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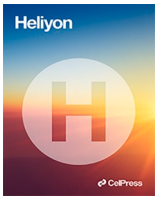

Research article

Surgical outcomes of transvaginal natural orifice transluminal endoscopy in treating ovarian cysts and risk factors for surgical conversions

Dan Feng [1], Tianjiao Liu [1], Xin Li [1], Lu Huang, Li He [*], Yonghong Lin [**]

Department of Gynecology, Chengdu Women's and Children's Central Hospital, School of Medicine, University of Electronic Science and Technology of China, No. 1617, Riyue Avenue, Chengdu, Sichuan, 610091, People's Republic of China

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ABSTRACT

Objective: This study aimed to assess the surgical outcomes and identify the conversion risk factors of Transvaginal Natural Orifice Transluminal Endoscopic Surgery (vNOTES) in treating ovarian cyst.

Methods: This was a retrospective study of 505 patients who underwent vNO TES for treating ovarian cyst from March 2019 to February 2022 wherein the patients were classified into "converted" or "nonconverted" groups. T-tests, χ^2 tests, and logistic regression were used for statistical analyses.

Results: There were 16 (3.17 %) surgical conversions and 12 (2.38 %) other surgical complications in our study cohort. Teratomas accounted for 56.8 % of complications in nonconverted cases and 18.8 % in converted cases. Adenocystomas were found in 12.3 % of nonconverted cases and 18.8 % of converted cases. Other types included paraovarian cysts (3.3 % and 0 %), fibroma, granulosa cell tumor, Brenner tumor (1.2 % and 0 %), corpus luteum cysts, follicular cysts (7.6 % and 6.3 %), old abscess (0.2 % and 0 %), and simple cysts (17.6 % and 12.5 %) in the nonconverted and converted groups, respectively. The converted group included more cases of endometriotic cysts (43.8 % vs 12.3 %, $p = 0.023$), bilateral cysts (37.5 % vs 8.2 %, $p < 0.001$), severe pelvic adhesion (68.8 % vs 3.3 %, $p < 0.001$), deep endometriosis (12.5 % vs 0.4 %, $p < 0.001$), and at least two cysts (37.5 % vs 8.81 %; $p < 0.001$). Severe pelvic adhesion (adjusted odds ratio [OR], 86.96; range, 18.33–431.77; $p < 0.001$), bilateral cysts (adjusted OR, 4.75; range, 1.05–21.57, $p = 0.043$) and endometriotic cysts (adjusted OR, 7.69; range, 3.11–17.08; $p < 0.001$) were also predictors of surgical conversion.

Conclusion: vNOTES demonstrates low complication and conversion rates in treating ovarian cyst compared with TU-LESS. Surgical conversion is associated with severe pelvic adhesions, bilateral cysts, and endometriotic cysts.

Abbreviations: vNOTES, transvaginal natural orifice translumenal endoscopic surgery; OR, odds ratio; CI, confidence interval; BMI, body mass index.

* Corresponding author.
** Corresponding author.
E-mail addresses: helisichuan@163.com (L. He), linyh.2007@aliyun.com (Y. Lin).

[1] These authors contributed equally to this work.

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1. Introduction

Ovarian cysts are observed in 7 % of females, most of which are routinely treated using surgical methods [1]. With the development of laparoscopy, the gynecological field has witnessed a trend of applying less invasive surgical approaches to treat ovarian cysts; these approaches include multiport laparoendoscopy (MPL), transumbilical laparoendoscopic single-site surgery (TU-LESS), and, most recently, transvaginal natural orifice transluminal endoscopic surgery (vNOTES) [2–4].

The clinical feasibility of vNOTES was demonstrated in 2007 [5]. Since then, this minimally invasive surgical technique has been successfully performed for many gynecological pathologies, reportedly resulting in superior cosmetic outcomes and faster post-operative recovery compared to those obtained by TU-LESS, despite relatively restricted visualization and operative space [6–10]. However, because the literature regarding the outcomes of ovarian vNOTES is scant, and none of the existing studies have reported on sufficiently large cohorts [3,7], clinical evidence of its outcomes is lacking, and there are many concerns regarding the technical difficulty, safety, and feasibility of this procedure [11]. Additionally, ovarian cysts have various pathological types and sizes, and multiple cysts can be observed at once. Therefore, vNOTES cystectomy or adnexectomy for treating ovarian cysts may be challenging and more likely to be converted to other laparoendoscopic approaches or even laparotomy.

To assess the feasibility and safety of vNOTES in treating ovarian cysts, we identified surgical outcomes and risk factors for surgical conversion, hoping to obtain robust evidence that will enable optimized patient selection and preoperative consultation.

