Chapter 21
Reconstructive Tubal Surgery

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DEFINITIONS

Falloposcopy—A transvaginal endoscopic procedure to examine the fallopian tubes, especially the intramural and isthmic segments.

Fimbrial phimosis—Agglutination of the fimbriae.

Fimbrioplasty—The reconstruction of the fimbriae or tubal infundibulum.

Hydrosalpinx—A distally occluded tube, usually secondary to infection, which distends with accumulation of serous fluid.

Hysterosalpingography (HSG)—An x-ray-based contrast test to assess the uterine cavity and the fallopian tubes.

Pelvic inflammatory disease (PID)—An inflammatory disorder of the uterus, fallopian tubes, and adjacent pelvic structures usually secondary to a sexually transmitted infection.

Salpingo-ovariolysis—The division and/or excision of periadnexal adhesions with the aim of restoring normal anatomy.

Salpingoscopy—An endoscopic examination of the ampullary portion of the tubal lumen.

Salpingostomy—The creation of a new stoma in a tube with a completely occluded distal end.

Tubal cannulation—The passage of a flexible guide wire and narrow-gauge cannula through the proximal tubal ostia along the length of the tube.

Tubotubal anastomosis—The surgical approximation of tubal segments after tubal sterilization or excision of an occluded or diseased portion of tube.

The fallopian tube is a very important organ for the survival of our species. Human life normally originates in the proximal ampulla of the fallopian tube where the oocyte and sperm meet and where fertilization takes place. The physiologic functions of the human oviduct include pro-ovarian sperm transport to the site of fertilization, ovum pickup and prouterine transport of the ovum, ampullary retention of the fertilized oocyte (approximately 72 hours), provision of a suitable environment for fertilization to occur and for the zygote to survive, and, eventually, transport of the zygote from the ampulla to the uterine cavity. Alterations in any of these functions (caused by either damage to the ciliated epithelium or tubal distortion or occlusion) can result in tubal implantation (owing to the lack of transport of the zygote to the uterus) or infertility (owing to the prevention of sperm meeting the oocyte).

In vitro fertilization (IVF) techniques, which have experienced significant improvement in the past three decades, in effect replicate most of the functions of the fallopian tube, except for transport of the preembryo into the uterine cavity. This last step (embryo replacement) is performed using a cannula into which the embryo(s) is aspirated; the cannula then is introduced into the uterus through the cervical canal, and the embryo(s) is deposited in the uterine cavity.

TUBAL FACTOR INFERTILITY

Much of the increase in the incidence of both infertility and tubal pregnancy in the past four decades has been

the result of tubal damage after sexually transmitted pelvic infections. The commonly isolated organisms are *Chlamydia trachomatis, Neisseria gonorrhoeae,* and *Mycoplasma hominis,* of which *Chlamydia* is the most common. These organisms appear to account for most primary invasions; however, in 15% to 60% of cases of acute pelvic inflammatory disease (PID), aerobic or anaerobic bacteria, or both, can also be identified. The clinical picture can vary from an almost asymptomatic condition to a life-threatening event. As demonstrated by Westrom and colleagues, and by Paavonen and Egert-Kruuse, patients with a more severe clinical appearance often have both aerobic and anaerobic infections.

The classic clinical picture of PID, which includes pain, fever, and lower genital tract infection, occurs in less than 50% of affected patients. Gomel reported that more than half of the patients who were investigated for infertility and were found to have a hydrosalpinx gave no previous history of acute PID. This observation has since been confirmed. Indeed, the wide variation in the clinical presentation makes the diagnosis problematic.

It has been estimated that acute PID occurs at a rate of 10 cases per 1,000 women per year in the age group 15 to 39 years and at a rate of 20 cases per 1,000 women per year in the age group 15 to 24 years. Just as there is difficulty in diagnosing PID, there is difficulty in ascertaining the trend in its incidence. Westrom and colleagues reported that in PID cases, the rate of isolating *Chlamydia* per population of 100,000 has increased annually since 1984.

Data from Westrom and colleagues, and from Paavonen and Egert-Kruuse, indicate the infertility rate after a single episode of PID correlates with the degree of residue of tubal damage. Tubal infertility also increases with recurrent episodes of PID. Infertility occurred in 8% of patients with one episode, 20% with two episodes, and 40% in those with three or more episodes of PID. Further, up to two thirds of cases of tubal factor infertility and one third of cases of ectopic pregnancy may be attributable to *C. trachomatis* infection.

INVESTIGATION

The investigation of the infertile couple should be concluded rapidly, accurately, and inexpensively, with as little invasion as possible. In addition, the emotional needs of the couple must be recognized and addressed. Investigation must commence with a thorough clinical assessment of the couple. A detailed history followed by a thorough physical examination permits the selection of the necessary tests to undertake. A positive history of PID or the finding of *Chlamydia* antibodies has a predictive value for tubal pathology of odds ratio (OR) 3.7 (1.7 to 8.4) and that of ruptured appendicitis of OR 4.4 (2.5 to 7.6). This chapter discusses only investigations specific to tubal and peritoneal factors of infertility.

Tubal Insufflation

Tubal insufflation is a tubal patency test, first described by Rubin, which is now rarely performed. The procedure uses an endocervical cannula connected, by rubber tubing, to a mercury manometer and a source of carbon dioxide (CO_2). The rate of gas flow through the system is gradually increased to approximately 30 to 60 mL per minute. Tubal patency is determined by one or more of the following: a written record of the rise and rapid fall of the gas pressure, auscultation of the lower abdomen for the gas passing through the tubes into the peritoneal cavity, or direct visualization of the pressure changes on a mercury manometer.

This historic tubal patency test has been replaced by hysterosalpingography (HSG) and/or salpingosonography. Both of these tests should be performed before ovulation, about the

tenth day of the cycle. Administration of one of the nonsteroidal anti-inflammatory medications is helpful to the patient as it reduces her discomfort due to uterine cramping and thus diminishes diagnostic errors.

Hysterosalpingography

Hysterosalpingography is a contrast study of the uterine cavity and fallopian tubes. It is a simple, inexpensive, safe, and rapid diagnostic procedure that, when performed properly, provides valuable information about the uterine cavity and tubal patency and architecture.

Contraindications to HSG include pregnancy, uterine bleeding, lower genital tract infection, PID, and allergy to the contrast material. In women with a history of recurrent PID, or with any suggestion of a recent exacerbation, there is a significant risk of reactivation of quiescent PID. This occurs in approximately 3% of such patients. To combat this risk, some centers prophylactically administer antibiotics. During the preliminary history and physical examination, the physician must search for possible contraindications and screen for and treat any lower genital tract infections, before performing an HSG. Prophylactic antibiotics prior to HSG are indicated in selected cases, particularly if hydrosalpinx is suspected.

Technique

Hysterosalpingography must be timed to occur between the complete cessation of menstruation and ovulation. This will avoid the risk of disturbing a luteal phase pregnancy. Such timing also avoids radiation exposure to the oocyte that will resume meiosis after the luteinizing hormone surge. Administration of a nonsteroidal anti-inflammatory medication before the procedure reduces the patient's discomfort and diminishes errors associated with HSG. The latter is especially applicable to errors regarding cornual occlusion. This has been clearly demonstrated in a study by Lang and Dunaway.

An oil-soluble or water-soluble contrast medium can be used. A recent Cochrane meta-analysis by Luttjeboer et al. concluded that use of an oil-soluble media increases subsequent pregnancy rates when compared with *no* intervention (OR 3.30; 95% confidence interval [CI] 2.00 to 5.43); however, there was no significant difference in the odds of pregnancy with oil-soluble versus water-soluble media (OR 1.49; 95% CI 0.95 to 1.54). Water-soluble media are most widely used; they are better tolerated by the patient; further, water-soluble media coat the surfaces without sticking to them, producing sharp and finely shaded images and greater visual detail of the lesions. These characteristics enable better assessment of the intraluminal architecture (**Fig. 21.1**). The contrast material is eliminated within 30 minutes.

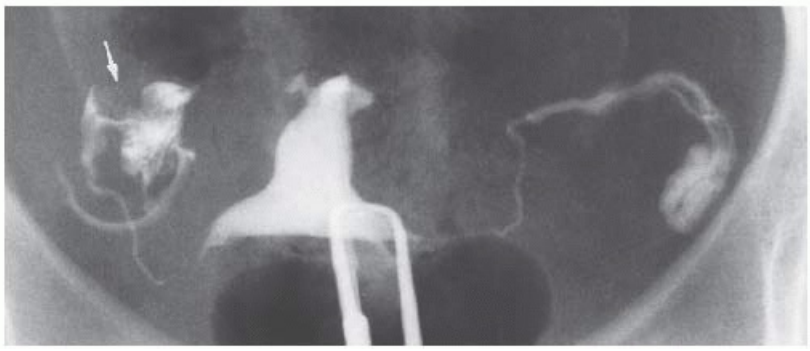

FIGURE 21.1 Hysterosalpingogram. Early film demonstrates a normal uterus and a left hydrosalpinx. On the right, there is an ampullary defect (*arrow*) at the site of a previous tubal pregnancy, which was treated with parenteral methotrexate administration.

After the patient has emptied her bladder, she is placed on the radiographic table. A bivalve speculum is inserted into the vagina, and the cervix and upper vagina are washed with an antiseptic solution. The appropriate cannula, which is filled with contrast material and emptied of any air, is attached to the cervix in such a way as to ensure a tight seal. The speculum is removed before the injection of contrast material. Removal of the speculum is important (especially if the metal variety is used), not only to decrease the patient's discomfort but also to avoid obscuring the cervical canal and vaginal fornices on the x-ray films.

Hysterosalpingography must be performed under fluoroscopic control with the use of an image intensifier. With the syringe attached to the cannula, the contrast material is injected very slowly to avoid discomfort, contraction of the uterus, spasm of the uterotubal junction, and obscuring of the lesions with a large quantity of contrast material. Films are taken to record salient features as they appear on the monitor. An average of three to five films are taken. Preliminary films are of limited value; they can be used to identify misplaced intrauterine contraceptive devices or areas of pelvic calcification. Such information can also be gained by examining the first film.

As the contrast material is injected slowly and intermittently, the endocervical canal, isthmus, and uterine cavity are visualized. To straighten the uterus, firm traction is maintained on the cervix. A film is taken at this point. It is essential to obtain films early during the procedure to record any intrauterine lesions and details of the intratubal architecture. Such details are obscured by larger amounts of contrast material in the uterus, tubes, and peritoneal cavity. Another film is taken when the contrast material starts to escape into the peritoneal cavity (**Fig. 21.1**). Injection of medium is continued slowly until tubal patency is unquestionably established. Manipulation of the uterus with the cannula may be necessary to display specific tubal segments. A film is obtained when abnormal findings are encountered. In certain cases, a true lateral film may provide useful information. When taking this exposure, the traction on the cervix is temporarily released to obtain information regarding the position of the uterus, the location of intrauterine lesions, and the course and configuration of the tubes.

The last phase of the procedure includes a delayed fluoroscopic examination and a film taken 10 to 20 minutes (when water-soluble contrast material is used) after removal of the cannula. This examination and film may yield information about the external contour of the internal genitalia, the shape of the ovarian fossa, and the presence of periadnexal adhesions.

With adherence to proper technique, complications are rare. Major complications include PID, uterine perforation, bleeding from the tenaculum site, and intolerance to iodine, especially if intravasation of contrast occurs. Oil-soluble media may cause granulomas in the pelvis and serious complications if intravasation occurs; a case of cerebral embolization has been reported by Dan et al.

Hysterosalpingography performed using water-soluble media provides precise information about the uterus and oviducts that can assist in patient management. Abnormal uterine findings include fusion anomalies, T-shaped uterus, submucous fibroids and endometrial polyps, intrauterine synechiae (**Fig. 21.2**), and other less commonly identified lesions, such as adenomyosis. Tubal abnormalities that can be observed are listed in **Table 21.1** and shown in figures from Gomel and colleagues (**Figs. 21.3**,21.4,21.5 and **21.6**).

It must be noted that HSG has limitations: (a) it often does not indicate the exact nature of intrauterine lesions; (b) it is associated with false-positive results with regard to cornual occlusion, which may necessitate a selective salpingography and/or tubal cannulation; and (c) it has a low positive

predictive value in the diagnosis of periadnexal adhesions and endometriosis. For these reasons, laparoscopy and, when necessary, hysteroscopy are undertaken to elucidate the diagnosis. Indeed, HSG and laparoscopy are complementary, not competitive, procedures in the investigation of infertility associated with tubal and peritoneal factors.

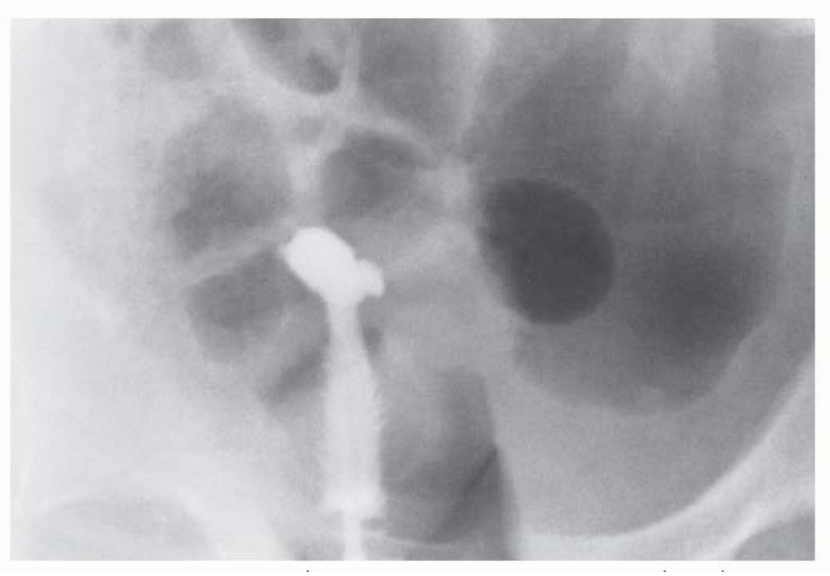

FIGURE 21.2 Hysterosalpingogram in a patient with Asherman syndrome. Contrast material outlines the cervical canal and a part of the lower uterine cavity, the remainder of which is obliterated by synechiae. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:106, with permission.)

In many instances, HSG demonstrates the presence of severe tubal damage or conditions deemed inoperable. Severe intratubal adhesions, and distal tubal occlusion in association with cornual lesions, such as salpingitis isthmica nodosa, are examples of contraindications of reconstructive surgery. In such instances, the couple may be advised of the significance of the findings, and IVF may be recommended as primary treatment, without recourse to laparoscopy.

We have been viewing and continue to view a well-performed HSG as a good, inexpensive, initial test to assess the uterine cavity and the fallopian tubes and are pleased to note concurrence in the American Society for Reproductive Medicine's (ASRM's) committee opinion in this regard: *"There is good evidence to support HSG as the standard first line test to asses tubal patency, but it is limited by false positive diagnoses of proximal tubal blockage."* It further states: *"The evidence is fair to recommend tubal cannulation for proximal tubal obstruction in young women with no other significant infertility factors."*

TABLE 21.1 Abnormalities of the Oviduct

ABNORMALITIES OF THE OVIDUCT		
ABNORMALITY	**SIGNS**	**COMMENTS**
TUBOCORNUAL REGION		
Failure of contrast to enter tube	Simple obstruction	May be owing to tubal spasm; may be unilateral or bilateral
Salpingitis isthmica nodosa (SIN)	Appears as a simple obstruction or as spicules of contrast radiating from tubal	May be unilateral or bilateral

	lumen	
Endometriosis	Similar to SIN, usually with more pronounced punctate pattern	May be unilateral or bilateral
Polyps	Small globular or elongated vacuoles surrounded by contrast medium	
ISTHMUS		
Occlusion	Contrast outlines portion of the isthmic segment.	Most commonly owing to prior surgical sterilization or tubal pregnancy, less commonly to SIN, and uncommonly to tuberculosis and endometriosis
AMPULLA		
Intraluminal adhesions	Patchy filling defects	Caused by endosalpingeal infection
Tubal pregnancy	Obstruction, stenosis, round defect, occasionally calcification	
INFUNDIBULUM		
Hydrosalpinx	Obstruction usually bilateral	Most common type of occlusion
Phimosis of distal tubal ostium	Intraluminal retention of contrast medium and slow intraperitoneal spill from stenosed tube	Both conditions are usually sequelae of PID
INTRAPERITONEAL SPREAD		
Adhesions	Localized pooling and loculation of contrast medium around distal end of oviducts	

Modified from Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:105.

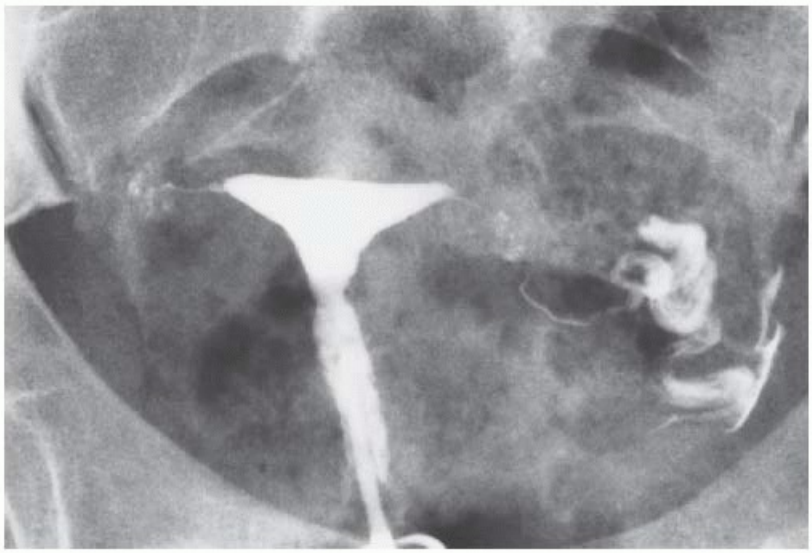

FIGURE 21.3 Hysterosalpingogram showing bilateral proximal isthmic lesions typical of salpingitis isthmica nodosa. The right tube is occluded, whereas the left is still patent. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995, with permission.)

Selective Salpingography and Tubal Cannulation

Selective salpingography is the injection of a contrast medium directly into the uterine tubal ostium with the use of a special radiopaque cannula inserted through the cervix. The increased pressure generated by the direct injection helps to overcome obstructions associated with mucous plugs or minor synechiae. Data from Thurmond, Novy et al, and Papaioannou et al. indicate selective salpingography is technically possible in approximately 90% of available tubes.

Cannulation of the tube requires the use of a special flexible guide wire and narrow-gauge cannula. This cannulation system is introduced through the larger cannula, which is used for selective salpingography.

If HSG demonstrates a cornual or proximal tubal obstruction (**Fig. 21.7**), selective salpingography with or without tubal cannulation (**Fig. 21.8**) should be the next step; this is ideally performed in the same setting. These techniques are useful in differentiating true from false cornual occlusion. The benefits of this approach have been shown for apparent cornual spasm, obstructions caused by amorphous material (tubal plugs), and tubal synechiae. Indeed, half of the tubes that were proximally blocked at selective salpingography were found to be normal after tubal catheterization in the largest series reported to date. It is doubtful that these techniques have a real therapeutic effect on pathologic occlusions that are due to obliterative fibrosis, chronic follicular salpingitis, salpingitis isthmica nodosa, or endometriosis.

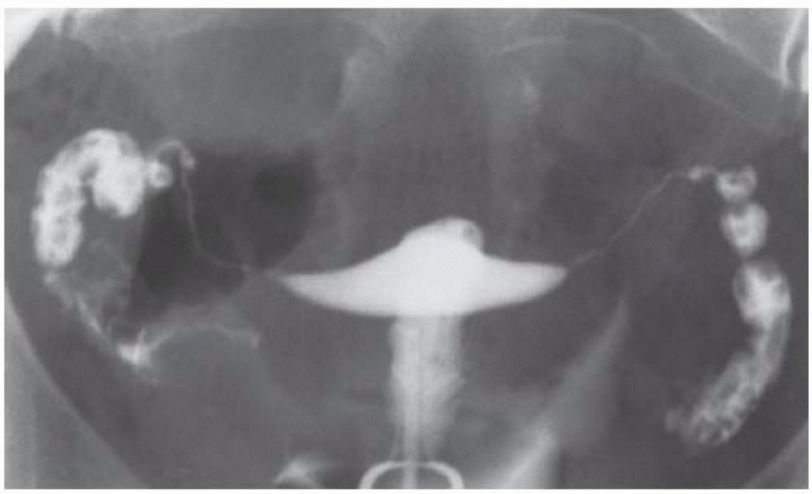

FIGURE 21.4 Hysterosalpingogram. Both tubes exhibit extensive intratubal adhesions. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:106, with permission.)

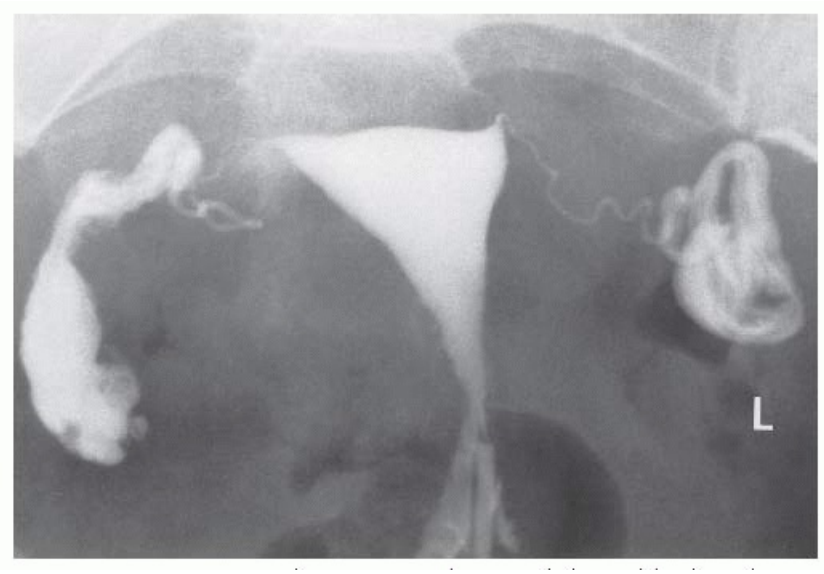

FIGURE 21.5 Hysterosalpingogram showing bilateral hydrosalpinx. The longitudinal epithelial folds are preserved in the left tube. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:106, with permission.)

Salpingosonography

Salpingosonography is a sonographic technique to assess the uterine cavity and tubal patency. After the insertion of a Foley catheter into the cervix, transvaginal sonography is carried out to assess the pelvic structures. Then, a 20-mL syringe is filled with 10 mL of saline solution followed by 10 mL of air. Air is injected first slowly, and passage is followed through the tube; saline is then injected to cause the air bubbles to flow more visibly through the tube. Air-filled albumin microspheres have also been used for this purpose. Several authors (Chenia et al., Inki et al., Strandell et al.) found salpingosonography to have a concordance with laparoscopy of

approximately 80% and with HSG between 72% and 90%. Although the concordance with HSG with regard to passage of contrast into the peritoneal cavity appears high, it is important to remember that salpingosonography does not provide any information about the intratubal architecture. Yet, the pain scores associated with both of these techniques were comparable, as demonstrated in a prospective study by Cheong and Li in 2005.

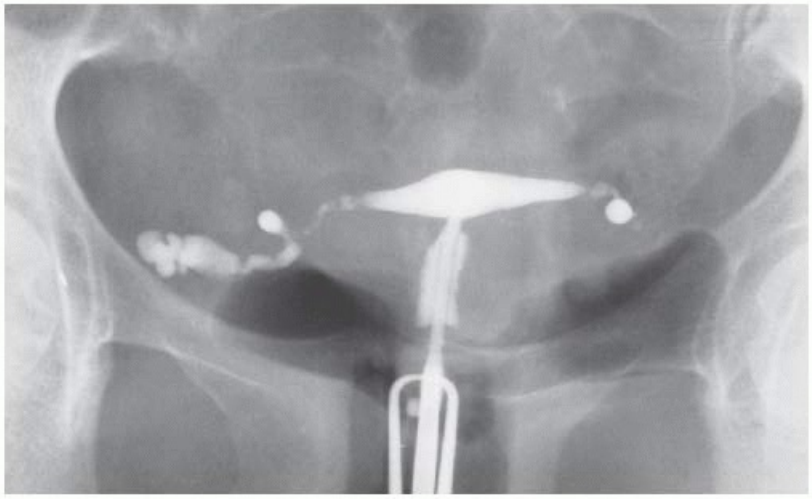

FIGURE 21.6 Hysterosalpingogram. The tubes exhibit findings typical of a prior tuberculous salpingitis. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:108, with permission.)

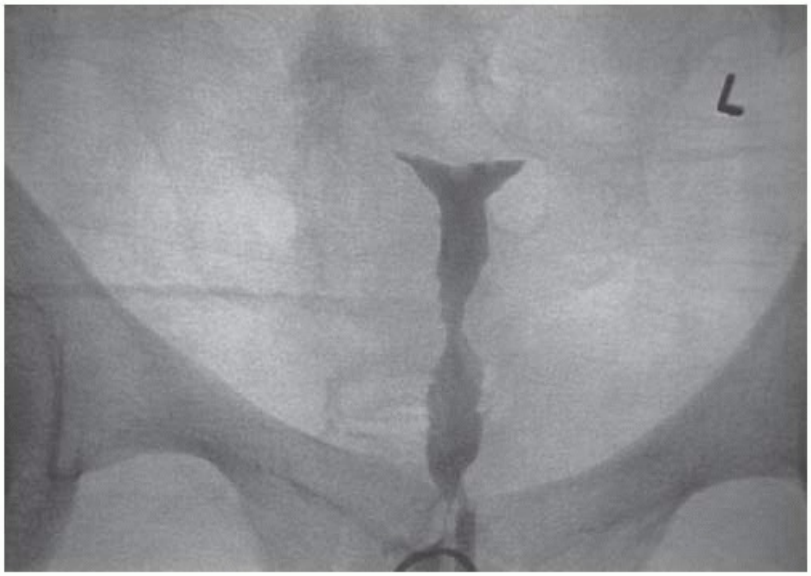

FIGURE 21.7 Hysterosalpingogram showing bilateral cornual occlusion. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St. Louis, MO: Mosby, 1995:109, with permission.)

Salpingoscopy

Salpingoscopy is the endoscopic examination of the ampullary portion of the tubal lumen. This can be accomplished with a small-gauge rigid or flexible endoscope during either laparoscopy or laparotomy. If the distal tube is totally occluded (hydrosalpinx), it is necessary to make a small opening at the fimbriated end to permit the introduction of the scope. The tubal lumen is visualized while distended with physiologic solution injected through the outer sheath of the rigid endoscope or the channel of the flexible scope. The distal end of the tube must be appropriately manipulated to bring it into the axis of the scope. Salpingoscopy permits direct assessment of the tubal epithelium. The findings have been classified into five grades. Grade 1 refers to normal mucosal architecture. Grade 2 refers to tubes that demonstrate variable degrees of flattening of both major and minor mucosal folds, which are largely preserved. Grade 3 refers to tubes that demonstrate focal adhesions between mucosal folds. Grade 4 refers to tubes with extensive intraluminal adhesions or disseminated flattened epithelial areas. Grade 5 refers to tubes that are rigid and hollow with a complete loss of epithelial folds. Findings at salpingoscopy appear to be predictive and prognostic of pregnancy outcome.

