INTRODUCTION — The availability of assisted reproductive technology has reduced the need for reconstructive surgery in subfertile women. When fertility surgery is indicated, operative laparoscopy results in outcomes as good as those from similar procedures performed via open laparotomy and is associated with a shorter hospital stay, lower incidence of ileus, and faster recovery. In addition, there is less contamination of the surgical field with glove powder or lint, bleeding is reduced due to tamponade of small vessels by the pneumoperitoneum, and drying of tissues is minimal because surgery occurs in a closed environment. All of these factors contribute to reduce postoperative adhesion formation and its associated morbidity (eg, pain, impaired fertility, bowel obstruction).

DIAGNOSTIC LAPAROSCOPY — We feel diagnostic laparoscopy is indicated as part of the infertility evaluation of young women with a history of pelvic inflammatory disease, ectopic pregnancy, pelvic surgery, or chronic pelvic pain. We proceed with diagnostic laparoscopy if three cycles of gonadotropin ovulation induction with intrauterine inseminations are unsuccessful. If adhesions or endometriosis are found during diagnostic laparoscopy and the patient has been appropriately consented, then an operative laparoscopic procedure for improving fertility can be undertaken at the same time.

Diagnostic laparoscopy can be avoided in older women and those with multiple infertility factors. These women are better served by in vitro fertilization, instead of a surgical approach to treatment. The presence of endometriosis and adhesions does not markedly influence the effectiveness of in vitro fertilization (IVF). (See "In vitro fertilization").

ADHESIOLYSIS — Pregnancy can occur in women with periadnexal adhesions, but the pregnancy rate appears to be higher in those who undergo adhesiolysis. 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 [1]. 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. (See "Preventing postoperative peritoneal adhesions").

ENDOMETRIOSIS

Excision and ablation — Whether there is an association between minimal/mild endometriosis and infertility has been debated for many years. This controversy was somewhat resolved following a Canadian study in which 341 infertile women with minimal/mild endometriosis were randomly assigned to undergo laparoscopic ablation or excision of endometriotic lesions or laparoscopy without further surgical intervention [2]. The 36-week cumulative probability of pregnancy was significantly higher in women who received surgical treatment (31 versus 18 percent in the no treatment group) [2]. In contrast, the only other randomized trial in this area did not find any difference in the pregnancy rate between the treated and no treatment groups (24 and 29 percent, respectively, at one year follow-up) [3]. These findings may have been due to
the small sample size (n = 101) of the latter study as a subsequent meta-analysis of these two trials found laparoscopic surgical treatment was associated with a significant increase in the ongoing pregnancy/live birth rate (OR 1.64, 95 percent CI 1.05 to 2.57) \[4\]. The number needed to treat (NNT) was 61; in other words, 61 patients would have to undergo laparoscopic ablation of endometriosis to achieve one pregnancy. (See "Pathogenesis and treatment of infertility in women with endometriosis".)

Endometriosis can be ablated or excised laparoscopically using electrocoagulation, laser, or ultrasonic cutting and coagulation device (e.g., Harmonic Scalpel®) \[5\]. It is not known whether one modality is more effective than another. A nonrandomized study of 91 women with minimal/mild endometriosis found the pregnancy rate after excision was not significantly different from than after electrocoagulation, 54 versus 57 percent \[6\]. However, in our experience, excision leads to more complete removal of endometriosis than electrocoagulation, which is especially important for women with pelvic pain.

**Excision of endometriomas** — The most effective treatment of endometriomas is excision. Medical therapy of an endometrioma larger than 1 cm is not effective \[7-12\]; nor is aspiration, which is associated with a recurrence rate of 88 percent at six months follow-up \[13,14\]. Fenestration and ablation (i.e., removal of part of the cyst wall followed by the coagulation of the inner side of the wall) is also less effective than excision, both in terms of improving fertility and for reducing pain \[8,12,15-17\]. (See "Diagnosis and management of ovarian endometriomas".)

**TREATMENT OF DISTAL TUBAL OCCLUSION** — Distal tubal obstruction is usually a sequelae of salpingitis. Other causes are previous ectopic pregnancy, previous abdominal or pelvic surgery, and peritonitis.

