Journal of Pediatric Surgery 56 (2021) 180–182

Contents lists available at ScienceDirect

Journal of Pediatric Surgery

journal homepage: www.elsevier.com/locate/jpedsurg

Other Conditions

Ovarian volume ratio is a reliable predictor of ovarian torsion in girls without an adnexal mass☆

Stephen J. Hartman [a,1], James M. Prieto [a,1], John H. Naheedy [b], Romeo C. Ignacio [a], Stephen W. Bickler [a], Karen M. Kling [a], Nicholas C. Saenz [a], Timothy J. Fairbanks [a], David A. Lazar [a,*]

[a] Division of Pediatric Surgery, Department of Surgery, University of California San Diego, San Diego, CA
[b] Department of Radiology, University of California San Diego, San Diego, CA

ARTICLE INFO

Article history:
Received 14 September 2020
Accepted 23 September 2020

Key words:
Ovarian torsion
Premenarchal
Ovarian volume
Ovarian width
Ovarian volume ratio
Doppler flow

ABSTRACT

Purpose: The aims of this study were to identify ultrasound-based predictors of ovarian torsion in girls without an adnexal mass and establish a set of normal values for ovarian volume ratio (OVR).
Methods: A retrospective review was performed of all premenarchal patients ≥3 years of age with a normal pelvic ultrasound between January 2016 and January 2019. A comparison group of premenarchal girls presenting between 2011 and 2019 with torsion in the absence of an adnexal mass was utilized.
Results: Five-hundred and four premenarchal girls underwent pelvic ultrasound evaluation with a normal examination. The mean OVR was 1.6 ± 0.7 (range 1.0–6.5). OVR did not vary with age ($r = -0.06$) as compared to ovarian width which increased steadily with age ($r = 0.53$, $p < 0.001$). OVR was increased in girls with torsion (7.6 vs 1.4, $p < 0.0001$), and by receiver operating characteristic (ROC) analysis a cutoff value of >2.5 demonstrated the best diagnostic accuracy of any predictive variable (sensitivity 100%, specificity 94%, AUC 0.991, $p < 0.001$).
Conclusions: OVR is an excellent predictor of ovarian torsion in premenarchal girls without an adnexal mass. Unlike ovarian width, OVR does not increase with age, and a cutoff OVR > 2.5 demonstrates high sensitivity and specificity for identifying ovarian torsion in this population.
Type of study: Study of diagnostic test.
Level of evidence: Level III.

Published by Elsevier Inc.

Ovarian torsion is a surgical emergency responsible for 4% of all girls presenting to the emergency department with abdominal pain [1]. Prompt operative management is critical to restore ovarian perfusion and minimize necrosis; however, establishing a diagnosis can be challenging. This is particularly true in premenarchal girls, as a subset of these patients with torsion presents without an associated adnexal mass [2]. This group of patients is at increased risk for a delay in diagnosis and ovarian necrosis as early sonographic signs of torsion can be suggestive (i.e. presence of an adnexal mass) but definitive signs such as absence of Doppler flow often present late [3]. Thus, a more reliable predictor of ovarian torsion in girls without an adnexal mass could allow for earlier diagnosis and treatment. The purpose of this study was to examine ovarian asymmetry, and specifically ovarian volume ratio (OVR) as a potential sonographic predictor of ovarian torsion in premenarchal patients presenting in the absence of an adnexal mass.

1. Methods

A single-center retrospective review was conducted of all premenarchal patients 3 to 14 years of age without ovarian torsion and with a normal pelvic ultrasound performed between January 2016 and January 2019. All ultrasound examinations were obtained transabdominally and performed by a certified diagnostic medical sonographer at an American College of Radiology accredited facility. Ovarian width was classified as the size of the ovary in the largest dimension, and ovarian volume was calculated using the formula for a prolate ellipsoid ($V = \text{length} \times \text{width} \times \text{height} \times \pi/6$) [4]. The ovarian volume ratio was calculated by dividing the volume of the larger ovary by that of the contralateral ovary. A comparison group was utilized and was comprised of premenarchal girls presenting between 2011 and 2019 with surgically confirmed ovarian torsion in the absence of an associated adnexal mass.

☆ How this paper will improve care: Premenarchal girls who present with ovarian torsion without an associated adnexal mass are at increased risk for delay in diagnosis. The ovarian volume ratio is a reliable sonographic marker for ovarian torsion in this population.

