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Effect of Simultaneous Cystectomy on Ovarian Reserve in Cases of Adnexal Torsion: A Prospective Case-Control Study

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ABSTRACT Objective: Adnexal torsion is one of the gynecological surgical emergencies that can be seen in women of all ages, with or without an ovarian cyst. In this study, it was aimed to investigate the effect of performing cystectomy on ovarian reserve in an ovary exposed to ischemia during emergency surgery in cases of adnexal torsion with an ovarian cyst, which is presumed to be benign. **Material and Methods:** The ovaries of nineteen women who underwent laparoscopic detorsion due to adnexal torsion (Group 1) and the ovaries of ten women who underwent laparoscopic detorsion+cystectomy in the same session with adnexal torsion due to a cyst, which was presumed to be benign (Group 2) were compared in terms of ovarian volume and antral follicular counts (AFC). **Results:** There was no statistically significant difference between the volumes and AFCs of the operated ovaries of the women in Group 1 (ovarian volume 11.56±9.58 cm3, AFC: 8.52±5.92 cm3) and the women in Group 2 (ovarian volume 10.99±5.07 cm3, AFC: 9.20±3.15 cm3) (p>0.05). **Conclusion:** Performing a cystectomy during detorsion surgery for a cyst presumed to be benign in a torsioned ovary exposed to ischemia does not seem to do any additional harm when evaluated in terms of AFC and volume.

Keywords: Ovarian cysts; ovarian reserve; ovarian torsion

Ovarian torsion is a partial or complete rotation of the ovary around the utero-ovarian and infundibulopelvic ligament. Normally, the tuba uterina rotates with the ovary, and is known as adnexal torsion. Ovarian torsion is one of the gynecological surgical emergencies that can be seen in females of all ages and constitutes 3% of all emergent surgeries.[1] While torsion can occur in completely normal adnexa, adnexal masses over 5 centimeters are thought to be associated with torsion, which often starts with sudden lower abdominal pain. However, sometimes non-specific symptoms may delay diagnosis and treatment.[2] Venous and lymphatic obstruction caused by torsion is followed by arterial insufficiency. First, ovarian congestion develops, followed by ischemia, necrosis, and local bleeding.[3] The number and tightness of rotations can change the severity of tissue damage. Prompt diagnosis and surgery are very important to prevent ovarian and tubal damage. Ovarian tissue should be preserved as much as possible, since in most studies, normal follicle development is seen after detorsion of even an ovary that appears to be bluish-black in color during surgery.[4] In patients with torsion who have completed their fertility, are older, or have a suspected malignant mass, the surgeon can decide on an oophorectomy more easily. However, there are reservations about performing cystectomy during detorsion in young women and on masses that are presumed to be benign. Cystectomy may be difficult due to surrounding edema and there may be concerns that dissection could further impair vascular perfusion. In fact, some clinicians may delay cystectomy for an elective period because of the

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concern that more damage may occur to the ovary in the acute period. There are various studies on the effects of elective removal of non-endometriotic or endometriotic cysts on ovarian reserve.[5,6] Since there is no data on this subject in the literature, this study was designed to determine whether there is additional ovarian damage when simultaneous cystectomy is performed during the emergency operation on a torsioned adnexa with a mass that is presumed to be benign in the ovary.

