INFORMATION ON MICROSURGICAL VASECTOMY REVERSAL AND SPERM ASPIRATION

Thank you for your inquiry. You will find attached information from my book The Couple’s Guide to Fertility and additional reprints, which should answer most of your questions about microsurgical reversal of vasectomy and sperm aspiration. I have also attached an information sheet on the financial arrangements, costs and insurance coverage for these procedures. This letter will provide additional information regarding the hospitalization and follow-up for reversal of vasectomy.

Because microsurgical reversal of vasectomy requires such a high degree of technical skill, I am unable to recommend other microsurgeons to you because I have no way of determining whether they have acquired the high degree of technical expertise that we have developed in our animal laboratory and extensive experience with human reversal. There is less than one tablespoonful of blood loss and a blood transfusion is never necessary.

Although, the success rates for microsurgical reversal of vasectomy correlate somewhat with the length of time since the original vasectomy, we have had successful reversals more than 20 years after vasectomy. If good sperm are found above the vasectomy site at the time of surgery, success can be expected regardless of the length of time since vasectomy. Longer periods of time between the original vasectomy and the reversal attempt, however, may necessitate a more extensive operation called vaso-epididymostomy to restore fertility. This determination is made at the time of the actual surgery. The attached information provides more details regarding the predictors of success after this type of surgery.

Our success rate for men who have undergone previous unsuccessful reversal surgery is almost as good as those undergoing reversal for the first time. Because of scarring from previous surgery, however, second operations may require more extensive surgery and take longer to perform.
Sperm Aspiration

We perform and, in fact, are pioneers in sperm aspiration here at The New York Presbyterian Hospital-Cornell Medical Center. Sperm aspiration involves extraction of sperm from either the ducts leading out from the testicle (vas deferens or epididymis) or from the testicle itself. Sperm obtained by aspiration can only be used for in-vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI). This is because aspirated sperm in men who are blocked do not swim well and will not fertilize the egg unless the sperm is injected directly into the egg (ICSI). For men undergoing microsurgical vaso-vasostomy on at least one side, we usually do not recommend aspiration of sperm at the time of the surgery because our success rate for return of sperm in the semen after vaso-vasostomy is 99.5%. If a vaso-epididymostomy is necessary on both sides however, the success rate drops to 80% for return of sperm. Therefore in all men undergoing only vaso-epididymostomy, we recommend the aspiration and freezing of sperm in the operating room at the time of surgery. This will allow sperm to be available for future IVF in the event that the surgery to repair the blockage is not successful.

Sperm aspiration may be performed instead of vasectomy reversal. We usually do not recommend this as the primary treatment, because it also requires the wife to go through an IVF procedure. This requires daily hormone injections for 30 days, at the end of which time the wife undergoes sonograms on a daily basis to determine when the follicles are ripe. When the follicles are ripe, the wife is brought into the hospital and either put to sleep or given heavy sedation. The eggs are then removed through the vagina with long needles. The sperm that was aspirated are injected directly into the egg. If the eggs fertilize, three or five days later they are transferred back into the wife with a plastic catheter. Currently the cost of the IVF with ICSI is $15,000 for each attempt. This does not include the cost of aspirating sperm from the man. A single attempt yields approximately a 45% chance of taking home a baby if the wife is under 35. This procedure must be repeated for each attempt at pregnancy and for each future pregnancy.

Because the reversal of vasectomy yields pregnancy rates between 50% and 70% with natural intercourse, we usually recommend sperm aspiration as a secondary procedure. That is, if sperm are present in the semen after the reversal operation, but the wife is not getting pregnant, then IVF with ICSI can be employed using sperm from the semen of the man without him requiring another operation. By performing a vasectomy reversal and if necessary, sperm aspiration simultaneously, all bets are covered.

For those who desire only sperm aspiration, this may be done in two ways. Under general anesthesia, the ducts of the epididymis are exposed under a microscope, the epididymis is punctured, the sperm is then sucked into glass pipettes and placed into a special medium for freezing. Currently the pregnancy rate with IVF and ICSI using frozen sperm is virtually identical to that with fresh sperm. Enough sperm can be extracted and frozen at a single operation for a least 4 or 5 attempts at in-vitro fertilization. This operation is less extensive than the reversal operation, but does require
a general anesthetic and does require a cut into the scrotum. This operation will take approximately 1-2 hours to perform.

A second way to obtain sperm is by putting a needle directly into the testicle under either a local or light general anesthetic. This is called a non-surgical sperm aspiration technique. We perform these here at Cornell as well. Because sperm obtained this way are much fewer in number, and cannot be frozen, this procedure must be done simultaneously with the attempt at IVF. With this procedure it is necessary for your wife to be seen at Cornell’s IVF program so that we can coordinate the aspiration of testicular sperm with the IVF cycle. Currently the pregnancy rates with testicular sperm are lower than the pregnancy rates using aspirated epididymal or vasal sperm obtained surgically or after reversal of the vasectomy. The complications of blind needle aspiration of sperm (non-surgical sperm aspiration technique) are injury to the blood vessels of the testicle, which have, on rare occasion, resulted in atrophy (disappearance of, or diminished in size) of the affected testicle.

I would be happy to discuss all of these options for fertility after vasectomy with you at the time of our consultation or over the phone.
Patient Information: **VASO-VASOSTOMY AND VASO-EPIDIDYMOSTOMY**

A microsurgical vaso-vasostomy (also known as a vasectomy reversal) is the reconnection of the two severed ends of the vas. The vas deferens is the conduit for sperm to travel from the testis to the urethra.

A microsurgical vaso-epididymostomy is the connection of a vas deferens end with the epididymis. This is a more extensive procedure and is performed when there is a blockage of the delicate epididymal tubule where the sperm mature after leaving the testis. The epididymis empties into the vas deferens.

**PRE-OPERATIVE PREPARATION:**

1. For any elective surgery you should be in the best of health. It is important to let our office know if you have any other health problems which might necessitate a consultation with an internist prior to your surgery.

2. For one week prior to surgery, avoid pharmaceutical medication or herbal supplement that may effect bleeding. Examples are:
   - Aspirin and Aspirin-containing products such as: Alka-Seltzer, Anacin, Arthritis Pain Formula, Ascriptin, Aspergum, Bufferin, Ecotrin, Empirin, Excedrin, Fiorinal, Percodan, Vanquish.
   - Non-steroidal anti-inflammatory products such as: Advil, Celebrex, Dolobid, Excedrin IB, Ibuprofen, Motrin.
   - Herbals such as: ginkgo biloba and ginger.

**HOSPITALIZATION:**

1. The week before surgery you will be asked to report to **L-1 Pre-admission Unit**, at which time necessary lab tests will be performed. If necessary, the lab testing can be done at an outside lab.

2. **DO NOT EAT OR DRINK ANYTHING AFTER MIDNIGHT BEFORE YOUR SURGERY!**

3. On the day of your surgery, you will be admitted through the **Ambulatory Surgical Center or Admission Office** at a designated time and must be accompanied by someone capable of driving you home.

4. Surgery will generally take between three and six hours, depending on the type of surgery necessary to restore your fertility. The procedure is performed under a light general anesthetic, which is extremely safe and effective.
5. You will remain in the recovery room for a minimum of two hours or until you feel comfortably alert. Family and friends are not allowed in the recovery room. They can visit you when you return back to the Ambulatory Surgery Center/Discharge Lounge.

6. You will be discharged in satisfactory condition for travel by train, automobile or plane. Wear loose fitting clothes (i.e. sweat pants) home from the hospital.

**POST-OPERATIVE CARE:**

1. **IT IS LIKELY THAT YOU WILL HAVE SOME DISCOMFORT FOR THE FIRST 2 TO 3 WEEKS AFTER SURGERY.** At the time of discharge from the hospital, you will have been given prescriptions for pain medication. When taking pain medication, be careful as you walk or climb stairs. Dizziness is not unusual.

2. **SWELLING AND BRUISING OF THE PENIS AND SCROTUM ARE NORMAL AND WILL TAKE ABOUT 3 WEEKS TO COMPLETELY RESOLVE. APPLYING ICE TO THE INCISION FOR 48 HOURS WILL HELP DECREASE PAIN OR SWELLING.**

3. A small amount of bright red blood is to be expected. **DO NOT BE ALARMED.** If you feel that the amount is excessive, call my office. You may replace your bloody bandages with clean ones.

4. Do not make any important judgement decisions or sign any legal documents for 24 hours after anesthesia.

5. A low-grade fever (up to 101°F) is common 2-3 days post-operatively. This fever can be lessened by coughing, deep breathing and walking. There is no danger that these activities will disrupt your incisions. Taking pain medication one hour before activities and placing a pillow over your lower abdomen when coughing will help decrease discomfort.

6. You should shower 48 hours after surgery. Before showering, remove the scrotal supporter and dressings. There may be steri-strips directly over the incisions. **DO NOT remove the steri-strips until 10 days after the surgery; you may shower with the steri-strips in place.** It is important to keep the surgical area clean. Allow the warm water to run over the incisions in the shower and wash gently with soap (**DO NOT rub hard or scrub the incision or steri-strips**).

7. You will need to wear the scrotal supporter (jock strap) at all times, even while sleeping for 6 weeks post-operatively. It may only be removed while showering. After 6 weeks wear the scrotal supporter when walking, running, engaging in sports or strenuous activity. The purpose of the scrotal supporter is to prevent your testicles from pulling down on the reconnected ducts.

8. To prevent FUNGUS INFECTION (jock itch), dry yourself well after showering and wear a clean scrotal supporter daily. **IF JOCK ITCH SHOULD OCCUR, USE A COMBINATION OF LAMISIL 1% CREAM AND HYDROCORTISONE 1% CREAM,** which can be purchased over the counter. Mix equal parts of each and apply to the area 3 times daily.
9. Do not return to work for one week post-operatively. However, if your job involves only desk work and very light activity, you may return 3 or 4 days after surgery.

10. Do not drive the first week after surgery, but you can ride in a car if someone else is driving.

11. No heavy work or sports are allowed for 3 weeks post-operatively. After 3 weeks, you should wear a snug fitting athletic supporter while engaging in sports or strenuous activity.

12. No sexual intercourse or ejaculation is allowed for 4 weeks post-operatively, in order to avoid disturbance of the delicate anastomoses and prevent contractions of the vas deferens (which occur during orgasm) until healing is complete.

13. Thereafter you can resume normal activities as you feel up to it.

14. Remember that the Codeine in your pain medication can cause constipation. To avoid straining, increase your fiber intake (fruits, vegetables, whole-grains, figs etc.). Drinking a great deal of water can help also. If necessary you can take two tablespoons of Milk of Magnesia at bedtime. You may also take Colace (stool-softener) while you are on Tylenol with Codeine.

If you have any problems, questions or complications after your surgery, please feel free to call our office.

POST-OPERATIVE SEMEN ANALYSIS:

If you live in the New York area, we ask that you call the office for an appointment for a post-operative semen analysis and examination by Dr. Goldstein. Please call ASAP after surgery for an appointment.

You should have sperm counts obtained after your surgery at 1 month, 3 months, 6 months and every 6 months until your partner becomes pregnant.

At the time of your 3rd month semen analysis, a blood specimen will also be obtained for determination of anti-sperm antibody levels.

In general, it will take between 3 to 12 months for sperm counts to return to normal, although on some occasions it may take up to 2 years.

PLEASE INFORM OUR OFFICE IMMEDIATELY OF ANY PREGNANCY!!
1. The surgeon’s fee, including the post-operative visit, varies from $15,000 to $18,750. Most insurance companies are paying large portions of this fee. Because of the elective nature of this surgery, a $10,000 deposit is required four weeks in advance of your surgery. The balance is due one month after the surgery. (A $4,500 deposit is necessary for patients having unilateral vasovasostomy or vaso-epididymostomy). We will accept payment with a credit card, cash, money order or a personal check made payable to Dr. Marc Goldstein. This fee is refundable in full if my office is notified of your intent to cancel at least two weeks prior to your surgery date.

2. You will be billed separately for anesthesia fees, which can vary from $6,000 to $8,000 depending on the length of the procedure. This must be paid directly to your anesthesiologist who will fill out your insurance forms for reimbursement to you, or payment directly to the anesthesiologist.

3. Hospitalization and laboratory costs tend to vary, but the basic cost for the operating room and hospital room averages between $16,000 and $20,000. Some insurance companies are paying these hospitalization costs.

4. Your insurance company is more likely to pay for your surgery if your policy does not specifically exclude vasectomy reversal. Unfortunately, we have no way of determining the extent of your insurance coverage until the claim is filed. To maximize your insurance reimbursement for microsurgical vasovasostomy, vaso-epididymostomy, aspiration of sperm from the ducts (vas deferens or epididymis) or testis your diagnosis will be recorded as: Bilateral Epididymitis with Obstruction (ICD 604.90). The operation is: Bilateral Scrotal Exploration (CPT 55110) $2,500; Bilateral Vasotomy and Vasogram (CPT 55300) $2,500; Insertion of Urinary Catheter (CPT 51701) $350; Exploration of the Epididymis (CPT 54865) $2,500; Bilateral Microsurgical Vasovasostomy (CPT 55400-50) $10,000 or Bilateral Microsurgical Vaso-epididymostomy (CPT 54901-50) $10,000. Unilateral Microsurgical Vaso-epididymostomy (CPT 54900) $5,000; Unilateral Microsurgical Vasovasostomy (CPT 55400) $5,000 and Intraoperative Micro. Sperm Aspiration (CPT 16666) $1,000. To maximize your reimbursement for sperm aspirated from the vas deferens or epididymis, your operation will be recorded as Microsurgical Epididymal Aspiration of Sperm (CPT 54865-22) $8,000; Microsurgical Exploration of the Epididymis (CPT 54820) $2,500 and Sperm Identified from Aspiration (CPT 89257) $500.

5. Our office will help you to obtain maximum reimbursement from your insurance company. After your surgery, we will send an insurance claim form and a bill to you for submittance to your insurance company. Reimbursement can be sent directly to you or to our office. Please be advised that if reversal of sterilization is an excluded service from your policy, you may not be reimbursed.

If you wish further information on any matters, please feel free to call or write.
Microsurgical management of male infertility
Marc Goldstein* and Cigdem Tanrikut

SUMMARY
The introduction of microsurgical techniques has revolutionized the treatment of male infertility. As a result of technical advances and innovation over the past 10–15 years, previously infertile couples are now able to conceive naturally or to parent their own biological children with the aid of assisted reproductive technologies. This article reviews the indications, techniques, and outcomes of the various microsurgical procedures currently used to optimize male fertility. The most up-to-date methods of microsurgical vasal and epididymal reconstruction, sperm retrieval, and varicocele repair are discussed.

KEYWORDS male infertility, microsurgery, varicocele, vasoepididymostomy, vasovasostomy

REVIEW CRITERIA
Information presented in this review is based on the authors’ extensive collection of research papers, textbooks, and Marc Goldstein’s vast personal experience in the field of male infertility.

INTRODUCTION
According to the Centers for Disease Control and Prevention 2003 Assisted Reproductive Technology (ART) Report, male factors play a significant role in 30–40% of couples dealing with infertility.1 The more common causes of infertility in men include obstruction of the reproductive tract, which can be congenital, acquired or iatrogenic, and impairment of sperm production associated with karyotypic or Y-chromosomal abnormalities, testicular pathology or the presence of varicocele. Most causes of male infertility are treatable, and many treatments restore the ability to conceive naturally.

The dramatic recent improvements in the management of male infertility are largely attributable to improved microsurgical techniques for the repair of obstruction, microsurgical varicocelectomy for enhancement of spermatogenesis, new options for sperm retrieval, and refined microsurgical intracytoplasmic sperm injection (ICSI). These factors have made male infertility one of the fastest growing subspecialties of urology.2–11

VASAL AND EPIDIDYMAL OBSTRUCTION
The most common causes of vasal and epididymal obstructions are vasectomy and iatrogenic vasal injury (7% of cases) from previous scrotal/inguinal surgeries, particularly those performed in childhood.12,13 Microsurgical reconstruction remains the safest and most cost-effective treatment option for these patients,14–16 and also allows natural conception, which is preferred by couples.

The lumina of the vas deferens and epididymal tubule are only about 0.3 mm and 0.2 mm in diameter, respectively, and, therefore, a precise microsurgical technique is the most important factor in the success of reconstruction (as defined by return of sperm to the ejaculate). With recent improvements in microsurgical techniques, the success rate for vasovasostomy is between 70% and 99%,2,3,17,18 and success rates between 40% and 90% have
been reported for microsurgical vasopididymostomy. Many patient-related factors, such as time interval from vasectomy, sperm granuloma at the site of anastomosis, and antisperm antibodies can influence the outcome of the reconstruction. The age of the female partner should be taken into account. In addition, the surgeon’s skill, reconstructive technique and experience all have a significant impact on surgical outcome.

