Vas Deferens

see Male Reproductive System

Vasectomy

Sherman J. Silber

Infertility Center of St. Louis, Saint Luke's Hospital

GLOSSARY

epididymis A coiled, 20-ft long, fragile, microscopic tubule that carries sperm from the testicle into the vas deferens.

epididymitis Inflammation and dilation of the epididymis.

microscopic vasectomy reversal A procedure in which the tiny inner canal of the vas deferens—which is roughly the size of a pinpoint—is microsurgically reconnected to restore fertility. Then the relatively thick muscular wall is sutured to ensure proper muscular contraction forming the sperm into the ejaculate. About 98% of patients develop normal sperm count after reversal.

sperm granuloma A lump at the vasectomy site caused by sperm leakage.

testicles The glands responsible for the production of sperm and the male hormone testosterone, which is needed for the development of male sexual characteristics and behavior.

vas deferens A sperm duct about one-eighth of an inch in diameter. The inner canal of the duct is about 1/70 to 1/100 in. diameter and carries the sperm out of the testicle into the ejaculate.

vasectomy The cutting and sealing of the male sperm duct (vas deferens) for the purpose of sterilization.

I. WHAT IS VASECTOMY?

Vasectomy is the cutting and sealing of the male sperm duct (vas deferens) for the purpose of sterilization. Vasectomy is the most popular method of birth control in the world today. It is a simple operation that can be completed in a few minutes in the doctor's office under local anesthesia with just a handful of surgical instruments. It can just as easily be performed in a tent or a hut in developing world countries and therefore is the bulwark of massive population-control programs in countries such as China, India, Bangladesh, and those in Southeast Asia. It involves a simple severing of the vas deferens, which carries the sperm from the testicle and epididymis into the ejaculatory duct. Because this duct can easily be palpated just underneath the scrotal skin, the operation requires only a tiny eighth-inch incision

and can be accomplished simply in a matter of minutes. It can even be performed with just sharpened hemostats with no incision. The only drawback to vasectomy has been its irreversibility.

There are about 1 million sterilizations performed in the United States every year, and almost half of those are vasectomies. Most men who undergo vasectomy are over 30 years of age, have two or three children, have already used other methods of birth control with their partner, and have decided they want a quick, simple, safe, permanent end to their worry about having more children. In many cases their wives have suffered from ill effects from birth control pills or have had painful cramping periods or infections from an IUD. Some already have unwanted children.

There is no effect on the man's sex drive or sexual ability. The patient who has had a vasectomy notices no difference in his orgasm or the amount of fluid in his ejaculation. It simply is all fluid and no sperm. He notices no physical change in any aspect of sex, except that he is unable to impregnate. Ninety-five percent of the fluid of the ejaculate issues from the prostate gland and seminal vesicles. At the time of ejaculation, normally, sperm are pumped from the epididymis, through the vas deferens, and up to the area of the ejaculatory duct at the base of the penis. There is very little fluid carrying the sperm to the ejacultory duct. Most of what constitutes the ejaculatory fluid meets the sperm at the ejaculatory duct and literally carries the sperm out, propelled with force from the penis. When the vas deferens is interrupted by vasectomy, none of this changes except that sperm never arrive at the ejaculatory duct. The ejaculation otherwise functions as though nothing were different.

The testicles produce testosterone, which continues to provide the men with their sex drive and secondary sex characteristics such as a beard, low voice, increased musculature, higher red blood cell count, increased facial oiliness compared to women, and, even to some extent, aggressiveness. Hormone levels in the blood are unaffected by vasectomy because the hormones are released directly into the bloodstream.

II. REVERSIBILITY OF VASECTOMY

Vasectomy has been considered irreversible in the past because of the difficulty of reuniting the tiny, delicate, inner canal, which is about 1/70 in. in diameter, or smaller than a period on this page. However, with microsurgical techniques, vasectomy can now usually be reversed. Unfortunately, the reversal operation is very intricate because after vasectomy the tiny amount of fluid that carries sperm from the testicles begins to accumulate in the vas deferens. The pressure from this accumulation is not felt at all because the canal is very small. However, pressure does build up, and sperm that otherwise would have been ejaculated instead stagnate and die of old age (the longevity of the sperm in the vas deferens is about 2 weeks to a month). The sperm then gradually decompose. Fluid and sperm accumulate in the epididymis, the tiny, coiled, delicate 20-ft-long tubule that carries sperm out of the testicle into the vas deferens.

Although the amount of fluid from the testicle is tiny compared to the volume of the ejaculate, the pressure that builds up eventually results in microscopic ruptures or "blowouts" in this delicate epididymal duct, causing blockage in that region. Thus, in time sperm can no longer even get to the vas deferens. With extremely refined microsurgical techniques, the damage in this area can be bypassed and the success rate for reversal of vasectomy can still be good. However, the technique is difficult. Thus, vasectomy, for practical purposes, still has to be considered a potentially permanent procedure unless it is performed in such a way as to prevent pressure buildup. Thus, vasectomy should still not be encouraged for those who do not wish permanent sterilization.

III. TECHNIQUE OF VASECTOMY

Vasectomy is a very simple procedure. It is performed in the doctor's office using local anesthesia only. It is much less painful than a simple dental extraction. The surgery requires only 10 min, although somewhat more time may be needed for vari-

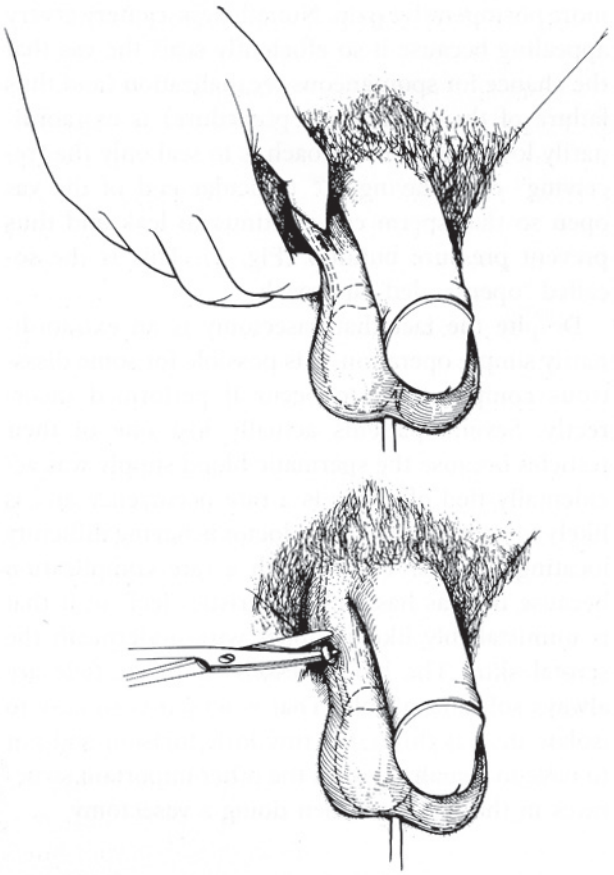

FIGURE 1 (A) Vasectomy incision (feeling vas under skin). (B) Freeing up vas through tiny incision.

ous preparations, such as washing and shaving the scrotum. The incisions are in the scrotum (not on the penis) and generally are only 1/8 in. long. They will hardly be visible postoperatively. The patient will generally feel pain for about 3 sec on each side when the local anesthetic is first injected.

The surgeon will feel the vas between his or her thumb and forefinger and then inject local anesthesia over the area of scrotal skin under which the vas is lying. The vas can be mobilized painlessly by the surgeon's fingers to any area of scrotal skin where he or she wishes to make the incision. Once the local anesthesia has been injected and the area is numb, the surgeon then clamps the vas deferens to the scrotal skin. This secures it just underneath the skin in that particular region where the anesthesia was injected.

A $\frac{1}{8}$-in. incision is then made just over the vas. The tiny incision goes through multiple layers of connective tissue that have all been squeezed between the vas and the scrotal skin by the clamp. The surgeon knows he or she has reached the surface of the vas deferens when these layers of "shiny" connective tissue are no longer seen and then he or she sees the more "dull" surface of the vas deferens. The physician then grasps the vas deferens through this incision with another tiny clamp, which allows him or her to pull it right out of the tiny incision (Fig. 1). The surgeon then either divides the vas with a scissors or cuts a piece of it out. The reason for removing a piece of vas is to ensure a large enough space between the two cut ends so they are less likely to heal together spontaneously and risk sperm getting through to the other side. The gap created by removing a large area of vas at the time of vasectomy can always be bridged during a reversal operation. Other considerations are more important regarding the issue of making vasectomy easily reversible, mainly preventing pressure buildup. Of course, a large area of vas need not be removed, but often it is; if so, reversibility should not be a problem.

If the vas were simply cut and nothing further done, sperm would continue to leak out of the end of the vas coming from the testicle and form an inflammatory cluster of scar tissue known as a sperm granuloma.

A better way to prevent this spontaneous "recanalization" is to seal the ends of the vas properly. In the late 1960s and early 1970s, when vasectomy was beginning to surge in popularity, the two ends of the vas were sealed simply by tying surgical thread around each end. This probably is the least effective way of sealing the vas. The problem is that when the surgical thread, or suture, is tied, the stump on the other side of the tie loses its blood supply, dies, withers away, and then sperm begin once again to leak out of the stump. This problem was not at first appreciated by surgeons because this method has been used successfully for a hundred years to occlude blood vessels. However, from the mid-1970s to the mid-1980s, another method of sealing the vas, cautery, became more popular because it was much more reliable.

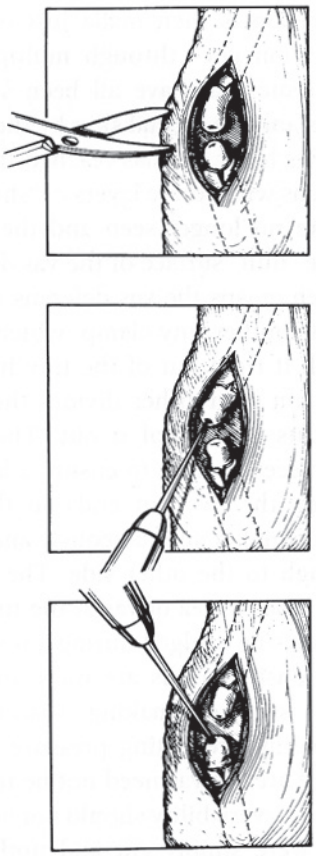

FIGURE 2 (Top) Cutting vas. (Middle) Cauterizing vas side toward ejaculatory duct only (open-ended). (Bottom) Cauterizing testicular end of vas and vas side (close-ended).

Cautery simply means burning. When the vas is cut, a little wire (or needle electrode) is slipped into the opening down a distance of about one-half inch into the vas canal. A button is pressed and the wire heats up, thus burning the delicate mucosal lining but leaving the outer musculature of the vas unburned. The inside of the vas becomes sealed solidly and does not allow sperm to leak.

The only problem with cautery is that it is "too good." Since its widespread adoption, there has been a much greater (and earlier) increase of pressure on the testicular side of the vas deferens after vasectomy. This has resulted in an earlier occurrence of blowouts in the more delicate epididymal duct near the testicle. