From the RSNA Refresher Courses

A Review of Selective Salpingography and Fallopian Tube Catheterization[1]

Amy S. Thurmond, MD • Lindsay S. Machan, MD • Antoine J. Maubon, MD • Jean-Pierre Rouanet • David M. Hovsepian, MD • Arl Van Moore, MD • Ronald J. Zagoria, MD • Kevin W. Dickey, MD • James C. Bass, MD

Use of selective salpingography and fallopian tube recanalization has revolutionized the diagnosis and treatment of infertility. Selective salpingography, a diagnostic procedure in which the fallopian tube is directly opacified through a catheter placed in the tubal ostium, has been used since the late 1980s to differentiate spasm from true obstruction and to clarify discrepant findings from other tests. In fallopian tube recanalization, a catheter and guide wire system is used to clear proximal tubal obstructions. The recanalization procedure is simple for interventional radiologists to perform and is successfully completed in most patients (71%-92%). Pregnancy rates after the procedure have been variable, with an average rate of 30%. The combination of selective salpingography with fallopian tube recanalization has improved the overall management of infertility caused by tubal obstruction. The same catheterization technique used in fallopian tube recanalization is currently being explored for use in tubal sterilization.

Index terms: Fallopian tubes, interventional procedures, 853.1269, 853.1289 • Fertility • Sterilization

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[1]From the Departments of Radiology, Legacy Meridian Park Hospital, 19300 SW 65th St, Tualatin, OR 97062 (A.S.T.); University of British Columbia, Vancouver, British Columbia, Canada (L.S.M.); Clinique Beau-Soleil, Montpellier, France (A.J.M., J.P.R.); Washington University, St Louis, Mo (D.M.H.); Carolinas Medical Center, Charlotte, NC (A.V.M.); Wake Forest University, Winston-Salem, NC (R.J.Z.); Hospital of Saint Raphael, New Haven, Conn (K.W.D.); and Miriam Hospital, Providence, RI (J.C.B.). Presented as a refresher course at the 1994–1999 RSNA scientific assemblies. Received November 3, 1999; revision requested January 17, 2000, and received February 25; accepted February 28. **Address correspondence to** A.S.T.

Introduction

The first hysterosalpingographic study may have been performed only 15 years after Roentgen discovered x rays (1). It is a standard test that figures prominently in the modern decision-making for more than 300,000 infertile couples in the United States alone. The application of angiographic techniques to this old-fashioned test has revolutionized diagnosis and treatment of obstruction of the proximal fallopian tube. Results from worldwide centers have shown that nonsurgical recanalization of proximally obstructed fallopian tubes can be accomplished in at least 80% of women by using a variety of catheterization techniques. The American Society for Reproductive Medicine has recommended that patients who have proximal tubal obstruction undergo selective salpingography and tubal recanalization before considering the more invasive and costly treatments that were used in the past (2).

To familiarize radiologists with these widely accepted procedures for the treatment of infertility, the authors describe their examination procedures for performing selective salpingography and fallopian tube catheterization. In addition, they review the historical predecessors and development of these procedures and discuss their outcomes, complications, and possible future applications.

Historical Perspective

The initial anatomic description of the oviducts dates back to 1561, with the publication of *Observationies Anatomicae* by Gabriele Fallopius in Modena, Italy. He described the different portions of the fallopian tube, with the "trumpet" shape of its distal end, and remarked on the similarities of this organ among female mammals (3).

The first description of selective tubal catheterization appeared in *The Lancet* in 1849, decades before the first x-ray image (4). William Tyler Smith, a lecturer in the Hunterian School in London, proposed a "new method of treating sterility by removal of obstructions of the fallopian tubes." He used a transvaginal route and tactile impression to pass a whalebone bougie through a J-shaped silver cannula positioned in the uterine cornua, thereby clearing proximal occlusions. He was inspired by the technique of Gairal, a French surgeon, who used whalebone bougies to catheterize the auditory tubes. In his 1849 article, Smith suggested the possibility that the fallopian tube was blocked by a "glutinous deposit," an opinion confirmed 148 years later by Sulak et al (5). Low-grade inflammation of the uterus and retrograde menstruation may explain proximal tubal obstruction by amorphous debris in some women. However, despite its long recognition as a cause of infertility, the underlying cause for tubal obstruction has never been proved.