MATERIAL AND METHODS

This prospective case-control study was conducted in a gynecology clinic at a tertiary university hospital in accordance with the Declaration of Helsinki principles (Clinical Trial ID: NCT05702099). After obtaining ethical approval (date: April 18, 2017, no: 2017-577) from the University of Health Sciences, Bağcılar Training and Research Hospital Ethics Committee, 67 women who underwent emergency surgery with adnexal torsion between April 2015 and August 2022 were analyzed. Age, marital status, obstetric history, presence of pregnancy at admission, history of surgery, additional systemic diseases, blood parameters, side of torsion, presence of cyst in torsioned ovary, method of surgery, amount of bleeding, type of incision, number of adnexal rotations, operation performed, and hospital stays were recorded for all patients. All women were operated within twelve hours at the latest after hospital admission. Except for two women at advanced gestational weeks, sixteen women who underwent oophorectomy for suspected malignancy or spontaneous amputation and isolated salpingectomy were excluded from the study. Laparoscopic surgery was performed by an experienced surgical team under general anesthesia for all the patients. Thirty-four women only underwent detorsion. Both detorsion and cystectomy were performed on seventeen women who were found to have cysts in their ovaries. The ovarian cysts were removed by standard cyst capsule excision using the stripping technique.[7] Bipolar electrocoagulation was used minimally for hemostasis in order not to damage the ovarian tissue. Hemostatic sutures were not used in any case. The specimens were examined histopathologically by experienced gynecopathologists. Every woman was called for a follow-up examination between six and twelve months postoperatively. Only nineteen of the women who had undergone detorsion (Group 1), and only ten who had undergone detorsion+cystectomy (Group 2) could be reached and examined. Other women was unfollowed. Consent was obtained from all the study patients. A total of 29 women were questioned in terms of pregnancy, infertility, and torsion recurrence after the operation and evaluated by ultrasonography (USG) in terms of ovarian reserve (Siemens Acuson X700, CA, USA). In order to evaluate ovarian reserve, antral follicle counts (AFC) in the early follicular phase of the cycle were counted by one of the authors (NKA) in an ultrasonographic examination blinded to the operated side. Ovarian volumes were calculated using the formula for a prolate ellipsoid ($V=length\times width\times height\times\pi/6$).[8] The primary outcome was to compare the operated ovaries and contralateral ovaries of women in Group 1 and Group 2 at 6-12 months postoperatively, both within and between groups for ovarian reserve. The secondary outcome was to perform demographic and pathological analyses of the adnexal torsion cases.

Mean, standard deviation, median, minimum, and maximum values were given in descriptive statistics for continuous data, and numerical percentage values were given in the discrete data. The Shapiro-Wilk test was used to examine the concordance of continuous data with the normal distribution, and the Mann-Whitney U test was used to compare the two groups. In comparisons between groups of continuous data, One-Way analysis of variance (ANOVA) was used for data with the normal distribution, and the Tukey test was used to examine between which groups the difference was. The Kruskal-Wallis ANOVA was used in the comparisons of the data that did not show a normal distribution between the groups, and the Kruskal-Wallis multiple comparison test was used to determine from which groups the difference originated. The Wilcoxon test was used to examine the differences in ovarian volume and AFC between the detorsioned ovaries and contralateral ovaries. The chi-square and Fisher's exact tests were used for group comparisons (cross tables) of nomi-

nal variables. The IBM SPSS program (version 20) (Chicago, IL, USA) was used in the evaluations with $p<0.05$ being accepted as the statistical significance limit.

RESULTS

The mean age of the 67 women who underwent surgery for adnexal torsion was 29.45±9.89 years (15-63 years). The demographic characteristics, obstetric histories, and surgeries of every woman with torsion are given in Table 1. Forty-nine women (73.1%) were operated laparoscopically, and eighteen women (26.9%) were operated by laparotomy. Every woman in Group 1 and 2 had been operated laparoscopically. At the time of torsion surgery, five of the women were pregnant (at 5, 8, 12, 33, and 39 weeks of gestation). Cesarean section was also applied in the same session to two women who were 33 and 39 weeks pregnant. Cysts were observed in the torsion ovary in 33 patients (49.3%) in the first examination and during the operation. Torsion was found on the right side in 43 women (64.1%) and on the left side in 24 women (35.9%). The number of turns of the adnexa around themselves varied between one and six. Detorsion surgery was performed on 34 women, detorsion+cystectomy on 17 women, and oophorectomy+salpingectomy on 15 women. Salpingectomy was performed on one woman because of isolated salpinx torsion. The pathological evaluations of the tissue specimens are given in Table 2. The ages of the women who had undergone oophorectomy (38.44±11.11 years) was statistically significantly higher than the women who had undergone detorsion (27.12±7.56 years) and cystectomy (25.65±7.9 years) ($p<0.001$). The parity and the number of previous operations of these women are given in Table 3. The mean time between surgery and examination with USG was 9.2±2.4 (6-12) months.

