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A Case–Control Study of Sonographic Maximum Ovarian Diameter as a Predictor of Ovarian Torsion in Emergency Department Females With Pelvic Pain

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ABSTRACT

Background: Color and power Doppler ultrasound are commonly used in the evaluation of ovarian torsion but are unreliable. Because normal-sized ovaries are unlikely to cause torsion, maximum ovarian diameter (MOD) could theoretically be used as a screening test in the ED. Identification of MOD values below which torsion is unlikely would be of benefit to providers interpreting radiology department or point-of-care pelvic ultrasound.

Objectives: The objective was to determine if sonographic MOD can be used as a screening tool to rule out torsion in selected patients.

Methods: Via a retrospective case–control study spanning a 14-year period, we examined the ultrasound characteristics of patients with torsion and age-matched controls, all presenting to the emergency department with lower abdominal pain and receiving a radiology department pelvic ultrasound for "rule-out torsion." Standardized data collection forms were utilized. Distributions of MOD were compared and sensitivity, specificity, and likelihood ratios were calculated for multiple cutoffs.

Results: We identified 92 cases of surgically confirmed ovarian torsion and selected 92 age-matched controls. In postmenarchal patients the sensitivity, specificity, positive likelihood ratio, and negative likelihood ratio of 3- and 5-cm MODs were 100% (96%–100%), 30% (20%–41%), 1.4 (1.3–1.7), and 0 and 91% (83%–97%), 92% (83%–97%), 11.2 (5.5–22.9), and 0.09 (0.04–0.19), respectively. The 5-cm MOD, however, excluded an additional 52 of 84 (62%) postmenarchal patients.

Conclusions: A threshold MOD of 5 cm on pelvic ultrasound may be useful to rule out ovarian torsion in postmenarchal females presenting with lower abdominal and pelvic pain.

Ovarian torsion is relatively uncommon, accounting for only 3% of gynecologic emergencies.[1] However, the initial clinical presentation of sudden severe pain, vomiting, palpable adnexal mass,

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leukocytosis, and fever is nonspecific and overlaps with many more common clinical entities such as appendicitis, diverticulitis, renal colic, ruptured ovarian cyst, tuboovarian abscess, and others.[2] Atypical presentations are common, with many patients reporting bilateral pain, mild rather than severe pain, intermittent pain, or lack of tenderness on examination. Up to 50% of patients are initially misdiagnosed.[3] Early diagnosis and treatment are necessary to relieve the torsion, restore blood flow, and salvage the ovary and fallopian tube, particularly in women desiring to maintain fertility. Given this combination of frequent atypical presentations and significant consequences for missed diagnosis, radiology department ultrasound evaluation for ovarian torsion is common in women presenting to the emergency department (ED) with pelvic pain, despite the rarity of the disease. This evaluation is time-consuming, expensive, and low yield.[4–6]

In the evaluation of ovarian torsion, overreliance on Doppler is a common pitfall. Studies have found normal Doppler findings in 45% to 61% of torsion cases.[7–11] In patients with ovarian torsion the most common finding is asymmetric ovarian enlargement, usually to greater than 5 cm.[3,11–14] In adults the incidence of ovarian torsion without an accompanying ovarian mass *of greater than 3 cm* is extremely rare.[8,15–17] In contrast, torsion in premenarchal females has been frequently reported with normal-sized ovaries and is thought to be due to the especially mobile uterine adnexa in children.[18–20] It is unknown whether ovarian torsion could be ruled out in postmenarchal females solely by evaluation of maximum ovarian diameter (MOD) and without Doppler evaluation.

Although the American College of Emergency Physicians recognizes the identification of intrauterine pregnancy as a core application of point-of-care pelvic ultrasound, the evaluation of adnexal pathology is categorized as an "adjunct or emerging application,"[21] because Doppler evaluation requires more expertise. If a size cutoff with appropriate accuracy could be identified, clinicians able to obtain accurate ovarian diameter measurements at the bedside could theoretically forego radiology department evaluation with Doppler in select patients, potentially improving a number of patient-centered outcomes such as length of stay, discomfort, and cost. Nevertheless, identification of threshold diameter values below which torsion is extremely unlikely would be of benefit both to providers utilizing radiology department ultrasound and to those comfortable with point-of-care ultrasound (POCUS) evaluation of the adnexa. We sought to evaluate the test characteristics of MOD with the hypothesis that either 3 or 5 cm may have an appropriately discriminatory sensitivity to rule out ovarian torsion without an accompanying Doppler evaluation.