Interestingly, also in 1849, Friorep in Berlin used the transcervical approach to the fallopian tube for the opposite purpose (6). He applied silver nitrate through a cervical cannula to the proximal portion of the tubes and to the uterine cornua to provoke a noninvasive tubal sterilization (6). In the following years, these techniques of transcervical catheterization were used mainly for sterilization purposes, with various chemical agents or physical devices applied to occlude the proximal tube.

In 1963, Sweeney (7) thought it would be impossible to pass devices from the uterine cavity to the fallopian tube lumen because of its narrow diameter and "extreme variability in configuration and directions." In 1966, Corfman and Taylor (8) used a curved metal cannula, similar to the model used by Smith in 1849, but the 3.5-mm tip was too big to pass directly into the tube. In 1977, using angiographic techniques, Rouanet and Chalut (9) placed a 7-F catheter usually used for bronchial artery catheterization into the interstitial portion of the fallopian tube of one woman for improved diagnosis of tubal obstruction. In 1985, Platia and Krudy (10) used a 3-F catheter to clear proximally occluded fallopian tubes for treatment of infertility. In 1988, Confino et al (11) described transcervical balloon tuboplasty, a procedure derived from arterial balloon angioplasty techniques, and proposed that it be used to treat proximal tubal occlusions. The more expensive balloon catheter, however, did not appear to offer any advantage, and this technique has fallen out of favor. In 1987, Thurmond et al (12) described their technique for selective salpingography and fallopian tube recanalization that has since been widely used to improve diagnosis of and to treat proximal tubal occlusions (13).

Steps for Fallopian Tube Catheterization in a Woman with Proximal Tubal Obstruction

Step	Possible Results	Next Radiologic Step
Hysterosalpingography	Tube open	None
	Proximal tube blocked	Selective salpingography
Selective salpingography (ostial injection)	Tube open	None
	Persistant tubal blockage	Fallopian tube recanalization
Fallopian tube recanalization (guide wire passage beyond obstruction and intratubal injection)	Tube open and looks normal or near normal	None
	Tubes still blocked proximally, tubes open proximally but blocked distally, or tubes open but abnormal	None; couple should consider in vitro fertilization or other fertility options

The progressive adoption of this technique has been favored by technologic improvements in catheters and guide wires and by its low cost and simplicity. Selective salpingography with fallopian tube recanalization can be performed in the same session as the hysterosalpingographic examination that fails to opacify the tubes (14). Because the procedure uses basic angiographic techniques, its performance is within the capabilities of any interested board-certified radiologist.

Examination Procedures

The steps of the procedure are outlined in the Table. Selective salpingography is a diagnostic test in which the fallopian tube is directly opacified by injecting contrast medium through a catheter placed in the tubal ostium. The most common indications for using selective salpingography are to differentiate spasm from true obstruction, clarify findings from an equivocal hysterosalpingogram, or resolve discrepancies between hysterosalpingographic and laparoscopic or clinical findings. Fallopian tube recanalization is a therapeutic procedure to open the fallopian tube by passage of a guide wire and catheter through a proximal fallopian tube obstruction (15).

