Clinical analysis of 52 adolescent patients with ovarian masses $\geq 10$ cm in diameter

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Abstract

Objective: To investigate the clinical characteristics and treatment of large ovarian masses in adolescents.

Methods: Adolescents with large ovarian masses ($\geq 10$ cm in diameter) who were treated in Beijing Obstetrics and Gynecology Hospital from March 2010 to December 2018 were retrospectively assessed.

Results: Fifty-two female patients (mean age: 16.17±2.04 years [11–19 years]) were included and 19 (36.5%) presented with abdominal pain. The blood flow signal rate in ultrasonography was significantly different among benign, borderline and malignant ovarian masses, unlike strong echo, dotted echo and septation rates. Carbohydrate antigen 125 positivity rates were significantly different among pathological types and the endometriotic cyst group showed the highest value (75.0%). Alpha-fetoprotein positivity rates were also different among pathological types. For ovarian cystectomy, 14 and 32 patients underwent laparotomy and laparoscopy, respectively. Mass diameters were significantly higher in the laparotomy group and the operative duration was significantly shorter in the laparoscopy group. There were no significant differences in intraoperative blood loss or postoperative recurrence rates between the two groups.

Conclusion: Teratomas constitute the greatest group of large ovarian masses in adolescents. Benign tumors should be treated by laparoscopic resection, while borderline or malignant tumors require individualized treatment of tumors and fertility-sparing treatments.

Keywords

Adolescent, laparoscopy, laparotomy, ovarian cyst, pathology, tumor

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Introduction

Ovarian tumors are the most common reproductive organ tumors in adolescents.\(^1\) Clinical manifestations, pathological types and treatment principles of disease differ between adolescent and adult women. The body of adolescents is in a stage of growth and development; therefore, the ovaries also begin to develop and gradually mature. In adolescence, the ovaries actively grow and are prone to mutatation.\(^2\) In adolescents who have masses, treatment should not only address these masses, but also preserve fertility.\(^3\) As long as the diameter of the ovaries is >1.5 cm after an operation, menstruation is normal in most cases and the pregnancy rate can reach 71.4%.\(^4\) Therefore, when evidence of ovarian malignant masses is insufficient, ovary-sparing surgery is recommended.

Because the ovaries are located deep in the pelvic cavity, detecting early lesions is challenging. Additionally, adolescents poorly appreciate the importance of regular physical examinations, and ovarian mass-related symptoms are not paid enough attention. Therefore, by the time adolescents seek healthcare, the mass is already large. Furthermore, the risk of malignancy increases with an increase in the ovarian mass.\(^5\) At present, there is no uniform definition standard for giant ovarian mass, but most scholars adopt the cutoff of 10 cm in diameter.\(^6\) Previous evidence has indicated that the diameter of ovarian masses is associated with the degree of malignancy,\(^7\) with a diameter exceeding 10 cm suggesting a high incidence of malignancy.

Borderline ovarian tumors (BOT) account for 10% to 20% of all epithelial ovarian tumors.\(^8\) BOT grow slower and show reduced malignancy, earlier diagnostic stages and a better prognosis, with a 5-year survival of 92% to 98% compared with epithelial ovarian cancer.\(^9\) Therefore, fertility-sparing surgery is the best surgical treatment for adolescent patients with BOT, including lateral adnexectomy and ovarian cystectomy. The recurrence of BOT after fertility-sparing surgery significantly increases, but the overall survival is not affected.\(^10\) Approximately 80% of patients with BOT are in the early stage at diagnosis and show a low recurrence of disease. Even if most recurred BOT are still borderline tumors pathologically, the prognosis after the second operation is still good.\(^11\)

On the basis of the above-mentioned reports, ovarian masses in adolescents should be handled differently from those in adult disease. Additionally, improving the understanding of clinical features of giant ovarian masses in adolescents could help clinicians better diagnose and treat such lesions. Therefore, this study aimed to investigate the clinical characteristics and treatment of large ovarian masses in adolescents. We retrospectively analyzed clinical data of adolescents with ovarian masses ≥10 cm in diameter who were diagnosed and treated in our center.