METHODS

Study Design and Setting

This was a retrospective case–control study over a 14-year period from January 1, 2000, to December 31, 2014, in a large tertiary care ED with a combined adult and pediatric volume of 100,000 to 120,000 patients/year. This study was approved by the hospital institutional review board.

Selection of Participants

All female patients age 2 to 100 presenting to the ED during the study period with a chief complaint of "pelvic" or "lower abdominal" pain and who received a radiology department transvaginal and/or transabdominal pelvic ultrasound with an indication of "rule-out torsion" were identified for inclusion in the study. These patients were identified by screening the ED database for female patients presenting with International Classification of Diseases (ICD-9) codes 625.9 (pelvic pain), 789.0 (abdominal pain), 789.03 (right lower abdominal pain), and 789.04 (left lower abdominal pain). The group was then further screened via the Current Procedural Terminology codes 76857 (transabdominal pelvic ultrasound, not pregnant), 76815 ("transabdominal pelvic ultrasound, pregnant"), 76830 ("transvaginal pelvic ultrasound, not pregnant"), and 76817 ("transvaginal pelvic ultrasound, pregnant"). The case and control groups were identified from this larger group. The torsion (case) group was defined as patients from this group who had a surgically confirmed diagnosis of ovarian torsion (ICD-9 code 620.5). The control group was matched 1:1 based on 5-year age strata (2–4, 5–9, 10–14, 15–19, 20–24, 25–29, etc.) and drawn from the same group as above, with any diagnosis other than ovarian torsion. Controls were included sequentially in each age strata until matching was achieved. Patients were excluded from either group if both ovaries were not completely visualized and measured or if no ultrasound report was available. Patients were also excluded from the torsion group if manual chart review did not confirm torsion via operative findings. Patients were

excluded from the control group if torsion was identified on subsequent visits within 3 months, and these patients were included in the torsion group.

Study Protocol

Selection of the study population and cohorts was performed by a departmental data analyst who was not an investigator in the study and who was blinded to the study purpose and hypothesis. Via manual chart review, data were abstracted from paper records for patients seen from 2000 to 2008 and from electronic records for patients seen from 2008 to 2014 (Cerner, Cerner Corp.). Standardized data abstraction forms were used and information entered into REDCap (Vanderbilt). All data abstractors underwent a 1-hour training session and reviewed five practice charts each under the supervision of the principal investigator. Abstractors were not blinded to the study group, nor to the study hypothesis. Ten percent of the charts were selected via random sampling to calculate inter-rater reliability with regard to MOD.

Measures

We recorded demographic information as well as relevant aspects of the patient's presentation such as fever, location of pain, and palpable pelvic mass. From ultrasound results, MOD and arterial/venous Doppler waveform information was obtained bilaterally. Surgical diagnosis was obtained from operative notes. Menarchal status was documented as identified in the chart, but if menarchal status was not noted patients younger than 12 were considered premenarchal, as median age of menarche in the United States is 12.[22]

The primary outcome was the association between ovarian torsion and a MOD of >3 or >5 cm as assessed by ultrasound in postmenarchal subjects. Secondarily, we also sought to examine this association in premenarchal patients.

Data Analysis

Our sample size was limited by the cohort of patients with ovarian torsion since 100% of eligible cases were included. However, we did wish to report test characteristics of the 3- and 5-cm threshold values; therefore, estimating the width of the 95% confidence interval (CI) around these estimates was of importance. Based on previously published data and our ED's yearly volume, we anticipated approximately 100 eligible cases (and therefore 100 controls) to be included in the study. Given this, the width of the 95% CI around estimated test characteristics of 0.50 to 0.90 would range from 20 to 13 points, respectively. With a reduction in sample size, these CIs would be wider.

