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Clinical characteristics of adnexal torsion and role of ovarian sparing surgery: a clinical retrospective analysis

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ABSTRACT

Objectives: To analyze the clinical characteristics and risk factors related to necrosis of adnexal torsion (AT) and improve the application of ovarian-sparing surgery (OSS).

Material and methods: Data of 142 patients with 144 surgically confirmed AT lesions between October 2011 and December 2021 were retrospectively analyzed.

Results: The risk of torsion caused by tumors was higher than that caused by tumor-like lesions ($p = 0.003$). The incidence of right adnexal necrosis was higher than that of left adnexal necrosis ($p = 0.03$). There were no significant differences in adnexal necrosis or onset time ($p = 0.29$) between groups. The main risk factor for adnexal necrosis was the degree of torsion with a threshold of 510°. The size of adnexal mass and the degree of torsion increased linearly with age. The OSS rate was 59.7% for all patients, and 71.6% in the premenopausal women. No serious complications occurred in any of the patients.

Conclusions: Age, histopathological type, adnexal size, degree of torsion, and pelvic anatomical structure are risk factors for AT and adnexal necrosis. There is no infinite correlation between adnexal necrosis and onset time. Adnexal size is the main risk factor for AT, and along with the risk of adnexal necrosis, increases with age. The degree of torsion is the main risk factor for adnexal necrosis, and torsional severity increases with age. OSS is safe and does not increase the incidence of postoperative complications.

Keywords: adnexal torsion; adnexal necrosis; ovarian-tumor; ovarian-sparing

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INTRODUCTION

Adnexal torsion (AT) is an uncommon gynecological emergency that can occur at any age, mainly in adolescents and women of childbearing age, but rarely in children and postmenopausal women [1–7]. Adnexal torsion accounts for only 2–3% of gynecological emergencies [5–7], and its incidence rate in women with adnexal masses is estimated to be 2–15%. However, as a definite clinical diagnosis can only be made during surgery, the true prevalence of AT remains unclear [3]. Recently, treatment of AT has evolved from oophorectomy for ischemic ovaries to ovarian preservation. This transformation is beneficial to women because it can prevent early menopause, early amenorrhea, and premature ovarian failure, which have been proven to affect all aspects of a woman's health, including bone mineral density and cardiovascular, neurological, mental, sexual health [8]. Knowledge of ovarian diseases has changed in relation to pulmonary embolism caused by the reduction of AT, sepsis secondary to necrosis, pathological changes in black/blue ischemic ovaries, and tumor recurrence caused by tumor rupture. The advantages of laparoscopy provide a strong guarantee for the diagnosis and treatment of AT [3, 6, 9]. This retrospective study aimed to analyze the clinical characteristics of AT and improve the application of ovarian sparing surgery (OSS).

MATERIAL AND METHODS

This retrospective observational study of patients with surgically verified AT was conducted at Weihai Municipal Hospital in China between January 2011 and December 2021. Data extracted from the patients' electronic

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medical records included demographic data, menstrual status, onset time, clinical symptoms, adnexal lesion size, surgical approach, ovarian procedure, intraoperative characteristics, postoperative complications, and pathological diagnoses. Onset time refers to the time from initial symptoms to surgical intervention. Adnexal size was extracted from the ultrasound report and was combined with subsequent computed tomography or magnetic resonance imaging examinations. The maximum length is selected as the adnexal diameter. Because an adnexal mass is an irregular ellipsoid, volume is also introduced as a variable. The volume of the mass was calculated using the formula of the long ellipsoid (0.52 × longitudinal diameter × anteroposterior diameter × transverse diameter) [10]. Torsion equal to 180° was defined as incomplete torsion, whereas torsion greater than 360° was defined as complete torsion. To study the risk factors of AT, the degree of torsion was divided into three groups: < 180, 360–720 and > 720. An ovary with a black or blue appearance was considered as necrotic or partially necrotic, respectively. The end point and time of follow-up were obtained by comparison with the outpatient and inpatient databases. If no information was available, the patient was considered unable to be followed-up.

The institutional ethical committee of the hospital approved the study and waived the need for informed consent from the participants due to the retrospective nature of the study.

