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ORIGINAL ARTICLE

Sonographic findings of ovarian torsion in children

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Abstract
Background The clinical diagnosis of ovarian torsion is challenging and findings on pelvic sonography can be pivotal in making the correct diagnosis.
Objective To determine the sonographic characteristics in children of surgically and pathologically proven ovarian torsion.
Material and methods We performed a retrospective review of the sonograms and medical records of 41 patients with surgically and pathologically proven ovarian torsion at a pediatric hospital between 1994 and 2005. All sonograms were reviewed retrospectively by two pediatric radiologists with attention to the size, echotexture, location, presence of peripheral round cysts, and evidence of flow on Doppler sonography within the torsed ovary. The amount of free pelvic fluid was also recorded.
Results The most common sonographic finding of ovarian torsion was an enlarged ovary/adnexal mass. All torsed adnexa were larger than the normal contralateral ovary, with the median volume 12 times that of the normal contralateral side. The majority (61%, n=25) of the torsions occurred on the right. Color flow, either venous or arterial, was present in 62% (n=21/34) of the torsed ovaries for which flow on Doppler sonography was documented. In 63% of the torsed ovaries (n=26), the torsed adnexa appeared heterogeneous. Ovarian or paraovarian pathology that may have acted as a potential lead point was present in 55% (n=24) of torsed ovaries. The volume ratio of the torsed to normal ovary can predict the presence of an ovarian mass within the torsed ovary. In 70% of torsed ovaries with a volume ratio greater than 20, an ovarian mass was present, and in approximately 90% of those with a volume ratio less than 20, an internal mass was absent.
Conclusion An enlarged heterogeneous appearing ovary is the most common finding in ovarian torsion. The presence or absence of flow by Doppler sonography is not helpful in the diagnosis. The volume ratio of the torsed to the normal ovary can predict the presence of an internal mass within the torsed adnexa.

Keywords Ovarian torsion · Ovarian mass · Pediatric

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Introduction

A significant proportion (15%) of ovarian torsions occur during childhood [1]. Ovarian torsion is a particularly challenging clinical diagnosis in children since children often cannot articulate their symptoms. Symptoms of torsion including lower abdominal pain, nausea, vomiting, and fever [2–5] mimic other clinical entities of the reproductive system (e.g., pelvic inflammatory disease, endometriosis, neoplasm, ruptured ovarian cyst, ectopic pregnancy) [6], the genitourinary system (e.g., nephrolithiasis), and the gastrointestinal system (appendicitis, gastroenteritis, diverticulitis, infected enteric duplication cyst or Meckel's diverticulum).

Sonography can be crucial in the correct diagnosis of this surgical emergency and the diagnosis of other conditions with similar symptoms. Sonography is the modality of choice in the evaluation of the female pelvis because it can be performed quickly, provides good visualization of pelvic organs, and involves no ionizing radiation to the patient. If the ovaries appear normal, sonography often elucidates the true diagnosis. We report here the sonographic characteristics of ovarian torsion in children and adolescents based on a retrospective review of children and adolescents with pathologically proven torsion.

Material and methods

Patients

Girls with surgically proven ovarian torsion and sonography prior to surgery were selected from a surgical database from a pediatric hospital between 1994 and 2005. The study was approved by the hospital institutional review board. No consent was required.

Sonographic analysis

The sonograms and medical records were reviewed retrospectively by two pediatric radiologists (S.S. and J.C.). The patient age, side and size of the normal and abnormal ovaries, sonographic appearance of the torsed ovary (solid, cystic, heterogeneous/complex), presence of peripheral round cysts measuring up to 2.5 cm in diameter, location of the torsed ovary, and presence of free fluid were evaluated in each patient. The volume of the ovary was calculated using the formula for a prolate ellipsoid (length×width×height×0.523) [7]. Surgical and pathological data were available in all cases.