2. Materials and methods

2.1. Study design

Fig. 1 presents a schematic diagram of the design of this retrospective study. The sociodemographic and clinical data of 505 patients who underwent ovarian vNOTES at our center between March 2019 and February 2022 were collected and analyzed, and the risk factors for its conversion were investigated. vNOTES was performed for patients with the following indications: 1) requirement for laparoendoscopy to treat unilateral or bilateral ovarian cysts; 2) preoperative examination showing low probability of malignancy; and 3) preference for vNOTES instead of other endoscopic approaches during the preoperative consultation. Patients with the following contraindications were excluded: 1) history of rectal surgery, severe pelvic inflammatory disease, or pelvic radiotherapy; 2) suspected rectovaginal endometriosis in preoperative assessment (based on the preoperative medical imaging, gynecological history of dysmenorrhea, and gynecological physical examination including vagino-recto-abdominal examination) or confirmed rectovaginal endometriosis in previous pelvic surgery; 3) confirmed severe pelvic adhesion in previous abdominopelvic surgeries; 4) lack of sexual

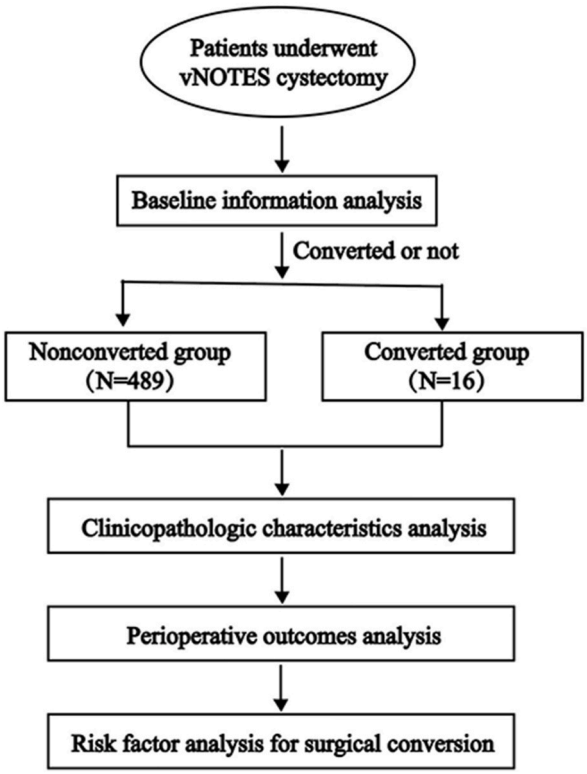


Fig. 1. Schematic diagram of study design.

history; and 5) coexistent uterine pathology or pelvic organ prolapse that required surgical intervention. The pelvic adhesion was classified based on the modified American Fertility Society scoring method, as per previous studies, which scores the severity of pelvic adhesion according to the tenacity (none, firmly, or dense) and extent (none, <25 %, 25–50 %, >50 %). A case with a total score at 1 or 2 is regarded as mild pelvic adhesion; a total score at 3 or 4 is regarded as mild adhesion; a total score at 5 or 6 is regarded as severe pelvic adhesion [12]. Detailed preoperative investigations, including ultrasonography or radiological investigations and tumor markers (CA-125), were performed to exclude malignancy for each patient. After surgery, these cases were routinely followed-up for 1 month to assess their prognoses. The surgical conversion of vNOTES was defined as uncompleted vNOTES procedure that was converted to any non-vNOTES approach, including traditional open laparotomy, MPL, and TU-LESS. Patients were classified into non-converted and converted ovarian vNOTES groups based on the occurrence or absence of surgical conversion; hereafter, these groups are referred to as the nonconverted and converted groups. Subsequently, between group comparison of the sociodemographic and clinicopathological features, including complications and short-term follow-up outcomes, was performed. Statistical analyses were conducted to evaluate sociodemographic, perioperative information, and follow-up outcomes, as well as risk factors for surgical conversion.