All statistical analyses were performed using SPSS 23.0 (IBM, Chicago, IL, United States). An independent samples t-test and one-way analysis of variance (ANOVA) were applied for continuous variables. All categorical variables were expressed as frequencies and percentages and compared using the Chi-squared test. Spearman's rank correlation coefficient was used to analyze the linear relationship between the two variables. Receiver operating characteristic (ROC) curve and Excel were used for specificity, sensitivity, area under the curve (AUC), and threshold calculation. The statistical significance level was set at $p \leq 0.05$.

RESULTS

A total of 2,452 patients (age range: 6–84 years) with 3,068 adnexal lesions underwent surgery between October 2011 and December 2021. Of these, 142 (5.8%) patients had 144 (4.7%) lesions confirmed as being AT, and their average age was 34 ± 16 years old. The incidence rates of AT were 5.9% (66/1,107), 6.6% (74/1,126), and 1.0% (4/388) on the left, right, and bilateral sides, respectively, with no significant differences in laterality (p = 0.55). The clinicopathological types and incidence rates are shown in Table 1. Tumors were the most common cause of AT in all patients (72.9%). Mature teratomas accounted for 24.1% of cases, with an incidence rate of 7.3%. Simple ovarian cysts accounted for 3.3% of cases and had the highest incidence of torsion (14.0%). There was a significant difference in the incidence of AT between the mature teratomas and simple ovarian cysts (p = 0.02). The incidence rate of AT caused by borderline tumors was not significantly different from that caused by benign tumors (p = 0.60), while that caused by malignant tumors was the lowest. The incidence rate of AT for tumors was higher than that for tumor-like lesions (p = 0.003). Only one AT did not have an ovarian mass.

Table 1. Clinicopathological types and risk of torsion

	Lesions n (%)	Torsion lesions n (%)	Incidence rate [%]
Total, lesions	3068 (100)	144 (100)	4.7
Tumor, lesions	1875 (61.1)	105 (72.9)	5.6
Benign tumor	1389 (45.3)	97 (67.4)	7.0
Mature teratomas	740 (24.1)	54 (37.5)	7.3
Serous cystadenoma	367 (12)	18 (12.5)	4.9
Mucinous cystadenoma	174 (5.7)	12 (8.3)	6.9
Thecoma	91 (3)	11 (7.6)	12.1
Other	17 (0.6)	2 (0)	11.8
Borderline tumor	122 (4.0)	7 (4.9)	5.7
Malignant tumor	364 (11.9)	1 (0.7)	0.3
Tumor-like, lesions	1193 (38.9)	39 (27.1)	3.3
Endometriosis cyst	824 (26.9)	8 (5.6)	1.0
Corpus luteum	118 (3.8)	9 (6.3)	7.6
Follicular cyst	62 (2.0)	5 (3.5)	8.1
Simple ovarian cyst	100 (3.3)	14 (9.7)	14.0
Other	91 (2.9)	3 (2.1)	3.3

Among the patients with AT, 138 (97.2%) had abdominal pain, 80 (56.3%) had persistent abdominal pain with nausea/vomiting, and five (2.8%) were asymptomatic. There were seven patients with AT, with a mean age of 31 ± 3 years, complicated with pregnancy (4.9%), of which five were in the first trimester and two were in the second trimester. The mean gestational period was 13 ± 8 weeks. Another patient developed AT on the 7th day after delivery. Three (2.1 %) patients were diagnosed as AT with appendicitis.

The risk factors for necrosis and treatment of AT are presented in Table 2. The mean age of patients with adnexal necrosis was higher than that of patients without necrosis (p = 0.001). The incidence of adnexal necrosis on the right side was higher than that on the left (p = 0.03).

The mean onset time was 164 ± 666 hours (range: 4 h–9 months) and there was no significant difference between the non-necrosis and necrosis groups (p < 0.11). Chi-squared test showed no significant differences between an onset time of 24 h, 24–48 h, and > 48 h (p = 0.16). Receiver

