COMPARATIVE STUDY BETWEEN LAPAROSCOPIC AND OPEN OVARIAN CYSTECTOMY ON OVARIAN RESERVE

Moustafa M. Zaitoun; Yousry K. Shallal; Amal M. Alanwar and Islam M.M. Ammar
Obstetrics and Gynecology Departments
Faculty of Medicine, Zagazig University

ABSTRACT

Objective: To investigate the impact of electrocoagulation on ovarian reserve after laparoscopic excision of ovarian cysts and the possible mechanisms.
Design: A prospective study.
Setting: Obstetrics and Gynecology Department of a university hospital.
Patient(s): 100 patients with benign ovarian cysts undergoing ovarian cystectomy.
Intervention(s): Laparoscopic ovarian cystectomy using bipolar electrocoagulation and laparotomic ovarian cystectomy using sutures after the excision of ovarian cysts.
Main Outcome Measure(s): Follicle-stimulating hormone (FSH & AMH) assays and transvaginal ultrasound evaluating basal antral follicle number, mean ovarian diameter, and ovarian stromal blood flow velocity at cycles 1, 3 and 6 after surgery.
Result(s): When comparing the bipolar group with the suture group, a statistically significant increase of the mean FSH value was found in bilateral-cyst patients at 1-, 3- and 6-month follow- up evaluations and in unilateral-cyst patients at the 1-month follow-up evaluation. When comparing the bipolar group with the suture group, a statistically significant decrease of the mean AMH value was found in bilateral-cyst patients at 1-, 3- and 6-month follow- up evaluations and in unilateral-cyst patients at the 1-month follow-up evaluation. Statistically significant decreases of basal antral follicle number and mean ovarian diameter were found during the 3-, 6-month follow-up evaluations as well as statistically significant decreases of peak systolic velocity at all of the follow-up evaluations.
Conclusion(s): Electrocoagulation after laparoscopic excision of ovarian cysts is associated with a statistically significant reduction in ovarian reserve, which is partly a consequence of the damage to the ovarian vascular system.
Key Words: Ovarian cysts, laparoscopic ovarian cystectomy, electrocoagulation, ovarian reserve

INTRODUCTION

Laparoscopic ovarian cystectomy is currently considered the treatment of choice in women with benign ovarian cysts and has gained increasing acceptance among gynecologic surgeons [(1).] However, the safety of laparoscopic ovarian cystectomy in terms of damage to the operated ovary has been questioned. A great deal of evidence supports that the removal of ovarian cysts is associated with injury to the ovarian reserve [(2-7).] Many of these studies involved patients who required assisted reproduction [(3-6),] and they reported that the number both of follicles and retrieved oocytes obtained in the operated ovary during ovarian hyperstimulation was markedly reduced when compared with the contralateral intact ovary[(8)]. However, most studies on the topic of ovarian reserve after surgery are provided by infertility centers and are consequently limited by the selection of patients. Postsurgical fertility is not a proper criterion for evaluating the ovarian reserve. Moreover, not all patients desire to get pregnant after surgery[(8)].

However, most of these studies applied ovarian response to gonadotropin hyperstimulation to measure the ovarian reserve. It has been argued that these patients are not representative of all patients undergoing laparoscopic ovarian cystectomy[(7).]

The ovarian reserve is defined as the functional potential of the ovary and reflects the number of the follicles left in the ovary at any given time [(9).]

Over the years, various tests and markers of ovarian reserve have been reported [(10).] Static tests include the age, hormonal parameters such as follicle-stimulating hormone (FSH), estradiol, luteinizing hormone (LH), anti-Müllerian hormone (AMH), and inhibin B levels and the FSH/LH ratio, and sonographic variables such as ovarian volume, antral follicle count (AFC), and ovarian stromal blood flow. Dynamic tests such as the clomifene citrate challenge test, the gonadotropin-releasing hormone agonist stimulation test, and the exogenous FSH ovarian reserve test have also been reported. Serum AMH and ovarian AFC seem to be the most sensitive noninvasive markers of ovarian reserve [(11).]

Anti-Müllerian hormone is a member of the transforming growth factor beta superfamily [(12).] It is produced by granulosa cells of pre-antral and small antral follicles. Its principal function is to inhibit the initiation of primordial follicle growth and it therefore has a potential role in dominant follicle selection [(13).] As the ovaries run out of primordial follicles, the number of pre-antral follicles entering the growth phase diminishes, resulting in a fall in plasma AMH levels [(14).]

The mechanisms underlying the reduction of ovarian reserve in an operated ovary have been poorly investigated. Several possible mechanisms can be hypothesized. First, the injury may precede

surgery. The cyst per se can negatively affect the surrounding ovarian tissue. It has been reported recently that the ovarian tissue surrounding an endometrioma is morphologically altered and possibly not functional, suggesting that a functional disruption is already present before surgery[15]. These alterations did not appear to be present when the ovarian cortex surrounding mature teratomas and cystadenomas was studied[15, 16]. The lesion inflicted to the ovarian stroma and vascularization by electrosurgical coagulation during hemostasis may have an impact[17].

Monopolar cautery appears to have the most lateral spread of thermal injury and is not recommended for use in ovarian cystectomy. Now bipolar and ultrasonic scalpels are being widely used in laparoscopic ovarian cystectomy. But does that mean they are safe to the ovarian reserve?[8]

The aim of this study is to investigate the impact of electrocoagulation on ovarian reserve after laparoscopic ovarian cystectomy in comparison with open ovarian cystectomy.

PATIENTS AND METHODS

Patients

This study was conducted at the Department of Obstetrics and Gynecology in Zagazig University Hospital.

Before enrollment, every patient who received a diagnosis of benign ovarian cysts was instructed to observe at least two menstrual cycles, at which point repeated day-3 ultrasound examinations was performed to determine whether the cyst size remained the same or became bigger. No oral contraceptives or other treatments were applied to the ovarian cysts. All patients gave a written consent to share in the study.

Inclusion criteria are as follows:

[1] Age 18 to 35 years.

[2] Uni/bilateral ovarian cyst(s) with clinical and sonographic findings suggesting benign nature.

[3] Regular menstrual cycles in the 6 months before surgery.

Exclusion criteria are as follows:

[1] Prior ovarian surgery.

[2] Surgical necessity to perform adnexectomy.

[3] Known endocrine disease.

[4] Postoperative pathologic diagnosis of malignant ovarian cyst.

[5] Oral contraceptive use within three months before surgery.

Procedures

After general, abdominal and local examination of the patient, routine pre-operative investigations were done. Trans abdominal ultrasound study was performed to detect ascites, enlarged para-aortic lymph nodes and distant metastasis.

The serum FSH and AMH levels of all the patients enrolled in this study were determined by ELISA on day 3 of the cycle before the surgical procedure. A high resolution transvaginal ultrasound examination was systematically performed before surgery to confirm the diagnosis of ovarian cyst and precisely record the dimensions of the cyst.

All patients were informed about alternative therapeutical approaches, and the patients chose between laparoscopy and an open procedure to remove the cyst(s). For patients who agreed to laparoscopic surgery bipolar diathermy was used. For patients who did not want to undergo laparoscopic surgery, conventional laparotomic ovarian cystectomy was applied. After peritoneal cytology and inspection of the peritoneal cavity, the cyst is freed and then carefully excised. 3-0 absorbable sutures were applied to reapproximate the edges of the ovary and to achieve a satisfying hemostasis. No electrocoagulation will be used for hemostasis.

Both laparoscopic and open procedures for cyst removal were performed by the same skilled surgical team. And the diagnosis was confirmed histologically for every patient.

Follow-up

All patients were asked to return on day 3 of menstrual cycles1, 3, 6, after their surgery, at which point an FSH and AMH assays were performed. All ovarian follicles measuring 3 mm to 10 mm on both ovaries were counted. Using the largest cross-sectional sagittal view of the ovary, the averaged ovarian diameters for each patient were calculated by measuring two perpendicular diameters. The stromal blood flow of the ovary was assessed by color Doppler ultrasound. Flow velocity waveforms were obtained from stromal blood vessels away from the ovarian capsule and the utero-ovarian ligament. The ‘‘gate’’ of the Doppler was positioned when a vessel with good color signals was identified on the screen. The peak systolic velocity of stromal vessels was calculated electronically when at least three similar, consecutive waveforms of good quality were obtained.

Statistical analyses were performed with Statistics Package for Social Sciences software (SPSS, Inc., Chicago, IL) version11.5 for windows. Qualitative data were expressed as number and compared using chi-squared test. Quantitative Keuls follow-up test was used for multiple comparisons between means. P<.05 was considered statistically significant.

RESULTS

Characteristics of Patients

According to the inclusion criteria, a total of 100 patients were enrolled in this study.During the study period, 100 patients were found to be eligible. There were no intraoperative or postoperative complications and no blood loss more than 200mL. Pregnancies occurred in six patients .The general patient characteristics are presented in Table 1. There was no significant difference for any of the variables considered.

FSH ASSAY

Because of the damage to the ovary is different for unilateral cyst and bilateral cysts, the patients were subdivided accordingly; when analyzing their FSH values before surgery and during the 6-month follow-up period. All patients had normal FSH values preoperatively. The mean values of FSH before surgery and during the 6-month follow-up period are shown in Tables 2 and 3. Comparing the bipolar group with the suture group, a statistically significant increase of the mean FSH value was seen in the bilateral-cyst patients during all the 6-month follow-up period and in the unilateral-cyst patients only at the 1-month follow-up visit.

AMH ASSAY

All patients had normal AMH values preoperatively. The mean values of AMH before surgery and during the 6-month follow-up period are shown in Tables 4 and 5. Comparing the bipolar group with the suture group, a statistically significant decrease of the mean AMH value was seen in the bilateral-cyst patients during all the 6-month follow-up period and in the unilateral-cyst patients only at the 1-month follow-up visit.

Transvaginal Ultrasound Examinations:

1- For the unilateral-cyst patients, No difference was detected for the quantitative data of the intact ovary among the two groups. At the 1-month follow-up visit, the peak systolic velocity of the operated group decreased statistically significantly in the bipolar group compared with the suture group; however, No statistically significant difference of basal antral follicle number or mean ovarian diameter of the operated ovary was found among the two groups. At the 3-, 6-month follow-up visits, the basal antral follicle number, peak systolic velocity, and mean ovarian diameter of the operated ovary in the bipolar group were statistically significantly decreased when compared with the suture group at the same time (Table 6, 7).

2- For bilateral-cysts patients, comparing the suture group with the bipolar group, statistically significant differences of basal antral follicle number and mean ovarian diameter were revealed during the 3-, 6- month follow-up evaluations; a statistically significant difference of peak systolic velocity was seen at all the follow- up visits (Table 8).

DISCUSSION

Our study has demonstrated that bipolar coagulation of the ovarian parenchyma during cystectomy adversely affects ovarian reserve. Most studies on the topic of ovarian reserve after surgery are provided by infertility centers and are consequently limited by the selection of patients.We did not consider the woman's postsurgical fertility a proper criterion for evaluating the ovarian reserve. Fertility is not the result of ovarian function alone and depends on multiple factors. Moreover, not all of our patients desired to get pregnant during the study period.

- **As regard to hormonal assays (FSH & AMH):**

Comparing the bipolar group with the suture group, a statistically significant increase of mean FSH value was seen in the bilateral-cyst patients at all of the 6-month follow-up visits and in the unilateral-cyst patients at the 1- month follow-up visit.

All patients had normal AMH values preoperatively. Comparing the bipolar group with the suture group, a statistically significant decrease of the mean AMH value was seen in the bilateral-cyst patients during all the 6-month follow-up period and in the unilateral-cyst patients only at the 1-month follow-up visit.

- **As regard to transvaginal ultrasound examinations:**

1- For the unilateral-cyst patients, No difference was detected for the quantitative data of the intact ovary among the two groups. At the 1-month follow-up visit, the peak systolic velocity of the operated group decreased statistically significantly in the bipolar group compared with the suture group; however, there was no statistically significant difference of basal antral follicle number or mean ovarian diameter of the operated ovary among the two groups. At the 3-, 6-month follow-up visits, the basal antral follicle number, peak systolic velocity, and mean ovarian diameter of the operated ovary in the bipolar group were statistically significantly decreased

when compared with the suture group at the same time.

2- For bilateral-cysts patients, comparing the suture group with the bipolar group, statistically significant differences of basal antral follicle number and mean ovarian diameter were revealed during the 3-, 6- month follow-up evaluations; a statistically significant difference of peak systolic velocity was seen at all the follow- up visits .

Several retrospective studies have reported reduced responses to gonadotropin after cystectomy [18-21], and others reported a marked reduction in the number of both dominant follicles and retrieved oocytes in the operated ovary after cystectomy [3, 4, 6]. In contrast, some retrospective studies have not found adverse outcomes after ovarian cystectomy compared with controls (tubal infertility) [22-25]. Garcia-Velasco et al. [22] and Marconi et al.[25] reported that laparoscopic cystectomy of ovarian endometriomas did not affect ovarian response to gonadotropin stimulation, although the gonadotropin dose was higher in the cystectomy group.

Furthermore, most of the above-mentioned investigations were retrospective studies, and the patients who had been operated on were compared with those who had not been operated on, which can cause bias[8].

Fedele et al. [2] reported that bipolar electrocoagulation of the ovarian parenchyma during laparoscopic removal of endometriotic ovarian cysts adversely affected ovarian function, but they only studied FSH levels of endometrioma patients, which does not rule out ovarian damage by endometriosis itself. Candiani et al.[7] studied the antral follicle count, ovarian volume, stromal blood flow, and side of ovulation In 31 patients after laparoscopic cystectomy, but they failed to observe the reduction of stromal blood flow so they could not classify the possible mechanisms that caused gonad injury.

Potential limitations in our study are as follows. First, we did not design a randomized clinical trial, and no power analysis was used in the design of the study. Without randomization, it is possible that the patients in the suture group had a more favorable ovarian reserve than the other group although the general characteristics of the two groups before surgery revealed no statistically significant difference. Patients were informed about alternative approaches and chose what kind of surgical technique they wanted to receive. Second, we did not compare the basal antral follicle number, peak systolic velocity, and mean ovarian diameter of the diseased ovary before surgery, so we cannot rule out the possibility of any difference. Third, a single sample of FSH was obtained preoperatively, so we cannot demonstrate that FSH levels were uniform and unchanging before the surgery. Thus, one could argue that the change of FSH merely represents variability in FSH values in these women secondary to some type of ovarian dysfunction.

It would have been more scientific to compare bipolar electrocoagulation with hemostatic suturing using the laparoscopic route for both approaches. However, laparoscopic ovarian stripping using bipolar electrocoagulation and open laparotomy using hemostatic suture are the 2 most commonly used techniques for managing benign ovarian cysts at the study hospital, and the surgeons participating in the study did not have adequate experience with laparoscopic suturing techniques.

Table (1): Statistical comparison between the general characteristics of the two studied groups.

Characteristics	bipolar (N=50)		Suture (N=50)		t-test	P-value
Age (Years)						
$\bar{X}$±SD	24.2±3.1		25.2±3.0		-1.6	0.1
Laterality	**No**	**%**	**No**	**%**	**χ^2**	
Unilateral	28	56.0	27	54.0	0.04	0.8
Bilateral	22	44.0	23	46.0		
Cyst						
E	22	44.0	28	56.0		0.2
O	28	56.0	22	44.0	1.4	
Pregnancy occurred	2	4.0	4	8.0	Fisher exact test	0.7

Number of patients = 100 (50 patients in each group)
(P > 0.05): means non-significant
SD: Standard Deviation $\bar{X}$: Mean

Table (2):Statistical comparison between the mean values of serum FSH (mIU/mL) between unilateral bipolar and suture groups.

Mean values	Bipolar unilateral cyst (N=28)	Suture unilateral (N=27)	t-test	P-value
FSH preoperative level				
$\bar{X}$±SD	6.4±0.4	6.3±0.4	0.2	0.85
FSH 1st month				
$\bar{X}$±SD	10.6±0.3	7.2±0.4	34.5	0.000***
FSH 3rd month				
$\bar{X}$±SD	7.3±0.4	7.2±0.4	0.9	0.3
FSH 6th month				
$\bar{X}$±SD	6.8±0.4	6.7±0.4	0.9	0.3
p-value	0.000***	0.000***		

Number of patients = 55 (28 in the bipolar group and 27 in the suture group).
(P > 0.05): means non-significant
SD: Standard Deviation $\bar{X}$: Mean

Table (3):Statistical comparison between the mean values of serum FSH (mIU/mL) between bilateral bipolar and suture groups.

Mean values	Bipolar bilateral cyst (N=22)	Suture bilateral (N=23)	t-test	P-value
FSH preoperative level				
$\bar{X}$±SD	6.5±0.4	6.5±0.4	-0.2	0.86
FSH 1st month				
$\bar{X}$±SD	11.4±0.3	7.3±0.4	31.7	0.000***
FSH 3rd month				
$\bar{X}$±SD	10.7±0.3	6.9±0.4	33.5	0.000***
FSH 6th month $\bar{X}$±SD				
	10.5±0.3	6.7±0.4	32.7	0.000***
p-value	0.000***	0.000***		

Number of patients = 45 (22 in the bipolar group and 23 in the suture group).
(P > 0.05): means non-significant
SD: Standard Deviation $\bar{X}$: Mean

Table (4): Statistical comparison between the mean values of serum AMH (ng/mL) between unilateral bipolar and suture groups.

Mean values	Bipolar unilateral cyst (N=28)	Suture unilateral (N=27)	t-test	P-value
AMH preoperative level				
$\bar{X}$±SD	4.6±0.8	4.6±0.8	0.1	0.8
AMH 1st m				
$\bar{X}$±SD	2.4±.5	4.4±0.8	-10.9	0.000***
AMH 3rd m				
$\bar{X}$±SD	4.4±0.8	4.3±0.8	0.6	0.5
AMH 6th m mmonths				
$\bar{X}$±SD	4.5±0.8	4.4±0.8	0.1	0.9
p-value	0.000***	0.3		

Number of patients = 55 (28 in the bipolar group and 27 in the suture group).
(P > 0.05): means non-significant
SD: Standard Deviation $\bar{X}$: Mean

Table (5): Statistical comparison between the mean values of serum AMH (ng/mL) between bilateral bipolar and suture groups.

Mean values	Bipolar bilateral cyst (N=22)	Suture bilateral (N=23)	t-test	P-value
AMH preoperative level				
$\bar{X}$±SD	4.5±0.8	4.6±0.9	-0.1	0.8
AMH 1st m				
$\bar{X}$±SD	2.4±0.5	4.5±0.9	-9.5	0.000***
AMH 3rd m				
$\bar{X}$±SD	2.7±0.5	4.4±0.9	-7.9	0.000***
AMH 6th m				
$\bar{X}$±SD	2.5±0.4	4.5±0.9	-8.9	0.000***
p-value	0.000***	0.32		

Number of patients = 45 (22 in the bipolar group and 23 in the suture group).
(P > 0.05): means non-significant
SD: Standard Deviation $\bar{X}$: Mean

Table (6): Statistical comparison between the mean values of AFC, PSV (cm/s) and MOD (cm) on transvaginal Ultrasound examinations of the intact ovaries between unilateral bipolar and suture groups:

Mean values	Bipolar unilateral cyst (N=28)	Suture unilateral (N=27)	t-test	P-value
1st month				
AFC	6.6 ± 2.3	6.4 ± 2.5	0.1	0.75
PSV	12.7 ± 2.2	13.3 ± 1.8	1.2	0.27
MOD	2.3 ± 0.6	2.4 ± 0.9	0.48	0.49
3rd month				
AFC	7.0 ± 3.0	6.5 ± 3.1	0.37	0.54
PSV	12.4 ± 2.9	12.2 ± 3.1	0.06	0.80
MOD	2.4 ± 0.6	2.5 ± 0.4	0.73	0.39
6th month				
AFC	6.8 ± 2.1	6.7 ± 2.2	0.03	0.86
PSV	12.4 ± 3.5	12.1 ± 3.6	0.10	0.75
MOD	2.4 ± 0.5	2.4 ± 0.6	0.00	0.98

Number of patients = 55 (28 in the bipolar group and 27 in the suture group).
(P > 0.05): means non-significant
AFC: Antral Follicle Count
PSV: Peak Systolic Velocity
MOD: Mean Ovarian Diameter

Table (7):Statistical comparison between the mean values of AFC, PSV (cm/s) and MOD (cm) on transvaginal Ultrasound examinations of the operated ovaries between unilateral bipolar and suture groups:

Mean values	Bipolar unilateral cyst (N=28)	Suture unilateral (N=27)	t-test	P-value
1st month				
AFC	3.3 ± 1.9	3.6 ± 2.2	0.3	0.6
PSV	8.8 ± 3.2	10.8 ± 4.2	3.9	0.05*
MOD	2.4 ± 0.7	2.6 ± 0.4	1.3	0.3
3rd month				
AFC	4.1 ± 2.4	5.8 ± 2.5	6.6	0.01**
PSV	6.4 ± 2.5	10.4 ± 3.8	4.6	0.03*
MOD	2.0 ± 0.5	2.9 ± 0.6	36.6	0.000***
6th month				
AFC	4.0 ± 2.0	6.1 ± 2.8	10.3	0.002**
PSV	7.9 ± 3.0	11.1 ± 3.5	13.3	0.000***
MOD	1.9 ± 0.5	2.9 ± 0.5	54.9	0.000***

Number of patients = 55 (28 in the bipolar group and 27 in the suture group).
(P > 0.05): means non-significant
AFC: Antral Follicle Count
PSV: Peak Systolic Velocity
MOD: Mean Ovarian Diameter

Table (8): Statistical comparison between the mean values of AFC, PSV (cm/s) and MOD (cm) on transvaginal Ultrasound examinations of the ovaries between bilateral bipolar and suture groups:

Mean values	Bipolar bilateral cyst (N=22)	Suture bilateral (N=23)	t-test	P-value
1st month				
AFC	3.0 ± 2.5	3.0 ± 2.1	0.0	1.0
PSV	8.4 ± 2.9	10.2 ± 3.4	4.1	0.05*
MOD	2.2 ± 0.6	2.4 ± 0.2	1.5	0.23
3rd month				
AFC	3.6 ± 2.0	4.8 ± 2.3	3.5	0.05*
PSV	8.0 ± 3.7	11.0 ± 2.9	9.2	0.004**
MOD	2.0 ± 0.5	2.6 ± 0.4	19.8	0.000***
6th month				
AFC	4.0 ± 2.6	5.9 ± 2.4	6.5	0.01**
PSV	7.8 ± 4.0	11.2 ± 3.8	9.9	0.003**
MOD	1.79 ± 0.3	2.4 ± 0.5	4.9	0.03*

Number of patients = 45 (22 in the bipolar group and 23 in the suture group).
(P > 0.05): means non-significant
AFC: Antral Follicle Count
PSV: Peak Systolic Velocity
MOD: Mean Ovarian Diameter

CONCLUSION

The purpose of this study was not to demonstrate that laparoscopic cystectomy is a bad choice for benign ovarian cysts. In fact, laparoscopic cystectomy has many advantages over conventional laparotomy, including reduced morbidity, shorter hospital stays, faster recovery time, and fewer postoperative adhesions .Ovarian cysts must be removed, but ovarian reserve is limited and nonreversible once damaged. The risks are clear—the more important question is how to reduce the damage.

Our results should make laparoscopic surgeons aware of the potential damage that electrocoagulation may induce on healthy ovarian parenchyma. A minimally invasive approach should consider not only the size of incision, but also the potential damage to organ function. Gentle, careful electrocoagulation of the bleeders after stripping the capsule during cystectomy is of paramount importance. Moreover, the surgeon should avoid electrocoagulation of the remaining ovarian stroma and the ovarian hilus . It is important to use some kind of cooling solution to minimize the thermal spread. In spite of the longer operative time and the need for proper training, synthesis of the ovary by suturing after removal of the cyst wall seems a valid alternative in such cases .

The results of our study support the following observations. First, the laparoscopic excision of ovarian cysts is associated with a statistically significant reduction in ovarian reserve. Second, the damage cannot be ascribed merely to the amount of ovarian tissue removed during surgery; the damage to the ovarian vascular system by electrocoagulation is another factor. However, further studies in a larger number of patients are required to make certain judgments whether the injury is related to other factors and to ascertain which is the less harmful alternative therapeutic approach.

REFERENCES

1. Alborzi S, Zarei A, Alborzi S, Alborzi M. Management of ovarian endometrioma. Clin Obstet Gynecol 2006;49:480–91.
2. Fedele L, Bianchi S, Zanconato G, Bergamini V, Berlanda N. Bipolar electrocoagulation versus suture of solitary ovary after laparoscopic excision of ovarian endometriomas. J Am Assoc Gynecol Laparosc 2004;11:344–7.
3. Somigliana E, Ragni G, Benedetti F, Borroni R, Vegetti W, Crosignani PG. Does laparoscopic excision of endometriotic ovarian cysts significantly affect ovarian reserve? Insights from IVF cycles. Hum Reprod 2003;18:2450–3.
4. Nargund G, Cheng WC, Parsons J. The impact of ovarian cystectomy on ovarian response to stimulation during in-vitro fertilization cycles. Hum. Reprod 1996;11:81–3.
5. Loh FH, Tan AT, Kumar J, Kumar J, Ng SC. Ovarian response after laparoscopic ovarian cystectomy for endometriotic cysts in 132 monitored cycles. Fertil Steril 1999;72:316–21.
6. Ho HY, Lee RK, Hwu YM, Lin MH, Su JT, Tsai YC. Poor response of ovaries with endometrioma previously treated with cystectomy to controlled ovarian hyperstimulation. J Assist Reprod Genet 2002;19: 507–11.
7. Candiani M, Barbieri M, Bottani B, Bertulessi C, Vignali M, Agnoli B, et al. Ovarian recovery after laparoscopic enucleation of ovarian cysts: Insights from echographic short-term postsurgical follow-up. J Minim Invasive Gynecol 2005;12:409–14.
8. Li CZ, Liu B, Wen ZQ, et al. The impact of electrocoagulation on ovarian reserve after laparoscopic excision of ovarian cysts: A prospective clinical study of 191 patients. Fertility and Sterility 2009; 92(4): 1428-1435.
9. Fedele L, Bianchi S, Zanconato G, Bergamini V, Berlanda N. Bipolar electrocoagulation versus suture of solitary ovary after laparoscopic excision of ovarian endometriomas. J Am Assoc Gynecol Laparosc 2004;11(3):344–7.
10. Somigliana E, Ragni G, Benedetti F, Borroni R, Vegetti W, Crosignani PG. Does laparoscopic excision of endometriotic ovarian cysts significantly affect ovarian reserve? Insights from IVF cycles. Hum Reprod 2003;18(11):2450–3.
11. Tremellen KP, Kolo M, Gilmore A, Lekamge DN. Anti-Müllerian hormone as a marker of ovarian reserve. Aust N Z J Obstet Gynaecol 2005;45(1):20–4.
12. Cate RL, Mattaliano RJ, Hession C, Tizard R, Farber NM, Cheung A, et al. Isolation of the bovine and human genes for Müllerian inhibiting substance and expression of the human gene in animal cells. Cell 1986;45(5):685–98.
13. Durlinger AL, Visser JA, Themmen AP. Regulation of ovarian function: the role of anti-Müllerian hormone. Reproduction 2002;124(5):601–9.
14. Chang HJ, Han SH, Lee JR, Jee BC, Lee BI, Suh CS, et al. Impact of laparoscopic cystectomy on ovarian reserve: serial changes of serum anti-Müllerian hormone levels. Fertil Steril 2010;94(1):343–9.
15. Maneschi F, Marasa L, Incandela S, Mazzarese M, Zupi E. Ovarian cortex surrounding benign neoplasms: a histologic study. Am J Obstet Gynecol 1993;169:388–93.
16. Muzii L, Bianchi A, Croce C, Manci N, Panici PB. Laparoscopic excision of ovarian cysts: is the stripping technique a tissue-sparing procedure? Fertil Steril 2002;77:609–14.
17. La Torre R, Montanino-Oliva M, Marchiani E, Boninfante M, Montanino G, Cosmi EV. Ovarian blood flow before and after conservative laparoscopic treatment for endometrioma. Clin Exp Obstet Gynecol 1998;25:12–4.

18. Pagidas K, Falcone T, Hemmings R, Miron P. Comparison of reoperation for moderate (stage III) and severe (stage IV) endometriosis-related infertility with in vitro fertilization–embryo transfer. Fertil Steril 1996;65:791–5.
19. Al-Azemi M, Bernal AL, Steele J, Gramsbergen I, Barlow D, Kennedy S. Ovarian response to repeated controlled stimulation in in-vitro fertilization cycles in patients with ovarian endometriosis. Hum Reprod 2000;15: 72–5.
20. Tinkanen H, Kujansuu E. In vitro fertilization in patients with ovarian endometriomas. Acta Obstet Gynecol Scand 2000;79:119–22.
21. Geber S, Ferreira DP, Spyer Prates LF, Sales L, Sampaio M. Effects of previous ovarian surgery for endometriosis on the outcome of assisted reproduction treatment. Reprod Biomed Online 2002;5:162–6.
22. Garcia-Velasco JA, Mahutte NG, Corona J, Z_u~niga V, Gil_es J, Arici A, et al. Removal of endometriomas before in vitro fertilization does not improve fertility outcomes: a matched, case-control study. Fertil Steril 2004;81:1194–7.
23. Donnez J, Nisolle M, Gillet N, Smets M, Bassil S, Casanas-Roux F. Large ovarian endometriomas. Hum Reprod 1996;11:641–6.
24. Canis M, Pouly JL, Tamburro S, Mage G, Wattiez A, Bruhat MA. Ovarian response during IVF–embryo transfer cycles after laparoscopic ovarian cystectomy for endometriotic cysts of >3 cm in diameter. Hum Reprod 2001;16:2583–6.
25. Marconi G, Vilela M, Quintana R, Sueldo C. Laparoscopic ovarian cystectomy of endometriomas does not affect the ovarian response to gonadotropin stimulation. Fertil Steril 2002;78:876–8.
26. Mohamed ML, Nouh AA, El-Behery MM, et al. Effect on ovarian reserve of laparoscopic bipolar electrocoagulation versus laparotomic hemostatic sutures during unilateral ovarian cystectomy. Internal Journal of Gynecology and Obstetrics 2011; 114: 69-72.