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Surgical intervention in infertility management

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Despite improvement in the success of IVF, reproductive surgery will remain an important option and complement to assisted reproductive technologies (ART) for many couples. Reproductive surgery should be considered as the first-line treatment when the correction of infertility pathologies is simple and a good result is expected once corrected, when the pathology is causing symptoms such as pain or abnormal bleeding, or if uncorrected will compromise the results or increase the risks of ART. The success of surgical infertility treatment depends on the careful selection of cases using appropriate investigative techniques, with procedures performed in centres with sufficient expertise. For both specialized reproductive and general gynaecological surgery it is crucial to follow microsurgical principles to avoid adhesion formation and conserve normal tissues, especially tubal and ovarian. These aspects of reproductive surgery, and different surgical techniques used for various tubal, peritoneal, uterine and ovarian conditions to achieve the optimal reproductive outcome are discussed in this article.

Tubal and peritoneal factors account for 30–40% of cases of female infertility. Tubal factors include damage to or obstruction of the Fallopian tubes, usually related to previous pelvic inflammatory disease or pelvic or tubal surgery. Peritoneal factors include pelvic and peri-adnexal adhesions and endometriosis. Although some are correctable with surgery, the limitations of surgical repair in many cases have been the driving force behind the development of assisted reproduction technology (ART).

Although ART results are improving, operative endoscopy has also made advances, ensuring an ongoing place in the management of infertility. Improvement in instrumentation and the feasibility of laparoscopic suturing has allowed many reconstructive procedures that traditionally required a laparotomy to be accomplished safely with laparoscopy on a day-surgery basis with lower costs, shorter hospital stays and faster recovery times. Surgical infertility treatment offers other advantages over ART. Unlike ART, which bypasses pelvic pathologies, surgical approaches improve fertility by correcting them and potentially improving other related symptoms such as pain and abnormal menstruation. After surgery, couples can have unlimited attempts to conceive naturally without being subjected to the risks of multiple pregnancy and ovarian overstimulation, stress and cost associated with ART cycles. The fact that more than 75% of couples who commence ART but have not conceived by the end of the third cycle drop out for non-clinical reasons independent of cost illustrates the difficulty that ART procedures present (Land *et al.*, 1997; Meldrum *et al*., 1998). ART cycles are expensive and the multiple cycles needed to achieve a reasonable cumulative pregnancy rate are unaffordable for many couples and communities. The age of the patient has a major effect on the cost-effectiveness of IVF treatment. Women who are older than 38 years have cost per delivery by IVF of nearly three times that of younger women (Trad *et al.*, 1995; Van Voorhis *et al.*, 1997). Older patients (especially over 40 years of age) also have additional deleterious effects of *in vitro* culture compared with the tubal environment, such as zona pellucida hardening (Cohen *et al.*, 1992). In these women, some surgical treatments such as sterilization reversal can achieve pregnancy rates of 42–64%, with a median interval to conception of 5 months (Trimbos-Kemper, 1990; Kim JD *et al.*, 1997; Yoon *et al.*, 1999), whereas IVF success rates tend to be poor with a per cycle pregnancy rate of less than 10% (ASRM–SART Registry, 2002). In addition, ART outcomes can be adversely affected by some surgically correctable pathologies, such as uterine and endometrial lesions, hydrosalpinx and endometrioma. Fertility related surgeries are listed in Box 1.

Many gynaecological operations are performed for women of reproductive age for indications unrelated to fertility. Some of these procedures have consequences that may compromise the future fertility of the patient through tubal damage or adhesions or by affecting ovarian reserve. Every effort should be made to avoid these complications.

Surgical principles and adhesion prevention

Previous surgery is a significant contributor to pelvic adhesions, and 75% of women develop adhesions after pelvic surgery (DeCherney and Mezer, 1984). Adhesions can result in pelvic pain as well as infertility in women of reproductive age. The potentially serious risks of intestinal obstruction and injury to vessels and viscera in future procedures are increased as a result of adhesions.

In the normal healing process endogenous fibrinolytic enzymes, such as plasminogen activator, lyse and remove fibrin matrix formed at the site of injury within 4 days. Local tissue ischaemia, tissue or peritoneal surface desiccation or infection can result in the generation of inhibitors to plasminogen activity, reducing fibrinolysis. Generation of excessive fibrin clots as a result of poor haemostasis and the early apposition of damaged peritoneal surfaces further limit the fibrinolytic capability and enhance fibroblast invasion and angiogenesis. The key principle of adhesion prevention is therefore first to limit the inciting event of tissue or peritoneal damage through microsurgical principles and second to keep the damaged peritoneal surfaces apart for a minimum of 5–7 days to maximize the potential for fibrinolysis while healing occurs.

Microsurgery is a surgical philosophy, a delicate surgical approach designed to minimize peritoneal trauma and tissue

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disruption while increasing the accuracy of the procedure and improving the outcome. These principles include:

- The use of techniques designed to minimize tissue injury including delicate handling of tissues and frequent intraoperative irrigation to prevent desiccation.
- Judicious dissection to minimize adjacent tissue damage and appropriate use of sutures, electrical or laser energy to achieve meticulous haemostasis.
- Avoiding the introduction of foreign bodies into the peritoneal cavity including the use of fine, inert or absorbable sutures, the use of powder-free gloves, peritoneal lavage and copious irrigation.
- Use of magnification that permits accurate identification of abnormal morphology for complete removal, recognition and avoidance of surgical injury, an application of the preceding principles with the use of fine microsurgical instruments and suture materials for precise alignment and approximation of tissue planes.

Endoscopic surgery has many inherent microsurgical advantages. Endoscopy provides some degree of magnification at all time and operating within a closed peritoneal cavity largely prevents desiccation of the peritoneal surfaces. It minimizes the need for tissue handling, eliminates the use of packs and prevents the introduction of foreign materials such as lint and talcum powder. Intraoperative irrigation can be performed easily to keep tissues moist and expose any bleeding vessels. Furthermore, the pressure effect of the pneumoperitoneum diminishes venous oozing and permits spontaneous coagulation of minor vessels. In addition it allows visualization of the operative field at angles that are not possible with open microsurgery. Both animal and human studies have shown that laparoscopic adhesiolysis is more effective in reducing adhesions, with less *de novo* adhesions formed after laparoscopic surgery as compared with laparotomy (Lundroff *et al.*, 1991).