Patient Preparation

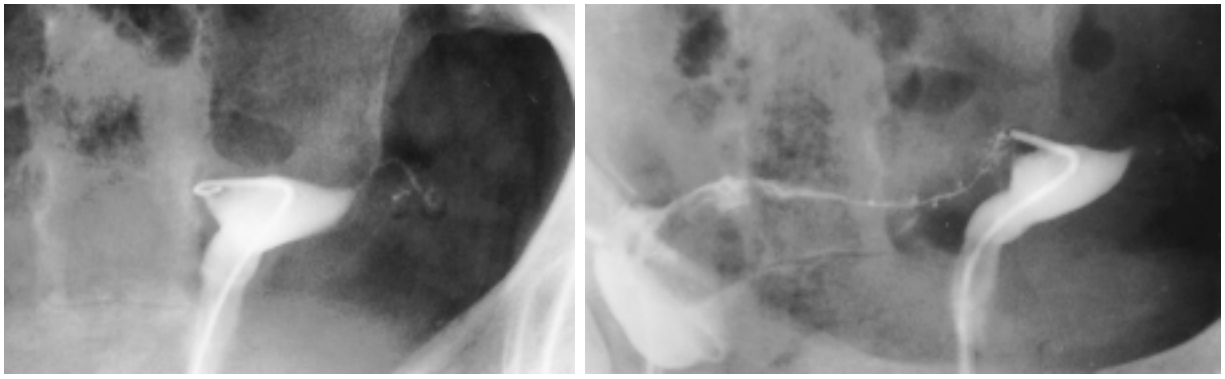
Patient calm and comfort are critical to the technical success of selective salpingography because tension will make the procedure considerably more difficult and theoretically may result in tubal spasm. To this end, it is vital that all staff, from the receptionist to the physician, be aware of the extra sensitivity and respect for privacy that these patients require.

There is variation among practitioners as to whether they give the patient sedatives or not, with some rarely using it and others routinely providing intravenous medazepam and fentanyl unless the patient has a strong aversion to it. Use of foam padding to elevate the patient's pelvis from the x-ray table and comfortable foam pads beneath the knees are helpful.

Periprocedural antibiotics are not given by all practitioners. Those that do, prescribe oral doxycycline and instruct the patient to take 100 mg twice daily for 5 days, starting up to 2 days before the procedure.

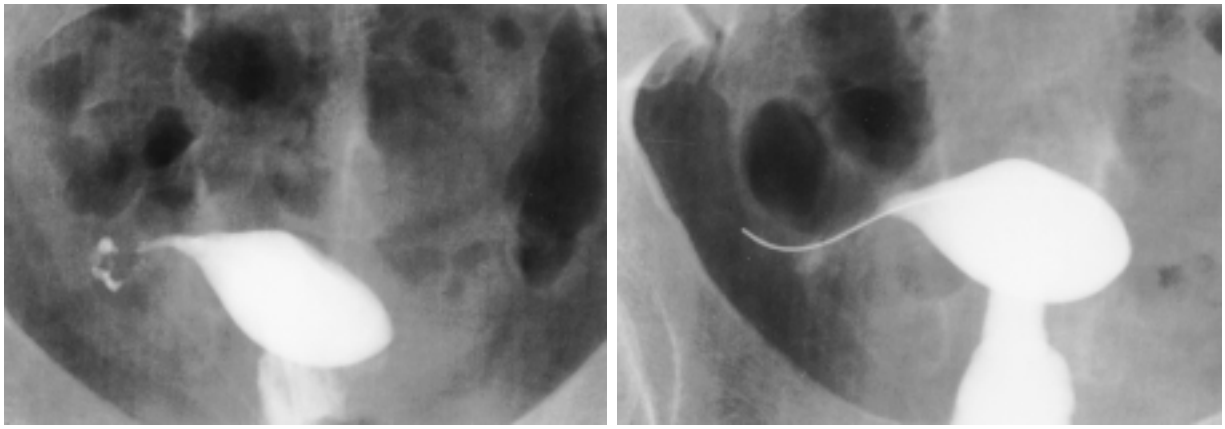
Cervical Cannulation

After sterile cleansing and draping of the patient, a warmed plastic speculum is inserted into the vagina and gently opened to allow visualization of the cervix. The cervix is swabbed and then cannulated with an occlusive catheter large enough to allow coaxial passage of a 5-F diagnostic catheter. The occlusive catheter can be fixed with a tenaculum, external cervical suction, or an endocervical or endouterine balloon. If a tenaculum is used, spraying the cervix with topical xylocaine is suggested. Once a good cervical seal has been achieved, the uterine cavity is opacified with an injection of ionic or nonionic water soluble contrast agent. Dilution of the contrast agent to approximately 30% allows visualization of the catheter and guide wire within the uterine cavity.



a. **b.**

Figure 1. Selective salpingography of the right fallopian tube. **(a)** Radiograph shows a 0.035-inch guide wire supported by a 5.5-F catheter that was used to catheterize the right tubal ostium. **(b)** Radiograph, obtained after the catheter was wedged firmly into the tubal ostium and after injection of contrast material, demonstrates the fallopian tube, which cannot be seen with conventional hysterosalpingography.