MICROSURGICAL VASECTOMY REVERSAL
Vasectomy is the most common urologic operation in North America, where between 500,000 and 1 million men undergo the procedure each year. Before undergoing vasectomy, the patient should receive counseling regarding the permanency of the procedure and be offered the option of sperm banking. Despite preoperative counseling, surveys suggest that 2–6% of vasectomized men will ultimately seek vasectomy reversal because of unforeseen changes in lifestyle.

Vasovasostomy
The microdot technique was developed at Cornell University as a means of improving the vasovasostomy procedure. It ensures precise suture placement by the exact mapping of each planned suture. When sperm are found in the fluid emanating from the testicular end of the vas, the patency rate of this technique for return of sperm to the ejaculate is 99.5%, and the 1-year cumulative pregnancy rate for patients undergoing this procedure is 70%. The microdot method separates the planning of suture position from the physical act of suture placement. Much as an architect prepares blueprints before the builder constructs the house, the perioperative planning of suture placement is critical to a successful surgical outcome. This painstaking planning allows the surgeon to focus on one task at the time of suture placement, ‘hitting the bulls eye.’ In addition, the discrepancy in diameter between the proximal (obstructed) and distal (nonobstructed) vasal lumen is typically 2:1 to 3:1, sometimes more; careful, even spacing of the sutures minimizes luminal discrepancy and limits ‘dogears’ and leaks, thus decreasing the risk of postoperative stricture, granuloma formation, and reconstructive failure. The microdot method results in substantially improved accuracy of suture placement and minimizes the discrepancy between luminal diameters of the proximal and distal vasal ends, allowing for a watertight anastomosis.
A microtip skin-marking pen is used to map out planned needle exit points. Exactly six monofilament 10-0 double-arm nylon mucosal sutures (first layer) are used for every anastomosis, because they are easy to map out and always result in a leak-proof closure, even when the lumen diameters are markedly discrepant. After completion of the mucosal layer, six 9-0 deep muscularis sutures are placed exactly in between each mucosal suture, just above, but not penetrating, the mucosa (second layer). Six additional 9-0 nylon interrupted sutures are then placed between each muscular suture (third layer). These sutures only involve the adventitial layer that covers the underlying mucosal suture. The anastomosis is finished by approximating the vasal sheath with six interrupted sutures of 7-0 PDS, completely covering the anastomosis and relieving it of all tension (fourth layer). All anastomoses consist of four layers of
six sutures, for a total of 24 sutures (Figure 1). The dartos layer is approximated with interrupted 4-0 absorbable sutures and the skin with subcuticular sutures of 5-0 Monocryl® (Johnson and Johnson, New Brunswick, NJ).

Vasoepididymostomy

Microsurgical vasoepididymostomy Microsurgical vasoepididymostomy is considered the most technically challenging type of surgery for the male reproductive system. In virtually no other operation are results so dependent upon the surgeon's technical expertise. Surgeons who perform vasoepididymostomy, therefore, must have extensive experience in microsurgical techniques and carry out the procedure frequently. The indications for performing vasoepididymostomy at the time of vasectomy reversal, based on gross appearance of the vasal fluid, are reviewed in Table 1. Although occasional discrepancies exist between gross and microscopic findings, they correlate approximately 80% of the time. It is, however, essential to view the vasal fluid under the microscope, in order to determine whether to proceed with vasovasostomy or with vasoepididymostomy. For obstructive azoospermia that is not due to vasectomy or absence of the vas deferens, vasoepididymostomy is indicated when the testis biopsy reveals complete spermatogenesis and scrotal exploration reveals the absence of sperm in the vasal lumen.

Microsurgical end-to-side two-suture intussusception vasoepididymostomy

The intussusception technique, originally known as the three-suture triangulation technique, was developed by Berger. Marmar described a modified technique that consists of two sutures with transverse double-needle placement within the epididymal tubule. At Cornell University, a longitudinal two-suture intussusception vasoepididymostomy approach (Figure 2A) was developed in order to further improve the procedure. With this method, four microdots are marked on the cut surface of the vas deferens and two parallel double-arm sutures are placed in the distended epididymal tubule; however, the needles are not pulled through. After the epididymal fluid is tested for sperm and aspirated into micropipettes for cryopreservation, the two needles within the epididymal tubule are pulled through, and all four

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**Table 1** Surgical recommendations based on gross appearance of vasal fluid and microscopic findings.

<table>
<thead>
<tr>
<th>Appearance of vasal fluid</th>
<th>Most common findings on microscopic examination</th>
<th>Surgical procedure recommended</th>
</tr>
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<tbody>
<tr>
<td>Copious, crystal clear, watery</td>
<td>No sperm</td>
<td>Vaovasostomy</td>
</tr>
<tr>
<td>Copious, cloudy thin, water soluble</td>
<td>Sperm with tails</td>
<td>Vaovasostomy</td>
</tr>
<tr>
<td>Copious, creamy yellow, water insoluble</td>
<td>Many sperm heads, occasional sperm with short tails</td>
<td>Vaovasostomy</td>
</tr>
<tr>
<td>Copious, thick white toothpaste-like, water insoluble</td>
<td>No sperm</td>
<td>Vasoepididymostomy</td>
</tr>
<tr>
<td>Scant white thin fluid</td>
<td>No sperm</td>
<td>Vasoepididymostomy</td>
</tr>
<tr>
<td>Scant fluid, no granuloma at vasectomy site</td>
<td>No sperm</td>
<td>Vasoepididymostomy</td>
</tr>
<tr>
<td>Scant fluid, granuloma present at vasectomy site</td>
<td>Barbottage fluid reveals sperm</td>
<td>Vaovasostomy</td>
</tr>
</tbody>
</table>

Table 2 Advantages and disadvantages of surgical techniques for sperm retrieval.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
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<tbody>
<tr>
<td>Microsurgical epididymal sperm aspiration</td>
<td>General anesthesia preferred</td>
</tr>
<tr>
<td>Low complication rate if performed microsurgically</td>
<td>Requires microsurgical skills</td>
</tr>
<tr>
<td>Epididymal sperm have better motility than testicular sperm</td>
<td>Not indicated for nonobstructive azoospermia</td>
</tr>
<tr>
<td>Large number of sperm can be harvested for cryopreservation of multiple</td>
<td></td>
</tr>
<tr>
<td>vials in a single procedure</td>
<td></td>
</tr>
<tr>
<td>Perineal epididymal sperm aspiration</td>
<td>Variable success in obtaining sperm</td>
</tr>
<tr>
<td>No microsurgical skill required</td>
<td>Smaller quantity of sperm obtained than with</td>
</tr>
<tr>
<td>Local rather than general anesthesia</td>
<td>microsurgical epididymal sperm aspiration</td>
</tr>
<tr>
<td>Epididymal sperm have better motility than testicular sperm</td>
<td>Not indicated for nonobstructive azoospermia</td>
</tr>
<tr>
<td>Testicular sperm aspiration</td>
<td>Complications include hematoma, pain and vascular</td>
</tr>
<tr>
<td>No microsurgical skill required</td>
<td>injury to testes and epididymia</td>
</tr>
<tr>
<td>Local rather than general anesthesia</td>
<td></td>
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<tr>
<td>Can be used for obstructive azoospermia</td>
<td></td>
</tr>
<tr>
<td>Testicular sperm extraction</td>
<td>Require general anesthesia and microsurgical skills</td>
</tr>
<tr>
<td>Low complication rate if performed microsurgically</td>
<td></td>
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<tr>
<td>Preferred technique for nonobstructive azoospermia</td>
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needles are placed through the vas lumen at the marked locations. Tying down the sutures allows the epididymal tubule to be intussuscepted into the vasal lumen, completing the anastomosis (Figure 2B). The patency rate with the longitudinal intussusception vasoepididymostomy approach was over 90% in a recent clinical series, and intussusception is the preferred method for all vasoepididymostomies.⁹

All successful vasovasostomy and vasoepididymostomy techniques rely on adherence to surgical principles that are universally applicable to anastomoses of all tubular structures: an accurate mucosa-to-mucosa approximation; leak-proof anastomosis; tension-free anastomosis; good blood supply; healthy mucosa and muscularis; and atraumatic anastomotic technique.

**EPIDIDYMAL SPERM ASPIRATION**

**When to perform sperm extraction**

Although most postvasectomy patients are candidates for microsurgical reconstruction, not all obstructive-azoospermic men can be managed surgically. In order that these men can become biological fathers, various sperm-retrieval techniques have been developed for use in conjunction with *in vitro* fertilization (IVF). Before the introduction of ICSI, sperm retrieval was performed with IVF and limited forms of micromanipulation, such as partial zona dissection. ICSI has now replaced all other types of assisted reproduction.

Congenital bilateral absence of the vas deferens (CBAVD) is an abnormality related to cystic fibrosis. In patients with mutations in the cystic fibrosis transmembrane conductance regulator (CFTR) gene, segments of the excurrent ductal system anywhere from the midportion of the epididymis to the seminal vesicles are missing.²⁸ Only a minority of patients with a CFTR gene mutation have enough healthy tissue for reconstruction to be feasible.²⁹ The majority of patients with CBAVD, therefore, will need epididymal sperm aspiration for IVF via ICSI.³⁰–³² Before IVF is performed, it should be determined whether both partners are carriers of the CFTR gene mutation.

There are various surgical techniques for sperm retrieval; their advantages and disadvantages are summarized in Table 2. These techniques are also useful for intraoperative retrieval of sperm during reconstructive procedures such as vasoepididymostomy, which have failure rates high enough that intraoperative cryopreservation of sperm for a future IVF cycle should be considered, in the event that the reconstructive surgery is unsuccessful.

Sperm obtained from patients with chronically obstructed reproductive systems usually have poor motility and decreased fertilization capacity. The use of ICSI is essential to achieve optimal results in most cases. One notable exception is chronic obstruction secondary to previous vasectomy. Female partners of
men who underwent vasovasostomy more than 15 years after their initial vasectomy still achieved a natural pregnancy rate of 44%.20 The sperm of patients with chronic epididymal obstruction in this setting will take longer to regain motility; however, even if natural conception does not occur, ejaculated sperm could be used for intruterine insemination or ICSI.

**Open epididymal tubule sperm retrieval technique**

Microsurgical epididymal sperm aspiration can be employed either for intraoperative sperm retrieval at the time of vasovasostomy or as an isolated procedure in men with congenital absence of the vas deferens or unreconstructable obstructions.33 Under the operating microscope, the epididymal tunic is incised and a dilated epididymal tubule is selected, isolated and incised with a 15° microknife (Figure 3A). The fluid is touched to a slide, a drop of saline or Ringer’s solution is added, a cover slip is placed over the slide, and the fluid is immediately examined under a bench microscope. As soon as motile sperm are found, a dry micropipette is placed adjacent to the effluxing epididymal tubule (Figure 3B). A standard hematocrit pipette is less satisfactory, but can be used if a micropipette is not available. Sperm are drawn into the micropipette by simple capillary action. Negative pressure, as is generated by the action of an in-line syringe, should not be applied during sperm retrieval as this can disrupt the delicate epididymal mucosa. Two micropipettes can be employed simultaneously in order to increase the speed of sperm retrieval. The highest rate of flow is observed immediately following incision of the tubule. Progressively better-quality sperm are often found following the initial washout. Gentle compression of the testis and epididymis enhances flow from the incised tubule. With patience, 25–50 μl of highly concentrated epididymal fluid, containing approximately 75 million sperm, can be recovered. This is diluted in multiple aliquots of 2–3 ml of human tubal-fluid medium, so that there are 5–10 million sperm per ml. Those specimens not used immediately for ART are cryopreserved for possible future use. If no sperm are obtained, the epididymal tubule and tunic are closed with 10-0 and 9-0 monofilament nylon sutures, respectively, and an incision is made more proximally in the epididymis, or even at the level of the efferent ductules, until motile sperm are obtained.

**Box 1 Causes of nonobstructive azoospermia.**

<table>
<thead>
<tr>
<th>Congenital and developmental</th>
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<tbody>
<tr>
<td>Genetic</td>
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<table>
<thead>
<tr>
<th>Teeticular</th>
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<tbody>
<tr>
<td>Cryptorchidism</td>
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<tr>
<td>Torsion</td>
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<tr>
<td>Bilateral anorchia</td>
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<thead>
<tr>
<th>Endocrinologic</th>
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<tbody>
<tr>
<td>Deficiency of gonadotropin-releasing hormone agonist, luteinizing hormone, and follicle-stimulating hormone</td>
</tr>
<tr>
<td>Excess of androgen, estrogen, prolactin, glucocorticoid</td>
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<td>Thyroid abnormalities</td>
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<td>Receptor abnormalities</td>
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<th>Varicocele</th>
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<td>Environmental hazards</td>
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<td>Radiation</td>
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<tr>
<td>Ischemic atrophy</td>
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<td>Radiotherapy</td>
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<td>Chemotherapy</td>
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<th>Disease</th>
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<td>Neoplastic diseases</td>
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<tr>
<td>Infectious or inflammatory causes</td>
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<tr>
<td>Systemic illness</td>
</tr>
<tr>
<td>Drugs or gonadotoxins</td>
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Sperm retrieval from the epididymides of men with obstructive azoospermia is possible in over 99% of patients when performed by experienced microsurgeons.34,35 Success rates such as these are possible even if multiple prior procedures have been performed and extensive scarring is present in the scrotum. If the epididymis is obliterated because of previous procedures or infection, the most proximal efferent ductules of the testis can be exposed by reflection of the caput epididymis to uncover the 7 to 11 dilated tubules. One should be able to aspirate sperm from at least one of these tubules.

In a study of 76 attempts at sperm retrieval using MESA and ICSI in men with obstructive azoospermia, clinical pregnancies were detected by a fetal heartbeat after 75% of attempts, with ongoing pregnancy or delivery achieved for 64% of attempts.36 For men with CBAVD, the success rate is even higher.37 Optimal fertilization and pregnancy rates are obtained with a technique of aggressive immobilization of spermatozoa prior to ICSI. It is possible that aggressive immobilization acts by enhancing sperm membrane permeability to improve the ability of immature spermatozoa to fertilize oocytes.38 The teamwork and collaborative effort of reproductive endocrinologists, embryologists, and male reproductive surgeons is of paramount importance for successful results.

NONOBSTRUCTIVE AZOOSPERMIA

Nonobstructive azoospermia (NOA), or testicular failure, is the most challenging type of male-factor infertility to manage. Various conditions that can lead to NOA have been identified (Box 1). While some of the underlying causes of NOA might be reversible to a degree, advanced ART techniques are needed for the majority of patients with this condition. With the advent of ART, particularly ICSI in conjunction with sperm obtained via testicular sperm extraction (TESE), many of these men are now able to father their own biological children. However, there remain subgroups of 20–40% of patients with NOA who, despite the advent of ICSI and advances in microsurgical sperm extraction techniques, are not able to have sperm retrieved for assisted reproduction.39 In these cases, the couples should consider donor-sperm fertilization or adoption as alternatives.

Testicular sperm extraction

Testicular sperm can be found within the testicular tissue of many men with NOA. The optimal technique of sperm extraction would be minimally invasive and avoid destruction of testicular function, without compromising the chance of retrieving enough spermatozoa with which to perform ICSI.

Microdissection testicular sperm extraction

Microdissection (TESE) is an advanced version of TESE that applies microsurgical techniques to the retrieval of sperm from the seminiferous tubules. Although microdissection TESE is not a minimally invasive technique, it results in the removal of a minimal amount of testicular tissue with maximal sperm yield, and minimizes the negative impact on testicular function. This method was developed by Schlegel.40 and is an effective method for the retrieval of sperm from men with NOA, for use in ICSI. The seminiferous tubules from different areas of the testis are often associated with different states.
of maturation of spermatogenesis. In other words, in some areas of the testis, the Sertoli-cell-only pattern might be present, whereas other areas might show maturation arrest, hypospermatogenesis, or even normal spermatogenesis. Under the operating microscope (×25), an experienced surgeon can usually distinguish between 'more active' and 'less active' seminiferous tubules by their appearance; tubules that appear full, opaque, and are larger in comparison to other tubules are more likely to contain sperm (Figures 4A and 4B).

