Middle East Fertility Society Journal Vol. 10, No. 2, 2005

REVIEW

Role of laparoscopic surgery in infertility

Bulent Berker, M.D.*
Ali Mahdavi, M.D.†
Babac Shahmohamady, M.D.‡
Camran Nezhat, M.D.§

Center for Special Minimally Invasive Surgery, Stanford University Medical Center, Palo Alto, California, USA

Recent advances in endoscopic surgical techniques and the increased sophistication of surgical instruments have offered new operative methods and techniques for the gynecologic surgeon (1). Recent years have witnessed a marked increase in the number of gynecological endoscopic procedures performed, mainly as a result of technological improvements in instrumentation. The addition of a small video camera to the laparoscope (videolaparoscopy) greatly enhanced the popularity of operative endoscopy because of the possibility of operating in a comfortable, upright position and using the magnification capabilities of the camera (2,3).

*Bulent Berker, M.D., Post Doctoral Fellow, Center for Special Minimally Invasive Surgery, Stanford University Medical Center, Palo Alto, California 94304
† Ali Mahdavi, M.D., F.A.C.O.G. Minimally Invasive Surgery Fellow, Division of Gynecologic Oncology, Department of Obstetrics, Gynecology and Reproductive Science, The Mount Sinai Medical Center, 1176 Fifth Avenue, Box 1173, New York, NY 10029
‡ Babac Shahmohamady, M.D., Post Doctoral Fellow, Center for Special Minimally Invasive Surgery, Stanford University Medical Center, Palo Alto, California 94304
§ Camran Nezhat, M.D., President Society of Laparo-endoscopic Surgeons, Director of Center for Special Minimally Invasive Surgery, Clinical Professor of OB/Gyn, Clinical Professor of Surgery, Stanford University School of Medicine
Corresponding Author: Camran Nezhat, M.D. FACOG, FACS, 900 Welch Road, Suite 403, Palo Alto, CA 94304, Email: cnezhat@stanford.edu, Tel: (650) 327-8778, Fax: (650) 327-2794

Currently, laparoscopy is perceived as a minimally invasive surgical technique that both provides a panoramic & magnified view of the pelvic organs and allows surgery at the time of diagnosis. Laparoscopy has become an integral part of gynecologic surgery for the diagnosis and treatment of abdominal and pelvic disorders of the female reproductive organs. Endoscopic reproductive surgery intended to improve fertility may include surgery on the uterus, ovaries, pelvic peritoneum, and the Fallopian tubes. The aim of this review is to critically review the role of laparoscopy in the management of infertility patients.

ENDOSCOPIC TUBAL SURGERY

A variety of procedures is collectively known as tubal surgery; salpingo-ovariolysis is division of adhesions involving Fallopian tube and ovary; salpingostomy is the refashioning of a distal tubal ostium for distal tubal occlusion and is designed to keep the Fallopian tube open; tubal reanastomosis is the rejoining of Fallopian tubes typically performed for reversal of sterilization; cornual anastomosis and utero-tubal implantation are recognized surgical treatments for corneal occlusion (4). All these procedures can be easily and effectively performed by laparoscopic surgery.

Adhesiolysis

Adhesions involving the fallopian tube are implicated as a cause of infertility. The decision to treat such disease to increase fertility rates may be based on certain prognostic factors associated with future fecundity. Regardless of whether performed via microsurgical techniques or via laparoscopy, data show that the removal of filmy adhesions is associated with improved fecundity. In the only controlled study examining this issue, salpingo-ovariolysis was performed in 69 infertile women with pelvic adhesions, while 78 women with a similar degree of adhesions were not treated (5). The cumulative pregnancy rate at 24 months follow-up was significantly higher in treated women, 45 versus 16 percent in the untreated group. Although adhesiolysis was done at laparotomy, equivalent results can be expected with laparoscopic adhesiolysis. In one study, one hundred sixty-seven patients with pelvic adhesions suffering from inability to conceive underwent operative laparoscopy and CO2 laser adhesiolysis (6). According to the severity of adhesions, the patients were categorized by diagnostic laparoscopy as mild, group I; moderate, group II; and severe, group III. After laparoscopic adhesiolysis, all patients were followed for one year. Pregnancy occurred in 51 (70.8%), 28 (48.3%), and 8 (21.6%) patients in group I, II, and III, respectively. Laparoscopic adhesiolysis still remains a useful and effective procedure for infertile couples with pelvic adhesions.

Salpingo-ovariolysis as a fertility-enhancing procedure is done by separating periadnexal adhesions with laparoscopic scissors, electrocautery or the laser. Before being divided, the adhesions can be stretched with laparoscopic forceps and an intrauterine canula. Vascular adhesions should be coagulated before being separated. Endoscopic surgery is precise enough that adhesions can be excised without destroying surrounding tissue or damaging vital structures such as the ureters, bladder and bowel. Removal of all adhesions and restoration of the normal anatomic relationship of the pelvic organs will certainly enhance the fertility (1). It has been claimed that second-look laparoscopy with adhesiolysis following pelvic reproductive surgery may increase the intrauterine pregnancy rate and decrease the ectopic pregnancy rate; however a recent systematic review of randomized controlled trials has failed to show a significant benefit of second-look laparoscopy with adhesiolysis following pelvic reproductive surgery (4). Future randomized controlled trials are necessary to give an adequate answer to this clinical approach.