Using the torsion and control cohorts, sensitivity, specificity, and likelihood ratios for the 3- and 5-cm threshold values were derived. Data analysis was performed using Stata Data Analysis and Statistical Software v15 (StataCorp LLC). A priori, we decided to analyze premenarchal subjects separately from postmenarchal subjects, as ovarian torsion is thought to occur more frequently with normal-sized ovaries in children.

RESULTS

After exclusions (Figure 1), 92 cases were identified with both surgically confirmed ovarian torsion and an ultrasound report. Ninety-two age-matched control patients who received a pelvic ultrasound to rule out torsion, but in whom torsion was not diagnosed, were also selected. Two patients with torsion presented twice for pelvic pain and were found to have MOD > 5 cm and normal Doppler studies. After gynecology consultation these patients were discharged, but presented again and found to have torsion at surgery. These patients were included in the torsion cohort and their index visit was excluded.

The characteristics of the included patients are seen in Table 1. Cases and controls were matched for age (median age = 28 years). Cases were slightly more likely to be white versus other race. Torsion patients were more likely to present with nausea and vomiting (50.8% vs. 19.6%) and a palpable pelvic mass (19.6% vs. 0%). Table 2 shows the final diagnoses in the control cohort.

Maximum ovarian diameter and Doppler findings by case and control status, in both pre- and postmenarchal patients, is summarized in Table 3. Zero patients in the postmenarchal torsion group had a MOD < 3 cm, while seven of 81 (8.6%) had MOD ≤ 5 cm. Among patients with torsion, 30 of 77 (39%) had normal arterial and venous Doppler signal. Doppler information was reported in a majority but not all of the ultrasound reports.

Table 4 shows test characteristics of both threshold MOD values as well as abnormal Doppler signals. In postmenarchal patients, the sensitivity for a 3-cm threshold value was 100% (95% CI = 95.5%–100%) but the specificity was 30% (95% CI = 20.8%–41.1%). Sensitivity decreased to 91% (95%