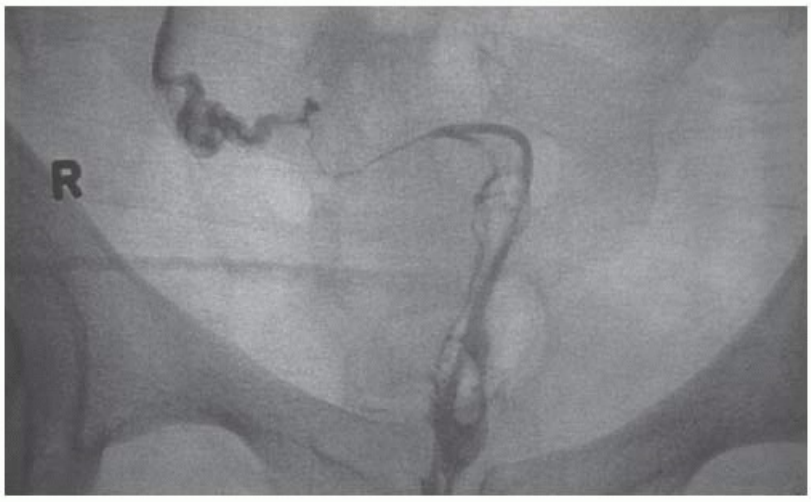

FIGURE 21.8 Tubal cannulation (same patient as in Fig. 21.7). The occlusion has been relieved, and the tube has opacified. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St. Louis, MO: Mosby, 1995:109, with permission.)

Microsalpingoscopy has been used to examine the integrity of the tubal mucosa more closely. Microsalpingoscopy uses an endoscope that has magnification capability enabling visualization of individual cells of the tubal epithelium. The epithelium is stained with concentrated methylene blue solution injected through the cervical cannula. It is then assessed under magnification. The level of staining of the nuclei of the tubal cells is inversely proportional to functional integrity of the mucosa. This technique is at present investigational; thus, its value remains to be determined.

Falloposcopy

Falloposcopy is a transvaginal microendoscopic technique aimed at exploring the entire length of the tube, especially the intramural and isthmic segments. A linear eversion catheter system has been used to perform falloposcopy without the need for preliminary hysteroscopy and anesthesia. The patient requires premedication to decrease the discomfort associated with the procedure.

The system includes a linear eversion catheter with an outer plastic polymer body 2.8 mm in diameter and a sliding stainless steel inner body 0.8 mm in diameter, containing a 0.48-mm fiberoptic endoscope. The tip of the outer catheter is angulated so it can be directed toward the uterotubal junction. Once the tubal ostium is identified, the tip of the catheter is held against the ostium. The pressure within the eversion catheter is increased, and the membrane of the eversion catheter is introduced into the fallopian tube for a short distance. The endoscope is pushed down the lumen to the tip of the introduced catheter. The image obtained is displayed on a high-resolution color monitor. The eversion catheter and the endoscope it houses are advanced in the described manner, slowly and gradually, with the endoscope always maintained within the inverting membrane to prevent the tip of the endoscope from piercing the tubal wall.

Falloposcopy may be used as a means of tubal catheterization and has the added benefit of permitting assessment of the lumen of the tube, especially its intramural and isthmic segments. Kerin et al. proposed a classification based on a scoring system that takes into account the degree of tubal patency, tubal dilatation, epithelial and vascular changes, intratubal adhesions, and other abnormal findings.

This technique, which requires expensive disposable equipment, did not gain clinical acceptance.

Tests Designed to Assess Tubal Function

Salpingography, salpingoscopy, and falloposcopy are designed to assess tubal patency and morphology. Many procedures designed to assess tubal function have been proposed but did not attain clinical acceptance.

Early attempts at using radioactive microspheres as oocyte surrogates to evaluate egg transport did not appear to be clinically valuable. Uher et al. have introduced biodegradable microspheres into the pouch of Douglas by either cul-de-sac puncture or laparoscopy. These microspheres, which

were recognizable by fluorescence, were collected in a cervical cup 24 hours later. Microspheres were present in the cup in 66% of 69 patients with unexplained infertility and in 100% of 20 patients with male factor infertility.

Radionuclide Hysterosalpingography

Radionuclide HSG is a scintigraphic procedure designed by Brundin and colleagues to evaluate the spontaneous pro-ovarian transport of microspheres in the genital tract. A solution containing ^{99m}Tc-labeled albumin microspheres is squirted toward the external cervical os of the cervix and upper vagina. The subsequent

transport of the microspheres through the cervix, uterus, and tubes is monitored by a gamma camera equipped with a pinhole collimator. The pro-ovarian transport of microspheres depends on both the anatomic patency and the functional integrity of the uterus and oviducts. This test is designed to assess primarily the sperm transport function of the uterus and tubes. This technique is still experimental, but preliminary work reported by Lundberg et al. indicates it is not predictive of fertility potential.

Laparoscopy

Laparoscopy permits direct visualization of the peritoneal cavity, pelvis, and internal reproductive organs. It can also test tubal patency with the use of concomitant chromopertubation. It is the most accurate way to identify periadnexal adhesive disease and endometriosis. Laparoscopy also provides the necessary surgical access to perform surgical procedures. Hysteroscopy and salpingoscopy, when indicated, may be performed during the same setting. Laparoscopy is an invasive procedure that usually requires a general anesthetic. It is important to be reminded that most of the major vascular and bowel injuries occur with the initiation of laparoscopy, during the introduction of the Veress needle, principal trocar, and ancillary trocars.

There are those who argue in favor of an immediate laparoscopy bypassing HSG. An analysis of 18 published series demonstrates good congruence between laparoscopic and HSG findings. These collected data indicate that the sensitivity and specificity of HSG are approximately 76% and 83%, respectively. These studies represent a selected population of patients in whom the prevalence of tubal occlusion was 38%. This prevalence figure falls to 10% in studies of large numbers of unselected patients, which reflects more accurately the general population. If the sensitivity and specificity figures reported above are applied to a hypothetical group of patients with a 10% rate of tubal occlusion, only 3% of those with a normal HSG will have an abnormal laparoscopy. Thus, the laparoscopy will be normal in approximately 97% of patients. These data support delaying endoscopy for 4 to 6 months in those with an apparently normal HSG, except in women of older reproductive age.

Based on the preceding information, a well-performed HSG should be the preliminary investigation for tubal factor infertility. This approach permits the identification of (a) uterine anomalies and lesions; (b) cornual occlusion or lesions, even in the presence of cornual patency; (c) distal tubal occlusion; and (d) assessment of intratubal architecture. This information is of paramount importance to the surgeon at the time of laparoscopy, especially if the condition is amenable to laparoscopic surgery, which should be performed in the same setting. Indeed, with the advanced imaging techniques and newer therapeutic modalities available today, laparoscopy, solely for the purpose of diagnosis, should be rarely required.

Laparoscopic Survey

A thorough laparoscopic survey will identify any adhesions, along with their extent and nature; reveal the presence of endometriosis, its extent, and other abdominal and pelvic lesions; and permit assessment of the uterus, ovaries, and tubes. The information yielded by the prior HSG and this survey enable the surgeon to undertake reconstructive laparoscopic surgery and to recommend surgery by open access or the use of assisted reproductive technologies. These will be discussed later.

A bimanual pelvic examination is performed on the anesthetized patient. The cervix is then exposed, and a uterine cannula is attached to the cervix. In addition to permitting intraoperative chromopertubation, the cannula enables manipulation of the uterus and enhances laparoscopic visualization.

Once the laparoscope is inserted, the entire peritoneal cavity is inspected. Inspection commences in the upper abdomen and includes the liver and the undersurface of the diaphragm, which are inspected in a clockwise fashion. Particular attention is then focused on the lower abdomen and pelvis. To improve access to the pelvis, the patient is placed in the Trendelenburg position. The bowel is displaced upward, initially by manipulating the uterus and thereafter by using a probe or other appropriate instrument inserted through a second puncture,

usually placed suprapubically in the midline, or in one of the lower quadrants.

A general panoramic inspection of the pelvis is performed with the laparoscope at some distance from the pelvic organs. This permits a general impression to be formed. Subsequently, a systematic survey is performed. The laparoscope is advanced; appropriate manipulation of the uterus, with the cervical cannula, and of the suprapubic probe enhances visibility of specific organs. The uterus is assessed, along with its anterior surface, the vesicouterine pouch, and the dome of the bladder.

The uterus is then moved into anteversion. The fundus and the posterior surface of the uterus, the uterosacral ligaments, and the pouch of Douglas are thoroughly inspected. If fluid is present in the pouch, its nature is noted. It may be necessary to aspirate the fluid to inspect the underlying peritoneal surfaces. To aspirate the fluid, the probe is replaced by a suction cannula, which can also be used as a manipulating probe. The aspirated fluid can be sent for microbiologic or biochemical studies as deemed necessary. The cul-de-sac and the lateral peritoneal surfaces are inspected for any scarring or evidence of endometriosis. In addition, the peritoneum over the pararectal spaces and over the sacrum should be evaluated.

The extent and type of pelvic and periadnexal adhesions are noted (**Fig. 21.9**). Each tube and ovary and the respective pelvic sidewalls are thoroughly scrutinized. Once the anterior surface of the ovary is inspected, the ovary is elevated and flipped upward with the probe, exposing its posterior surface, the fossa ovarica, and the pelvic sidewall down to the level of the uterosacral ligament, which are assessed. The tube is inspected from the proximal to the distal end. Attention is paid for any evidence of fusiform swelling at the uterotubal junction (which is usually caused by salpingitis isthmica nodosa or endometriosis); the distal end of the tube is scrutinized for the presence of fimbrial phimosis or frank distal tubal occlusion (hydrosalpinx) (**Fig. 21.10**). The ovarian fimbrial relation is assessed, and the fimbriae are viewed en face. Once the other adnexa are similarly assessed, chromopertubation is performed by injection of dilute indigo carmine or methylene blue solution through the uterine cannula. The passage of the dye solution is followed through the tube, and the nature of the spill is examined by viewing the fimbriae to determine the presence of prefimbrial phimosis or fine fimbrial adhesions that may impede ovum pickup.

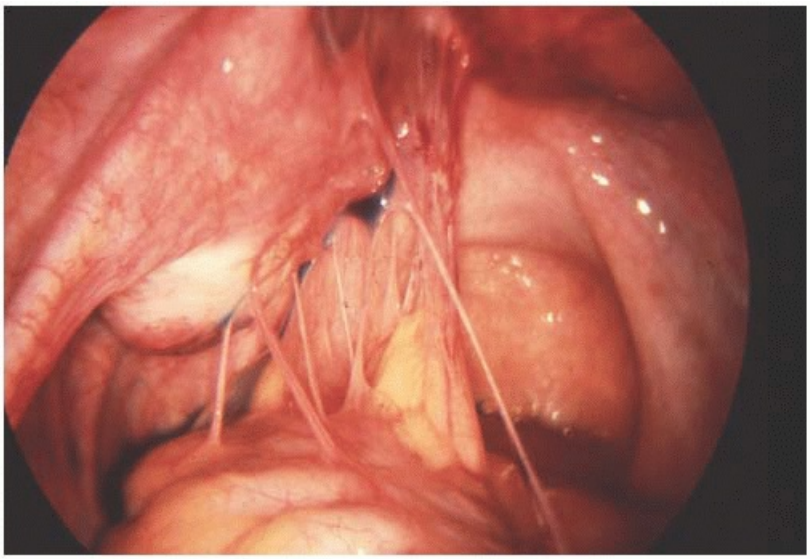

FIGURE 21.9 Laparoscopy. Periadnexal adhesions cover and fix the distal half of the fallopian tube.

Abdominal, pelvic, and periadnexal adhesions may impede laparoscopic access to the pelvis and the adnexa; this may necessitate preliminary adhesiolysis.

Hydroculdoscopy (Fertiloscopy)

Hydroculdoscopy was introduced to visualize the fallopian tubes, ovaries, and the cul-de-sac of Douglas. The technique is a modification of the traditional “culdoscopy,” which has been largely abandoned. It was introduced as a diagnostic technique to replace laparoscopy in the investigation of infertile women, hence the name “fertiloscopy.”

With the patient properly positioned, a bimanual examination is carried to examine the pelvic organs and confirm that the pouch of Douglas is free. The posterior fornix of the vagina is exposed, and the pouch of Douglas is entered using a Veress-type needle. Once the needle is appropriately placed, 200 to 250 mL of saline solution is introduced into the pouch of Douglas through the Veress needle. A trocar/cannula that permits the introduction of a small-caliber endoscope or a “fertiloscope” is then inserted.

The procedure permits the visualization of the pouch of Douglas, the posterior surface of the uterus, the fallopian tubes, and ovaries. Tubal patency can be ascertained by the introduction of a dilute methylene blue solution into the uterine cavity, through an appropriate cannula. If tubal damage is suspected, a salpingoscopy may be performed during the same procedure.

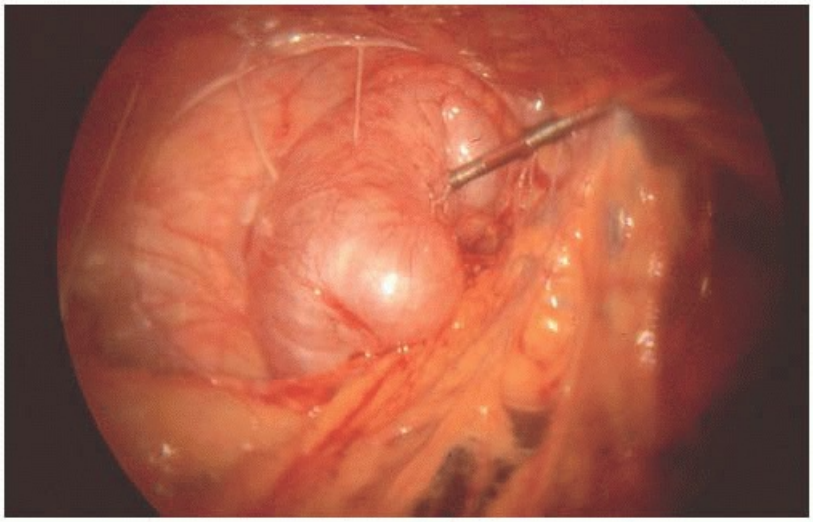

FIGURE 21.10 Laparoscopy. Thin-walled dilated hydrosalpinx with extensive pelvic and periadnexal adhesions.

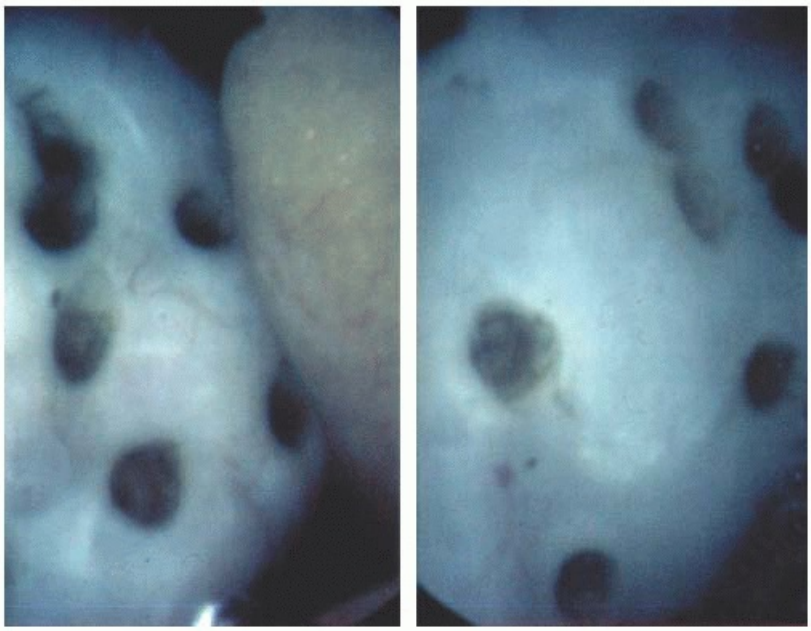

FIGURE 21.11 Fertiloscopy: views of ovarian drilling via hydroculdoscopy using a bipolar electrode.

Initially introduced as a diagnostic tool, the technique has also provided surgical access for certain therapeutic

procedures including minor adhesiolysis and ablation of minor endometriotic lesions; it also permits performance of ovarian drilling.

The first ovarian drilling by hydroculdoscopy was performed in France in 1999 at the Antoine Beclère Hospital by Hervé Fernandez, introducing a bipolar Versapoint probe into the pouch of Douglas through a site lateral to that of the endoscope. The patient was markedly obese and was found to have polycystic ovaries as reported by Fernandez in 2001 (**Fig. 21.11**). Ovarian drilling using this access has since been performed in many centers; the reported results appear similar to those performed by laparoscopy.

It is evident that the procedure cannot be undertaken if the cul-de-sac of Douglas is occluded. The view obtained with hydroculdoscopy is localized and very different from the panoramic view obtained by laparoscopy; furthermore, it does not offer the wide surgical applications that laparoscopic surgical access offers. However, it does have a role in replacing a laparoscopy in appropriately selected patients.

TREATMENT OF TUBAL INFERTILITY

Until the mid to late 1980s, reproductive surgery was the main option of treatment for the infertile woman with damaged fallopian tubes to achieve a pregnancy. This changed dramatically due to significant progress realized in IVF in the decade of the 1990s. The Society for Assisted Reproductive Technology reports rates in the United States progressed from 12.3% of births per initiated cycle in 1990 to 25.4% in 1999, 2004. The 1990s also witnessed the introduction and acceptance of intracytoplasmic sperm injection (ICSI), which proved to be a panacea in the treatment of male infertility.

There are now two realistic treatment options for the treatment of tubal and peritoneal factor infertility: reconstructive surgery and assisted reproduction techniques (ART). Surgery also experienced significant progress and development in the last three decades. Furthermore, presence of a credible alternative with IVF permits the reproductive surgeon to operate on cases with a better prognosis, which was not the case before the end of the 1980s. We have known for a long time that one of the important factors influencing surgical outcome is the degree of tubal damage. Operating on patients with better prognosis translates in superior outcomes as has been

well demonstrated. Surgery and IVF must not be regarded as competitive but rather as complementary treatments necessary to achieve the desired goal. The choice of treatment is ideally dependent on multiple considerations, both technical and nontechnical.

Technical considerations refer to proper assessment of the clinical findings of the couple. It is evident that IVF is the only treatment option for women with inoperable fallopian tubes and tubal disease coincident with another important fertility factor, such as male factor infertility. Not infrequently, a woman will require reconstructive surgery to make IVF possible or more frequently to increase the success rate with IVF. Some patients are better served with surgery.

The provision of accurate information regarding both IVF and tubal surgery is essential in the decision-making process of the couple. The couple must be given the live birth rate per cycle of IVF, the cumulative birth rate after multiple cycles of treatment, and the potential complication rates, including multiple pregnancy, abortion, and ectopic pregnancy. In addition, the effect of frozen embryo replacement on the cumulative pregnancy rate must be considered in the analysis. Similar information must also be provided regarding reconstructive tubal surgery. It is imperative that such figures reflect the experience of the center in which treatment will be performed and not those reported in international journals.

Nontechnical considerations include age, cost, and the wishes of the couple. Female fecundity is adversely affected by age. Fecundity begins to decline at approximately 31 years of age. This trend has been observed

both in “normal” couples and in those with unexplained infertility. This decline becomes even more evident after 35 years of age. In women of advanced reproductive age, the marked decline of fecundity rate per cycle of IVF must be weighed against the fact that reconstructive surgery offers multiple cycles during which conception can occur. Therefore, although the younger woman may consider surgery for a given condition, those in more advanced reproductive age, 37 and over, may be advised to consider IVF first.

Health insurance coverage and the cost of the procedure, depending on the jurisdiction, and the resources of the couple play important roles in the decision-making process. Another, often underestimated potential factor is the economic impact of a multiple pregnancy, which occurs much more frequently with IVF.

The perceptions and wishes of the couple regarding treatment options depend on many influences, including their own values and ethical views. There may be disagreement between partners. The physician should provide detailed information for the couple as clearly and accurately as possible and should abstain from interfering with their decision making except to clarify misunderstandings and misinterpretations. The physician must advise against active treatment when the prognosis is poor because treatment with essentially no chance of success cannot be justified.

The significant improvement in the outcomes of ART was largely due to the simplification of techniques, both clinical and laboratory, progress made in cryopreservation, and the replacement of multiple embryos. Another important factor was the commercialization of these services, which proved lucrative. The number of IVF programs in the United States increased from 267 in 1994 to 461 in 2004, and the number of cycles performed quadrupled during the intervening 20 years from approximately 32,000 to 128,000, which represented a $1.25 billion business. During the same period, there has been a significant decline in the use and teaching of reconstructive infertility surgery. In vitro fertilization started increasingly to be offered, as primary treatment option, in most cases of tubal factor infertility. These changes have occurred despite the acceptance of laparoscopic access to perform many of the reconstructive tubal operations and the use of minilaparotomy incision for more complex anastomotic procedures, both of which have become day care procedures. Concerned with this trend, as early as 1992, we emphasized that both therapeutic options had a place, that treatment should be individualized based on the clinical findings and circumstances of the couple, and that these two options were not competitive but rather complementary. We are of the same opinion today.

Assisted reproduction has revolutionized reproductive medicine; we are in full recognition of this fact. We also believe that reproductive surgery has an important place in the treatment of tubal infertility and in assisting to improve ART outcomes in those who need preliminary surgery. We are gratified to find in ASRM’s “Committee Opinion: Role of Tubal Surgery in the Era of Assisted Reproductive Technology” published in March 2012 support for many opinions we have held about the role of reproductive surgery since early 1990s, when ART results started to show significant progress. We strongly recommend the reader to obtain a copy of this document.

In Vitro Fertilization and Embryo Transfer

Reconstructive tubal surgery was the only treatment option for infertile women with damaged fallopian tubes, until the recent past. This is no longer the case due to significant improvement in outcomes and much wider availability of IVF and ART that provide such couples with a realistic therapeutic alternative.

Data collected prospectively for ART treatments during the year 2009, the last year for which there was a detailed analysis available at the time of writing, from 441 clinics in the United States provided the following outcome data, which were tabulated by the Centers for Disease Control and Prevention (CDC) in 2011. There were 146,244 cycles of ART in 2009. Of these 102,478 (70.1%) were fresh nondonor and 26,069 (17.8%) were frozen nondonor cycles; 11,038 (7.5%) were fresh donor and 6,659 (4.6%) were frozen donor cycles. The majority of the women treated (61.1%) were 35 years of age and more, and only 38.9% were under 35. The

overall live birth rate per cycle started in the fresh nondonor group was 30% and in the frozen nondonor group was also 30%. The birth rate was the same in 2010. In cycles that resulted in a clinical pregnancy, 81.3% resulted in live births. Of live births, 69.5% were singleton births and 28.9% were twins and 1.6% triplets or greater multiples.

Of note, a 2013 report from the CDC indicates the number of ART cycles performed in the United States has more than doubled from 64,036 cycles in 1996 to 147,260 in 2010. More important is the improvement in the overall live birth rate per cycle started from 12.3% in 1990 to 30% in 2010.

Intracytoplasmic sperm injection represents a very important progress in ART; it has proven to be a panacea in the treatment of male infertility. As early as 2003, it was demonstrated that in male factor infertility, the use of ICSI is associated with a success rate that almost equals that of standard IVF in the absence of male factor (**Table 21.2**). Furthermore, since the same time there has been an increasing use of ICSI for fertilization of oocytes even in couples without a male factor. In the United States in 2010, ICSI was used in 66% of IVF cases.

The outcome of both standard IVF and ICSI is adversely affected by the age of the female partner. There is a linear decline after age 35 in both the overall live birth rates and the implantation rate of embryos as clearly evident in **Table 21.3** that summarizes the US IVF results for the year 2010.

TABLE 21.2 CDC 2003 Assisted Reproductive Technology Report

LIVE BIRTHS PER OOCYTE RETRIEVAL IN ART CYCLES 2003

	AGE (YEARS)				
	<35	**35-37**	**38-40**	**41-42**	**>42**
Male factor infertility					
IVF	42.6%	35.9%	26.2%	16.1%	6.0%
IVF with ICSI	41.8%	35.0%	24.1%	13.5%	4.2%
No male factor infertility					
IVF	42.6%	35.9%	26.2%	16.1%	6.0%
IVF with ICSI	37.8%	32.2%	21.8%	11.0%	4.2%

ART, assisted reproductive technology; IVF, in vitro fertilization; ICSI, intracytoplasmic sperm injection.

There has been an increase in the use of frozen nondonor embryos and improvement in outcomes. Frozen nondonor embryos were used in approximately 18% of all ART cycles performed in 2009, compared to 14% in 2003. The rate of thawed embryos resulting in live births is 30.3%, similar to the overall rate with fresh nondonor cycles, which is quite impressive. Although replacement of frozen thawed embryos improves the cumulative

success rate for a couple, the overall net effect remains limited because not all of the cycles provide spare embryos and not all of the frozen embryos withstand the thawing process.

In vitro fertilization and embryo transfer is not risk free, especially in stimulated cycles. Although uncommon, ovarian hyperstimulation, bleeding, and infection can occur. Pregnancies resulting from IVF have an abortion rate of approximately 17%. The overall tubal pregnancy rate is approximately 1% to 2% of ART cycles. A 1991 study from our center by Zouves et al. demonstrated a tubal pregnancy rate of 2.6% (of clinical pregnancies) among IVF patients without tubal factor infertility. However, this rate was 12% in patients with prior tubal disease and tubal surgery.

Assisted reproductive technology procedures are associated with a significant increase in the rate of multiple pregnancies (relative risk [RR] >20). The Centers for Disease Control (CDC) Assisted Reproductive Technology report for 2009 indicated that of the resulting live births, only 69.5% were singletons, 28.9% twins, and 1.6% triplets or higher order. These results show a modest improvement compared to those of 2003, which were 65.8%, 31.0%, and 3.2%, respectively. The high rate of multiple pregnancies is due to the number of embryos transferred. Since transfer of more embryos improves the overall pregnancy rate, there is a temptation to do so. In Europe, where in many jurisdictions the number of embryos to be transferred is limited, both the live birth outcomes and the multiple pregnancy rates are lower (**Table 21.4**).