2.2. Surgical procedures

The surgical procedures and equipment used in our study were similar to those reported previously [3,13–15]. Trendelenburg positioning and general anesthesia were applied before establishing the surgical platform. Following the insertion of a Foley catheter, endotracheal intubation was performed. Subsequently, a 2 cm-incision, through which a multiple-instrument port was inserted to access the pelvic cavity, was made in the vaginal posterior fornix to open the Douglas pouch. Carbon dioxide (not exceeding 14 mmHg) was then insufflated into the abdominal cavity to achieve pneumoperitoneum. The endoscope (10-mm, 30) was inserted for viewing the abdominopelvic cavity. Due to the effect of Trendelenburg positioning and the muscle relaxant, the bowel descended toward the head, thus leaving the pelvic cavity, in most of the patients. In cases where the bowel remained “descended” into the pelvic cavity, we used gauze to separate the bowel. After localization of the ovarian cyst, its capsule was excised using an electric hook followed by careful excision of the cyst while attempting to avoid its rupture. Along the ovary’s longitudinal axis, the ovarian cyst wall was then teared. The separation of the ovarian cyst from the ovary was achieved using blunt dissection between the cyst wall and the rest of the ovarian stroma. A 3–0 Vicryl suture was then applied to close the ovarian incision. Through the incision in the posterior fornix, the ovarian cyst was incorporated into a bag and then removed from the pelvic cavity following the suture of the posterior fornix incision using a 2–0 Vicryl suture. In total, there were 27 surgeons who performed vNOTES-type adnexectomies. Based on their occupational titles and years of experience practicing medicine, they were divided into the attending group (n = 17; those having practiced gynecology for 9–12 years and performed more than 30 vNOTES procedures) and fellow group (n = 10; those having practiced gynecology for 25–35 years and conducted more than 55 vNOTES procedures).

2.3. Data collection

Patient data were anonymously retrieved from the Hospital Information System of our hospital and transcribed to an electronic Microsoft Excel file. Demographic data, such as age, ethnicity, body mass index (BMI), parity, and gravidity, were extracted. Based on the patients’ age, they were subdivided according to menstrual status: premenopause (45 years or younger), perimenopause (45–55 years), and postmenopause (older than 55 years). We also collected data on clinicopathological features, such as the history of abdominopelvic surgery; operative time, estimated intraoperative blood loss; blood transfusion volume; postoperative hospitalization duration; pain score (visual analogue scale, VAS) for the first three consecutive postoperative days [16]; and surgical complications, referring to the injury, loss of function, and dysfunction of tissues or organs caused by the surgical operation. Further, we recorded the features of ovarian cysts, including pathological types, unilateral or bilateral status, and sizes. The type of approach that vNOTES was converted to, cause of conversions, and adverse events were also recorded by the surgeon who performed the procedure. The Clavien–Dindo (C-D) method was used to classify the postoperative complications of each patient [17].

2.4. Statistics analysis

SPSS version 25.0 (IBM Corporation, Armonk, NY, United States) was used for statistical analyses. Dichotomized and other unordered categorical data are described in the form of numbers and percentages. A Fisher’s exact test or χ^2 test was applied to investigate the differences between groups, as appropriate. Continuous data were analyzed using the Mann–Whitney *U* test and are shown as the median and interquartile range (age, BMI, ovarian cyst size, and surgical duration) or range (postoperative pain scores and postoperative hospitalization duration) due to the non-normal data distribution. We also carried out a logistic regression analysis to identify risk factors that predict surgical conversions. The variables in the regression model were those with statistical significance in the univariate analysis or reportedly relevant to surgical conversion in gynecologic endoscopic surgery, including BMI, history of abdominopelvic surgery, presence of pelvic adhesion or endometriosis, procedure performed by attendings, endometriotic pathological type, ovarian cyst size, and bilateral cysts [18]. The results are expressed as odds ratios (ORs) and 95 % confidence intervals (CIs). P-values <0.05 were considered statistically significant.

3. Results

3.1. Demographical and clinicopathologic features of the cohort

As listed in Table 1, data from a total of 505 patients were collected, which included 489 (96.8 %) nonconverted cases and 16 (3.2 %) converted cases. The converted group was notably older (37.5 [33.3, 46.0] vs 32.0 [27.0, 38.0] years; p = 0.008); however, no statistical difference in the subdivision of their menstrual status was observed. Comparison of other demographics, such as BMI, ethnicity, gravity, parity, and vaginal delivery, showed no statistically significant differences. The mean BMI of the nonconverted group was 21.0 (19.5, 23.5) kg/m^2, and that of the converted group was 21.5 (20.0, 23.7) kg/m^2 (p = 0. 458). Seven (1.4 %) patients in the nonconverted group were ethnic minorities; the others in both groups were Han Chinese. The obstetrical history of both groups was also relatively similar.