**Fimbrioplasty** — Fimbrioplasty is performed for treatment of fimbrial phimosis, which is a partial obstruction of the distal end of the fallopian tube. The tube is patent, but there are adhesive bands that surround the terminal end. The longitudinal folds of the tube are usually preserved. Fimbrioplasty involves dividing the peritoneal adhesive bands that surround the fimbria. Gentle introduction of an alligator laparoscopic forceps into the tubal ostium followed by opening and withdrawal of the forceps helps to stretch the tube and release minor degrees of fimbrial agglutination \[18\].

In one series of 35 infertile women with severe fimbrial occlusions treated with laparoscopic fimbrioplasty, the intrauterine pregnancy rate was 51 percent, the live birth rate was 37 percent, and the ectopic pregnancy rate was 23 percent after two years follow-up \[19\]. Another study found similar outcomes after fimbrioplasty or salpingostomy: the pregnancy and fecundity rates after laparoscopic fimbrioplasty were 40 and 4 percent, respectively, compared to 56 and 16 percent following salpingostomy \[20\]. The overall ectopic pregnancy rate was about 5 percent. It appears that the results of salpingostomy are equivalent to that of fimbrioplasty. The latter procedure results in more normal tubal anatomy.

**Terminal salpingostomy** — Terminal salpingostomy is performed to relieve tubal obstruction associated with hydrosalpinx. Efficacy for improving fertility is generally poor, but depends upon tubal wall thickness, ampullary dilation, presence of mucosal folds, percentage of ciliated cells in the fimbrial end, and peritubal adhesions \[20-24\]. The average pregnancy rate following salpingostomy is 30 percent, with an ectopic pregnancy rate of 5 percent. However, the pregnancy rate can be as low as zero if the tube is rigid and thick without rugae, and as high as 80 percent when tubal damage is absent or minimal by hysterosalpingogram, salpingoscopy, or inspection at surgery \[22-24\].

**Recommendation** — Surgery may be considered for young women with mild distal tubal disease because, if successful, one surgical procedure can lead to several pregnancies whereas IVF must be attempted each time pregnancy is desired. IVF is more likely than surgery to be successful in women with bilateral hydrosalpinx, older women (due to the rapid decline in fertility with advancing age), and women with severe disease (e.g., severe hydrosalpinx, extensive and dense adhesions, both proximal and distal tubal occlusion). The pregnancy rate after
reconstructive surgery in women with combined tubal occlusion (bipolar tubal blockage) is only 12 percent at 2.5 years follow-up [25].

**SALPINGECTOMY BEFORE IN VITRO FERTILIZATION** — Several reports have described a detrimental effect of hydrosalpinx on implantation and pregnancy rates [26-28]. The leakage of hydrosalpingeal fluid from the tube into the uterine cavity may impede implantation either by flushing the embryos out of the cavity or disrupting the endometrium at the implantation site. Furthermore, hydrosalpinx fluid contains microorganisms, debris, toxins, cytokines, and prostaglandins that may impair endometrial receptivity [27] and possibly reduce the percentage of motile spermatozoa [28].

On a molecular level, one group demonstrated decreased endometrial HOXA10 expression in response to hydrosalpinx fluid, with restoration of HOXA10 expression after salpingectomy [29]. Since HOXA10 is an important transcription factor for implantation of the embryo, impaired expression of this gene may be a mechanism for the deleterious effect of hydrosalpinges on implantation during IVF.

The deleterious effects of hydrosalpinx on achieving pregnancy in women undergoing IVF was demonstrated by the following meta-analyses:

- One meta-analysis of the clinical pregnancy rate in 5569 IVF cycles without hydrosalpinx and 1144 cycles with hydrosalpinx found this rate was about 50 percent lower and the miscarriage rate more than twofold higher in patients with hydrosalpinx [30].
- Another meta-analysis in which all of the women had tubal factor infertility reported the pregnancy rate in women with hydrosalpinx was lower than in women without hydrosalpinx, 20 versus 31 percent [31]. The incidence of early pregnancy loss was also higher in the hydrosalpinx group 44 versus 31 percent.