The high rate of multiple births has a tremendous personal and social impact. Perinatal morbidity and mortality are markedly increased in pregnancies complicated by multiple gestations. The cost, both emotionally and financially, of caring for premature or abnormal children is great. It was demonstrated that monofetal pregnancies also are associated with elevated risk as compared with non-ART singleton pregnancies; more than 10% of monofetal births are preterm, and the perinatal mortality rate (approximately 19 per 1,000) is higher than non-ART singleton pregnancies. This has not changed; the 2009 US outcomes for fresh nondonor ART cycles indicate preterm birth rates of 11.6% for singletons from single-fetus pregnancy, 19.0% for singletons from multiple-fetus pregnancy, 60% for twins, and 97.5% for triplets or more. The percentages of low-birth-weight infants for the same group were 8.7%, 16.7%, 56.1%, and 92.1%, respectively.

A 1994 study by Rufat et al. from France that analyzed a total of 1,637 IVF pregnancies resulting in 1,263 deliveries and 1,669 live born or stillborn children demonstrated a preterm birth rate of 22.7% of all deliveries and 12.2% of singleton deliveries compared with 5.6% among all deliveries in France, and 34.7% of babies weighed less than 2,500 g compared with 5.2% among all deliveries in France. The rates of perinatal, neonatal, and infant mortality were higher than the national

average. Another important study by Bergh et al. from Sweden compared the obstetric outcomes of babies conceived with IVF (*n* = 5,856) to all babies born in the general population during a span of 13 years (1982-1995) demonstrated that children resulting from IVF conception had increased rates of low birth weight (RR = 5), major malformations (RR = 1.4), cerebral palsy (RR = 4), and death (RR = 2). Such elevated personal and societal costs must be considered when embarking on any ART procedure.

TABLE 21.3 ART Results in the United States for the Year 2000[a]

AGE	<35	35-37	38-40	41-42	42-44	>44
Implant %	36.5	26.9	17.7	9.6	4.2	1.7
Live birth %	41.5	31.9	22.1	12.4	5.0	1.0

Twins%	32.9	27.3	21.6	15.0	8.1	2.3
Triplet+%	2.6	3.1	3.7	3.0	0.6	2.3

[a]Percentage of live births per cycle; 147,260 cycles from 443 clinics. Intracytoplasmic sperm injection in 66% CDC Reproductive Health; www.cdc.gov/art/ART.2010

TABLE 21.4 ART Results in Europe for the Year 2007

DELIVERY/OPU %	IVF	ICSI	MULTIPLE PREGNANCY
Europe	21.1	20.2	22.3
France	19.2	20.5	19.3
Germany	16.0	16.1	21.8
Italy	15.2	14.3	23.4
United Kingdom	26.4	27.5	17.9

From de Mouzon J, et al. Assisted reproductive technology in Europe, 2007: results generated from European registers by ESHRE. *Hum Reprod* 2012;27:954, with permission. Copyright 2012, Oxford University Press.

REPRODUCTIVE SURGERY

Reproductive surgery encompasses much more than procedures designed to improve fertility, as understood by some. In fact, in addition to fertility-promoting procedures, such as reconstruction of fallopian tubes and salpingo-ovariolysis, it includes all surgical procedures performed on the pelvic organs of female children, adolescents, and childbearing age women, and not only when performed in those who present with infertility. It must be noted that *"female infertility is frequently caused by misdiagnosis or delayed diagnosis and treatment of acute conditions in young and/or reproductive age women, such as PID, ectopic pregnancy, appendicitis, etc. It is also caused by surgical procedures that are unnecessary, unnecessarily extensive and/or traumatic, resulting in damage to or loss of normal reproductive organs and development of post-operative adhesions."* These observations clearly demonstrate the need to stress the importance of reproductive surgery, and to avail surgeons and especially gynecologists with training opportunities in this field.

Surgery was the only available therapeutic option for infertility caused by tubal and peritoneal factors until the mid-1980s. Traditional surgical techniques often yielded poor outcomes frequently as a result of extensive postoperative adhesions. In my textbook "Microsurgery in Female Infertility" published in January 1983, I wrote "I have vivid recollections of the frustration and disappointment I felt, when assisting as a resident at second-look laparotomies for removal of prosthetic devices such as Mulligan hoods, at finding extensive adhesions in the

peritoneal cavity; with bowel, omentum, and the internal genitalia adherent to one another. Extensive adhesiolysis and separation of structures were often necessary in order to visualize the oviducts and remove the prosthetic devices left in situ during the prior reconstructive operation."

We have had important developments in the field of reproductive surgery in the past four decades. Gynecologic microsurgery was introduced in the early 1970s; simultaneously, laparoscopic surgical access was used for tubal reconstruction, especially in distal tubal disease. Used initially by open access, microsurgical tenets were also applied in procedures performed by laparoscopic access. The use of magnification and especially microsurgical principles yielded significantly improved outcomes, particularly in tubal anastomosis.

The use of laparoscopy for surgical access provided the advantages that are now well recognized: less postoperative discomfort and analgesic requirement, shorter hospital stay and postoperative recovery period, improved cosmetics, and frequently reduced costs. Many laparoscopic interventions became ambulatory procedures, the patient being able to return home the same day. It also did not take long to realize that this mode of surgical access yielded results that were not dissimilar to those obtained via laparotomy, provided of course the technique used was the same. Experience with laparoscopy permitted modification of open interventions for more complex cases, such as tubocornual anastomosis, where a small minilaparotomy incision replaced a formal laparotomy, permitting such procedures also to be performed on ambulatory basis.

The overall risks of reconstructive tubal surgery are small and include the recognized complications of anesthesia and surgery. Surgery, if successful, offers multiple cycles in which to achieve conception and the opportunity to have more than one pregnancy. The abortion rate subsequent to reconstructive tubal surgery is not increased over that of the normal population. The live birth and ectopic pregnancy rates depend on the specific nature of the tubal disease and the extent of tubal damage.

MICROSURGERY

Principles

Microsurgery has been defined as "surgery under magnification." In fact, magnification is only a single facet of microsurgery, which embraces a broad concept of tissue care designed to minimize tissue damage and the use of measures that prevent and/or decrease an acute inflammatory reaction in the peritoneal cavity. These are measures applicable to both open and laparoscopic access; they include the following:

- Use of a delicate, atraumatic technique designed to minimize tissue injury, which in addition includes judicious use of electrical or laser energy and frequent intraoperative irrigation with heparinized lactated Ringer solution to keep serosal surfaces moistened to prevent desiccation
- Prevention of foreign body contamination of the peritoneal cavity
- Obtaining meticulous pinpoint hemostasis, using a microelectrode, minimizing adjacent tissue damage.
- Complete excision of abnormal tissues
- Identifying proper cleavage planes and precisely align and approximate tissue planes with fine nonreactive sutures
- Performing a thorough pelvic lavage using heparinized lactated Ringer solution at the close of the procedure to remove from the peritoneal cavity any blood clots, foreign body, or debris that may be present.

Additional measures help to decrease acute inflammatory reaction. Specifically before the close of the procedure, we leave 300 to 500 mL of lactated Ringer solution with 500 mg

of hydrocortisone succinate in the peritoneal cavity. General measures assist in this regard: use of preoperative

and postoperative antiinflammatory medications, for example, Voltaren suppository, infiltration of a local anesthetic before placing the incision, and the administration of a single dose of prednisone postsurgery.

Magnification, with an operating microscope or with an endoscope, provides many advantages; it permits prompt identification of abnormal morphologic changes, recognition and avoidance of surgical injury, and application of the preceding principles with the use of fine instruments and suture materials. Microsurgery is a surgical attitude as much as a technique.

In the late 1960s, Swolin used magnification with loops— electrosurgery with a fine electrode for the reconstruction of distal tubal occlusion. In addition, he strived to reduce peritoneal trauma by keeping the operative site moistened by frequent irrigation. In Vancouver, we expanded the microsurgical techniques; using an operating microscope, we applied them in the correction of pathologic cornual and midtubal occlusions (tubocornual anastomosis and tubotubal anastomosis) and in reversal of sterilization. This approach permitted us to perform tubocornual anastomosis as opposed to a tubouterine implantation—which was the standard procedure at the time—in cases of pathologic cornual occlusion. An anastomosis in such cases preserves tubal integrity and thus is a more physiologic approach of tubal reconstruction.

Microsurgery, in fact, finds its ultimate application in tubal anastomosis. The use of magnification, microsurgical instruments, and sutures enables the recognition of subtle abnormalities—even in the presence of tubal patency, excision of abnormal tissues, and correct alignment of the tubal segments and precise apposition of each layer. Indeed, the application of microsurgery has significantly improved the outcome of such procedures. However, in the treatment of distal tubal occlusion, any improvement attributable to the use of microsurgical techniques has been relatively modest, despite the reduction in postoperative adhesions and improved tubal patency rates.

The introduction of microsurgery into gynecology has yielded benefits much greater than simple improvement in the outcome of certain fertility operations. It created a great awareness of the effects of peritoneal trauma and the resulting postoperative adhesions. It also promoted the use of conservative approaches that are now considered standard *of* care for women undergoing surgical treatment for benign gynecologic disease. These are additional and important reasons to continue to teach reconstructive infertility surgery. Thus, microsurgery is a surgical philosophy, a delicate surgical approach designed to minimize peritoneal trauma and tissue disruption and prevent postoperative adhesions while increasing the accuracy of the procedure and improving the outcome.

Microsurgical techniques are equally applicable to both open and laparoscopic access. We demonstrated the applicability of microsurgical techniques by laparoscopy for adhesiolysis, salpingo-ovariolysis, fimbrioplasty, and salpingostomy as early as the mid-1970s. Microsurgical techniques must be used in all reproductive operations, irrespective of the mode of access. This is especially important today because most such procedures are performed by laparoscopy and minilaparotomy.

The laparoscope also provides a degree of magnification. Bringing the distal end of the laparoscope close to the area of interest, one achieves excellent visibility and illumination. There are microsurgical advantages inherent to laparoscopic access. Operating within a closed peritoneal cavity eliminates the need to use packs and prevents the introduction of foreign materials such as lint and talcum powder. The pressure effect of the pneumoperitoneum diminishes venous oozing and permits spontaneous coagulation of minor vessels. It is possible to perform intraoperative irrigation to expose any bleeding vessels and keep tissues moistened. Fine electrodes can also be used to achieve precise electrosurgical hemostasis. Like microsurgery, laparoscopic procedures are performed with few instruments. The instrument manufacturers have at last recognized the need for proper microsurgical instruments for laparoscopy; they are now readily available.

We must stress, however, that the large volume of gas insufflation necessary in operative laparoscopy causes desiccation of the mesothelial cells that line the peritoneum; furthermore, it has been recognized that CO_2 is toxic to mesothelial cells. This phenomenon may enhance the development of postoperative adhesions. Hypoxia

causes retraction of the mesothelial cells exposing the extracellular matrix. This causes substances and cellular elements that enhance adhesion formation or decrease repair to enter the peritoneal cavity. Both animal and more recently human work demonstrated that the noxious effects of CO_2 pneumoperitoneum may largely be avoided by modifying the gas mixture by adding small percentages of O_2 and N_2O, keeping the gas mixture fully humidified and at a temperature of 31°C.

Major Equipment and Surgical Instruments

The major equipment includes an electrosurgical generator suitable for both general and microsurgical work and, depending on the access mode used, either an operating microscope or appropriate laparoscopic equipment. Most of the good modern electrosurgical generators can be used for both general work and microsurgical work. Such generators are now standard equipment in most operating rooms.

When access to the pelvis is achieved by laparotomy or minilaparotomy, magnification is obtained by the use of an operating microscope or loops. Loops provide low levels of fixed magnification. It is difficult to work with loops that provide a magnification greater than four times. They are suitable for use only in simple short procedures and are quite helpful when used to divide adhesions or excise endometriotic lesions located deep in the pelvis. Magnification is best obtained with an operating microscope that provides magnification ranges from 2 to 40 times; coaxial illumination of a constant visual field enables precise focusing and change of levels of magnification. In gynecologic microsurgery, an objective lens with a focal distance of 250 to 300 mm allows for a suitable working distance under the lens. The microscope can be mounted on the floor or ceiling. Focusing, varying the level of magnification, and other functions of the microscope can be manual or motorized. The latter version is preferable because changes can be readily accomplished through controls on a foot pedal while the surgeon's hands remain in the operative field. Most modern operating microscopes are equipped with beam splitters, which permit the fitting of two pairs of binoculars so that both the surgeon and the assistant can simultaneously view the operative field. A miniature television camera can also be fitted to the same beam splitter, which enables the operating room personnel to follow the surgery on the monitor and allows video recordings of the procedure to be made.

When laparoscopic access is used, a good laparoscope equipped with a high-resolution mini TV camera and a highresolution monitor is required. The laparoscope does not offer the stereoscopic vision and the excellent depth of field that the operating microscope provides. Nonetheless, first generations

of three-dimensional laparoscopic equipment and magnification devices have been produced. Progress is under way.

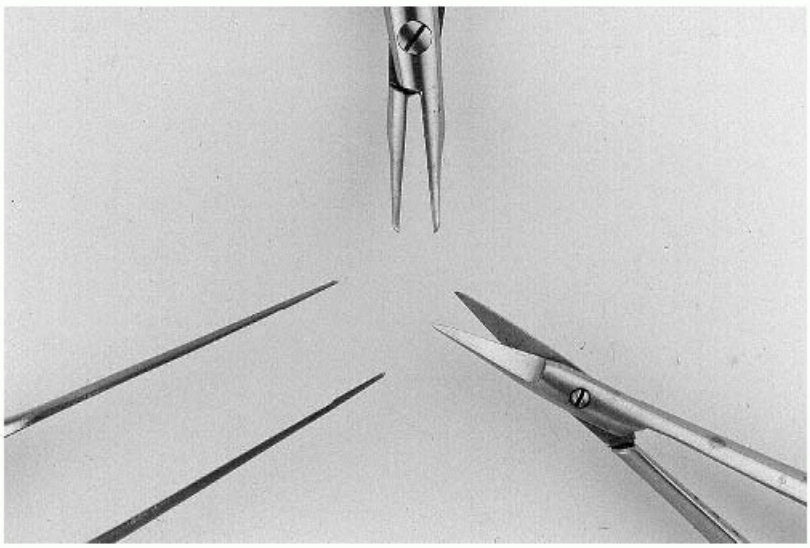

FIGURE 21.12 The working tips of the principal microsurgical instruments: plain forceps, scissors, and needle holder.

Good microsurgical instruments for open access have been present since the 1970s. Microsurgical instrument for laparoscopic access became available in the last two decades. Although their shapes are obviously different, their functions are similar. The basic microsurgical instruments are few and include plain and toothed platform microforceps, microscissors, microneedle holder, and straight scissors and/or a microblade to transect the tube (**Fig. 21.12**). The forceps have rounded tips with a shaft designed so that they, like the scissors and needle holder, have good ergonomics and can be used comfortably. Teflon-coated probes with variable rounded tips are used for retraction.

Electromicrosurgery requires the use of a true insulated microelectrode of 100 or 150 μm in diameter with a free pointed conical tip. The microelectrode is connected to the handle of the electrosurgical unit with an adaptor. A rocker switch mounted on the handle allows delivery of current in cutting, coagulating, or blend modes. Irrigation can be performed with an appropriate laparoscopic irrigator. For open procedures, a device with a fingertip control (Gomel irrigator) (**Fig. 21.13**) is commercially available and enables accurate irrigation.

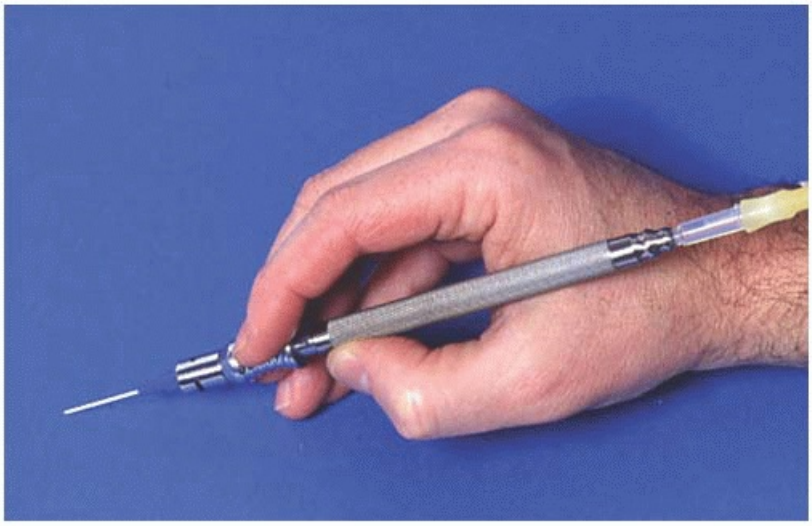

FIGURE 21.13 The Gomel microsurgical irrigator. An intravenous cannula has been attached to the tip of the irrigator. Fingertip control of the sliding valve permits one to initiate or stop irrigation.

Immediate Preoperative Preparation

Before the induction of anesthesia, the surgeon must ensure that all necessary equipment and instruments are present and in working order. After the induction of anesthesia, the patient's bladder is catheterized with a Foley catheter, which is connected to continuous drainage. If intraoperative chromopertubation is required, either a pediatric Foley catheter or an appropriate uterine cannula is introduced through the cervix and fixed in place. The catheter or cannula is connected either directly or by means of an extension tube to a syringe filled with dilute dye solution.

When open surgical access is used, anteversion and elevation of the uterus can be achieved either by selecting a suitable uterine cannula or by packing the vagina. With the latter option, a pediatric Foley catheter should first be placed in the uterine cavity if intraoperative chromopertubation is desired.

Surgical Access

As indicated earlier in the text, many reconstructive tubal operations can be performed by laparotomy, minilaparotomy, or laparoscopic access. The selection of the specific access route depends on the nature of the lesion, the type of procedure required, and the skill of the surgeon. The aim is to select the access route that will

yield the best outcome for the patient.

Many reconstructive operations, especially those for distal tubal disease, can be efficiently performed by laparoscopic access. Because of the advantages inherent in undertaking such a procedure at the time of the initial diagnostic laparoscopy, it is preferable that a surgeon trained in this type of surgery perform the initial laparoscopy.

Access by Laparoscopy

Once a proper pneumoperitoneum is obtained, the principal trocar and cannula are inserted (usually intraumbilically), the trocar is removed, and the laparoscope is introduced through the cannula. The details of performing a laparoscopy will not be described in this chapter. A thorough laparoscopic survey is performed as described earlier in this text, and the nature and extent of the tubal and pelvic lesions is assessed. The information yielded by the prior complemented by the laparoscopic findings and the status of the other fertility parameters, permits the surgeon to select the therapeutic approach that is best for the patient.

The laparoscopic survey requires the establishment of a secondary portal for the introduction of a probe or other appropriate instrument. This ancillary portal is placed suprapubically in the midline or in one of the lower abdominal quadrants. The undertaking of reconstructive surgery will necessitate the establishment of additional portals of entry. These are placed, depending on the clinical findings and the procedure to be performed, at sites that permit easy access to the operative field.

Open Access: Minilaparotomy

In reconstructive tubal surgery, a transverse suprapubic incision is the type used most often. Since 1985, we have used a small, minilaparotomy, suprapubic transverse or vertical (if a midline or paramedian scar is present) incision to gain access to the pelvis. The length of this minilaparotomy incision is usually 4.5 to 6 cm. The prior pelvic findings and especially the depth of the patient's subcutaneous adipose layer determine the length of the incision. The site of the proposed incision is infiltrated with a long-acting anesthetic agent, such as

0.25% bupivacaine (Marcaine) solution. A transverse suprapubic incision is made and extended down to the fascia. The subcutaneous fat is dissected over the fascia, in the midline upward and downward. The fascia is then incised vertically in the midline. The recti muscles are separated in the midline, and the peritoneum is incised vertically, with the incision curbed laterally at the lower end to avoid the bladder. The subcutaneous tissues are reinfiltrated with the same solution before closure of the skin incision. Thereafter, a bilateral ilioinguinal nerve block is established. The small size of the incision; the lack of bowel manipulation, along with gentle handling of tissues during the procedure; and the use of local anesthesia reduce postoperative discomfort and analgesia requirements. This approach permits prompt mobilization of the patient and discharge from the hospital or surgical center usually on the same day. These patients return to normal activity almost as rapidly as those who have had their procedures performed laparoscopically.

It is essential that the surgical personnel thoroughly wash their gloves after they have been put on and again before making the peritoneal incision. Once the peritoneal cavity is entered, retraction is obtained with a disposable device that provides both wound protection and circumferential retraction with maximal exposure for the incision size. Varying sizes of such devices are available from many manufacturers and are preferable to standard retractors. Pads soaked in heparinized (5,000 U/L) lactated Ringer solution can be introduced into the pouch of Douglas to further elevate the uterus and isolate the bowel already displaced by a mild (10- to 15-degree) Trendelenburg tilt.

Once the surgical site is well exposed, the operating microscope is positioned. Although the operating microscope can be draped, we have not found this to be necessary, particularly if foot pedals control the

microscope. Intraoperative irrigation is performed with heparinized lactated Ringer solution in an intravenous bag that is elevated and connected with intravenous tubing to a Gomel microsurgical irrigator (**Fig. 21.12**). This enables periodic irrigation of the exposed peritoneal surfaces and ovaries to prevent desiccation and to visualize individual bleeders.

Pelvic Lavage

At the close of a reconstructive procedure, irrespective of the type and the mode of access, the operative site is inspected to ensure that complete hemostasis has been achieved. Any bleeding vessels are electrodesiccated. A thorough pelvic lavage is then performed with the irrigation solution until the fluid remains clear. Pelvic lavage serves to remove from the peritoneal cavity any blood clots or other debris that may be present.

When laparoscopic access is used for the procedure, underwater examination of the operative site may be performed. When the irrigation fluid remains clear, the pneumoperitoneum pressure is reduced and the region inspected with the distal end of the laparoscope under the surface of the fluid. This permits prompt recognition of any small bleeding vessels, which can be desiccated with the use of a microelectrode or microbipolar forceps.

Once the irrigation fluid is completely suctioned out of the pelvis, some investigators leave varying amounts of physiologic solution in the peritoneal cavity to reduce postoperative adhesions. We use 300 to 500 mL of lactated Ringer solution to which 500 mg of hydrocortisone succinate is added. There are promising new products designed to prevent adhesion formation that are easy to apply by both open and laparoscopic access; these are currently undergoing clinical trials. The topic of ancillary measures for adhesion prevention is outside the purview of this chapter and will not be discussed further.

SURGICAL TECHNIQUE

In this chapter, the following procedures are discussed: salpingo-ovariolysis, fimbrioplasty, salpingostomy, tubotubal anastomosis to repair midtubal disease or to reverse a prior sterilization, tubocornual anastomosis to treat proximal tubal disease, and other procedures performed rarely in unusual circumstances. The techniques used for these procedures are essentially the same irrespective of the access route.

Whereas procedures for distal tubal disease are very amenable to laparoscopic access, anastomotic procedures are technically more difficult to accomplish by this route. Isthmicisthmic and isthmic-ampullary anastomosis (usually used for sterilization reversal) have been performed with varying degrees of accuracy via laparoscopic access, but accomplishing other types of anastomoses (especially tubocornual) through this access route is much more challenging.

With microsurgical procedures, our aim has always been to keep the techniques as simple as possible for the outcomes to be reproducible, not only by surgical virtuosi but also by all physicians who practice in this field. Our more recent technical modifications, including access through a minilaparotomy incision and the use of a protractor, were the result of the same thought process. Although we remain enthusiastic proponents of laparoscopic access, we do not let this enthusiasm blind us to the possibility that some procedures may still be performed better by modifications and improvements in traditional methods.

Salpingo-Ovariolysis

Pelvic and periadnexal adhesions usually are the sequel of PID. These adhesions may be broad or shallow; they are usually not too vascular and extend from one structure to another. In so doing, they tend to leave a space or potential space between the involved structures, an aspect that facilitates adhesiolysis (**Fig. 21.14**). Dense cohesive adhesions often result from prior surgery. In this case, adjacent structures are intimately conglutinated. The adherent surface is devoid of the superficial mesothelial layer of the peritoneum. In other words, the underlying stromal layers of the two structures coalesce. The lysis of such an adhesive process is technically

difficult and is associated with a very high percentage of recurrence.

Periadnexal adhesions usually coexist with other types of tubal damage. Thus, salpingo-ovariolysis is often an integral part of other reconstructive procedures. However, periadnexal adhesive disease may be the sole apparent lesion, in which case

fertility depends on the severity and nature of the adhesions. Even in the presence of a patent tube, extensive adhesions may encapsulate the tube (especially the fimbriated end, the ovary, or both) and prevent ovum pickup (**Fig. 21.9**). By fixing the fimbriated end of the patent tube away from the ovary, adhesions may distort their spatial relationship and, hence, the functional proximity that exists between these two organs. For example, the fimbriated end of a patent tube may be adherent to the anterior abdominal wall or the uterine fundus, whereas the ovary is fixed in the pouch of Douglas. Periovarian adhesions may also affect follicular development, as has been demonstrated in both animal and human studies. Human studies were usually performed on patients undergoing IVF treatment.

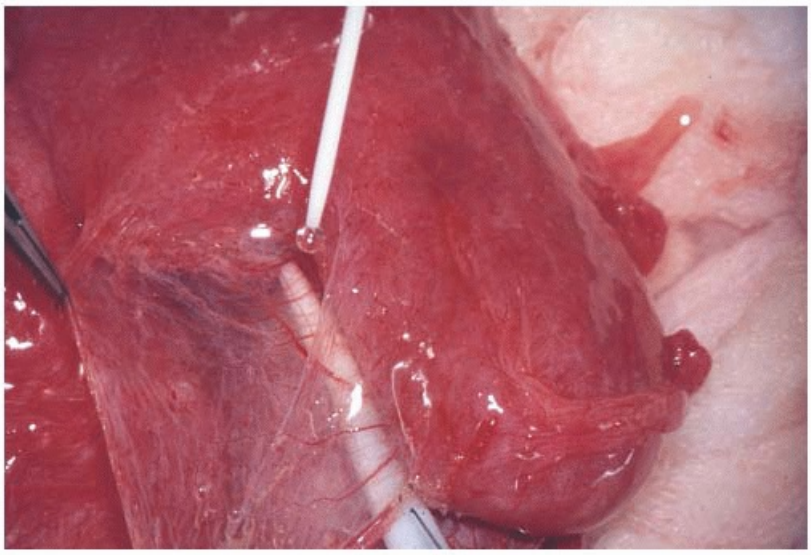

FIGURE 21.14 Salpingolysis. The space between the two involved structures facilitates division.

When salpingo-ovariolysis is performed by open access, adhesiolysis is usually commenced by defining the distal margins of the adhesions. The division of adhesions at their distal attachment frees the adnexa, making it possible to elevate and bring them closer to the abdominal wall. This move facilitates the remainder of the procedure. Elevation of the adnexa is achieved by the use of inert pads soaked in the irrigation fluid. Adhesiolysis is then completed by systematically excising the adhesions from the tubal serosa or ovarian surface (**Fig. 21.14**). With laparoscopic access, it is usually preferable to reverse this order and commence the adhesiolysis at the level of the adnexa.