* Corresponding author at: Division of Pediatric Surgery, Rady Children's Hospital San Diego, 3020 Children's Way, MC 5136, San Diego, CA 92123. Tel.: +1 858 966 7711; fax: +1 858 966 7712.
E-mail address: dlazar@ucsd.edu (D.A. Lazar).

[1] Drs. Hartman and Prieto contributed equally and are co-first authors.

https://doi.org/10.1016/j.jpedsurg.2020.09.031
0022-3468/Published by Elsevier Inc.

Table 1
Demographic Characteristics

	Torsion (n=15)	Controls (n=504)	*p-value*
Age (y), mean (range)	9.0 (3-13)	9.2 (3-12)	0.78
Weight (kg), mean (SD)*	37.1 (13.5)	38.5 (15.1)	0.72
Indication for ultrasound, n (%)			
Abdominal pain	15 (100)	427 (85)	
Rule out anatomic abnormality	0 (0)	66 (13)	0.44
Vaginal discharge	0 (0)	9 (2)	
Other	0 (0)	2 (<1)	

* Calculated among 498 (96%) patients with a recorded weight

Patient demographics and clinical data were analyzed using Student's t-, Mann–Whitney U, and chi-square tests where appropriate. Receiver operating characteristic (ROC) curve analysis was used to select cutoff values for continuous variables based upon optimal sensitivity and specificity. Statistical analysis was performed using IBM SPSS Statistics 25 and MedCalc v18. Approval for this study was obtained from the institutional review board at our facility (#161993).

2. Results

A total of 4314 patients underwent a pelvic ultrasound during the study period, of which 504 were found to be premenarchal without adnexal pathology. The mean age of this cohort was 9.2 years, and the majority of patients were referred for pelvic ultrasound with a primary indication of abdominal pain (85%, Table 1). Measurements of ovarian width demonstrated a mean of 2.6 ± 0.7 cm, a median of 2.5 cm (IQR 2.0–3.1), and were slightly skewed to the right (Pearson's coefficient = 0.3). Furthermore, measurements of ovarian width increased with age (r = 0.53, Figure 1). Measurements of OVR demonstrated a mean of 1.6 ± 0.7, a median of 1.4 (IQR 1.2–1.7), and were more substantially skewed to the right (Pearson's coefficient = 3.1). These measurements show that on average for the premenarchal girls in this cohort, one ovary is approximately 50% larger than the other. In contrast to ovarian width, measurements of OVR did not correlate with age (r = −0.06). Additional OVR descriptive statistical data based on age can be found in Table 2.

Fifteen premenarchal patients were identified with surgically confirmed ovarian torsion in the absence of an associated adnexal mass. The mean age of this cohort was 9.0 years and there were no significant differences in age, weight, or indications for ultrasound between patients with torsion and the control group. Patients with ovarian torsion were found to have a higher median OVR than those in the control group (7.6 vs. 1.4, p < 0.0001). Median ovarian width was also increased among patients with torsion (5.3 cm vs. 2.5 cm, p < 0.001). Interestingly, despite undergoing a preoperative duplex study, five of the fourteen patients with ovarian torsion (36%) presented with normal Doppler flow.

Table 2
Descriptive statistical data for OVR by age.

Age (y)	Mean	Median	Range	St Dev	95% CI
3–4 *(n = 22)*	1.94	1.65	1.00–5.12	1.23	1.40–2.50
5–6 *(n = 59)*	1.54	1.33	1.00–3.50	0.58	1.39–1.69
7–8 *(n = 80)*	1.56	1.43	1.00–4.20	0.53	1.44–1.67
9–10 *(n = 169)*	1.53	1.36	1.00–5.33	0.62	1.44–1.63
11–12 *(n = 174)*	1.54	1.33	1.00–6.50	0.69	1.44–1.64

The ovarian volume ratio, ovarian width, and Doppler flow were all evaluated as potential predictive variables for ovarian torsion (Table 3). ROC curve analysis revealed that the OVR demonstrated the best diagnostic accuracy at a cutoff value of 2.5 with a sensitivity of 100% and specificity of 94% (AUC 0.991, p < 0.001, Figure 2). A cutoff value of 3.7 cm for ovarian width demonstrated a sensitivity of 93% and specificity of 94% (AUC 0.969, p < 0.001). Abnormal Doppler flow was the least sensitive of these three diagnostic markers for ovarian torsion (64%).