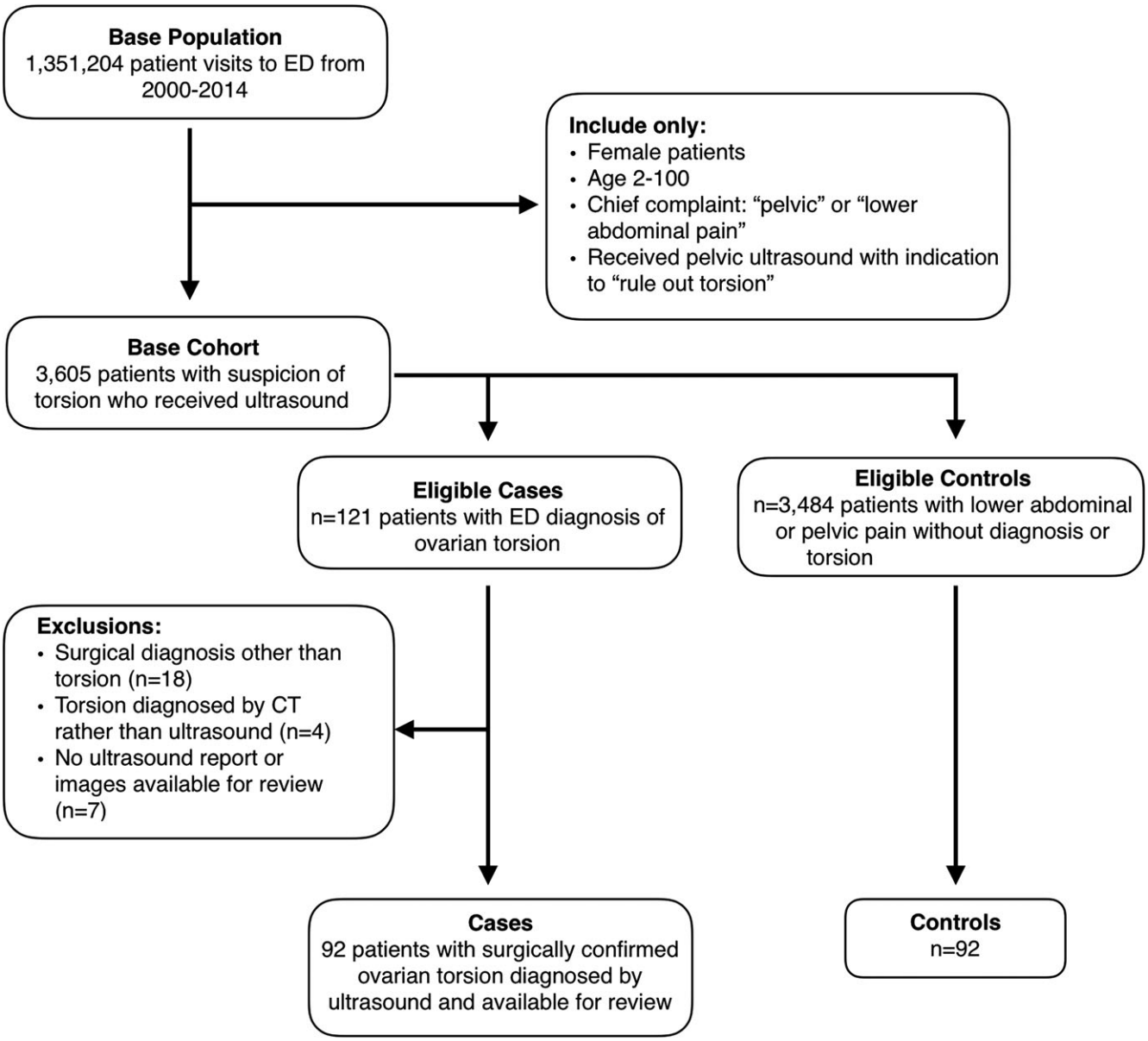

Figure 1. Study cohort flowchart.

CI = 83%–96.5%) using a 5-cm MOD and specificity increased to 92% (95% CI = 83.9%–96.7%). In the postmenarchal group, the negative likelihood ratios for the 3- and 5-cm threshold values were 0 and 0.09 (95% CI = 0.04–0.19), respectively. Abnormal Doppler signal was a very specific finding for torsion in our study group (98%, 95% CI = 92.1%–99.7%), but not sensitive (61%, 95% CI = 49.2%–72%).

Figure 2 illustrates the MOD between the torsion and control cohorts in the premenarchal and postmenarchal populations. Regarding the 3-cm MOD, no patients (either postmenarchal or premenarchal) were found to have torsion with largest ovarian diameter < 3 cm. In the premenarchal group, torsion tended to occur within a smaller range of ovarian diameter, between 4 and 7 cm. In the postmenarchal group, the range was much larger, between 3 and 16 cm.

Figure 3 shows the distribution of ovarian sizes in the postmenarchal population. Two distinctive but overlapping distributions of MOD are identified between the torsion and control cohorts, with the torsion cohort heavily skewed toward larger MOD. Although not one of our predefined outcome measures, an MOD value of <4 cm was only found in two of 80 postmenarchal patients with torsion. Of the 10% of charts selected to assess for inter-rater reliability with regard to MOD, there was complete agreement between data abstractors and the second reviewer resulting in $\kappa = 1.0$.

Table 1
Baseline Patient Characteristics

	Control (n = 92)	Case (n = 92)
Demographics		
Age (years)	28 (15–41)	28 (15–40)
Race		
White	36 (39.1)	50 (54.4)
Black	13 (14.1)	8 (8.7)
Hispanic	14 (15.2)	13 (14.1)
Other	8 (8.7)	0 (0.0)
Refused/unknown	21 (22.8)	21 (28.8)
Reproductive status		
Premenarchal	8 (8.7)	12 (13.0)
Postmenarchal	84 (91.3)	80 (87.0)
Signs/symptoms		
Fever	3 (3.3)	7 (7.6)
Nausea/vomiting	18 (19.6)	55 (59.8)
Location of pain		
Right lower quadrant	27 (29.4)	46 (50.0)
Left lower quadrant	16 (17.4)	22 (23.9)
Bilateral lower quadrants	32 (34.7)	21 (22.3)
Suprapubic	17 (18.4)	3 (3.3)
Palpable pelvic mass	0 (0.0)	18 (19.6)

Data are reported as median (IQR) or *n* (%).
IQR = interquartile range.