Adhesions are put on tension with a toothed forceps, and the site of incision is exposed. Division is effected electrosurgically or with appropriate microsurgical scissors. It is imperative to divide adhesions one layer at a time, slightly lateral to their attachments to the organ to avoid damaging the adjacent peritoneum. Adhesions are often composed of two layers, even though they may initially appear as a single layer. They tend to attach to an organ at two different levels. It is essential to enter between the two layers first; this permits exposure of the demarcation line between the adhesion and the mesothelium of the adjacent structure. Each layer of adhesion is then put on a stretch with toothed forceps, the demarcation line is identified, and the adhesion is transected. With open access, placement of a Teflon rod under the incision line enhances exposure. Damage to the peritoneum or ovarian surface is avoided by keeping the transection line 1 mm away from these surfaces. Prominent vessels along the transection line are individually electrodesiccated.

When a microelectrode is used for this purpose, the electrosurgical unit is put on the blend or cut setting. Pure coagulating current (coag mode) may be used to obtain hemostasis of individual bleeders, which are exposed under a jet of irrigation fluid. With open access, an elongating adaptor may be attached to the handle of the electrosurgical unit to facilitate adhesiolysis in the deeper parts of the pelvis.

All of the broad adhesions are excised and removed from the pelvis. Shallow adhesions are simply divided. In this case, a small opening is made on the adhesion, through which a fine instrument or Teflon rod is introduced. This permits separation of the adjacent structures and better visualization of the adhesion, which is incised without damaging these structures. The procedure is completed with a thorough pelvic lavage with the irrigation solution mentioned earlier in the text.

The technical principles are identical when laparoscopic access is used for the procedure. In this case, however, because there is no need to lift the adnexa close to the abdominal wall, the salpingo-ovariolysis is commenced with the tube and ovary. Once again, the performance of effective and safe salpingo-ovariolysis requires clear identification of each adhesive layer, which is grasped and retracted, permitting clear identification of the attachments to the organ of interest. The adhesions are incised parallel to the organ of interest and approximately 1 mm away to prevent damaging its mesothelial envelope (**Figs. 21.15** and **21.16**). Division is accomplished electrosurgically with a microelectrode or mechanically with fine scissors. We use scissors for laparoscopic salpingo-ovariolysis and electrodesiccation to secure obvious vessels or bleeders encountered along the incision line. As described earlier, shallow adhesions are simply divided, whereas broad adhesions are excised (by dissecting them free at all points of attachment) and removed through one of the ancillary portals (**Fig. 21.16**).

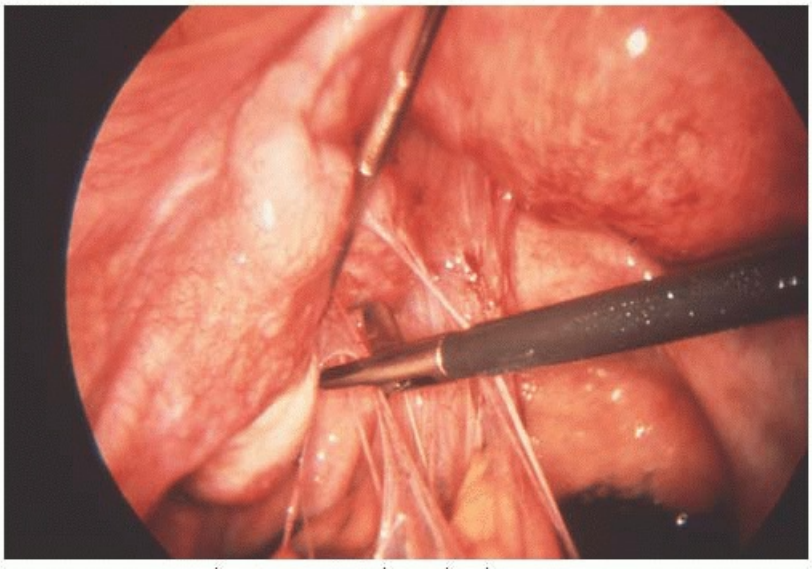

FIGURE 21.15 Salpingo-ovariolysis by laparoscopic access (same patient as in **Fig. 21.9**). Division of adhesions parallel to the tube.

Cohesive adhesions require identification of the dissection plane. This is achieved by making a small incision and developing a tissue plane either by spreading the jaws of the scissors, by blunt dissection, or by hydrodissection (injecting irrigation solution into the site under pressure). It is important to abstain from using thermal energy in such cases because of the inherent danger.

It should not be necessary to use open access, excepting rare circumstances, for the purpose of salpingo-ovariolysis. Our primary approach in such cases has always been by laparoscopic access and whenever possible at the time of the diagnostic survey.

Results of Salpingo-Ovariolysis

The reported intrauterine pregnancy rates resulting from open microsurgical salpingo-ovariolysis range from 41% to 57%. The rates for live births are 37% to 57%, and the rates for ectopic pregnancies are 5% to 8% of operated patients. In one of these studies, 33 of 63 (52.4%) patients who underwent open microsurgical salpingo-ovariolysis achieved intrauterine pregnancies; in addition, 3 (4.8%) had ectopic pregnancies at 2-year followup. These 63 patients reported by Tulandi had been randomized to two cutting modalities: electrosurgery (n = 33) and CO_2 laser (n = 30). The results were identical in both subgroups. Indeed, there has been no demonstrable improvement in the outcome of such procedures with the use of lasers in both clinical and experimental studies.

The preexisting tubal patency and the uncontrolled nature of the salpingo-ovariolysis series reported in the literature may cast doubt on the value of this procedure. The Canadian Infertility Evaluation Study Group addressed this issue by studying treatment-dependent and treatment-independent pregnancies in patients with periadnexal disease whose fallopian tubes were not completely occluded. This was a multicenter, controlled, randomized study. The cumulative pregnancy rates reported by Tulandi and colleagues in 1989 were 59% among 69 patients in the group who underwent microsurgical salpingo-ovariolysis and only 16% among the

78 control patients who were not treated. This study confirms that pregnancies may occur in a small proportion of women with periadnexal adhesions and patent tubes and also proves the therapeutic value of salpingo-ovariolysis in such cases.

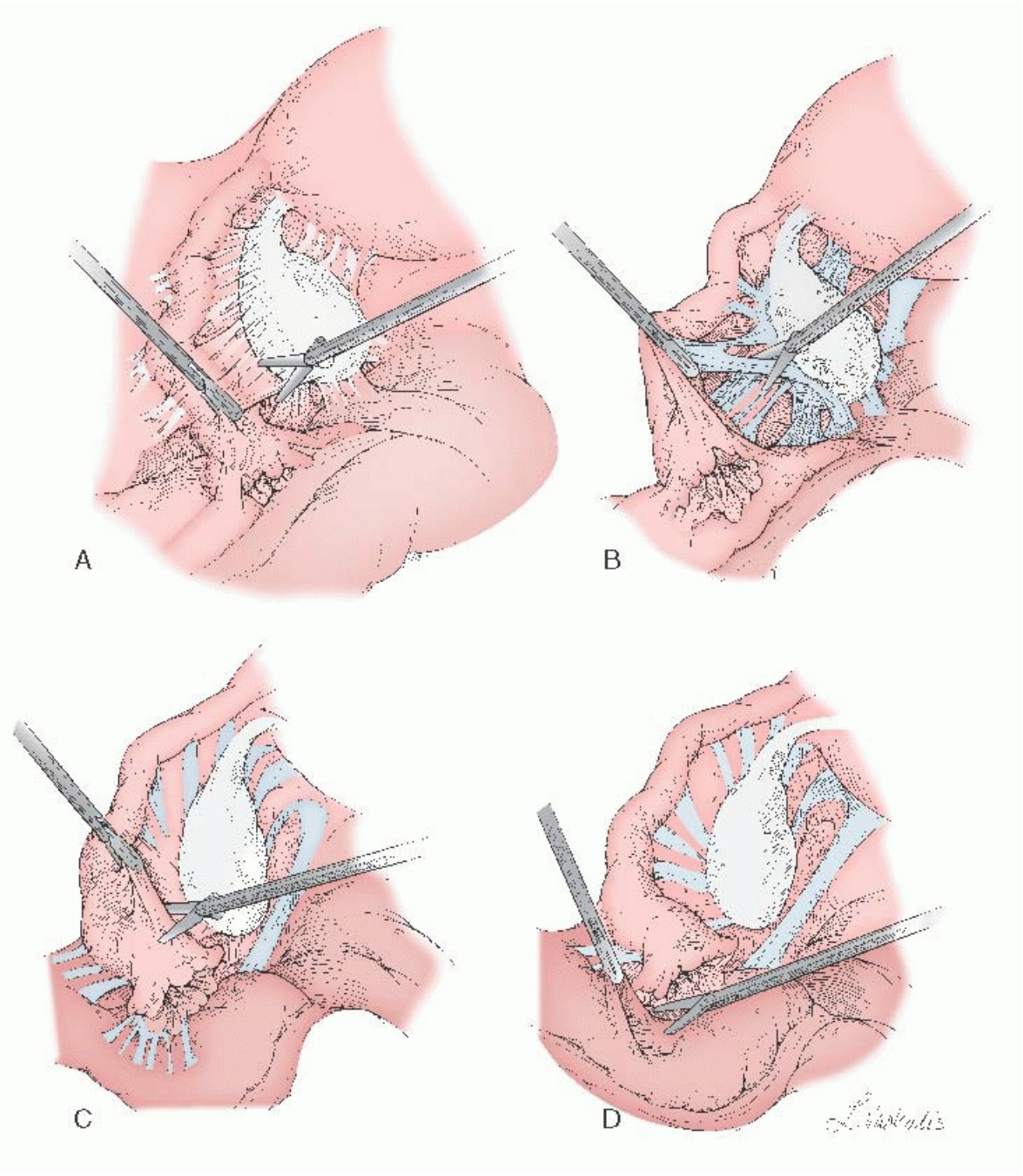

FIGURE 21.16 Salpingo-ovariolysis. **A:** Division of adhesions commences in a wellexposed area. **B:** Adhesions are stretched and are divided one layer at a time parallel to the organ of interest. **C:** Broad adhesions are freed at all points and removed from the peritoneal cavity. **D:** Salpingo-ovariolysis being completed. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:171, with permission.)

In the early stages of development of operative laparoscopy, we demonstrated that laparoscopic salpingo-ovariolysis yields results similar to those obtained by open access. We also stressed the importance of adhering to microsurgical principles in the performance of such procedures by both open and laparoscopic access. In 1983, we reported a series of 92 patients who underwent salpingo-ovariolysis by laparoscopy. The duration of involuntary infertility was longer than 20 months for all patients. Periadnexal adhesions were severe in 79 patients and moderate in 13. Moreover, the series included only those patients in whom ovum pickup by the tube on the side with lesser disease was deemed impossible or greatly hampered. At the time of the survey, the patients had been monitored postoperatively for a period of 9 months or longer. Of the 92 patients, 57 (62%) achieved at least one intrauterine pregnancy, 54 (59%) had one or more live births, and 5 (5.4%) had ectopic pregnancies. Ten of the patients who did not get pregnant had a second-look laparoscopy that demonstrated no

significant residual adhesive process.

Similar results were corroborated by Bruhat et al. and Donnez et al. at other centers in Europe and by Fayez in North America. This demonstrates that the results of laparoscopic salpingo-ovariolysis, as expected, depend on the severity of the adhesions. The reported intrauterine pregnancy rates after laparoscopic salpingo-ovariolysis range from 51% to 62%, and ectopic pregnancy rates range from 5% to 8% of operated cases. Although no prospective, randomized trials exist, these results appear similar to those yielded by laparotomy.

Fimbrioplasty

Fimbrioplasty is the reconstruction of the fimbriae or infundibulum in a tube that exhibits fimbrial agglutination or prefimbrial phimosis and results in partial distal occlusion. Often, the tube and ovary are involved in adhesions, in which case salpingo-ovariolysis must precede the fimbrioplasty. The technique of fimbrioplasty, which will be described further, is the same irrespective of the access route used. Our approach is invariably by laparoscopic access.

Fimbrial phimosis results from the agglutination of the fimbriae. A small opening is usually present at the distal end of the tube unless this opening is covered by fibrous tissue. The latter usually becomes evident when the tube is distended by transcervical chromopertubation. When the opening is covered by fibrous tissue, this tissue must be incised or excised

to gain access to the fimbriae (**Fig. 21.17**). Agglutination of the fimbriae can be corrected simply by introducing a fine forceps, a 2-mm alligator forceps with jaws closed through the phimotic fimbrial opening. The jaws of the forceps are opened within the tubal lumen, and the forceps are gently withdrawn with the jaws open. Deagglutination is achieved by repeating this movement a few times, varying the direction in which the jaws of the forceps are opened (**Fig. 21.18**). When sufficient gentleness is used during this manipulation, bleeding is usually negligible and stops spontaneously.

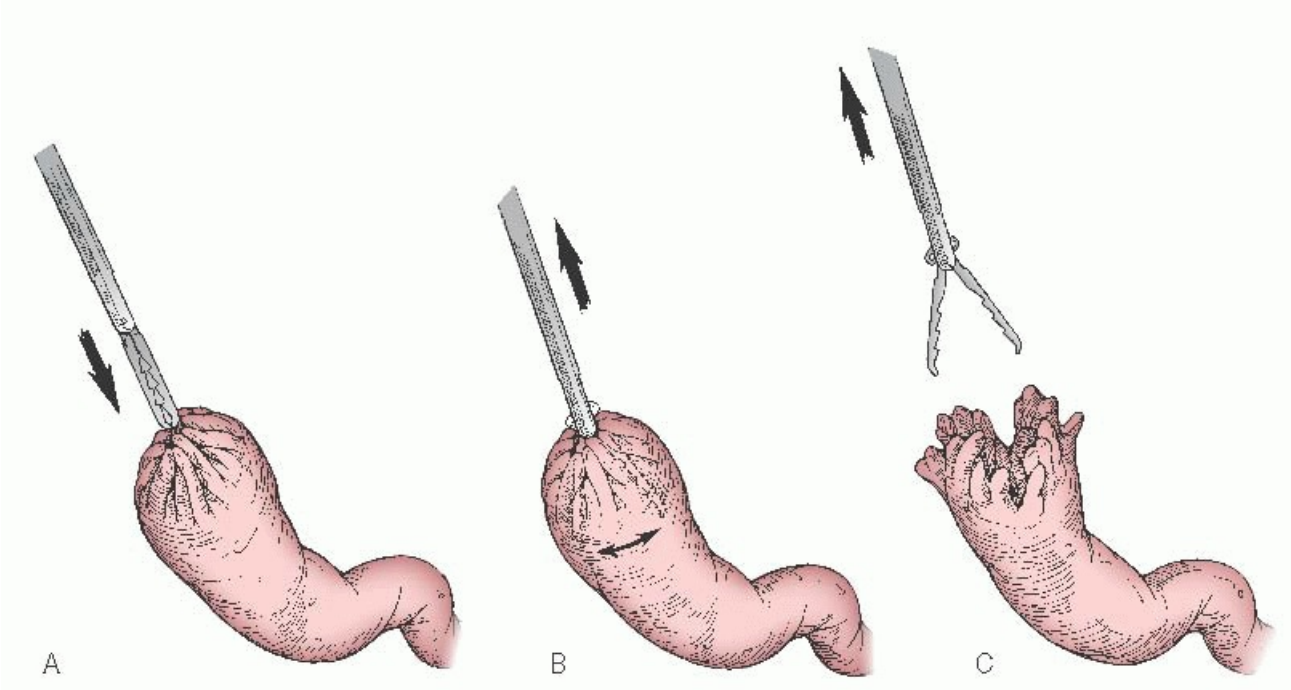

FIGURE 21.17 Fimbrioplasty: to free agglutinated fimbriae. **A:** The 3-mm alligator-jawed forceps is introduced through the stenosed opening. **B:** The jaws of the forceps are opened within the tube. **C:** The forceps is gently withdrawn while the jaws are kept open. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:173, with permission.)

When the stenosis is located at the level of the true abdominal tubal ostium, which is located at the apex of the infundibulum, the fimbriae may have a normal appearance. However, when chromopertubation is performed, the ampullary portion of the tube distends before any exit of dye solution. In this instance, it is necessary to place an incision on the antimesosalpingeal border of the tube, which commences at the infundibulum and continues past the stenotic area into the distal ampulla. The tube is stabilized by introducing a thin Teflon probe through the stenotic opening into the distal ampulla; the incision is made electrosurgically by using a microelectrode. This is the approach we generally use. Alternatively, the area can be injected with 1 mL of dilute vasopressin solution (1 IU in 30 mL of normal saline) and the incision made mechanically with microsurgical scissors. Bleeders are desiccated electrosurgically. The edges of the two flaps thus created are folded back either by securing them to the adjacent ampullary serosa with no. 7-0 or 8-0 polyglactin 910 (Vicryl) sutures or by electrosurgery (or a defocused CO_2 laser beam), which desiccates the serosal aspect of the flaps, causing them to fold backward (**Fig. 21.19**).

Results of Fimbrioplasty

Very few investigators have classified fimbrioplasty as an independent procedure. Most include such patients in their salpingostomy series. French and Belgian centers include fimbrioplasty (correction of partial distal tubal occlusion) as stage 1 in their salpingostomy series.

Patton et al., in a series of microsurgical fimbrioplasty procedures in 40 patients, reported total intrauterine and ectopic pregnancy rates of 63% (25 patients) and 5% (2 patients), respectively, after 24 months of follow-up. The outcome of the intrauterine pregnancies and the live birth rates were not provided.

In 1983, we reported 40 such patients, all treated by laparoscopic access. Live births occurred in 19 (48%), and two patients (5%) had tubal gestations. In 1979, Mettler et al. reported a crude pregnancy rate of 31% among 51 women. The anatomic location and outcome of these pregnancies were not recorded. In 1990, Dubuisson et al. reported 31 such patients. After 18 months of follow-up, eight patients (25.8%) had intrauterine pregnancies, and four (12.9%) had ectopic pregnancies. In 1986 in a series of 100 patients, Donnez et al. reported a total pregnancy rate of 61%. The location and outcome of these pregnancies were not provided. A 1991 report by Canis et al. included 32 such patients with their salpingostomy patients; 16 (50%) of these achieved intrauterine pregnancies, but the outcome was not reported. Surprisingly, there were no tubal pregnancies.

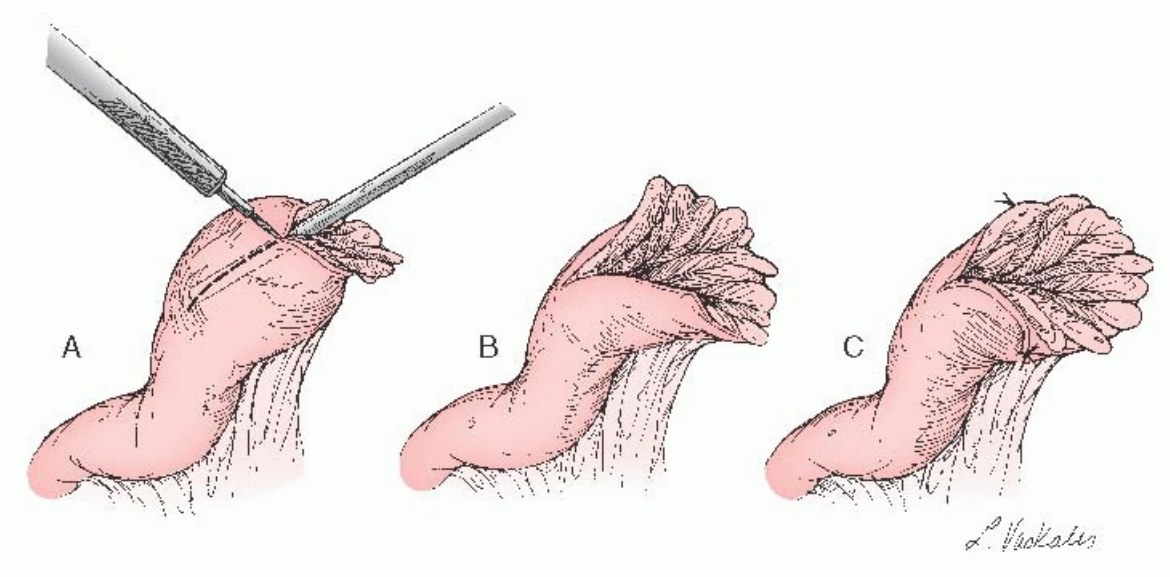

FIGURE 21.18 Fimbrioplasty: correction of prefimbrial phimosis. **A and B:** An incision is placed at the antimesosalpingeal border of the tube. **C:** Completed procedure with flaps everted. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:173, with permission.)

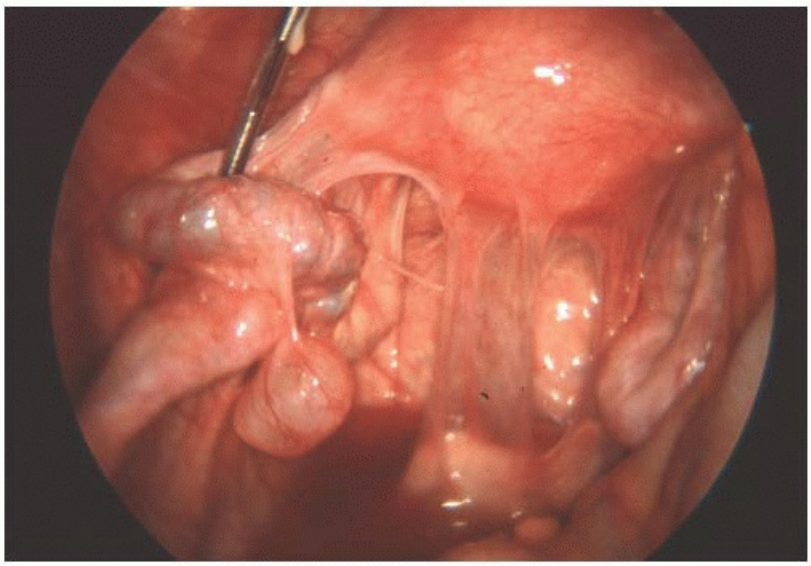

FIGURE 21.19 Bilateral hydrosalpinx with periadnexal and pelvic adhesions.

Salpingostomy (Salpingoneostomy)

Salpingostomy, or salpingoneostomy, is the creation of a new stoma in a tube with a completely occluded distal end (hydrosalpinx). Salpingostomy can be terminal, ampullary, or isthmic, depending on the anatomic location at which the new stoma is fashioned.

Isthmic and ampullary salpingostomy are of historic interest, except for the reversal of prior fimbriectomy (Kroener sterilization), in which ampullary salpingostomy may have a place. We demonstrated that success with ampullary salpingostomy in such cases is dependent on ampullary length and suggested that reconstructive surgery should only be undertaken when more than one half of the ampulla is present. In 1980, we reported a small series of 14 patients submitted to ampullary salpingostomy for reversal of sterilization. They all met the requirement of having more than one half of the ampullary segment preserved, at least on one side. Six of these women had one or more intrauterine pregnancies (42.9%); of whom five had live births (35.7%); the other had a midtrimester abortion. There were no ectopic pregnancies. Subsequently, experiments by Halbert et al. performed on rabbits corroborated the necessity of having one half or more of the ampulla preserved. This recommendation is corroborated by a 2001 study, by Tourgeman et al. reporting on 41 women who had fimbriectomy reversal.

Distal tubal occlusion is usually associated with varying degrees of pelvic and periadnexal adhesions that must first be lysed. Thereafter, the distal end of the tube is examined to ensure that it is not adherent to the ovary or other structures. If the distal tube is adherent, it must be dissected free until the tubo-ovarian ligament is exposed. Only by freeing the tube can the surgeon ensure that the neostomy is being performed at the appropriate site.

Once the salpingo-ovariolysis is completed and the tube is totally freed, it is distended by transcervical chromopertubation. The occluded terminal end of the tube is examined under magnification, which permits recognition of the relatively avascular zones that radiate from a central punctum. The tube is entered at this central point with use of the microelectrode or microsurgical scissors, and the incision is extended toward the ovary over an avascular line (**Figs. 21.20A, B**, and **21.21A**). This incision fashions a new fimbria ovarica that maintains the tuboovarian relation. At this point in the procedure, it becomes

possible to view the tube from within when placing additional incisions along its circumference to complete the creation of a new stoma. These additional incisions are made between endothelial folds over avascular areas. In

so doing, one avoids cutting through vascular mucosal folds, which will be shaped as fimbriae, and bleeding is minimized as a result (**Figs. 21.20C, D** and **21.21B, C**). Any bleeding points that occur are exposed under a jet of irrigation fluid and desiccated individually with a microelectrode or microbipolar forceps. Once a satisfactory stoma is achieved, the flaps created in the process are everted either by securing them without tension to the ampullary seromuscularis with interrupted no. 7-0 or 8-0 Vicryl sutures (**Fig. 21.20E**)—this is the approach we prefer—or by desiccating their serosal surface, which causes them to fold backward. Desiccation is achieved either electrosurgically with a small ballshaped electrode and a low power density or with CO_2 laser using a defocused beam. The procedure is concluded with a thorough pelvic lavage, as described earlier in this chapter (**Fig. 21.21D**).

