cycle, and are therefore exceedingly common as incidental findings on pelvic ultrasound. When complicated by hemorrhage and/or rupture they may cause pelvic pain, accounting for many outpatient and emergency room visits [2–5].

In the setting of acute pelvic pain, pelvic ultrasound is commonly requested to evaluate for ovarian torsion, a surgical emergency. The most sensitive findings of ovarian torsion on ultrasound are increased ovarian size ($> 95\%$ of cases) and ovarian stromal edema leading to peripheral displacement of follicles [6]. More specific findings of ovarian torsion include twisting of the vascular pedicle (the "whirlpool sign") and decreased arterial and venous flow to the affected ovary [6–8]. Ovarian torsion is frequently caused by twisting of the vascular pedicle around a lead-point mass. This most commonly is a mature cystic teratoma; however, corpus luteum cysts may also serve as a lead-point for torsion [9, 10].

There is little literature regarding an association between corpora lutea and edema of the adjacent ovarian stroma, mimicking the appearance of ovarian torsion. Beyth et al. [11] published five cases of unexplained ovarian edema associated with hemorrhagic corpus lu-

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teum cysts, which prospectively were concerning for ovarian torsion. Laparoscopy was negative for torsion in three cases; two of the patients spontaneously improved with nonoperative management.

This was a blinded, retrospective study evaluating patients with a documented corpus luteum on transvaginal ultrasound. The hypothesis was that corpora lutea are associated with ovarian stromal edema, which may lead to pelvic pain and false-positive diagnoses of ovarian torsion by prospectively interpreting radiologists. Specifically, the presence of ovarian stromal edema was demonstrated through calculation of a residual ovarian volume (total ovarian volume minus corpus luteum volume), and the presence of peripherally displaced follicles. Since approximately half of the patients in our cohort presented with pelvic pain, we identified imaging and clinical factors associated with pelvic pain in this population. Radiology reports were reviewed in order to define the prevalence of false positive diagnoses of ovarian torsion in patients with pelvic pain and a corpus luteum. Ultrasound imaging findings were evaluated in confounding cases for recurring features that might be compared and contrasted to cases of true ovarian torsion in future studies. Direct comparison of cases of corpus luteum with stromal edema to cases of true ovarian torsion was beyond the scope of this study.

Methods

Subjects and imaging

This was a HIPAA compliant and institutional review board exempted retrospective study. Using our radiology report search tool (Montage, Nuance Communications, Inc.), we searched ultrasound studies performed at an academic university hospital from January 2016 to September 2017 using the keywords "corpus luteum." These studies were prospectively interpreted by a mix of subspecialized abdominal imagers and general radiologists, and included patients presenting with pain or for other indication. Studies were included if a corpus luteum was identified and documented by the prospectively interpreting radiologist, and a well-defined and measurable corpus luteum was again seen on retrospective review. A corpus luteum was considered to be present on retrospective review if there was (1) a circumscribed structure within the ovary that had a diffusely thickened wall with crenulated inner margins, with or without a central cystic space OR (2) a circumscribed structure within the ovary that was hyperechoic or hypoechoic relative to the adjacent ovarian stroma, with increased peripheral enhancement (the "ring-of-fire") on color Doppler [12].

Exclusion criteria included lack of transvaginal images, lack of color Doppler evaluation, the presence of ectopic pregnancy, ovarian mass, or other diagnosis to explain pain. Patients with potential confounding causes of ovarian stromal edema or enlargement were also excluded, including patients with polycystic ovarian syndrome, patients undergoing infertility treatment, or patients who were surgically proven to have ovarian torsion. All of the ultrasound images were reviewed to evaluate for inclusion and exclusion criteria as long as exclusion criteria were not obviously met by available clinical information.

All ultrasound examinations were performed both trans-abdominally and trans-vaginally using the Siemens Acuson S3000 Ultrasound System, HELX Evolution. The transvaginal ultrasounds were done using either an 8 or 9 MHz probe. Both grayscale and color Doppler evaluation of the ovaries were performed. For color Doppler, there was a standard pulse repetition frequency of 781 Hz.