Table 2
Clinical Diagnoses in the Control Cohort

Diagnosis (*n* = 92)	
Abdominal/pelvic pain NOS	36 (74)
Ovarian cyst	19 (21)
Pelvic inflammatory disease	11 (12)
Hemorrhagic/ruptured ovarian cyst	8 (9)
Uterine fibroids	7 (8)
Colitis	2 (2)
Constipation	2 (2)
Gastroenteritis	2 (2)
Other	5 (5)

Data are reported as *n* (%).
NOS = not otherwise specified.

Table 3
US Findings by Case Status

	Torsion	Control
≤3 cm premenarchal		
≤3 cm	0	6
>3 cm	11	0
Totals	11	6
≤3 cm postmenarchal		
≤3 cm	0	26
>3 cm	81	60
Totals	81	86
≤3 cm total cohort		
≤3 cm	0	32
> 3 cm	92	60
Totals	92	92
≤5 cm premenarchal		
≤5 cm	4	6
>5 cm	7	0
Totals	11	6
≤5 cm postmenarchal		
≤5 cm	7	79
> 5 cm	74	7
Totals	81	86
≤5 cm total cohort		
≤5 cm	11	85
>5 cm	81	7
Totals	92	92
Abnormal arterial waveform		
Abnormal	45	1
Normal	34	88
Totals	79	89
Abnormal venous waveform		
Abnormal	40	1
Normal	36	88
Totals	76	89
Abnormal arterial or venous waveform		
Abnormal	47	2
Normal	30	87
Totals	77	89

US = ultrasound.

DISCUSSION

Over a 14-year period, the ED treated 1,351,204 patients and ovarian torsion was only diagnosed in 103 patients, approximately 0.007% of all ED visits. As this hospital is a referral center, it is possible that the true population prevalence is even lower. Although torsion is historically a poorly recognized clinical entity with difficult diagnosis, our findings are consistent with the largest study of ovarian torsion done to date by Houry and Abbott,[3] who found an overall prevalence of 0.006%.

The most common grayscale sonographic abnormality in torsion is asymmetric ovarian enlargement, usually to greater than 5 cm, frequently due to an underlying mass.[3,11–14] In adults, the incidence of ovarian torsion without an accompanying ovarian mass greater than 3 cm is extremely rare.[8,15–17,23] Lee et al.[11] found ovarian enlargement in 100% of 32 torsion cases, with single largest diameter ranging from 5 to 33 cm. Houry and Abbott[3] described a mean ovarian size of 9.5 cm in a series of 87 torsion cases, with 89% measuring greater than 5 cm. In 2010, Huchon

Table 4
Test Characteristics

	Sensitivity	Specificity	LR (+)	LR (–)
3 cm	100% (96.1%–100%)	35% (25.1%–45.4%)	1.5 (1.3–1.8)	0
5 cm	88% (79.6%–93.9%)	92% (84.9%–96.9%)	11.6 (5.7–23.7)	0.13 (0.07–0.23)
3 cm	100% (95.5%–100%)	30% (20.8%–41.1%)	1.4 (1.3–1.7)	0
5cm	91% (83%–96.5%)	92% (83.9%–96.7%)	11.2 (5.5–22.9)	0.09 (0.04–0.19)
3 cm	100% (71.5%–100%)	100% (54.1%–100%)		
5 cm	63.6% (30.8%–89.1%)	100% (54.1%–100%)		0.4 (0.17–0.8)
	57% (45.3%–68.1%)	99% (93.9%–100%)	50.7 (7.2–359)	0.4 (0.33–0.56)
	53% (40.8%–64.2%)	99% (93.9%–100%)	46.8 (6.6–333)	0.5 (0.38–0.61)
	61% (49.2%–72%)	98% (92.1%–99.7%)	27.2 (6.8–108)	0.4 (0.30–0.53)

LR(+) = positive likelihood ratio; LR(–) = negative likelihood ratio.