Various substances have been used in an attempt to minimize postoperative adhesions. The administration of systemic anti-inflammatory adjuvants produces disappointing results. Adhesions tend to occur in devascularized sites where systemic agents penetrate poorly. Instillation of fluid at the time of surgery is also generally unsuccessful, as the peritoneal cavity rapidly absorbs fluid and electrolytes, with most fluid being absorbed within 24 h, well before the healing process of the peritoneal surface is completed. Heterologous barriers either of permanent (Gore-Tex) or delayed bioresorbable synthetic products based on hyaluronic acid compositions and regenerated cellulose (Seprafilm, Interceed) produce various degrees of success. After application they create a barrier effect during the re-epithelialization stages before undergoing absorption. Several barrier gels based on hyaluronic acid, which can be easily administered even during laparoscopy to cover large operative areas, have recently been introduced, with promising initial results. Most of these products have been demonstrated to be effective in laboratory models of adhesion formation and oxidized regenerated cellulose has been demonstrated to reduce adhesion formation in women in well-controlled randomized prospective studies (Nordic Adhesion Prevention Group, 1995; Franklin, 1995). However, none of these agents has yet been demonstrated to be effective in increasing the fecundability of women undergoing infertility surgery. For now, we should strive to apply microsurgical principles to minimize the morbidity and costs caused by the postoperative formation of adhesions.

Box 1. Commonly performed fertility related surgeries in males and females

Male	Female
Varicocele (varicocelectomy or embolization)	Tubal diseases
Reversal of male sterilization (vasovasostomy)	Pelvic adhesions
Ejaculatory duct obstruction (transurethral resection)	Endometriosis
Sperm extraction (PESA, MESA, TESE, TESA)	Uterine
	Fibroid
	Uterine septum and other congenital anomalies
	Endometrial polyp
	Intrauterine adhesions
	Ovarian
	Polycystic ovarian syndrome
	Ovarian cysts/accidents
	Cancer preservation surgery
	Ovarian transposition
	? Ovarian tissue harvest, freezing and grafting

PESA: percutaneous epididymal sperm aspiration; MESA: microsurgical epididymal sperm aspiration; TESA: testicular sperm aspiration; TESE: testicular sperm extraction.

Tubal disease

Tubal function and testing

The tubal epithelium with its secretions provides a unique nurturing environment that enhances oocyte maturation and sperm function leading to improved fertilization, and is the site of early embryo development. Tubal patency testing alone cannot reflect the full functional roles of the Fallopian tubes. It was observed in both animal and human studies that fertility diminishes in a linear fashion with the shortening or mucosal damage of the ampulla.

Hysterosalpingogram (HSG) allows the visualization of the uterine cavity and tubes by X-ray using iodine-based contrast medium, which outlines the endometrium and tubal mucosa. A meta-analysis of 20 investigations comparing the accuracy of diagnosis of tubal patency by HSG with laparoscopy showed a low overall sensitivity of 65% (Swart *et al.*, 1995). Mucosal adhesions and flattening were seen at salpingoscopy (Marconi *et al.*, 1992) and falloposcopy (Surrey *et al.*, 1997) in about 40% of infertile patients with normal laparoscopy or HSG. Pregnancy outcome (after a 2-year follow-up) correlated with the status of the mucosa as determined by salpingoscopy (Surrey and Surrey, 1996) and falloposcopy (Kerin *et al.*, 1992) but not with laparoscopy or HSG findings.

Approximately 50% of patients with documented tubal damage have no identifiable risk factor for tubal disease (Rosenfeld *et al*., 1983), and a considerable proportion of patients with endometriosis also present with no symptoms apart from reduced fertility. Laparoscopy with salpingoscopy should ideally be the preferred investigation over HSG, with additional advantages of permitting treatment at the same time. However, this is often not practical due to the need for general anaesthesia, the associated morbidity involved and the greater demand on resources. For the low-risk patients who want to avoid laparoscopy, HSG may be considered as the first line of investigation. The utilization of screening for *Chlamydia* antibodies may help to define this low-risk group (Mol *et al.*, 1997). The development of new techniques, such as hydrolaparoscopy, that can be performed under local anaesthetic and sedation in an outpatient setting shows great promise. Hydrolaparoscopy not only permits examination of peritubal and peritoneal conditions, but an examination of the ampullar mucosa can also be achieved (Brosens *et al.*, 1999).

Peritubal adhesiolysis and distal tubal disease

The effect of tubal and ovarian adhesions on fertility was investigated in a controlled study which evaluated the effect of salpingo–ovariolysis on subsequent fertility (Tulandi *et al*., 1990). The cumulative pregnancy rate in the group that underwent salpingo–ovariolysis was three times higher than in the non-treated group (32% versus 11% at 12 months and 45% versus 16% at 24 months).

Laparoscopic salpingo–ovariolysis should be the treatment of choice for women with periadnexal adhesions as *de novo* adhesion is less likely to occur when compared with laparotomy (Lundroff *et al.*, 1991). High cumulative pregnancy rates of about 60% with low ectopic pregnancy (EP) rate (6%) have been reported, and almost half of the intrauterine pregnancies (IUP) occur within 6 months after surgery (Donnez, 1987; Gomel, 1989). Pregnancy rate fell sharply to below 20%, with an EP rate rising to a similar figure in the presence of dense or incomplete removal of adhesions, or when a good anatomical relationship between Fallopian tube and ovary failed to be restored. Adhesiolysis can often be performed at the time of the routine diagnostic laparoscopy during the infertility work-up. Lysis of dense adhesions is occasionally difficult by laparoscopy requiring microsurgical laparotomy, but this often carries a poorer prognosis and such patients should be referred for IVF.

The inflammatory process in tubal disease may be limited to the serosal surface of the Fallopian tube or may cause extensive destruction of mucosal folds and the microscopic cilia that line the ampullary portion. Results for distal tubal surgery in general are less satisfactory, and pregnancy rates are about 30% (Kasia *et al.*, 1997). However, the results vary widely, mainly because of bias in case selection in the absence of standardized assessment of the extent of tubal damage, especially the mucosal state. In a prospective study, mild disease was defined as absent or small hydrosalpinx (15 mm) with easily recognized fimbriae when tubal patency was restored, no significant peritubal or periovarian adhesions, and hysterosalpingogram demonstrating normal rugal folds. Up to 80% of these patients achieved IUP. Moderate disease consisted of a hydrosalpinx 15–30 mm in diameter, with a portion of fimbriae not easily identified, the presence of perifimbrial or periovarian adhesions, few cul-de-sac adhesions and absent rugal folds on preoperative hysterosalpingogram. The pregnancy rate in this group was only 21%. Severe disease was characterized by a large hydrosalpinx (≥ 30 mm), total absence of fimbriae, dense pelvic or adnexal adhesions with a fixed ovary and tube and obliteration of cul-de-sac. Pregnancy rates of only 3% could be achieved in this subgroup. EP occurred in 4–20% of these patients, dependent on severity of tubal damage (Bower-Meisel *et al*., 1986; Schlaff *et al*., 1990).