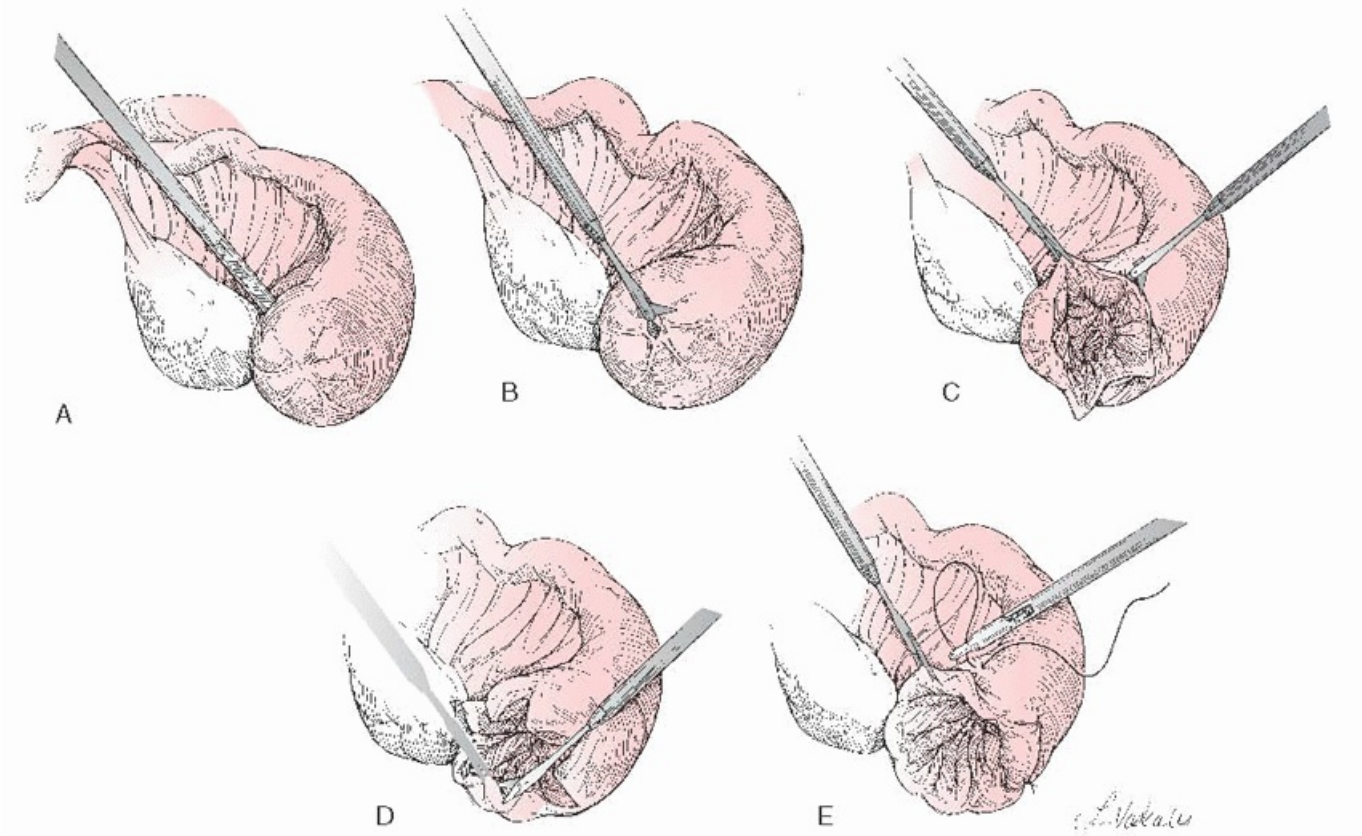

FIGURE 21.20 Salpingostomy. **A:** The occluded distal end of the tube usually has a centrally placed avascular area, from which avascular scarred lines extend in a cartwheel manner. **B:** The first incision is made along an avascular line toward the ovary. **C:** Avascular lines are incised by viewing from within the tube along the circumference of the initial opening. **D:** Cutting along the avascular lines is continued until a satisfactory stoma is fashioned. **E:** The flaps can be everted by placing two or three no. 6-0 absorbable synthetic sutures. (From Gomel V, Taylor PJ. *Diagnostic and operative gynecologic laparoscopy.* St Louis, MO: Mosby, 1995:174, with permission.)

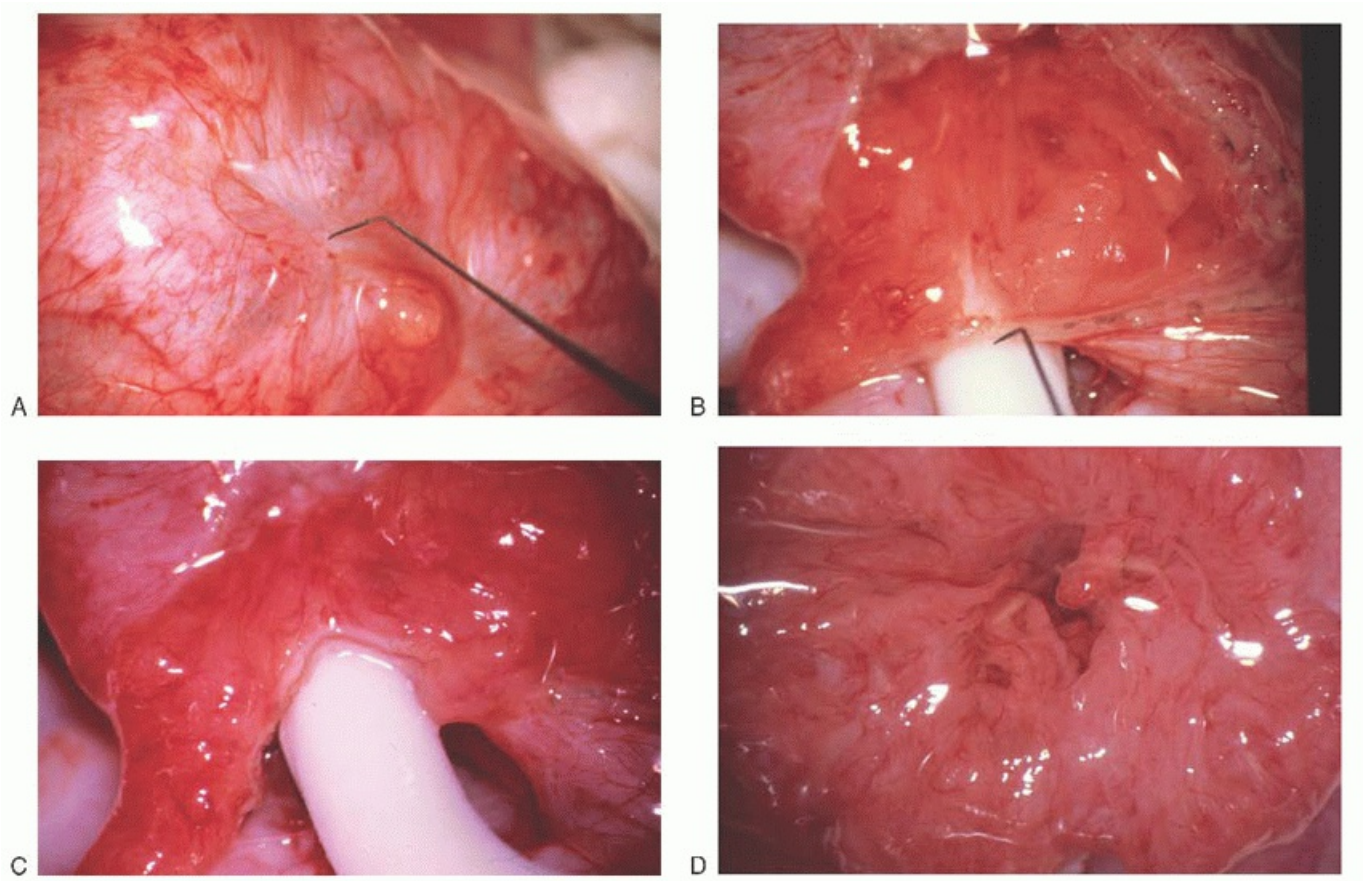

FIGURE 21.21 Microsurgical salpingostomy by open access. **A:** The terminal end of the tube is entered at an avascular central point, and the incision is extended toward the ovary. **B and C:** The tube is then viewed from within, and small incisions are placed along the circumference of the tube. **D:** Completed salpingostomy; the infundibular portion of the tube has well-preserved epithelium and folds.

Considering the results of salpingostomy obtained by laparoscopy approach and those obtained by open access, and considering further the significant improvement in IVF results, an open salpingostomy should rarely be indicated.

If during the initial diagnostic laparoscopy, the surgeon decides to perform the salpingostomy, or for that matter any other reconstructive tubal procedure, by open access, and if pelvic and/or periadnexal adhesions exist, these adhesions can be lysed laparoscopically at their distal margins, thus mobilizing the adnexa. Such an undertaking permits the subsequent salpingostomy or other procedure to be readily performed through a minilaparotomy incision.

Results of Salpingostomy

In the major published series, the live birth rate after microsurgical salpingostomy ranges from 20% to 37%, and the ectopic pregnancy rate ranges from 5% to 18% (**Table 21.4**). Work performed in the past 40 years has made it evident that the major determinants of the outcome of salpingostomy are the degree of preexisting tubal damage, the extent and nature of periadnexal adhesions (**Figs. 21.21** and **21.22**), and the surgical technique (**Fig. 21.23**). The following factors were quantified in a numerical scoring system to predict the prognosis of the surgical outcome: ampullary diameter, tubal wall thickness, nature of the tubal endothelium, extent of adhesions, and type of adhesions. This scoring system was approved by the American Fertility Society (current ASRM) and published in 1988. In cases deemed favorable (mild), the reported live birth rates after microsurgical salpingostomy range from 40% to 60%. This rate drops to less than 20% in cases considered unfavorable (severe).

In 1990, we reported a series of 90 patients who underwent microsurgical salpingostomy with a minilaparotomy incision. Nineteen (21.1%) were lost to follow-up and were considered failures. Twenty-seven (30%) patients achieved one or more intrauterine pregnancies, and eight (8.9%) had tubal pregnancies. Ectopic gestations occurred in two additional patients

who also had intrauterine pregnancies. Twenty-three (25.6%) women were successful in having one or more live births. These 90 patients were assessed with the classification approved by the American Fertility Society. On the basis of this classification, 73 patients had extensive (severe) damage, and 17 had limited (mild) damage. In the group of 73 patients, 15 (20.5%) had one or more intrauterine pregnancies, and 13 (17.8%) had one or more live births. In the “mild” group of 17 patients, 12 (70.6%) had one or more intrauterine pregnancies, and 10 (58.8%) had one or more live births ($P < 0.05$) (**Table 21.5**). These observations emphasize the importance of a thorough preoperative investigation and proper patient selection.

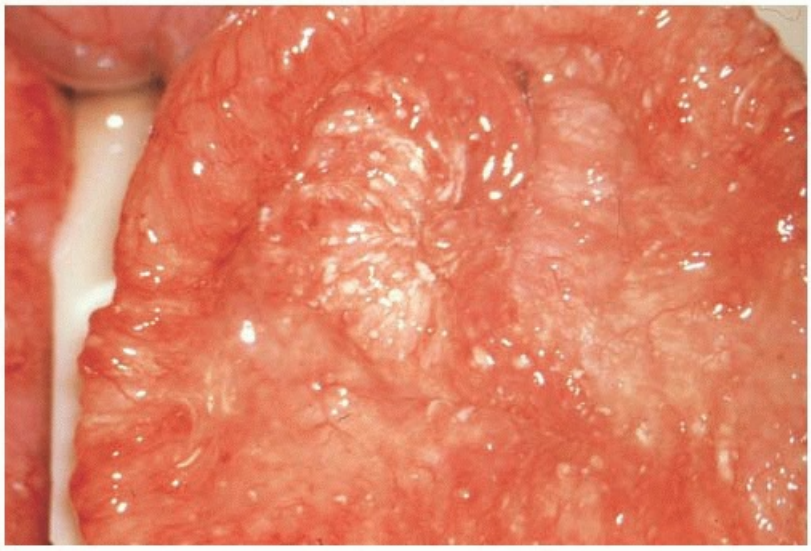

FIGURE 21.22 Microsurgical salpingostomy by open access. The tube is markedly dilated and exhibits a flat epithelium with poorly preserved folds.

On the surface, the results yielded by laparoscopic salpingostomy appear to be somewhat inferior to those obtained by open access. However, laparoscopic salpingostomy offers distinct advantages: it can be performed during the initial diagnostic laparoscopy, avoiding a second intervention and resulting in cost savings.

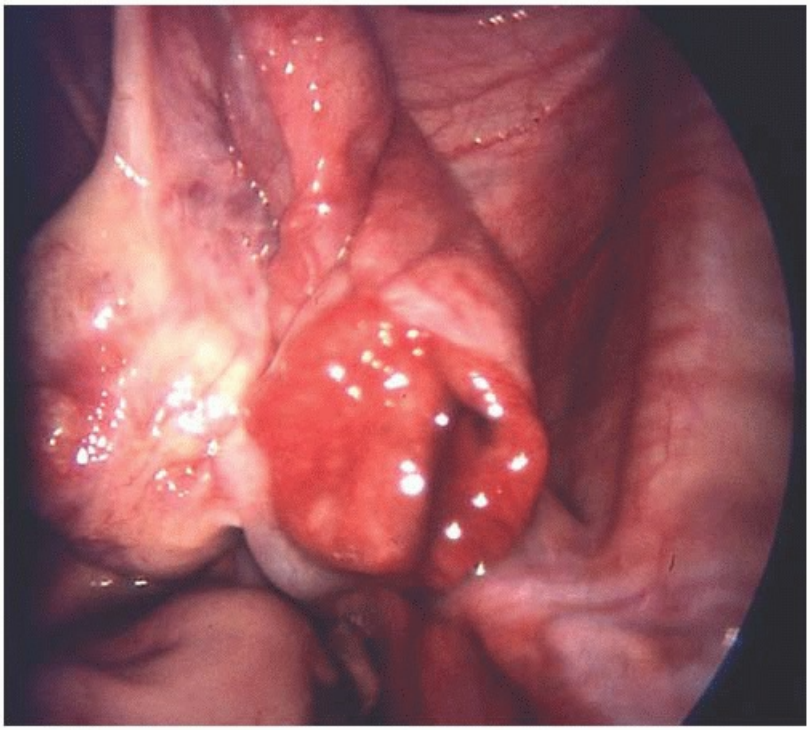

FIGURE 21.23 Second-look laparoscopy following salpingostomy demonstrating a patent tube and a paucity of adhesions (the same patient as **Fig. 21.10**).

The ASRM's committee opinion, in regard to fimbrioplasty and salpingotomy, is as follows: "Although IVF is preferred over salpingostomy for mild hydrosalpinges in older women and for those with male factor or other infertility factors, salpingostomy before IVF may improve the subsequent likelihood of success of IVF while still giving the patient the option to attempt spontaneous conception…. The evidence is fair to recommend laparoscopic fimbrioplasty and neo-salpingostomy for the treatment of mild hydrosalpinges in young women with no other significant infertility factors."

Hydrosalpinx and IVF

Since the work of Strandell et al. in 1994, 1999, and 2001, many more reports confirmed the deleterious effect of hydrosalpinx on the outcome of IVF treatment and corroboration on the benefit of salpingectomy before IVF, which significantly increases the rate of success. A Cochrane meta-analysis by Johnson et al. in 2004 confirms the earlier work of Strandell et al. in demonstrating that the odds of ongoing pregnancy and live birth (OR 2.13, 95% CI 1.24 to 3.65) were increased after laparoscopic salpingectomy for unilateral or bilateral hydrosalpinges, visible by ultrasonography, before IVF.

Surprisingly, there have been few reports on the effect of a salpingostomy, as opposed to a salpingectomy, on pregnancy outcomes with subsequent IVF.

Several hypotheses have been put forward to explain the detrimental effect of a hydrosalpinx on fertility and specifically IVF outcome. A "washout effect" owing to the passage of the collected tubal fluid to the uterine cavity at the time when embryos are transferred is one such—and more likely— hypothesis. This washout may also occur sometime after transfer. As evidence indicates, many embryos ascend to the tube after transfer and eventually return to the uterus when the tube assumes a prouterine transport. It is at this time that the fluid contained in the hydrosalpinx, by passing to the uterus, may wash the embryos out. Other hypotheses related to the hydrosalpinx fluid include an embryotoxic effect, bioactive factors in the fluid adversely affecting endometrial receptivity, and an inadequate glucose supply in this fluid. These latter hypotheses have not been confirmed scientifically; the washout effect remains the most likely mechanism.

The assumption that the deleterious effect of large hydrosalpinges may be owing to a washout of the transferred embryos is supported by a study of Van Voorhis et al. in 1998. They compared women with hydrosalpinges (n = 34) with women who had tubal disease but no hydrosalpinges (n = 124) undergoing IVF treatment. Women with hydrosalpinges were found to have a reduced clinical pregnancy rate (18% vs. 37%, P = 0.053), a reduced ongoing pregnancy rate (15% vs. 34%, P = 0.051), and a reduced implantation rate (7% vs. 18%, P = 0.003) after IVF procedures. Among women who had hydrosalpinges, 16 had their hydrosalpinges aspirated at the time of oocyte retrieval and 18 did not. Aspiration of hydrosalpinges was associated with a higher clinical pregnancy rate (31% vs. 5%, P = 0.07), a higher ongoing pregnancy rate (31% vs. 0%, P = 0.015), and a higher implantation rate (14 vs. 1%, P = 0.015) as reported by Van Voorhis et al. However, others have indicated that aspiration of hydrosalpinx fluid is of little value before oocyte retrieval or embryo transfer.

In a study performed in our department reported by McComb and Taylor, in 2001, 23 infertile women, with a duration of infertility of 19 to 146 months (mean 53.6 months) and who had a unilateral hydrosalpinx and a patent contralateral patent tube, were submitted to a laparoscopic salpingostomy of their terminally occluded fallopian tube. The subsequent intrauterine and ectopic pregnancy rates were

43.5% and 4%, respectively. The average time to conception was 13.4 months (range 0 to 71 months). If a single patient whose surgery-pregnancy time interval was 71 months is excluded, the average surgery-pregnancy time interval of the others becomes 7 months. Both the high intrauterine pregnancy and low ectopic pregnancy rates and the short surgery-pregnancy time frame strongly suggest these conceptions occurred through the previously patent (lesser damaged) oviduct. It also suggests that salpingostomy alleviated the deleterious effect of the unilateral hydrosalpinx on embryo implantation.

TABLE 21.5 Results of Microsurgical Salpingostomy

INVESTIGATORS	YEAR	PATIENTS	INTRAUTERINE PREGNANCIES	LIVE BIRTHS	ECTOPIC PREGNANCIES
ACCESS BY LAPAROTOMY					
Swolin[a]	1975	33	9	8 (24.2%)	6
Gomel[b]	1978	41	12	11 (26.8%)	5
Gomel[b]	1980	72	22	21 (29.2%)	7
Larsson[c]	1982	54	21	17 (31.5%)	0
Verhoeven et al.[d]	1983	143	34	28 (19.6%)	3
Tulandi and Vilos[e]	1985	67	15	NS	3

Boer-Meisel et al.	1986	108	31	24 (22.2%)	19
Donnez and Casanas-Roux[a]	1986	83	26	NS	6
Kosasa and Hale	1988	93	37	34 (36.6%)	13
Schlaff et al.	1990	82	14	NS	6
Winston and Margara	1991	323	106	74 (22.9%)	32
Schippert et al.[f]	2010	153	53	32 (22.2)	12
ACCESS BY MINILAPAROTOMY					
Gomel	1990	90	27	23 (25.6%)	8
ACCESS BY LAPAROSCOPY					
Gomel[g]	1977	9	4	4	0
Daniell and Herbert[h]	1984	22	4	3 (13.6%)	1
Dubuisson et al.	1990	34	10	NS	1
Canis et al.	1991	55	13	NS	6
McComb and Paleologou	1991	22	5	5 (22.7%)	1
Dubuisson et al.	1994	90	29	26 (29.9%)	4
Oh	1996	82	29	NS	8
Millingos et al.	2000	61	14	NS	2
Taylor et al.	2001	139	44	25	23

					(18%)

[a]Follow-up period more than 8 years.

[b]Follow-up period more than 1 year.

[c]Follow-up period more than 4 years.

[d]Twenty-three of these were iterative procedures; only three of these patients (13%) had live births.

[e]Thirty-seven of these procedures were performed with the carbon dioxide laser.

[f]The total number of salpingostomies was not given; 153 is the number of patients who responded to the questionnaire.

[g]Eight of the nine patients had prior salpingostomy by conventional techniques that resulted in reocclusion.

[h]Performed with the carbon dioxide laser.

NS, not stated.

The beneficial effect of salpingostomy in IVF was demonstrated in 1998 by Murray and colleagues in a small number of cases. Obviously salpingostomy, in addition, offers the woman the potential of achieving a pregnancy naturally. This and other evidence suggest that there may well be a place for laparoscopic salpingostomy, instead of salpingectomy, in selected cases.

We in Vancouver have preferred to perform a salpingostomy instead of a salpingectomy preceding IVF treatment in the absence of factors contraindicating this approach. The ASRM's committee opinion, in this regard, is as follows: "Although IVF is preferred over salpingostomy for mild hydrosalpinges in older women and for those with male factor or other infertility factors salpingostomy before IVF may improve the subsequent likelihood of success of IVF while still giving the patient the option to attempt spontaneous conception…. Patients with poor-prognosis hydrosalpinges are better served by salpingectomy followed by IVF." And further on the text: "Intuitively, it makes sense that laparoscopic neo-salpingostomy before IVF should improve the pregnancy rate, but there are still no confirmatory studies."

Tubotubal Anastomosis

The term *tubotubal anastomosis* refers to an anastomosis performed anywhere along the tube either to treat occlusions resulting from disease processes or to reverse a prior sterilization. The procedure used to repair proximal or cornual tubal disease is usually referred to as *tubocornual anastomosis.*

Microsurgery finds its ultimate application in tubotubal anastomosis. The precision afforded by this technique allows total excision of occluded or diseased portions, proper alignment, and excellent apposition of each layer of the proximal and distal tubal segments.

Depending on the tubal segments that are approximated, tubotubal anastomosis can be intramural-isthmic, intramuralampullary, isthmic-isthmic, isthmic-ampullary, ampullaryampullary, or ampullary-infundibular. This section first describes the fundamentals of tubotubal anastomosis and then the technical variations necessary to deal with each specific type of anastomosis.

Basic Principles of Tubotubal Anastomosis

When periadnexal adhesions are present, salpingo-ovariolysis is first completed. When access is achieved through minilaparotomy, the side to be worked on is elevated with the use of pads soaked in the irrigation solution. The contralateral adnexa are left in their natural position to prevent desiccation. When access occurs by way of laparoscopy, the mesosalpinx under the site of anastomosis may be injected with 1 to 2 mL of dilute vasopressin solution to reduce oozing and facilitate hemostasis.

The principles of tubotubal anastomosis are the same, irrespective of the mode of access used. The proximal tubal segment is distended by transcervical chromopertubation. This helps in the identification of the site of occlusion. The tube is transected, with appropriate scissors, adjacent to the site of the occlusion or, in the case of a previous tubal sterilization, near the occluded end. The occluded end or the occluded segment of the tube is grasped with a strong-toothed forceps to expose the site and facilitate the transection (**Fig. 21.24A, B**), which is effected with straight scissors or a sharp microblade. It is essential to halt the incision at the mesosalpinx, in the immediate periphery of the tubal muscularis, to avoid damaging the adjacent vascular arcade. Dye solution can now escape from the transected tubal lumen (**Fig. 21.24C**).

The occluded tubal segment is excised from the mesosalpinx electrosurgically or with scissors, the line of incision kept close to the tube to avoid damaging the vessels mentioned earlier (**Fig. 21.24D, E**). The cut surface is examined under high magnification to ensure that the tube is normal. Healthy tube is devoid of scarring and exhibits normal muscular and vascular architecture together with intact mucosal folds (**Fig. 21.24F**). Hemostasis is obtained by precise electrodesiccation of the more significant bleeders, which are located between the serosa and muscularis. Each is exposed by irrigation and desiccated with an insulated microelectrode. If open access is used, gentle compression of the tube between thumb and forefinger facilitates this process. Desiccation of minor bleeders is unnecessary because they stop spontaneously. Desiccation of the tubal epithelium must be avoided to prevent damaging it and adversely affecting future tubal function. Major tubal vessels (such as those composing the vascular arcade) may be divided inadvertently or by necessity. These can be electrodesiccated with monopolar or bipolar current. Overzealous electrodesiccation must be avoided to prevent devitalizing the anastomosis site.

When there is no significant luminal disparity between the two segments, the distal portion is prepared in a similar manner. Before transection, the distal segment is distended by

descending hydropertubation, which consists of injecting a few milliliters of irrigation fluid or dilute dye solution through the fimbriated end to identify the distal limit of the occluded portion or, in the case of a prior sterilization, to identify the real extremity of the stump. The tubal segments are approximated in two layers. The first of these joins the epithelium and muscularis, and the second joins the serosa. We generally use no. 8-0 Vicryl sutures swaged on a 130-micron shaft, 4- or 5-mm-long, taper-cut needle for tubal anastomosis. The first suture of the inner musculoepithelial layer is always placed at the mesosalpingeal border (6 o'clock position) to ensure proper alignment of the two segments of the tube (**Fig. 21.24G**). All of the sutures are placed in a way that positions the knots peripherally.

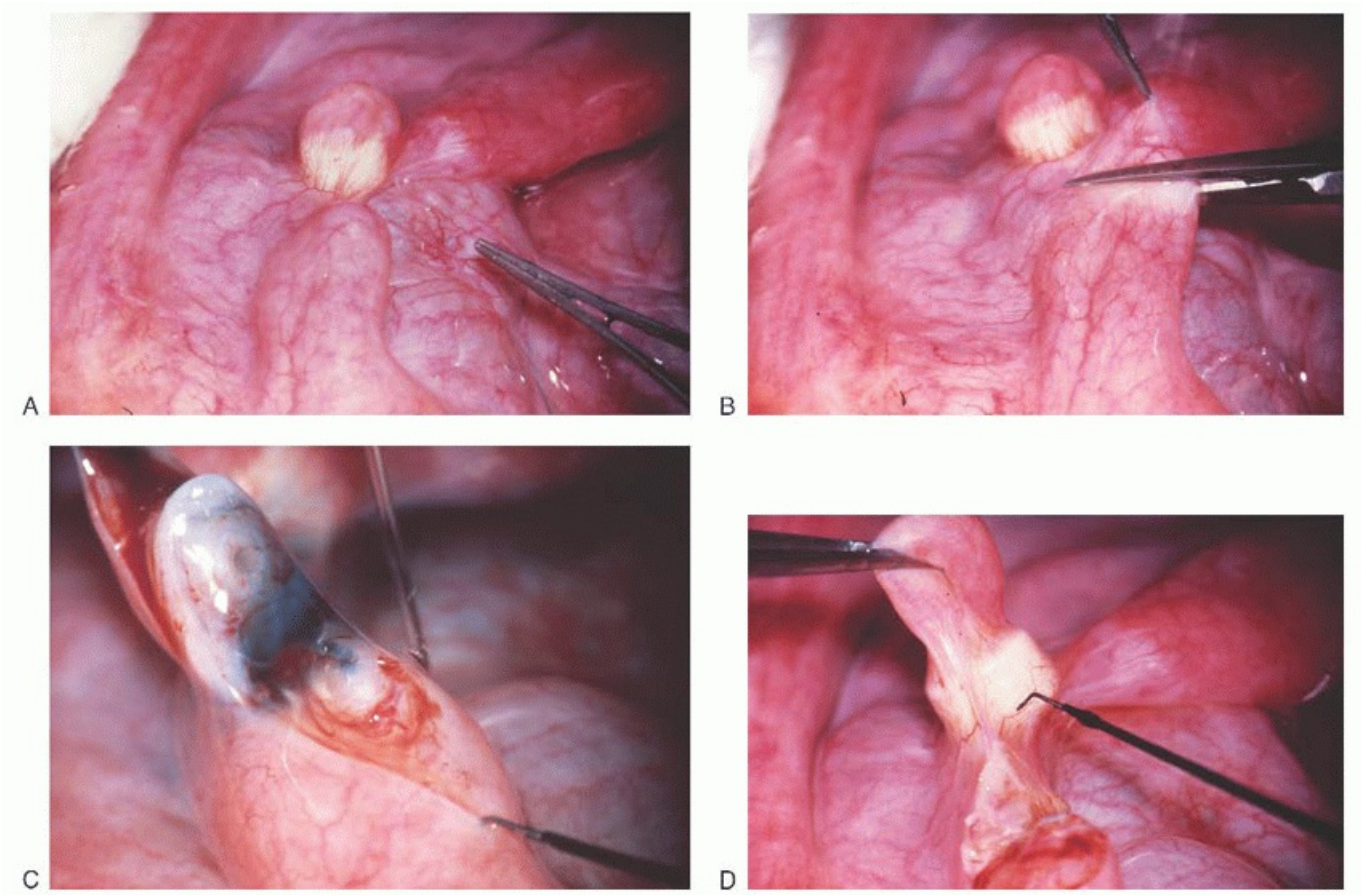

FIGURE 21.24 Microsurgical tubotubal anastomosis for reversal of Fallope-ring sterilization. **A:** Prior tubal sterilization with Fallope ring. **B:** The occluded end of the isthmus is grasped, and the tube is transected with scissors. **C:** Dye solution escapes from the lumen. **D:** The occluded tubal segment is excised from the mesosalpinx electrosurgically by the use of a microelectrode.