Image analysis and chart review

A radiologist retrospectively reviewed the cases in a blinded manner. The ovaries and corpora lutea were measured in three dimensions. Care was taken to include the entirety of the corpus luteum in the measurement, including both the thickened wall and central cystic space (if present). For measurement, the corpus luteum edge was determined to be the point that normal ovarian stroma could be seen forming the "claw sign" around the corpus luteum (Fig. 1). The volumes of the ovaries and corpora lutea were calculated using the equation for the volume of an ellipsoid: $(\pi/6) \times$ (Dimension $1 \times$ Dimension $2 \times$ Dimension 3) [13]. The volume of residual tissue of the ovary that contained the corpus luteum was obtained by subtracting the volume of the corpus luteum from the overall volume of the ovary. To avoid bias, we used this residual volume measurement as a surrogate for ovarian enlargement and amount of stromal edema. This was used instead of overall ovarian volume in order to correct for varying contributions of the corpus luteum to ovarian volume in each case.

Other imaging features were evaluated, including the presence or absence of a central cystic space within the corpus luteum, increased vascularity around the corpus luteum, peripherally displaced follicles, and complex free pelvic fluid. Increased peripheral vascularity was defined as color Doppler flow present at multiple locations along the rim of the corpus luteum greater than that seen within the ovarian stroma on one or more still images or on a cine. The follicles were considered peripherally displaced if all follicles were along the edge of the ovary, with non-cystic parenchymal stroma centrally.

Clinical parameters documented on chart review included patient age, pregnancy status, location and acuity of pain if present, and presentation to the emergency department vs. an outpatient clinic. Radiology reports were evaluated to see if the prospectively interpreting
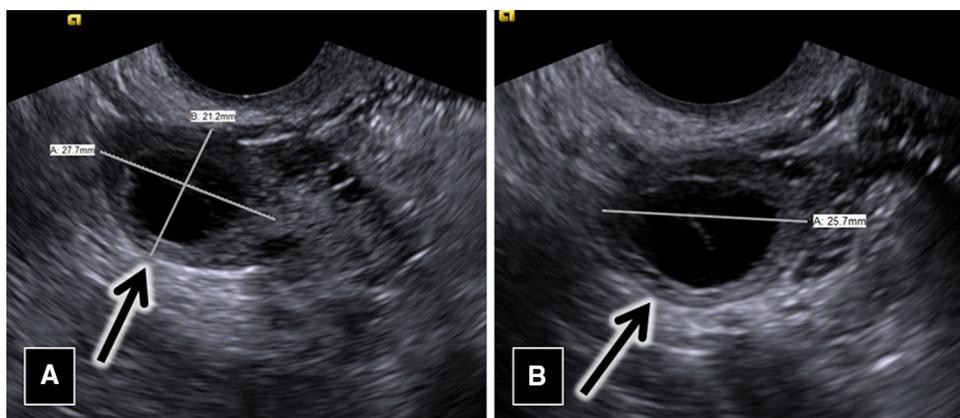
Fig. 1. 33-year-old woman with a corpus luteum. **A** Longitudinal grayscale ultrasound image demonstrates measurements of a corpus luteum cyst within the ovary (arrow). Care was taken to include the rim of soft tissue around the central cystic space in the measurement, extending to the point at which normal ovarian stroma was identified forming the "claw sign" around the corpus luteum. **B** Transverse grayscale ultrasound image demonstrates measurement of a corpus luteum within the ovary (arrow).

radiologist raised concern for ovarian torsion. If patients underwent laparoscopy, the results were reviewed.

Statistical analysis

Participants' demographics, clinical characteristics and ultrasound findings were summarized as mean, standard deviation (SD), median, interquartile range (IQR), and range for continuous variables or count (%) for categorical variables, and compared between patients who presented with and without pain. For continuous variables with an approximately normal distribution, t tests were used; otherwise, Wilcoxon rank sum tests were used. For categorical variables, a Chi squared (χ^2) or Fisher's exact test (when any expected cell count was less than 5) was used. Variables that had clinical and statistical significance were selected to be included in a logistic regression model to predict the presence of pain. In addition, within the pain cohort group, summaries and comparisons were made for patients with and without concern for torsion as well as based on pain acuity. We used ANOVA or Kruskal–Wallis tests for continuous variables and Chi squared (χ^2) or Fisher's exact tests as indicated. All analyses were performed using R 3.2.3 statistical software (R Foundation for Statistical Computing, Vienna, Austria).