A thorough preoperative and intraoperative assessment is important to identify those patients with distal tubal or peritubal disease who would benefit most from surgery. If HSG films are obtainable, evidence of proximal disease, ampullary mucosal folds, strictures, intratubal adhesions and spillage, and dispersion of the contrast medium should be specifically investigated. When distal and proximal obstruction are both present (that is, bipolar disease), the surgical success rate is ≤ 5%. At laparoscopy direct inspection of the crucial distal one-third of the tubal lumen can be carried out by salpingoscopy using either a rigid hysteroscope or fine flexible endoscope capable of visualizing intratubal adhesions or loss of normal landmarks.

Proximal tubal disease and sterilization reversal

Up to 25% of female infertility is attributed to tubal occlusion, of which proximal tubal problems account for one-third. Mid-tubal obstruction is often a result of a previous sterilization procedure or management of an EP. Other tubal occlusions are attributed to intratubal adhesions and plugs, pelvic inflammatory disease, salpingitis isthmica nodosa or other intratubal causes such as polyps and endometriosis.

Non-structural occlusion can often be dislodged by simple measures. A meta-analysis of six randomized and six non-randomized controlled studies comprising a total of 2635 patients demonstrated that flushing the tubes with oil-soluble media at hysterosalpingography increases subsequent pregnancy rates in infertile patients (odds ratio (OR) 1.80, 95% confidence interval (CI) 1.29–2.50). Similarly, a review of 11 studies of transcervical Fallopian tube catheterization in 1990 described an 82% cannulation rate with IUP and EP rates of 24% and 6%, respectively (Thurmond and Rosch, 1990). However, the 60% discrepancy between the cannulation and pregnancy rates raises concerns regarding the effect of cannulation on tubal mucosal health or pre-existing tubo–peritoneal conditions in these women, despite tubal patency being achieved.

Microsurgery is considered to be an effective approach to non-sterilization related structural proximal tubal obstruction. Pregnancy rates as high as 70% can be achieved by microsurgical resection and re-anastomosis in a highly selected group of patients (Dubuisson *et al.*, 1997). However, the amount of affected portion that must be removed can be difficult to assess in patients with disorders such as salpingitis isthmica nodosa. Rates of subsequent IUP and EP can vary widely; adverse prognostic factors for future fertility include reduced residual length of tube, significant intramural damage and evidence of pelvic infection or inflammation.

Up to 14% of women who have had surgical tubal sterilization will request a reversal procedure (Schmidt *et al.*, 2000).

Tubal reanastomosis for reversal of sterilization is the most successful technique in microsurgery, as these patients are otherwise fertile and healthy tubal tissues are anastomosed after the localized damage is removed. Seven large series including a total of 2018 patients available for follow-up with many sterilized by cautery showed an average pregnancy rate of 68% and EP rate of 4% after microsurgical reversal either open or laparoscopically (Table 1). In two series about 80% of patients who conceived did so within 12 months with a median interval from surgery to pregnancy of about 5 months (Kim JD *et al*., 1997; Yoon *et al.,* 1999). Even in women at or over 40 years of age reversal can achieve high pregnancy rates averaging 46% for 149 patients (Trimbos-Kemper, 1990; Glock *et al.,* 1996; Kim JD *et al.,* 1997; Kim SH *et al*., 1997; Yoon *et al*., 1999). The ability to perform tubal anastomosis by laparoscopy (Table 1) or mini-laparotomy (Daniell and McTavish, 1995) on a day-surgery basis with comparable results to laparotomy has made the procedure even more attractive to patients.

The success of tubal reanastomosis is dependent on the method of sterilization, site of anastomosis, length of tube remaining and the presence of other infertility factors. Reversal of Falope rings or clips sterilization produces higher conception rates than in those sterilized by the use of the Pomeroy technique, whereas the worst results are observed in those sterilized with tubal cautery (Rock *et al.,* 1987; Kim JD *et al.,* 1997). The prognosis is best when the anastomotic sites have no significant discrepancy in diameter (for example, isthmic–isthmic or cornual–isthmic anastomosis). Higher pregnancy rates and a lower median interval between surgery and pregnancy are expected with a longer tube remaining (Kim JD *et al.,* 1997; Kim SH *et al.,* 1997). Pregnancy rates decrease by 50% if the tubal length is 3–4 cm and pregnancy does not occur if there is less than 3 cm of tube (Silber and Cohen, 1980). The time between sterilization and reversal is not generally regarded as important but one study noted an increased risk of damaged mucosa with flattening of epithelium and polyp formation in the proximal portion of the tube after 5 years following sterilization (Vasquez *et al*., 1980). When compared with the macrosurgical approach, the use of a microsurgical technique has significantly improved the outcome of tubal anastomosis with reduced EP rates (Lavy *et al.,* 1987).

The patient's ovarian function, tubal condition and male infertility factors need to be assessed and considered in counselling the patient of the outcomes and likelihood of future fertility after reversal. Occasionally, laparoscopy may be necessary to assess surgical prognosis in complicated cases.

Table 1. Results of microsurgical tubal sterilization reversal by laparotomy and laparoscopy

Approach	*n*	% Pregnant	% Ectopic	Reference
Open	922	55.0	5.0	Kim SH *et al*., 1997
Open	364	90.0	2.0	Kim JD *et al*., 1997
Open	206	70.0	2.0	Dubuisson *et al*., 1995
Open	124	74.0	6.0	DeCherney *et al*., 1983
Open	118	64.0	1.0	Gomel, 1980
Laparoscopy	186	80.6	3.2	Yoon *et al*., 1999
Laparoscopy	98	70.0	7.0	Bissonnette *et al*., 1999
Total	2018	67.6	3.9	

Ectopic pregnancy

With improved awareness and earlier detection of EPs, the treatment focus for EPs has largely evolved from saving lives to preserving fertility. In carefully selected patients medical treatment for EP can be highly successful. Although one meta-analysis showed an inferior successful resolution rate of 71% after a single dose of intramuscular methotrexate (Parker *et al.,* 1998), a more recent meta-analysis showed a success rate of 87% (range 75–90%), which is similar to that of laparoscopic salpingostomy (91%, range 72–100%; Morlock *et al*., 2000). The subsequent IUP and EP rates were 54% and 8%, respectively, after medical treatment (Morlock *et al.,* 2000). Medical treatment was found to have a more negative impact on patients' health-related quality of life (Nieuwkerk *et al.,* 1998), but was generally less expensive than surgery when appropriately selected (Nieuwkerk *et al.,* 1998; Morlock *et al.,* 2000), with initial human chorionic gonadotrophin concentrations < 3000 mIU ml^{-1} (Mol *et al.,* 1999). As there is risk of tubal rupture and surgical intervention may be necessary in the post-therapy period, access to transportation, patient contact and patient assistance are all key factors to be considered.