Methods

The reporting of this study conforms to the STROBE statement.\(^12\)

Patients

Adolescents who were admitted to the Gynecological Minimally Invasive Center of Beijing Obstetrics and Gynecology Hospital with large ovarian masses (≥10 cm in sectional diameter) from March 2010 to December 2018 were retrospectively analyzed. Inclusion criteria were as follows: 1) age of 10 to 19 years; 2) surgical treatment for large ovarian masses confirmed by pathology; and 3) complete clinical data of surgical treatment. Exclusion criteria were as follows: 1) recurrence of ovarian masses after surgery and
additional surgery; and 2) secondary ovarian tumors or a history of cancer. This study was approved by the Ethics Review Committee of Beijing Obstetrics and Gynecology Hospital affiliated to Capital Medical University (approval number: 2020-KY-025-01). Informed consent was waived by the committee because of the retrospective nature of the study.

**Operations**

Surgical treatments were performed under general anesthesia or combined spinal epidural anesthesia by a chief surgeon with >20 years of experience. A pathological examination was performed for appropriate sampling perioperatively. In case of limited operative vision due to excessive lesion size in laparoscopic ovarian cystectomy, a puncture needle was initially inserted into the masses through a trocar in the abdominal wall for cyst fluid suction. Suspected non-benign tumors were collected by specimen bags, which were inserted into the pelvic cavity via the trocar. Cysts were removed after appropriate suction of cystic fluid. Normal ovarian tissue was retained as much as possible because the patients were teenagers. Hemostasis was performed by suturing and ovarian morphology was reconstructed. For extremely large ovarian cysts, external purse-string sutures of approximately 2 × 2 cm² were performed on the surface, and cyst fluid was drained to reduce the cyst volume. The cyst was then pulled out of the abdominal cavity. The ovarian wound was sutured and ovarian morphology was reconstructed.

**Data collection**

All patients underwent an ultrasonographic examination before the operation to investigate the size, internal echo and blood flow around and inside ovarian masses. All patients had four tumor markers measured, namely carbohydrate antigen (CA) 125, CA199, carcinoembryonic antigen (CEA) and alpha-fetoprotein (AFP), preoperatively. A volume of 3 mL of venous blood was drawn before the operation for measurement of these markers. These tumor markers were measured by a chemiluminescence immunoassay using an automatic electrochemiluminescence analyzer (ADVIA Centaur XP; Siemens Healthineers, Erlangen, Germany).

**Follow-up**

The patients were followed up by telephone and outpatient visits, starting at 1 month postoperation, for 3 to 12 months according to the benign/malignant condition of the ovarian masses. A gynecological examination, pelvic ultrasound and fertility after the operation were investigated, and relapse times and follow-up treatments in relapsed patients were recorded. The follow-up period ended in May 2019.

**Statistical analysis**

IBM SPSS version 22.0 (IBM Corp., Armonk, NY, USA) was used for data analysis. Measurement data with a normal distribution are shown as mean ± standard deviation and were compared by the t-test. Enumeration data are shown as n (%) and were compared by the χ² test. Fisher’s exact test was performed for enumeration data with a minimum theoretical frequency of <5. Two-sided P values <0.05 were considered statistically significant.

**Results**

**General characteristics**

A total of 111 adolescents with ovarian masses received treatment, including 52 (46.85%) with large masses (≥10 cm in diameter). They were aged 11 to 19 years, with a mean age of 16.17±2.04 years.
Fifty adolescents had menstruation. The age of menarche ranged from 9 to 15 years, with a mean age of 12.40 ± 1.46 years. The body mass index ranged from 16.89 to 35.29 kg/m², with a mean body mass index of 22.30 ± 3.77 kg/m². The mean diameter of ovarian masses was 13.60 ± 4.53 cm (10–30 cm). Among the 52 masses, there were 29 cystic teratomas, 9 mucinous cystadenomas, 1 serous cystadenoma, 2 seromucinous cystadenomas, 4 endometriotic cysts, 1 sclerosing stromal tumor, 3 borderline mucinous tumors, 2 yolk sac tumors and 1 mucinous cystadenocarcinoma.