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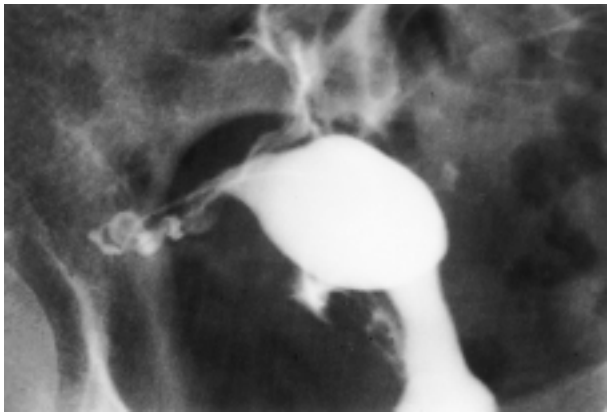


c.

Figure 2. Recanalization of the right fallopian tube. **(a)** Selective salpingogram demonstrates an occlusion 2.5 cm from the tubal ostium. **(b)** Radiograph shows a 0.015-inch diameter guide wire supported by a 3-F catheter that was used to pass the tubal obstruction. **(c)** Radiograph, obtained after recanalization and an intratubal injection of contrast material, reveals a tortuous but patent fallopian tube.

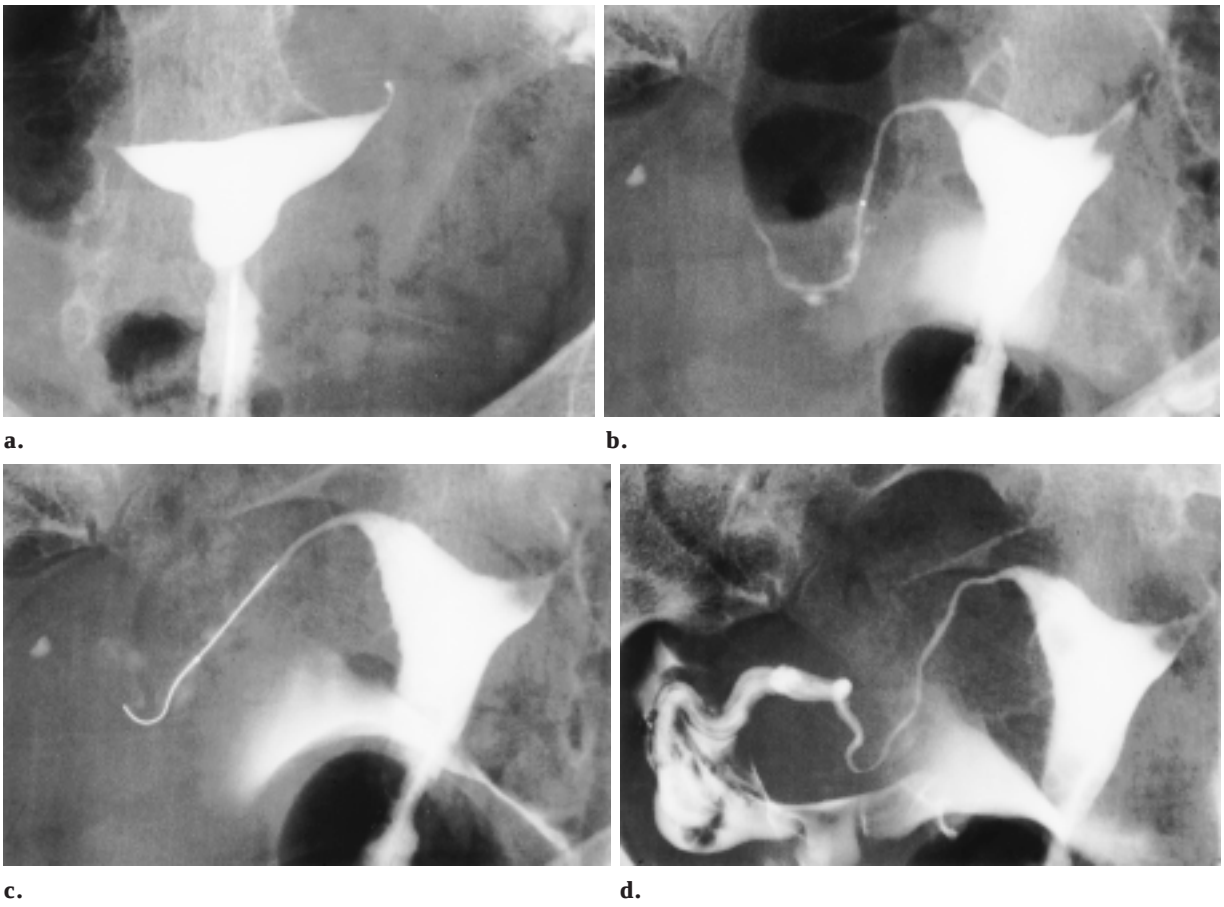


Figure 3. Successful recanalization of a more distal tubal obstruction with use of a softer tapered system. **(a)** Hysterosalpingogram demonstrates bilateral proximal tubal obstruction. **(b)** Radiograph, obtained after successful recanalization of the proximal obstruction of the right tube, reveals a second obstruction in the isthmic portion of the same tube. **(c)** Radiograph shows a 0.014-inch