Table 2. Risk factors of necrosis and treatment for adnexal torsion

	Necrosis n (%)	Non-necrosis n (%)	Total n (%)	p value
Age [years]	39 ± 17	30 ± 14	34 ± 16	0.001
Laterality, lesions	71 (100)	73 (100)	144 (100)	0.03
Left	27 (38)	41 (56.2)	68 (47.2)	
Right	44 (62)	32 (43.8)	76 (52.8)	
Symptom to surgery [hours]	76 ± 157	251 ± 917	164 ± 665	0.11
Duration of onset	71 (100)	73 (100)	144 (100)	0.16
< 24 hours	30 (42.3)	20 (27.4)	50 (34.7)	
24–48 hours	19 (26.8)	22 (30.1)	41 (28.5)	
> 48 hours	22 (31.0)	31 (42.5)	53 (36.8)	
Degree of torsion [°]	821 ± 302	458 ± 270	637 ± 338	0.000
Grade of torsion	71 (100)	73 (100)	144 (100)	0.000
< 180°	2 (2.8)	27 (37)	29 (20.1)	
360–720°	14 (19.7)	20 (27.4)	34 (23.6)	
> 720°	55 (77.5)	26 (35.6)	81 (56.3)	
Diameter [cm]	10 ± 3	10 ± 3	10 ± 3	0.36
Volume [cm^3]	376 ± 373	286 ± 235	332 ± 314	0.09
Ovarian procedure	71 (100)	73 (100)	144 (100)	0.00
Ovarian sparing	19 (26.8)	67 (91.8)	86 (59.7)	
Oophorectomy	52 (73.2)	6 (8.2)	58 (40.3)	

operating characteristic curve analysis showed that the AUC was 0.60 (95% CI: 0.51–0.70, p = 0.03), and the threshold of onset time was 24 h (sensitivity, 43%; specificity, 77%). Of all patients, onset time exceeded 72 h in 38 (26.4%) patients; of these, 12 (31.6%) having adnexal necrosis or suspicious necrosis. Four patients without abdominal pain had AT of 180–720°, but there was no adnexal necrosis during elective surgery. Meanwhile, three patients with abdominal pain for 3–9 months had AT of 540°–1,080°, but there was no necrosis.

The mean degree of torsion was 636° ± 338° (range: 180–1,440°), and there was a significant difference between the non-necrosis and necrosis groups (p < 0.001). The Chi-squared test showed significant differences among torsional degrees of < 180°, 360–720°, and > 720° (p < 0.001). Receiver operating characteristic curve analysis showed that the AUC was 0.80 (95% CI: 0.73–0.87, p < 0.001), and the threshold was 510° (sensitivity 86%; specificity 58%). Spearman's rank correlation coefficient showed that the degree of torsion increased linearly with age (r = 0.27, p = 0.001); however, this linear relationship was not significant for the necrosis group (r = 0.16. p = 0.19) (Fig. 1).

The relationship between the onset time, degree of torsion, and necrosis is shown in Figure 2.

The mean maximum diameter of the adnexal masses was 10 ± 3 cm (range 5–22 cm), and the mean volume was 332 ± 314 cm^3 (range 36–1,863 cm^3). To reduce statistical deviation, masses with a diameter of 40 cm and a volume of 73.33 cm^3 were deleted. There was no difference in the size of adnexal masses between the necrosis and non-necrosis groups. Spearman rank correlation coefficient showed that the size of the adnexal mass significantly increased with age (diameter, r = 0.19, p = 0.02; volume, r = 0.18, p = 0.03); this relationship was also significant for the necrosis group (diameter, r = 0.34, p = 0.004; volume, r = 0.30, p = 0.01) (Fig. 3).

The OSS rate was 59.7% for all patients, and 91.8% and 26.8% for the non-necrosis and necrosis groups, respectively. In the premenopausal women, 71.6% (86/120) of patients underwent OSS without hysterectomy, whereas in the postmenopausal woman, none underwent OSS, while 50% (12/24) underwent additional hysterectomy.

The rate of laparoscopic surgery was 47.2% (67/142). The mean diameter of the adnexal mass in the laparoscopic and laparotomy groups were 9 ± 3 cm and 11 ± 5 cm, and the mean volume of the adnexal mass were 221 ± 179 cm^3 and 502 ± 873 cm^3, respectively. There was a significant difference between the two groups (diameter, p < 0.001; volume, p = 0.007).

Pulmonary embolism or serious complications did not occur in any of the patients. Of the 84 patients who underwent OSS, 29 were followed-up for more than half a year, and