TABLE 1: Demographic, disease and operation-related characteristics of all women.

	$\bar{X}$±SD (Minimum-Maximum)	Median (Minimum-Maximum)	n (%)
Age (years) (n=67)	29.45±9.89 (15-63)		
Marital status (n=67)			
Married			47 (70.1)
Single/divorced/widowed			20 (29.9)
Parity (n=67)		1 (0-8)	
Nulliparity			32 (47.8)
Multiparity			35 (52.2)
Type of delivery (n=35)			
Vaginal delivery			16 (45.7)
Cesarean section			13 (37.1)
Vaginal delivery+cesarean section			6 (17.1)
Presence of pregnancy at the time of admission to the hospital (n=67)			
None			62 (92.5)
Pregnant			5 (7.5)
History of previous abdominal surgery (n=67)			
None			45 (67.2)
Yes (number)		1 (1-3)	22 (32.8)
Presence of cyst in torsioned ovary (n=67)			
None			34 (50.7)
Yes			33 (49.3)
The size of the cyst (n=46) (cm)	7.89±4.05	6.5 (3-20)	
Side of torsioned ovary (n=67)			
Right			43 (64.2)
Left			24 (35.8)
The method of operation (n=67)			
Laparoscopy			49 (73.1)
Laparotomy			18 (26.9)
Type of incision (n=18)			
Pfannenstiel			16 (89)
Median			2 (11)
Number of rotations of the torsioned side (n=67)	2.36±4.05	2 (1-6)	
Type of operation			
Detorsion			34 (50.7)
Detorsion+cystectomy			17 (25.4)
Oophorectomy±salpingectomy			15 (22.4)
Salpingectomy			1 (1.5)

SD: Standart deviation.

In women in the detorsioned group (Group 1), the operated ovarian volume (11.56±9.58 cm^3 vs. 15.51±7.63 cm^3) was found to be statistically significantly smaller, and the AFC (8.52±5.92 cm^3 vs. 10.94±5.09 cm^3) was lower than their contralateral ovaries ($p<0.05$). Although the operated ovaries of the women in the cystectomy group (Group 2) were lower in volume than the volume of their contralateral ovaries, the difference was not statistically significant (10.99±5.07 cm^3 vs. 12.41±5.98 cm^3, $p>0.05$). In Group 2, the AFC of the operated ovaries was statistically significantly lower than the AFC of the contralateral ovaries (9.20±3.15 vs. 12.20±4.05 cm^3,

TABLE 2: Pathological findings of cystectomy and oophorectomy specimens.

Pathological findings (n=33)	n (%)
Mature cystic teratoma	7 (21.2)
Benign serous cyst	6 (18.2)
Corpus luteum	6 (18.2)
Benign mucinous cystadenoma	4 (12.1)
Benign necrotic tissues	4 (12.1)
Endometrioid cyst	1 (3)
Fibroma	1 (3)
Fibrothecoma	1 (3)
Struma ovarii	1 (3)
Serous borderline tumor	1 (3)
Juvenile granulose cell tumor	1 (3)

p<0.05). There was no difference between the volumes (11.56±9.58 cm^3 vs. 10.99±5.07 cm^3) and AFCs (8.52±5.92 cm^3 vs. 9.20±3.15 cm^3) of the operated ovaries of the women in Group 1 and the women in Group 2 (p>0.05) (Table 4). After the operation, five women in Group 1 and one woman in Group 2 were able to conceive spontaneously resulting in live birth. In Group 2, two women could not conceive despite wishing to do so, and they did not receive any treatment. There was no statistically significant difference between the post-operative pregnancy and infertility rates of the women in either group (p>0.05).