As depicted in Table 2, teratomas constituted 278 (56.8 %) cases among nonconverted cases and 3 (18.8 %) cases among converted cases. Adenocystomas were present in 60 (12.3 %) cases among nonconverted cases and 3 (18.8 %) cases among converted cases; other pathological types included paraovarian cysts (16 [3.3 %] cases vs 0 [0 %] cases), fibroma, granulosa cell tumor, Brenner tumor (6 [1.2 %] cases vs 0 [0 %] cases), corpus luteum cysts, follicular cysts (37 [7.6 %] cases vs 1 [6.3 %] case), old abscess (1 [0.2 %] case vs 0 [0 %] case), and simple cysts (32 [17.6 %] cases vs 2 [12.5 %] cases). The converted group had a significantly lower proportion of teratomas (3/16 [18.8 %] vs 278/489 [56.8 %]) and a higher percentage of endometriotic cysts (7/16 [43.8 %] vs 60/489 [12.3 %]; p = 0.023). A remarkably larger percentage of patients in the converted group had bilateral cysts (6/16 [37.5 %] vs 40/489 [8.2 %]; p < 0.001), severe pelvic adhesions (11/16 [68.8 %] vs 16/489 [3.3 %]; p < 0.001), deep endometriosis (2/16 [12.5 %] vs 2/489 [0.4 %]; p < 0.001), at least two cysts (6/16 [37.5 %] vs 43/489 [8.8 %]; p < 0.001), and intraoperative blood loss of more than 50 mL (12/16 [75.1 %] vs 78/489 [13.7 %]; p < 0.001) than that in the nonconverted group. The converted group also had notably longer operative time (137.5 [101.5, 196.3] vs 70.0 [55.0, 90.0] minutes; p < 0.001) and postoperative hospitalization duration (3.0 [1.0, 9.0] days vs 3.0 [1.0, 10.0] days; p = 0.008) than the nonconverted group. We did not observe any statistically significant difference when comparing ovarian cyst size, pain score during the first three consecutive postoperative days, surgical approaches, or C-D classifications of postoperative complications; however, the converted group had slightly more C-D II complications (1/16 [6.3 %] vs 7/489

Table 1
Baseline information of patients who underwent ovarian vNOTES without and with surgical conversion.

Characteristics	Nonconverted vNOTES n = 489 (96.8 %)	Converted from vNOTES n = 16 (3.2 %)	P value
Age (y)	32.00(27.00, 38.00)	37.50(33.25, 46.00)	0.008[a]
			0.182[b]
≤45	418(85.5 %)	11(68.8 %)	
45–55	41(8.4 %)	3(18.8 %)	
>55	30(6.1 %)	2(12.5 %)	
BMI (kg/m^2)	21.03(19.53, 23.46)	21.50(20.04, 23.70)	0.458[a]
Ethnicity			0.630[b]
Han Chinese	482(98.6 %)	16(100.0 %)	
Minority groups	7(1.4 %)	0	
Gravidity			0.611[b]
0	115(23.5 %)	4(25.0 %)	
1	112(22.9 %)	2(12.5 %)	
≥2	262(53.6 %)	10(62.5 %)	
Parity			0.497[b]
0	167(34.2 %)	4(25.0 %)	
1	225(46.0 %)	7(43.8 %)	
≥2	97(19.8 %)	5(31.3 %)	
Cesarean delivery			0.168[b]
0	369(75.5 %)	12(75.0 %)	
1	102(20.9 %)	2(12.5 %)	
≥2	18(3.7 %)	2(12.5 %)	
Vaginal delivery			0.892[b]
0	279(57.1 %)	9(56.3 %)	
1	138(28.2 %)	4(25.0 %)	
≥2	72(14.7 %)	3(18.8 %)	
Previous pelvic or abdominal surgery			0.809[b]
0	324(66.3 %)	10(62.5 %)	
1	126(25.8 %)	4(25.0 %)	
≥2	39(7.9 %)	2(12.5 %)	
Coexistent uterine pathology			0.667
Uterine myoma without surgical indications	17(3.5 %)	1(2.0 %)	
Adenomyosis	5(1.0 %)	0	
cervical polyp	7(1.4 %)	1(2.0 %)	
endometrial polyps	11(2.3 %)	0	
submucous myoma	2(0.4 %)	0	

[a] Mann-Whitney *U* test, results were represented as the median and interquartile range.
[b] Chi-square test, results are shown as the case number and percentage.

Table 2
Perioperative Clinicopathologic Characteristics of Patients Undergoing Ovarian vNOTES With and Without Surgical Conversion.