The conventional TESE technique requires multiple, blind testis biopsies with excision of large volumes (>500 mg) of testicular tissue, which can result in permanent damage to the testis (Figure 4C). The microdissection TESE technique of sequential excision of microdissected seminiferous tubules (10–15 mg, or 2 mm in length, of seminiferous tubule) has been shown to be more successful, compared with the results achieved by conventional TESE, or random biopsies of testicular tissue. In a sequential series of TESE attempts, Schlegel showed that sperm-retrieval rates improved from 45% (10 out of 22 patients) with conventional TESE to 63% (17 out of 27 patients) with microdissection TESE. Microdissection samples yielded an average of 160,000 spermatozoa per 9.4 mg sample, whereas only 64,000 spermatozoa were found in an average 720 mg conventional biopsy sample (P<0.05 for all comparisons).41

Outcomes of testicular sperm extraction

By using microdissection TESE in men with NOA, a sufficient number of spermatozoa can be retrieved with a minimal amount of testicular tissue being excised. In addition, optical magnification allows for the minimal disturbance of the testicular blood supply.42 Microdissection TESE is a more efficient technique for sperm retrieval in men with NOA than conventional TESE, and results in less postoperative intratesticular scarring.43

The likelihood of sperm retrieval in patients with nonobstructive azoospermia can be estimated on the basis of the most advanced pattern of spermatogenesis (not the most predominant pattern) seen on histopathology; if a previous testis biopsy has been performed.44 In men with at least one area of hypospermatogenesis, microdissection TESE resulted in successful sperm retrieval in 81% of patients. In men where the most advanced form of spermatogenesis was maturation arrest, the retrieval rate was 44%. Even those who exhibited a Sertoli-cell-only pattern had sperm retrieved in 41% of cases.45

In an extension of the 1999 study by Palermo et al.,45 the team at Cornell University made 684 attempts at sperm retrieval, using microdissection TESE for men with NOA, with encouraging results. Sperm were retrieved from 59% of the men. The fertilization rate from subsequent ICSI procedures using the extracted sperm was 59% per injected oocyte, and clinical pregnancy, as defined by detection of a fetal heartbeat, was achieved in 48% of the cycles in which sperm were retrieved (PN Schlegel, unpublished data).

Varicocelectomy

Varicocelectomy is the most common procedure for male infertility. Varicoceles are found in approximately 10–15% of unmarried, male military recruits.46 In 35% of fertile men who have never fathered a child, and in 81% of men who were once fertile, as proven by previous conception, but who are now infertile (secondary infertility).47 Repair of varicocele for treatment of male infertility is controversial;48 however, any studies that have not shown an improved pregnancy rate after varicocele repair were small, were not stratified by grade of varicocele, and did not control for type of repair technique.49
Table 3 Techniques of varicocelectomy and potential complications.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Artery preserved</th>
<th>Incidence of hydrocele (%)</th>
<th>Failure rate (%)</th>
<th>Potential for serious morbidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Microscopic inguinal</td>
<td>Yes</td>
<td>&lt;1</td>
<td>&lt;1</td>
<td>No</td>
</tr>
<tr>
<td>Conventional inguinal</td>
<td>No</td>
<td>3–30</td>
<td>5–15</td>
<td>No</td>
</tr>
<tr>
<td>Retroperitoneal</td>
<td>No</td>
<td>7</td>
<td>15–25</td>
<td>No</td>
</tr>
<tr>
<td>Laparoscopic</td>
<td>Yes</td>
<td>12</td>
<td>5–15</td>
<td>Yes</td>
</tr>
</tbody>
</table>


It is possible that varicocelectomy can halt further damage to testicular function and improve spermatogenesis, as well as enhancing Leydig-cell function (as reflected by an increase in postoperative serum testosterone levels in infertile men).

Urologists might, therefore, have a valuable role in preventing future infertility and androgen deficiency in aging men, and this underscores the importance of using a varicocelectomy technique that minimizes the risk of complications and varicocele recurrence.

Preferred approaches: microsurgical inguinal and subinguinal operations

The advantages of microsurgical techniques over other approaches to varicocelectomy repair (e.g. open surgical, laparoscopic, and percutaneous techniques) are the reliable identification and preservation of the testicular artery or arteries, cremasteric artery or arteries, and lymphatic channels, as well as the reliable identification of all internal spermatic veins and gubernaculur veins. Delivery of the testis through the subinguinal incision allows inspection of the gubernaculur veins, assuring direct visual access to all possible routes of venous return, including external spermatic, cremasteric, and gubernaculur veins. Postoperatively, venous return is via the deferential (vasal) veins, which drain into the internal pudendal veins and usually have competent valves.

The application of microsurgical technique to varicocelectomy has resulted in a substantial reduction in the incidence of hydrocele formation. This is because the lymphatic vessels can be more easily identified and preserved (Figure 5A). Furthermore, the use of magnification enhances the surgeon’s ability to identify and preserve the 0.5–1.5 mm testicular artery (Figure 5B), thus avoiding the complications of atrophy or azoospermia.

Varicocelectomy outcomes

The goals of varicocelectomy repair are to relieve pain in symptomatic cases and to improve semen parameters, testicular function, and pregnancy rates in couples with male-factor infertility associated with varicocele. Studies have shown that varicocelectomy repair can improve all three of these in infertile men, with a significant improvement in semen analysis seen in 60–80% of men. Varicocelectomy repair in young men might be able to prevent infertility and androgen deficiency later in life.

The clinical outcomes of varicocelectomy are also related to the size of the varicocele. Repair of large varicoceles results in a significantly greater improvement in semen quality than repair of small varicoceles. In addition, large varicoceles are associated with greater preoperative impairment in semen parameters than small varicoceles; consequently, overall pregnancy rates are similar regardless of varicocele size. In the presence of small (grade 1) varicoceles along with larger (grade II and III), contralateral varicoceles, greater improvement in semen parameters can be expected if repair is performed bilaterally, rather than only the larger side being repaired. Some evidence suggests that the younger the patient is at the time of varicocelectomy repair, the greater the improvement after repair and the more likely the testis is to recover from varicocele-induced injury. Testicular artery ligation and post-varicocelectomy hydrocele formation may be associated with poor postoperative results.

In a controlled trial of varicocelectomy repair in infertile men that compared surgery with no surgery, the surgery group had a pregnancy rate of 44% at 1 year, compared with 10% in the no-surgery group. Using the microsurgical technique in 1,500 men who underwent varicocelectomy, the pregnancy rate in couples was
43% after 1 year and 69% after 2 years, compared to 16% in couples with men who declined surgery and instead had hormone treatment or used ART. There have been only 14 recurrences (1%), no reports of hydrocele or testicular atrophy, and only a 1% incidence of inadvertent unilateral testicular artery ligation. The most common complications of varicocelectomy are hydrocele formation, varicocele recurrence, and testicular artery injury (Table 3). Use of the operating microscope allows for reliable identification of spermatic cord lymphatics, internal spermatic veins and venous collaterals, and the testicular artery or arteries; the incidence of such complications can, therefore, be significantly reduced. Delivery of the testis through a small subinguinal incision provides direct visual access to all possible avenues of testicular drainage to ensure complete ligation. Failure to deliver the testis might result in varicocele recurrence in 7% of patients because of scrotal collaterals. Additional benefits of delivery of the testis include the identification of otherwise-undetected small testicular tumors and previously undiagnosed epididymal or vasal obstructions (M Goldstein, unpublished data).

Advocates of nonmicrosurgical techniques contend that the deferential (vasal) artery and, if preserved, the cremasteric artery, will ensure blood supply to the testes that is adequate to prevent atrophy. Anatomic studies, however, have shown that the diameter of the testicular artery is greater than the diameter of the deferential and cremasteric artery combined. The testicular artery is the main blood supply to the testes. At the very least, it is inarguable that ligation of the testicular artery is unlikely to enhance testicular function. Microsurgical varicocelectomy is a safe and effective approach to varicocele repair, and preserves testicular function, improves semen quality and pregnancy rates in a significant number of couples. Ultimately, the ideal intervention for varicoceles can only be determined by a large, prospective, randomized and controlled study using a microsurgical, artery and lymphatic-sparing technique.

CONCLUSION

Very few medical fields have changed as dramatically over the past decade as reproductive medicine, particularly in terms of the diagnostic and treatment strategies for male infertility. These advances include ICSI, refined microsurgical reconstructive techniques (vasovasostomy and vasoepididymostomy), microsurgical techniques for surgical sperm retrieval from the epididymis and testis, and microsurgical varicocelectomy repair. These techniques remain the safest and most cost-effective ways of treating infertile men, and, perhaps more importantly for the couples involved, many of these techniques enable couples to conceive naturally.

KEY POINTS

- Successful vasovasostomy is predicated on the basic surgical principles of a tension-free, watertight anastomosis with mucosa-to-mucosa apposition.
- Performing vasovasostomy or vasoepididymostomy is more cost-effective for achieving pregnancy than assisted reproductive technologies that use sperm aspiration.
- Vasovasostomy is the most technically difficult of all microsurgical procedures, and should only be performed by experienced microsurgeons.
- Vasoepididymostomy is a risk factor for impaired spermatogenesis and Leydig-cell function, and varicocele repair can improve testicular function.
- Ligation of the testicular artery during varicocele repair is not likely to improve testicular function.
- Preservation of lymphatic drainage during varicocele repair decreases the risk of postoperative hydrocele.

References

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43 Ramaasamy R et al. (2005) Structural and functional changes to the testis after conventional versus microdissection testicular sperm extraction. Urology 65: 1190–1194


**Acknowledgments**

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**Competing interests**

The authors declared they have no competing interests.
MICROSURGICAL VASOVASOSTOMY: THE MICRODOT TECHNIQUE OF PRECISION SUTURE PLACEMENT

MARC GOLDSTEIN, PHILIP SHIHUA LI AND GERALD J. MATTHEWS*
From the Center for Male Reproduction and Microsurgery, Department of Urology, The New York Hospital-Cornell Medical Center, New York, New York

ABSTRACT

Purpose: A technique of vasovasostomy that facilitates precision suture placement is presented. Materials and Methods: The technique involves mapping of the planned suture exit points with "microdots" placed on the cut ends of the vas deferens with a microtip marking pen. Microdots are placed at 12, 3, 6 and 9 o'clock positions. Four additional dots are placed between each of the previous 4 dots. Exactly 8 mucosal sutures (double armed 10-zero monofilament sutures) are used for each anastomosis. The anastomosis is completed with 8 muscularis sutures (9-zero monofilament) and 6 to 8 sutures (6-zero monofilament) approximating the vasal sheath.

Results: In a series of 194 consecutive vasovasostomy procedures using this technique a patency rate of 99.5% was achieved. Pregnancy rates of 54% (crude) and 64% (excluding female factor infertility) were observed for the first 100 subjects of this cohort.

Conclusions: The microdot technique ensures precision suture placement and facilitates the anastomosis of lumens of discrepant diameters by exact mapping of each planned suture. The microdot method separates the planning from the placement. Patency rates using the microdot technique approach 100%.

KEY WORDS: vas deferens, vasovasostomy, surgery

The Vasovasostomy Study Group reporting on a cohort of more than 1,200 vasovasostomy reversal procedures observed a mean interval of obstruction before surgery of 7 years.† The physiological effect of prolonged obstruction on the testicular end of the vas deferens in the absence of a more proximal pressure vent is dilatation of the lumen up to or greater than a diameter of 1 mm. The unobstructed abdominal end of the vas deferens retains its normal dimensions with a luminal diameter of 0.3 mm. Therefore, vasectomy reversal following an interval of obstruction requires an anastomosis of lumina of widely discrepant diameters. Suture placement must be accurate to approximate the testicular and abdominal ends of the vas deferens precisely without gaps or dog-ears and to ensure a leak-proof anastomosis. Failure to achieve a technically sound anastomosis may have a negative impact on patency and subsequent fertility. We present a method of vasectomy reversal that addresses these issues, and ensures precise and accurate suture placement.

TECHNIQUE

Setup. Surgeon and assistant should be comfortably seated on well padded stools to stabilize the lower body. A simple rolling stool supplemented by a round bean bag or thick foam cushioning provides a comfortable and stable platform. Two arm boards placed on either side of the surgeon and assistant provide excellent support, and improve arm stability and microsurgical accuracy. The arm boards may be bolstered with folded towels to provide the appropriate elevation for patients of any body habitus. This setup is flexible and maneuverable, and can be had at a fraction of the cost of more cumbersome microsurgery chairs. A right-handed surgeon should sit on the right side of the patient so the foreground stitch will always be on the smaller and more difficult abdominal side lumen.

Anastomosis. The microdot technique of vasovasostomy can accommodate lumina of markedly discrepant diameters in either the straight or convoluted vas deferens. If the mucosa is not sharply defined, the cut surface of the vas may be highlighted with indigo carmine (fig. 1). Microdot placement is facilitated by drying the cut surface of the vas with a Weck cell and a microtip marking pen is used to map out planned needle exit points. Microdots are placed at the 3 and 9 o'clock positions. Lines are extended from these 2 dots as reference points. Then dots are placed at the 12 and 6 o'clock positions. Four more dots are placed between the previous 4 dots. Microdots are placed midway between the mucosa and serosal margins. The abdominal and testicular ends of the vas deferens are identically marked (fig. 2). Mapping planned suture exit points eliminates dog-ears and leaks when anastomosing lumens of discrepant diameters.

Double-armed 10-zero monofilament sutures are used. The double-armed sutures reduce tissue trauma by eliminating any need for mucosal dilation and manipulation. A double-armed suture, using an inside out technique of suture placement, further reduces the risk of iatrogenic obstruction ("back walling") possible with an outside technique. If the mucosal edges of the small abdominal side lumen are not clearly visualized even with indigo carmine staining, momentary and gentle dilatation with a microvessel dilator just before suture placement may be used.

The anastomosis is begun with the placement of 4, 10-zero mucosal sutures (fig. 3). Sutures are exited precisely through the center of each microdot (fig. 4, A). Include exactly the same amount of tissue on each side (fig. 4, B). After the first 4 mucosal sutures are tied, 3, 9-zero polypropylene sutures are placed between the 4 mucosal sutures in the muscularis above but not through the mucosa. This suture eliminates any gap between mucosal sutures.

The vas is then rotated 180 degrees (fig. 5, A) and 4 additional 10-zero sutures are placed to complete the mucosal anastomosis (fig. 5, B). Exactly 8 mucosal sutures are used.
for each anastomosis. Just before tying the last 2 mucosal sutures, the lumen is gently irrigated with heparinized Ringer’s lactate solution to reduce the risk of clot formation. The muscularis layer is completed with the placement of 5 additional 9-zero sutures as previously described. A watertight anastomosis is achieved. The anastomosis is completed by approximation of the vasal sheath with 6 to 8 interrupted sutures of 6-zero monofilament. The third layer covers the anastomosis and relieves tension.

RESULTS

The 194 consecutive vaso-vasostomy procedures performed by a single surgeon (M.G.) using the microdot technique were reviewed. Only men with sperm in the testicular end of at least 1 vas deferens were enrolled in the study. Unilateral (18 cases) and bilateral (176) vaso-vasostomy procedures were considered. Men undergoing unilateral vaso-vasostomy with contralateral vasopresidymostomy were excluded from review. The initial postoperative semen analysis is obtained 1 month after surgery and subsequent analyses are obtained at 3 months and then every 3 months for the first post-reversal year, at 6-month intervals in postoperative year 2 and annually thereafter. All men not contributing to pregnancy were followed for a minimum of 1 year. Patency (complete sperm with tails present) was observed in 193 of the 194 men (99.5%).²,³ For the first 100 men with a mean duration of 17 months of follow-up 54 (54%) have contributed to pregnancies with their partners. Excluding those couples with associated female factor infertility, a 64% pregnancy rate was observed.

**DISCUSSION**

Following obstruction the testicular end of the vas deferens is subjected to increased storage pressures resulting in marked dilatation of its lumen in contrast to the unobstructed and essentially normal caliber abdominal end of the vas deferens. Vaso-vasostomy following vasectomy and an interval of obstruction necessitates an anastomosis between lumina of widely discrepant diameters. Precise end-to-end vasal anastomosis requires that the arc of circumference covered between adjacent sutures be equal for the testicular and abdominal ends. For lumina of unequal diameters this anastomosis necessitates that distances between sutures on the obstructed testicular end are greater than those on the abdominal vas. Unequal distribution of sutures along the circumference of the testicular and abdominal ends of the vas deferens may result in large gaps and/or dog-ear deformities. An anastomosis in which sutures are unevenly distributed is
more likely to leak, resulting in sperm granuloma formation and increased risk of failure.\textsuperscript{4}

The microdot technique of vasovasostomy ensures precise placement of sutures. The anastomosis of lumens of discrepant diameters is facilitated by the exact mapping of each planned suture. The microdot method separates suture planning from suture placement. This technique is performed without the need for or expense of additional microsurgical tools or instruments. Microdot vasovasostomy requires no additional surgical skills to adopt successfully and may be of benefit in improving technique among less experienced microsurgeons. In our experience no additional operative time is required.