In addition to the severity of the pre-existing disease, postoperative adhesion formation is the most important determinant of the success of infertility surgery and is largely responsible for the majority of failures associated with these procedures. An inverse relationship exists between the grade of adhesions and pregnancy rates, regardless of the condition of the adnexa. Increased rate of adhesion formation has been reported in the majority of patients underwent reproductive surgery by laparotomy (7,8). When performed by laparotomy, reproductive pelvic surgery procedures are frequently complicated not only by adhesion reformation but also by de novo adhesion formation. However, endoscopic surgery fulfills the important microsurgical principles of gentle handling of tissue, constant irrigation, meticulous hemostasis, and precise tissue dissection without the need for laparotomy, which is itself a significant invasion of the peritoneal cavity. In their study, Nezhat et al. demonstrated that endoscopic reproductive surgery was very effective in reducing peritoneal adhesions, was associated with a low frequency of postoperative adhesion recurrence and mostly avoided the formation of de novo adhesions at most surgical sites (9).

Hydrosalpinx

Hydrosalpinx is a chronic pathological condition of the Fallopian tube, and is a major cause of infertility. In most patients, the fimbriated end of the tube adjacent to the ovary is occluded and the distal half of the tube is distended with fluid (10). The main causes of hydrosalpinx are pelvic inflammatory disease, ectopic pregnancy, previous abdominal operations, and a history of peritonitis and tuberculosis (11). Distal occlusion may also result from endometriosis (12). The presence of hydrosalpinx can be diagnosed by

hysterosalpingogram or by laparoscopy with or without chromopertubation. A meta-analysis of all the studies comparing hysterosalpingography to the gold standard of laparoscopy with chromopertubation showed the hysterosalpingogram to have a sensitivity of 65% in the diagnosis of tubal obstruction and a specificity of 83% (13,14). Laparoscopy provides both the certain diagnosis and the treatment of hydrosalpinx at the same session.

Distal tubal occlusion with a hydrosalpinx has been reported to be associated with a lower implantation rate per embryo as well as with a lower clinical pregnancy rate. One meta-analysis demonstrated the deleterious effects of hydrosalpinx on achieving pregnancy in women undergoing IVF. It was shown that the clinical pregnancy rate was about 50 percent lower and the miscarriage rate was more than twofold higher in patients with hydrosalpinx (1144 IVF cycles) compared to the patients without hydrosalpinx (5569 IVF cycles) (15). There may be a direct effect on embryos, as well as an alteration in uterine implantation. The proposed mechanism by which embryo toxicity occurs begins with a leakage of the fluid from the hydrosalpinx into the uterine cavity. This fluid may not only be harmful to embryos but may have an effect on uterine receptivity and implantation mechanisms. In addition to improving overall pregnancy rates by removal of the diseased tubes, it has been suggested that treatment decreases the rate of miscarriage compared with those with untreated hydrosalpinges (16).

Shelton et al. were the first to conduct a prospective study that demonstrated a positive impact on pregnancy rates in patients with repeated IVF failures by removing the hydrosalpinges (17). Fifteen patients with unilateral or bilateral hydrosalpinges with a history of repeated IVF failures underwent laparoscopic excision of the affected tubes. Because the patients undergoing surgical excision served as their own control, the ongoing pregnancy rate per transfer was 0% presalpingectomy. After salpingectomy the ongoing pregnancy per transfer rate was 25%. Improved pregnancy rates were noted for both the fresh and frozen embryo transfers after surgery. Pregnancy rates can be improved by removal of the hydrosalpinx prior to IVF. A Cochrane review confirmed that the odds of pregnancy were increased with laparoscopic salpingectomy for hydrosalpinges prior to IVF (OR = 1.75, 95 percent CI 1.07 to 2.86), as were the odds of ongoing pregnancy/live birth (OR = 2.13, 95 percent CI 1.24 to 3.65) (18). All these data demonstrate that laparoscopic salpingectomy for hydrosalpinges is the preferred procedure for improving pregnancy rates.

Endoscopic surgery in the management of tubal obstruction

Fallopian tube disorders are responsible for over 20 to 30% of female infertility world wide. In the literature, there have been many techniques used in the treatment of tubal disease. These range from observation to laparotomy, gaseous insuflation, hydrotubation, microsurgery to the more recent laparoscopic surgery, modern microsurgery using the CO_2 laser and the micro endoscopic procedures. Currently, a 50% overall success rate in surgery on the fallopian tube has been claimed. This improvement may be due to the recent development of endoscopic techniques that have lead to better assessment of tubal disease and less invasive tuboplasty or tubal recanalisation procedures. Irrespective of the type of surgical procedure, the general principles of infertility surgery include gentle manipulation, meticulous hemostasis, prevention of post operative infection and adhesion formation. These could be met by the use of good magnification instruments, continuous saline cleansing, pinpoint hemostasis and gentle manipulation.

Proximal disease is found in 10-25% of cases of tubal infertility. Proximal tubal obstruction is most commonly due to salpingitis isthmica nodosa, and disease is usually limited to the proximal tube unlike distal disease which is more often pan-tubal. For proximal tube lesions or obstruction, treatment by endoscopic techniques includes tubocornual anastomosis. The goal of this technique is to resect the damaged portion of fallopian tube. Proximal tubal surgery is rarely performed nowadays outside very few specialized centers. Disease of the distal tube can be secondary to any pelvic inflammatory condition including infection, endometriosis, appendicitis and abdomino-pelvic surgery. Tubal preservation surgery for distal tubal lesions

includes salpingostomy and fimbrioplasty. An occluded distal tube in the presence of no adhesions is associated with more favorable outcomes.