Sonography was performed with the machines available at the time and included Acuson Sequoia, Acuson XP (Mountain View, Calif.) or ATL 5000 (Advanced Technology Laboratory, Bothell, Wash.) machines using 4, 5, 6 and 8 MHz transducers at a variety of frequencies. Transverse and longitudinal sonograms of the uterus and ovaries were obtained in all imaged patients using a transabdominal approach, using a full bladder as the acoustic window to the pelvic organs. The bladder was distended by the oral intake of fluids or intravenous hydration. Ovarian width measurements were obtained from transverse images while length and thickness measurements were obtained from parasagittal images. Images were stored electronically using a picture archiving and communication system (Synapse, Fujifilm Medical Systems USA, Stamford, Conn.).

Statistical analysis

A histogram was used to describe the distribution of volume ratios of the 41 patients in the study population. The volume ratio was compared between patients with a normal ovary and those with an ovarian mass using the nonparametric Mann-Whitney *U*-test since the data did not follow a Gaussian distribution. Boxplots were used to represent the volume ratio data graphically for normal ovary and ovarian mass groups with the box divided at the median and the length of the box representing the interquartile range (IQR). In differentiating a mass inside the ovary from a normal ovary based on pathology results, logistic regression was used to evaluate the probability of an ovarian mass based on volume ratio, and a probability curve was determined from the regression coefficients in the model with the likelihood ratio test used as the measure of significance. In addition, the sensitivity and specificity and odds ratio were calculated using a cut-off value of >20 for the volume ratio. To calculate the positive and negative predictive values (PPV and NPV) of an ovarian mass based on volume ratio cut-off, an estimate of prevalence and Bayes' formula was applied. Statistical analysis was performed using the SPSS software package (version 14.0, SPSS, Chicago, Ill.). Two-tailed P values <0.05 were considered statistically significant.

Results

Of 74 patients with ovarian torsion treated surgically between 1994 and 2005, 41 had pelvic sonography immediately prior to surgery and were included in our study group. The median age was 11 years (IQR 7–14.5 years, range 1 month to 21 years). The vast majority of torsed ovaries were salvaged.

The abnormal torsed ovary was identified in all patients by sonography. The most common sonographic finding of torsion was an enlarged ovary/adnexal mass (Fig. 1). The median volume of the torsed adnexa was 12 times that of the contralateral normal ovary when both ovaries were visualized. In two patients, the ovary contralateral to the torsion was not identified. In 61%, the torsion occurred on the right (n=25), and in 39% occurred on the left (n=16).

Sonographically the torsed ovary had the appearance of a complex or heterogeneous mass in 26 (63%) or a simple cyst in 8 (19.5%), was solid in 5 (12%), was calcified in 1, and was enlarged in 1 (Table 1). Small peripheral follicles were present in 9 (38%) of the 24 patients in whom the presence or absence of follicles could be determined. In some, the massively enlarged ovary was too large to visualize the presence of follicles. The torsed ovary appeared medial to its normal expected location in 14 (34%).