Results

Two hundred and forty-one patients met the selection criteria. There were bilateral corpora lutea in two patients. In total, 243 corpora lutea were included in the statistical analysis. Of these, 51.0% (124/243) of patients presented with pelvic pain. Patient demographics and ovarian morphology in those who presented with pain compared to those without pain are shown in Table 1. Patients presenting with pain were slightly younger ($p = 0.001$). Larger ovary ($p < 0.001$), larger corpus luteum ($p = 0.002$), larger residual ovarian volume ($p < 0.001$), peripherally displaced follicles ($p < 0.001$), and the presence of complex free fluid within the pelvis ($p = 0.002$) were significantly associated with pelvic pain. Multivariate regression analysis including patient age, corpus luteum volume, residual volume, presence of complex free pelvic fluid, and peripheral displacement of follicles left only an increased residual volume as significantly associated with pain [OR 1.02–1.16; $p = 0.01$]. This remains statistically significant after applying the Bonferroni correction. Box plots illustrating differences in ovarian volume between patients with and without pelvic pain are shown in Fig. 2.

When comparing the mean ($\pm$ SD) residual ovarian volume (total ovary volume minus corpus luteum volume) to the mean ($\pm$ SD) volume of the contralateral ovary, the residual volume was significantly greater in both patients with pain (12.3 $\pm$ 10.3 to 6.6 $\pm$ 4.0 cc; $p < 0.001$) and those without pain (7.0 $\pm$ 3.9 to 6.0 $\pm$ 3.3 cc; $p = 0.005$). The median relative increase of ovarian parenchymal volume compared to the contralateral ovary [100*(residual volume—contralateral ovary volume)/residual volume] was significantly greater in patients with pain ($p < 0.001$) and in cases concerning for torsion ($p < 0.001$).

Features that led the prospectively interpreting radiologist to raise concern for ovarian torsion were present in 12.9% (16/124) of the patients with pelvic pain. Patient demographics and ovarian morphology in those who had imaging concern for torsion compared to those without concern are shown in Table 2. Larger ovary ($p < 0.001$), larger corpus luteum ($p = 0.006$), larger residual ovarian volume ($p < 0.001$), peripherally displaced follicles

Table 1. Demographics and ovarian morphology in patients with and without pain

	With pain ($n = 124$)	Without pain ($n = 119$)	p value
Mean age ± SD (range)	31.2 ± 7.2 (16–49)	34.3 ± 7.7 (16–52)	**0.001**
Pregnant	38 (30.6%)	36 (30.3%)	0.95
Presented to ER	52 (41.9%)	20 (16.8%)	**< 0.001**
Presented outpatient	72 (58.1%)	99 (83.2%)	
Median ovary volume including corpus luteum in cc (IQR)	15.2 (10.6, 22.4)	10.3 (8.0, 14.8)	**< 0.001**
Median corpus luteum volume in cc (IQR)	5.2 (3.6, 7.5)	3.9 (2.8, 6.1)	**0.002**
Median residual volume in cc (IQR)	8.8 (6.2, 15.2)	6.0 (4.2, 9.1)	**< 0.001**
Median contralateral ovary volume in cc (IQR)	5.9 (4.0, 8.7)	5.0 (3.7, 7.5)	0.27
Median relative increase of ovarian parenchymal volume (IQR)	56.2% (2.6, 167.3)	15.9% (− 15.7, 67.6)	**< 0.001**
Imaging concern for torsion	16 (12.9%)	0 (0%)	**< 0.001**
Complex free fluid (indicative of Cyst Rupture)	10 (8.0%)	0 (0%)	**0.002**
Peripherally displaced follicles	18 (14.5%)	1 (0.8%)	**< 0.001**
Central cystic space within corpus luteum	95 (76.6%)	93 (78.2%)	0.77
Hyperemia around corpus luteum ("ring of fire")	101 (81.5%)	105 (88.2%)	0.14
Corpus luteum side–left	51 (41.1%)	57 (47.9%)	0.29
Corpus luteum side–right	73 (58.9%)	62 (52.1%)	