Patency rates following vasovasostomy in contemporary series range from 86 to 90%.\textsuperscript{1,5,6} The Vasovasostomy Study Group reported a 92% patency rate for men in whom intact sperm were observed in the testicular end of the vas deferens at the time of anastomosis.\textsuperscript{1} For the present series the overall 99.5% patency rate (90% with motile sperm) is somewhat higher than those previously reported. Pregnancy rates for the present series (54% crude, 64% adjusted for female factor) compare favorably with those previously reported (51 to 52%).\textsuperscript{1,5}

In summary, the microdot method of vasovasostomy promotes accuracy and precision in anastomatic technique. For the current series patency rates using this technique approach 100%.

REFERENCES
A SIMPLIFIED METHOD OF EPIDIDYMAL SPERM ASPIRATION

GERALD J. MATTHEWS, AND MARC GOLDSTEIN

ABSTRACT
We present a simple technique of epididymal sperm aspiration that uses inexpensive and readily available materials. Men undergoing epididymal reconstruction with vasoepididymostomy or autogenous sperm reservoir had sperm aspiration for cryopreservation. Mean total and total motile sperm per aspirate recovered from 25 men have been 25.1 ± 4.8 × 10⁷ and 4.0 ± 1.4 × 10⁷, respectively. Two ongoing pregnancies have been achieved with intracytoplasmic sperm injection using thawed epididymal sperm. Sperm aspiration and cryopreservation maximize a couple's fertility potential with a single procedure and provide a viable fertility alternative to a second surgical procedure in the event of a primary reconstructive failure. UROLOGY® 47: 123–125, 1996.

Men undergoing a microsurgical vasoepididymostomy (VE) or an autogenous sperm reservoir (ASR) procedure face a significant possibility of reconstructive failure. We have previously reported that the likelihood of a durable response, as measured by the recovery of motile sperm either in the ejaculate following a VE or from a percutaneous aspiration of an ASR is 52% and 47%, respectively.¹,² For men who fail initial reconstructive attempts, the only alternative available for those desiring a pregnancy is a repeat surgical procedure. However, if sperm were recovered and cryopreserved at the time of the initial surgery, an alternative to a second surgical procedure can be considered.

We have attempted to maximize ultimate success in a single procedure by using a simple and atraumatic method of sperm recovery at the time of epididymal reconstruction. This method uses inexpensive materials, readily available in most operating theaters. We currently offer all men with epididymal obstruction the option for simultaneous epididymal sperm aspiration and cryopreservation.

TECHNIQUE
Our technique for the construction of an ASR and for microsurgical VE has previously been reported.²,³ Prior to reconstruction and epididymal sperm recovery, communication with the sperm bank or in vitro fertilization (IVF) laboratory is made to ensure the timely processing and cryopreservation of the aspirate. Using an operating microscope, epididymal tubule dissection and aspiration are performed using ×15 to ×32 magnification. The epididymal tubule and tunic are prepared for either VE or an ASR. Meticulous hemostasis is obtained with micro-bipolar forceps prior to aspiration, as the presence of erythrocytes and leukocytes has been demonstrated to diminish sperm function.⁴,⁵

The most distal tubule containing clear or opalescent fluid should be selected. Tubules containing yellow impissated material should be avoided. A 0.5- to 1.5-mm buttonhole is made in the epididymal tubule with fine blunted microscissors. Alternatively, the epididymal tubule may be sharply incised with a microknife. After opening the epididymal tubule, a 5-µL micropipette with a 0.5-mm internal diameter, 0.9-mm outer diameter, and scored at 1-µL intervals (Drummond Scientific Co., Broomall, Pa.) is placed adjacent to the effluxing epididymal tubule. A standard hemocrit pipette is also satisfactory and readily available.

Sperm are drawn into the micropipette by simple capillary action. Negative pressure, as is generated by action of an in-line syringe, should not be applied during sperm recovery, as this may damage the delicate epididymal mucosa. For this reason, we do not recommend a syringe and angiocatheter technique. The micropipette/capillary action technique provides a direct visual confirmation and quantification of epididymal fluid recovery (Fig. 1). Air drawn into a syringe during the negative pressure aspiration of epididymal fluid results in less precise volume quantification and a more difficult transfer into buffer. Multiple micropipettes may be used simultaneously to increase speed of recovery. With patience, 10 to 20 µL of epididymal fluid is easily recovered in no more than 5 to 10 minutes.

The highest rate of flow is observed immediately following incision of the tubule; however, progressively better quality sperm are found following the

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UROLOGY® 47 (I), 1996
initial washout. Gentle compression of the testis and epididymis enhances flow from the incised tubule. During fluid recovery, a drop is examined under the microscope to confirm the presence of sperm. Since processing techniques, including pentoxifylline incubation, stimulate sperm motility, we aspirate in the presence of both motile and non-motile sperm. If intact sperm are not encountered, then a more proximal epididymotomy is performed.

The micropipette is connected to a short (3 to 5 cm) segment of medical grade silicone tubing (American Scientific Products, McGaw Park, Ill) (Fig. 2). Alternatively, the tubing attached to a butterfly needle may be used. A 20-gauge needle fitted to a Luer-tip syringe is then placed in line (Fig. 2). The fluid is flushed into a sterile container of buffer solution (0.5 to 1.0 mL) obtained from the sperm-processing laboratory. Once a micropipette has been used, it is discarded. Residual fluid in the pipette will disrupt capillary action. A typical procedure requires 4 to 8 micropipettes.

The sperm bank is instructed to cryopreserve the aspirate in multiple straws ( aliquots), so that several IVF cycles may be used if required. At our institution, epididymal aspirates are diluted in an equal volume of glycerol cryoprotectant. Aliquots are then slowly cooled to 4°C, transferred to a sequential freezer for refrigeration to −90°C prior to immersion in liquid nitrogen (−196°C).

RESULTS
The results of atraumatic epididymal sperm aspirations are presented for the last 25 men undergoing either a VE procedure (n = 15) or the creation of an ASR (n = 10) (Table I). In each case, epididymal fluid was rapidly recovered with no more than 10 minutes of added surgical time. Motile sperm were recovered from the epidiymides and cryopreserved in 21 of 25 (84%) men. As the epididymal aspirate was immediately diluted in a buffer solution, aspirate volume and sperm density recorded by the processing labora-

tory do not accurately represent the initial aspirate parameters. Semen parameters reported are limited to percent motility, total sperm per aspirate, and total motile sperm per aspirate.

Two couples, the male partners with congenital absence of the vas deferens having undergone the microsurgical creation of an ASR, elected to undergo an IVF cycle with aspirated cryopreserved sperm prior to an evaluation of reservoir status. Two ongoing pregnancies have been established for these couples using IVF with intracytoplasmic sperm injection (ICSI).

COMMENT
In reviewing treatment outcomes following 100 consecutive VE procedures, we observed the return of motile sperm in only 52 men.1 Subsequently, 21% (11 of 52), after initial demonstration of patency with motile sperm, have experienced a late anastomotic failure.3 Similarly, motile sperm have been recovered by percutaneous aspiration from only 47% of men undergoing an ASR procedure.2 For the majority who fail epididymal reconstruction, fertility treatment options necessitate additional surgical procedures.

The technique of atraumatic epididymal sperm aspiration presented provides couples with an alternative to surgery following reconstructive failure. The method of sperm recovery presented should not be confused with the technique of epididymal micropuncture with sperm aspiration (MESA).6 Epididymal micropuncture requires highly modified micropipettes used to puncture into the lumen of an individual epididymal tubule. These micropipettes are not commercially available and must be hand-manufactured from commercial stock. The
TABLE I.  Aspirate parameters are summarized for the entire cohort and for men undergoing either a vasoepididymostomy procedure or the creation of an autogenous sperm reservoir.*

<table>
<thead>
<tr>
<th></th>
<th>Motility</th>
<th>Total Sperm/Apirate</th>
<th>Total Motile Sperm/Apirate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort (n = 25)</td>
<td>15.2 ± 3.7</td>
<td>25.1 ± 4.8 x 10^6</td>
<td>4.0 ± 1.4 x 10^6</td>
</tr>
<tr>
<td>Range: 0–66%</td>
<td></td>
<td>1.6–106 x 10^6</td>
<td>0–26.5 x 10^6</td>
</tr>
<tr>
<td>ASR (n = 10)</td>
<td>20.2 ± 6.9</td>
<td>32.1 ± 9.6 x 10^6</td>
<td>5.6 ± 2.6 x 10^6</td>
</tr>
<tr>
<td>Range: 0–66%</td>
<td></td>
<td>4.9–106 x 10^6</td>
<td>0–26.5 x 10^6</td>
</tr>
<tr>
<td>VE (n = 15)</td>
<td>11.8 ± 4.0</td>
<td>20.4 ± 4.6 x 10^6</td>
<td>3.0 ± 1.6 x 10^6</td>
</tr>
<tr>
<td>Range: 0–56%</td>
<td></td>
<td>1.6–60 x 10^6</td>
<td>0–22 x 10^6</td>
</tr>
</tbody>
</table>

*No difference in sperm motility was observed for men undergoing either a vasoepididymostomy (VE) or autogenous sperm reservoir (ASR) procedure (P > NS).

equipment used for the modification of micropipettes for epididymal micropuncture is not available at many institutions and requires technical skill to fashion a micropipette suitable for epididymal micropuncture. The technique we present has a minimal learning curve and requires no specialized equipment. On the contrary, we have successfully recovered motile sperm using standard hematocrit pipettes attached to butterfly-needle tubing.

Additionally, for men with reconstructive tracts, a simultaneous epididymal micropuncture may compromise surgical results. MESA typically uses epididymal micropunctures at multiple points along the length of the epididymis. VE, performed in conjunction with MESA, thus requires an anastomosis proximal to the highest level of epididymal micropuncture. This results in a sacrifice of potentially viable epididymal length. We have previously reported that no man undergoing a simultaneous ASR with epididymal micropuncture has had sperm recovered from his ASR.2 The technique ofatraumatic aspiration of epididymal sperm with cryopreservation offers the clinician a simple and inexpensive method of sperm collection and the couple the opportunity to maximize their chances for fertility with a single procedure without compromise of the primary reconstructive efforts. For men with congenital absence of the vas deferens in whom a simultaneous IVF/ICSI cycle is to be undertaken with epididymal sperm, epididymal sperm quality should be maximized. This may necessitate multiple epididymal micropunctures.

We do not recommend sperm aspiration and cryopreservation at the time of vasovasostomy (VV). As motile sperm are observed in the ejaculate of 98% of men following VV in our hands, we believe that postoperative sperm collection is more economic and practical for men undergoing a VV.1 We also recommend postoperative sperm banking for all men with motile sperm in the ejaculate following a VE procedure.

The pregnancies established with cryopreserved sperm recovered with this technique from patients undergoing a simultaneous reconstructive procedure reinforces the concept of maximizing a couple’s reproductive options. Pregnancy with cryopreserved sperm requires IVF. Chances for pregnancy will be maximized by IVF with ICSI. At our institution, pregnancy (ongoing) rates of 38.5% per cycle are achieved with IVF/ICSI.7 Current per cycle costs for IVF/ICSI average $12,000. Couples should be informed of the risks, benefits, and costs for IVF and IVF/ICSI prior to surgery and sperm aspiration. Those unwilling to accept IVF should not be offered sperm cryopreservation.

In our experience, the recovery of epididymal sperm is accomplished quickly with little added operating time. In 21 of 25 cases, motile sperm, in sufficient numbers for multiple cycles of IVF, were cryopreserved by the sperm bank.

CONCLUSIONS

It is incumbent on the clinician treating the infertile couple to maximize their options and therefore their chances for a pregnancy with a single surgical procedure. The simultaneous atraumatic recovery of epididymal sperm is advantageous and practical for men in whom epididymal reconstruction is being considered. This technique is rapid, inexpensive, and requires no special or modified instruments.

REFERENCES


UROLOGY® 47 (1), 1996 125
THE IMPACT OF OBSTRUCTIVE INTERVAL AND SPERM GRANULOMA ON OUTCOME OF VASECTOMY REVERSAL

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ABSTRACT

Purpose: We studied the impact of the interval from vasectomy to reversal and presence of sperm granuloma on outcomes of reversal.

Materials and Methods: A total of 213 microsurgical vasectomy reversals performed by a single surgeon were stratified according to obstructive intervals of less than 5 years, 5 to 10 years, 10 to 15 years and greater than 15 years. The effects of obstructive interval on patency and pregnancy rates were assessed using multivariate logistical regression. The impact of sperm granuloma on patency and pregnancy was assessed using the chi-square test.

Results: Patency did not change with increasing obstructive intervals as can be seen with 91% patency at less than 5 years, 91% at 5 to 10 years, 91% at 10 to 15 and 89% at greater than 15 years. There was no difference in pregnancy rates (89%, 82% or 86%) at obstructive intervals of 0 to 5, 5 to 10 or 10 to 15 years, respectively. Pregnancy rates were significantly lower (44% vs 78%) at obstructive intervals greater than 15 years. Men with at least unilateral sperm granuloma had patency of 95% vs 78% without granulomas, a trend which did not quite reach statistical significance (p = 0.07). There was no difference in pregnancy rates with or without granulomas.

Conclusions: Vasectomy reversal patency rates are high regardless of time since vasectomy. Pregnancy rates are lower than 15 years after vasectomy. Sperm granuloma had a favorable impact on patency. Our data indicate that for obstructive intervals less than 15 years vasectomy reversal yields much higher pregnancy rates than in vitro fertilization and intracytoplasmic sperm injection, and that even for intervals greater than 15 years reversal outcomes equal or exceed those of in vitro fertilization and intracytoplasmic sperm injection.

Key Words: vasectomy, vasoovasostomy, pregnancy rate, granuloma

The number of vasectomies performed each year in the United States is about 500,000, and it is estimated that between 2% and 6% of these men will ultimately seek reversal. With the advent of in vitro fertilization and intracytoplasmic sperm injection (IVF/ICSI), which currently results in clinical pregnancy rates of 20% to 45% per initiated cycle, the therapeutic options for couples with male factor infertility have increased. Thus, to provide couples with information to make decisions regarding infertility treatment, particularly in an era of increased cost consciousness, the need exists to establish the success rate of vasectomy reversals as well as to determine potential preoperative predictors for reversal success.

One parameter which has been evaluated for its impact on post-reversal pregnancy rates is the obstructive interval, defined as the length of time from vasectomy to reversal. Although previous studies have agreed that the obstructive interval is inversely related to reversal success, there has been considerable controversy regarding the specific impact of interval on postoperative outcome. A second potential predictor of outcome after vasectomy reversal is the presence of a sperm granuloma at the vasectomy site. The presence of sperm granuloma is associated with better quality intraoperative vasal fluid but has not been consistently associated with improved postoperative patency or pregnancy rates. We studied the impact of the obstructive interval and the presence of sperm granuloma on the outcome of vasectomy reversal on a series of reversals performed by a single surgeon in a tertiary care university setting.

MATERIALS AND METHODS

Patients. We retrospectively reviewed randomly selected vasectomy reversals performed by a single surgeon from 1984 through 2001. Demographic data, patient history and followup were obtained from chart review. Enrollment criteria for the study included first time vasectomy reversals, whereas men who presented for repeat reconstruction were excluded. Only men undergoing bilateral reconstruction were considered. Female factor infertility was excluded from study in all cases. Beginning in alphabetical order from the reversal chart rack, the first 213 couples who met these criteria were selected for study.

Groups. Patients were stratified by obstructive interval (defined as the time from vasectomy to reversal, rounded off to the nearest complete year) into those less than 5 years, 5 to 10 years, 10 to 15 years and greater than 15 years. The presence or absence of a sperm granuloma at the vasectomy site was determined by preoperative physical examination and confirmed by histological evaluation of the surgical specimen.

Surgery. Vasoovasostomy (VV) and vasaoepididymostomy (VE) were performed using a multilayer microsurgical approach previously described. The entire vasectomy site including sperm granuloma, if present, was always excised. Suspected sperm granuloma were sent for histological evaluation by a surgical pathologist.

Postoperative evaluation. Postoperative evaluation included serial semen analyses beginning at 6 weeks and con-
continuing until a pregnancy was achieved or patients were lost to followup. For those men whose partner has yet to conceive, the minimum followup was 6 months. Only naturally con-
ceived pregnancies were included in the calculations, and none of the female partners used assisted reproduction tech-
tiques to achieve pregnancy. Only clinical pregnancies with documented heartbeats were included in the study. Pregnancy rates were calculated for the cohort of patients within each obstructive interval. We defined patency as the presence of any sperm (motile or nonmotile) with tails in the ejaculate.