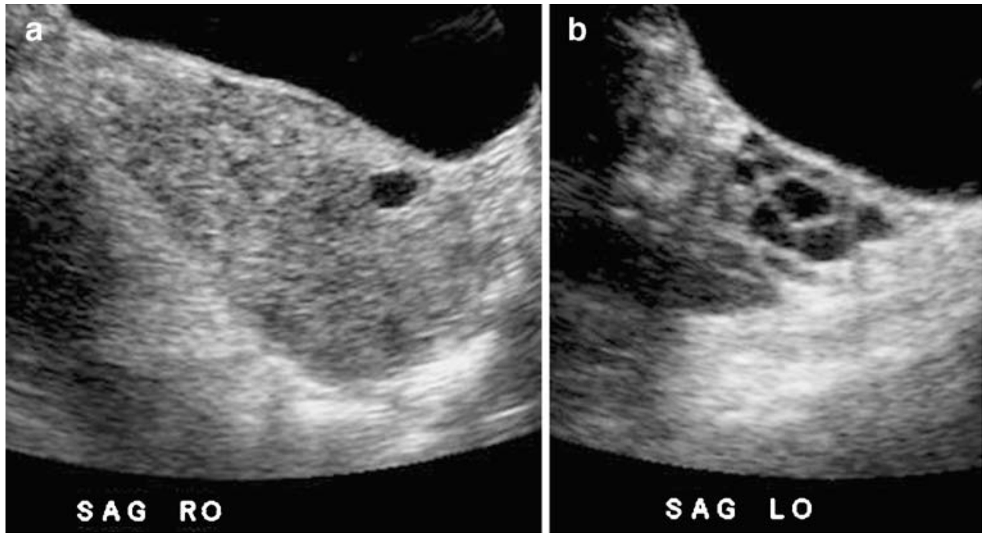

Fig. 1 Representative ultrasound images of a torsed ovary (**a**) and the normal contralateral ovary (**b**) in an 8-year-old prepubertal girl presenting with right lower quadrant pain. **a** The torsed ovary is enlarged and heterogeneous and measures 7.9×3.8×6.3 cm corresponding to a volume of 361.6 cm^3. **b** The contralateral normal ovary measures 2.8×1.4×1.9 cm corresponding to a volume of 14.2 cm^3

Color flow, either venous or arterial, was present in 62% (n=21/34) of the torsed ovaries for which flow on Doppler sonography was documented. In 13 patients, Doppler sonographic flow measurements were attempted but no flow was identified. In the remaining patients, no Doppler sonographic recordings were present. Free fluid was present in the pelvis in 30% (n=12) and in all of these the amount of fluid was trace to small in quantity.

Surgical and pathological reports were available in all patients. Torsion occurred in otherwise normal ovaries without a potential lead point in 34% (n=14). An associated ovarian or paraovarian abnormality was found at pathology in 55% (n=24). In three, the torsion occurred in utero. Although these ovaries contained cysts, the original appearance of the ovary and cause of the torsion could not be identified.

Masses inside the torsed ovaries which may have contributed to torsion consisted of teratomas (n=10), hemorrhagic cysts (n=2), simple cyst (n=1) and serous cystadenoma (n=1), or were in patients with polycystic ovarian syndrome (n=3). In seven patients, the ovary was normal but there was a paratubal cyst found at pathology. In two patients with ovarian hemorrhagic cyst, a paratubal cyst was also present at pathology (Table 2).

Since ovarian volume depends on age and pubertal status [8], and there is a broad range of normal ovarian volumes, the size of the torsed ovary was compared with that of the contralateral ovary. This ratio, the volume ratio, was used to compare the volumes of the abnormal to normal sides. Normal ovaries were identified in all but two patients on the side contralateral to the torsion. In the three patients who had ovarian torsion and polycystic ovarian disease, the volume of the untorsed ovary was within the normal range for the patient's age.

Among all patients the median volume ratio, or the median ratio between the torsed side and the normal contralateral side was 12 (IQR 4.4–27.3). The distribution of volume ratios indicates that 15 patients (37%) had volume ratios over 20 (Fig. 2).

The median volume ratio was significantly greater in patients with a mass inside their ovary (31.3, IQR 13.1–99.2, range 2.6–333) than in those with a normal ovary (6.7, IQR 4.5–19.4, range 1–33). The boxplots indicate a significantly greater volume ratio among patients with an ovarian mass compared to patients with a normal ovary (P=0.01, Fig. 3).

Logistic regression confirmed that the volume ratio was a highly significant predictor of an ovarian mass (likelihood ratio test 11.62, $P<0.001$). Empirical histograms for patients with a normal ovary and those with an ovarian mass reveal a clear separation in volume ratio (Fig. 4).