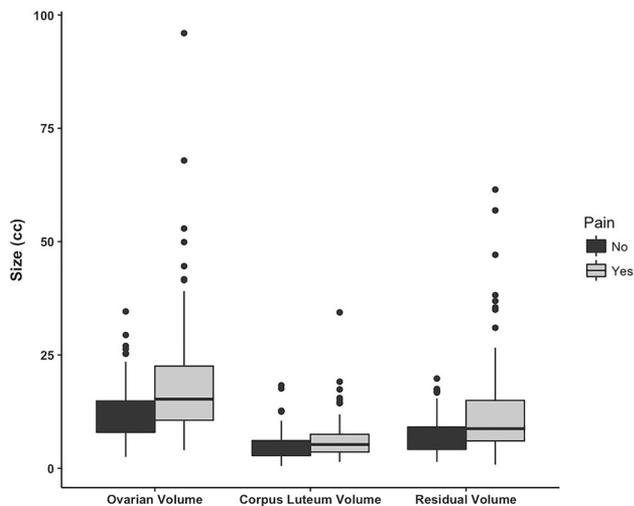Bold values are statistically significant ($p < 0.05$)

Fig. 2. Tukey box plots demonstrating differences in ovarian composition and size in patients with and without pelvic pain. After multivariate analysis, only residual volume was found to be significantly associated with pelvic pain ($p = 0.01$).

($p < 0.001$), and higher acuity of pain ($p = 0.01$) were significantly associated with imaging concern for torsion. Of note, 84.8% (206/243) of corpora lutea had increased peripheral vascularity relative to the ovarian stroma, a feature that was absent in the single case of surgically proven ovarian torsion that was excluded from the statistical analysis.

Pain presentation was categorized by acuity, including hyperacute (< 1 day), acute (1–6 days), subacute (7–14 days), and chronic (> 14 days). Mean ovarian volumes (± SD) by pain acuity were 23.2 ± 18.1 cc for hyperacute, 20.5 ± 12.7 cc for acute, 16.5 ± 7.1 cc for subacute, and 13.7 ± 7.1 cc for chronic ($p = 0.018$) (Fig. 3). Notably, 15 of the 16 cases in which the prospectively interpreting radiologist raised concern for ovarian torsion presented with pain that was either acute or hyperacute ($p = 0.01$).

Pain localized to the side of the corpus luteum in 63.7% (79/124) of cases, localized to the opposite side of the pelvis in 12.9% (16/124), and was nonspecific or midline in 23.4% (29/124) of cases ($p < 0.001$). Broken down further, in cases of hyperacute pain (< 1 day), pain localized to the side of the corpus luteum in 77.4% (24/31) of cases, and to the opposite side of the pelvis in only 6.5% (2/31) of cases. Conversely, in cases of chronic pain (> 14 days), pain localized to the side of the corpus luteum in only 39.3% (11/28) of cases, and to the opposite side of the pelvis in 17.9% (5/28) of cases (Fig. 4).

Of the 16 cases that were prospectively concerning for ovarian torsion on imaging, two went to surgery. One had active hemorrhage from a ruptured corpus luteum cyst, and the other had an edematous ovary without torsion. The other 14 were observed closely by the surgical team with serial abdominal examinations, and improved with supportive care.

Discussion

Our study revealed that varying degrees of ovarian enlargement and stromal edema are commonly associated with corpora lutea, and should be expected. A greater degree of ovarian edema, as defined by the increased residual ovarian size and the peripheral follicular displacement, was significantly associated with pelvic pain ($p < 0.001$). All 10 patients with complex free fluid (indicative of bleeding in the setting of corpus luteum cyst rupture) presented with pelvic pain.

Given the strong association between the ovarian size and pelvic pain, we hypothesize that ovarian stromal edema causes stretching of the ovarian capsule, leading to localized pain. Our study demonstrated a strong correlation between the side of the patient's pain and the side of the corpus luteum ($p < 0.001$). Despite this, many of the radiologic reports had impressions that read,

Table 2. Demographics and ovarian morphology in patients with pain, with and without imaging concerns for ovarian torsion