**Statistical analysis.** The effect of obstructive interval on vasal patency and postoperative pregnancy rates was as-
sessed using multivariate logistical regression. The impact of sperm granuloma on patency and pregnancy was assessed using the chi-square test. Statistical analysis was performed using SAS 8.2 software (SAS Institute, Inc., Cary, North Carolina).

**RESULTS**

The characteristics of the patient population according to obstructive interval are shown in table 1. Neither the mean age of the men nor of the female partners differed among the intervals. There was no significant difference in the type of reconstruction performed within the groups; that is, the percentage of men in each interval who underwent at least a unilateral VE was equivalent.

Patency and pregnancy rates were determined according to obstructive interval (table 2). Vasal patency did not change with increasing obstructive interval: 91% at less than 5 years, 88% at 5 to 10 years, 91% at 10 to 15 years and 89% for more than 15 yrs. There was also no difference in pregnancy rate at obstructive intervals of 0 to 5, 5 to 10 or 10 to 15 years. However, pregnancy rates were significantly lower (44%, p < 0.05) for patients with obstructive intervals greater than 15 years. The pregnancy rate for the entire cohort was 81%. Mean followup was 25 months.

A total of 54 patients (25% of total population studied) underwent at least a unilateral VE during reconstruction, and 18 patients underwent VV/VE, while 36 patients underwent a bilateral VE. Patients who underwent bilateral VE had a significantly higher patency rate (95%) than patients who had unilateral VV and VE (83%) and patients who had bilateral VE (83%, p < 0.05), as shown in table 3. However, pregnancy rates did not differ significantly among the proce-
dures performed.

A total of 28% (76) patients had evidence of at least a unilateral sperm granuloma on physical examination before treatment (all of which were subsequently confirmed histo-
logically). Of these 76 men, 65 underwent a bilateral VE, while 5 had a VV/VE and 6 men a bilateral VE. After reversal patients with a palpable sperm granuloma had a patency of 95% vs 78% for patients without a sperm granuloma, a trend which did not quite reach statistical significance (p = 0.07). There was no significant difference in pregnancy rates with or without sperm granuloma (83% vs 78%).

**DISCUSSION**

The patency rate after vasectomy did not significantly change with increasing obstructive interval even at intervals

<table>
<thead>
<tr>
<th>Table 2. Impact of obstructive interval on postoperative outcomes</th>
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<tr>
<td><strong>Obstructive Interval (yrs)</strong></td>
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<tr>
<td>---------------------------------</td>
</tr>
<tr>
<td>Less than 5</td>
</tr>
<tr>
<td>5–10</td>
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<tr>
<td>10–15</td>
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<tr>
<td>Greater than 15</td>
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<table>
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<tr>
<th>Table 3. Outcome according to procedure performed</th>
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<tr>
<td><strong>Reconstruction Type</strong></td>
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<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>VV/VE</td>
</tr>
<tr>
<td>VV/VE</td>
</tr>
<tr>
<td>VE/VE</td>
</tr>
</tbody>
</table>

greater than 15 years. This finding conflicts with previous vasectomy reversal studies which consistently reported an inverse relationship between patency and obstructive inter-
val.3–5 These results may reflect our policy of routinely per-
forming VE in the face of intravasal azoospermia (except when copious clear fluid is present) as well as the use of newer VE techniques with higher reported pregnancy rates.1–3–11

The difference in patency rates between the VV and VE procedures is similar to that reported previously from our institution.12,13 In the present study the frequency of VE procedures was similar (approximately 25%) among obstructive intervals, thus our outcomes cannot be attributed solely to differences inherent in the reconstructive approach.

The pregnancy rate after vasectomy reversal at our institu-
tion remained constant (at 82% to 89%) for obstructive intervals less than 15 years. This absence of an inverse rela-
tion between pregnancy rate and obstructive interval up to 15 years, as well as the high pregnancy rate during the interval, differs from prior reversal studies.3–5 Pregnancy rates were significantly lower (44%) in our series for patients with obstructive intervals greater than 15 years, which con-
curs with results from previous studies.3–5

A discrepancy between patency and pregnancy rates after reconstruction was noted across all obstructed intervals in our series. This disparity widened with increasing interval, from 2% for obstructed intervals less than 5 years to 45% for intervals greater than 15 years. The difference between pa-
tency and pregnancy rates which has been noted in previous studies may be the result of female factors, antisperm antibi-
obies,14 a time dependent post-vasectomy germ cell dam-
age15,16 or post-vasectomy epididymal dysfunction.

The frequency of palpable sperm granulomas in our series (28%) was in accord with prior reports.17 Previous studies have demonstrated an association between the presence of sperm granulomas and the intraoperative finding of better quality vasa fluid.6,17 This beneficial effect of sperm gran-
uloma is thought to be due to a "pop off valve," pressure releasing effect of the granuloma on the proximal duct sys-
tem.18 That is, the increase in intratubular pressure which occurs after vasectomy may induce rupture of the epididymis and subsequent epididymal obstruction.19,20 Formation of a granuloma at the vasectomy site, reflecting leakage of sperm and a subsequent decrease of intratubular pressure, may thus prevent epididymal obstruction. This potential protection of the epididymis may be reflected by our experience in that the subset of patients with a sperm granuloma had a lower incidence of unilateral or bilateral VE (11 of 76 or 14%) than patients without a sperm granuloma (43 of 137 or 31%).

In spite of the presumed benefit of sperm granuloma, pre-
vacuole studies have failed to demonstrate an improvement in patency or pregnancy rates in the presence of a granuloma.4,6 Likewise, although our study demonstrated a trend toward increased patency associated with sperm granuloma, this

**Table 1. Patient characteristics by obstructive interval**

<table>
<thead>
<tr>
<th>Obstructive Interval (yrs)</th>
<th>Pts</th>
<th>Mean Age (yrs)</th>
<th>% Pts With 1 or More VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5</td>
<td>45</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>5–10</td>
<td>85</td>
<td>41</td>
<td>33</td>
</tr>
<tr>
<td>10–15</td>
<td>56</td>
<td>44</td>
<td>32</td>
</tr>
<tr>
<td>Greater than 15</td>
<td>27</td>
<td>49</td>
<td>34</td>
</tr>
</tbody>
</table>
association did not reach statistical significance (p = 0.07). Moreover, there was no difference in pregnancy rates with or without sperm granuloma.

CONCLUSIONS

The results of our study may be useful in counseling patients seeking post-vasectomy fertility. The information here concerning the chance for successful vasectomy reversal is particularly relevant when considering the current alternative to reversal, IVF/ICSI, using aspirated sperm. Our data indicate that for obstructive intervals less than 15 years vasectomy reversal yields much higher pregnancy rates than IVF/ICSI, and that even for intervals greater than 15 years reversal outcomes equal or exceed those of IVF/ICSI. Reversal is a more cost-effective option regardless of the interval since vasectomy, especially for couples seeking more than 1 child post-vasectomy.

REFERENCES

Reassessing Reconstruction in the Management of Obstructive Azoospermia: Reconstruction or Sperm Acquisition?

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Infertility currently affects approximately 15% of all couples, with an increase anticipated over the next 20 years [1,2]. Approximately 50% of cases of infertility may be attributed to male factors. Male reproductive medicine has undergone significant changes in recent years, and the advent of assisted reproductive technology (ART) has substantially improved our ability to successfully manage male factor infertility. Specifically, improved techniques in microsurgical reconstruction and refinement in techniques for sperm retrieval combined with in vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI) have materially altered our ability to treat obstructive azoospermia.

Selecting the optimal therapy for couples with obstructive azoospermia can be challenging. In this article, we limit our discussion to patients with reconstructable obstruction, such as the common situation of men desiring fertility after vasectomy. Sperm retrieval with IVF/ICSI offers the allure of early achievement of a relatively high live delivery rate, although its use consigns the male partner to the greater costs and complications of an IVF cycle and potential health problems in the resulting offspring. In contrast, surgical reconstruction does not require treatment of the female partner, and pregnancy usually occurs naturally after sexual intercourse. However, reconstruction may not always be successful, and the time to achieve a pregnancy is longer, especially in patients who have endured long durations of obstruction. We examine the various therapeutic options available for surgical reconstruction and sperm retrieval, specifically their rates of success and attendant costs in an effort to define the optimal treatment for couples with obstructive azoospermia.

Methods of surgical reconstruction

Vasovasostomy

The first-line method for surgical reconstruction of obstructive azoospermia secondary to vasectomy consists of vasovasostomy, in which the obstructed length of vas deferens is excised and the cut ends are reanastomosed [3,4]. Microsurgical reconstruction seems to be superior to macro-surgical reconstruction and currently represents the standard of care. Variations of the microsurgical technique exist, including multilayer vasovasostomy versus a modified single-layer adaptation.

Vasoepididymostomy

Some patients with obstructive azoospermia require a vasoepididymostomy instead of
a vasovasostomy if their epididymis is found to be obstructed. Vasoepididymostomy consists of anastomosing a patent epididymal tubule directly to the vas deferens, thus bypassing any obstruction in the epididymis distal to the tubule. Multiple techniques have been described, although three variations are currently used: direct end-to-end, direct end-to-side, and end-to-side intussusception [5]. Epididymal obstruction and the need for vasoepididymostomy seem to be related to the duration of deferential obstruction [6–8]. Fuchs and Burt [6], for example, reported that 62% of patients who had undergone vasectomy at least 15 years before reversal required vasoepididymostomy. Significantly lower patency and pregnancy rates have been reported after vasoepididymostomy compared with vasovasostomy [5].

Methods of sperm acquisition

One should note that all methods of sperm acquisition consign the female partner to IVF/ICSI for successful fertilization and delivery.

Microsurgical epididymal sperm aspiration

Microsurgical epididymal sperm aspiration (MESA) was introduced in the 1980s by Temple-Smith and colleagues and Silber and colleagues [9,10] originally to enable sperm retrieval in the setting of congenital bilateral absence of the vas deferens. It consists of microsurgically exposing the epididymis, incising the epididymal tubule, and then aspirating sperm-filled epididymal fluid. MESA enables the collection of large quantities of motile sperm for cryopreservation.

Percutaneous epididymal sperm aspiration

Percutaneous epididymal sperm aspiration (PESA) was introduced in 1994 by Craft and Shrivastav [11,12] as a simpler, less invasive alternative to MESA for patients with obstructive azoospermia who were unable to undergo or who decided against surgical reconstruction. A needle is introduced through the skin into the epididymis and is then aspirated. Three pregnancies (43%) were obtained in seven couples, and one set of twins was delivered in the original description [12]. Criticisms of this technique include frequently unreliable sperm retrieval [5]. Our data analysis focuses on the more reliable microsurgical approach.

Some surgeons prefer MESA or PESA as the source of sperm in obstructive azoospermia, because epididymal sperm tend to be more mature and are obtainable in higher, bankable numbers relative to that obtained from the testis [13]. In 1998, Sheynkin and colleagues [14] compared percutaneous and microsurgical sperm retrieval in men with obstructive azoospermia. Nine men underwent simultaneous MESA, testicular fine needle aspiration, and PercBiopsy. As expected, the mean number of sperm retrieved via MESA (15 × 10^6) was higher than that retrieved percutaneously (testicular fine needle aspiration = 0.014 × 10^6 and PercBiopsy = 0.116 × 10^6). Overall, testicular sperm aspiration pregnancy rates have been reported to be as high as 31%, with a calculated live delivery rate of 27% if one assumes a miscarriage rate of 11.6% rate after ICSI [15,16]. Similarly, PESA pregnancy rates have been reported to be as high as 43%, with a calculated live delivery rate of 38% if one makes a similar assumption regarding ICSI miscarriage rate [12,16,17].

Open testis biopsy

The original description of sperm retrieval for assisted reproduction by open testicular biopsy was proposed by Silber and colleagues [18] in 1995. Multiple pieces of testicular tissue from the same incision are taken for use in IVF/ICSI.

Microsurgical testicular sperm extraction

Microsurgical testicular sperm extraction (TESE), as described by Schlegel and colleagues [19] in 1999, uses the operating microscope to identify larger caliber, sperm-containing seminiferous tubules. Microsurgical TESE is traditionally used in the setting of nonobstructive azoospermia and offers the advantages of less bleeding and greater sperm extraction per gram of testicular tissue extracted. It plays little role in the setting of obstructive azoospermia.

Percutaneous testicular sperm extraction

Like PESA, percutaneous TESE offers a less costly and invasive alternative to its microsurgical counterpart. A needle is introduced percutaneously into the testis and is then aspirated; the tissue obtained is then processed for use in IVF. Percutaneous TESE also represents a less invasive choice compared with open testis biopsy, although less tissue is generally obtained with the percutaneous technique. Belker and colleagues [15] described a 100% sperm retrieval rate when used in obstructed patients. Fine-needle mapping
as described by Turek and colleagues [20] is designed for use in nonobstructive azoospermia and plays little role in this particular analysis.

Outcome metrics

This article focuses on three main metrics to assess outcomes: (1) cost, (2) effectiveness, and (3) various analytic methods to combine the information embodied in cost and effectiveness data.

Costs

Costs may be broken down into two main components: direct and indirect [21–23]. Direct costs encompass expenditures for medical products or services, including office examination fees, surgeon fees for microsurgical reconstruction or sperm retrieval, associated anesthesia and operating room or facility fees, recovery room fees, the cost of diagnostic imaging tests, the cost of blood tests, the cost of gonadotropins if IVF/ICSI is used, and finally the cost of the IVF cycle, including all technical and professional fees if sperm retrieval is chosen. Indirect costs represent the economic impact that occurs from morbidity, mortality, or loss of livelihood secondary to a procedure. In this analysis, indirect costs would represent the economic impact of procedure-associated complications, lost productivity because of time away from work, and the impact from multiple gestation pregnancies that may ensue.

This analysis uses complication and multiple gestation rate data that have appeared in the peer-reviewed literature. Male infertility procedure-related complications include bleeding, infection, and testicular atrophy and occur at a rate of 0.3% to 2% [5,24,25]. Maternal complications caused by IVF are estimated to occur in 3% to 6% of all cases and include ovarian hyperstimulation syndrome, pelvic hemorrhage, infection, stroke, myocardial infarction, and possibly ovarian cancer [26–29]. The impact of multiple gestation pregnancies has been well studied. Such pregnancies are associated with higher rates of neonatal complications and longer intensive care unit stays compared with singleton infants [27,30]. Much of the increase in costs associated with higher order gestations can be traced to greater neonatal lengths of stay in addition to greater direct use of medical resources.

It is important to note that the true cost of care is best represented by the amount resources consumed in providing that care. Because the true economic burden of providing services is usually difficult to measure, charges are instead used as a proxy [31]. Charges are set by the marketplace and may not accurately reflect the true burden of providing care, although they do represent the best available metric for cost-effectiveness evaluations.

Effectiveness

Multiple definitions of success are possible when treating obstructive azoospermia. Patency, as signified by the return of sperm to the ejaculate, may be used as one measure of success with surgical reconstruction. Successful fertilization and pregnancy after reconstruction or sperm retrieval may constitute a separate metric. Finally, delivery of at least one or more live children after either treatment may represent yet another measure of success. It is the opinion of the authors that live delivery represents the most relevant and appropriate metric to consider: the outcome of most value to couples is the delivery of at least one live child. All other markers of success are of secondary value.

Analysis and evaluation methods

Economic analyses weave the dual components of cost and effectiveness into a rational framework for decision making. Because choices must be made between alternative uses of scarce or limited health care resources, economic analyses are able to consider cost and outcome to arrive at an optimal allocation decision [21–23]. Different types of economic analyses include cost-identification analysis, cost-effectiveness analysis, and cost-benefit analysis [31,32].

Cost-identification analysis consists of ascertaining the economic resources involved in providing a product or service or that involved in disease burden. Cost-identification studies do not consider the benefits derived from the expenditure of economic resources. In contrast, cost-effectiveness analysis considers the cost of providing a service in addition to the benefit or outcome that arises from that service; the metric given in this type of analysis usually refers to cost per unit of outcome. This evaluation allows a comparison of the relative value of different treatment approaches. Cost-benefit analyses attempt to determine if a given outcome is worth its requisite cost to an individual. Clinical outcomes are translated into monetary terms via willingness-to-pay
approaches and the outcomes compared with the benefits on a direct monetary basis.