floppy guide wire supported by a 2.7-F tapered catheter (with a radiopaque bead at the tip) that was used to pass the second obstruction. **(d)** Subsequent radiograph obtained after a repeat ostial injection of contrast material now reveals a patent normal tube.

Selective Salpingography

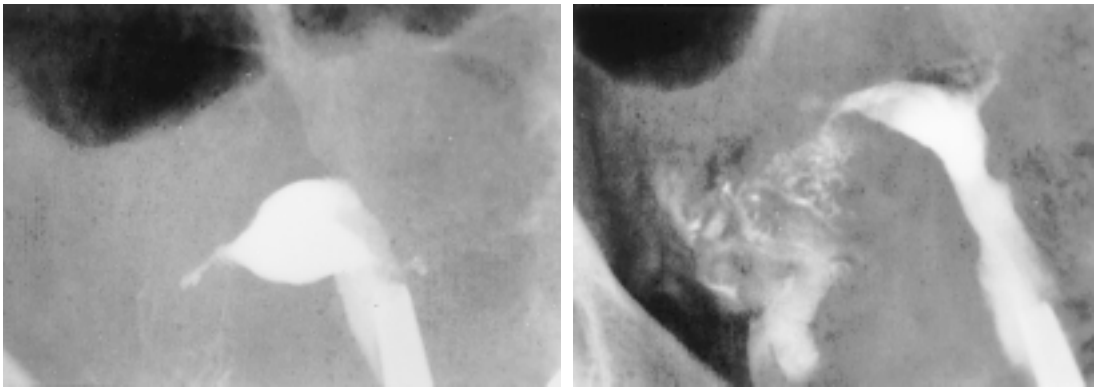
If the fallopian tubes do not fill with contrast agent when the uterus is opacified, or if the images of the fallopian tubes are inadequate for diagnostic purposes, a 5-F curved catheter is advanced over a guide wire and wedged into the cornual region (Fig 1). Virtually any primary curve catheter and guide wire combination will work, but most practitioners use the Thurmond-Rosch set (16) (Cook, Bloomington, Ind). Gentle injection of contrast agent will result in a selective salpingogram. When the fallopian tube is patent, radiographs are taken and the catheter is directed over a guide wire into the opposite cornual region.