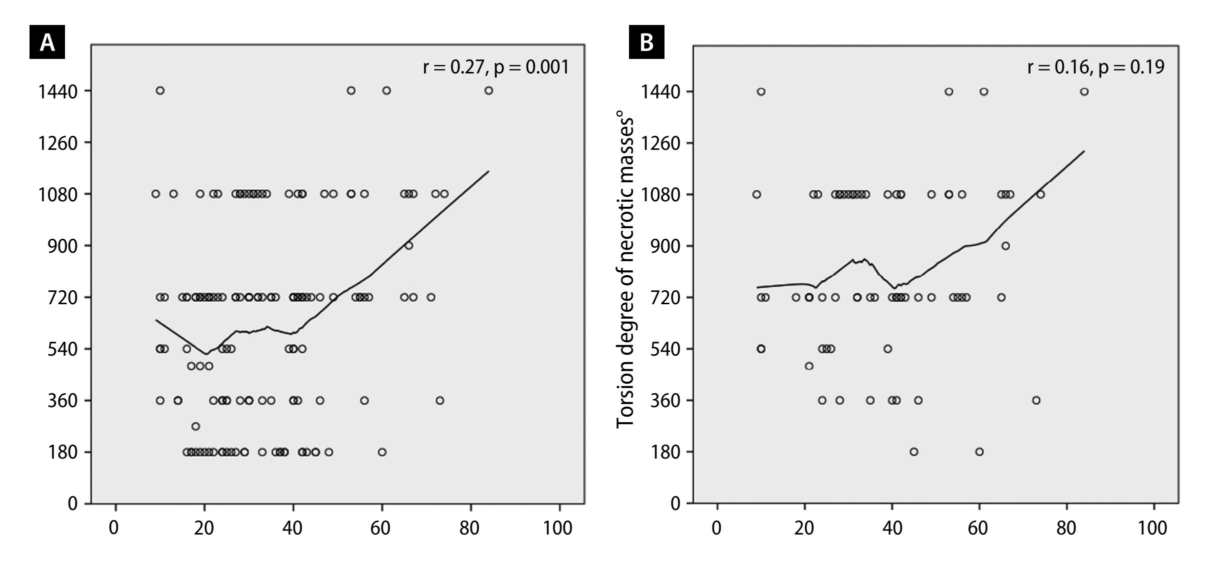

Figure 1. A. Degree of torsion increases linearly with age (p = 0.001); **B.** The linear relationship was not significant in the necrosis group (p = 0.19)

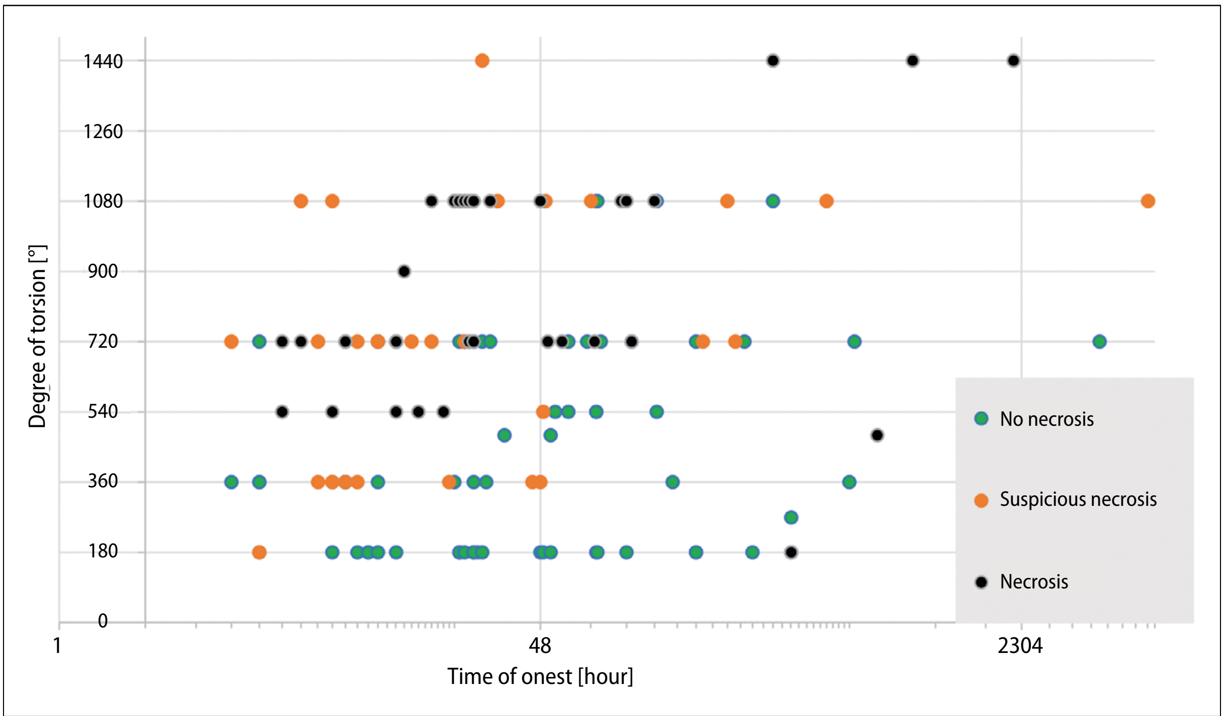

Figure 2. The relationship between the onset time, degree of torsion, and necrosis

only one patient with a mucinous cystadenoma experienced recurrence after 24 months.