Characteristics	Nonconverted vNOTES n = 489 (96.8 %)	Converted from vNOTES n = 16 (3.2 %)	P value
Pathological type of ovarian cyst			0.023[a]
Teratoma	278(56.8 %)[d]	3(18.8 %)	
Aadenocystoma	60(12.3 %)[d]	3(18.8 %)	
Paraovarian cyst	16(3.3 %)	0	
Endometriotic cyst	60(12.3 %)	7(43.8 %)	
Fibroma, granulosa cell tumor, Brenner tumor	6(1.2 %)	0	
Corpus luteum cyst, follicular cyst	37(7.6 %)	1(6.3 %)	
Old abscess	1(0.2 %)	0	
Simple cyst	32(17.6 %)	2(12.5 %)	
Unilateral or bilateral			<0.001[a]
Unilateral	449(91.8 %)	10(62.5 %)	
Bilateral	40(8.2 %)	6(37.5 %)	
Surgeon type			0.321[a]
Attendings	244(49.9 %)	10(62.5 %)	
Fellows	245(50.1 %)	6(37.5 %)	
Presence of pelvic adhesion			<0.001[a]
None	364(74.4 %)	3(18.8 %)	
Mild	78(16.0 %)	1(6.3 %)	
Moderate	31(6.4 %)	1(6.3 %)	
Severe	16(3.3 %)	11(68.8 %)	
Presence of pelvic endometriosis			<0.001[a]
None	478(97.8 %)	14(87.5 %)	
Shadow	9(1.8 %)	0	
Deep	2(0.4 %)	2(12.5 %)	
Number of oophoritic cysts			<0.001[a]
1	446(91.2 %)	10(62.5 %)	
≥2	43(8.8 %)	6(37.5 %)	
Size of first ovarian cyst	5.2(4.0, 6.3)	6.00(4.5, 7.0)	0.274[b]
Size of second ovarian cyst	3.3(2.2, 4.5)	3.25(2.3, 4.5)	0.964[b]
Surgical approach			0.107[a]
Adnexectomy	57(11.7 %)	4(25.0 %)	
Oophorocystectomy	432(88.3 %)	12(75.0 %)	
Surgical duration (min)	70.0(55.0, 90.0)	137.50(101.5, 196.3)	<0.001[b]
Estimated intraoperative blood loss (mL)			<0.001[a]
≤50	411(84.0 %)	4(25.0 %)	
50 to 100	45(9.2 %)	5(31.3 %)	
100 to 200	22(4.5 %)	7(43.8 %)	
>200	11(2.3 %)	0	
Intraoperative complications			<0.001[a]
No	487 (99.6 %)	0	
Yes	2(0.4 %)	1(6.3 %)	

[a] Chi-square test.
[b] Mann–Whitney *U* test.

[1.4 %]) (Table 3). Two intraoperative complications (rectal injuries: one full-thickness and one seromuscular) were repaired using vNOTES without intraoperative conversion in the nonconverted group. No C-D III or C-D V postoperative complications occurred. Two (0.4 %) C-D I postoperative complications occurred in the nonconverted group (1 [0.2 %] case of fever and one [0.2 %] case of urinary retention requiring catheterization). No C-D I complications occurred; however, one (6.3 %) C-D II complication (paralytic

Table 3
Postoperative Clinicopathologic Characteristics of Patients Undergoing Ovarian vNOTES With and Without Surgical Conversion.

Postoperative complications (Clavien-Dindo classification)			0.280[a]
None	474(96.9 %)	15(93.8 %)	
I	8(1.8 %)	0	
II	7(1.6 %)	1(6.3 %)	
III-V	0	0	
Postoperative pain score[c]			
Day 0	3.0(1.0, 5.0)(n = 488)	3.00(2.0,3.0) (n = 16)	0.208[b]
Day 1	2.0(0.0, 3.0) (n = 488)	2.0(1.0, 3.0) (n = 16)	0.809[b]
Day 2	1.0(0.0, 3.0) (n = 463)	2.0(0.0, 3.0)(n = 15)	0.473[b]
Day 3	1.0(0.0, 3.0)(n = 398)	1.0(0.0, 2.0)(n = 14)	0.242[b]
Postoperative hospitalization duration (days)	3.0(1.0, 10.0)	3.0(1.0, 9.0)	0.008[b]

[a] Chi-square test.
[b] Mann–Whitney *U* test.
[c] Visual analogue scale.

obstruction) occurred in the converted group. Pelvic inflammation occurred in five (1.0 %) cases, and postoperative blood transfusion was required in one (0.2 %) case in the nonconverted group (Table 4).

3.2. Risk factors for surgical conversion

To identify the risk factors that predicted intraoperative conversion from ovarian vNOTES, a logistic regression model was built (Fig. 2). The results showed that patients with severe pelvic adhesions were approximately 87 times more likely to experience surgical conversion during ovarian vNOTES (adjusted OR, 87.0; 95 % CI, 18.3–431.8; $P < 0.001$). Bilateral cysts (adjusted OR, 4.8; 95 % CI, 1.1–21.6; $P = 0.043$) and endometriotic pathological type were predictive of a higher chance of undergoing surgical conversion (adjusted OR, 7.7; 95 % CI, 3.1–17.1; $P < 0.001$). Surprisingly, mild and moderate pelvic adhesions did not increase the risk of surgical conversion. Other factors, such as BMI (adjusted OR, 1.1; 95 % CI, 0.9–1.4; $P = 0.269$), previous abdominopelvic surgery (adjusted OR, 0.7; 95 % CI, 0.3–1.6; $P = 0.385$), procedures performed by attendings (adjusted OR, 1.6; 95 % CI, 0.4–6.0; $P = 0.514$), and superficial pelvic endometriosis (adjusted OR, 1.1; 95 % CI, 0.7–1.7; $P = 0.999$) were not predictive of conversion from vNOTES to other approaches.