Laparoscopic surgery has been shown to be superior to laparotomy in the treatment of EP in three prospective randomized trials, including a total of 231 patients (Vermesh *et al.,* 1989; Lundroff *et al.,* 1991; Murphy *et al.,* 1992). A meta-analysis with a total of 1514 patients published in 1997 showed that the subsequent IUP and recurrent EP rates after linear salpingostomy for treatment of EP were 61% and 15%, respectively (Yao and Tulandi, 1997). Lower IUP and EP rates of 38% and 9.8%, respectively, were observed in a total of 3584 patients from 18 studies who had salpingectomy (Yao and Tulandi, 1997). However, it is uncertain whether the lower IUP rates in those who had salpingectomy were the result of surgery or the severity of the tubal pathology. A history of previous infertility or tubal pathology detected at the time of surgery had the strongest impact on future fertility. Patients with neither of these risk factors had a 75% IUP rate after salpingectomy for EP, whereas patients with one or both risk factors had a 36.6% IUP rate (Dubuisson *et al.,* 1996). The rate of persistent EP after salpingostomy is 3–20% and is often cured with single-dose methotrexate (Yao and Tulandi, 1997). In the absence of a randomized study, salpingostomy if technically feasible should be the preferred treatment option for EP in women who wish to preserve their fertility and are haemodynamically stable.

Hydrosalpinx

Numerous retrospective studies in the 1990s indicated that the presence of extensive tubal disease, especially a hydrosalpinx, might have a deleterious effect on the outcome of IVF. These reports were summarized in two meta-analyses which showed that pregnancy rates are reduced by half and the rates of spontaneous abortion are more than doubled in the presence

of a hydrosalpinx (Zeyneloglu *et al*., 1998; Camus *et al.,* 1999). Animal and *in vitro* studies have further demonstrated that hydrosalpingeal fluid can inhibit sperm motility and is embryotoxic, though the latter has not been confirmed in humans (Mukherjee *et al*., 1996). Endometria in women with a hydrosalpinx expressed significantly lower concentrations of integrins than endometria of women without a hydrosalpinx, and normal expression was restored after removal of the hydrosalpinx (Meyer *et al*., 1997).

A recent Cochrane review of three prospective randomized trials showed that laparoscopic salpingectomy for hydrosalpinges before IVF increased pregnancy (OR 1.75, 95% CI 1.07, 2.86) and live birth (OR 2.13, 95% CI 1.24, 3.65) rates (Johnson *et al.,* 2002). In the subset of women with hydrosalpinges visible on ultrasonography and those affected bilaterally, salpingectomy increased the delivery rates by more than twofold and 3.5-fold, respectively (Strandell *et al.,* 1999).

Despite these findings, there are concerns about the potentially negative impact of salpingectomy on ovarian function. Though numerous early retrospective studies reported no immediate adverse effects on ipsilateral or contralateral ovarian function, some indicated that salpingectomy when not properly performed may disrupt the normal blood flow to the ovary, resulting in fewer oocytes retrieved from the side of operation during IVF cycle in comparison with the side with intact adnexa (Lass *et al.,* 1998). Options other than salpingectomy have been considered. Studies on simple aspiration of the hydrosalpinx have shown conflicting results (Sowter *et al.,* 1997; Van Voorhis *et al*., 1998). The roles of proximal tubal occlusion and distal salpingostomy have yet to be clarified.

Endometriosis and endometrioma

Endometriosis is a common finding in women of reproductive age. It often presents with pelvic pain and infertility. Although both medical and surgical treatments are generally effective in treatment of pain due to endometriosis, the surgical approach is associated with lower recurrence rates as the disease is removed rather than suppressed as in medical therapy. However, for patients who are infertile, medical treatment is nowadays accepted as ineffective in enhancing fertility, whereas its role as an adjuvant therapy for ART remains debatable. Earlier studies indicated that women with moderate or severe disease had improved fecundity with the removal of implants. Further studies, including meta-analyses of non-randomized studies (Adamson and Pasta, 1994) and a randomized study in Canada (Marcoux *et al.,* 1997), have shown small but significant increases in fecundity when implants in mild disease are removed.

ART is effective in the treatment of infertility in patients with endometriosis. Although ART pregnancy rates in patients with endometriosis in general are comparable with those of women with tubal disease, the results for women with tubal disease may be suboptimal due to the presence of a hydrosalpinx. There are reports of poorer ovarian responses to stimulation and poorer outcomes of ART cycles in women with advanced endometriosis, especially those with endometriomas (Dicker *et al*., 1991; Loh *et al*., 1999). Ovarian hyperstimulation during ART cycles can worsen the disease and patient's symptoms. There is also an increased risk of infection during egg collection in the presence of endometrioma. Medical suppression of the endometriosis or the removal of the endometriotic cyst should thus be considered before IVF. Both approaches have been shown to improve the ovarian response to ovarian hyper-stimulation and improve pregnancy rates during the IVF cycle (Dicker *et al.,* 1991; Marcus and Edwards, 1994; Loh *et al.,* 1999).

Various strategies have been used to treat endometrioma including aspiration, cystectomy and coagulation of cyst capsules. Medical therapy or simple puncture and drainage of endometrioma offer a poor response rate with recurrence rates greater than 80% at 6-month follow-up (Vercellini *et al.,* 1992). Removal of the cyst lining, by either stripping or sharp excision of the capsule, has been shown to produce a good outcome with recurrence rates from 0 to 12.2% and a pregnancy rate of 43–45% (Bateman *et al*., 1994; Catalono *et al*., 1996). However, not all endometriotic cysts have a 'true' cyst wall or obvious cleavage plane, and in one study up to 81% of suspected endometriomas were in fact luteal cysts (Nezhat *et al.,* 1992). There are concerns about the damage that this technique may cause to the underlying ovary; changes in ovarian artery vascular dynamics as assessed by Doppler ultrasonography have been reported following laparoscopic stripping (La Torre *et al.,* 1998). Alternatively, the visible deposits on cyst lining can be ablated by bipolar or KTP laser energy after exposure and irrigation (Sutton *et al.,* 1997), or as a two-step procedure after initial drainage and a period of medical suppression (Brosens *et al.,* 1996). The latter is more invasive though possibly produces better long-term results. Retrospective studies have shown that women with endometriomas treated by fenestration and ablation had threefold higher recurrence and re-operation rates at 18 and 42 months compared with those treated by total excision of the cyst (Saleh and Tulandi, 1999). However, these findings were not confirmed in a small prospectively randomized study, although the power of that study was too low to distinguish all but a large difference in outcome (Beretta *et al*., 1998). Pre-treatment with gonadotrophin-releasing hormone agonist (GnRH-a) has little to offer (Muzii *et al.,* 1996), and the benefit of postoperative use is still unclear. The one area in which GnRH-a treatment does appear to be beneficial is as an adjuvant to a two-stage ablative procedure (Donnez *et al*., 1996).

Excision of endometriotic deposits or stripping of the capsule can result in a significant amount of adhesion formation, leading to decreased fecundity (Canis *et al.,* 1992; Gurgan *et al.,* 1996). On the other hand, patients may continue to suffer pain and compromised fertility as a result of residual infiltrating disease that is undiagnosed or under-treated. A carefully considered treatment plan according to the main surgical indication together with intraoperative assessment should be made to strike a balance. For endometrioma, stripping of its capsule would seem reasonable if the capsule is well-defined, but with resort to ablation in areas where the cyst wall is densely adherent. If there is no obvious tissue plane, it may be prudent to consider the use of an ablative procedure either in one or two stages in conjunction with GnRH-a therapy.

Uterine fibroids and endometrial lesions

Uterine fibroids are found in 25% of women older than 35 years with common symptoms ranging from excessive uterine

bleeding, pelvic pressure and pain, recurrent pregnancy loss and infertility. Pregnancy loss and infertility appear to be mainly related to submucous or intramural myomas that distort uterine cavity. A recent review of 11 observational studies showed that neither intramural nor subserosal fibroids with no intracavitary component had significant adverse effect upon implantation, pregnancy and delivery rates (Pritts, 2001). However, this remains an issue of debate as recent publications have indicated that intramural fibroids can impair results of ART despite the absence of intracavitary involvement (Bajekal and Li, 2000; Bernard *et al*., 2000; Hart *et al.,* 2001). However, as significant morbidity and adhesion formation that may compromise future fertility can follow surgery, patients should carefully consider the risks and benefits of myomectomy before proceeding to surgery. For women who have uterine fibroids without intracavitary involvement, myomectomy should be considered only in those with otherwise unexplained infertility or recurrent miscarriage in which all other causes of infertility have been excluded. Laparoscopy may become the preferred approach as it is associated with reduced risks of haemorrhage and postoperative adhesions when compared with open myomectomy (Dubuisson *et al*., 2000). These findings are supported by two randomized trials, involving a total of 171 patients, which demonstrated that the laparoscopic approach is associated with less febrile morbidity, haemoglobin drop, pain and shorter hospital stay, with compatible sizes of fibroids removed and similar subsequent pregnancy outcomes when compared with laparotomy (Mais *et al*., 1996; Seracchioli *et al.,* 2000).

Conversely, women who had a submucosal or intramural fibroid resulting in abnormal endometrial cavities had significantly lower IVF pregnancy (relative risk (RR) 0.32, 95% CI 0.13–0.70) and implantation (RR 0.28, 95% CI 0.10–0.72) rates than infertile controls, with pregnancy and delivery rates increased above those of infertile controls after myomectomy (Bajekal and Li, 2000; Pritts, 2001). Similarly, other studies have demonstrated a significant reduction in ongoing pregnancy rates in patients with other intracavitary lesions such as intrauterine adhesions (Pabuccu *et al.,* 1997), uterine septum (Simon *et al*., 1991; Acien, 1997; Homer *et al*., 2000) and endometrial polyps (Varasteh *et al*., 1999). With the advent of hysteroscopic resection, such lesions can be removed easily via a relatively minor surgical procedure with reduced risks, shortened hospitalization, reduced costs and better results. Complete removal of submucosal fibroids can be achieved by hysteroscopic myomectomy in more than 90% of cases. In the remaining 10% with a significant intramural component, the lesion can be removed during a second operation optionally under laparoscopic guidance in up to 98% of cases (Mencaglia and Guidetti, 1995).

Septate uterus accounts for approximately 80–90% of congenital uterine pathologies and is associated with the poorest reproductive performance with delivery rates of only 6–28% and miscarriage rates of over 60% (Simon *et al*., 1991). Hysteroscopic metroplasty can be highly successful with data showing a fall in overall miscarriage rates to 6% and a live birth rate of 80–90% achievable in the next pregnancy (Acien, 1997; Homer *et al*., 2000). In patients with recurrent pregnancy loss and infertility resulting from intrauterine adhesions, hysteroscopic adhesiolysis restored normal menstrual flow in 81% and achieved a favourable obstetric outcome in up to 71% of the pregnancies (Pabuccu *et al.,* 1997).

Ovarian surgery for polycystic ovarian syndrome

Polycystic ovarian syndrome (PCOS) affects 5–10% of women of reproductive age and is the most common cause of anovulatory infertility (Lobo and Carmina, 2000). Medical treatment has been advocated as the first-line treatment for anovulation in women with PCOS. Although up to 80% of women ovulate in response to clomiphene, only 40–50% will conceive. Historically, those who do not conceive with clomiphene move on to intensive treatment with gonadotrophin either in the form of ovulation induction or superovulation for IVF. The ovarian response to gonadotrophin in this group of patients can be highly unpredictable and difficult to control. They may either not develop any large follicles or over-respond with a significant risk for hyperstimulation syndrome and multiple pregnancy. The need for prolonged stimulation and intensive monitoring, and the high cancellation and miscarriage rates can be extremely stressful to these patients.

In comparison, ovarian drilling is not only a much simpler form of treatment for patients with clomiphene-resistant PCOS but it may also correct other associated endocrinopathy, improving symptoms of hirsutism and lowering miscarriage rates. In a review of 27 studies with a total of 729 patients who underwent ovarian drilling, 84.2% ovulated and 55.7% conceived (Donesky and Adashi, 1995). Peri-ovarian adhesions are common even with an endoscopic approach but most are mild and do not have a significant adverse effect on fertility. One long-term follow-up study reported that most women with PCOS became ovulatory soon after surgery and 74% were still ovulating when studied 18–20 years later (Gjonnaess, 1998). Several pregnancies can be achieved after a single treatment with lower risk of early pregnancy loss compared with gonadotrophin therapy, and with no additional risk of multiple pregnancy or ovarian hyperstimulation. In addition, ovarian drilling also renders patients with PCOS more responsive to either clomiphene or gonadotrophin and may facilitate these treatments if required, with reduced risks of complications. Reports of successful ovulation and conceptions after the use of insulin-sensitizing agents such as metformin are encouraging; however, results are still inconsistent (Norman *et al.,* 2001). Further research is needed to identify the subgroup of PCOS patients who will benefit most from ovarian drilling and those who would be better treated with metformin.

Conclusion

Reproductive surgery will remain a significant part of the range of modern infertility treatments available to patients. Advanced surgical training should be part of the experience of all trainees in reproductive medicine and units should be prepared to audit and publish their success rates. Although it is undeniably difficult to conduct adequately powered randomized controlled trials in reproductive surgery, large centres should strive to undertake such work, thereby demonstrating the clinical- and cost-effectiveness of reproductive surgery in comparison with medical treatment and IVF in different groups of infertile patients.

References

Acien P (1997) Shall we operate on Müllerian defects? Incidence of Müllerian defects in fertile and infertile women *Human Reproduction* **12** 1372–1376

Adamson GD and Pasta DJ (1994) Surgical treatment of endometriosis-associated infertility: meta-analysis compared with survival analysis *American Journal of Obstetrics and Gynecology* **171** 1488

ASRM–SART Registry (2002) Assisted reproductive technology in the United States: 1999 results generated from the American Society for Reproductive Medicine–Society for Assisted Reproductive Technology Registry *Fertility and Sterility* **78** 918–931

Bajekal N and Li TC (2000) Fibroids, infertility and pregnancy wastage *Human Reproduction Update* **6** 614–620

Bateman BG, Kolp LA and Mills S (1994) Endoscopic versus laparotomy management of endometriomas *Fertility and Sterility* **62** 690–695

Beretta P, Franchi M, Ghezzi F, Busacca M, Zupi E and Bolis P (1998) Randomized clinical trial of two laparoscopic treatments of endometriomas: cystectomy versus drainage and coagulation *Fertility and Sterility* **70** 1176–1180

Bernard G, Darai E, Poncelet C, Benifla JL and Madelenat P (2000) Fertility after hysteroscopic myomectomy: effect of intramural myomas associated *European Journal of Obstetrics, Gynecology and Reproductive Biology* **88** 85–90

Bissonnette F, Lapensée L and Bouzayen R (1999) Outpatient laparoscopic tubal anastomosis and subsequent fertility *Fertility and Sterility* **72** 549–552

Boer-Meisel ME, te Velde ER, Habbena JDF and Kardaun JWPF (1986) Predicting the pregnancy outcome in patients treated for hydrosalpinx; a prospective study *Fertility and Sterility* **45** 23–29

Brosens IA, Van Ballaer P, Puttemans P and Deprest J (1996) Reconstruction of the ovary containing large endometriomas by an extraovarian endosurgical technique *Fertility and Sterility* **66** 517–521

Brosens I, Campo R and Gordts S (1999) Office hydrolaparoscopy for the diagnosis of endometriosis and tubal infertility *Current Opinion in Obstetrics and Gynaecology* **11** 371–377

Camus E, Poncelet C, Goffinet F, Wainer B, Merlet F, Ni-sand I and Philippe HJ (1999) Pregnancy rates after *in vitro* fertilization in cases of tubal infertility with and without hydrosalpinx: a meta-analysis of published comparative studies *Human Reproduction* **14** 1243–1249

Canis M, Mage G, Wattiez A, Chapron C, Pouly JL and Bassil S (1992) Second-look laparoscopy after laparoscopic cystectomy of large ovarian endometriomas *Fertility and Sterility* **58** 617–619

Catalano GF, Marana R, Caruana P, Muzii L and Mancuso S (1996) Laparoscopy versus microsurgery by laparotomy for excision of ovarian cysts in patients with moderate or severe endometriosis *Journal of the American Association of Gynecologic Laparoscopists* **3** 267–270

Cohen J, Alikani M, Trowbridge J and Rosenwaks Z (1992) Implantation enhancement by selective assisted hatching using zona drilling of embryos with poor prognosis *Human Reproduction* **7** 685–691

Daniell JF and McTavish G (1995) Combined laparoscopy and minilaparotomy for outpatient reversal of tubal sterilization *Southern Medical Association Journal* **88** 914–916

DeCherney AH and Mezer HC (1984) The nature of post tuboplasty pelvic adhesions as determined by early and late laparoscopy *Fertility and Sterility* **41** 643–649

DeCherney AH, Mezer HC and Naffolin F (1983) Analysis of failure of microsurgical anastomosis after midsegment, non-coagulation tubal ligation *Fertility and Sterility* **39** 618–622

Dicker D, Goldman JA, Feldberg D, Shelef M and Levy T (1991) Transvaginal ultrasonic needle-guided aspiration of endometriotic cysts before ovulation induction for *in vitro* fertilization *Journal of* In Vitro *Fertilization and Embryo Transfer* **8** 286–289

Donesky BW and Adashi EY (1995) Surgically induced ovulation in the polycystic ovary syndrome: wedge resection revisited in the age of laparoscopy *Fertility and Sterility* **63** 438–443

Donnez J (1987) CO2 laser laparoscopy in infertile women with endometriosis and women with adnexal adhesions *Fertility and Sterility* **48** 390–394

Donnez J, Nisolle M, Gillet N, Smets M, Bassil S and Casanas-Roux F (1996) Large ovarian endometriomas *Human Reproduction* **11** 641–646

Dubuisson JB, Chapron C, Nos C, Morice P, Aubriot FX and Garnier P (1995) Sterilization reversal: fertility results *Human Reproduction* **10** 1145–1151

Dubuisson JB, Morice P, Chapron C, De Gayffier A and Mouelhi T (1996) Salpingectomy – the laparoscopic surgical choice for ectopic pregnancy *Human Reproduction* **11** 1199–1203

Dubuisson JB, Chapron C, Ansquer Y and Vacher-Lavenu MC (1997) Proximal tubal occlusion: is there an alternative to microsurgery? *Human Reproduction* **12** 692–698

Dubuisson JB, Fauconnier A, Babaki-Fard K and Chapron C (2000) Laparoscopic myomectomy: a current view *Human Reproduction Update* **6** 588–594

Franklin RR (1995) Reduction of ovarian adhesions by the use of Interceed. Ovarian Adhesions Study Group *Obstetrics Gynecology* **86** 335–340

Gjonnaess H (1998) Late endocrine effects of ovarian electrocautery in women with polycystic ovary syndrome *Fertility and Sterility* **69** 796–801

Glock JL, Kim AH, Hulka JF, Hunt RB, Trad FS and Brumsted JR (1996) Reproductive outcome after tubal reversal in women 40 years of age or older *Fertility and Sterility* **65** 863–865

Gomel V (1980) Microsurgical reversal of female sterilization: a reappraisal. *Fertility and Sterility* **33** 587–597

Gomel V (1989) Operative laparoscopy: time for acceptance *Fertility and Sterility* **52** 1–11

Gurgan T, Urman B and Yarali H (1996) Adhesion formation and reformation after laparoscopic removal of ovarian endometriomas *Journal of the American Association of Gynecologic Laparoscopists* **3** 389–392

Hart R, Khalaf Y, Yeong CT, Seed P, Taylor A and Braude P (2001) A prospective controlled study of the effect of intramural uterine fibroids on the outcome of assisted conception *Human Reproduction* **16** 2411–2417

Homer HA, Li TC and Cooke ID (2000) The septate uterus: a review of management and reproductive outcome *Fertility and Sterility* **73** 1–14