Table 1 Description of torsed ovary and adnexa for different age groups

Age group (years)	Number of patients	Simple (cystic)	Complex (heterogeneous)	Calcified	Solid	Enlarged
0–4	6	1	5	0	0	0
5–8	7	0	5	0	2	0
9–12	11	1	6	1	2	1
13–17	12	4	8	0	0	0
18–21	5	2	2	0	1	0
Total	41	8	26	1	5	1

Table 2 Pathology characterization for different age groups

Age group (years)	Number of patients	Normal ovary	Mass inside ovary	Cyst outside ovary	Prenatal torsion	Polycystic ovaries	Hemorrhagic cysts
0–4	6	2	1	0	3	0	0
5–8	7	4	3	0	0	0	0
9–12	11	4	5	1	0	1	0
13–17	12	2	1	5	0	2	2
18–21	5	2	2	1	0	0	0
Total	41	14	12	7	3	3	2

Using a 2×2 table to determine sensitivity and specificity, we chose a volume ratio cut-off of >20 versus ≤20. Of the 12 patients with an ovarian mass, nine were correctly classified (sensitivity 75%) whereas 12 of the 14 patients with a normal ovary were correctly classified (specificity 86%). The accuracy for a volume ratio cut-off of 20 was 81% (21 of 26 correct classifications). A patient with a volume ratio over 20 was 18 times more likely to have an ovarian mass than to have a normal ovary (odds ratio 18, 95% confidence interval 2.5–131). To determine the PPV and NPV, we assumed an ovarian mass prevalence in the study population evaluated by sonography of 30% and applied Bayes' formula (PPV 70%, NPV 89%). Thus, if the volume ratio was greater than 20, the probability that the patient had an ovarian mass was 70%. On the other hand, if the volume ratio was 20 or less, the probability that the patient had a normal ovary was 89%.

Discussion

Pelvic sonography is a very useful tool in diagnosing ovarian torsion in children and adolescents. In our series of surgically proven cases of ovarian torsion, all those patients who had pelvic sonography prior to surgery showed abnormal adnexa. Torsions occurred more commonly on the right than on the left. Others have also described torsion as more common on the right [1, 9, 10] and although the exact cause for this is unknown, the presence of the sigmoid colon on the left may help to prevent left-sided torsion. The most common characteristic of a torsed ovary is an adnexal mass or ovarian enlargement.

In our group of children, the median volume ratio of the abnormal adnexa compared to the normal adnexa was 12. The likelihood of an underlying ovarian mass, such as a teratoma or hemorrhagic cyst, increased with increasing volume ratio. If the volume ratio was greater than 20, the probability of the patient having an ovarian mass was 70%. If the volume ratio was 20 or less, the probability that the torsed ovary was otherwise normal was approximately 90%.

Ovarian enlargement is well described in the literature [2, 11] as a sign of ovarian torsion. In adults, an enlarged ovary may be due to torsion, benign or malignant tumor, hemorrhagic or simple ovarian cyst, endometrioma or tubo-ovarian abscess. In prepubertal children, endometriosis and tubo-ovarian abscess are exceedingly rare. Hemorrhage into an ovarian cyst is not as common in children as in adults [12]. The incidence of ovarian masses, both benign and malignant, increases with age [13] and are thus less