Like most infertility-related peer-reviewed literature, this article focuses primarily on cost-effectiveness analysis as a method of identifying optimal treatment for obstructive azoospermia. First, the effectiveness and then more importantly the cost effectiveness of IVF treatments in general are examined because they constitute a major component of treatment by sperm retrieval. The analysis then focuses on examining male factor infertility treatments for obstructive azoospermia in similar fashion.

**In vitro fertilization studies**

*Effectiveness of in vitro fertilization for male factor infertility*

The most complete set of data regarding the effectiveness of IVF for male factor infertility is found within the Society of Assisted Reproductive Technology (SART) database, published by the Centers for Disease Control and Prevention under the 1992 Fertility Clinic Success Rate and Certification Act [33]. A summary of SART data from 1995, the first available year, to 2004, the latest available year, is shown in Table 1. Although the number of total IVF cycles has risen from approximately 46,000 to 89,500 cycles over the intervening years, the percentage of cycles undertaken for male factor infertility alone has declined from a peak of 32% to the current level of 17%.

Similarly, the percentage of total ICSI cases used for male infertility cases has declined from 57.8% in 2001 to 51.4% in 2004. The live delivery rate for male factor infertility IVF cases in contrast has improved from 21% to 33% over the same time period.

One should note that although the SART summary data offer an impression of the effectiveness of IVF-driven treatments for male factor infertility, they do not offer fine enough resolution to distinguish IVF treatments undertaken for obstructive versus nonobstructive azoospermia cases. SART data reflect a mixture of the two. Theoretically, however, IVF treatments undertaken solely for obstructive azoospermia should be even more effective than the outcomes reported by SART, as the nonobstructive azoospermia cases reported by SART would be expected to generally yield lower live delivery rates compared with their obstructive counterparts.

**Cost effectiveness**

Neumann and colleagues [27] were the first to study the cost of a successful live delivery with an IVF pregnancy. Direct and indirect costs were considered in this analysis. The cost per live delivery ranged from $66,667 in 1992 dollars with one cycle of IVF to $114,286 by the sixth cycle in the study. A subgroup analysis that examined couples with advanced maternal age (ie, > 40 years) and male-factor subfertility (ie, sperm concentration < 20 million/mL or motility

<p>| Table 1 |</p>
<table>
<thead>
<tr>
<th>Summary SART statistics for 1995 to 2004 for couples undergoing assisted reproductive technology treatment</th>
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<tbody>
<tr>
<td>Total cycles (fresh embryo, non-donor eggs)</td>
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<tr>
<td>% cycles for male factor infertility by diagnosis</td>
</tr>
<tr>
<td>Pregnancies per cycle (%)</td>
</tr>
<tr>
<td>Live deliveries per cycle (%)</td>
</tr>
<tr>
<td>Live delivery rate for male factor infertility (%)</td>
</tr>
<tr>
<td>Multiple gestation live births</td>
</tr>
<tr>
<td>single (%)</td>
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<tr>
<td>twin (%)</td>
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<td>triplet or more (%)</td>
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< 40%) was conducted. The cost per live delivery increased to $160,000 for the first cycle to $800,000 by the sixth cycle.

Since the study conducted by Neumann and colleagues, various other groups have examined the costs of IVF. Chambers and colleagues [34] performed a population-based costing study of resources consumed during ART in Australia using a decision analytic model that drew upon data from the Australian and New Zealand Assisted Reproduction Database. Direct costs were queried from various fertility centers and rebates through the Medicare or Pharmaceutical Benefit Scheme. The cost per live delivery was calculated to be $32,903 in 2005 Australian dollars, although this cost increased to $182,794 for women older than 42 years. The most complete survey of IVF costs was perhaps undertaken in a review by Collins [35] in 2002. The use of IVF was studied in 48 countries, where direct and some indirect costs were considered. The mean cost per live delivery in the United States was estimated to be $58,394 in 2002 dollars per live birth, compared with $22,048 in non-US countries. As in previous studies, multiple gestation pregnancies were shown to pose a significant economic burden, costing 36% more than regular IVF singleton pregnancies. Price elasticity estimates indicate that a 10% decrease in IVF/ICSI costs would result in a 30% increase in overall ART use. Of note, the study emphasized that most IVF-related economic studies in the peer-reviewed literature possessed no outcomes assessment or comparison with alternative policies.

The costs of multiple gestation pregnancies have been well studied. The landmark study by Callahan and colleagues [30] demonstrated that predicted charges for an IVF singleton pregnancy were $9845 in 1991 dollars, compared with $37,947 for twins and $107,965 for triplets. Low birthweight and gestational age were found to represent the major contributors to the increased use of health care resources with IVF-related multiple gestation pregnancies [36]. Subsequent studies have confirmed the major contribution of multiple gestation pregnancies toward overall IVF cost. Lukassen and colleagues [37] retrospectively compared the relative cost of twin versus singleton IVF pregnancies in a single institutional study in the Netherlands from 1995 to 2001. They calculated the cost of twin pregnancies to be €13,469 in 2002 euros, more than five times higher than the €2,550 of a singleton pregnancy, because of longer maternal and neonatal admissions. Ledger and colleagues [38] modeled the cost impact to the British National Health System of IVF-related multiple births and concluded that multiple gestation pregnancies represented 56% of the cost of all IVF pregnancies, although they represented less than one third of the total number of maternities in the United Kingdom. Singletons cost £3313 in £ year 2002 sterling, whereas twins cost £9122, and triplets cost £32,354. Wolner-Hanssen and Rydstroem [39] modeled the use of single-embryo transfer, compared with actual standard two-embryo transfer protocols, and concluded that although more cycles would be needed to achieve a single live delivery with single-embryo transfer, the strategy would still be more cost efficient than the standard two-embryo transfer protocol because of the lower rate of twin pregnancies.

The highest quality studies to examine the cost effectiveness of IVF consist of three randomized controlled trials (Table 2). As the earliest, the Ontario trial compared one stimulated treatment cycle without embryo freezing versus a 6-month period of untreated observation or elective conventional therapy, including ovulation induction and intrauterine insemination (IUI), in the 1980s [40]. The live delivery rate was 10% in the former group versus 6% in the latter. The marginal cost of live delivery was calculated as $89,427 in 1992 Canadian dollars. A major

<table>
<thead>
<tr>
<th>Trial</th>
<th>Reference</th>
<th>Intervention</th>
<th>Marginal cost of delivery (in trial year currency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ontario</td>
<td>Soliman et al [40]</td>
<td>IVF cycle versus 6 mo of observation or IUI with ovulation induction</td>
<td>$89,427</td>
</tr>
<tr>
<td>Illinois</td>
<td>Karande et al [41]</td>
<td>IVF cycle versus 6 mo of clomiphene and gonadotropin cycles</td>
<td>$21,627</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>Goverde et al [42]</td>
<td>IVF versus IUI versus IUI/ovarian hyperstimulation</td>
<td>$26,779 NLG</td>
</tr>
</tbody>
</table>
weakness of the trials was that it occurred in the 1980s; ostensibly, the effectiveness of ART treatments has since improved considerably. A second trial in Illinois compared 46 couples undergoing IVF to 50 couples randomized to 6 months of standard therapy that consisted of three clomiphene cycles and three gonadotropin cycles followed by four IVF cycles [41]. The former group achieved a 35% pregnancy rate, whereas the latter group achieved a 56% pregnancy rate. As with the Ontario trial, only direct costs were considered. The marginal cost of an additional live delivery was calculated to be ~$21,627 in 1999 dollars (ie, IVF was deemed to be not only more expensive but also to offer less benefit). The final trial occurred in the Netherlands [42]. Eighty-six couples with idiopathic subfertility or male subfertility were assigned to six cycles of IUI alone, 85 to six cycles of IUI with ovarian hyperstimulation, and 87 to six cycles of IVF. After 3.5 years, the live birth rates were 7.4%, 8.7%, and 12.2%, respectively. Couples in the IVF arm were more likely to discontinue treatment before the maximum of six attempts. IUI (10,406 NLG per live delivery for male subfertility in 1995 NLG) and IUI with ovarian hyperstimulation (15,448 NLG per live delivery) were found to be more cost effective than IVF (37,185 NLG per live delivery), even at higher maternal ages, when the effectiveness of IUI declines. Questions regarding the generalizability of the Netherlands trial arise because few couples undergo more than three IVF cycles, whereas the trial tested up to six cycles. Overall, these three trials differed in terms of patient population, treatments offered, and country-specific health economic systems, thus potentially accounting for the differences in results seen. It was unclear whether these studies included patients with obstructive azoospermia undergoing sperm acquisition and IVF.

On a broader basis, one should note that the improved live delivery rates and decreased multiple gestation rates with IVF reported by more recent SART data might materially affect the outcomes of the cost-effectiveness analyses mentioned. Direct comparison of the IVF studies is also limited by the heterogeneity in the definition of costs used. Some studies examined only direct costs, whereas others included direct and indirect costs. Finally, some studies assumed costs to be equal to charges, whereas others considered the two to be separate. Several well-written reviews regarding the cost impact and cost effectiveness of IVF treatments have been published [31,32,35,43,44].

Male factor infertility studies

Effectiveness of surgical techniques

The peer-reviewed literature was queried for articles pertaining to microsurgical vasectomy reversal and sperm retrieval; specifically, a Medline search using the terms “vasectomy reversal,” “vaso-vasostomy,” “vasoepididymostomy,” “sperm retrieval,” “sperm aspiration,” “sperm extraction,” “TESE,” “TESA [testicular sperm aspiration],” “PESA,” “MESA,” and “testis biopsy” was conducted. All relevant studies were identified, and only articles that presented original primary data sufficient to calculate patency, when relevant, and live delivery rates were included for analysis. All data from the studies were pooled and are presented in Tables 3–5.

The overall patency rate for vasectomy reversal is approximately 86% in the peer-reviewed literature (see Table 3). The corresponding live delivery rate in these studies is 58%. One should note that the results of one study were substantially different from the remainder of published literature; the rationale for this difference and the generalizability of the study could not be determined [45]. In this study, the overall reported patency rate was 90% for the 3378 (86.5%) patients with data available. Live delivery rates were 84% for the 1738 (44.5%) patients with data available. If data from this particular study were separated from the others, the overall patency rate for microsurgical vasectomy reversal would decrease to 81%, and the live delivery rate would decrease to 44%.

More than the rate of successful sperm retrieval, the live delivery rate with sperm retrieval techniques represents the critical metric of success if a couple chooses retrieval as treatment for obstructive azoospermia. According to the peer-reviewed literature, the overall live delivery rate for couples undergoing MESA is 44%. One should note that Tables 3 and 4 present all vasectomy reversal and MESA studies identified by Medline and contain multiple studies from same clinical groups. Some of these studies may represent subgroup analyses of an identical larger patient population. Because improvements in surgical technique may have occurred over time, however, all studies have been presented in toto.

Data were gathered for the 1990 and 2005 years for TESE procedures from the SART
Table 3
Patency and live delivery rates for peer-reviewed literature studying vasectomy reversal

<table>
<thead>
<tr>
<th>Vasectomy reversal studies</th>
<th>Patency rate (%)</th>
<th>Live delivery rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuchs EF, Burt R. Vasectomy reversal performed 15 years or more after vasectomy: correlation of pregnancy outcome with partner age and with pregnancy results of in vitro fertilization with intracytoplasmic sperm injection. Fertil Steril 2002;77:516–9</td>
<td>147/173 (85)</td>
<td>66/173 (38)</td>
</tr>
<tr>
<td>Kolettis PN, Sabanegh ES, D’Amico AM, et al. Outcomes for vasectomy reversal performed after obstructive intervals of at least 10 years. Urology 2002;60(5):885–8</td>
<td>57/74 (77)</td>
<td>26/74 (35)</td>
</tr>
<tr>
<td>Kolettis PN, Sabanegh ES, Nalesnik JG, D’Amico AM, Box LC, Burns JR. Pregnancy outcomes after vasectomy reversal for female partners 35 years old or older. J Urol 2003;169(6):2250–2</td>
<td>37/46 (81)</td>
<td>15/46 (33)</td>
</tr>
<tr>
<td>Kolettis PN, Woo L, Sandlow JI. Outcomes of vasectomy reversal performed for men with the same female partners. Urology 2003;61:1221–3</td>
<td>30/32 (93)</td>
<td>18/32 (56)</td>
</tr>
<tr>
<td>Schlegel PN, Goldstein M. Microsurgical vasopididymostomy: refinements and results. J Urol 1993;150:1165–8</td>
<td>77/110 (70)</td>
<td>43/110 (39)</td>
</tr>
<tr>
<td>Silber SJ. Results of microsurgical vasopididymostomy: role of epididymis in sperm maturation. Hum Reprod 1989;4:298–303</td>
<td>NA/190 (NA)</td>
<td>81/190 (42)</td>
</tr>
<tr>
<td>Silber SJ, Grothman HE. Microscopic vasectomy reversal 30 years later: a summary of 4010 cases by the same surgeon. J Androl 2004;25:845–9</td>
<td>3040/3378 (90)</td>
<td>1460/1738 (84)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5386/6266 (86)</strong></td>
<td><strong>2808/4816 (58)</strong></td>
</tr>
</tbody>
</table>
Table 4
Live delivery rates for peer-reviewed literature studying microsurgical epididymal sperm aspiration

<table>
<thead>
<tr>
<th>Study</th>
<th>Live delivery rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td><strong>372/843 (44)</strong></td>
</tr>
</tbody>
</table>

The database, the former representing the earliest year for which complete data were readily available and the latter the latest year for which robust SART data existed for TESE (see Table 5). Only 1.6% of cycles undergone for male factor infertility used TESE with IVF/ICSI to treat male factor infertility in 1999 (1029 cycles); this percentage remained unchanged for 2003 (1425 cycles). The live delivery rate for TESE cycles increased from 28.3% to 33.6% (P = .042) in couples in whom sperm was successfully retrieved. Although the multiple gestation pregnancy rate decreased from 37% to 31.9% for all IVF cycles, it did not do so for TESE cycles (29.6% to 28.0%, P = .737). The percentage of cycles resulting in triplet or more infants in the latter group did decline from 5.8% to 2.1%, however (P = .008). One should note that the "TESE" designation within the SART database does not differentiate between sperm obtained via percutaneous TESE versus microsurgical TESE versus open testicular biopsy, nor does the database distinguish between
Table 5
Society of Assisted Reproductive Technology live delivery rates for testicular sperm extraction patients for 1999 to 2005

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of cycles</td>
<td>62,991</td>
<td>88,422</td>
</tr>
<tr>
<td>% cycles for male factor infertility with TESE/ICSI</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>% cycles for male factor infertility with TESE/ICSI resulting in live births</td>
<td>28.3</td>
<td>33.6</td>
</tr>
<tr>
<td>% male factor infertility TESE+ICSI live births</td>
<td>29.6</td>
<td>28.0</td>
</tr>
<tr>
<td>% male factor infertility TESE+ICSI live births with multiple infants</td>
<td>70.4</td>
<td>72.0</td>
</tr>
<tr>
<td>% male factor infertility TESE+ICSI live births with singleton</td>
<td>23.7</td>
<td>25.9</td>
</tr>
<tr>
<td>% male factor infertility TESE+ICSI live births with twins</td>
<td>5.8</td>
<td>2.1</td>
</tr>
<tr>
<td>% male factor infertility TESE+ICSI live births with triplets or more</td>
<td>5.8</td>
<td>2.1</td>
</tr>
</tbody>
</table>

Cycles in this table refer to those using use fresh, autologous eggs with cervical transfer.

obstructive versus nonobstructive azoospermia for “male factor infertility.” The live delivery rates cited by the database likely underestimate the success rates that would be obtained by patients with obstructive azoospermia.

Cost effectiveness: vasectomy reversal versus sperm retrieval studies

Prior groups have compared different treatments for obstructive azoospermia. Pavlovich and Schlegel [25] studied the use of vasectomy reversal via vasovasostomy or vasoepididymostomy versus sperm retrieval via MESA and percutaneous and testicular sperm retrieval with ICSI in men with postvasectomy infertility and female partners 39 years old or younger. Direct costs for all procedures were considered and surveyed from multiple US centers reporting results for ICSI and vasectomy reversal, as were the indirect costs of complications, lost productivity, and multiple gestation pregnancies. Vasectomy reversal was calculated to cost $25,475 per live delivery (95% confidence interval: $19,609–$31,339) in 1994 dollars. Sperm retrieval and IVF, in contrast, were calculated to cost $72,521 per live delivery (95% confidence interval: $63,357–$81,685). The main driver responsible for the spread in costs in the sperm retrieval arm consisted of IVF-associated and higher order gestation costs. They concluded that the most cost-effective approach to postvasectomy infertility lay with microsurgical vasectomy reversal; microsurgical vasectomy reversal was also the most effective method with which to produce a live delivery with only one intervention.