There may be discrepancies between the findings at HSG, laparoscopy and intraluminal endoscopy in the presence of peritubal adhesions or endometriosis (19). Patency of the distal tube does not necessarily equate with normality of the mucosa and pathological lesions may be missed if more accurate methods of tubal assessment are not employed. Fimbrioscopy and salpingoscopy are the procedures that can be performed to ascertain the quality of the fimbriae, endosalpinx and the prognosis for future fertility (12).

Tubal Anastomosis

Indications for tubal anastomosis include reversal of sterilization, midtubal block secondary to pathology, tubal occlusion from ectopic pregnancy, and salpingitis isthmica nodosa. The goal is to remove abnormal tissue and reapproximate the healthy tubal segments with as little adhesion formation as possible. Although not always successful, sterilization reversal is the most successful surgical reconstructive procedure for improving fertility. Several factors dictate success after a tubal ligation reversal procedure. Knowing how the initial sterilization was accomplished and the remaining tubal length are fundamental to counseling patients on outcome. In one large series, for example, tubal anastomosis resulted in live births in 41 percent of women with a previous electrocautery procedure, 50 percent of those who had a Pomeroy tubal ligation, 75 percent of women with rings, and 84 percent of those with clips (20). Regarding tubal length, in one study, a normal pregnancy occurred in every patient if the total tubal length was ≥5 cm before reversal. The pregnancy rate decreased by 50% if the length was 3 to 4 cm, whereas no patient became pregnant if there was ≤3 cm of tube (21).

The likelihood of pregnancy after tubal reversal versus other interventions should be discussed with the patient before formulating a treatment plan. In selecting patients for surgery, a tubal reversal performed by the reproductive surgeon offers a reasonable degree of success. The patient's age, ovarian function, and tubal condition are all factors to be weighed in counseling outcomes and likelihood of future fertility.

LAPAROSCOPIC MYOMECTOMY AND PREGNANCY OUTCOME

Uterine leiomyomas are the most common tumor of the female reproductive tract and affect 30-40% of reproductive-age women. Although they are seldom the sole cause of infertility, myomas have been linked to fetal wastage and premature delivery. Several elements indicate that myomas are responsible for infertility. For example, pregnancy rate is lower in patients with myomas, and in cases of medically assisted procreation, the implantation rate is lower in patients presenting interstitial myomas. There are other indirect evidences supporting a negative impact, including lengthy infertility before surgery (unexplained by other factors), and rapid conception after myomectomy (22). Approximately 50% of women who have not previously conceived become pregnant after myomectomy (23). Because medically treated fibroids tend to grow back or recur, most fibroids that cause symptoms are managed surgically. Depending on their number and their location myomas with mostly intracavitary development should be dealt with by hysteroscopy. Interstitial and subserosal myomas can be operated either by laparotomy or by laparoscopy. Technological advancements in endoscopic instrumentation, equipment and the surgeon's expertise have lead to an ever-increasing number of informed women choosing the advantages of the new and innovative techniques utilizing hysteroscopy and laparoscopy. Laparoscopy is most often employed in women that are diagnosed early when their fibroids are small and more suited to laparoscopic removal. However, new surgical devices called oscillators allow the safe and efficient removal of fibroid tumors much larger than could have been accomplished in the past. It is imperative to know the size, location and number of uterine myomas. This is especially important in a laparoscopic approach to myomectomy as tactile feedback is diminished.

As fertility preservation is one of the primary goals of myomectomy, the marked reduction of adhesion formation by laparoscopic myomectomy (LM) gives it a distinct advantage over laparotomy. The incidence of adhesions following laparotomic myomectomy and laparoscopic myomectomy is nearly 100% and 36-67%, respectively (24-28). These adhesions can adversely affect fertility, cause pain, and increase the risk of ectopic pregnancy. Dubuisson et al. studied the risk of adhesions after LM (28). A second look procedure was performed in 45 of 271 LM patients. Additional laparoscopic procedures were performed at the time of LM in 19 patients (42.2%). The overall postoperative adhesion rate was 35.6%, with 16.7% of myomectomy sites affected. Most importantly, the adnexal adhesion rate was 24.4% with 11.1% bilaterally. In patients without associated laparoscopic procedures the adhesion rates were even lower, with an overall adhesion rate of 26.9% and an adnexal adhesion rate of only 11.5%, none of which was bilateral. Other factors that are related with the increase in the risk of adhesions are depth (intramural and submucosal), posterior location, and suturing.

The factors responsible for prolonged surgical times in LM are the need to morcellate large or multiple fibroids for removal through the trocar and suture repair of the myometrium. In 1994, we described Laparoscopically-assisted myomectomy (LAM) where myoma enucleation was done laparoscopically or through a 5 cm Pfannenstiel minilaparotomy, following which the uterus could be exteriorized for palpation and multilayered open suturing (29). This technique combines the advantages of increased exposure, visibility, and magnification provided by the laparoscope (especially for evaluation of the posterior cul-de-sac and under the ovaries) with the ease of adequate uterine repair and removal of specimen that is associated with mini-laparotomy. LAM is a safe alternative to LM and is less difficult and less time consuming. This technique can be used for large (greater than 8 cm), multiple or deep intramural myomas. Using a combination of laparoscopy and a 2-4 cm abdominal incision, uterine defect can be closed in three layers to reduce the risk of uterine dehiscence, fistula and adhesion formation. Women who desire future fertility and require myomectomy for an intramural tumor may benefit from LAM to ensure proper closure of the myometrial incision. Cesarean delivery is recommended in patients who have deep intramural or multiple myomas even if the endometrial cavity is not entered.

One of the concerns regarding LM has been adequate reconstruction and healing of the uterine defect with subsequent ability for the uterus to withstand the elements associated with pregnancy and labor. Concerns have been raised regarding complications of pregnancy after LM, such as uterine dehiscence or rupture. This latter complication is rare, and has been reported in women who conceive after both laparotomic myomectomy and laparoscopic myomectomy. Its real incidence remains unknown, as several reports investigating the follow-up of myomectomy failed to document any case of uterine dehiscence. Several factors may increase the risk of uterine wall rupture after LM, including extensive use of electrosection for fibroid cleavage. This may contribute to adjacent myometrial necrosis and thereby impair surgical wound healing. At laparotomy, closure of the excision site is usually accomplished by a multilayered suture. With operative laparoscopy, suturing can be cumbersome and tedious, and restoration of the uterine wall integrity to an equivalent manner may be difficult. The four reported cases of dehiscence following LM (30-33) occurred during the third-trimester of pregnancy. No cases of dehiscence occurred in the study of Soriano et al., even though 75% of the laparoscopy patients and 50% of the LAM patients gave birth by the vaginal route (34). In our series, a total of 115 women underwent LM for pressure and pain, abnormal bleeding and/or infertility (35). Of the 115 women, there were 42 pregnancies in 31 patients. Average length of follow-up from the date of surgery was 43 months. This series did not confirm the hypothesis that LM is associated with an increased risk for uterine dehiscence during pregnancy. However, we have recently reported uterine rupture following LM at 3rd trimester. Furthermore, a larger series and randomized clinical trials are needed to make a conclusive judgment. In any case, LM should be performed cautiously. Excess thermal damage should be avoided and adequate uterine repair must

Table 1. Pregnancy outcome after laparoscopic myomectomy

Author	No. of patients	Average Number of myomas removed	Average size of myomas (cm)	No. of pregnancies achieved
Hasson et al. (1992)	56	144 total	range 3-16	15
Dubuisson et al. (1996)	21	2	6.2	7
Stringer et al. (1996)	5	2	3.6	5
Seinea et al. (1997)	54	1	4.2	5
Darai et al. (1997)	143	1.5	5.4	19
Nezhat et al. (1999)	115	3	5.9	42
Dessolle et al. (2001)	88	1.7 (range 1-4)	6.2 cm (range 3-11)	42

be assured using multiple layer suturing techniques.

Aside from the dehiscence case reports, few studies have evaluated pregnancy rate after LM (26, 35-40). Their results are summarized in Table 1. In our study, the observed frequency of miscarriages, ectopic pregnancies and preterm deliveries in our series was within normal limits. Additionally, few studies (41,42) have evaluated the effect of myoma uteri on the pregnancy rate after assisted reproductive treatment (ART). Eldar-Geva et al. (41) compared 106 ART cycles in patients with uterine fibroids with 318 ART cycles in age-matched patients without fibroids and concluded that implantation and pregnancy rates were significantly lower in patients with intramural or submucosal fibroids, even those with no deformation of the uterine cavity. Stovall et al. (42) showed that even after patients with submucosal fibroids are excluded, the presence of fibroids reduces the efficacy of ART. Therefore, if women with unexplained infertility have a better chance of conception after myomectomy and if the main factors in treatment success are patient age and duration of infertility, this conservative operation should not be postponed for too long. Although the indications for laparotomy and for laparoscopic surgery for myomectomy are completely different, the fertility results observed after each of these techniques are comparable. Excellent pregnancy rates obtained for those infertile patients with no other associated factor to explain their infertility. After IVF, implantation rates are better in patients without interstitial myoma. Consequently, the goal of the myomectomy will essentially be to optimize the results of ART, rather than to hope for a spontaneous pregnancy.

ENDOSCOPIC SURGERY IN ENDOMETRIOSIS ASSOCIATED INFERTILITY

Endometriosis is a heterogeneous disease with typical and atypical morphology and spans a spectrum from a single 1-mm peritoneal implant to 10-cm or larger endometriomas with cul-de-sac obliteration (43). The American Society for Reproductive Medicine revised classification system for endometriosis (ASRM 1996) is the most widely accepted staging system (44). Endometriosis is frequently associated with infertility. Indeed, 30% to 70% of infertile women have been reported to have endometriosis (45). Fecundity rates in women with endometriosis tend to be lower than normal, and despite extensive research, no agreement has been reached concerning the mechanism of infertility. Severe endometriosis is associated with pelvic adhesions and a distortion of pelvic anatomy leading to a possible mechanic or anatomic disturbance of fertility. However, the impact of mild and moderate endometriosis on fertility is less obvious, so many putative mechanisms have been suggested. These fall into three broad groups: disorders of folliculogenesis or endocrine abnormality, inflammatory or immunological abnormality, and increased miscarriage rate. The exact relationship between infertility and endometriosis, in the absence of pelvic distortion, is unknown (46).

As previously reported we classify endometriomas into two kinds (47,48). Type I endometriomas are pure endometriomas made up of endometrial glands and stroma. These endometriomas result from invagination of endometriosis plaques into the stroma. In general, type I endometriomas are 1 to 2 cm in size. Although theoretically can get larger, the maximum diameters observed in our practice have been less than 5 cm. While small, these endometriomas are difficult to remove intact because of associated fibrosis and adhesions. They can be biopsied, drained, and vaporized by using a laser or electrosurgery or removed in pieces. Most often surgeons end up coagulating these endometriomas which leads to inadequate treatment. Type II endometriomas are invasion of functional cysts like corpus luteum in varying degrees by endometriosis plaques. Therefore, only the excision of the endometriosis plaques will aid to the preservation of the ovarian reserve. Type IIA endometriomas are hemorrhagic cysts and grossly look like endometriomas. The cyst wall is separated easily from the ovarian tissue. Endometrial implants are superficial and adjacent to a hemorrhagic cyst, which is either follicular or luteal in origin; microscopically, no endometrial lining is seen. Type IIB and type IIC endometriomas are large and are associated with periovarian adhesions that attach them to the pelvic side wall and the back of the uterus. In type IIB lesions, the cyst lining is separated easily from the ovarian capsule and stroma except near the endometrial implant. In type IIC lesions, surface endometrial implants penetrate deeply into the cyst wall, making excision difficult. Histologic findings of endometriosis are seen in the cyst wall in these two subtypes. Furthermore, the value of initial surgery in the treatment of moderate or severe endometriosis-related infertility is well established. Initial surgery has been reported to give cumulative pregnancy rates of up to 65 to 70% for 2 years after treatment (49,50).

Technique of endoscopic surgery in endometriosis

Since laparotomy does not seem to have any advantages in terms of pregnancy rate or recurrence rate in the surgical treatment of ovarian endometrioma (51), laparoscopy can be considered to be the best surgical approach for ovarian endometriotic cysts. Although details can be found somewhere else (48), here, we want to summarize our practice in the treatment of endometriosis. The goal of treating of peritoneal endometriosis is to destroy the implants in the most effective and the least traumatic way to minimize the formation of postoperative adhesions. Hydrodissection and CO_2 laser are the best choices for treatment. Superficial peritoneal endometriosis is vaporized with the laser, coagulated with monopolar or bipolar current or excised. Implants less than 2 mm can be coagulated, vaporized, or excised. When lesion is greater that 3 mm, vaporization or excision is needed. Lesions greater than 5 mm must be excised or deeply vaporized. For the treatment of endometriomas the cyst wall is opened, halved and dissected. Mainly, there are two different surgical techniques to treat the endometrioma: (i) cystectomy with excision of the endometriotic cyst; and (ii) drainage/ aspiration of the cyst content and ablation of the cyst capsule with laser or electrocoagulation. After the capsule is stripped from the ovary, the base is cauterized to seal tiny blood vessels and help ensure that the entire endometrioma has been removed. Draining endometrioma or partially removing its wall is inadequate because the cyst lining remains functional leading to reoccurrence of the symptoms. If possible sutures should not be used since they can cause adhesion formation. However, when necessary, suture is placed within ovarian stroma, and the knot is tied inside the ovary, to minimize adhesion formation.

Fertility outcomes after endoscopic surgery

In 1986, we reported our results for the treatment of endometriosis associated infertility patients with videolaseroscopy (52). The carbon dioxide laser has been used laparoscopically for the removal of endometriotic implants, excision of endometrioma capsules, and lysis of adnexal adhesions in 102 patients. Of 102 patients presenting with infertility attributed to endometriosis, 60.7% conceived within 24 months after laser laparoscopy. The rates of conception after

Table 2. Studies comparing the number of follicles in the operated and in the contralateral non-operated ovary during IVF techniques

Reference	Surgical technique	No. of cycles	Control ovary	Operated ovary	P
Nargund et al. (1996)	Not reported	90	8.9±5.1	6.3±5.2	<0.001
Loh et al. (1999)	Cyst enucleation	12	3.6	4.6	NS
Donnez et al. (2001)	Cyst wall vaporization	87	6.6±3.5	5.2±3.0	NS
Ho et al. (2002)	Cyst enucleation	38	3.3±2.1	1.9±1.5	<0.001
Somigliana et al. (2003)	Cyst enucleation	46	4.2±2.5	2.0±1.5	<0.001

surgery were as follows: 75% for patients with mild endometriosis, 62% for patients with moderate endometriosis, 42.1% for patients with severe endometriosis, and 50% for patients with extensive endometriosis. Controversy remains regarding the benefit of surgical treatment of endometriosis in respect of improvement in fecundity at the time of laparoscopy (53,54). However, because of the progressive nature of the disease in many patients, combined with the largest prospective, randomized trial demonstrating improved fecundity with therapy at the time of surgery, it appears prudent to ablate endometriotic lesions at the time of endoscopic surgery in patients with minimal and mild endometriosis (55-57). Since there are no prospective, randomized studies yet, we are unable to draw any conclusions as to whether endoscopic treatment of advanced endometriosis will improve reproductive outcome, however, there is no reason to be pessimistic. Hence, if the multiple aspects of the reproductive cycle are found to be impaired in women with endometriosis or endometriomas as some investigators claim, it can be normalized by surgery. Supporting this, a 50% pregnancy rate was obtained after laparoscopic management in a series of 814 women with endometriomas (58). It could be that the removal or destruction of endometriomas provides more benefit than simply restoring the normal anatomy and ovarian structure.

However, it has been suggested that ovarian surgery in cases of ovarian endometriomas could be deleterious for the residual normal ovarian tissue either by removing ovarian stroma with oocytes together with the capsule or by thermal damage provoked by coagulation. In a case controlled study, Aboulghar et al. reported that the outcome of IVF in stage IV endometriosis with previous surgery was significantly lower compared with an age-matched group of tubal factor infertility (59). Some investigators reported a marked reduction in the number of both dominant follicles and retrieved oocytes in the operated ovary (60-62). In contrast, others failed to observe this difference (45,63). The results from these studies are summarized in Table 2. The results from randomized trials comparing laser vaporization and stripping enucleation for the treatment of endometriomas are warranted to draw definitive conclusions on this topic. The decreased ovarian response may not be related to the surgical procedure. In this regard, based on histological analysis, it has been reported recently that the ovarian tissue surrounding the cyst wall in endometriomas is morphologically altered and possibly not functional, thus suggesting that a functional disruption may already be present before surgery (64). Therefore, the decreased ovarian response, which may be observed in patients previously treated for a large ovarian endometrioma, may also be a consequence of the disease. This needs to be taken into account when proposing non-surgical management of these patients.

Effect of endometriosis on IVF cycles: value of endoscopic surgery

With the advances obtained in IVF, a large number of patients, especially when age is a factor, opt to proceed with IVF, without undergoing adequate surgical evaluation and treatment of endometriosis. Although IVF is one of the options that can be offered to an infertile couple with endometriosis, its success rate is lower compared with that of women undergoing IVF for other indications. Numerous studies have compared IVF

outcome in terms of fertilization rate, embryo development, and implantation and pregnancy rates in women with endometriosis with other diagnostic entities. The question of whether the presence of endometriosis affects the outcome of women undergoing IVF has not been resolved, with some authors noting negative associations and others noting no association. Recently, in a meta-analysis, Barnhart et al. investigated the IVF outcome for patients with endometriosis (65). It was demonstrated that patients with endometriosis have more than 50% reduction in pregnancy rate after IVF compared with women with tubal factor infertility. Multivariate analysis also demonstrated a decrease in fertilization and implantation rates, and a significant decrease in the number of oocytes retrieved for endometriosis patients. These data therefore suggest that the presence of endometriosis affects multiple aspects of the reproductive cycle, including oocyte quality, embryogenesis, and/or the receptivity of the endometrium. Thus, it is unlikely that the effect of endometriosis is due solely to alterations of normal pelvic anatomy, and an effect on the developing follicle, oocyte, and embryo is suggested. Further evidence of poor oocyte quality, and thus reduced implanting ability of embryos, is strengthened by studies showing no adverse effect on implantation rates in women with endometriosis using donated oocytes, and recipients of oocytes from donors with endometriosis may result in lower implantation rates (46,56,57). Currently, in advanced endometriosis cases, there are no randomized, controlled trials comparing the outcome of endoscopic infertility surgery and IVF to definitively lead us to a conclusion. On the bases of the accumulated data, we believe that laparoscopic diagnosis and treatment of endometriosis will be useful in increasing the probability of conception either spontaneously or with IVF treatment. This should be also valid for patients with multiple IVF failures. The Practice Committee of the ASRM, in May 2004 developed a report. According to their recommendations, when laparoscopy is performed, the surgeon should consider safely ablating or excising visible lesions of endometriosis. In women with stage I/II endometriosis-associated infertility, expectant management or superovulation/IUI after laparoscopy can be considered for younger patients. Women 35 years of age or older should be treated with superovulation/IUI or IVF-ET. In women with stage III/IV endometriosis-associated infertility, conservative surgical therapy with laparoscopy and possible laparotomy are indicated (66).

Conclusively, since it is a well-known fact that endometriosis is more prevalent in the setting of infertility, with proper patient selection, a meticulously performed laparoscopic surgery is an excellent option that provides these patients the potential to achieve repeated future pregnancies. The inability to thoroughly treat the endometriosis might have also been a contributing factor to the contradictory results of the studies. Patients with endometriomas have increased rate of accompanying peritoneal endometriosis also, and should be thoroughly treated in patients who desire to get pregnant. According to us, another important point is the declining number of endoscopic surgeries being performed in response to the increasing numbers of patients opting for IVF. This phenomenon results in fewer physicians who develop adequate proficiency in performing these technically advanced procedures.

CONCLUSION

Advances in endoscopic surgery have revolutionized our approaches to gynecological surgery. Among reproductive operations, most of them could and should be done by laparoscopy. The variety of conditions indicative of surgery demonstrates the importance of maintaining surgical skills in the reproductive medicine practice, so that patients can be offered the most appropriate treatment. It appears that endoscopic surgery for infertility patients, when performed by an experienced endoscopist, is efficacious and can produce as good or better results than traditional procedures.

REFERENCES

1. Nezhat C, Winer WK, Cooper JD, Nezhat F, Nezhat C. Endoscopic infertility surgery. J Reprod Med 1989;34(2):127-34

2. Nezhat C, Hood J, Winer W, Nezhat F, Crowgey SR, Garrison CP. Videolaseroscopy and laser laparoscopy in gynaecology. Br J Hosp Med 1987;38(3):219-24
3. Nezhat C, Nezhat F, Nezhat CH, Admon D. Videolaseroscopy and videolaparoscopy. Baillieres Clin Obstet Gynaecol 1994;8(4):851-64
4. Johnson NP, Watson A. Cochrane review: post-operative procedures for improving fertility following pelvic reproductive surgery. Hum Reprod Update 2000;6(3):259-67
5. Tulandi T, Collins JA, Burrows E, et al. Treatment-dependent and treatment-independent pregnancy among women with periadnexal adhesions. Am J Obstet Gynecol 1990;162:354
6. El Sahwi S. Laparoscopic pelvic adhesiolysis using CO2 laser. J Am Assoc Gynecol Laparosc 1994;1(4):10-1
7. Risberg B. Adhesions: preventive strategies. Eur J Surg Suppl 1997; 577:32-9.
8. Brill AI, Nezhat F, Nezhat CH, Nezhat C. The incidence of adhesions after prior laparotomy: a laparoscopic appraisal. Obstet Gynecol 1995;85(2):269-72
9. Nezhat CR, Nezhat FR, Metzger DA, Luciano AA. Adhesion reformation after reproductive surgery by videolaseroscopy. Fertil Steril 1990;53(6):1008-11.
10. Mansour R, Aboulghar M, Serour GI. Controversies in the surgical management of hydrosalpinx. Curr Opin Obstet Gynecol 2000;12(4):297-301
11. Bontis JN, Dinas KD. Management of hydrosalpinx: reconstructive surgery or IVF? Ann N Y Acad Sci. 2000;900:260-71.
12. Nezhat F, Winer WK, Nezhat C. Fimbrioscopy and salpingoscopy in patients with minimal to moderate pelvic endometriosis. Obstet Gynecol 1990;75(1):15-7.
13. Mol BWJ, Swart P, Bossuyt PMM, van Beurden M, van der Veen F. Reproducibility of the interpretation of hysterosalpingography in the diagnosis of tubal pathology. Hum Reprod 1996;11:1204-8.
14. Swart P, Mol BWJ, van der Veen F, van Beurden M, Radekop WK, Bossuyt PMM. The accuracy of hysterosalpingography in the diagnosis of tubal pathology, a meta-analysis. Fertil Steril 1995;64:486 -91.
15. Zeyneloglu, HB, Arici, A, Olive, DL. Adverse effects of hydrosalpinx on pregnancy rates after in vitro fertilization-embryo transfer. Fertil Steril 1998; 70:492
16. Spielvogel K, Shwayder J, Coddington CC. Surgical management of adhesions, endometriosis, and tubal pathology in the woman with infertility. Clin Obstet Gynecol 2000;43(4):916-28
17. Shelton KE, Butler L, Toner JP, Oehninger S, Muasher SJ. Salpingectomy improves the pregnancy rate in in-vitro fertilization with hydrosalpinx. Hum Reprod 1996;11:523-5.
18. Johnson, NP, Mak, W, Sowter, MC. Laparoscopic salpingectomy for women with hydrosalpinges enhances the success of IVF: a Cochrane review. Hum Reprod 2002; 17:543
19. Donnez J, Langerock S, Lecart CI, Thomas K. Incidence of pathological factors not revealed by hysterosalpingography but disclosed by laparoscopy. Euro J Obstet Gynaec Reprod Biology 1982; 13: 369-75,
20. Yoon, TK, Sung, HR, Cha, SH, et al. Fertility outcome after laparoscopic microsurgical tubal anastomosis. Fertil Steril 1997; 67:18.
21. Silber SJ, Cohen R. Microsurgical reversal of female sterilization: the role of tubal length. Fertil Steril 1980;33:598-601.
22. Rosenfeld DL. Abdominal myomectomy for otherwise unexplained infertility. Fertil Steril 1986;46:328-30
23. Verkauf BS. Myomectomy for fertility enhancement and preservation. Fertil Steril 1992;58:1-15
24. Tulandi T, Murray C, Guralnick M. Adhesion formation and reproductive outcome after myomectomy and second-look laparoscopy. Obstet Gynecol 1993; 82:213-15
25. Nezhat C, Nezhat F, Silfen SL. Laparoscopic myomectomy. Int J Fertil 1991;36:275-80
26. Hasson HM, Rotman C, Rana N. Laparoscopic myomectomy. Obstet Gynecol 1992;80:884-88
27. Mais V, Agossa S, Guerriero S, Mascia M, Solla E, Melis GB. Laparoscopic versus abdominal myomectomy: a prospective, randomized trial to evaluate benefits in early outcome. Am J Obstet Gynecol 1996;174:654-58
28. Dubuisson JB, Fauconnier A, Chapron C, Krieker G, Norgaard C. Second look after laparoscopic myomectomy. Hum Reprod 1998;13:2102-6
29. Nezhat C, Nezhat F, Bess O, et al. Laparoscopically assisted myomectomy: a report of a new technique in 57 cases. Int J Fertil 1994; 39:34-44.
30. Harris WJ. Uterine dehiscence following laparoscopic myomectomy. Obstet Gynecol 992;80:545-6
31. Dubuisson JB, Chavet X, Chapron C, Gregorakis SS, Morice P. Uterine rupture during pregnancy after laparoscopic myomectomy. Hum Reprod 1995;10:1475-77
32. Friedman W, Maier RF, Luttkus A, Schafer APA, Dudenhausen JW. Uterine rupture after laparoscopic myomectomy. Acta Obstet Gynecol Scan 1996;75:683-84.
33. Pelosi MA, Pelosi MA., Spontaneous uterine rupture at 33 weeks subsequent to previous superficial laparoscopic myomectomy. Am J Obstet Gynecol 1997;177:1547-49
34. Soriano D, Dessolle L, Poncelet C, Benifla JL, Madelenat P, Darai E. Pregnancy outcome after laparoscopic and laparoconverted myomectomy. Eur J Obstet Gynecol Reprod Biol 2003;108(2):194-8
35. Nezhat CH, Nezhat F, Roemisch M, Seidman DS, Tazuke SI, Nezhat CR. Pregnancy following laparoscopic myomectomy: preliminary results. Hum Reprod 1999;14:1219-21.
36. Dubuisson JB, Chapron C, Chavet X. Fertility after laparoscopic myomectomy of large intramural myomas: preliminary results. Hum. Reprod 1996;11:518-22
37. Stringer NH, Strassner HT. Pregnancy in five patients after laparoscopic myomectomy with the harmonic scalpel. J Gynecol Surg 1996;12:129-33
38. Seinera P, Arisio R, Decko A. Laparoscopic myomectomy: indications, surgical technique and complications. Hum Reprod 1997;12:1927-30
39. Darai E, Dechaud H, Benifla JL.Fertility after laparoscopic myomectomy: preliminary results. Hum Reprod 1997;12:1931-34
40. Dessolle L, Soriano D, Poncelet C, Benifla JL, Madelenat P, Darai E. Determinants of pregnancy rate and obstetric outcome after laparoscopic myomectomy for infertility. Fertil Steril 2001;76:370-4
41. Eldar-Geva T, Meagher S, Healy DL, MacLachlan V, Breheny S, Wood C. Effect of intramural, subserosal, and

submucosal uterine fibroids on the outcome of assisted reproductive technology treatment. Fertil Steril 1998;70:687-91.
42. Stovall DW, Parrish SB, Van Voorish BJ, Hahn SJ, Sparks AET, Syrop CH. Uterine leiomyomata reduce the efficacy of assisted reproduction cycles: results of a matched follow-up study. Hum Reprod 1998;13:192-7.
43. Azarani A, Osias J, Berker B, Nezhat C, Nezhat C. Endometriosis: insights into its pathogenesis and treatment. Surg Technol Int 2004;12:178-81
44. American Society for Reproductive Medicine. Revised American Society for Reproductive Medicine classification of endometriosis: 1996. Fertil Steril 1997;67:817-21
45. Donnez J, Wyns C, Nisolle M. Does ovarian surgery for endometriomas impair the ovarian response to gonadotropin? Fertil Steril 2001;76(4):662-5.
46. Elsheikh A, Milingos S, Loutradis D, Kallipolitis G, Michalas S. Endometriosis and reproductive disorders. Ann N Y Acad Sci 2003;997:247-54.
47. Nezhat F, Nezhat C, Allan CJ, Metzger DA, Sears DL. A clinical and histologic classification of endometriomas: Implications for a mechanism of pathogenesis. J Reprod Med 1992;37(9):771-6.
48. Nezhat C, Siegler A, Nezhat F, Nezhat C, Seidman D, Luciano A. Operative gynecologic laparoscopy: principles and techniques. 2nd Edition. McGraw-Hill Publishing Co. 2000:169-209
49. 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(4):791-5
50. Valle RF, Sciarra JJ. Endometriosis: treatment strategies. Ann N Y Acad Sci 2003;997:229-39
51. Busacca M, Vignali M. Ovarian endometriosis: from pathogenesis to surgical treatment. Curr Opin Obstet Gynecol 2003; 15(4):321-6
52. Nezhat C, Crowgey SR, Garrison CP. Surgical treatment of endometriosis via laser laparoscopy. Fertil Steril 1986; 45(6):778-83
53. Hughes EG, Fedorkow DM, Collins JA. Fertil Steril 1993;59:963-70
54. Parazzini F. Ablation of lesions or no treatment in minimal-mild endometriosis in infertile women: a randomized trial. Gruppo Italiano per lo Studio dell'Endometriosi. Hum Reprod 1999;14:1332-4
55. Marcoux S, Maheux R, Berube S. Laparoscopic surgery in infertile women with minimal or mild endometriosis. Canadian Collaborative Group on Endometriosis. N Engl J Med 1997;337:217-22
56. Buyalos RP, Agarwal SK. Endometriosis-associated infertility. Curr Opin Obstet Gynecol 2000;12(5):377-81
57. Winkel CA. Evaluation and management of women with endometriosis. Obstet Gynecol 2003;102: 397- 408
58. Donnez J, Nisolle M, Gillet N, Smets M, Bassil S, Casanas-Roux F. Large ovarian endometriomas. Hum Reprod 1996;11:641-6.
59. Aboulghar MA, Mansour RT, Serour GI, Al-Inany HG, Aboulghar MM. The outcome of in vitro fertilization in advanced endometriosis with previous surgery: a case-controlled study. Am J Obstet Gynecol 2003;188:371-5
60. 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.
61. 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.
62. 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
63. Loh FH, Tan AT, Kumar J, Ng SC. Ovarian response after laparoscopic ovarian cystectomy for endometriotic cysts in 132 monitored cycles. Fertil Steril 1999; 72: 316-21.
64. 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
65. Barnhart K, Dunsmoor-Su R, Coutifaris C. Effect of endometriosis on in vitro fertilization. Fertil Steril 2002;77(6):1148-55
66. The Practice Committee of the American Society for Reproductive Medicine. Endometriosis and infertility. Fertil Steril 2004; 81(5):1441-6

Received January 11, 2005; revised and accepted March 28, 2005