The reasons for consultation were irregular menstruation (n = 15, 28.9%), abdominal pain (n = 19, 36.5%), including acute abdominal pain caused by torsion of an ovarian tumor pedicle in four patients, an asymptomatic pelvic mass (n = 8, 15.4%), self-palpation of a lower abdominal mass (n = 7, 13.5%) and abdominal distention (n = 3, 5.8%).

**Ultrasonographic data**

Ultrasonography showed strong echoes of ovarian cystic solid masses in 20 adolescents. These masses comprised 17 (85.0%) benign teratomas, 1 yolk sac tumor, 1 sclerosing stromal tumor and 1 borderline mucinous tumor. Additionally, fine punctate echoes of ovarian cystic masses representing endometriotic cysts were found in two adolescents. Septation in ovarian cystic masses was observed in 14 adolescents, with 7 (50%) cystadenomas (5 mucinous cystadenomas, 1 serous cystadenoma and 1 seromucinous cystadenoma), 5 benign teratomas, 1 yolk sac tumor and 1 mucinous cystadenocarcinoma. Septal and strong echo components of ovarian cystic solid masses were observed in five (71.43%) benign teratomas, one seromucinous cystadenoma and one borderline mucinous tumor. Septal and fine punctate echoes were found in five adolescents with ovarian cystic masses, namely two endometriotic cysts, two mucinous cystadenomas and one borderline mucinous tumor.

Blood flow signals were found in three borderline and three malignant tumors. The occurrence rates of strong echoes, punctate echoes and septation were not different among benign, borderline and malignant ovarian masses. Ultrasound data are summarized in Table 1.

**Tumor markers**

AFP levels were elevated in two adolescents with yolk sac tumors (>1000 ng/mL), but were normal in the remaining adolescents. Among eight adolescents with elevated CA125 levels (>35 U/mL), three had endometriotic cysts (78.2–234.4 U/mL), one had a yolk sac tumor (79.6 U/mL), two had benign teratomas (36.9–76.6 U/mL) and two had serous cystadenomas (47.6–133.7 U/mL). Among 19 adolescents with elevated CA199 levels (>37 U/mL), 12 had benign teratomas (37.1–373.89 U/mL), 3 had endometriotic cysts (37.54–92.91 U/mL), 2 had mucinous cystadenomas (54.54–57.39 U/mL), 1 had a borderline mucinous neoplasm (37.18 U/mL) and 1 had a mucinous cystadenocarcinoma (77.77 U/mL). No adolescents had elevated CEA levels (>5 ng/mL). The positive rate (percentage of test results that exceeded the reference range) of CA125 differed by pathological type and the endometriotic cyst group showed the highest value. Additionally, the positive rate of CA125 was higher in yolk sac tumors and mucinous and/or serous cystadenomas compared
with the other types. The positive rate of AFP was highest in yolk sac tumors, and was significantly different compared with that of other pathological types \((P=0.002)\). The positive rate of CA199 was comparable among the groups (Table 2).

### Surgical approaches and intraoperative cyst rupture

Laparotomic ovarian cystectomy was performed in 14 patients and 32 patients underwent laparoscopic ovarian cystectomy. Different surgical approaches were performed in the remaining six patients.

In laparotomic ovarian cystectomy, two (14.3%) patients had complete cyst removal with cyst diameters of 10 to 18 cm, nine (64.3%) had cyst removal with cyst diameters of 11 to 25 cm after cystic fluid suction for volume reduction and three (21.4%) had cyst rupture during cyst removal with cyst diameters of 10 to 16 cm. In laparoscopic ovarian cystectomy, 14 (43.8%) patients had complete cystectomy with cyst diameters of 10 to 16 cm, 5 (15.6%) had cyst removal with cyst diameters of 13 to 18 cm after cystic fluid suction and 13 (40.6%) had cyst rupture with cyst diameters of 10 to 13 cm. Additionally, perioperative ovarian cystectomy was performed in three patients with borderline mucinous tumors and in one with a mucinous cystadenoma, without a rapid pathological examination. Intraoperative rapid pathology suggested one case of highly suspicious, borderline ovarian mucinous cystadenoma. However, a borderline tumor could not be identified because the patient was young. After communicating with family members, the surgical scope was not extended, and oophorocystectomy was performed. Intraoperative rapid pathology suggested a borderline mucinous tumor in one patient and lateral adnexectomy + omentectomy + appendectomy + peritoneal multipoint biopsy were performed. Lateral adnexectomy was performed in three patients with torsion of an ovarian cyst pedicle because of adnexal necrosis. Lateral adnexectomy + omentectomy + peritoneal multipoint biopsy were performed in two patients with stage IA yolk sac tumors. Oophorocystectomy was performed in one patient with stage IA mucinous cystadenocarcinoma without a rapid perioperative pathological examination. Postoperative pathology suggested a mucinous cystadenocarcinoma, and staging surgery for ovarian cancer with fertility preservation was further performed. This patient was not

| Item                                      | Benign ovarian mass (n=46) | Borderline ovarian mass (n=3) | Malignant ovarian mass (n=3) | \(P^*\) |
|-------------------------------------------|---------------------------|-------------------------------|-----------------------------|--------|
| Strong echo, n (%)                        | 18 (39.1)                 | 1 (33.3)                      | 1 (33.3)                    | 1.000  |
| Fine punctate echo, n (%)                 | 2 (4.3)                   | 0 (0)                         | 0 (0)                       | 1.000  |
| Septation, n (%)                          | 12 (26.1)                 | 0 (0)                         | 2 (66.7)                    | 0.186  |
| Septation + strong echo, n (%)            | 6 (13.0)                  | 1 (33.3)                      | 0 (0)                       | 0.600  |
| Septation + fine punctate echo, n (%)     | 4 (8.7)                   | 1 (33.3)                      | 0 (0)                       | 0.473  |
| Cystic and sound transmission, n (%)      | 4 (8.7)                   | 0 (0)                         | 0 (0)                       | 1.000  |
| Blood flow signal, n (%)                  |                           |                               |                             |        |
| Positive                                  | 3 (6.5)                   | 3 (100)                       | 3 (100)                     | <0.001 |
| Negative                                  | 43 (93.5)                 | 0 (100)                       | 0 (0)                       | <0.001 |

*Data were analyzed by Fisher’s exact test.
Table 2. Positive rates of CA125, CA199, CEA and AFP in ovarian masses of different pathological types

| Group                          | Number of cases | CA125 (>35 U/mL) | CA199 (>37 U/mL) | CEA (>5 ng/mL) | AFP (>20 ng/mL) |
|-------------------------------|-----------------|-------------------|------------------|----------------|-----------------|
|                               | Number          | Positive number   | Rate (%)         | Positive number | Rate (%)         | Positive number | Rate (%)         | Positive number | Rate (%)         |
| Benign teratoma               | 29              | 2                 | 6.90             | 12              | 41.38           | 0               | 0               | 0               | 0               |
| Myxoid and/or serous cystadenoma | 12             | 2                 | 16.67            | 2               | 16.67           | 0               | 0               | 0               | 0               |
| Sclerosing stromal tumor      | 1               | 0                 | 0                | 0               | 0               | 0               | 0               | 0               | 0               |
| Endometriotic cyst            | 4               | 3                 | 75.00            | 3               | 75              | 0               | 0               | 0               | 0               |
| Borderline mucinous tumor     | 3               | 0                 | 0                | 1               | 33.33           | 0               | 0               | 0               | 0               |
| Mucinous cystadenocarcinoma    | 1               | 0                 | 0                | 1               | 100.00          | 0               | 0               | 0               | 0               |
| Yolk sac tumor                | 2               | 1                 | 50.00            | 0               | 0               | 0               | 0               | 2               | 100.00          |

*Data were analyzed by Fisher's exact probability.

The term “positive” indicates that test results exceeded the reference range.

CA, carbohydrate antigen; CEA, carcinoembryonic antigen; AFP, alpha-fetoprotein.
treated by chemotherapy after surgery. Patients who had laparotomy showed significantly greater ovarian cyst diameters and a prolonged operation time compared with those with laparoscopy (excluding those who had a rapid pathological examination during operation) (both $P < 0.05$). However, there were no significant differences in the intraoperative bleeding volume or recurrence rate between the two groups (Table 3).

**Follow-up findings and treatments**

Five patients were lost to follow-up. The remaining patients were followed up for 49 months (range, 4–108 months). Among 29 cases of benign teratoma, 3 recurred and 3 were lost to follow-up. Gonadotropin-releasing hormone agonist treatment was performed in four patients with endometriotic cysts (aged 17–19 years) for 3 months postoperation, two patients had recurrence and one was lost to follow-up. Two patients with yolk sac tumors underwent five courses of bleomycin + etoposide + cisplatin regimen chemotherapy after the operation without recurrence. Recurrence occurred in one of three patients with a borderline mucinous tumor. Among 12 patients with mucinous and/or serous cystadenomas, one was lost to follow-up and no recurrence was observed. There was no recurrence in patients with a sclerosing stromal tumor or mucinous cystadenocarcinoma.

Among the 47 patients who were followed up, one with a teratoma gave birth and the others were not fertile. However, there was no definite diagnosis of infertility. Table 4 shows the data of patients with recurrent ovarian masses following oophorocystectomy.

**Discussion**

This study showed that teratomas constitute the most prevalent pathological group of large ovarian masses in adolescents. For benign tumors, laparoscopic resection can be considered, while individualized treatment of tumors and fertility-sparing treatment should be applied in patients with borderline or malignant tumors.

In this study, 63.46% of patients had ovarian masses with diameters $\geq 10$ cm at the initial visit. Two patients were misdiagnosed with appendicitis among four patients with torsion of an ovarian tumor pedicle. Abdominal pain was the most common symptom, which is consistent with Pogorelic et al.’s study. Therefore, adolescent women with abdominal pain should be examined in detail, considered comprehensively and treated promptly.

The main diagnostic markers of ovarian tumors, namely CA125, CA199, CEA and AFP, were assessed. At present, CA125’s sensitivity in the diagnosis of early ovarian cancer is only approximately 50%. Chen et al. found that the positive expression rate of CA125 was 6.09% in ovarian mature
Table 4. Clinical data of six patients with recurrent ovarian masses after oophorocystectomy

| Case | Age (years) | Organization type | Tumor size (cm) | Surgical approach | Complete resection | Recurrence time | Recurrence site | Follow-up treatment |
|------|-------------|-------------------|----------------|------------------|-------------------|----------------|----------------|-------------------|
| 1    | 15          | Benign teratoma of the right ovary | 13 | Laparoscopy | No | 8 years after the operation | Bilateral ovaries | Laparoscopic exfoliation of the ovarian teratoma |
| 2    | 16          | Benign teratoma of the left ovary | 16 | Laparoscopy | Yes | 3 months after the operation | Right ovary | Laparoscopic exfoliation of the ovarian teratoma |
|      |             |                   |                |                  |                   | 2 years after the operation | Bilateral ovaries | Laparoscopic exfoliation of the ovarian teratoma |
|      |             |                   |                |                  |                   | 4 years after the operation | Bilateral ovaries | Being followed up |
| 3    | 17          | Benign teratoma of the right ovary | 18 | Laparotomy | Yes | 9 months after the operation | Right ovary | Being followed up |
| 4    | 18          | Left ovarian endometriotic cyst | 13 | Laparoscopy | No | 3 years after the operation | Left ovary | Laparoscopic exfoliation of the ovarian endometriotic cyst |
|      |             |                   |                |                  |                   | 9 years after the operation | Left ovary | Laparotomy of an ovarian endometriotic cyst (cystectomy) |
|      |             |                   |                |                  |                   | 9 years after the operation | Right fallopian tube | Laparotomy for resection of ureteral stricture + ureterovesical re-implantation |
| 5    | 18          | Left ovarian endometriotic cyst | 10 | Laparoscopy | No | 3 years after the operation | Bilateral ovaries | Oral contraceptive and follow-up |
| 6    | 16          | Borderline mucinous tumors of the right ovary | 17 | Laparoscopy | No | 2 years after the operation | Right ovary | Torsion of the pedicle of a right ovarian mucinous cystadenoma. Conversion to laparoscopy for resection of right adnexectomy. |
cystic teratoma. In our study, CA125 levels in three borderline mucinous tumors and in one mucinous cystadenocarcinoma were <35 U/mL. Therefore, CA125 has some deficiencies in detecting early non-ovarian benign tumors. Güralp et al. found that CA199 levels in endometriosis were significantly higher than control values and associated with disease severity. CA199 is the most reliable marker among many tumor markers in mature cystic teratoma. In our study, 19 adolescents had elevated CA199 levels (>37 U/mL) in whom cystic teratoma accounted for 63.16%. CEA is a common tumor marker used in the diagnosis of epithelial ovarian cancer. In this study, elevated CEA levels (>5 ng/mL) were not observed in any patients, which suggested that CEA alone is of little diagnostic significance. AFP is an important tumor marker of yolk sac tumors. Serum AFP levels are usually increased in patients with yolk sac tumors and associated with disease severity. In this study, two patients with yolk sac tumors had an abnormal elevation in AFP levels (>1000 ng/mL). In clinical work, these serum biomarkers are often combined to increase the diagnostic efficacy.

Larger ovarian lesions are less likely to resolve spontaneously, be more prone to torsion, and are more likely to be malignant. Preoperative imaging showed that the odds ratio of malignancy was 19.0 (95% confidence interval, 4.42–81.69) when the ovarian mass was ≥8 cm. Ovarian tumors >9.9 cm are associated with an increased risk of malignant transformation, and tumors >15 cm are associated with more aggressive behavior. In this study, in 52 adolescents with ovarian masses with a diameter of 10 to 30 cm, there were 3 malignant tumors with diameters of 12, 20 and 25 cm, respectively. A larger and more complex ovarian lesion is more likely to be a neoplastic process and require surgical removal. Treatment of adolescents should also take into consideration preservation of fertility. Reddy and Laufer performed cystectomy for ovarian neoplasms >10 cm and measured the size and volume of the ovaries postoperatively. They found no significant difference in the size or volume between the affected and contralateral ovaries postoperatively. There was also no significant difference in the mean number of antral follicles between the affected and contralateral ovaries after the first and third menstrual cycles postoperatively.

At present, minimally invasive surgery is being increasingly used in the treatment of ovarian tumors. Recurrence and survival rates in patients with epithelial early ovarian cancer who are treated with minimally invasive conservative surgery appear to be comparable to those treated with open surgery for more aggressive comprehensive staging. Gallotta et al.'s study on robotic versus laparoscopic staging for early ovarian cancer showed that the operative time was significantly shorter in the robotic group compared with the laparoscopic group, while the amount of estimated blood loss was similar. In our study, the operation time was significantly shorter in patients who had laparoscopy compared with those who had laparotomy, while intraoperative bleeding was not different between these groups of patients. Shiota et al. showed that the average rate of cyst rupture for cysts >10 cm for cystectomy was 56.8% by laparotomy versus 82.8% by laparoscopy. In our study, cyst fluid was initially aspirated to reduce the tumor volume before cystectomy. However, tumor dissemination and implantation may occur during the operation of malignant tumors owing to cyst rupture, cyst fluid overflow, and specimen collection. Therefore, evaluating the nature of ovarian masses before the operation is important. Intraoperative aspiration of cystic fluid reduces not only
the volume of cysts, but also cystic fluid overflow.