Pregnancy rates can be improved by removal of unilateral or bilateral hydrosalpinges prior to IVF:

- A trial that randomly assigned women with hydrosalpinges to salpingectomy or no salpingectomy before their IVF procedure reported implantation and pregnancy rates per transfer in the salpingectomy group were 10 and 34 percent, respectively, but were only 5 and 19 percent in those without salpingectomy [32].
- A Cochrane review including three randomized trials confirmed that the odds of pregnancy were increased with laparoscopic salpingectomy for hydrosalpinges prior to IVF (OR = 1.75, 95% CI 1.07-2.86), as were the odds of ongoing pregnancy/live birth (OR = 2.13, 95% CI 1.24-3.65) [33]. The relative increase in the pregnancy rate after salpingectomy was greatest in women with a large hydrosalpinx visible on ultrasound (hazard ratio 3.8, 95% CI 1.5-9.2) [34]. Of note, seven to eight women would have to undergo salpingectomy prior to IVF to achieve an additional live birth from the IVF procedure. The meta-analysis did not show salpingectomy-related improvement in rates of embryo implantation, ectopic pregnancy, or miscarriage, nor was the analysis able to assess the efficacy of other surgical interventions, such as proximal tubal occlusion by clip or cautery.

Salpingostomy can eliminate the accumulation of hydrosalpinx fluid without removing the tube. The tube becomes patent and the fluid will not reaccumulate because drainage is maintained. In one small study, pregnancy rates were similar to those after salpingectomy [35]. Further research is required to determine whether laparoscopic salpingostomy is as effective as salpingectomy. In addition, reocclusion may occur.

Drainage of the hydrosalpinx at the time of oocyte collection is not effective as the tubes will refill rapidly (as little as two days) and the primary pathology (blocked tube) remains [36].

The use of antibiotics to treat hydrosalpinx prior to IVF has also been advocated. In one study, doxycycline was administered to women with documented hydrosalpinx before and after oocyte
retrieval [37]. In patients with tubal occlusion or obstruction, endometriosis, and unexplained infertility who received the antibiotic, the implantation rates were 30, 27, and 24 percent, respectively. The authors concluded that antibiotic administration in patients with hydrosalpinx achieved IVF success rates similar to those in controls, and was less costly than surgery.

A small randomized trial reported that proximal tubal occlusion using bipolar diathermy prior to IVF also improved implantation and pregnancy rates [38]. Proximal tubal occlusion was not more effective than salpingectomy.

**Recommendation** — Laparoscopic salpingectomy for hydrosalpinges (unilateral or bilateral) is the preferred procedure for improving pregnancy rates from IVF. Alternatives such as salpingostomy, antibiotic therapy, and proximal tubal occlusion were effective in small studies, but there are insufficient data to recommend them as a first line therapeutic intervention.

**TREATMENT OF PROXIMAL TUBAL OCCLUSION** — The incidence of true cornual occlusion is low and surgical treatment (ie, resection and anastomosis) is not highly successful.

**Diagnosis** — Hysterosalpingographic findings suggestive of cornual or proximal tubal occlusion must be interpreted with caution as sensitivity and specificity are only 65 and 83 percent, respectively [39]. In one study of resected tubes thought to be proximally occluded by hysterosalpingography and/or laparoscopy but later found to have normal histology, the etiologies of the false positive diagnosis were presumed to be amorphous debris or minimal adhesions (40 percent), extensive fibrosis or salpingitis isthmica nodosa (about 40 percent), and tubal spasm (20 percent) [40]. In addition, we reported that repeat hysterosalpingogram in 98 women with hysterosalpingographic findings of bilateral proximal tubal occlusion revealed bilateral tubal patency in 14 women and patency of one of the tubes in 12 others; true occlusion was encountered in 72 patients (74 percent) [41].

If the fallopian tubes are not visualized on hysterosalpingogram, a repeat procedure should be done to exclude the possibility of a random technical problem or tubal spasm. If the test remains abnormal, then selective tubal catheterization under fluoroscopic or hysteroscopic control is indicated to confirm the diagnosis and potentially open the tube (see below) [42,43].

**Nonsurgical therapy** — Selective tubal catheterization alone is successful in obtaining tubal patency in 60 to 80 percent of patients, with pregnancy rates of 20 to 60 percent [44-46]; however, most studies did not have a control group of nontreated patients. Approximately one-half of the pregnancies occur in the first 12 months after the procedure. Women with good tubal perfusion pressures had significantly higher pregnancy rates than those with medium or poor perfusion pressure [46].