3. Discussion

Premenarchal females with ovarian torsion often present without an associated adnexal mass and are at increased risk for a delay in diagnosis [3]. This retrospective review sought to evaluate sonographic predictors of ovarian torsion in this unique population and establish normal values for ovarian volume ratio as a marker of ovarian asymmetry. This study demonstrates that the OVR remains constant with age and is a reliable diagnostic marker for ovarian torsion in premenarchal females.

Pelvic ultrasound is the imaging modality of choice in the evaluation of ovarian torsion [5]. Presence of an adnexal mass is typically the primary risk factor for ovarian torsion, and is seen in up to 80% of reported cases [6–8]. These hormone-mediated masses are more common in postmenarchal females and thus ovarian torsion is less often included in the differential diagnosis of abdominal pain in the premenarchal patient [9,10]. Furthermore, lack of a mass on ultrasound often results in a radiologic diagnosis of torsion hinging upon abnormal Doppler flow

Table 3
Predictors of ovarian torsion.

	Sensitivity	Specificity
Ovarian volume ratio (>2.5)	100	94
Ovarian width (>3.7 cm)	93	94
Abnormal Doppler flow	64	100

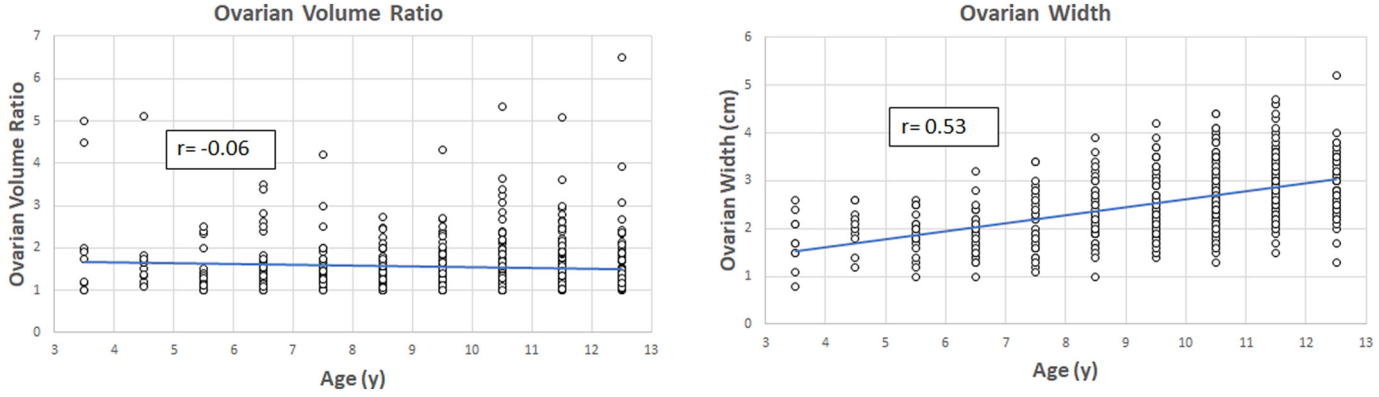

Fig. 1. Scatter plots of ovarian width and ovarian volume ratio versus age.

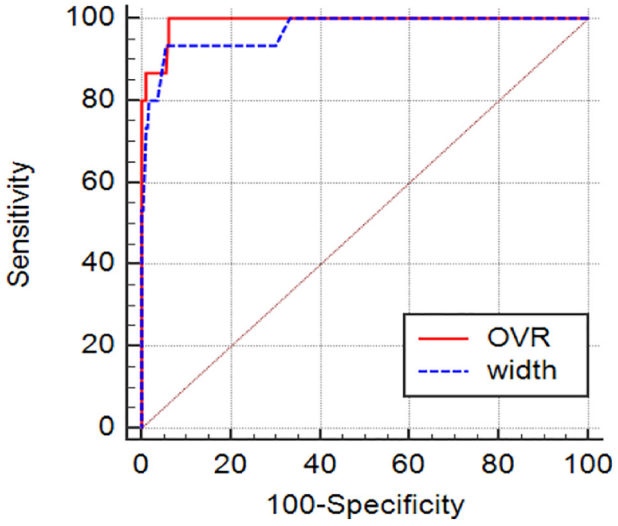

Fig. 2. Receiver operating characteristic curves illustrating ovarian volume ratio (OVR) and ovarian width as predictive of ovarian torsion.

to the affected ovary. Previous studies have suggested that Doppler flow cannot be used exclusively for the diagnosis of ovarian torsion as diminished or absent Doppler flow is reported in less than two-thirds of surgically-proven cases [6,11]. This finding was reproduced in our cohort as more than one-third of premenarchal girls without an associated mass presented with torsion in the setting of normal Doppler flow. Because abnormalities in Doppler flow are not always seen in this population with torsion, other more consistent ultrasound findings would aid in establishing a prompt diagnosis.