3.3. Clinical characteristics of patients who underwent surgical conversion

The detailed clinicopathologic information from 16 converted cases is summarized in Table 5. Ten females had no history of pelvic surgery, and no cysts >8 cm were found in the converted group. Five females had bilateral cysts, and all conversions involved cysts with sizes varying from 2.0 to 7.9 cm in diameter. Various pathological types were involved in these conversions, including three cystadenocarcinomas, three teratomas, seven endometriotic cysts, one corpus luteum cyst or follicular cyst, and two simple cysts. Three vNOTES were converted to MPL, and the other 13 were converted to TU-LESS. Based on the cause of conversion, these 16 cases were subclassified as follows: failure to enter the abdominal cavity via the posterior vaginal fornix, which might have been caused by the severe pelvic adhesion or adhesion of the pouch of Douglas (10 cases); or successful entry into the pelvic cavity through the posterior vaginal fornix and establishment of the vNOTES platform (6 cases) but without successful surgery completion because of unpredicted intraoperative malignant findings (1 case), an abnormal cyst location (1 case), or severe adhesion of the ovary with adjacent tissues (4 cases). Additionally, only one postoperative complication (incomplete ileus) occurred with these conversions.

4. Discussion

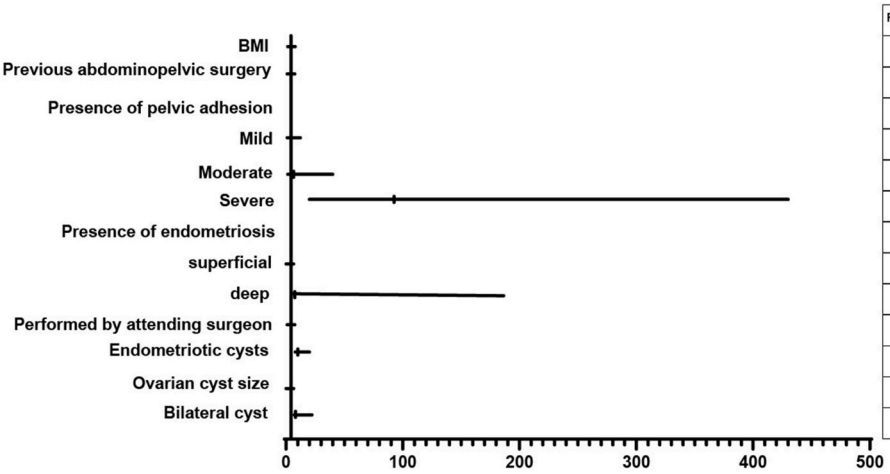
vNOTES is a minimally invasive approach that combines the advantages of transvaginal surgery and TU-LESS. Several studies have highlighted the feasibility of vNOTES-type salpingectomies and other adnexal approaches, such as salpingostomy. These studies indicated that vNOTES offers multiple advantages over TU-LESS, including faster postoperative recovery, shorter hospitalization duration, lower postoperative pain scores, and improved cosmetic satisfaction [14,19]. vNOTES is also reportedly beneficial for large ovarian cysts and those containing solid components, such as teratomas or fibromas, because of its faster and easier removal attributable to the elastic distension of the colpotomy incision [3,20]. Since Ahn et al. and Lee et al. first reported vNOTES-type oophorectomy and ovarian cystectomy in 2012 [21,22], many studies have attempted to demonstrate the effectiveness and safety of ovarian vNOTES [23–27]. However, the cohort size in these publications was relatively small, with three articles documenting only about 50 cases. Therefore, studies presenting clinical data, especially perioperative outcomes and surgical conversions of ovarian vNOTES, and those involving larger sample sizes are needed [24].

Though the present study included a variety of pathological types, including teratomas, serous or mucinous cystadenomas, endometriomas, sex cord-stromal tumors, paraovarian cysts, functional ovarian cysts, simple cysts and localized tubo-ovarian abscesses, and diverse sizes, vNOTES was completed without surgical conversions for most of these cases. Three studies have indicated

Table 4
Surgical complications of ovarian vNOTES.