	Concern for torsion ($n = 16$)	No concern for torsion ($n = 108$)	p value
Mean age $\pm$ SD (range)	31.2 $\pm$ 7.3 (16–41)	31.1 $\pm$ 7.2 (17–49)	0.96
Pregnant	4 (25.0%)	34 (31.5%)	0.77
Presented to ER	12 (75.0%)	40 (37.0%)	**0.004**
Presented outpatient	4 (25.0%)	68 (63.0%)	
Median ovary volume including corpus luteum in cc (IQR)	37.6 (28.8, 45.9)	13.3 (10.2, 20.0)	**<0.001**
Median corpus luteum volume in cc (IQR)	7.0 (5.4, 10.6)	5.0 (3.4, 7.4)	**0.006**
Median residual volume in cc (IQR)	28.8 (24.1, 37.2)	8.2 (5.7, 11.6)	**<0.001**
Median contralateral ovary volume in cc (IQR)	8.0 (5.4, 9.5)	5.6 (3.6, 8.1)	0.06
Median relative increase of ovarian parenchymal volume (IQR)	350.0% (180.6, 568.2)	44.9% (− 2.1, 120)	**< 0.001**
Complex free fluid (Indicative of Cyst Rupture)	1 (6.3%)	9 (8.3%)	1
Peripherally displaced follicles	10 (62.5%)	8 (7.4%)	**<0.001**
Central cystic space within corpus luteum	12 (75.0%)	83 (76.9%)	1
Hyperemia around corpus luteum ("ring of fire")	13 (81.3%)	88 (81.5%)	1
Pain acuity		*	**0.01**
< 1 day	7 (43.7%)	24 (23.8%)	
1–6 days	8 (50.0%)	29 (28.7%)	
7–14 days	1 (6.3%)	20 (19.8%)	
> 14 days	0 (0%)	28 (27.7%)	

Bold values are statistically significant ($p < 0.05$)
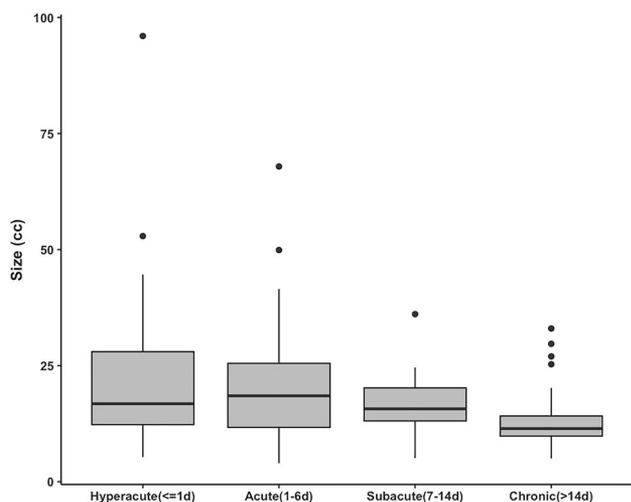*7 cases did not have reported pain acuity

Fig. 3. Tukey box plots demonstrating differences in ovarian size in patients by pain acuity. Greater acuity of pain was significantly associated with greater ovarian size ($p = 0.018$).

Fig. 4. Bar chart illustrating percentage of cases when pain localized to the side of the corpus luteum by pain acuity. The corpus luteum is unlikely the culprit for pain in patients with symptoms > 14 days' duration.

"no findings are present to explain pain," or "normal pelvic ultrasound." We recommend that the radiologic report documents the corpus luteum as a possible source of pain, particularly when the pain is ipsilateral and there is no apparent alternative source. Patients who had pelvic pain for > 14 days had pain localizing to the side of the corpus luteum only 39.3% of the time. Given this and the notable lack of ovarian enlargement (Fig. 3), the corpus luteum is unlikely to be the culprit for pain in these patients with longer-standing symptoms.

In some patients, the ovarian stromal edema associated with the corpus luteum may become so great that it mimics torsion on ultrasound and CT (Fig. 5) [11]. In our study, 12.9% of patients presenting with pelvic pain had findings that concerned the prospectively interpret-
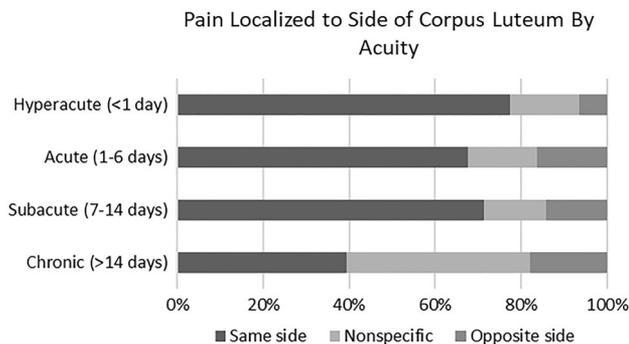
ing radiologist for ovarian torsion. This confusion is not surprising, as the most sensitive findings of ovarian torsion on ultrasound and CT are the same as those that we found to be significantly associated with corpora lutea: ovarian enlargement and peripheral displacement of follicles [6, 7]. The largest ovary in our cohort measured 96 cc, which is approximately 10 times normal ovarian volume.