Koletis and Thomas [46] next compared the cost effectiveness of MESA to vasoepididymostomy in the Cleveland Clinic experience. Fifty-five men undergoing vasoepididymostomy for vasectomy reversal were studied. A patency rate of 85% was achieved at 6 months, with an accompanying live delivery rate of 36%. The cost of MESA was calculated to be $51,024 per live delivery in 1997 dollars versus $31,099 for vasoepididymostomy. These figures also considered the impact of direct and indirect costs. Donovan and colleagues [47] compared MESA versus repeat surgical reconstruction in postvasectomy patients in the University of Iowa experience. A patency rate of 78% was achieved in the latter group. Only direct costs were considered. The cost per live delivery for MESA was calculated to be $35,570 in 1998 dollars compared with $14,892 for repeat vasectomy reversal.

Deck and Berger [48] described the University of Washington experience with vasectomy reversal compared with IVF/ICSI. The clinical course of 29 patients undergoing vasectomy reversal with ovulating partners older than 37 years was retrospectively studied. With a patency rate of 75%, the live birth rate achieved was 17%. The cost per live delivery was calculated to be $28,530 in 2000 dollars, compared with $103,940 for testicular sperm aspiration/IVF/ICSI. These figures only accounted for direct procedural costs and did not consider the impact of indirect costs.

Meng and colleagues [49] also examined the issue of vasectomy reversal through either microsurgical vasovasostomy or vasoepididymostomy versus sperm retrieval via unspecified means by use of a decision analytic model. In contrast to the Pavlovich and Schlegel analysis, although direct procedural costs were considered, the impact of indirect costs was not; all costing data came from a single institution. The results of the analysis by Meng and colleagues favored vasectomy reversal as the more cost-effective treatment for postvasectomy related obstructive azoospermia, as long as postreconstruction patency rates could be maintained more than 79%. Their analysis calculated that the cost per live delivery for vasectomy reversal in the base case scenario was $38,983 in 2004 dollars, whereas that for sperm
retrieval/ICSI was $39,506. Although their sensitivity analysis suggested that the cost effectiveness of vasectomy reversal depends on male—not female—fertility factors, it is important to note that the effects of age on maternal fecundity were not considered. It was also suggested that sperm retrieval/ICSI would be more cost effective in situations where the need for uni- or bilateral vasoepididymostomy arose (ie, where the expected patency rate of reconstruction would be lower).

Lee and colleagues (unpublished data) most recently compared vasectomy reversal versus MESA versus percutaneous TESE for the treatment of obstructive azoospermia via use of a decision analytic model that accounts for direct and indirect costs. Costing and IVF outcomes were taken from population-based databases for maximum generalizability of results. The cost-effectiveness performance of all three therapies was also examined over time. In this study, the cost per live delivery for vasectomy reversal was $20,019 in 1999, compared with $43,886 for percutaneous TESE and $46,133 for MESA. In 2005, vasectomy reversal ($21,304) remained the most cost-effective treatment over TESE ($53,356) and MESA ($55,317). The cost effectiveness of all treatments during this time period improved over projections by inflation. Unlike the analysis by Meng and colleagues, however, sensitivity analysis suggested that cost effectiveness of vasectomy reversal was superior to MESA and TESE under all conditions, implying that the additional cost per pregnancy generated by the lower patency rates in patients requiring uni- or bilateral vasoepididymostomy is still outweighed by the cost of IVF in MESA and TESE. The duration of obstruction becomes an insignificant factor in deciding which therapy to recommend. Conversely, the improved cost effectiveness from an enhanced ability to achieve successful delivery with IVF is still outweighed by the indirect costs of the therapy. The magnitude of IVF-related indirect costs seemed to significantly alter the outcome of this decision model compared with prior studies. For instance, the probability- and inflation-adjusted cost of multiple gestation pregnancies alone ($31,637 in 1999 and $35,105 in 2005) outweighed the procedural cost of an IVF cycle in the base ($9765) and latter ($12,507) years of the study.

It should be emphasized that all cost-effectiveness studies reflect locoregional costs, which can vary dramatically. As mentioned elsewhere in the surgical literature, the results of the most experienced or successful surgeons form the basis of this analysis, which creates further bias in the results.

Summary

A detailed examination of the data regarding surgical reconstruction versus sperm retrieval with IVF/ICSI for the treatment of obstructive azoospermia reveals several key points. First, multiple techniques for surgical reconstruction and sperm retrieval exist. Vasovasostomy represents the first-line modality for surgical reconstruction and is clearly preferable to vasoepididymostomy. MESA is more effective than PESA in terms of quantity and quality of sperm retrieved with consequent impact on live delivery rates. Excellent sperm retrieval and pregnancy rates can be achieved with epididymal or testicular sperm obtained by each of these techniques. All modalities of sperm retrieval consign the female partner of a couple to undergo the greater costs and complications of an IVF cycle and expose the resulting offspring to potential health problems. It seems that reconstructive procedures should be offered as a first-line therapy to couples who seek conception after vasectomy. The treatment eventually chosen by an individual couple, however, should be an informed one based on the data available.

Cost-effectiveness analysis reveals multiple implications. First, although the direct cost of undergoing IVF can be tremendous and may vary greatly between countries, the indirect costs are even more significant, most specifically because of the impact of multiple gestation pregnancies. Randomized controlled trials have failed to consistently demonstrate the cost effectiveness of IVF over conventional, less invasive fertility treatments, such as IUI. When these data are taken into consideration for sperm retrieval in the treatment of obstructive azoospermia, it is clear why multiple studies have demonstrated the superior cost effectiveness of surgical reconstruction over sperm retrieval in linear and decision analytic models: the cost of the IVF that must be coupled to sperm retrieval is so great that it becomes a less cost-effective therapy compared with surgical reconstruction.

Limitations

It is important to note that limitations exist with cost-effectiveness analysis. Cost-effectiveness
analysis by its nature involves implicit assumptions and judgments. First, such analysis operates on the premise of maximizing health care benefits across a target population given a limited amount of economic resources (i.e., it encompasses a societal perspective). Individual outcomes to specific patients are not considered, because the analysis instead considers net gains and benefits to all individuals in the population equally. Issues such as equity in individual access to health care services, the internal validity and comparability of cost-effectiveness studies, and the external validity of applying generalized cost-effectiveness models to specific locoregional conditions all remain unanswered.

Many of the studies assumed costs to be equal to charges to best evaluate the overall impact of ART on society. The impact on individual patients and individual patient willingness to undergo ART varies depending on the extent of specific health insurance coverage. None of the studies considered the downstream costs of raising children conceived by ART; higher rates of chromosomal anomalies, prematurity, and low birthweight are found in ART children, which would lead to greater downstream costs in children born via sperm retrieval IVF [50–52]. Petrou and colleagues, for example, studied the cumulative cost impact of preterm birth infants and found longer duration of hospital admissions, significantly greater inpatient service costs, and a persistent cost difference of £11,958 in £1998 sterling up to £14,614 over the first 5 years of life depending on gestational age. Few studies also considered the issue of maternal age impact on fecundity. For example, vasectomy reversal would represent a suboptimal therapy with greater maternal age; couples would be more likely to choose sperm retrieval in the interests of expediting the time to pregnancy and delivery, yet few of the studies considered this trend. How would the decision process be altered if a couple desired more than one child? Finally, some of the broader effects of ART were also not considered. The economic impact of multiple births, for instance, on downstream social welfare and public health programs may become significant in the future. What proportion of public resources should optimally be used to help pay for ART versus other potentially life-saving or extending technologies? What is the most efficient allocation of these resources, and how does one determine who should be the recipients? These are critical and possibly the most important questions that remain unanswered in the limited scope of cost-effectiveness analysis.

References


Vasectomy Reversal

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INTRODUCTION

Although vasectomy remains a popular method of contraception, the number of men requesting reversal has risen dramatically. The microsurgical techniques described in this article have yielded excellent results.

Approximately 500,000 vasectomies are performed each year in the United States. It is estimated that 2% to 6% of vasectomized men ultimately seek reversal. Divorce with subsequent remarriage is by far the most common reason given for requesting reversal. In developing countries, the death of a child is the most common reason. In Bangladesh, for example, 5% of all couples who choose sterilization experience the death of a child within 1 year after the operation.

Although this article focuses on vasectomy reversal, or vasovasostomy, the same technique can be used to repair vasal obstructions of other etiologies. Iatrogenic injuries to the vas deferens are, unfortunately, quite common. It is estimated that injury to the vas deferens occurs in 0.3% of adult inguinal hernia repairs and up to 2% of pediatric inguinal surgeries.

Before the refinement of microsurgical techniques, the results of vasovasostomy were relatively poor. The lumen of the vas deferens is only about 0.3 mm in diameter. As one might imagine, creating an accurate, leakproof anastomosis of a structure this small is a formidable challenge. Microsurgical techniques of vasectomy reversal now result in return of sperm to the ejaculate in over 90% of men and yield naturally conceived pregnancy rates over 50%.

PREOPERATIVE EVALUATION

History. In men presenting for vasectomy reversal, the prevasectomy fertility status should be ascertained. If a man had trouble conceiving prior to the vasectomy, this may certainly be the case again even if the operation is technically successful. The time since vasectomy is also an important factor influencing outcome. There is no length of time beyond which vasectomy reversal uniformly fails. However, it is clear that success rates are lower...
with longer obstructive intervals. This is due to the increased rate of secondary epididymal obstruction as the obstructive interval lengthens.

A history of complications following the vasectomy, such as a scrotal hematoma or epididymitis, may also affect the results of reversal. Any scrotal or inguinal surgeries performed subsequent to the vasectomy should alert the urologist to the possibility of a second site of vasal obstruction.

Finally, the reproductive health of the female partner should be assessed before embarking on reconstructive surgery for the male. A young, healthy woman with no previous pelvic surgery and with normal menstrual cycles does not require a formal gynecologic work-up. However, older female partners without proven fertility should undergo gynecologic evaluation.

**Physical Examination.** A complete physical examination should be performed with particular attention to the male genitalia. The spermatogenic component of the testis, called the seminiferous tubules, makes up 80% of the testicular volume. Therefore, small or soft testicles suggest impaired sperm production and predict a poorer outcome. An indurated epididymis suggests secondary epididymal obstruction that may require a more complex procedure, called a vasopadidymostomy, for repair.

Sometimes men who have undergone vasectomy will leak sperm from the end of the vas deferens on the testicular side. This leaking sperm incites an inflammatory response that leads to formation of a sperm granuloma. Palpable as a nodule at the testicular end of the vas, these sperm granulomas are actually a good prognostic sign. The leaking sperm vents the high pressure away from the epididymis, thus protecting the epididymis from pressure-induced damage. Men with palpable sperm granulomas have an improved prognosis regardless of the time interval since vasectomy.

Careful palpation of the relaxed scrotum in a warm examining room reveals the size and location of the vasal gap. Some urologists remove or cauterize a large segment of vas deferens when performing the vasectomy. These destructive vasectomies may require a more extensive dissection when performing the reversal in order to achieve a tension-free anastomosis. In addition, some physicians perform the vasectomy high in the scrotum near the external ring; others perform the procedure lower down, closer to the testicle. These findings also may affect the complexity of the reversal procedure.

Varicoceles are very common in the male population and are frequently detected in men seeking vasectomy reversal. Although varicoceles are the most common surgically correctable cause of male infertility, they do not all need to be repaired. Therefore, we recommend performing the vasovasostomy first, followed by the varicocelectomy several months later if semen analysis parameters remain suboptimal. Performing the procedures concurrently presents technical problems that could jeopardize the success of both operations.

Finally, it is important to note any operative scars in the inguinal or scrotal region that may suggest a possible vasal obstruction at a site remote to the vasectomy. Performing 2 vasovasostomies simultaneously in the same vas is not recommended because devascularization of the intervening segment with subsequent fibrosis and failure of the reversal is likely to result.

**Laboratory Tests.** The majority of men who have undergone a vasectomy are azoospermic (ie, have no sperm in the ejaculate). Indeed, this is the purpose of the vasectomy in the first place. However, we have observed that 10% of all men presenting for reversal will have a few nonmotile sperm detected in their centrifuged semen specimen. This is due to the spontaneous formation of microscopic channels and not from "reconnection" of the vas deferens. As one might expect, finding rare sperm in the prereversal semen specimen is an excellent prognostic sign. Under these circumstances, sperm are certain to be found in the vas deferens on at least 1 side, improving the likelihood of restored fertility.

A serum follicle-stimulating hormone (FSH) should be measured in any man with small and/or soft testes. Elevated FSH levels suggest impaired spermatogenesis and a poorer prognosis. Antisperm antibodies can be detected in the blood of most men who have undergone vasectomy. The unique surface characteristics of sperm, as well as the delay in their appearance until puberty, make them potential targets for recognition as foreign by the immune system.

The tight junctions between Sertoli cells of the seminiferous tubules create a "blood-testis barrier" that effectively shields sperm and their surface antigens from the systemic circulation. The integrity of this barrier is maintained from the testis to the urethra by an unbroken epithelial lining. When this barrier is violated by surgery, such as vasectomy, or any other injury that allows sperm leakage outside the barrier, antibodies to sperm antigens can form in the blood. Although preoperative antibody levels in serum or seminal fluid do not predict the ultimate outcome of vasovasostomy, the presence of sperm-bound antibodies postoperatively does appear to predict a lower pregnancy rate.
Surgical Technique

Microsurgical vasectomy reversal is an extremely difficult operation, preferably done under general or regional anesthesia, and takes 2 to 4 hours to perform. The operation is best reserved for urologists with extensive microsurgical training who perform the procedure frequently. The keys to a successful anastomosis are summarized in Table 1.

Bilateral high vertical scrotal incisions are made (Figure 1). Once the scarred ends of the vas are identified, the vas is transected and patency of the abdominal side is confirmed by injection of saline. If large segments of the vas were removed or destroyed during the vasectomy, extension of the incision into the groin may be necessary. The obstructed portion of the vas deferens is dissected out and serial transections of both ends of the vas are performed until a patent lumen with healthy, well-vascularized mucosa and muscularis are found.

Fluid emanating from the testicular end of the vas should be sampled and examined microscopically. If sperm are observed, a vasovasostomy is performed. The absence of sperm indicates epididymal obstruction, necessitating a more difficult operation (vasoepididymostomy) connecting the vas deferens to the epididymis at a point closer to the testis where it remains patent.

Our multilayer microdot technique for vasovasostomy has been described in detail elsewhere. Briefly, a microtip marking pen is used to map out planned needle exit points (Figure 2). This helps to accurately approximate lumina that frequently have markedly discrepant diameters. Very fine (10–0 nylon) nonabsorbable sutures with needles at both ends are placed inside-out through the dots (Figure 2).

After these sutures are tied, the anastomosis is flipped over to complete the mucosal layer (Figure 3). Another layer of sutures is placed through the muscularis exactly between each of the previously placed mucosal stitches (Figure 4). This creates a watertight anastomosis that prevents sperm from leaking postoperatively. As mentioned previously, leaking sperm creates an intense inflammatory reaction (sperm granuloma) that compromises the chances of achieving a patent anastomosis. A final layer of suture is placed through the vasal sheath to provide added strength and remove all tension from the anastomosis (Figure 5). An identical procedure is carried out on the opposite side and a multilayer skin closure is accomplished. The patient can be discharged on the day of surgery, and normal activities, including intercourse, may be resumed after 4 weeks.

Table 1

<table>
<thead>
<tr>
<th>Keys to a Successful Anastomosis</th>
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<tbody>
<tr>
<td>- Accurate mucosa-to-mucosa approximation</td>
</tr>
<tr>
<td>- Leakproof anastomosis</td>
</tr>
<tr>
<td>- Tension-free anastomosis</td>
</tr>
<tr>
<td>- Good blood supply to anastomosis</td>
</tr>
<tr>
<td>- Healthy vasal mucosa and muscularis</td>
</tr>
<tr>
<td>- Preciseatraumatic technique</td>
</tr>
</tbody>
</table>

Figure 1.—Preferred incisions for vasectomy reversal. Dotted line indicates extent of incision if needed for gaining extra vasal length. The “x” marks the external inguinal ring. (Reprinted, with permission, from Goldstein M. Vasovasostomy. In: Goldstein M, ed. Surgery of Male Infertility. Philadelphia: WB Saunders Co.; 1995:47.)