Johnson NP, Mak W and Sowter MC (2002) Surgical treatment for tubal disease in women due to undergo *in vitro* fertilisation (Cochrane Review). In *The Cochrane Library* Issue 4. Update Software, Oxford

Kasia JM, Raiga J, Doh AS, Biouele JM, Pouly JL, Kwiatkowski F, Edzoa T and Bruhat MA (1997) Laparoscopic fimbrioplasty and neosalpingostomy. Experience of the Yaounde General Hospital, Cameroon (report of 194 cases) *European Journal of Obstetrics, Gynecology, and Reproductive Biology* **73** 71–77

Kerin J, Williams D, San Roman GA, Pearlstone AC, Grundfest WS and Surrey ES (1992) Falloposcopic classification and treatment of Fallopian tube lumen disease *Fertility and Sterility* **57** 731–771

Kim JD, Kim KS, Doo JK and Rhyeu CH (1997) A report on 387 cases of microsurgical tubal reversals *Fertility and Sterility* **68** 875–880

Kim SH, Shin CJ, Kim JG, Moon SY, Lee JY and Chang YS (1997) Microsurgical reversal of tubal sterilization: a report on 1,118 cases *Fertility and Sterility* **68** 865–870

La Torre R, Montanino-Oliva M, Marchiani E, Boninfante M, Montanino G and Cosmi EV (1998) Ovarian blood flow before and after conservative laparoscopic treatment for endometrioma *Clinical and Experimental Obstetrics and Gynecology* **25** 12–14

Land JA, Courtar DA and Evers JLH (1997) Patient dropout in an assisted reproductive technology program: implications for pregnancy rates *Fertility and Sterility* **68** 278–281

Lass A, Ellenbogen A, Croucher C, Trew G, Margara R, Becattini C and Winston RM (1998) Effect of salpingectomy on ovarian response to superovulation in an *in vitro* fertilization–embryo transfer program *Fertility and Sterility* **70** 1035–1038

Lavy G, Diamond MP and DeCherney AH (1987) Ectopic pregnancy: its relationship to tubal reconstructive surgery *Fertility and Sterility* **47** 543–556

Lobo RA and Carmina E (2000) The importance of diagnosing the polycystic ovary syndrome *Annals of Internal Medicine* **132** 989–993

Loh FH, Tan AT, Kumar J and Ng SC (1999) Ovarian response after laparoscopic ovarian cystectomy for endometriotic cysts in 132 monitored cycles *Fertility and Sterility* **72** 36–41

Lundroff P, Hahlini P, Kallfelt B, Thornburn J and Lindblom B (1991) Adhesion formation after laparoscopic surgery in tubal pregnancy: a randomised trial after laparotomy *Fertility and Sterility* **55** 911–915

Mais V, Ajossa S, Guerriero S, Mascia M, Solla E and Melis GB (1996) Laparoscopic versus abdominal myomectomy: a prospective randomised trial to evaluate benefits in early outcome *American Journal of Obstetrics Gynecology* **174** 654–658

Marconi G, Auge L, Sojo E, Young E and Quintana R (1992) Salpingoscopy: systematic use in diagnostic laparoscopy *Fertility and Sterility* **57** 742–746

Marcoux S, Maheux R, Berube S and The Canadian Collaborative Group on Endometriosis (1997) Laparoscopic surgery in infertile women with minimal or mild endometriosis *New England Journal of Medicine* **337** 217–222

Marcus SF and Edwards RG (1994) High rates of pregnancy after long-term down-regulation of women with severe endometriosis *American Journal of Obstetrics and Gynecology* **171** 812–817

Meldrum DR, Silverberg KM, Bustillo M and Stokes L (1998) Success rate with repeated cycles of *in vitro* fertilization–embryo transfer *Fertility and Sterility* **69** 1005–1009

Mencaglia L and Guidetti R (1995) Hysteroscopy in infertility: diagnostic and surgical applications. In *Annual Progress in Reproductive Medicine* Eds RH Asch and JWW Studd. Parthenon Publishing Group, Carnforth

Meyer WR, Castelbaum AJ, Somkuti S, Sagoskin AW, Doyle M, Harris JE and Lessey BA (1997) Hydrosalpinges adversely affect markers of endometrial receptivity *Human Reproduction* **12** 1393–1398

Mol BW, Dijkman B, Wertheim P, Lijmer J, Vanderveen F and Bossuyt PM (1997) The accuracy of serum chlamydial antibodies in the diagnosis of tubal pathology: a meta-analysis *Fertility and Sterility* **67** 1031–1037

Mol BW, Hajenius PJ, Engelsbel S, Ankum WM, Hemrika DJ, Van der Veen F and Bossuyt PM (1999) Treatment of tubal pregnancy in the Netherlands: an economic comparison of systemic methotrexate administration and laparoscopic salpingostomy *American Journal of Obstetrics and Gynecology* **181** 945–951

Morlock RJ, Lafata JE and Eisenstein D (2000) Cost-effectiveness of single-dose methotrexate compared with laparoscopic treatment of ectopic pregnancy *Obstetrics and Gynecology* **95** 407–412

Mukherjee T, Copperman AB, McCaffrey C, Cook CA, Bustillo M and Obasaju MF (1996) Hydrosalpinx fluid has embryotoxic effects on murine embryogenesis: a case for prophylactic salpingectomy *Fertility and Sterility* **66** 851–853

Murphy AA, Nager CW, Wujek JJ, Kettel LM, Torp VA and Chin HG (1992) Operative laparoscopy versus laparotomy for the management of ectopic pregnancy: a prospective trial *Fertility and Sterility* **57** 1180–1185

Muzii L, Marana R, Caruana P and Mancusso S (1996) The impact of preoperative gonadatrophin-releasing hormone agonist treatment on laparoscopic excision of ovarian endometriotic cysts *Fertility and Sterility* **65** 1235–1237

Nezhat F, Nezhat C, Allan C, Metzger DA and Sears DL (1992) Clinical and histologic classification of endometriomas *Journal of Reproductive Medicine* **37** 771–776

Nieuwkerk PT, Hajenius PJ, Ankum WM, Van der Veen F, Wijker W and Bossuyt PM (1998) Systemic methotrexate therapy versus laparoscopic salpingostomy in patients with tubal pregnancy. Part I. Impact on patients' health-related quality of life *Fertility and Sterility* **70** 511–517

Nordic Adhesion Prevention Group (1995) The efficacy of Interceed for prevention of reformation of postoperative adhesions on ovaries, Fallopian tubes and fimbriae in microsurgical operation for fertility: a multi center study *Fertility and Sterility* **63** 709–714

Norman RJ, Kidson WJ, Cuneo RC and Zacharin MR (2001) Metformin and intervention in polycystic ovary syndrome. Position statement *Medical Journal of Australia* **174** 580–583