DISCUSSION

Adnexal torsion without pathological changes is rare and usually occurs in premenarchal girls without hormone-mediated masses [4, 11]. Meanwhile, 51–84% of AT cases are caused by pathological changes, with a higher incidence rate on the right side [2, 11, 12]; however, some studies have reported no differences in laterality [9, 13, 14]. Reportedly, mature cystic teratomas and follicular cysts are the most common lesions causing AT, although simple cysts, teratomas, and serous cysts have also been reported [2, 6, 9, 13]. Approximately 80% of all AT cases are caused by benign

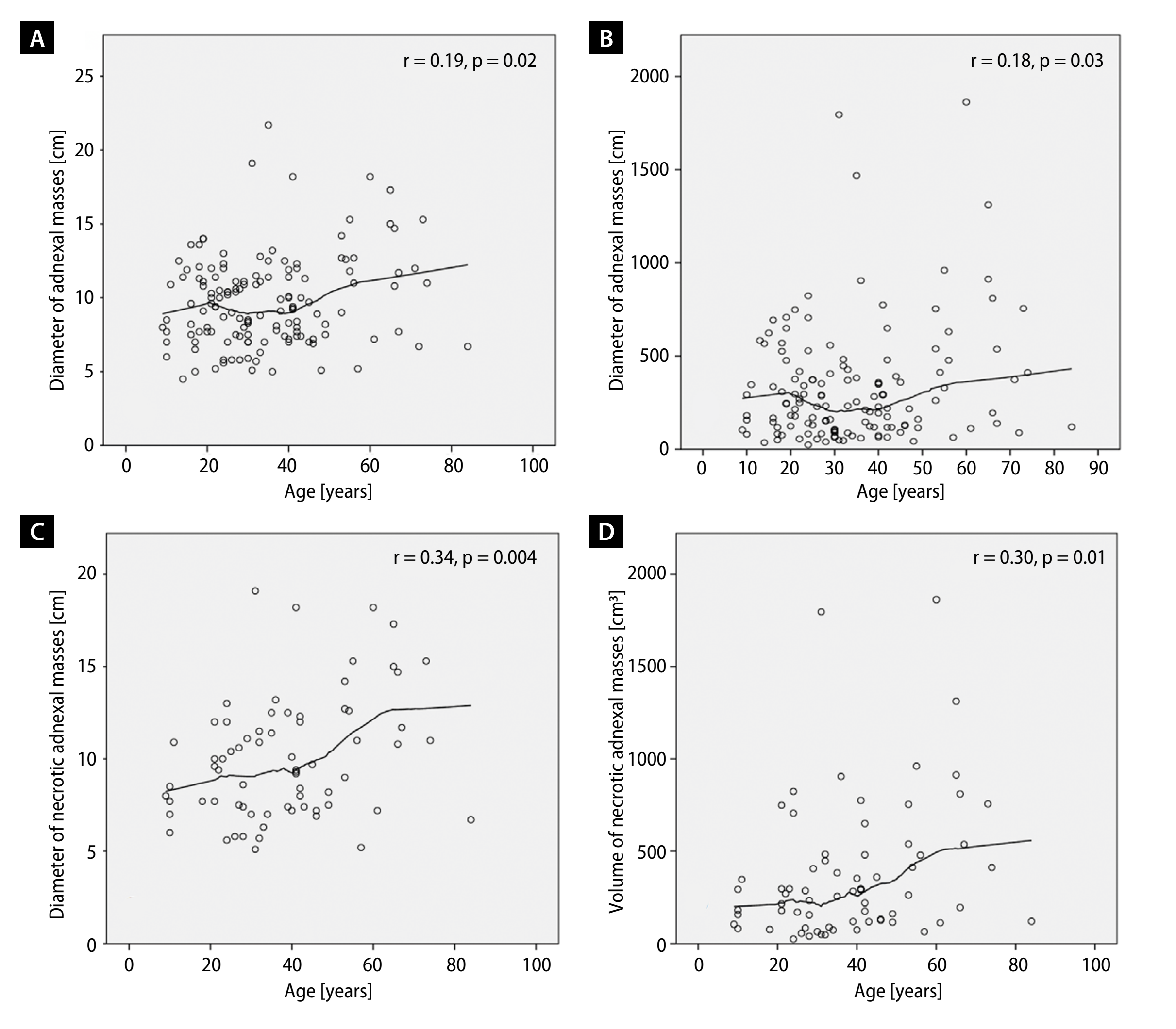

Figure 3. A, B. The size of the adnexal mass increases linearly with age, with a significant difference (diameter, p = 0.02; volume, p = 0.03); **C. D.** The size of the necrotic adnexal masses increases linearly with age, with significant difference (diameter, p = 0.004; volume, p = 0.01)

tumors, whereas only 2% are caused by malignant tumors [1, 2, 6, 13, 15], which may be related to malignant tumor edema and peripheral adhesion. In this study, the prevalence of AT due to adnexal lesions was 4.7%. Tumors were the main cause of AT, of which mature cystic teratomas were the most common; however, the risk of torsion caused by a mature cystic teratoma is not the highest when compared with that of other more common lesions as simple ovarian cysts and thecomas have the highest risk of AT. The histopathological type seems to be a risk factor for AT. Additionally, there were no significant differences in laterality, which differs from studies reporting right-sided dominance.

Abdominal pain is the main symptom of AT and has diagnostic significance especially when it is accompanied by nausea/vomiting and a lower abdominal mass. Previous studies showed that 86–98% of patients with AT experience abdominal pain, and 47–70% of patients experience abdominal pain with nausea and vomiting [4, 7, 9, 16, 13]. Of the patients with adnexal tumors and acute abdominal symptoms, 86% had AT [6, 17].