Results

Using the vasovasostomy technique outlined above, we have observed a patency rate of 99% and a pregnancy rate of 64% (excluding couples with female-factor infertility). The results for vasoepididymostomy are lower (65% and 41%, respectively). The major factors affecting the chances of successful vasectomy reversal are summarized in Table 2. Some patients who are initially patent will develop stenosis and closure of the anastomosis 2–5 years postoperatively. The late failure rates are 12% for vasovasostomy and 21%
following vasoepididymostomy. For this reason, we encourage men who have undergone vasectomy reversal to cryopreserve sperm for future use should it be needed. Because men requiring vasoepididymostomy have a lower patency rate, we will also obtain sperm for cryopreservation at the time of their reversal procedure.

The widespread availability of advanced assisted reproduction techniques such as in vitro fertilization and intracytoplasmic sperm injection [IVF-ICSI] has given men who wish to have their own biologic offspring following vasectomy an additional option.

Instead of undergoing vasectomy reversal, they may now choose to have sperm aspiration from the testis or epididymis for use with IVF-ICSI.

Although seemingly simple, this approach has distinct disadvantages. First, it subjects an otherwise healthy female partner to the risks of ovarian stimulation and procedural intervention for egg retrieval. Second, it could make future attempts at reconstruction difficult or impossible should the couple opt for reversal following a failed attempt at IVF-ICSI. Third, it is dramatically more expensive. A recent cost-effectiveness analysis was performed compa-
TABLE 2
Factors Influencing the Success Rate of Reversal Surgery

<table>
<thead>
<tr>
<th>Factor</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time interval since vasectomy</td>
<td>Longer obstructive intervals are associated with lower success rates</td>
</tr>
<tr>
<td>Sperm granuloma</td>
<td>Sperm granulomas at the vasectomy site are a favorable prognostic sign</td>
</tr>
<tr>
<td>Antisperm antibodies</td>
<td>Postoperative sperm-bound antibodies result in lower pregnancy rates</td>
</tr>
<tr>
<td>Quality of vasal fluid</td>
<td>Vasoepididymostomy is required when sperm are absent in the vasal fluid</td>
</tr>
<tr>
<td>Microsurgical technique</td>
<td>Technique, judgment, and experience are important factors for success</td>
</tr>
<tr>
<td>Comorbid conditions</td>
<td>Any condition that impairs spermatogenesis (eg, varicocele) may lower</td>
</tr>
<tr>
<td></td>
<td>postoperative pregnancy rates</td>
</tr>
</tbody>
</table>

ing vasectomy reversal with IVF-ICSI. The analysis assessed cost per delivery, taking the following factors into account: success rates and costs of the 2 treatments, cost of treating complications, cost of delivery, and the costs attributable to multiple gestations that are very common with assisted reproduction. This analysis revealed an average cost per delivery of $25,500 for vasectomy reversal and $72,500 for sperm retrieval and IVF-ICSI.

Finally, the greatest advantage of vasectomy reversal is, perhaps, the most obvious: It allows natural conception, an option preferable to most couples when possible. Therefore, we believe vasectomy reversal is the best option except in cases where female infertility factors exist (such as advanced age) that make natural conception unlikely.

Depending on the clinical situation, men who fail vasectomy reversal may have the procedure repeated or proceed directly to IVF-ICSI. ‘Redo’ vasectomy reversals carry a lower success rate than first-time procedures, primarily because a vasoepididymostomy frequently will be required on at least 1 side. Nevertheless, we have obtained good results in this situation, with patency rates of 67% and pregnancy rates of 30%.

CONCLUSION

Microsurgical technique and intraoperative judgment are the most important factors in determining the success of vasectomy reversal. Hundreds of hours of laboratory practice are necessary to acquire the requisite skills. Although vasectomy is usually considered a permanent form of sterilization, the procedure can be reliably reversed with excellent patency and pregnancy rates. Vasectomy reversal has several advantages over proceeding directly to IVF-ICSI, not the least of which is superior cost effectiveness.

REFERENCES

Vasectomy Myth Debunked: NewYork-Presbyterian/Weill Cornell Study Finds Vasectomy Reversal Highly Effective, Even After 15 Years

New York, NY (February 19, 2004) -- Debunking a popular myth about vasectomy, a new study by physician-scientists at NewYork-Presbyterian Hospital/Weill Cornell Medical Center finds that vasectomy reversal is highly effective, even 15 years or more after the testicles, the tube that carries sperm, is blocked. The study, published in the January *Journal of Urology*, documents the highest pregnancy rates following vasectomy of any study to date.

Whether a man had a vasectomy this year or 15 years ago, there was no difference in the pregnancy rate achieved following a vasectomy reversal, with an average 84-percent likelihood of pregnancy over two years, the study finds. (Comparatively, healthy men without vasectomy can expect a pregnancy rate of 90 percent.) Previous studies have demonstrated pregnancy rates following vasectomy reversal of only 50–60 percent, a difference that can be attributed to advancements in vasectomy-reversal techniques. The study also finds that at intervals of greater than 15 years, the pregnancy rate dropped to 44 percent.

"Vasectomy is not a permanent condition. For men who had a vasectomy less than 15 years ago, a reversal will result in a much higher pregnancy rate than sperm aspiration and in vitro fertilization (IVF) with intracytoplasmic sperm injection (ICSI). Even at intervals greater than 15 years, reversal outcomes will equal or exceed those of IVF with ICSI," says Dr. Marc Goldstein, the study’s lead author, Professor of Reproductive Medicine and Urology at Weill Cornell Medical College, and Surgeon-in-Chief of Male Reproductive Medicine and Microsurgery at NewYork-Presbyterian Hospital/Weill Cornell Medical Center. IVF with ICSI results in pregnancy (MORE)
rates of up to 50 percent per attempt at the best centers, and may take two or three tries to achieve one pregnancy.

"Additionally, vasectomy reversal is a more cost-effective option, especially for couples seeking more than one child," adds Dr. Goldstein. "IVF with ICSI typically costs approximately two to three times more than vasectomy reversal. And, unlike IVF with ICSI, a reversal is covered by health insurance in certain states, including New York."

Men seek to reverse a vasectomy for two main reasons: they either remarried or they lost a child, says Dr. Goldstein. Approximately half a million vasectomies are performed each year in the U.S., and it is estimated that between two percent and six percent of the men will ultimately seek reversal.

The study involved a retrospective analysis of 213 vasectomy reversals performed at NewYork-Presbyterian Hospital/Weill Cornell Medical Center between 1984 and 2001. Outcomes data were stratified according to obstructive interval: less-than 5 years, 5-10 years, 10-15 years, and greater than 15 years. Only men with fertile female partners were studied.

The study also found that the level of patency (or lack of obstruction) in the vas deferens remained high up to 15 years, averaging at 90 percent, and holding at this rate no matter when the vasectomy was performed. This finding contradicts other study results; this may be explained by the recent introduction of improved surgical techniques for vasectomy reversal. One such technique, the microdot method for precision suture placement, was pioneered by Dr. Goldstein in 1998.

Another vasectomy myth holds that the presence of granulomas -- knots that form in the vas deferens when a vasectomy is too tight -- result in a higher patency and pregnancy rate. The current study finds that granulomas, which occurred in 28 percent of vasectomies, did not increase patency to a statistically significant level and had no impact on pregnancy.

The study represents the first analysis of pregnancy and patency following two different types of vasectomy reversal -- vasovasostomy (VV) and vasoepididymostomy (VE) -- finding that patients who underwent a bilateral VV had a significantly greater patency rate (95%) than
patients who had unilateral VV and VE (83%) and bilateral VE (83%). However, pregnancy rates were consistent.

Vasovasostomy (VV) involves a reconnection of the vas deferens to the vas deferens. Vasoepididymostomy (VE) connects the vas deferens to the epididymis, a duct that carries sperm to the vas deferens. In general, if sperm is present in the vas fluid, VV is performed. If sperm is not present in the vas fluid, VE is performed. Both outpatient procedures take less than three hours.

For men unable to achieve pregnancy following VV or VE, the next step is assisted reproductive techniques such as intra-uterine insemination (IUI) or IVF with ICSI, says Dr. Goldstein.

The study’s co-authors are Dr. Stephen Boorjian, a urology resident at NewYork-Presbyterian Hospital/Weill Cornell and Michael Lipkin, a medical student.

Recognized as leaders in the field male reproductive surgery, Dr. Goldstein and his colleagues at the Center for Male Reproductive Medicine and Microsurgery at NewYork-Presbyterian Hospital/Weill Cornell Medical Center have received honors for their instructional videos. In 2003, they received the American Urological Association’s “Audio-Visual Award” (first prize) for “Ultra-Precise Multilayer Microsurgical Vasovasostomy: Trick of the Trade.” And in 2002, they received the American Society for Reproductive Medicine’s “Best Video Award” for “Three Techniques of Microsurgical Intussusception Vasoepididymostomy: Cost-Effective Options for Obstructive Azoospermia.”

# # #
THE COUPLE'S GUIDE TO FERTILITY

THIRD EDITION

Entirely Revised and Updated with the Newest Scientific Techniques to Help You Have a Baby

Gary S. Berger, M.D.
Marc Goldstein, M.D.
Mark Fuerst

Broadway Books
New York
Unblocking Ducts

Blocked ducts in a man’s reproductive tract contribute to another 10 percent of male infertility. Half of these men are born with abnormal or missing ducts, such as an absent vas deferens or an abnormal epididymis. The other half have acquired blockages, most commonly due to scarring from infections with gonorrhea or chlamydia. If the epididymis becomes infected on both testicles, or if a man has only one healthy, functioning testicle and its epididymis becomes infected, this tiny tube may become blocked and the man may become completely sterile.

New microsurgical techniques have dramatically improved the results in repairing a blocked epididymis. In Dr. Goldstein’s latest studies, sperm reappear in the ejaculate in 83 percent of men, and 40 percent will father a child naturally. Those who don’t father a child naturally can be helped with assisted reproductive technologies. Lower fertility rates have to do with how the epididymis functions. When sperm first enter the epididymis, they can’t swim and won’t penetrate an egg. As the sperm come out the other end of the epididymis, they can swim and penetrate an egg. If the epididymis is damaged and repaired microsurgically, it may still not allow sperm to mature fully and develop their full swimming and fertilizing abil-
The Couple's Guide to Fertility

pecies. IVF with injection of sperm directly into the egg (intracytoplasmic sperm injection, or ICSI) can now help these men impregnate their wives.

Another cause of blocked ducts includes injury to the vas deferens from a hernia repair. From 5 to 17 percent of males who have a hernia repaired suffer a blocked vas. Fortunately, the blockage is usually on only one side. But if hernias are repaired on both sides, or a hernia on the side of the only functioning testicle is repaired, it could damage the vas deferens and cause infertility. These blocked tubes can be repaired microsurgically, and more than half of these men's wives become pregnant.

Vasectomy Reversal

"I thought I never wanted any more kids," recalls Roy, age forty-six, who had a vasectomy at thirty after fathering three children. Then he divorced his first wife and married Dawn, age thirty-seven, and after "spending a lot of time talking about having a child together, we decided to give it a try." A little apprehensive about the vasectomy reversal, Roy had the delicate surgery with no major trouble. He was in the hospital on a Wednesday, rested at home for a few days, and went back to his job at the phone company the next Monday.

Although Roy's reversal operation was a technical success—his tubes were open and healthy—his sperm count remained low a year later. "The doctor told me I had one strike against me since it had been so long since my vasectomy," he says. He and Dawn kept trying anyway, and she got pregnant about a year later, but lost the baby to a miscarriage. "I thought that was our one and only shot," says Dawn. Six months later, Roy was started on hormone treatments. His sperm count rose sharply, and within four months, Dawn was pregnant. Their son, Andy, is now seven and a half years old.

"I'm experiencing more with Andy than when I watched my first three kids grow up," says Roy. "I can enjoy him more. I'm looking forward to being a Little League coach again."

A vasectomy causes sterility by blocking the vas deferens. Each year, about half a million American men choose vasectomy as their primary form of birth control. It can be safely performed as an outpatient procedure with minimal discomfort using local anesthesia. The doctor removes about a one-inch segment of the vas deferens and seals the cut ends of the vas with stitches, heat, or clips.

Inevitably some of the men who had vasectomies have reconsidered and regret their earlier decision. Most men who have had vasectomies
Other Medical and Surgical Treatments

and want them reversed are in their late thirties or early forties. These men had children, then divorced, and have now remarried, usually to younger women who do not have children of their own.

Another group of men who regret having undergone vasectomy are those in their early thirties who put off marriage and having children. Now these socially conscious men have married and they want children.

Still others want their fertility restored in response to improved financial status, allowing the couple to afford more children, or the improved health of either the man or the woman.

Urologic microsurgeons can perform the delicate sterilization reversal surgery. Before the introduction of microsurgery, less than 25 percent of the approximately three thousand men who had vasectomy reversals were able to impregnate their wives. Microsurgical repair of the vas has more than doubled the success rate. With recent publicity about greater successes, more of the nearly 17 million men who have had vasectomies are seeking reversals.

The length of time since the vasectomy has some effect on the success of a reversal operation. The more years that have passed since vasectomy, the lower the natural pregnancy rates after microsurgery. If the reversal is performed within a decade of vasectomy by an expert reproductive microsurgeon, more than 90 percent of men have sperm return to their ejaculate. In the more than 1,250 vasectomy reversals he has performed, Dr. Goldstein's overall return of sperm rate is 96 percent and the pregnancy rate is 63 percent for all men who have fertile wives. This includes men who have blockages of the epididymis. For those who had the sterilization procedure less than five years ago, the pregnancy rate is 73 percent. A man who had a vasectomy more than ten years ago should know that his odds of success are good but lower.

A new technique for vasectomy reversal developed by Dr. Goldstein increases the chances for fertility. The Microdot technique facilitates more accurate placement of sutures, which, in turn, helps to secure a leak-proof reconnection of the vas deferens. Like an architect making a blueprint before building a building, Dr. Goldstein makes a blueprint before performing the microsurgery. Using an operating microscope that magnifies this tiny duct thirty times and a microscopic marking pen, he places six dots at 1, 3, 5, 7, 9, and 11 o'clock positions. Then he reattaches the vas deferens by lining up the dots with six sutures for each of four separate layers.

The challenge faced by microsurgeons for a vasectomy reversal is to reattach two widely discrepant sides of the vas deferens without gaps in
order to prevent sperm leakage. The Microdot technique facilitates this process. As a result, Dr. Goldstein's overall success rate for return of sperm to the semen after vasectomy reversal has increased to 99.5 percent using the Microdot technique for men who have sperm found in at least one vas at the time of the surgery.

Dr. Goldstein also has imported a Chinese technique to do a quicker, less painful vasectomy without a scalpel that also is highly reversible. He makes a tiny puncture in the scrotum, pulls the vas deferens out, cuts it and seals both ends with heat, then slips the tube back in. There are no stitches and little blood. The no-scalpel vasectomy takes ten minutes or less and the man can return to work the same day.

In contrast, a crudely performed vasectomy can damage the nerve supply of the vas deferens and possibly compromise its function, making a vasectomy reversal less successful. Also, if too much of the vas has been removed, a reversal is more difficult.

In addition to blocking the vas deferens, a vasectomy may also later result in a block of the epididymis. Between 30 and 50 percent of vasectomies ultimately result in ruptures of the epididymis and a secondary obstruction in that tiny tube. In order to repair the obstruction, the urologic microsurgeon must open up the epididymis to allow a free flow of fluid and sperm through it and reconnect it to the vas deferens. This is a much more difficult procedure than the standard microsurgical vasectomy reversal because the epididymis is considerably thinner and more delicate than the muscular vas deferens. Nevertheless, in the hands of a skilled microsurgeon using newer microsurgical techniques, the damaged epididymis can be repaired with more than 80 percent return of sperm to semen. Pregnancy rates, however, are in the 40 to 50 percent range, lower than that of men who have a vasectomy reversal and no epididymis obstruction.

In some men after vasectomy, sperm leak from the vas, provoking an inflammatory reaction. The immune system responds by forming a nodule, called a sperm granuloma, at the vasectomy site. The end of the vas forms a network of pockets and channels that trap the sperm. This small knot of tissue, from pea to grape size, relieves the pressure on the epididymis and protects that delicate tube. Men with a sperm granuloma have a better chance of pregnancy after a reversal.

Vasectomy may also lead to the production of antisperm antibodies, which play a significant role in those men who have reasonably good sperm counts after reversal surgery, yet can't get their wives pregnant. Up
Other Medical and Surgical Treatments

to two thirds of vasectomized men develop antibodies that can interfere with sperm motility and fertilizing capability. This problem can sometimes be overcome by treatment with steroid medications to reduce antibody production and with sperm washing and separation procedures, followed by artificial insemination into the uterus. If this doesn't work, then ICSI is a very successful treatment for sperm antibodies.