	Nonconverted vNOTES(n = 489)	Converted from vNOTES(n = 16)	All cases(n = 505)
Intraoperative complications	2(0.4 %)	0	2(0.4 %)
Full thickness rectal injury	1(0.2 %)	0	1(0.2 %)
Rectal injury	1(0.2 %)	0	1(0.2 %)
Postoperative complications			
C-D I	2(1.6 %)	0	2(0.4 %)
Fever (without treatment with antibiotics)	1(0.2 %)	0	3(0.6 %)
Urinary retention requiring catheterization	1(0.2 %)	0	1(0.2 %)
C-D II	7(1.4 %)	1(6.3 %)	8(1.6 %)
Pelvic inflammation	5(1.0 %)	0	5(1.0 %)
Postoperative blood transfusion	1(0.2 %)	0	1(0.2 %)
Hematoma	1(0.2 %)	0	
Paralytic obstruction	0	1(6.3 %)	1(0.2 %)
C-D III-V	0	0	0
Total	11(2.2 %)	1(6.3 %)	12(2.4 %)

Note: C-D, Clavien–Dindo classification.



P value	Adjusted OR (95% CI)
0.269	1.1 (0.9,1.4)
0.385	0.7 (0.3, 1.6)
0.697	1.6 (0.2, 16.3)
0.270	3.9 (0.4, 42.3)
<.001	87.0 (18.3, 431.8)
0.999	1.1 (0.7,1.7)
0.288	6.2 (0.2, 180.7)
0.514	1.6(0.4,6.0)
<0.001	7.7(3.1,17.1)
0.333	0.9 (0.6, 1.2)
0.043	4.8 (1.1, 21.6)

Fig. 2. Logistic regression analysis of risk factors for ovarian vNOTES conversion.

Table 5
Key clinical features of patients who underwent surgical conversion during attempted ovarian vNOTES.

	Number of cases	Percentage(%)
Age		
25–50	13	81.3
>50	3	18.7
BMI		
18.5–24.9	13	81.3
25.0–29.9	3	18.7
History of gestation		
0	4	25
1	2	12.5
2	1	6.3
3	6	37.5
4	2	12.5
5	1	6.3
History of parity		
0	2	12.5
1	9	56.3
2	5	31.3
History of abdominal surgery		
None	7	43.8
Cesarean delivery	3	18.8
Laparoscopic tubal fimbrioplasty	1	6.3
appendectomy	1	6.3
Cholecystectomy	1	6.3
Entered the abdominal cavity in a vNOTES manner		
Yes	5	31.3
No	11	68.8
Conversion to		
MPL	3	18.7
LESS	13	81.3
Cause of conversion		
Unpredicted ovarian malignance	1	6.3
Severe pelvic adhesion	11	68.8
Presacral teratoma	1	6.3
Abnormal location of fallopian tube and ovary	1	6.3
Perioperative complication		
Incomplete ileus	1	6.3
none	15	93.7

Abbreviation: vNOTES, transvaginal natural orifice transluminal endoscopic surgery; LESS, laparoendoscopic single port; MPL, multiport laparoscopy.

that endometriosis might lead to adhesion of the pouch of Douglas and that vNOTES should not be performed for such cases [20]; however, only one vNOTES-type endometriotic cystectomy has been reported for such cases [22,23,28]. Our data indicated the feasibility of performing vNOTES for treating ovarian endometrioma; nonetheless, detailed preoperative evaluation is necessary.

Previous publications have reported that ovarian cysts larger than 8 cm may be contradictory to vNOTES [24,28], thus underestimating the applicability of vNOTES for treating large ovarian cysts [28]. We performed 46 vNOTES-type cystectomies of ovarian cysts larger than 8 cm in diameter; the largest cyst had a diameter of 12.5 cm. Despite the large size, no conversion was necessary for these cases. Therefore, our findings provide evidence that large ovarian endometrioma can also be treated with vNOTES.

Our study also showed that, when detailed preoperative examination and proper patient selection are performed, menopause is not a contradiction for ovarian vNOTES. Among the 20 patients who were older than 60 years in our cohort, surgery was completed for 19 of them without conversion; only one patient required conversion because of severe pelvic adhesion, which is consistent with a previous study of vNOTES-type adnexectomy for older females [29].

