Research Letter

A diagnosis with a twist: Ultrasonographic sensitivity and predictors of pediatric ovarian torsion within a large pediatric hospital

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The diagnosis of ovarian torsion (OT) in girls is challenging compared to that of testicular torsion in boys for many reasons, but it behooves the medical community to continue to strive to better identify this uncommon but clinically important pathology.^[1] OT occurs when the ovary and associated structures rotate around its vascular pedicle, leading to eventually irreversible necrosis.^[2,3] Studies attempting to identify clinical features for early diagnosis have not reached a consensus on the best clinical predictors of this condition, making radiographic imaging of the ovaries even more crucial.^[4,5]

Greyscale and Doppler ultrasound are commonly used imaging modalities for the assessment of OT. Specific ultrasound features such as ovarian edema and pelvic free fluid can be diagnostically important but show wide-ranging test characteristics.^[6-8] Similarly, the overall ultrasound sensitivity ranges from 51% to 92%.^[2,6,9,10] Prompt diagnosis of OT is paramount to maximize viability of the affected ovary. Current guidelines endorse that OT is a clinical diagnosis and that the decision to operate should not be based on imaging alone.^[11] Therefore, the aim of this study is to evaluate ultrasound sensitivity and radiographic predictors of OT within the context of a large pediatric emergency department (ED).

METHODS

This study is an ethics-approved retrospective review of all female patients aged 0–18 years presenting to an ED in McMaster Children's Hospital in Hamilton, Ontario, Canada. They were diagnosed with OT over a 10-year consecutive period from 2009 to 2018. All patients included required

either a transabdominal or transvaginal gynecological ultrasound.

Using a standardized data extraction form, two trained reviewers extracted previously reported radiographic data from identified patients. For sensitivity analysis, the ultrasound report was deemed positive for OT if the radiologist explicitly stated either the diagnosis or “could not rule out OT”. All ultrasound diagnoses were compared to gold standard laparoscopic diagnosis when available. In cases where the gynecologist determined a patient did not require laparoscopy following referral from the emergency physician, the patient was deemed a false-positive referral and negative for OT if they did not re-present to our catchment area within two weeks of initial consultation with a subsequent diagnosis of OT.

Sensitivity was calculated for greyscale and Doppler ultrasound for all patients. The affected ovarian size was compared to contralateral normal ovaries for all three dimensions calculated for true-positive patients and compared using non-paired two-tailed *t*-tests. Non-paired two-tailed *t*-tests and Fisher's exact tests were performed on continuous and categorical variables of ultrasound characteristics, respectively for the analysis of predictors for false-positive referral, false-positive operative, and true OT cases.

RESULTS

Sixty-two unique cases of abdominal pain were referred to the gynecology team for possible OT by either the ED (fifty-five) or another inpatient unit (seven). Overall, greyscale ultrasound had a sensitivity of 85.7%

and a positive predictive value (PPV) of 73.1% for OT in this patient population. Furthermore, Doppler ultrasound possessed similar test characteristics with a sensitivity of 80.0% and a PPV of 71.0%. Available mean sizes of affected ovary ($n=34$) were compared to the patients' contralateral unaffected ovary ($n=28$) and were found to be significantly larger across all three dimensions (5.61 ± 2.20 cm vs. 2.56 ± 0.90 cm, 5.12 ± 2.30 cm vs. 2.35 ± 0.90 cm, and 4.12 ± 1.60 cm vs. 2.43 ± 1.10 cm, respectively, $P<0.05$).

When comparing true-positive cases of OT to all false-positive referred by emergency physicians and all false-positive patients operated on by gynecologist (Table 1), patients with OT were significantly younger; the absolute age difference was 4.6 years and 4.2 years, respectively. Patients with OT were significantly more likely to show free fluid on an ultrasound when compared to all false-positive patients ($P=0.045$), but not when compared to false-positive patients taken for laparoscopic evaluation. Similarly, patients with OT were significantly more likely to have diminished or absent blood flow ($P<0.005$) and were more likely to be reported as positive for OT ($P<0.001$) when compared to all false-positive referral patients but not to operative false-positive patients. The largest cyst/mass diameter was not found to be significantly different in OT patients compared with false-positive patients.

DISCUSSION

There is conflicting evidence surrounding Doppler ultrasound for detecting OT. In their retrospective review, Naiditch et al^[12] reported a high negative predictive value (96.3%) when blood flow was present. However, the sensitivity of Doppler ultrasound was only 78.7%, similar to the results of this review (80%)^[2] and other published literature ranging from 55% to 73%.^[8,10,12-14] Variability in Doppler ultrasound seems likely given that OT is thought to be a continuum of progressive disruption in blood flow.