Ovarian asymmetry has previously been reported as the most common finding among children with ovarian torsion [6]. Servaes et al. reviewed the ultrasounds of all pediatric patients presenting to their institution with ovarian torsion over an 11-year period, and found that an OVR > 20 was likely associated with an adnexal mass. Our study further demonstrates the diagnostic value of ovarian asymmetry, as an OVR > 2.5 can be applied to premenarchal patients without a mass to assess their risk of ovarian torsion. The OVR offers an objective way in which to measure asymmetry, and demonstrated a high sensitivity and specificity for ovarian torsion in this premenarchal population. Ovarian asymmetry in this clinical context could be because of a number of factors. First, an enlarged ovary may be the initial cause for torsion. Similar to the mechanism by which a distinct adnexal mass can be the nidus for torsion, an enlarged ovary may allow for rotation along its axes of fixation. Second, impairment of venous outflow owing to torsion may result in vascular congestion and edema of the ovary.

Further, this study also demonstrates that OVR remains relatively constant with age. This consistency makes OVR an appealing, objective radiologic measurement as it can be reliably applied to all premenarchal girls without an adnexal mass. By comparison, ovarian width increased with age in this study. Size criteria of adnexal masses are often utilized in postmenarchal patients to raise suspicion of ovarian torsion. For instance, the risk of ovarian torsion in adolescents is higher in patients with adnexal masses greater than 5 cm [7,12]. However, for premenarchal girls of various ages, our data suggest an ovarian size cutoff may be difficult to apply with clinical accuracy.

Limitations of this study include its retrospective design and single center nature. Furthermore, ultrasound can be operator-dependent and there is potential for variability among sonographers in technique.

4. Conclusion

As a measure of ovarian asymmetry, OVR remains constant with age, thus making it a potentially more reliable marker for torsion than ovarian width alone. An OVR > 2.5 is an excellent predictor of ovarian torsion in premenarchal females without an adnexal mass. In this population, an elevated OVR may be helpful in establishing an early preoperative diagnosis of ovarian torsion. Prospective evaluation will help to confirm the efficacy of this diagnostic tool and potentially expand its application.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpedsurg.2020.09.031.

References

[1] Childress KJ, Dietrich JE. Pediatric ovarian torsion. Surg Clin North Am. 2017;97:209–21.
[2] Herman HG, Shalev A, Ginat S, Kerner R, Keidar R, Bar J, et al. Clinical characteristics of adnexal torsion in premenarchal patients
[3] Prieto JM, Kling KM, Ignacio RC, et al. Premenarchal patients present differently: a twist on the typical patient presenting with ovarian torsion. J Pediatr Surg. 2019;54:2614–6.
[4] Smolinski SE, Kreychman A, Catanzano T. Ovarian torsion: multimodality review of imaging characteristics. J Comput Assist Tomogr. 2015;39:922–4.
[5] Nur Azurah AG, Zainol ZW, Zainuddin AA, et al. Update on the management of ovarian torsion in children and adolescents. World J Pediatr. 2014;11:35–40.
[6] Servaes S, Zurakowski D, Laufer MR, et al. Sonographic findings of ovarian torsion in children. Pediatr Radiol. 2007;37:446–51.
[7] Oltmann SC, Fischer A, Barber R, et al. Cannot exclude torsion—a 15-year review. J Pediatr Surg. 2009;44:1212–7.
[8] Varras M, Tsikini A, Polyzos D, et al. Uterine adnexal torsion: pathologic and gray-scale ultrasonographic findings. Clin Exp Obstet Gynecol. 2004;31:34–8.
[9] Kim JS. Acute abdominal pain in children. Pediatr Gastroenterol Hepatol Nutr. 2013;16:219–24.
[10] Ashwal E, Hiersch L, Krissi H, et al. Characteristics and management of ovarian torsion in premenarchal compared with postmenarchal patients. Obstet Gynecol. 2015;126:514–20.
[11] Grunau GL, Harris A, Buckley J, et al. Diagnosis of ovarian torsion: is it time to forget about Doppler? J Obstet Gynaecol Canada. 2018;40:871–5.
[12] Houry D, Abbott JT. Ovarian torsion: a fifteen-year review. Ann Emerg Med. 2001;38(2):156–9.