Fallopian Tube Recanalization

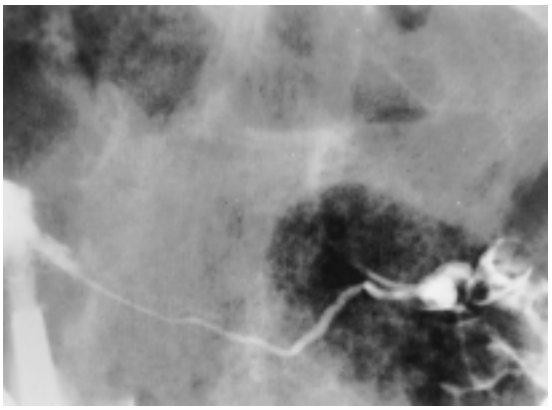
If selective salpingography reveals a proximal fallopian tube obstruction (Fig 2a), a 3-F tapered catheter preloaded over an 0.015-inch guide wire is gently advanced through the obstruction via the cornual catheter (Fig 2b, 2c). If this guide wire does not pass easily, the obstruction can usually be crossed with a 0.016-inch diameter floppy-tipped tapered guide wire (Fig 3) (Target Therapeutics; San Jose, Calif) (17) or a 0.035-inch diameter angled-tip hydrophilic guide wire (18) (Terumo, Tokyo, Japan).

Patient Communication

It is important to review the findings with the patient and her husband after the procedure and to stress the importance of follow-up with her referring physician. Sexual intercourse and other normal activities can be resumed the next day. Most patients have pelvic discomfort that lasts less than 24 hours and that responds well to their usual medication for menstrual cramps. Up to 3 days of vaginal spotting can occur.



a. b.



c.

Figure 4. Successful recanalization in a patient with a flexed uterus. **(a)** Hysterosalpingogram demonstrates bilateral proximal tubal obstruction and a flexed uterus. **(b)** Radiograph, obtained after attempts to recanalize the right tube, reveals contrast agent in the pelvic veins, indicating that the tube has been perforated. Subsequently, the uterus was straightened by applying traction on the cervical vacuum cup device, and recanalization of the left tube was attempted. **(c)** Radiograph of the left side shows the successfully recanalized left fallopian tube. The patient conceived shortly after the procedure and delivered a healthy infant.

Technical Challenges

Fallopian tube catheterization and recanalization is a simple procedure, but occasionally the patient's anatomy will thwart the radiologist's efforts. Two of the more frequently encountered problems are difficulty in cannulating the cervix and difficulty in advancing the catheter into a cornu.

Difficulties in cannulating the cervix most frequently occur because of poor visualization. Use of a large metal speculum and patient sedation may help. Gently applying a tenaculum to the 12 o'clock position of the cervix may facilitate cannulation and subsequent manipulations.

Difficulties in advancing the catheter can arise because of normal variations in uterine orientation. These variations can be significant and can cause the guide wire or catheter to preferentially go into one cornu. Use of firm traction on the cervix to straighten the uterus by employing either the vacuum cup device (Fig 4) or a tenaculum (Fig 5), use of an hydrophilic wire, or use of a preformed curved catheter may help in some patients.

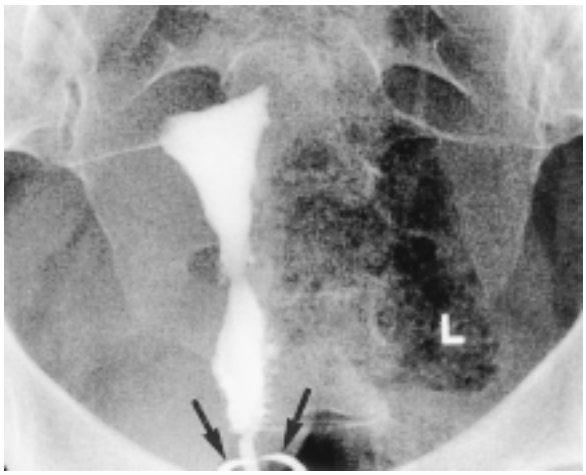


Figure 5. Pelvic radiograph demonstrates a tenaculum on the cervix (arrows). This device can also be used to help straighten the uterus for tubal catheterization.