TABLE 3: Comparison of demographic characteristics of women who underwent detorsion, detorsion+cystectomy, and oophorectomy+salpingectomy.

	Detorsion (a) X̄±SD Median (Minimum-Maximum)	Detorsion+Cystectomy (b) X̄±SD Median (Minimum-Maximum)	Oophorectomy±Salpingectomy (c) X̄±SD Median (Minimum-Maximum)	p value	Post hoc test
Age (years)	27.12±7.56 27 (15-42)	25.65±7.90 25 (16-45)	38.44±11.11 39.5 (23-63)	**<0.001***	a-b p=0.803 a-c **p<0.001** b-c **p<0.001**
Parity	0 (0-3)	0 (0-4)	2 (0-8)	**0.001****	a-b p=1.000 a-c **p=0.001** b-c **p=0.045**
	n (%)	**n (%)**	**n (%)**		
History of previous abdominal surgery					
None	26 (76.5)	14 (82.4)	5 (31.2)	**0.002*****	a-b p=0.731 a-c **p=0.002** b-c **p=0.003**
Yes	8 (23.5)	3 (17.6)	11 (68.8)		

*One-Way analysis of variance (ANOVA); **Kruskal-Wallis analysis of variance; ***Chi-square test/Fisher's exact test; SD: Standart deviation.

TABLE 4: Comparison of women who underwent detorsion only (Group 1) and women who underwent detorsion+cystectomy (Group 2) in terms of ovarian size and antral follicle count (within and between groups).

		Detorted ovary X̄±SD Median (Minimum-Maximum)	Contralateral ovary X̄±SD Median (Minimum-Maximum)	p value
Ovarian volume (cm^3)	Group 1 (n=19)	11.56±9.58 10.9 (0.6-39.5)	15.51±7.63 14.9 (3.3-32.4)	**0.012***
	Group 2 (n=10)	10.99±5.07 9.1 (5.2-22.1)	12.41±5.98 12.6 (4.7-25)	0.074*
	p value	0.668**	0.266**	
Antral follicle count (n)	Group 1 (n=19)	8.52±5.92 9 (0-19)	10.94±5.09 10 (4-22)	**0.029***
	Group 2 (n=10)	9.20±3.15 9 (5-15)	12.20±4.05 12.5 (7-20)	**0.015***
	p value	0.668**	0.429**	

*Wilcoxon test; **Mann-Whitney U test; SD: Standart deviation.

DISCUSSION

In this study, it was found that performing cystectomy in the same session as detorsion surgery in the presence of a cyst in a torsioned ovary did not cause additional damage to the ovary. There is no clear consensus on whether to perform detorsion or oophorectomy for the bluish-black ovary in patients with ovarian torsion. While the decision for oophorectomy is easier for older women and women with suspected malignancy, detorsion is widely accepted in younger women with fertility expectations.[2] We witnessed spontaneous amputation of the ovaries of the two women on whom we performed oophorectomies during the operation. We performed oophorectomies in the remaining thirteen women who completed their fertility with suspicion of malignancy. The histopathology of two of the women was reported as malignant (serous borderline tumor and juvenile granulose cell tumor). Staging surgeries of both patients were completed in our clinic within one month.

In torsion, with an ovarian mass presumed to be benign, clinicians are undecided about performing a cystectomy during detorsion or leaving it for the second session as there are reservations about performing a cystectomy on an ovary that is already damaged by torsion, or inability to perform a correct excision in an edematous and necrotic ovary, or due to the risk of additional bleeding. In all studies examining follicular development in the preservation of the ovary after detorsion in humans, it has been shown that the function of the ovary continues.[4] However, the follicle cohort may be adversely affected despite the ovary remaining viable after detorsion. The increase in ovarian tissue damage has been attributed to oxidative stress products of post-ischemia reperfusion.[9] As a matter of fact, in the study of Ozler et al., when control, torsion, and detorsioned rat ovaries were compared, the detorsion group had the highest score in ovarian damage parameters.[10] Compared with a contralateral ovary, there is a lack of data in terms of hormones and the reserve of the ovary despite damage to the ovary due to ischemia-reperfusion injury having been shown histopathologically.[11] The size of the primordial follicle pool and the quality of the oocytes constitute the ovarian reserve.[12] It is not possible to directly measure the primordial follicle pool. In the current literature, it is accepted that the number of growing primordial follicles and the Anti-Mullerian hormone (AMH) secreted from preantral-antral follicles most accurately reflect the size of the follicle pool.[13,14] Comparing the AFC of the operated side ovary with that of the contralateral ovary seems to be the most appropriate approach to assess ovarian reserve. Bozdag et al. compared the operated and contralateral ovaries after detorsion in terms of AFC and ovarian volumes, but they could not find a statistically significant difference between the ovaries.[15] Unlike this study, we found lower AFC and volume of operated ovaries in both groups. We believed that this could be due to the heterogeneity of the cases and the multifactorial causes of ischemia. Bozdag et al. performed cystectomies in only six patients and did not observe a statistically significant difference in AFC and ovarian volume in these patients. In our study, however, the high number of women evaluated via cystectomy (Group 2) makes the study a little stronger. Bozdag et al., on the other hand, had already focused on the effects of detorsion rather than the effect of cystectomy.[15]

Surgical resection is required to relieve pelvic pain due to ovarian cysts and to perform histopathological examination.[16] If the cyst has especially caused torsion, it is quite reasonable to perform a cystectomy during the same session to prevent the recurrence of torsion. Laparoscopic cyst excision, which involves stripping the cyst wall, is the most widely used surgical technique.[17] Normal ovarian tissue may also be inadvertently removed during ovarian cystectomy, which may adversely affect ovarian reserve.[18-23] Most of the studies in the literature examining the effects of cystectomy on ovarian reserve have been performed on patients with endometriosis and after endometrioma excisions.[5] In the meta-analysis published by Raffi et al., it was revealed that there was a statistically significant decrease in serum AMH concentrations after surgical removal of endometriomas and a negative effect on ovarian reserve.[18] In the meta-analysis published by Muzii et al., however, when evaluated by the AFC, it was shown that endometrioma surgery does not significantly affect ovarian reserve.[24]

In most studies, it has been shown that AMH decreases significantly in the early period after excision of endometrioma and other non-endometriotic cysts, but AMH tends to improve in 3-month follow-ups.[25] However, it was clearly seen that the decrease in AMH was much more severe in endometriomas and when they were bilateral.[16] Because of its inflammatory nature and lack of a true capsule, the risk of accidental removal of ovarian tissue is estimated to be higher for endometriomas.[18,26,27] Salihoğlu et al. compared 34 endometriomas and 33 non-endometriotic cysts in terms of ovarian reserve tests at two months after laparoscopic cystectomy. They found that after non-endometriotic cyst excision, AMH significantly decreased, and AFC, FSH, and E2 levels did not change in the second month.[6] Torsion is not an expected situation due to the fixed pelvic organs specific to endometriosis. Indeed, in our study, the histopathology of only one woman was an endometriotic cyst. Li et al., in a study investigating the time required for the recovery of ovarian reserve after laparoscopic unilateral non-endometriotic cystectomy, did not observe any difference in AFC and ovarian artery resistance index in the first, third, and sixth months postoperatively. Although the postoperative AMH levels decreased significantly in the first month, it was observed that it gradually increased and reached its best level in the sixth month [pre-operative AMH: 2.81 (2.48-3.12) ng/mL, postoperative first month: 1.88 (1.61-2.16) ng/mL, postoperative sixth month: 2.41 (2.24-2.85) ng/mL]. This decrease in AMH was not statistically different from the non-operated women group in the same age group.[28] In other words, after waiting six months, it can be said that, unlike endometriomas, the excision of non-endometriotic cysts does not significantly affect the ovarian reserve. Therefore, we did not evaluate patients for ovarian reserve before six months postoperatively. However, in our study, we believed that the low AFC and ovarian volume in benign pathology cystectomies were related to the negative effect of torsion.

When Exacoustos et al. compared ovarian volumes before surgery and three years after surgery for endometrioma and dermoid cystectomies, they found a significant reduction in ovarian volume from endometrioma cystectomies.[29] The significance of reporting a non-significant reduction in ovarian volume on the operated side is unclear. AFC seems to be superior than ovarian volume for the prediction of response to ovarian stimulation as experienced from assisted reproduction cycles.[30] In our study, the volumes of the operated ovaries in both groups were reduced, but those who had only detorsion were measured to be smaller than those who also had a cystectomy. The fact that the ovaries that underwent cystectomy were relatively less damaged may be due to the fact that they were more symptomatic due to the cyst and received intervention earlier.

The exact incidence of torsion during pregnancy is unknown.[31] In this study, five women (7.5%) were pregnant at the time of admission to the hospital. Two women, 33 and 39 weeks pregnant, were delivered by cesarean section because labor contractions started and masked the symptoms. During this time, it was observed that their adnexa were torsioned. The other three pregnant women (at 5, 8, and 12 weeks of gestation) were detorsioned via the laparoscopic approach without any issues. Laparoscopy is already an effective and safe surgical method that is frequently preferred in the treatment of adnexal torsion in pregnant and non-pregnant women in experienced centers.[32,33] In our clinic, we prefer the laparoscopic approach in most cases, including for pregnant women.

Isolated fallopian tube torsion is very rare in women of reproductive age.[34] We also observed isolated fallopian tube torsion in only one patient (1.5%) and performed laparoscopic salpingectomy without touching the normal ovary.

The right ovary is more likely to be torsioned than the left, possibly due to the right utero-ovarian ligament being longer than the left and the presence of the sigmoid colon in the left pelvis being able to help prevent torsion on that side.[35] In this study, at a 64.2% rate, the right adnex was torsioned more frequently than the left.

In comparison to other studies, the strength of our study lies in its prospective design and longer patient follow-up. However, this situation causes many patients to be excluded from follow-up. In addition,

surgeries were performed by an experienced team with ovarian volume and AFC being evaluated by a single clinician.

The limitations of this study are the small number of patients and the inability to define the time between the onset of symptoms and surgery. Due to the heterogeneity of the patients' ages, we could not establish an appropriate control group, thereby preventing us from comparing the hormonal parameters of ovarian reserve. We could not compare the effect of excision of different cyst types on ovarian reserve as the number of patients with each cyst type was small. Moreover, since not all of these patients attempted to conceive after surgery, we could not calculate future fertility rates.

CONCLUSION

The purpose of torsion surgery in our daily practice is to correct the emergency and exclude malignancy in suspected cysts. Therefore, restoring the ovarian reserve after surgery is not the main purpose of the surgery. However, the effect of surgery on ovarian reserve is important for women who may want to have children in the future. In conclusion, performing cystectomy on the ovary exposed to torsion-inducing ischemia in the same session does not seem to have an additional negative effect on AFC-based ovarian reserve. However, more comprehensive prospective studies are needed to determine whether cystectomy in an ischemia-exposed ovary has an effect on conception and live birth rates.

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Conflict of Interest

No conflicts of interest between the authors and/or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Nurşen Kurtoğlu Aksoy;* ***Design:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***Control/Supervision:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***Data Collection and/or Processing:*** *Nurşen Kurtoğlu Aksoy, Mevlide Şan Karaman;* ***Analysis and/or Interpretation:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***Litrature Review:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***Writing the Article:*** *Evrim Ebru Kovalak;* ***Critical Review:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***References and Fundings:*** *Nurşen Kurtoğlu Aksoy, Evrim Ebru Kovalak;* ***Materials:*** *Nurşen Kurtoğlu Aksoy, Mevlide Şan Karaman.*

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