Pabuccu R, Atay V, Orhon E, Urman B and Ergun A (1997) Hysteroscopic treatment of intrauterine adhesions is safe and effective in the restoration of normal menstruation and fertility *Fertility and Sterility* **68** 1141–1143

Parker J, Bisits A and Proietto AM (1998) A systematic review of single-dose intramuscular methotrexate for the treatment of ectopic pregnancy *Australian and New Zealand Journal of Obstetrics and Gynaecology* **38** 145–150

Pritts EA (2001) Fibroids and infertility: a systematic review of the evidence *Obstetrical and Gynaecological Survey* **56** 483–491

Rock JA, Guzick DS, Katz EK, Zacur HA and King TM (1987) Tubal anastomosis: pregnancy success following reversal of Falope ring or monopolar cautery sterilization *Fertility and Sterility* **48** 13–17

Rosenfeld DL, Seidman SM, Bronson RA and Scholl GM (1983) Unsuspected chronic pelvic inflammatory diseased in the infertile female *Fertility and Sterility* **39** 44–48

Saleh A and Tulandi T (1999) Reoperation after laparoscopic treatment of ovarian endometriosis by excision and by fenestration *Fertility and Sterility* **72** 322–324

Schlaff WE, Hassiakos D, Damewood MD and Rock JA (1990) Neosalpingostomy for distal tubal obstruction: prognostic factors and impact of surgical technique *Fertility and Sterility* **54** 984–990

Schmidt JE, Hillis SD, Marchbanks PA, Jeng G and Peterson HB for the US Collaborative Review of Sterilization Working Group (2000) Requesting information about and obtaining reversal after tubal sterilization: findings from the US Collaborative Review of Sterilization *Fertility and Sterility* **74** 892

Seracchioli R, Rossi S, Govoni F, Rossi E, Venturoli S, Bulletti C and Flamigni C (2000) Fertility and obstetric outcomes after laparoscopic myomectomy of large myomata: a randomised comparison with abdominal myomectomy *Human Reproduction* **15** 2663–2668

Silber SH and Cohen R (1980) Microsurgical reversal of female sterilization; the role of tubal length *Fertility and Sterility* **33** 598–601

Simon C, Martinez L, Pardo F, Tortajada M and Pellicer A (1991) Müllerian defects in women with normal reproductive outcome *Fertility and Sterility* **56** 1192–1193

Sowter MC, Akande VA, Williams JA and Hull MG (1997) Is the outcome of *in vitro* fertilization and embryo transfer treatment improved by spontaneous or surgical drainage of a hydrosalpinx? *Human Reproduction* **12** 2147–2150

Strandell A, Lindhard A, Waldenstrom U, Thorburn J, Janson PO and Hamberger L (1999) Hydrosalpinx and IVF outcome: a prospective, randomized multicentre trial in Scandinavia on salpingectomy prior to IVF *Human Reproduction* **14** 2762–2769

Surrey ES and Surrey MW (1996) Correlation between salpingoscopic and laparoscopic staging in the assessment of the distal Fallopian tube *Fertility and Sterility* **65** 267–271

Surrey ES, Adamson GD, Nagel TC, Malo JW, Surrey MW, Jansen R and Molloy D (1997) Multicenter feasibility study of a new coaxial falloposcopy system *Journal of the American Association of Gynecologic Laparoscopists* **4** 473–478

Sutton CJG, Ewen SP, Jacobs SA and Whitelaw N (1997) Laser laparoscopic surgery in the treatment of ovarian endometriomas *Journal of the American Association of Gynecologic Laparoscopists* **4** 319–323

Swart P, Mol BWJ, Van der Veen F, van Beurden M, Redekop WK and Bossuyt PM (1995) The accuracy of hysterosalpingography in the diagnosis of tubal pathology: a meta-analysis *Fertility and Sterility* **64** 486–491

Thurmond AS and Rosch J (1990) Non-surgical Fallopian tube recanalization for treatment of infertility *Radiology* **174** 371–374

Trad FS, Hornstein MD and Barbieri R (1995) *In vitro* fertilization: a cost-effective alternative for infertile couples? *Journal of Assisted Reproduction and Genetics* **12** 418–421

Trimbos-Kemper TC (1990) Reversal of sterilization in women over 40 years of age: a multicenter survey in the Netherlands *Fertility and Sterility* **53** 575–577

Tulandi T, Colliins JA, Burrows E, Jarrell JF, McInnes RA, Wrixon W and Simpson CW (1990) Treatment-dependent and treatment-independent pregnancy among women with periadnexal adhesions *American Journal of Obstetrics and Gynecology* **162** 354–357

Van Voorhis BJ, Stovall DW, Sparks AE, Allen BD, Stovall DW, Syrop CH and Chapler FK (1997) Cost-effectiveness of infertility treatments: a cohort study *Fertility and Sterility* **67** 830–836

Van Voorhis BJ, Sparks AE, Syrop CH and Stovall DW (1998) Ultrasound-guided aspiration of hydrosalpinges is associated with improved pregnancy and implantation rates after *in vitro* fertilization cycles *Human Reproduction* **13** 736–739

Varasteh NN, Nzeuwirth RS, Levin B and Keltz MD (1999) Pregnancy rates after hysteroscopic polypectomy and myomectomy in infertile women *Obstetrics and Gynecology* **94** 168–171

Vasquez G, Winston RML, Boeckx W and Brosens I (1980) Tubal lesions subsequent to sterilisation and their relation to fertility after attempts at reversal *American Journal of Obstetrics and Gynecology* **138** 86–92

Vercellini P, Vendola N, Bocciolone L, Colombo A, Rognoni MT and Bolis G (1992) Laparoscopic aspiration of ovarian endometriomas: effect with postoperative gonadotropin releasing hormone agonist treatment *Journal of Reproductive Medicine* **37** 577–580

Vermesh M, Silva PD, Rosen GF, Stein AL, Fossum GT and Sauer MV (1989) Management of unruptured ectopic gestation by linear salpingostomy: a prospective, randomized clinical trial of laparoscopy versus laparotomy *Obstetrics and Gynecology* **73** 400–404

Yao M and Tulandi T (1997) Current status of surgical and non-surgical treatment of ectopic pregnancy *Fertility and Sterility* **67** 421–433

Yoon TK, Sung HR, Cha SH, Lee WS, Lee CN and Cha KY (1999) Laparoscopic tubal reanastomosis; fertility outcome in 202 cases *Fertility and Sterility* **70** *Supplement* **1** 3

Zeyneloglu HB, Arici A and Olive DL (1998) Adverse effects of hydrosalpinx on pregnancy rates after *in vitro* fertilization embryo transfer *Fertility and Sterility* **70** 492–499S58