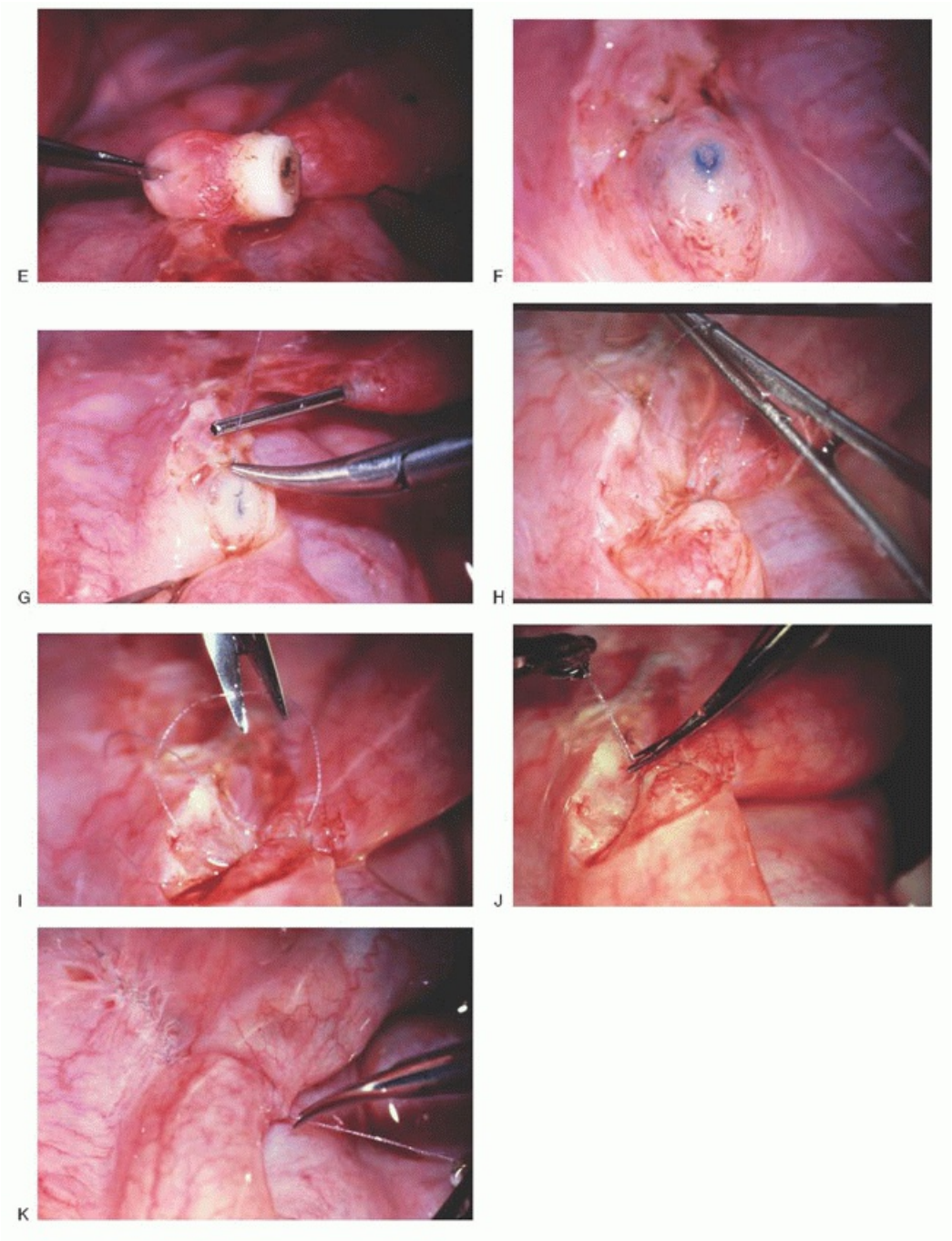

FIGURE 21.24 (*Continued*) **E:** The excised Fallope ring with the attached loop of the tube. **F:** The cut surface of the patent tube is assessed under high magnification. **G:** The first suture is placed at the 6 o'clock position. **H:** Once the 6 o'clock suture has been tied, subsequent sutures are placed with the use of a single strand of suture as a continuous series of loops. **I:** Each suture is tied individually after the division of the loop between successive sutures. **J:** The apposition of the inner musculoepithelial layer is complete. **K:** The anastomosis is completed with approximation of the serosa.

In exceptional circumstances when the distance between the two segments is great, the mesosalpinx adjacent to the cut ends of the two tubal segments can be approximated first, using a single interrupted no. 7-0 or 8-0 suture. This step brings the tubal segments into close proximity; thus, it facilitates placement of the sutures of the inner layer and reduces the tension that would have existed when tying these sutures.

Once the 6 o'clock suture is tied, the placement of three or more additional sutures (depending on the type of anastomosis) is required to appose the inner layer. These additional sutures can be placed by using a single strand of suture as a continuous series of loops, including the muscularis and the epithelium of the two segments

(**Figs. 21.24H** and **21.25**). The sutures are tied individually, after the division of the loop between each successive suture (**Fig. 21.24I**). This approach facilitates and speeds up suture placement. We advise against the use of a splint in the lumen of the tube because this does not facilitate the procedure and may traumatize the endothelium. Instead, if necessary, the cut surface may be stained with methylene blue or indigo carmine solution to accentuate the visibility of the individual layers.

After approximation of the inner layer (**Fig. 21.24J**), chromopertubation should demonstrate tubal patency and a watertight anastomotic site. The serosa is joined either with interrupted sutures or with two continuous sutures, one that runs anteriorly and the other posteriorly, starting at the antimesosalpingeal border (12 o'clock). Finally, the defect in the mesosalpinx is repaired (**Fig. 21.24K**).

Tubotubal Anastomosis to Repair Midtubal Disease

The most common reason to perform a tubotubal anastomosis is reversal of sterilization. Midtubal occlusions resulting from disease processes are rare. Such lesions usually affect the intramural or proximal isthmic segments and require a tubocornual-type anastomosis.

The causes of midtubal occlusion include endometriosis and tubal pregnancy, usually undiagnosed or treated by observation and rarely medically. A tubal pregnancy treated medically with methotrexate administration or surgically by linear salpingotomy may result in tubal occlusion at the gestational site (**Fig. 21.26A-C**). As described by Urma et al., treatment of tubal pregnancy by segmental excision will leave the tube in two segments, as with a tubal sterilization. Rare causes of occlusion include congenital absence of a midtubal segment and tuberculosis. In the latter instance, reconstruction is contraindicated.

In an intact tube, the site of occlusion may be apparent on inspection; palpation of the tube may identify an indurated segment that is the likely site of occlusion. As mentioned earlier, transcervical chromopertubation distends the proximal segment up to the site of occlusion and helps the surgeon define its proximal limit. The tube is transected either immediately proximal to the occluded segment or in the occluded zone itself. Successive transection of the tube at 1- to 2-mm intervals helps identify the normal segments proximal and distal to the occlusion site.

Irrespective of the type of anastomosis, the basic steps of the procedure are the same. The luminal diameter of the tube is not uniform and is significantly greater in the ampullary segment. The technical variations required largely depend on the disparity of the luminal calibers of the two segments to be joined.

Intramural-Isthmic Anastomosis

Anastomosis between the intramural and isthmic segments is the type of anastomosis most often required to treat cornual disease. In most cases of reversal of sterilization, a short segment of isthmus is usually present. This short segment is frequently adherent to the side of the uterus as a result of retraction of the adjacent mesosalpinx, thus giving the appearance of total absence of the proximal tube. The presence of

a portion of isthmus would have been evident from HSG. Transcervical chromopertubation distends this small segment of isthmus, facilitating identification of its distal margin and its dissection from the uterus. The dissection must be effected carefully to avoid damaging the tube itself and the vessels supplying it. The conservation and appropriate preparation of this segment, even when very small, converts the anastomosis to an isthmic-isthmic type and facilitates the procedure.

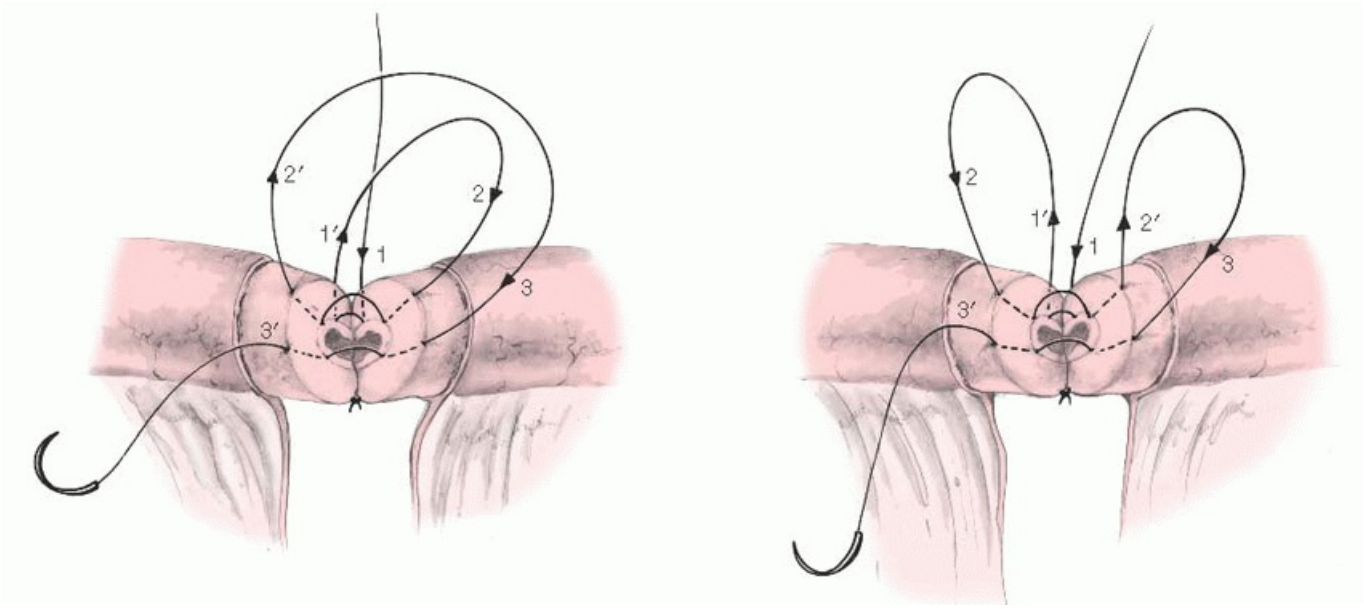

FIGURE 21.25 Microsurgical tubotubal anastomosis: after the 6 o'clock suture has been tied, placement of subsequent sutures using a single strand of suture as a continuous series of loops.

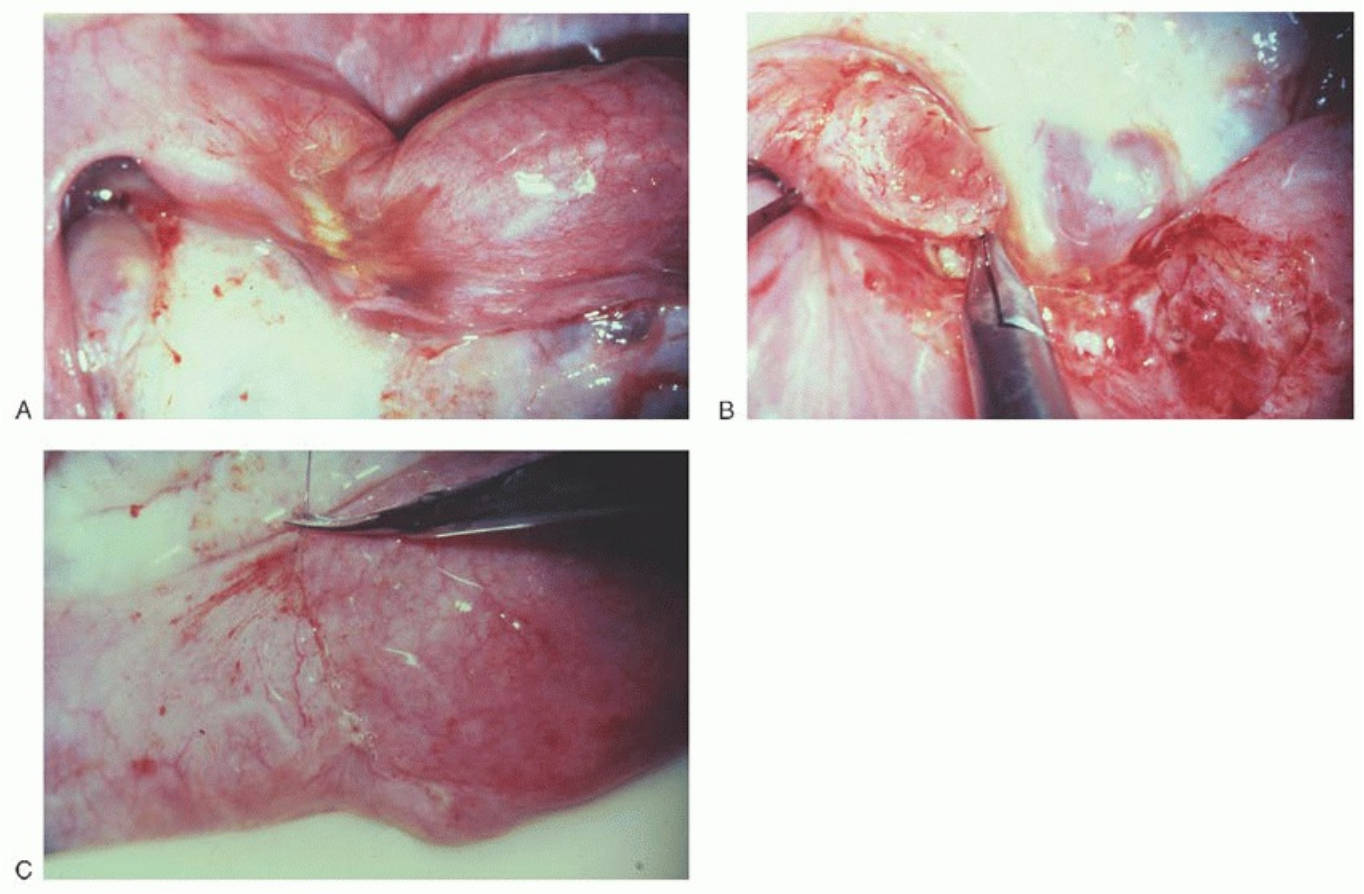

FIGURE 21.26 A: Midtubal occlusion due to prior ectopic pregnancy. **B:** The occluded portion of the tube has been excised and (**C**) two layer anastomosis performed between the two normal-appearing tubal segments.

In the absence of any isthmus (as may be the case subsequent to either a tubal sterilization or excision of an isthmic pregnancy), maintenance of uterine distention by chromopertubation will indicate the site where the intramural segment should be sought, between the uterine insertion points of the round and ovarian ligaments. Excision of the serosa and underlying scar tissue over the distended area may permit the dye solution to stream out of the intramural segment. In some instances, to access normal tube, it is also necessary to dissect the muscularis of this segment from the surrounding uterine muscle for 1 or 2 mm with microscissors or a

microelectrode. After this, the tube is transected with microscissors. This process may have to be repeated until the patent and normal tube is reached, at which point dye solution should stream out of the lumen.

Because of extensive vascularity, dissection in the cornu usually causes significant oozing that hinders visibility. When more than superficial dissection of this region is anticipated, initial infiltration with dilute vasopressin solution (1 U of vasopressin in 30 mL of normal saline) significantly decreases capillary oozing and facilitates the procedure. With the use of a 30-gauge needle on a 3-mL syringe, the cornual region of the uterus is injected with 2 mL of this solution in a circular fashion under the serosa 1 cm medial to the uterotubal junction. The resulting vasoconstriction is recognized by serosal blanching.

In this type of anastomosis, there is no significant luminal disparity between the two segments of the tube. Hence, the isthmus is simply transected near the occluded end and prepared, as described earlier. A two-layer anastomosis is then performed. Once the inner layer has been joined, the serosa and superficial muscle of the cornual region are approximated to the serosa of the isthmus. The defect under the tube is repaired by suturing the mesosalpinx to the serosa of the lateral edge of the uterus.

Intramural-Ampullary Anastomosis

The salient feature of intramural-ampullary anastomosis is the considerable luminal disparity that exists between the intramural and ampullary segments. The key technical issue lies in the preparation of the occluded proximal end of the ampulla, where an opening into the ampullary lumen, which is not much larger than that of the intramural segment, must be fashioned.

The intramural segment is first prepared as described under intramural-isthmic anastomosis. To identify the occluded end of the ampulla, which may be buried between the leaves of the mesosalpinx, the tube is distended with a few milliliters of dye or irrigation solution introduced through the fimbriated end. Alternatively, a malleable blunt probe can be introduced through the infundibulum and gently threaded toward the occluded end. With the use of microscissors, the serosa over the tip of the ampullary stump is incised in a circular manner. The serosa and any scar tissue under it are then excised to expose the muscularis of the occluded end. The center point of the exposed muscularis is grasped with toothed microforceps, and a small incision is made into the ampullary lumen with the microscissors. This opening is enlarged to correspond in size

to the lumen of the proximal tubal segment by excising a tiny circular portion of muscularis and epithelium (**Figs. 21.27A, B** and **21.28**). The resulting opening is slightly larger than the intramural lumen, and because of absence of significant disparity, anastomosis of the two segments can be performed as described for isthmic-isthmic anastomosis (**Fig. 21.29**).

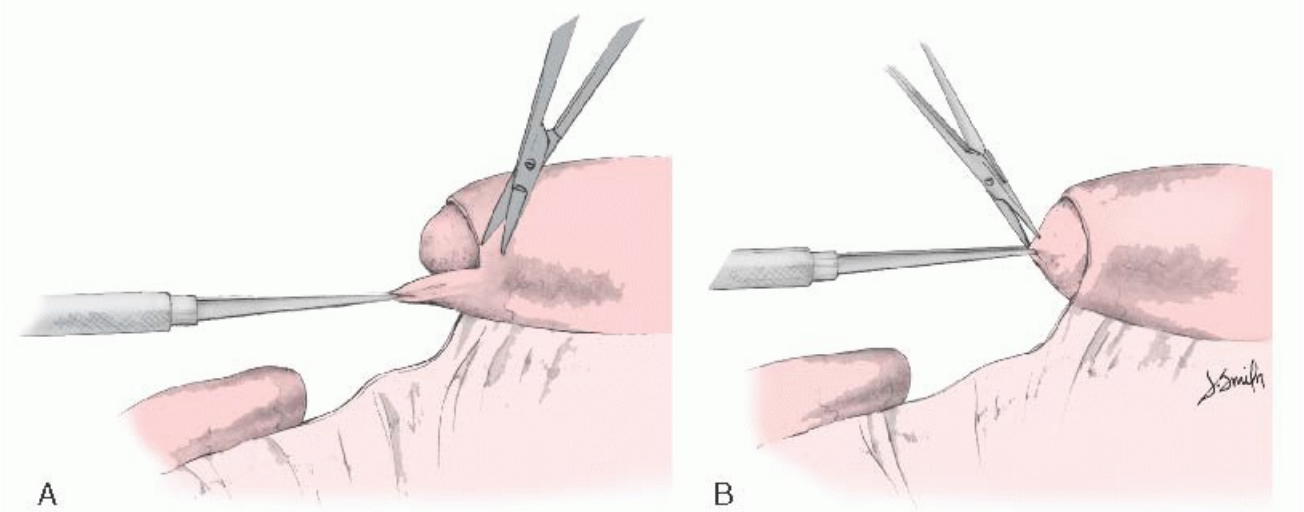

FIGURE 21.27 Preparation of the ampullary stump in intramural-ampullary or isthmic-ampullary anastomosis. **A:**

The serosa over the tip of the ampullary stump is incised in a circular manner and excised. **B:** The center point of the exposed muscularis is grasped, and a small opening is made into the lumen.

Isthmic-Isthmic Anastomosis

Isthmic-isthmic anastomosis is the simplest type of anastomosis to perform. The lumina are comparable in size. The technique is the same as that described earlier under the basic principles of tubotubal anastomosis.

Isthmic-Ampullary Anastomosis

The salient feature of this type of anastomosis is also the considerable luminal disparity that usually exists between the lumina of the isthmic and ampullary segments. The isthmic stump is prepared as described under "basic principles of tubotubal anastomosis." In most instances, the occluded end of the ampullary stump will be free, enabling a lumen of appropriate diameter (comparable in size to that of the isthmic segment) to be fashioned, as described under intramural-ampullary anastomosis (**Figs. 21.27A, B** and **21.28**). A two-layer anastomosis is then performed as described under the basic principles of tubotubal anastomosis (**Fig. 21.25**). Although the muscularis of the ampulla is considerably thinner than that of the isthmus, this poses no problem in approximating the epithelium and muscularis of the two segments.

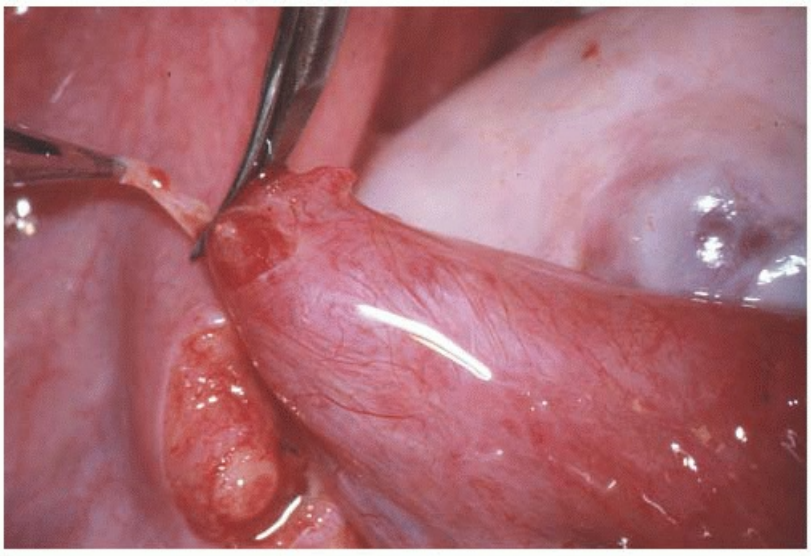

FIGURE 21.28 Preparation of the ampullary stump in intramuralampullary or isthmic-ampullary anastomosis.

Occasionally, circumstances will not permit the use of the technique described earlier in the preparation of the occluded ampullary end. The ampullary stump may be occluded by a permanent suture or clip, and removal of this suture or clip may lead to the creation of an opening that is much larger than the isthmic lumen and through which lush epithelial folds will prolapse. If the opening into the ampullary lumen is significantly larger than that of the isthmic segment (either inadvertently or by necessity), it will be necessary to either enlarge the isthmic lumen or narrow the ampullary lumen. To enlarge the lumen of the isthmic segment, a 2- to 3-mm slit is made with scissors at its antimesosalpingeal border. Partial excision of the corners thus created results in an enlarged oval opening (**Fig. 21.30A**). To approximate the inner musculoepithelial layer, the 6 o'clock suture is placed first and tied. Five additional sutures are usually required, and these are placed as described earlier. The 12 o'clock suture must incorporate the muscularis and epithelium of the ampulla and the same tissues at the apex of the isthmic slit (**Fig. 21.30B**). Approximation of the serosa and closure of the defect in the mesosalpinx complete the anastomosis. An alternative approach is to reduce the size of the large ampullary opening. This is achieved by plicating the muscular layer

surrounding the opening with interrupted sutures, after which the prolapsing epithelium is invaginated.

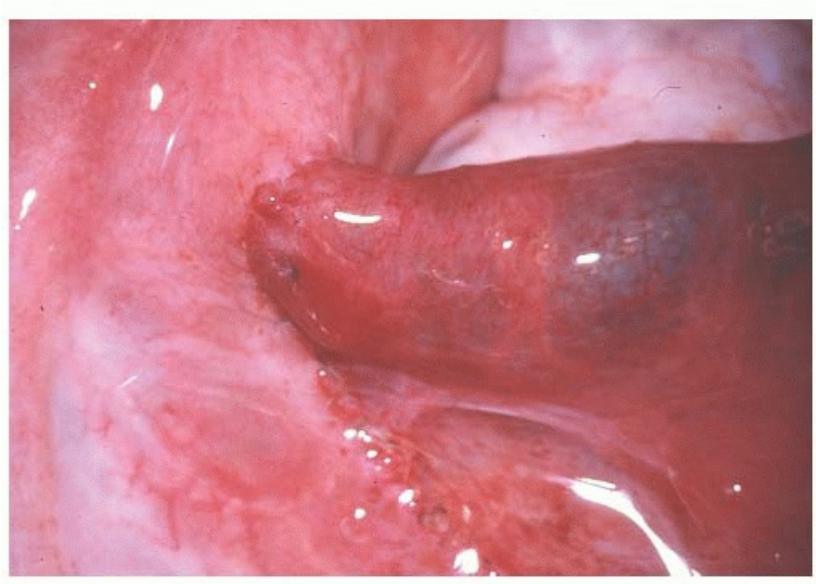

FIGURE 21.29 Tubocornual anastomosis (intramural-ampullary) completed. The anastomosis site is patent, as evident from the distention and blue discoloration of the tube as a result of chromopertubation. There is no leakage from the anastomotic site.