The value of ultrasonography in the diagnosis of AT should be based on adnexal size rather than Doppler flow results as color Doppler flow has poor sensitivity in excluding AT. Although the "whirlpool sign" is specific for AT [18], it may be technically difficult to evaluate ovarian arterial and venous blood flow because of the influence of body shape, intestinal gas, and other factors. Because the ovary is supplied by the uterine and ovarian arteries and torsion may be intermittent, Doppler results may be unreliable. In addition to measuring the maximum adnexal diameter, measuring the adnexal volume is a common and effective method for evaluating the adnexal size [9, 19]. Torsion usually occurs when adnexal masses measure 5–10 cm [20–22]. The threshold value of the maximum diameter of the AT after menarche is 5 cm, and a value less than 5 cm may help exclude AT [6, 7, 9, 19–22]. However, necrosis development is not related to adnexal size [22], which was confirmed by the data obtained in this study. The mean diameter and volume of the torsional adnexal masses were 10 ± 3 cm and 332 ± 314 cm^3, respectively, and no significant correlation was observed between adnexal necrosis and size. Both the diameter and volume of adnexal masses were statistically significant. This may be explained by the fact that smaller tumors cannot induce AT, while larger tumors are too large to rotate in the pelvic space. The incidence of adnexal necrosis on the right side was higher than that on the left side and was unrelated to the size, suggesting that the anatomical structure of the pelvic cavity on the right side was more likely to cause severe torsion.

There was no positive relationship between adnexal necrosis and onset time. It has been reported that ovarian function remains normal even after 72 h and declines within 5 days after the appearance of symptoms [2]. However, not all patients who underwent surgery after 24 h had adnexal necrosis; even if surgery was delayed, ovarian function was preserved. Therefore, the visual evaluation of intraoperative ovarian necrosis cannot accurately determine true necrosis on histopathology [3, 9, 22]. In this study, the data did not show a difference in the onset time between necrotic and non-necrotic ovaries. The threshold necrosis time was 24 h, with a sensitivity of 43%. In 38 patients, only a third with an onset time of > 72 h had ovarian necrosis or suspected necrosis, while three patients with an onset time of 3–9 months had no ovarian necrosis. Therefore, it is speculated that some AT processes may be chronic or intermittent, and compensatory vascular hyperplasia occurs because of the dual arterial blood supply of the ovaries.