Outcomes of Tubal Recanalization

Recanalization Rates

Fallopian tube recanalization has now been performed in a large number of patients, and results in 1,466 patients have been published (11,14,15,

19–39). In these series, the technique used has been similar or identical to the standard procedure previously described (15). Because many patients with proximal tubal occlusion have bilateral involvement, recanalization of both tubes is attempted during the same procedure. When one tube is patent, attempts to recanalize a contralateral proximally obstructed tube is justified because of the ease of the procedure and the presumed benefit.

The 1,466 reported cases constitute a diverse group of patients, and some authors have reported statistics per patient whereas others have reported success rates per fallopian tube or recanalizations attempted. On the basis of these data, successful recanalization of the proximal fallopian tube was achieved in 71%–92% of recanalizations attempted. Results reported to date indicate that this procedure is successful in 62%–90% of patients in whom it is attempted and that it provides important diagnostic information in all these women.

Recanalization is possible but potentially less successful in women who have occluded tubes after surgical anastomosis for reversal of tubal ligation. Reported success rates per fallopian tube are presumably related to the degree of postoperative scarring at the anastomosis and range from 44% (34) to 77% (37).

In patients with fallopian tube occlusion related to salpingitis isthmica nodosa, recanalization was successful in 77%–82% of tubes but was technically more challenging (38,39).

Although recanalization of the fallopian tubes has a high success rate, some tubes do reocclude. In several series of patients who failed to achieve pregnancy 6–12 months after successful proximal tubal recanalization, only 62% of the tubes remained patent (40). Repeat recanalization is usually successful.

Fallopian tube catheterization and recanalization is not successful in a few patients. Occasionally, it may be impossible to engage the fallopian tube because of congenital malformation or because of uterine leiomyomas or polyps. Successful catheterization of the tube but failure to recanalize it is likely caused by fibrotic scarring of the tube from salpingitis, endometriosis, or surgery.

Pregnancy Rates

Pregnancy rates have been variable, reflecting the diversity of the patient populations. Of the 1,079 women who have undergone successful fallopian tube recanalization, 319 available for follow-up have conceived, yielding an average pregnancy rate of 30% (11,14,15,19–39).

The lowest pregnancy rate reported after successful recanalization of proximal tubal occlusion was 9% and occurred in a population with a high prevalence of coexistent distal tubal disease (19). The highest pregnancy rate was 58% after an average follow-up of 1 year. This rate was recorded in a population with some ovulation and sperm disorders but no distal tubal disease as documented with laparoscopy (15).

Alternative techniques are available to treat proximal tubal obstruction. In vitro fertilization and embryo transfer results in a 10%–15% pregnancy rate (25). The pregnancy rate after microsurgical repair of proximal fallopian tube obstruction is 30%–50% (25).

Complications

Complications of fallopian tube recanalization are unusual and are of little clinical significance when they do occur. The possibilities of tubal perforation, vasovagal response, and adnexal infection should be discussed with the patient. The theoretic possibility of idiosyncratic reaction to the contrast agent might be mentioned, although this complication has never been reported following fallopian tube catheterization or hysterosalpingography. If one or both tubes are recanalized, the possibility of a tubal pregnancy should be discussed with the patient, and she should be advised to visit her gynecologist as soon as she misses a period and has a positive pregnancy test.

Tubal Perforation

The fallopian tube is a relatively thick, muscular structure and is not easily punctured by the guide wires employed in the procedure. Occasionally, a through-and-through perforation does occur and is manifested as contrast agent free in the peritoneal cavity. More often perforation is submucosal and is manifested as an extraluminal collection of contrast agent or intravasation of contrast agent into the pelvic veins (Fig 4b). Tubal perforation occurs 2% of the time (40), and no adverse sequelae have been reported.

Ectopic Pregnancy

In patients with completely normal fallopian tubes following recanalization, the tubal pregnancy rate should be similar to that in the normal population. Some women, however, have tubal mucosal abnormalities or peritubal adhesions, which increase their risk for tubal pregnancy once the

tube is opened. After a successful fallopian tube recanalization, tubal pregnancies occurred in an average of 3% of women (40).

Pelvic Infection

Pelvic infection following fallopian tube recanalization has not yet been reported and therefore presumably occurs in less than 1% of cases. The majority of practitioners have used the prophylactic antibiotic regimen previously described.

Radiation Exposure

Occasionally, women ask about the effects of radiation from the procedure. The radiation dose to the ovaries from the procedure is approximately 1 rad (10 mGy), a dose that is within accepted limits for women of reproductive age (40). Although the fertilized gamete is radiosensitive, the ovum before fertilization is relatively radioresistant. Selective salpingography with fallopian tube recanalization is performed in the follicular phase of the ovulatory cycle to ensure that the patient is not pregnant.

Future Directions and Applications

The access to the fallopian tube that tubal catheterization provides has resulted in discussion of other potential new treatments, such as aspiration of a dilated tube, injection of antibiotics into an inflamed tube, and injection of chemotherapeutic agents to treat tubal tumors or peritoneal metastases. Other diagnostic procedures have also been tried, including endotubal sonography (unpublished data) and measurement of tubal pressures (42,43). Selective intratubal delivery of methotrexate was used to treat extrauterine pregnancies (44); however, because of the success of simple intravenous injection, this technique was not developed further. The most promising new procedure utilizing fluoroscopic fallopian tube catheterization is tubal occlusion for prevention of unwanted pregnancy.

Selective Tubal Occlusion

Presently, the most widely used technique of female sterilization is surgical tubal ligation (45–47). There is a worldwide demand for nonsurgical methods of temporary and permanent tubal sterilization (48). Few modifications are needed to adapt the technique of tubal catheterization to tubal sterilization. The animal model for fallopian tube catheterization is the female rabbit (49–51).

Whether surgical or nonsurgical, tubal sterilization methods can be classified according to one of the following patterns regarding the mode of tubal obstruction: (*a*) occlusion by a mechanical device (clips, plug), (*b*) occlusion by a toxic compound or destructive energy source (tetracycline, laser, cautery), or (*c*) occlusion by a combination of mechanical and toxic (acrylic glue) devices. Whatever the mode of action, the successful method must be as safe, as inexpensive, and as effective as currently available methods of contraception and sterilization.

Several methods of permanent tubal sterilization via selective transcervical tubal catheterization have been evaluated. Use of ethanol (50), collagen glue (52), and fibrin sealant (53) failed to achieve permanent occlusion after injection into rabbit fallopian tubes and merit no further testing. Mixed results were obtained with hydrogel and a sclerosing agent (54), bipolar radio frequency (55), and some coil designs (56). Several methods had a high success rate in preventing pregnancy in rabbits or in women but either were difficult to use (eg, silicone plugs [57,58], Nd:YAG laser [59,60], controlled radio frequency [61], coagulation combined with fibrin sealant [53]) or used compounds that are not likely to be approved by the Food and Drug Administration (eg, hydrogels [52], quinacrine [62], and n-butyl-cyanoacrylate [63,64]). Microcoils appear to have the most potential success at this point because they are inert, easily delivered through a microcatheter, and potentially retrievable (65,67; Thurmond AS, et al, unpublished data, 1996). However, an ideal method of sterilization via selective fallopian tube catheterization has yet to be identified.

The discovery of a suitable method is a difficult task that will require extensive investigations, as one can conclude by the variety of sterilization methods that have been tried and the wide-ranging results. The potential benefit is great, however, and continued efforts are warranted in this field, which combines interventional radiology, fertility, biomaterials, and politics.

Conclusions

The fallopian tube is critical to normal reproduction. The proximal 4–5 cm of the fallopian tube has a luminal diameter of 1 mm or less. In addition, the first 1–2 cm of the tube is buried in the wall of the uterus, which has made intervention problematic. Fallopian tube catheterization has allowed blockages or potential blockages in this area to be approached radiologically, improving the overall management of infertility caused by tubal obstruction. The techniques used in fallopian tube catheterization have the potential to improve other tubal interventions that are currently performed surgically, particularly tubal sterilization.

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