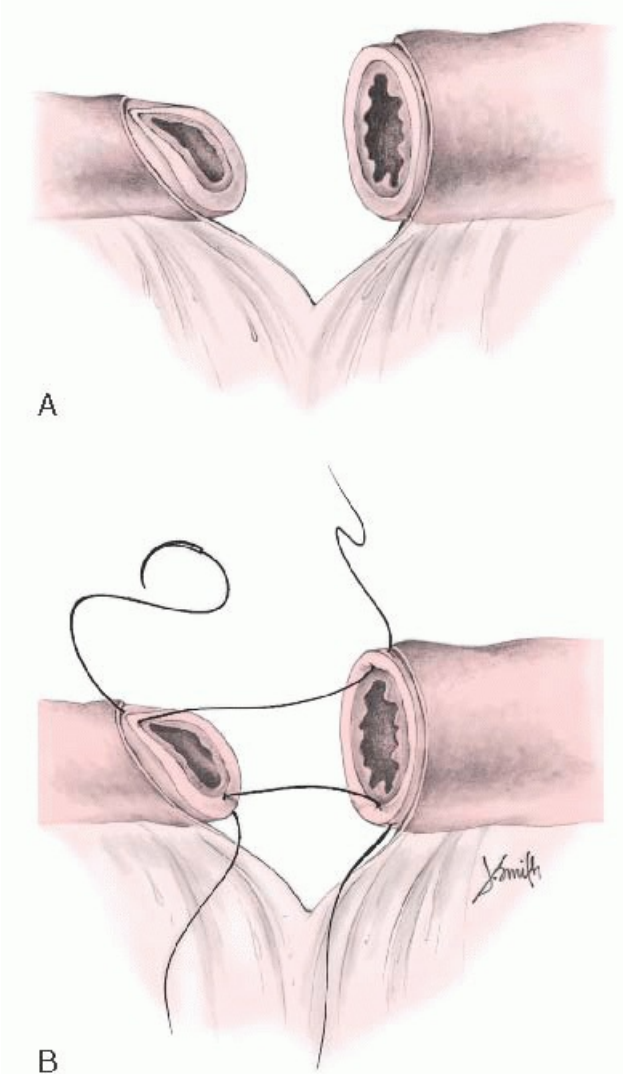

FIGURE 21.30 Isthmic-ampullary anastomosis in the presence of significant luminal disparity. **A:** Enlargement of the isthmic lumen. **B:** Placement of the 12 o'clock suture.

Ampullary-Ampullary Anastomosis

The proximal ampullary segment is transected near the occluded end, which is then excised from the mesosalpinx as previously described. An opening that corresponds in size to the lumen of the proximal segment is made in the occluded end of the distal ampullary segment, as described under isthmicampullary anastomosis.

In this type of anastomosis, the major difficulty to be overcome is the propensity of the ampullary epithelium to prolapse through the lumen. Although investigators such as Winston have advocated excision of these epithelial fronds, we advise against this approach because it may lead to development of intratubal adhesion formation at this site. The epithelial fronds can be replaced with pressure from the irrigating solution or with the tip of the plain microforceps while the successive sutures of the inner layer are tied. One must be careful not to include these epithelial fronds within a suture or knot or between the segments that are being approximated. Because of the larger circumference of the ampulla, approximation of the two ampullary segments will require a greater number of interrupted sutures than in an isthmic-isthmic anastomosis.

Ampullary-Infundibular Anastomosis

An ampullary-infundibular anastomosis may be necessary when a distal ampullary portion of the tube has been ablated or excised either during a prior sterilization or during removal of a tubal gestation, leaving distally the infundibular segment only. The occluded ampulla is prepared as described previously. To make anastomosis of the two segments possible, it is necessary to fashion an opening in the infundibular portion. To do so, a Teflon probe with a conical tip is introduced into the infundibulum from the fimbriated end, and a circular opening is fashioned with microscissors, from the medial side, corresponding in size to the lumen of the ampullary segment. A two-layer anastomosis is then performed.

Results of Tubotubal Anastomosis for Reversal of Sterilization

The major published series report live birth rates between 40% and 80% after microsurgical tubotubal anastomosis for reversal of sterilization (**Table 21.6**). The ectopic gestation rates are usually low.

The factors that affect the outcome of such procedures are multiple and include the following: the type of prior sterilization, the site of anastomosis, and the length of the reconstructed tube or tubes, which are interrelated factors; the presence of single versus double reconstructed oviducts; the status of the tubes (presence or absence of disease); the extent and nature of adhesions and the presence of other pelvic disease; the status of other fertility parameters, especially that of the male partner; and significantly the age of the woman and the surgical technique used. Therefore, the outcome depends on the degree of rigor in selection criteria and the quality of the surgical technique. This is corroborated by the results of two relatively recent reports on sterilization reversal, which include two large series from Korea by Kim and colleagues in 1997 (**Table 21.6**). In our experience, in the absence of a male factor, the three most important parameters that predict outcome are the age of the female partner, the length of the reconstructed tube, and the surgical technique. A reconstructed tubal length of less than 4 cm adversely affects outcome; this likely reflects the loss of ampullary length and consequent loss of oviductal oocyte retention.

It is possible to perform tubotubal anastomosis by laparoscopic access to reconstruct a previous tubal sterilization. The outcomes reported in the literature are very variable, and most report results inferior to those obtained by open access. This is largely due to modification of the recognized microsurgical technique to make the laparoscopic procedure simpler to perform.

The first report on laparoscopic tubotubal anastomosis was a case report by Sedbon et al. in 1989; instead of microsurgical suturing for the apposition of the tubal segments, they used biologic glue over a stent. Pregnancy outcome was not reported. Early reports on tubotubal anastomosis were small case series, performed with simplified techniques, and despite the majority of the cases in these series were reversal of simpler types of

sterilization reversal, the results were relatively poor.

Most surgeons who attempted tubotubal anastomosis by laparoscopic access using the microsurgical technique, described earlier in this text, found that operating times are prolonged. Many attempted to simplify the technique by using glue as described above or using only two sutures for the apposition of the prepared tubal segments, as first reported by Dubuisson and Swolin in 1995. In this technique, the first suture (4-0 Vicryl) approximates the mesosalpinx immediately beneath the two segments of the tube and the second (6-0 Vicryl) the tube at 12 o'clock position. The second suture incorporates the serosa and muscularis of the two segments of the tube. There are several recent reports in the literature on this type of modified technique.

TABLE 21.6 Results of Microsurgical Tubotubal Anastomosis for Reversal of Sterilization

INVESTIGATORS	YEAR	PATIENTS	INTRAUTERINE PREGNANCIES	LIVE BIRTHS	ECTOPIC PREGNANCIES
ACCESS BY LAPAROTOMY					
Gomel	1974	14	8	NS	1
Gomel	1980c	118	76	NS	1
Winston	1980	105	63	NS	3
Gomel[a]	1983b	118	96	93 (78.8%)	2
DeCherney et al.[b]	1983	124	84	72 (58.1%)	8
Schlosser et al.	1983	119	NS	44 (37%)	11
Silber and Cohen[c]	1984	48	33	31 (64.6%)	2
Henderson	1984	95	61	51 (53.7%)	5
Paterson	1985	147	93	87 (59.2%)	5
Spivak et al.[d]	1986	83	48	39 (47%)	6
Boeckx et al.	1986	63	44	NS	3

Rock et al.	1987	80	58	49 (61.3%)	10
Xue and Fa[e]	1989	117	98	95 (81.2%)	2
Putman et al.	1990	86	64	55 (64%)	NS
teVelde et al.	1990	215	156	137 (63.7%)	8
Kim JD et al.[f]	1997	387	329	295 (76.2%)[f]	6
Kim SH et al.[g]	1997	1,118	505	366 (32.7%)[g]	42
Cha et al.	2001	44	31	NS	1
Wiegerinck et al.	2005	41	26	NS	1
Gordts et al.[h]	2009	172	119	98 (60.0%)	10
Schippert et al.	2011	89	65	45 (50.6%)	6
Moon SM et al.[i]	2012	961	732	630 (71.1%)	22
ACCESS BY LAPAROSCOPY					
Dubuisson et al.[j]	1998	32	17	13 (40.6%)	NS
Bisonette et al.[j]	1999	102	64	49 (50.5%)	5
Yoon et al.[k]	1999	202	154	98 (48.5%)[l]	5
Mettler et al.[j,m]	2001	28	15	15 (53.6%)	2

Cha et al.[k]	2001	37	28	NS	1
Ribeiro et al.	2003	26	13	NS	0
Wiegerinck et al.[n]	2005	41	15	NS	1
Schepens et al.[o]	2010	134	74	NS[o]	5
ROBOTIC					
Falcone et al.	2000	10	5	NS	0
Caillet et al.[p]	2010	97	66	58 (59.8%)	NS

[a]Resurvey of 1980 series; follow-up period more than 18 months.

[b]Follow-up period more than 18 months.

[c]Follow-up period more than 4 years.

[d]Follow-up period more than 1 year.

[e]Follow-up period more than 3.5 years.

[f]Follow-up period more than 2 years. There were eight ongoing pregnancies in addition to the live births.

[g]Follow-up period more than 5 years. There were 31 ongoing pregnancies in addition to the live births.

[h]Excluded 89 patients lost to follow-up and 8 patients who did not attempt a pregnancy from their series of 172 women, limiting the evaluation to the remaining 164.

[i]They only reviewed 886 of the 961 patients. The 71.1% birth rate is the result of 630 births from the 886 cases included in the analysis.

[j]Tubal anastomosis performed with single-suture technique.

[k]Tubal anastomosis performed by using two-layer microsurgical technique.

[l]There were 31 ongoing pregnancies in addition to the live births.

[m]A screening laparoscopy was performed, and only those having a distal tubal segment of 4 cm and a

proximal segment of 3 cm were included.

[n]Comparative study with cases performed with open access. Laparoscopic anastomosis performed without sutures; the technique is described in the text.

[o]Excluded 7 patients lost to follow-up, analyzing 127 of the 134 cases. The text does not give birth rates; it indicates that 51 of 120 women with bilateral anastomosis and 4 of 7 women with unilateral anastomosis had ongoing pregnancies. Therefore, 55 of the 127 women (43%) had ongoing pregnancies.

[p]They excluded 14 of the 160 cases for various reasons together with 49 lost to follow-up, and analyzed the remaining 97 patients. NS, not stated.

There are also publications reporting on the laparoscopic use of a truly microsurgical, two-layer anastomosis technique. The largest of these series is from 1999 by Yoon et al. from Korea, which includes 202 cases. Fifteen of these were lost to followup, and one had no partner. The remaining 186 were monitored for a minimum of 12 months. One hundred fifty-four achieved intrauterine pregnancies, a rate of 77% if we consider, as most series do, 15 cases lost to follow-up as failures. Ninety-eight delivered healthy infants, 25 pregnancies ended in abortion, and 31 patients had ongoing pregnancies at the time of the survey. If we assume all 31 ongoing pregnancies resulted in a live birth, the live birth rate in this series would have been 64%. There were five cases of ectopic pregnancy. These results are not too dissimilar to those achieved by open access, which supports the premise of the importance of the technique used and not the mode of access. In 2001, Cha et al., also from Korea, further supported this assumption. In their study, they compare the fertility outcome in 81 women who had microsurgical reversal of sterilization, 37 by laparoscopic and 44 by open access. The outcomes include only intrauterine and tubal pregnancy rates, which were similar in both groups: 75.7% and 70.5%, respectively; there was one tubal pregnancy in each group (**Table 21.6**).

Attempts to develop simple techniques that would yield equivalent results by laparoscopic access continue to be made. A 2005 study by Wiegerinck et al. reports the use of the following laparoscopic technique for tubal anastomosis: *"Once the tubal ends to be anastomosed were prepared, a splint was inserted into the proximal tube through a guiding catheter inserted vaginally."* The splint was then introduced into the distal portion of the tube. The distal portion was aligned with the proximal segment over the splint. The seromuscularis of the two segments was fixed at the 3 and 9 o'clock positions using microclips of 3-mm size. Subsequently, fibrin glue was applied on the anastomotic surface. The splint was taped externally to the Foley catheter and removed 4 hours after the end of the procedure. Although they report similar results for both the laparoscopic group and a control group (selected from patients whose procedure was performed through a Pfannenstiel incision), it is surprising that the cumulative rate of ongoing pregnancy at 3 years in the control group was only 52% and in the laparoscopic group only 45%. This, despite the fact that in the latter group more than 90% of the sterilizations had been performed by clips or Silastic rings, and their average age was only 34.9 years. Schepens et al. from

the same group more recently reported on 134 patients; due to the fact that the patient population includes cases from 1997 to 2008, they must have included the 41 reported earlier (**Table 21.6**).

Several groups have explored robotically assisted tubal anastomosis. Initial reports in 2000 of small series by Falcone and Degueldre, both of whom were proficient in microsurgery, used a technique similar to that described earlier in this text. They reported the use of the robot-facilitated suturing but increased the length of the procedure. A recent large series that included Degueldre reported a birth rate of 60% following roboticassisted reversal of sterilization. They stressed the fact that the use of the robot was associated with prolonged operating times and increased costs. Tubotubal anastomosis is a relatively simple operation for a physician skilled in microsurgery. It is difficult at this stage to justify the use of a robot for such cases, while it use would better serve more complex surgical procedures.

Using metaanalysis, Watson et al. examined the role of microsurgery versus macrosurgery in the reversal of sterilization. The available studies were limited by the lack of randomized controlled trials and the use of historical control groups. However, as expected, the use of magnification and microsurgical approach for sterilization reversal and for adhesiolysis and salpingostomy led to higher intrauterine pregnancy and lower ectopic rates.

Microsurgical tubotubal anastomosis for reversal of sterilization produces excellent results that are principally dependent on the status and the length of the reconstructed tube. Live birth rates of 60% to 80% can be achieved, provided that the reconstructed tube is longer than 4 cm and the ampullary portion greater than 2 cm. The second most important factor is the woman's age. The tubal pregnancy rates are usually low.

The advantages of laparoscopic access are well recognized. These include a shorter hospital stay and recovery time and lower postoperative analgesic requirements. We tried laparoscopic access for sterilization reversal and decided to continue using an operation microscope through a minilaparotomy incision. Our experience demonstrates that access by a minilaparotomy incision, using the technique described earlier in this text, provides the same advantages. We perform tubal anastomosis for reversal of sterilization, tubocornual anastomosis for pathologic tubal occlusion, and other more complex reconstructive microsurgical procedures via minilaparotomy. Patients are admitted to hospital on the morning of surgery and most are discharged a few hours postoperatively. Each surgeon must balance patient factors, his or her expertise, and the resources of the center in deciding how to approach such procedures.

The ASRM's committee opinion in regard to sterilization reversal supports the position we have held for more than three decades and is as follows: *"There is good evidence to support the recommendation for microsurgical anastomosis for tubal ligation reversal… it can be accomplished by mini-laparotomy as an outpatient procedure." Comparable results may be obtained by laparoscopy if the procedure is performed "in an identical fashion to open microsurgical tubal anastomosis…. Operating times are prolonged…. Only surgeons who are very facile with laparoscopic suturing and who have extensive training in conventional tubal microsurgery should attempt this procedure."*

Tubocornual Anastomosis for Proximal Tubal Disease

Various disease processes can affect the proximal tube and occlude the region of the uterotubal junction. On the basis of histologic studies on resected tubal segments, these occlusive lesions in order of frequency are as follows: obliterative fibrosis, chronic inflammation, salpingitis isthmica nodosa, intratubal endometriosis, and, rarely, ectopic gestation and tuberculosis. All of the published series report a varying but usually low percentage of cases with no demonstrable lesions. This may be related to tubal spasm (at the time of HSG or laparoscopy) or to the presence of tubal plugs or synechiae. Such conditions, as opposed to occlusive disease, are amenable to treatment with selective salpingography and tubal cannulation, as was discussed earlier in this chapter.

The management strategy in proximal tubal occlusion must take into account other variables, including the condition of the distal tube, the extent and nature of pelvic adhesions, the presence of associated pelvic disease, and the status of other fertility parameters, especially male factor infertility. This strategy must also respect the following principles: simplicity, reproducibility, and cost-effectiveness.

The selection of treatment must be individualized according to the investigative findings, the wishes of the couple, the expertise of the surgeon, and the results achieved by the center in which the couple will be managed. **Figure 21.31** diagrammatically summarizes a process to manage proximal tubal occlusion.

The traditional surgical treatment of occlusive proximal tubal disease was uterotubal implantation. The application of microsurgery has made it possible to perform an anastomosis instead, after removal of the affected tubal segment. Central to this approach is the complete excision of the affected portion of the tube, whether it is intramural or isthmic. In cases

of pathologic occlusion, a portion of healthy intramural tube is usually spared, permitting the conservation of sometimes all but more often a part of this segment. In other instances, the whole intramural segment is involved in the disease process and must be excised. In such cases, microsurgery permits an anastomosis to be performed between the uterine tubal ostium and the healthy portion of the isthmus. Depending on the extent of intramural tube that is excised and thus the site at which the anastomosis is performed, tubocornual anastomosis may be juxtamural, intramural, or juxtauterine (**Fig. 21.32**).

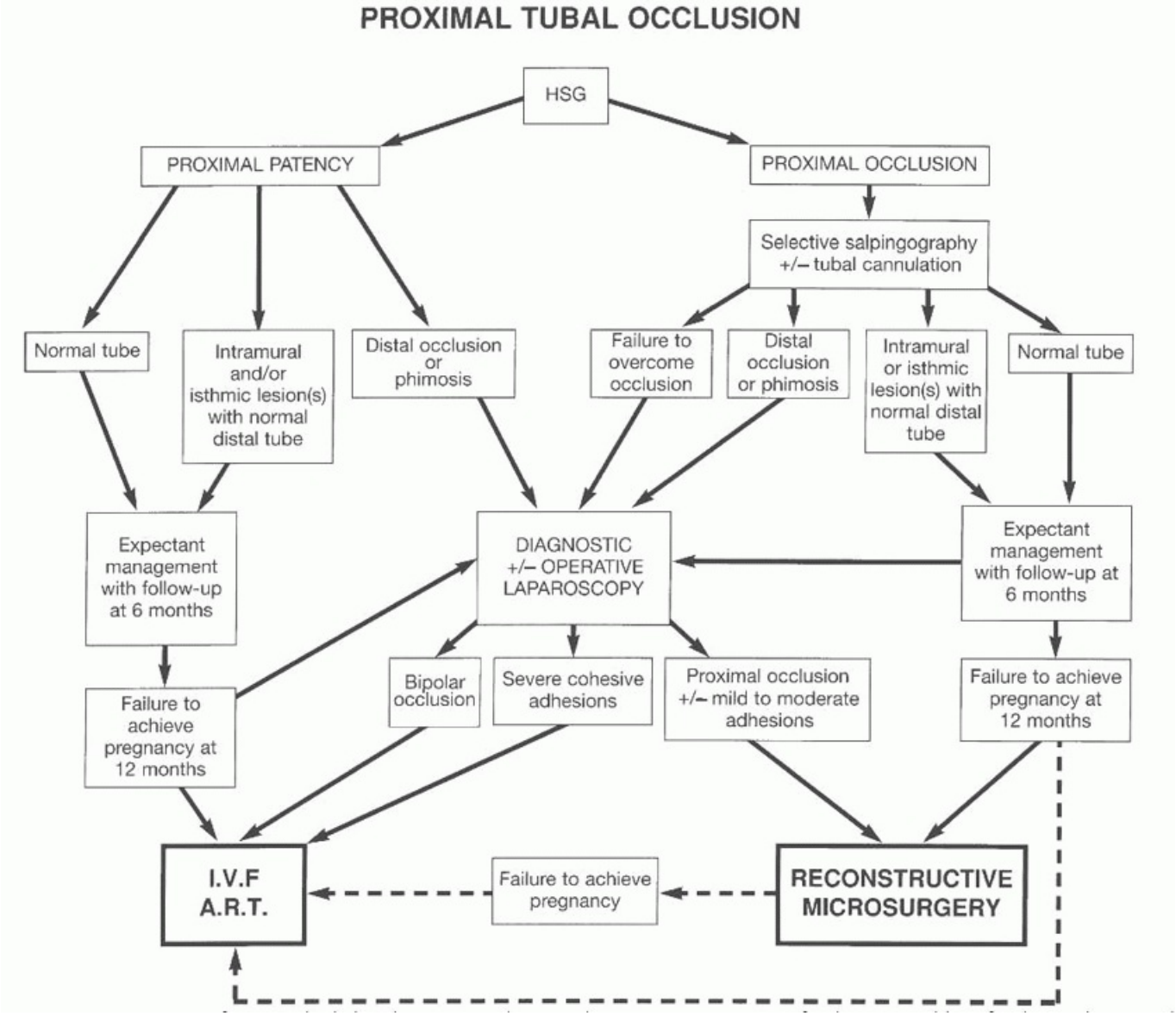

FIGURE 21.31 Management of proximal tubal occlusion. HSG, hysterosalpingogram; IVF, in vitro fertilization; ART, artificial reproductive technology. (Modified from Gomel V, Dubuisson JB. *References en gynecologie et obstetrique.* Poulnoy, France: SPEI, 1995:251.)

The cornual region of the uterus is infiltrated with dilute vasopressin solution. This is done by injecting 2 mL of this solution in a circular fashion under the serosa 1 cm medial to the uterotubal junction with the use of a 30-gauge needle on a 3-mL syringe. The vasoconstriction that follows is recognized by the blanching of the serosa. The tube is then incised at the uterotubal junction, with care taken not to divide the arteriovenous arcade at its mesosalpingeal margin. After transection of the tube, patency of the intramural segment is assessed by transcervical chromopertubation, and the normalcy of the cut surface is evaluated under high magnification (**Fig. 21.33A**).

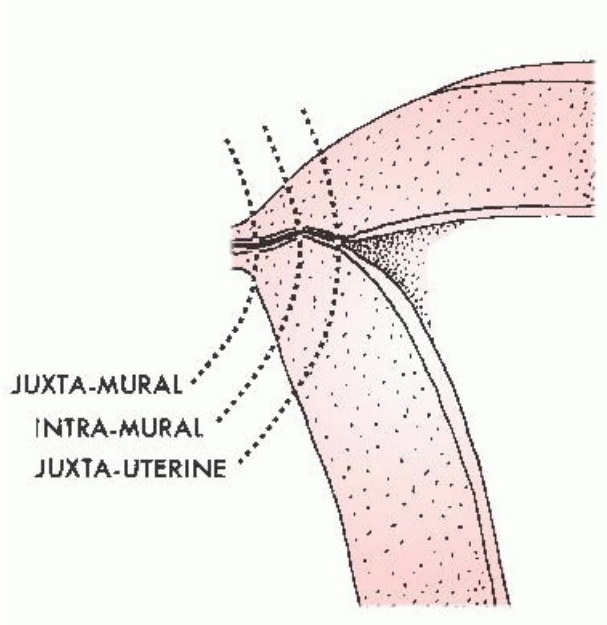

FIGURE 21.32 Types of tubocornual anastomosis.

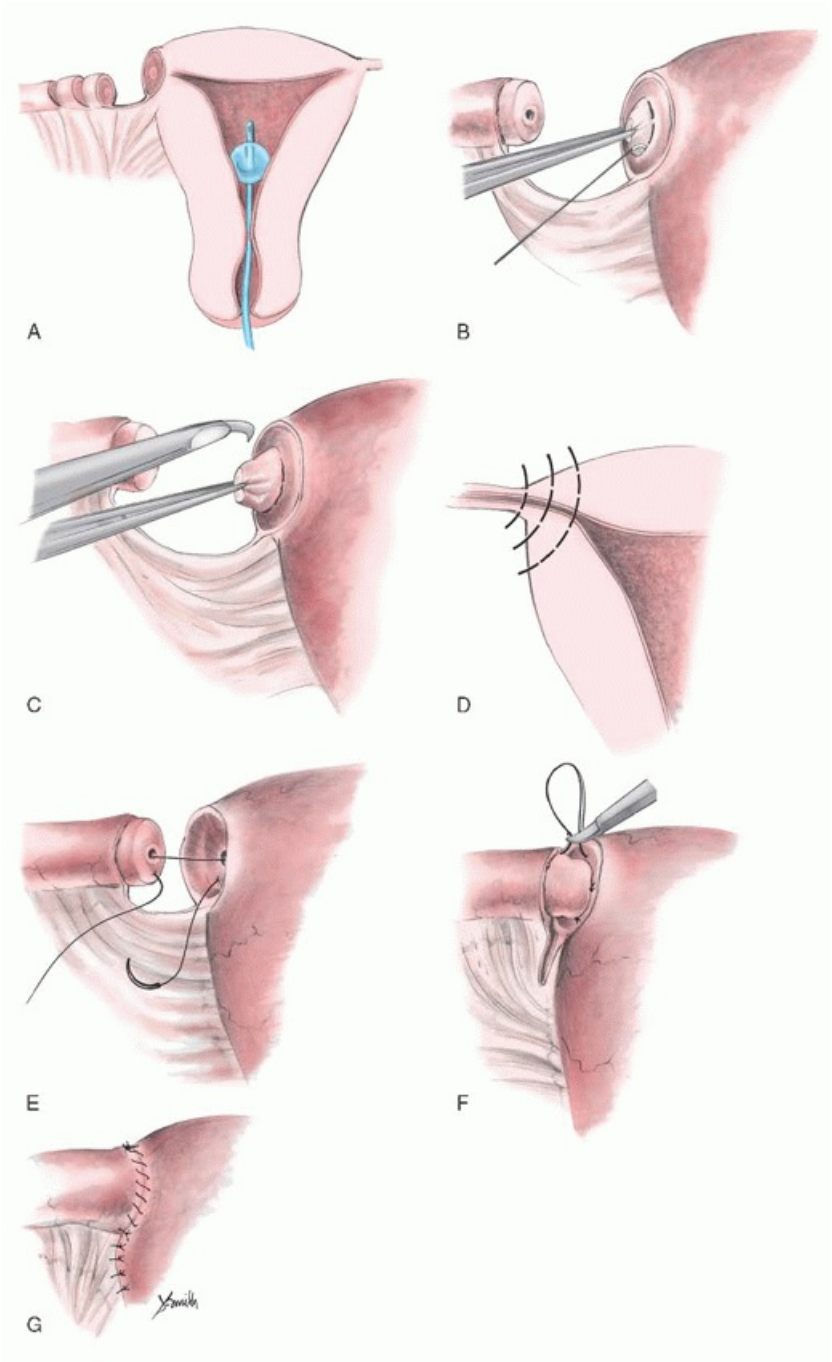

FIGURE 21.33 Microsurgical tubocornual anastomosis for proximal tubal disease. **A:** The tube is transected at the uterotubal junction (UTJ). Commencing at the UTJ, serial cuts are made on the isthmus until patent and normal tube is identified. **B:** The intramural tube is dissected electrosurgically, by using a microelectrode, from the surrounding uterine muscle, 1 to 2 mm at a time, and (**C** and **D**) transected until patent and normal tube is reached. **E:** The first anastomotic suture of the inner musculoepithelial layer is placed at the 6 o'clock position. **F:** Subsequent sutures are placed with a single strand of suture. **G:** After the apposition of the inner layer, the seromuscularis of the uterus is joined to the serosa of the tube and the mesosalpinx is joined to the lateral aspect of the uterus.