Greyscale ultrasound appears to be superior with a sensitivity finding of 85.7% in this study. Current literature again reports variable sensitivity ranging from 51% to 92%.^[6,7,9,10] In a recent meta-analysis, it was determined that the sensitivity of ultrasound was 92%, the highest reported.^[10] However, many studies used in this analysis did not report their false-negative rate, likely leading to over-estimation of the sensitivity.

In this study, we found a significant association between the presence of diminished or absent blood flow (abnormal) and OT when compared to our false-positive referral patients. In a similar study design to ours, Mashiach et al^[11] found a significant association between abnormal blood flow and OT, with 75% of their adult OT patients possessing an abnormality. However, 62% of Mashiach's laparoscopy false-positive patients also had flow abnormalities with no evidence of OT, supporting that this finding was not solely in patients with OT.^[11] There are other studies that have found significant associations between abnormal blood flow and pediatric OT.^[5,12] However, they report abnormal blood flow in their non-OT or false-positive populations as well, ranging from 27% to 69%, illustrating that normal ovaries can have doppler abnormalities.^[5,12,13] Interestingly, Schwartz et al^[15] found no statistical significance between the presence of abnormal blood flow and OT, questioning the utility of this finding. Given these results, the low prevalence of this disease and the non-specific presentation, normal blood flow on Doppler ultrasound should not be used in isolation to rule out the diagnosis of OT; however, there appears to be some association with Doppler flow abnormalities and OT. The findings in this study support the Society of Obstetricians and Gynecologists of Canada's position statement that while ultrasound is a useful tool to aid in OT diagnosis, a normal ultrasound alone cannot rule out the diagnosis of OT.^[11]

Contradicting previous literature,^[5,12] pelvic free fluid was significantly associated with a diagnosis of OT in our study. The affected ovary was significantly larger than the

Table 1. Comparison of demographic and ultrasonographic features of girls with a true-positive diagnosis of ovarian torsion compared with radiographic and operative false-positive cases

Parameters	True-positive ($n=35$)	False-positive (false-positive referred) ($n=27$)	P-value	False-positive (operative) ($n=8$)	P-value
Age, years, mean $\pm$ standard deviation	10.5 $\pm$ 5.0	15.1 $\pm$ 2.3	0.001	14.7 $\pm$ 1.6	0.025
Ultrasound findings, n					
Free fluid +	21	9	0.045	4	0.700
Blood flow, n					
Normal	3	13	<0.005	4	0.054
Diminished	16	6		3	
Absent	12	5		2	
Not comment	4	3		1	
Cyst/mass presence, n	20	15		5	
Largest cyst/mass diameter, mm, mean $\pm$ standard deviation	6.85 $\pm$ 2.85 ($n=16$)	5.69 $\pm$ 3.42 ($n=14$)	0.310	6.00 $\pm$ 3.25 ($n=5$)	0.800
Final ultrasound report, n					
Positive torsion	29	8	<0.001	5	0.080
Cannot rule out	1	3		2	
Negative torsion	5	16		1	

contralateral side in our study population, supporting the idea that ovarian enlargement should signal pathology to the clinician.^[5,7-9,13,15] Specifically, an ovarian dimension >5 cm has been previously introduced as the most sensitive individual variable in a large retrospective review,^[9] which is in keeping with our results. Several studies^[7,13,15,16] have suggested using ovarian volume or volume ratios instead of gross size calculations and have found similar results. The consistency of these findings indicates that these individual characteristics are important for the overall diagnostic pathway for emergency clinicians and should be formally reported to aid in diagnosing OT.

Compared with false-positives cases, we found that OT patients were significantly younger. Historically, OT has been thought to be more common in post-pubertal females; however, a recent review by Schuh et al^[17] reported that approximately 58% of their torsion patients occurred prior to the onset of puberty. Furthermore, other studies found OT to be more likely in younger populations when compared to false-positive and control populations.^[5,12]

Given the retrospective nature of this study, there are a number of limitations. Patients who were falsely discharged may not have re-presented to our institution. However, any cases diagnosed in the nearby communities would be referred to our center, limiting this loss of re-presentation. There was also heterogeneity in the length and detail of ultrasound reports between radiologists, so it is possible that data on cysts, free fluid, and adnexal position were under-reported. Lastly, we did not have the data to stratify patients based on pubertal status.

CONCLUSIONS

Our results illustrate that ultrasound possesses moderate sensitivity as a rule-out diagnostic test, that affected ovary size is consistently larger than its contralateral counterpart, and that the presence of abnormal blood flow and pelvic free fluid possesses a significant association with OT. Furthermore, the consistency of these results across the literature indicates that unilateral ovarian enlargement, blood flow abnormalities, pelvic free fluid, and younger age should heighten a clinician's suspicion for OT. Most importantly, the absence of these signs cannot rule out OT in the pediatric population.

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Contributors: MH and AK designed the study. MH and JMS

extracted data. MH analyzed data and drafted the manuscript. The final manuscript was approved by all co-authors.

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