Misdiagnosis of torsion is likely more common than previously recognized; prior research evaluating surgical outcomes found hemorrhagic corpus luteum cysts to be a common false positive for ovarian torsion on imaging. In a study by Mashiach et al. [14], of 63 women with suspected ovarian torsion on sonography who underwent laparoscopy, 7 were false positives due to hemorrhagic corpus luteum cysts. In a study by Melcer et al. [15], of 87 adolescent patients with suspected ovarian torsion on sonography who underwent laparoscopy, 18 were false
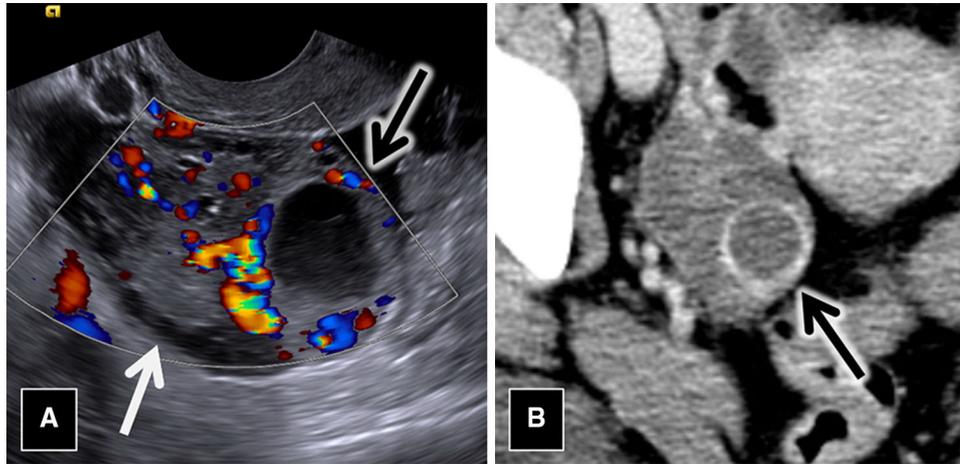
Fig. 5. 34-year-old woman with corpus luteum associated with ovarian edema. **A** Color Doppler image shows an enlarged ovary associated with a corpus luteum cyst (black arrow). There is a rim of hyperemia around the corpus luteum ("ring of fire"), and the follicles are peripherally displaced. The peripheral displacement of follicles (white arrow) is caused by central stromal edema, an overlapping finding with ovarian torsion. This case was confused for ovarian torsion, leading to laparoscopy. **B** Axial contrast-enhanced CT demonstrates the edematous ovary with an associated enhancing corpus luteum cyst (arrow).

positives due to hemorrhagic corpus luteum cysts. Melcer et al. later reported that the presence of hemorrhagic corpus luteum cyst on ultrasound was negatively associated with ovarian torsion [16].

Of note, the single ovary that was excluded from our study that was surgically confirmed torsion had demonstrable blood flow in the ovarian stroma on transvaginal ultrasound, but the corpus luteum did not have the typical peripheral vascularity ("ring of fire") on ultrasound or CT (Fig. 6). This is in contrast to the clear peripheral vascularity shown by color Doppler and peripheral enhancement on contrast-enhanced CT demonstrated in Fig. 5. Our study demonstrated that 84.8% (206/243) of corpora lutea had increased peripheral vascularity relative to the ovarian stroma on color Doppler. We hypothesize that the presence of peripheral vascularity typical of a corpus luteum in an edematous ovary on either ultrasound or CT may be a diagnostically useful finding differentiating corpora lutea with adjacent stroma edema from ovarian torsion. Further study comparing imaging features of corpus luteum with associated stromal edema mistaken for ovarian torsion to cases of true ovarian torsion is an attractive avenue for further research.

Of the 16 cases in our study with a corpus luteum that were mistaken for ovarian torsion by the prospectively interpreting radiologist, two were referred to surgery. One had active hemorrhage from a ruptured corpus luteum cyst, and the other had an edematous ovary without torsion. The other 14 patients improved with close observation and supportive care. We acknowledge that most of these patients were observed by the surgeons, who performed serial abdominal examinations instead of proceeding directly to the operating room, despite the radiologist's concern on imaging. This demonstrates that the clinical presentation and physical examination findings (such as peritoneal signs) remain the most important factors leading surgeons to perform laparoscopy [16].