Recurrence rates for endometriosis were reported to be 9.2% and 15.4% at 3 and 5 years, respectively, after laparoscopic cystectomy. Among the four patients with an ovarian endometriotic cyst assessed in this study, one was lost to follow-up, one had recurrence 3 years postoperation and another had multiple recurrences 3 to 9 years post-surgery. To reduce recurrence, adolescent patients older than 16 years could undergo gonadotropin-releasing hormone agonist treatment for 3 to 6 months postoperatively. However, this drug can cause bone loss. Therefore, continuous or periodic oral contraceptives should be used as the first-line drug treatment in adolescent patients with endometriosis who are younger than 16 years.

In this study, two patients with stage IA borderline mucinous cystadenoma underwent ovarian cystectomy without a definite intraoperative diagnosis. No additional operation was performed. In patients with BOT, lymphadenectomy does not improve survival. The benefits of chemotherapy for borderline epithelial tumors are still controversial. The first edition of the National Comprehensive Cancer Network guidelines for 2019 states that the benefits of chemotherapy are not clear for tumors in which the postoperative pathology does not suggest microscopic infiltration.

Because adolescent patients with malignant ovarian tumors have a strong desire to retain reproductive function, staged fertility-sparing surgery should be performed. Malignant ovarian germ cell tumors are predominant in young women and account for <5% of all malignant ovarian tumors. In cases of early disease, comprehensive staging can be omitted and lymph nodes are not necessarily resected. Yolk sac tumors of the ovary account for approximately 20% of malignant ovarian germ cell tumors and 1% of all malignant ovarian tumors. Most of these tumors occur in young women, with characteristics of a high malignancy, short course and rapid development. Yolk sac tumors are highly sensitive to chemotherapy. In this study, two patients with yolk sac tumors underwent laparotomy for lateral adnexectomy + omentectomy + multipoint peritoneal biopsy. Both patients received five courses of bleomycin + etoposide + cisplatin regimen chemotherapy after operation. After 3 and 5 years of follow-up in one patient each, no recurrence was observed.

Epithelial ovarian cancer accounts for 90% of malignant ovarian tumors, and 3% to 17% of patients are younger than 40 years. Based on current evidence-based medicine, fertility-sparing surgery is suitable for stage I epithelial ovarian cancer. However, screening criteria for patients who are suitable for fertility-sparing surgery remain controversial. The first edition of the National Comprehensive Cancer Network in 2021 pointed out that unilateral salpingectomy, ovariectomy and comprehensive staging surgery might be sufficient for selective young patients who wish to retain fertility. Tumors in the current patients were unilateral at stage I (IA and IC, but not IB) and/or low risk (e.g., early grade G1 tumors). For patients with stage IB who wished to retain fertility, bilateral adnexectomy and comprehensive staging surgery (uterine sparing) were required. Systemic chemotherapy was required for most patients with epithelial ovarian cancer after the operation. Patients with stage IA/IB mucinous cancer, low-grade serous carcinoma and G1 endometrioid cancer were followed up for observation. Patients with stage IA clear cell carcinoma, IC mucinous cancer, IC low-grade serous carcinoma and G1 endometrioid cancer were followed up for observation or treated by chemotherapy. Other patients were recommended for chemotherapy.
This study has some limitations. First, the numbers of borderline and malignant ovarian tumors were relatively small. Therefore, a comparative analysis of benign and malignant ovarian tumors was not carried out, and the clinical characteristics of ovarian malignant tumors $\geq 10$ cm were not well summarized. Additionally, this study had a retrospective design and was performed in a single center, with inherent shortcomings. Therefore, larger well-designed, prospective trials are required for a more comprehensive analysis.

In conclusion, adolescents should have regular physical examinations and timely visits to the doctor when they have ovarian symptoms. Ultrasound and tumor markers can be used to improve the diagnosis of ovarian masses with diameters $\geq 10$ cm in adolescents. For most patients with benign tumors, laparoscopic tumor resection can be considered. For borderline or malignant tumors, curing of the tumor and fertility-sparing treatments should be considered and individualized.

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Author contributions
BZ and GM substantially contributed to conception or design of the study. BZ and LZ contributed to acquisition, analysis, or interpretation of data. BZ drafted the manuscript for important content. BZ, LZ and GM critically revised the manuscript for important intellectual content. All authors gave final approval for the manuscript.

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