If the intramural tube is found to be occluded or abnormal at this site, its musculature is dissected further from the surrounding uterine muscle, 1 to 2 mm at a time, toward the uterine cavity (**Fig. 21.33B, D**). The small portion of the tube thus dissected is transected, and the cut surface is reassessed. If the intramural tube is still occluded or abnormal, the same procedure is repeated until normal patent tube is reached. Dye solution will spurt from the open lumen. It is essential that dissection of the intramural tube from the surrounding uterine muscle be effected at the level of the immediate periphery of the tubal muscularis. The preoperative HSG usually provides

information about the length of the normal intramural segment and the extent of excision required. Transection of successive portions of the intramural tube can be achieved with either curved microscissors or especially designed cornual blade (Gomel cornual blade,

Spingler-Tritt, Jestetten, Germany). By limiting the excised tissue to the intramural tube, there is little risk of creating a large defect at the cornu.

After the preparation of the cornual end, the occluded or abnormal isthmic segment is prepared by making serial cuts 1 to 2 mm apart, beginning at the initial transection site at the uterotubal junction and continuing until normal patent tube is identified (**Fig. 21.33A**). Patency of the distal segment is confirmed by descending hydropertubation, with injection of a few milliliters of dye or irrigation solution through the fimbriated end. Hemostasis of the cut end of the normal distal tube is obtained by precise electrocoagulation of bleeders located between the muscularis and serosa. The intervening abnormal tubal segments are excised from the mesosalpinx mechanically or electrosurgically, avoiding the vascular arcade beneath the tube.

The intramural and isthmic segments are approximated in two layers as follows: The initial suture of the first layer, which incorporates the muscularis and epithelium of the two segments, is placed at the 6 o'clock position (**Fig. 21.33E**). If the anastomosis is superficial (juxtamural type), the suture is tied.

With anastomoses located deep in the cornua, as in intramural or juxtauterine types, the 6 o'clock suture is held with a clip until the remaining sutures have been placed, because tying this initial suture would make placement of the subsequent sutures difficult if not impossible. In such cases, the subsequent sutures are placed with the use of a continuous strand of suture, as described earlier (**Fig. 21.25**). This approach facilitates suture placement and prevents the individual sutures from becoming tangled. Three additional sutures, placed at cardinal points, are usually sufficient to join the inner layer. If the cornual crater is deep and the placement of sutures is difficult, this task can be facilitated by making a small coronal incision on the uterus, above the cornual crater. The edges of this incision must be properly approximated at the end of the procedure.

If the distance between the two segments of the tube is significant or if there is undue tension, it is necessary to hold the distal tubal segment close to the intramural segment while tying the sutures. Alternatively, a single no. 7-0 Vicryl suture is passed through the mesosalpinx below the cut end of the distal segment of the tube and then through the border of the uterus immediately beneath the cornual crater. The suture is tied to bring the two segments into close proximity. The 6 o'clock suture is tied first. Then, the loop between each succeeding suture is divided and tied in turn. After approximation of the first layer, the seromuscularis of the uterus is joined to the serosa of the tube with no. 8-0 sutures. The defect under the tube is closed by approximating the mesosalpinx to the lateral edge of the uterus (**Fig. 21.33F, G**).

Compared with tubouterine implantation, microsurgical tubocornual anastomosis offers several advantages: It largely maintains the integrity of the uterine cornu; preserves a longer tube; obviates the need for a cesarean section, except for obstetric reasons; and yields better results (**Fig. 21.34**).

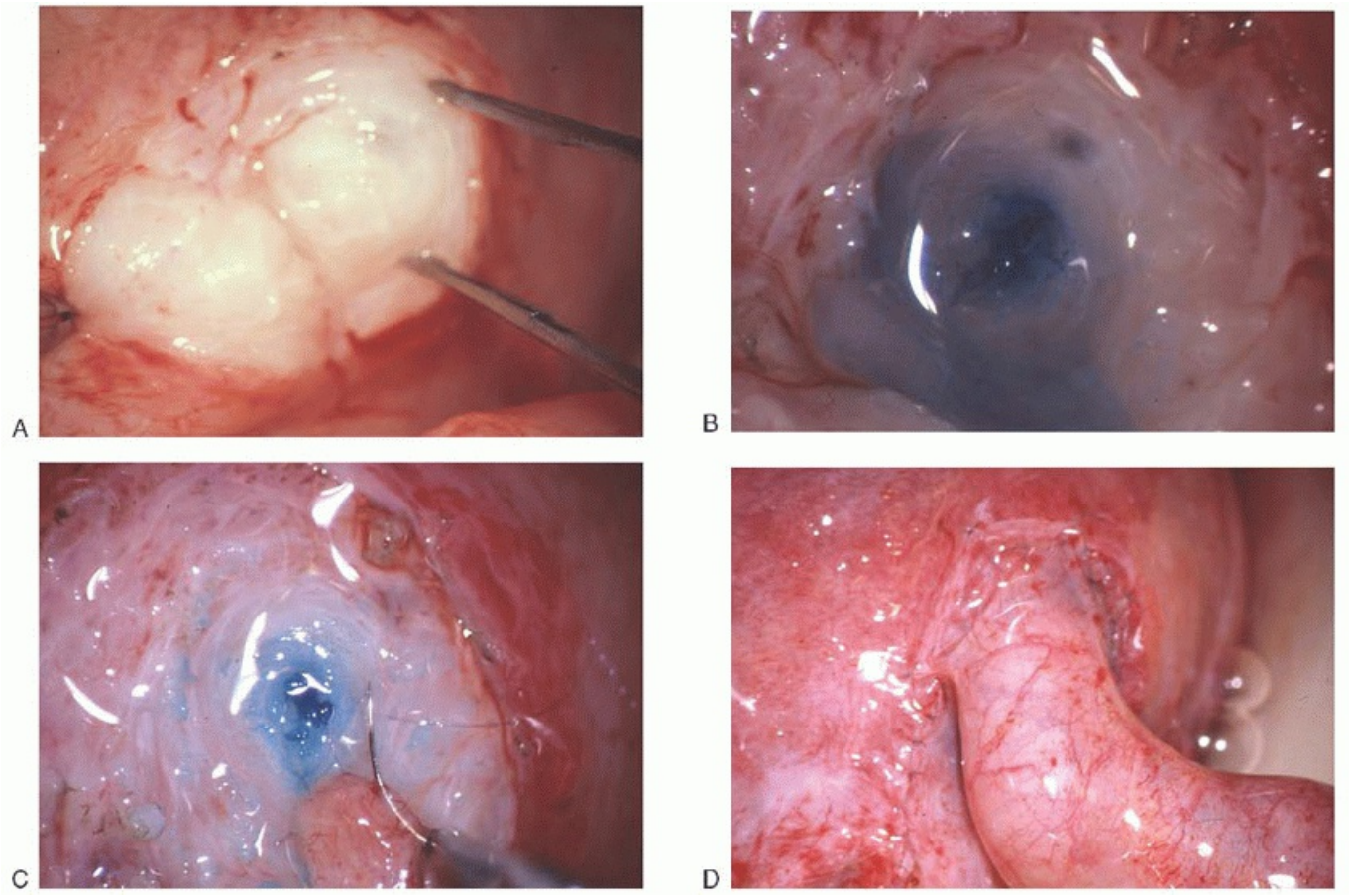

FIGURE 21.34 Microsurgical tubocornual anastomosis for proximal tubal disease. **A:** Serial cuts are made through the intramural segment to reach normal tube. **B:** Normal-appearing tube; methylene blue solution coming through. **C:** Subsequent to the 6 o'clock sutures the other sutures are in process of being placed. **D:** The procedure is completed by apposing the seromuscularis of the uterus to the serosa of the tube and the mesosalpinx to the lateral aspect of the uterus.

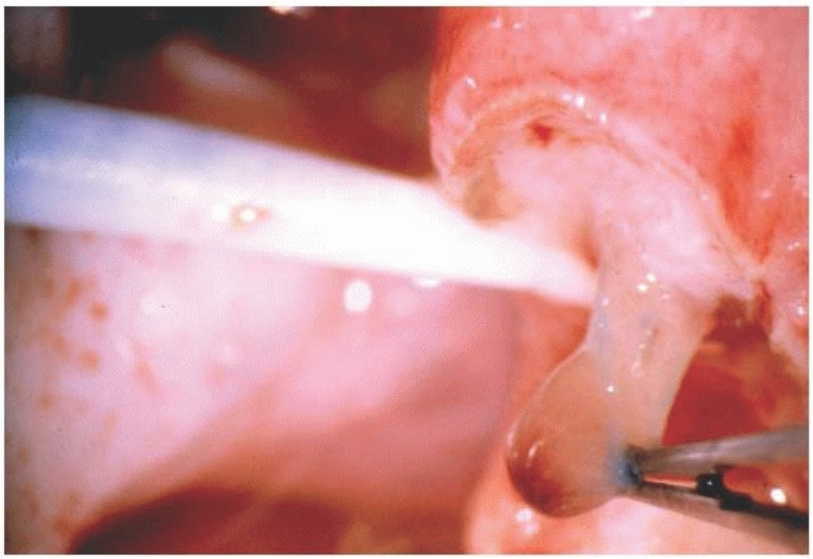

FIGURE 21.35 Cornual polyp.

Cornual polyps, when large, may cause infertility (**Fig. 21.35**). They can be removed placing a small coronal incision in the cornual region to access the tube at the site of the polyp. The polyp is excised, and the incision is closed in layers.

Results of Tubocornual Anastomosis

Microsurgical tubocornual anastomosis for the treatment of occlusive cornual disease yields fairly good results in centers experienced with this procedure. The published series report live birth rates between 33% and 56% and ectopic pregnancy rates between 5% and 7% (**Table 21.7**). This table makes it clearly evident that there has been a paucity of reports regarding this procedure for more than a decade. Tubocornual anastomosis for pathologic proximal occlusion is the most difficult type of tubal anastomosis. This procedure is performed less and less with such patients referred for IVF. We continue to perform this procedure in Vancouver and continue to obtain live birth rates of approximately 50%. It is imperative to confirm the cornual obstruction with selective salpingography and/or tubal cannulation, before recommending this procedure.

The ASRM's committee opinion states: "*Unless the proximal blockage on HSG is clearly due to SIN, selective salpingography or tubal cannulation can be attempted… Before performing this procedure, there should be confirmation of normal distal tubal anatomy."*

"In these cases, IVF is preferred to resection and microsurgical anastomosis… However microsurgery may be considered after failed tubal cannulation if IVF is not an option for the patient, but it should be attempted only by those with appropriate training."

Rare Procedures and Technically Difficult Cases

Rare circumstances may be encountered that are amenable to microsurgical correction. Some of these circumstances are discussed in this section.

The technical difficulty of a procedure must be differentiated from the prognosis that the procedure offers. Furthermore, difficulty is a relative term because what is commonplace work for some may be difficult or even impossible for others to achieve. From the patient's standpoint, what is important is the prognosis, the yield associated with the surgical procedure. Furthermore, the prognosis is not necessarily inversely proportional to the difficulty of the procedure. For example, microsurgical tubocornual anastomosis to treat occlusive cornual lesions is one of the technically more difficult reconstructive tubal operations. However, centers experienced in this procedure achieve excellent results. An even more technically difficult operation is tuboovarian transposition.

Tubo-Ovarian Transposition

In the case of a unicornuate uterus without an ipsilateral tube and ovary, the contralateral tube and ovary, if present, may be transposed while preserving their vascular pedicle.

We performed such a procedure in a woman with a single left unicornuate uterus whose ipsilateral tube and ovary were removed subsequent to a left tubal pregnancy. On the right side, placed high on the pelvic sidewall, were an ovary and a short oviduct, composed of infundibulum and ampulla only (**Fig.21.36A**).

TABLE 21.7 Results of Microsurgical Tubocornual Anastomosis for Occlusive Proximal Tubal Disease

INVESTIGATORS	YEAR	PATIENTS	INTRAUTERINE PREGNANCIES	LIVE BIRTHS	ECTOPIC PREGNANCIES
Gomel	1977	13	NS	7 (53.8%)	1
Gomel	1980	38	21	20	2

				(52.6%)	
Winston	1980	49	NS	16 (32.7%)	2
McComb	1986	26	15	14 (53.8%)	2
Donnez and Casanas-Roux	1986	82	NS	36 (43.9%)	6
Gillett and Herbison	1989	32	19	18 (56.3%)	2
Tomazevic et al.[a]	1996	59	NS	27 (45.8%)	NS
Awartani and McComb	2003	26	12	NS	3

[a]Of the 32 operated patients who did not deliver within 2 years after surgery, 21 were treated with 66 cycles of IVF, resulting in live births for 12.

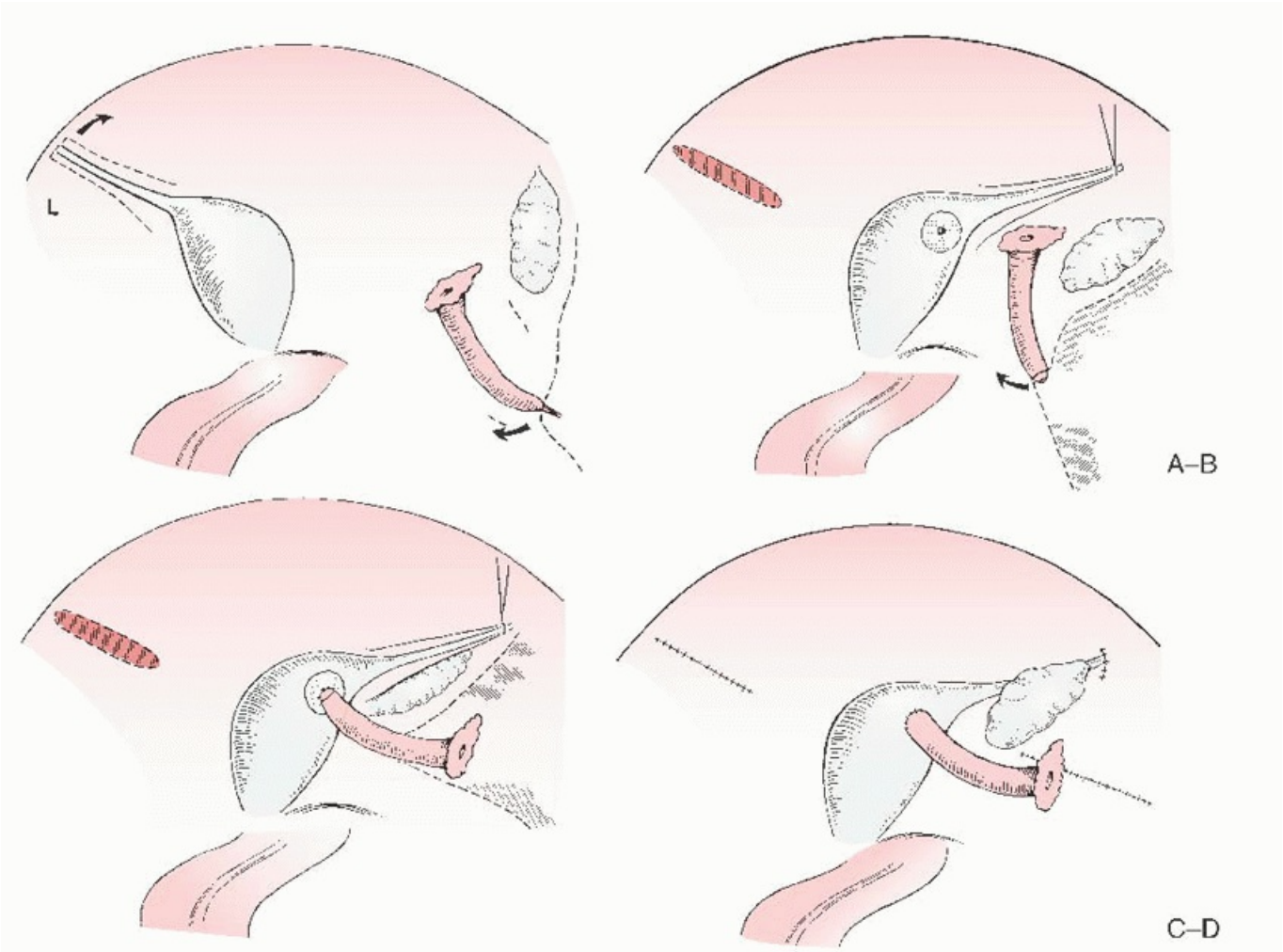

FIGURE 21.36 Microsurgical tubo-ovarian transposition. **A:** Schematic drawing of the findings. **B:** The uterus was centered by moving the left round ligament and attaching it to right inguinal fossa. The intramural segment of the left tube is identified. **C:** The right adnexa is mobilized, with its vascular pedicle intact. The right tube is rotated clockwise to bring its ampullary stump in proximity of the left intramural segment, and permit a two layer anastomosis to be performed. **D:** the anastomosis is completed by apposition of the cornual seromuscularis to the serosa of the tube. All peritoneal incisions are closed. The *dotted lines* indicate the peritoneal incisions made during the procedure. (L = left side.) (From Gomel V, McComb P. Microsurgical transposition of the human fallopian tube and ovary with subsequent pregnancy. *Fertil Steril* 1985;43:804, with permission. Copyright 1985 American Society for Reproductive Medicine. Published by Elsevier Inc. All rights reserved.)

The uterus was mobilized centrally as follows: The left round ligament was divided near its inguinal insertion and dissected from the broad ligament with its vascular supply intact (**Fig. 21.36A**). The divided end of the round ligament was then affixed to the right inguinal region (**Fig. 21.36B**). Microsurgical transposition of the right ovary and tube with preservation of their vascular supply permitted anastomosis between the left intramural and right ampullary tubal segments (**Fig. 21.36C**). The ovary was mobilized further to achieve the proper spatial relation with the fimbrial extremity of the tube (**Fig. 21.36D**). In the third postoperative cycle, the patient was successful in achieving an intrauterine pregnancy, which resulted in a normal live birth. Subsequently, she had two additional pregnancies resulting in live births. Since the publication of this report in May 1985, there have been at least five case reports of successful transposition of the fallopian tube without the ovary. These reports clearly illustrate the potential of surgery, even though technically difficult, in restoring fertility in the face of unusual pelvic anatomy.

Other Unusual Procedures

The following procedures are of historic interest and have little place—excepting very unusual circumstances—in view of the results ART presently offers.

Correction of Bipolar Tubal Disease

The results associated with surgical correction of bipolar (both proximal and distal) tubal occlusion are dismal. A report from the Mayo Clinic included 31 such patients: bipolar tubal occlusion of both tubes (*n* = 13) or their only remaining tube (*n* = 5), bilateral distal and unilateral proximal occlusion (*n* = 7), and bilateral proximal and unilateral distal occlusion (*n* = 6). Despite a mean follow-up period of more than 3 years, pregnancies occurred in only three patients. Furthermore, two of these were ectopic, and one was a spontaneous abortion.

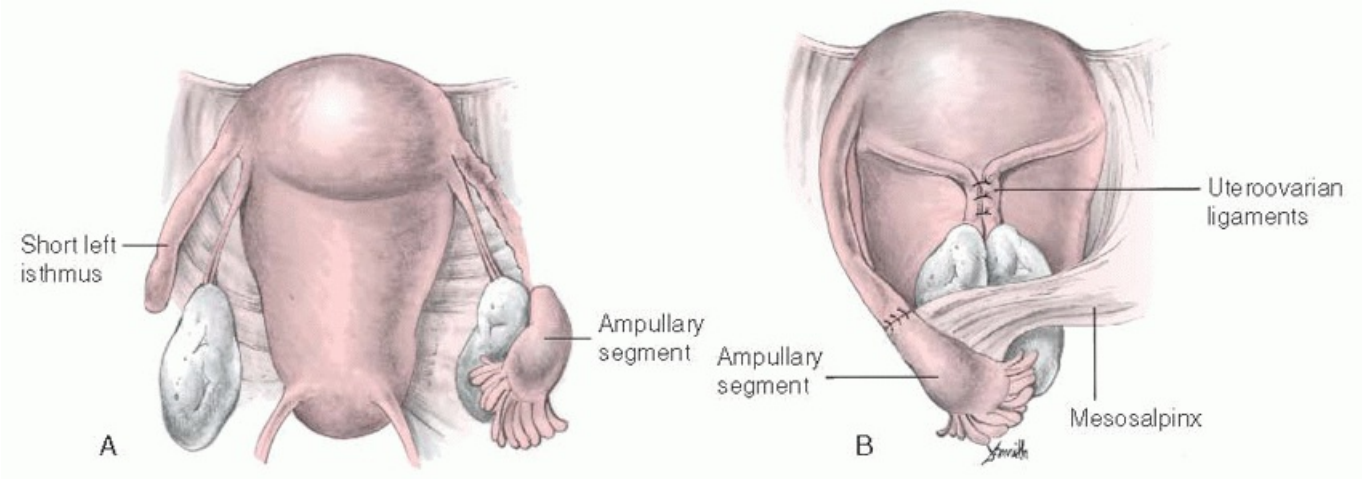

FIGURE 21.37 Microsurgical anastomosis of contralateral tubal segments. **A:** Isthmic segment of the tube on the left and ampullary-infundibular segment on the right. **B:** The uteroovarian ligaments are approximated with nonabsorbable sutures behind the uterus; the left isthmic segment of the tube is anastomosed to the right ampullary-infundibular segment.

Anastomosis of Contralateral Tubal Segments

A patient may have a healthy proximal segment of tube on one side and an ampullary-infundibular segment on the other. In such a circumstance, microsurgical reconstruction of one functional tube can be achieved by anastomosis of the contralateral tubal segments behind the uterus, maintaining the physiologic relation between the tubal infundibulum and ovary. In the presence of both ovaries, the utero-ovarian ligaments are first approximated with interrupted, nonabsorbable no. 4-0 or 5-0 Nylon sutures. This brings the ovaries together and helps reduce tension in achieving the subsequent tubal anastomosis (**Fig. 21.37**). Successful delivery after such a procedure has been reported.

Approximation of the Fimbriated End of the Oviduct to the Contralateral Ovary

When a single ovary exists on the side opposite the patient's only tube, simple approximation of the fimbriated extremity of the tube to the ovary may be possible. The ovary is mobilized, and the mesovarium is fixed to the posterior surface of the uterus with nonabsorbable sutures. The contralateral oviduct is mobilized, and its mesosalpinx is sutured to the posterior aspect of the uterus. The nonabsorbable sutures are placed on the mesosalpinx approximately 1 cm from the tube. This will effectively place the infundibulum in close proximity to the ovary. Alternatively, the ovary can be transposed to the contralateral side with its vascular pedicle kept intact.

Iterative Reconstructive Surgery

Except in rare circumstances, there are no data to support the undertaking of an iterative surgical procedure

when a prior reconstructive operation has failed. Rare exceptions include cases of tubotubal anastomosis that failed for purely technical reasons, provided sufficient lengths of healthy tube are available for reconstruction. In such instances, an iterative microsurgical anastomosis may be undertaken if tubal cannulation fails to restore patency.

Tubal cannulation, performed at the time of the postoperative control HSG that demonstrates an obstruction at the anastomosis site, may prove beneficial in a small percentage of cases by breaking down synechiae or dislodging debris that may be present at this site.

Iterative surgery yields a modest success rate if the initial procedure was performed with the use of conventional techniques. However, the success rate of iterative procedures is disappointing when they are undertaken after a failed microsurgical intervention. Most of the available data on iterative surgery concern salpingostomy. Of the 119 such cases reported in the literature, 18 (15.1%) achieved live births, 5 had spontaneous abortions, and 7 (5.9%) had ectopic gestations. All of these 119 patients had their first procedure performed by conventional techniques and their second intervention performed by microsurgery.

The first report on laparoscopic salpingostomy by Gomel in 1997 included, except for one case, iterative procedures on patients who had previously undergone surgery with conventional techniques. This fact may explain the satisfactory rate of success that was obtained.

The conception rate after iterative microsurgical fertilitypromoting procedures is significantly lower than that obtained with primary microsurgical interventions. Thie et al. (1986) reported a conception rate of 51% after various primary microsurgical procedures in 161 patients. This rate was only 18% at 3-year follow-up in a similar group of 21 patients who had microsurgery after a failed primary operation performed by conventional techniques.

The preceding data strongly suggest that iterative surgery may be indicated in selected, rare instances and that most of these patients may be better served with IVF.

Observations on Current Practice

The enormous progress in IVF and ART in the past 20 years has been accompanied with the commercialization of this technology and its services all over the world. In parallel fashion, there has been a significant decline in the practice and teaching of reconstructive surgery. There is a paucity of publications on this subject. In vitro fertilization is offered now, as a primary treatment option, in most cases of tubal factor infertility. These changes have occurred despite the greater acceptance of laparoscopic access to perform many of the reconstructive tubal operations and the use of minilaparotomy incision for more complex anastomotic procedures, which represents a major progress in gynecologic surgery. These changes have occurred despite the satisfactory results

yielded by reconstructive surgery in appropriately selected cases and despite the fact that surgery offers the couple the opportunity to attempt a pregnancy over a long period of time and to conceive more than once. Furthermore, as already stated before, the presence of a credible alternative with IVF permits the reproductive surgeon to operate on cases with better prognosis, which translates in superior outcomes as has been well demonstrated.

In addition, training in microsurgery renders the gynecologist much more conscious of avoiding peritoneal trauma and more careful in tissue handling and tissue care. It makes him/her more conscious of conservation and overall a better surgeon. Skills that may well be lost with lack of teaching of reconstructive microsurgery.

The evidence suggests that surgery should retain its place in the treatment of tubal infertility. Preservation of the place of surgery will require a concerted effort on the part of the teaching institutions. We are pleased to note the

recommendations in support of this approach in ASRM's recent "Committee Opinion: Role of Tubal Surgery in the Era of Assisted Reproductive Technology."

Surgery and ART are complementary approaches that can be used singly or in combination to improve the outlook of couples suffering from tubal infertility. This was clearly demonstrated in a study by Tomazevic published in 1996. Fiftynine women with pathologic cornual occlusion were treated by microsurgical tubocornual anastomosis; 27 of these (45.8%) had live births. The 32 women in whom the surgery did not yield a birth were offered IVF treatment; 21 of them had a total of 66 cycles of IVF. Twelve of these had a live birth, bringing the total of women with a baby to 39 (66.1%). The reader must be reminded that the success rate with IVF in the late 1980s and early 1990s was fairly low compared to current outcomes.

In the preface of the book *Microsurgery in Female Infertility,* published in early 1983, it is stated: "This manuscript has been completed during a time of rapid change and expansion with the understanding that it represents not an end point but merely an accounting at a given point in time. Further developments are also occurring in the area of IVF and embryo transfer (IVF & ET), which will undoubtedly produce improved results. Nonetheless, I do not consider the techniques of microsurgery on the one hand and IVF & ET on the other as competitive; on the contrary, I see them as complementary, enabling us to achieve a greater success rate among those patients presenting with complex fertility problems." This statement is still valid today.

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