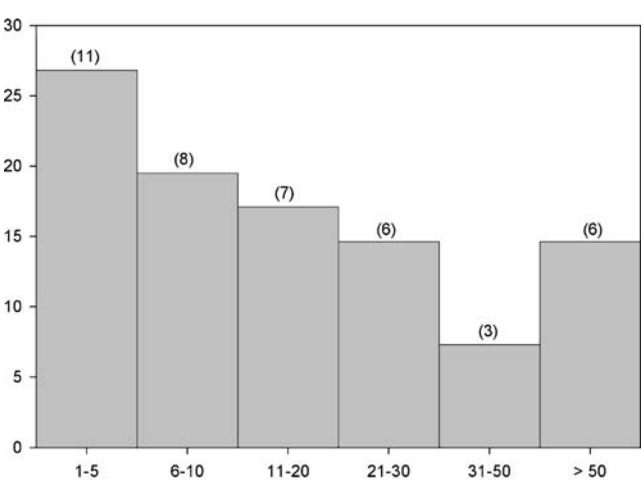

Fig. 2 Distribution of volume ratios among the 41 patients with a torsed ovary

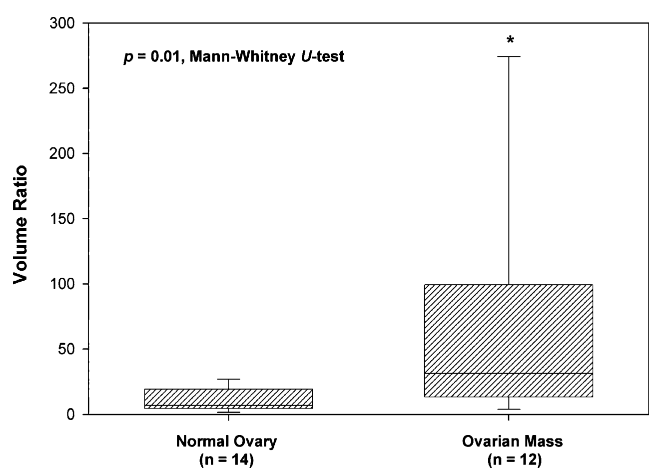

Fig. 3 Boxplots representing the volume ratio data from patients with a normal ovary and those with an ovarian mass. The boxes are divided at the median and the length of each box represents the IQR

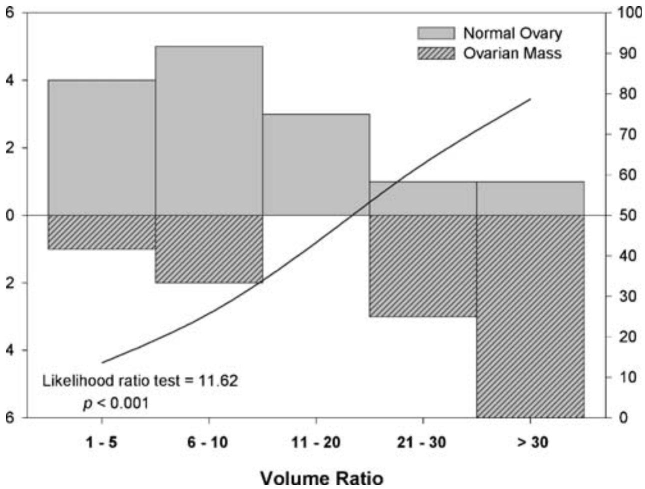

Fig. 4 Empirical histograms for patients with a normal ovary and those with an ovarian mass. The theoretical curve describes the positive relationship between five categories of volume ratio and the corresponding probability from the regression analysis of an ovarian mass. For example, a volume ratio between 1 and 5 has an estimated probability of an ovarian mass of 13%, a ratio between 6 and 20 has a probability of 26%, a ratio between 11 and 20 has a probability of 43%, a ratio between 21 and 30 has a probability of 63%, and a ratio of >30 has a probability of nearly 80%

common in children than adults. Because many of the causes of ovarian masses in adults are uncommon in children and torsion is a surgical emergency, torsion should always be considered in children with pain and an adnexal mass. The detection of an ovarian mass which induces the torsion is less important than identifying the torsion because torsion is a surgical emergency.

Many other sonographic findings have been used to predict torsion. Spherical cysts measuring up to 2.5 cm in the periphery of the enlarged ovary have been found in 74% of patients with ovarian torsion [2]. Fluid-debris levels within the peripheral cysts have been described as pathognomonic of torsion [14]. In our series, small peripheral cysts were present in only 38% of those patients in whom follicles could be evaluated. An abnormal medial location of the ovary [15] has also been described as a useful feature but occurred in only 34% of our patients. Free fluid was present in the pelvis in 30% (n=12) and in all it was trace to small in quantity

The presence or absence of arterial and venous flow has been shown to be a variable predictive of torsion [16–22] and was not found to be a useful indicator of torsion in our group of children. In 64% of our patients, flow, either arterial or venous, was shown in the torsed ovary. The whirlpool sign [23, 24] and the use of 3-D power Doppler sonography [25] have been advocated to improve the diagnosis of torsion in adults, but have not been used in children and were not used in our patients. Some torsed ovaries do demonstrate flow on Doppler sonography, thus the absence of flow is not indicative of ovarian torsion.