The degree of torsion is an important risk factor for adnexal necrosis. A report showed that the ovary can be successfully preserved if the degree of torsion is less than 540°, suggesting the presence of blood flow despite chronic abdominal pain [21]. In this study, the threshold for adnexal necrosis was 510°, with a sensitivity of 86%. Additionally, the degree of torsion increases with age, and the risk of necrosis increases accordingly. Hence, timely surgical treatment can still preserve severely twisted ovaries.

Adnexal torsion exhibits distinct clinical characteristics during various physiological stages. In the present study, both the degree and size of AT increased with age, and the mean age of patients with adnexal necrosis was higher than that of patients without adnexal necrosis, suggesting that the risk of necrosis increases with age.

The American College of Obstetricians and Gynecologists recommends that oophorectomy should not be performed on adolescent girls, regardless of the appearance of ovaries, unless oophorectomy is inevitable [23]. The hemorrhagic appearance of AT does not indicate loss of function as it is not an indicator of the degree of ischemia. Moreover, ovarian function mostly recovers over time after torsion. Currently, there is no effective clinical method to predict the survival of ovaries. Therefore, the appearance of the ovaries alone cannot be used as an indication for oophorectomy, and that OSS should be the primary surgical consideration [1–3, 5, 9, 22]. Concerns for OSS include persistent pain, risk of malignancy associated with AT, increased risk of pulmonary embolism associated with torsion, sepsis secondary to necrosis, and irreversible damage to the hemorrhagic ovary [2,7], but these have not yet been proven to be associated with OSS. Additionally, the increased risk of pulmonary embolism due to AT is theoretical; the incidence of peripheral thromboembolism after AT surgery is only 0.2–0.3% in the literature [1–3, 9, 13]. So, OSS was safe. The OSS rate for AT varies according to country and region, but it is estimated to be 43.2–95% [2, 9, 13]. In this study, 72% of premenopausal women underwent OSS, whereas no postmenopausal woman underwent OSS. Additionally, 50% of postmenopausal women underwent additional hysterectomy. This may reflect gynecologists' perceptions of subsequent ovarian atrophy in postmenopausal women and their concerns regarding malignant tumors. Postmenopausal women are not considered candidates for OSS.

Laparoscopic exploration is the first option when ultrasound does not exclude AT [6, 23]. The laparoscopic surgery rate for AT is 56–82.6% [3, 13, 12, 24]. with variations in different areas. One factor limiting the application of laparoscopic surgery is the size of the AT, which should be smaller during laparoscopic surgery than during laparotomy [13, 25, 26]. Additionally, tumor rupture or intraoperative spillage is the main complication of laparoscopic surgery, but this is not associated with recurrence [26–29]. In this study, the rate of laparoscopic surgery was 47.2%. Rupture and spillage of the AT during surgery are inevitable; however, no adnexa-related pulmonary embolism, recurrence, or complications have been observed. The size of the adnexal mass in the laparoscopic group was larger than that in the laparotomy group. This limited the use of laparoscopy. The laparoscopic surgery rate can be improved through cystic decompression because the recurrence rate is low and malignant tumors are rare.

This study lacked an effective follow-up protocol. Of the 29 patients with OSS who were followed-up for more than half a year, one patient experienced recurrence after 24 months.

The main limitation of this study was its retrospective nature. There was no unified standard measurement, which might have created a bias in tumor size caused by different operators. Additionally, because of the lack of a follow-up protocol, information regarding visits to other institutions could not be obtained, which could have potentially biased the rates of recurrence and late postoperative complications. Further prospective multicenter clinical studies with detailed follow-up are required to confirm these results.

CONCLUSIONS

Age, histopathological type, adnexal size, degree of torsion, and pelvic anatomical structure are risk factors for AT and adnexal necrosis. There is no infinite correlation between adnexal necrosis and the onset time. Adnexal size is the main risk factor for AT, and along with the risk of adnexal necrosis, and increases with age. The degree of torsion is the main risk factor for adnexal necrosis, and torsional severity increases with age. OSS, either via laparoscopy or laparotomy, is safe and does not increase the incidence of postoperative complications.

Article information and declarations

Data availability statement

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics statement

The study protocol was approved by the institutional review board of Weihai Municipal Hospital. The need for informed consent was waived owing to the retrospective nature of the study.

Author contributions

Dr. Hao designed this study. Hao made a major contribution to the acquisition, analysis, and interpretation of the data and drafting of the manuscript. Sun was involved in data statistics, writing the manuscript, and revising it.

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Conflict of interest

The authors declare that they have no competing interests.

Supplementary material

None.

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