**Tubocornual anastomosis** — Tubocornual anastomosis can be performed in women with true cornual obstruction. The cornual portion of the tube is resected followed by anastomosis [47]. Depending upon the extent and severity of tubal damage, intrauterine pregnancy rates range from 16 to 55 percent and ectopic pregnancy rates are 7 to 30 percent [21]. Since this procedure is traditionally performed by laparotomy, rather than laparoscopically, and the intrauterine pregnancy rate is relatively low, IVF is often a better alternative. Tubocornual anastomosis can be performed by laparoscopy; however, the number of reported cases is small [48].

**Recommendation** — Selective tubal catheterization may achieve tubal patency and improve short-term pregnancy rates in women who appear to have proximal tubal occlusion by hysterosalpingography. In women with true cornual occlusion, IVF is likely to be more successful than tubocornual anastomosis.

**TUBAL REANASTOMOSIS**

**Overview** — 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. The technique involves micros suturing using 6-0 to 10-0 sutures.
Sterilization reversal, although not always successful, is the most successful surgical reconstructive procedure for improving fertility. Factors that may influence the success rate of tubal reanastomosis include the age of the patient, time from sterilization, and sterilization technique. (See "Surgical sterilization of women".)

In one large series, pregnancy rates after sterilization reversal among women aged 15 to 30 years, 30 to 33 years, and 34 to 49 years were 73, 64, and 46 percent, respectively [49]. Most pregnancies occurred within two years after reversal. Of interest, 23 percent of patients subsequently underwent another sterilization. In another series, 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 [50].

In a retrospective cohort study of 163 patients, the cumulative delivery rate over 72 months was comparable in women who had undergone IVF versus those who had surgical sterilization reversal (52 versus 60 percent). The only significant difference in delivery rates was found in a subset of patients aged <37 years (52 percent after IVF and 72 percent after reversal). Surgery is associated with lower cost than IVF. Based on their findings, we could consider laparoscopic sterilization reversal in women younger than 37 years who have ≥4 cm of residual tube. For others, IVF is a better option [51].

Indeed, tubal length is another important factor in successful reversal. The pregnancy rate after tubal anastomosis is 75 percent in women with tubal length of 4 cm or more, but only 19 percent in those with shorter tubes [52].

Pregnancy rates after laparoscopic tubal anastomosis and conventional microsurgical anastomosis are equivalent, 80 to 81 percent 12 months after surgery [53]. Ectopic pregnancy rates are also similar at 2.5 to 2.8 percent. However, the laparoscopic approach is more economical: at our institution $861 for laparoscopic reconstruction versus $1348 with laparotomy [54]. The disadvantage of laparoscopic tubal anastomosis is that it is more demanding technically than an open microsurgical procedure.

Tubal reanastomosis can also be performed using robot-assisted laparoscopy. (See "Robot-assisted laparoscopy in gynecology", section on 'Tubal reanastomosis'.)

Recommendation — We consider sterilization reversal in women with more than 4 cm of residual tube and prior ring or clip sterilization. In other women, IVF may be a better option. We recommend a laparoscopic approach (for the usual advantages of laparoscopic surgery) if a surgeon experienced in laparoscopic tubal anastomosis is available. Otherwise, laparotomy can be performed with good results.

OVARIAN WEDGE RESECTION AND DRILLING — The first line of treatment for polycystic ovary syndrome (PCOS)-related anovulatory infertility is medical, using drugs such as clomiphene citrate, gonadotropins, gonadotropin-releasing hormone, and metformin [55,56]. (See "Treatment of polycystic ovary syndrome in adults" and "Metformin for treatment of the polycystic ovary syndrome".)

The traditional surgical treatment for PCOS was ovarian wedge resection. The procedure was performed by excising approximately one third of the ovary via laparotomy. In an initial series of 108 patients undergoing bilateral ovarian wedge resection, regular menstrual cyclicity was restored in 95 percent of patients, with a pregnancy rate of 85 percent [57]. Subsequent reports confirmed the benefits of the procedure, with varying rates of success. However, it became clear that wedge resection was often associated with development of periadnexal adhesions, thus obviating the beneficial effects of surgery [56]. Ovarian wedge resection can also be performed laparoscopically [58,59]. One small series of 25 patients reported a pregnancy rate of 60 percent; however, 36 percent of patients developed postoperative adhesions, again negating some of the benefits of the surgery [60]. In addition, ovarian resection, whether performed laparoscopically or by laparotomy, is associated with substantial tissue loss. Instances of premature ovarian failure
have been described, rendering the procedure obsolete by any approach [60].