Torsion occurred in otherwise normal ovaries without a potential lead point in 34% (n=14). Torsion of normal uterine adnexa has been reported previously [26, 27] and may be due to the especially mobile uterine adnexa in children. An associated ovarian or paraovarian abnormality was found at pathology in 55% (n=24). In three, the torsion occurred in utero. Although these ovaries contained cysts, the original appearance of the ovary and the cause of the torsion could not identified.

Additional pathologic abnormalities were present in 24 patients; 15 were only ovarian, 7 were only paraovarian and 2 were both ovarian and paraovarian. Abnormal ovaries contained teratomas (n=10), hemorrhagic cysts (n=2), a simple cyst (n=1) or a serous cystadenoma (n=1), or were in patients with polycystic ovarian syndrome (n=3). In seven, the ovary was normal but a paratubal cyst was found at pathology. The two children with hemorrhagic ovarian cysts also had paratubal cysts.

Torsed adnexa that appeared cystic (n=8) were due to torsions associated with potential lead points and included tubal cysts (n=4), serous cystadenoma (n=1), simple ovarian cyst (n=1) and benign teratoma (n=1). Otherwise, the appearance of the torsed adnexa was not helpful in determining whether the torsion was of a normal ovary or an ovary/adnexa with pathology. For example, torsion that occurred in otherwise normal ovaries (n=14) appeared either heterogeneous (n=9) or solid (n=5). Ovaries which contained teratomas (n=10) appeared mainly complex or heterogeneous (n=8), solid (n=1) or cystic (n=1).

The variety of appearances in normal torsed ovaries or abnormal torsed ovaries is not surprising. Hemorrhage, such as within a torsed ovary, can have a variety of appearances depending on the age of the blood products [28]. Teratomas, the most common ovarian mass in our patients with torsion, are composed of different mesenchymal components and thus contain a combination of solid, cystic or calcified elements. Cystic adnexal masses are also known to have a variety of causes [29]. In the pediatric literature, an incidence of torsion related to underlying ovarian abnormalities of 27–48% is reported, the most common causes being ovarian cysts and teratomas [1, 30, 31]. In the adult literature a higher percentage of additional abnormalities within the torsed ovary, between 69% [15] and 85% [1], is reported. Only one simple ovarian cyst was found at pathology in our patients with torsion. Those with predominantly cystic abnormalities on sonography were due to a variety of cystic lesions, the most common being para-ovarian cysts. This is surprising given that ovarian cysts are common in children [6, 32, 33]. Para-ovarian cysts are less common than ovarian cysts but were associated with torsion in 17% of our patients. The high number of teratomas in the patients with ovarian torsion is not surprising given that teratomas are the most common benign ovarian tumor in children and adolescents

[13, 32], and that torsion is the most common complication of this mass [34]. Teratomas have been found to be the most common ovarian mass associated with torsion in adults [35].

Our study, although it is the largest sonographic evaluation of children and adolescents with surgically proven ovarian torsion [2, 21, 30], has several limitations. Because this was a retrospective review and the patients were not studied by a strict sonographic protocol, not all of the studies included images of Doppler sonographic flow, evaluation of both venous and arterial flow in the center or periphery of the ovary, or specific attention to peripheral cysts in the enlarged ovary. Because we did not study all patients with ovarian masses, this study did not distinguish sonographic characteristics which help the sonographer decipher ovarian masses from torsion. We did not divide the appearance of the torsed ovaries based on whether the children were prepubertal or pubertal, as others have [21], since their pubertal status was unknown at the time of retrospective review.

Conclusion

An enlarged ovary or ovarian adnexal mass, with or without flow on Doppler sonography, is the most common finding of ovarian torsion in children and adolescents. The volume ratio of the torsed adnexa compared to that of the normal side can predict if there is an underlying ovarian mass which may potentially be the lead point of the torsed ovary.

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