Considering the application of vNOTES for treating ovarian cysts is still new, reports of its complication and conversion rates are scarce. In the present study, a conversion rate of 3.17 % and a complication rate of 2.38 % were observed. The conversion rate observed in the present study surpassed that reported in our prior case-control investigation on vNOTES ovarian cystectomy ($n = 86$; conversion rate of 0 % and complication rate of 2.32 %) and marginally exceeded that documented in another retrospective study that concentrated on vNOTES adnexal procedures and hysterectomy (conversion and complication rates of 1.90 % and 5.56 %, respectively) [3,30]. However, the complication rate observed in our current study was not inferior to those reported in these previous two studies. The higher conversion rate observed in the present study might be attributed to the fact the 86 procedures in our prior study were conducted exclusively by the two most experienced, high-volume surgeons at our center, and the patient selection criteria were stricter when vNOTES was first performed at our center at that time [3]. Several cases of minor complications (C-D I and C-D II) occurred, while no C-D III and C-D IV complications were experienced in our cohort. Although there were two cases of intraoperative rectal injuries, the surgeons repaired the wound using vNOTES, and conversion to other surgical approaches was not required. Further, the different surgical approaches might explain the higher complication rate in the later study, as both cases of complications were bladder injuries in hysterectomy cases [30]. Therefore, vNOTES can be considered safe and feasible for treating various pathological types and sizes of ovarian cysts.

Consistent with previous studies, our data revealed that severe pelvic adhesion is the most significant predictor of ovarian vNOTES [30]. The majority of cases among the converted group encountered severe pelvic adhesion and were subsequently converted to TU-LESS. When failure to enter the abdominal cavity occurred, the adjacent organs, including the rectum, were at high risk for injury, and surgery was very likely to be converted. Evidence suggests that adhesions and the pouch of Douglas can be accurately evaluated by transvaginal ultrasonography using the sliding sign technique [31]. Ma et al. also reported that transabdominal ultrasonography reduced rectal injuries during transvaginal hydrolaparoscopy in patients with subfertility [32]. Therefore, intraoperative ultrasonic guidance to establish the operative platform might help avoid these injuries. Additionally, intraoperative diagnostic laparoscopy, with considerably high accuracy, can also help with avoidance of futile transvaginal endoscopic procedures and only requires approximately 5–10 min to perform [33]. Furthermore, even after successfully entering the pelvic cavity, if the pelvic cavity is severely adhered, then vNOTES will be greatly hindered. Lastly, we found that patients with bilateral cysts were also at higher risk for surgical conversion. Noteworthy, none of the previous studies evaluating vNOTES and other laparoendoscopic ovarian surgeries mentioned the impact of bilateral ovarian cysts on the surgical conversion. We speculated that it might be because a higher percentage of patients with bilateral cysts had an endometriotic pathological type than those with a unilateral cyst. The endometriotic cystectomy has higher surgical difficulty. Besides, bilateral cysts require the performance of more surgical procedures, resulting in longer operative time. Of note, a history of previous pelvic surgery and gestation or childbirth did not predict the surgical conversion of vNOTES, although approximately half of converted cases had experienced at least two gestions, and the majority of patients had undergone childbirth once.

This study reported the largest cohort of patients who underwent vNOTES for ovarian cysts and their perioperative outcomes. Additionally, this is the first study to focus on the surgical conversion of ovarian vNOTES. Such data may help surgeons optimize the patient selection and preoperative consultation. However, there were several limitations to this study that may hinder the generalizability of our findings, such as the retrospective design and fact that patients' long-term follow-up outcomes, including sexual function, childbirth, and vaginal incision-related complications, were not evaluated. Nonetheless, due to the exclusion of suspected or confirmed cases of rectovaginal endometriosis and severe pelvic adhesion before surgery, the risk of surgical conversion caused by endometriosis would be relatively underestimated.

5. Conclusions

vNOTES-type ovarian cystectomy is relatively safe due to the low complication and conversion rates. Severe pelvic adhesions, bilateral cysts, and endometriotic cyst were identified as predictors of surgical conversion during ovarian vNOTES.

Ethical statement

The present study was approved by the Ethics Committee of Chengdu Women's and Children's Central Hospital (CWCCH-2021122). Only patients who signed the consent form for participation in the study and the publication of their data were included in this study. No image of any patient was used in the current study. Permission for the retrieval of patient data from the Hospital Information System was also granted by the Ethics Committee. Patients' identifiable information, such as names, telephone numbers, and addresses, was not extracted from the Hospital Information System because of privacy concerns.

Data availability statement

The original data of this study were deposited in Figshare at http://doi.org/10.6084/m9.figshare.25653525 and openly available.

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CRediT authorship contribution statement

Dan Feng: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Tianjiao Liu:** Writing – review & editing, Writing – original draft, Methodology, Formal analysis. **Xin Li:** Writing – original draft, Methodology, Data curation. **Lu Huang:** Methodology, Data curation. **Li He:** Writing – review & editing, Supervision, Investigation. **Yonghong Lin:** Writing – review & editing, Supervision, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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