Laparoscopic ovarian drilling is a modification of the ovarian wedge resection. Multiple holes are made on the surface of the ovary using either laser or electrocautery. This results in a decrease in circulating androgen levels, with resumption of cyclic ovulation. The procedure is associated with an ovulation rate of 80 percent and pregnancy rates at 12, 18, and 24 months of 54 to 68, 62 to 73, and 68 to 82 percent, respectively [61-63]. Although these results are encouraging, long-term effects are not known. Therefore, a surgical approach to treatment of PCOS is recommended only in those women who meet the following criteria:

- Failure of ovulation despite an adequate trial of clomiphene citrate and metformin
- Normal weight, because the procedure is often unsuccessful in obese women (body mass index >30 kg/m2 body surface area)
- An elevated serum luteinizing hormone concentration (>10 IU/L)
- Absence of other causes of infertility

A detailed discussion of laparoscopic ovarian drilling for treatment of PCOS can be found separately. (See "Laparoscopic surgery for ovulation induction in polycystic ovary syndrome".)

LEIOMYOMA — Treatment of leiomyoma to enhance fertility in subfertile women is discussed separately. (See "Overview of treatment of uterine leiomyomas (fibroids)."

LAPAROSCOPIC PRESERVATION OF FERTILITY — We perform laparoscopic surgery for preservation of ovarian function and fertility in young women at risk of premature ovarian failure, such as those undergoing chemotherapy or radiation therapy for malignancy [64]. Options for these women are discussed in detail separately. (See "Fertility preservation in patients undergoing gonadotoxic treatment or gonadal resection".)

SUMMARY AND RECOMMENDATIONS

- We suggest diagnostic laparoscopy as part of the infertility evaluation of young women with a history of pelvic inflammatory disease, ectopic pregnancy, pelvic surgery, or chronic pelvic pain. If adhesions or endometriosis are found during diagnostic laparoscopy, then an operative laparoscopic procedure for improving fertility can be undertaken at the same time. If successful, one surgical procedure can lead to several pregnancies whereas in vitro fertilization (IVF) must be attempted each time pregnancy is desired. (See 'Diagnostic laparoscopy' above and 'Endometriosis' above and 'Treatment of distal tubal occlusion' above.)

- Diagnostic laparoscopy can be avoided in older women and those with multiple infertility factors. These women are better served by IVF, instead of a surgical approach to treatment, because IVF is more likely than surgery to be successful in women with bilateral hydrosalpinx, older women (due to the rapid decline in fertility with advancing age), and women with severe disease (eg, severe hydrosalpinx, extensive and dense adhesions, both proximal and distal tubal occlusion). (See 'Diagnostic laparoscopy' above and 'Endometriosis' above and 'Treatment of distal tubal occlusion' above.)

- Laparoscopic salpingectomy for hydrosalpinges is the preferred procedure for improving pregnancy rates in women planning to undergo IVF. Alternatives such as salpingostomy and antibiotic therapy have been shown to be effective in small studies, but there are insufficient data to recommend them as a first line therapeutic intervention. (See 'Salpingectomy before in vitro fertilization' above.)

- We suggest selective tubal catheterization in women who appear to have proximal tubal occlusion by hysterosalpingography. In women with true cornual occlusion, IVF is more likely to be effective than tubocornual anastomosis. (See 'Treatment of proximal tubal occlusion' above.)

- We suggest sterilization reversal in women with more than 4 cm of residual tube and prior ring
or clip sterilization. In other women, IVF appears to be a better option. We recommend a laparoscopic approach (for the usual advantages of laparoscopic surgery) if a surgeon experienced in laparoscopic tubal anastomosis is available. Otherwise, laparotomy can be performed with good results. (See 'Tubal reanastomosis’ above.)

- Advances in cancer treatment have improved the long-term survival of young women suffering from malignancies. However, cancer treatment carries adverse side effects, including loss of ovarian function and sterility. There have been a few options for young women undergoing cancer treatment, and the advent of new methods for preserving gonadal function and fertility is promising. These include laparoscopic ovarian suspension, and ovarian cryopreservation and transplantation.

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REFERENCES