It is unclear what causes the observed sporadic increase in ovarian stromal size in the presence of a corpus luteum. Significant vascular and lymphatic remodeling occurs during the menstrual cycle, particularly during the formation of a corpus luteum. Increased capillary permeability of these new vessels or deficiencies in the development of veins or lymphatics during this process theoretically could lead to fluid retention [17]. The corpus luteum may also cause varying degrees of direct venous or lymphatic obstruction depending on its size or location within the ovary. Lymphatic obstruction has been described as the cause of edema associated with ovarian involvement by lymphoma and metastatic carcinoma [18–20]. The entity "massive ovarian edema" is also thought to share a similar mechanism of venous and lymphatic outflow obstruction due to incomplete torsion of the vascular pedicle [21–23]. A possible avenue for further research is assessment of the corpus luteum location in relation to the ovarian hilum, where it may obstruct vessels and lymphatics entering and exiting the ovary.

We acknowledge the limitations to this retrospective study. Since we used a report search engine to identify subjects for our study, selection bias was present. Patients in which a corpus luteum was present but not identified by the prospectively interpreting radiologist, or not included in the radiologic report, were not included in our study. In addition, our cohort is patients who presented for imaging due to either pelvic pain or other indication, and should not be generalized. However, this
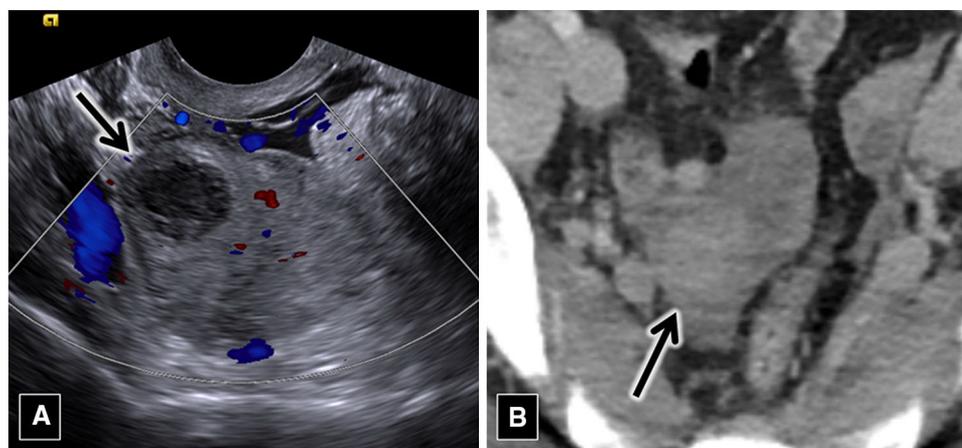
Fig. 6. 41-year-old woman with ovarian torsion. **A** Color Doppler ultrasound demonstrates an edematous right ovary with a hemorrhagic corpus luteum cyst (arrow). This was proven as ovarian torsion at laparoscopy. While blood flow was documented by spectral Doppler, the peripheral hyperemia on color Doppler that is typical of corpus luteum cysts was not present. **B** Axial contrast-enhanced CT of the same case demonstrates an enlarged right ovary with an associated corpus luteum cyst (arrow), which does not enhance. This may prove to be an important finding in distinguishing when an ovary with a corpus luteum has undergone torsion.

cohort is a representation of cases radiologists will encounter in routine practice. Power Doppler was not routinely obtained in our cohort, so color Doppler was instead used to evaluate for peripheral vascularity around corpora lutea. Power Doppler may be more sensitive to flow compared to color Doppler, raising the possibility of under-detection of vascularity in our study. To avoid serial under-measurement of corpus luteum cysts, care was taken to accurately measure their dimensions, including the crenulated peripheral soft tissue component if a central cystic space was present (Fig. 1). If a corpus luteum was not demonstrated clearly enough on ultrasound to be measured, it was not included in our study.

Conclusion

Increased residual ovarian volume, which we consider a surrogate for ovarian stromal edema, is common in the setting of a corpus luteum. This entity is associated with pelvic pain, and can mimic the appearance of ovarian torsion on transvaginal ultrasound. For many patients, ovarian enlargement associated with a corpus luteum is an adequate explanation for ipsilateral pain lasting less than 2 weeks' duration. A promising avenue for further research is to explore diagnostically useful differences between cases of ovarian torsion and cases of ovarian edema related to corpora lutea, such as the presence of the peripheral vascularity typical of corpora lutea on ultrasound or CT.

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