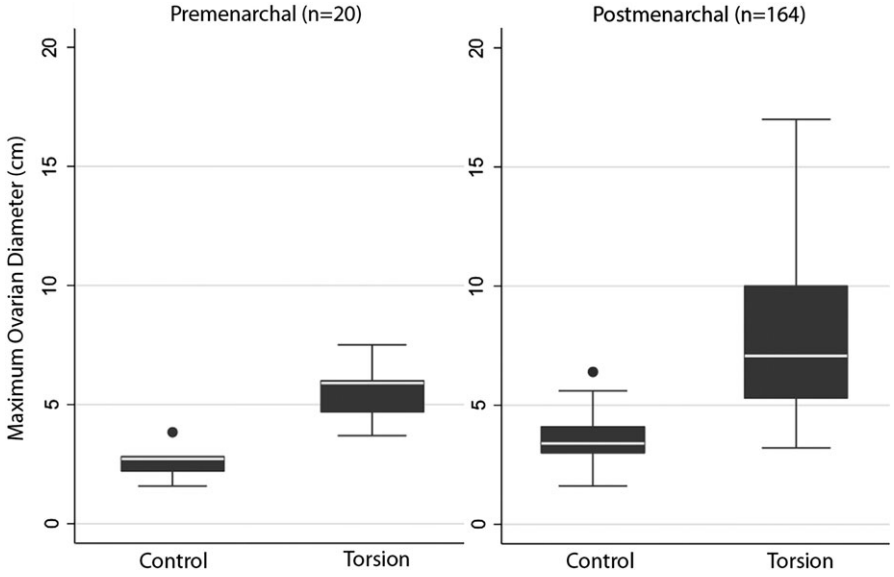

Figure 2. Distribution of ovarian diameter (cm) in control (*left*) and torsion (*right*) patients. *Box plots* represent 25th (Q1)–75th (Q3) percentile, with 50th percentile noted as *white midline*. *Whiskers* represent the distribution's lower inner fence (Q1 – (1.5 × interquartile range)) and upper inner fence (Q3 + (1.5 × interquartile range)). *Dots* represent values outside of the inner fences and are considered outliers.

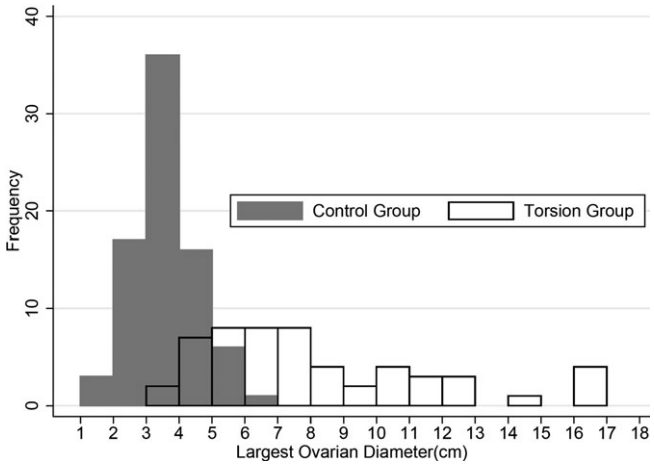

Figure 3. Distribution of mean ovarian diameter in postmenarchal patients.

et al.[24] even used a logistic regression analysis on a cohort of 142 patients with acute pelvic pain to derive a scoring system for torsion based on five independent predictors for torsion: cyst > 5 cm on ultrasound, pain duration < 8 hours, vomiting, spontaneous unilateral abdominal or lumbar pain, and absence of leucorrhea and metrorrhagia. They then prospectively evaluated a group of 35 women with pelvic pain and assigned them to a high-risk versus low-risk categories using the scoring tool, showing 0% probability of torsion in the low-risk group and 75% probability in the high-risk group.

In our study, the 3-cm threshold value demonstrated excellent sensitivity (100%) for torsion in the postmenarchal and total cohorts but was nonspecific. The 5-cm threshold value was somewhat less sensitive

(88% in the total cohort, 91% in the postmenarchal cohort), but was much more specific (92% in both the total and the postmenarchal cohorts). Of note, in our postmenarchal control population a large proportion of patients (52/84, 62.0%) had MOD > 3 and < 5 cm. Using a 5-cm rather than a 3-cm MOD in these patients would have excluded torsion in these additional 52 patients. Given the previously reported extremely low prevalence of ovarian torsion in the general population,[3,14] our findings suggest that 5 cm might be the more useful threshold value in patients presenting with pelvic pain.

Our study confirms the poor sensitivity of Doppler in ruling out ovarian torsion that has been described in previous studies. Assessment of arterial and venous blood flow in the ovaries can be technically difficult due to body size, interposed bowel gas, or other patient factors.[11] Even if properly identified and measured Doppler findings can still be unreliable due to the dual blood supply from the uterine and ovarian arteries and also because torsion may be intermittent.[25]

Our findings suggest that screening decisions for patients with lower abdominal pain should be based on ovarian size rather than Doppler findings. Clinicians who rely on a radiology department ultrasound should be reassured by normal-sized ovaries and cautious when ovaries are larger than 5 cm even if arterial and venous waveforms are normal. Physicians who are comfortable with POCUS evaluation of the adnexae for torsion may be justified in solely measuring ovarian diameter without Doppler.[3,14]

Clinicians should be careful not apply these findings to premenarchal patients. Ovarian torsion in patients with normal-sized ovaries has been reported in the pediatric literature and is thought to occur in up to 25% of cases of adnexal or ovarian torsion.[26] Our findings in premenarchal patients are consistent with previous studies. Hypotheses for the etiology of torsion of normal adnexa include excessively mobile mesovaria or fallopian tubes, congenitally long pelvic ligaments, tubal spasm, or abrupt changes in intraabdominal pressure.[18,19,27,28] Among premenarchal girls with torsion in our study, eight of 12 had a MOD > 5 cm and 12 of 12 had a MOD > 3 cm. This suggests that although a cutoff of 3 cm may be valid in this population, further study is needed and the clinician should still maintain a high index of suspicion for torsion even with normal-sized ovaries.

LIMITATIONS

Due to the rare nature of ovarian torsion and our exclusion criteria, only 92 patients with torsion over the 14-year period were identified. Therefore, CIs around some of our findings are large.

Our study also has limitations inherent to a retrospective case–control study design. Selection bias is a possibility as charts were retrospectively pulled for analysis. We attempted to compensate for spectrum bias by including all patients who received a pelvic ultrasound to rule out torsion, so that our study population would reflect the actual spectrum of illness in clinical practice. In addition, we tried to make sure our control population was appropriately selected to include the same presenting complaint, symptoms, and receiving the same investigational studies as the torsion cohort.

Since only cases that received an ultrasound for rule-out torsion were included, the reported numbers for sensitivity and specificity may artificially be increased (incorporation bias). Torsion was diagnosed surgically in 18 of 121 and by computed tomography in four of 121 cases, all in patients who did not receive an ultrasound.

Only six of 92 patients in the control cohort went on to receive surgery, subjecting our study to "double-criterion-standard" bias, which may artificially elevate the sensitivity and specificity.

As this study included only radiology department ultrasounds, it is difficult to draw conclusions regarding POCUS examinations. Given the large number of examinations needed for assessment of this relatively rare diagnosis, and the completeness and searchability of our POCUS database over the 14-year time period, we were unable to directly study POCUS for the detection of torsion. Large multicenter studies would be needed to prospectively evaluate the clinician's ability to rule out torsion at the bedside. Also, while this study demonstrates a distinct and useful size difference between torsed and nontorsed ovaries, it does not address the clinician's ability to reliably visualize ovaries and measure ovarian diameter. To our knowledge no studies to date have assessed this skill. Data abstractors in this study were not blinded to study group or study hypothesis; however, inter-rater reliability among a 10% sample of the study population showed 100% agreement with the reported MOD in both groups.

In addition to measurement of length/width/height, ovarian volume (defined as length × width × height × 0.5) is a commonly used sonographic means of describing ovarian size. The upper limit of normal for ovarian

volume is 20 cm.[3,29] We chose to use MOD rather than ovarian volume because this variable was more commonly identified in the radiology report and because it is simpler for novice sonographers to measure a maximum diameter than to calculate a volume. It is possible that volume is a more useful measurement.

CONCLUSIONS

A threshold maximum ovarian diameter of 5 cm on pelvic ultrasound may be useful to rule out ovarian torsion in postmenarchal females presenting with lower abdominal and pelvic pain. Doppler ultrasound is not sensitive enough to be used as a rule-out test for ovarian torsion.

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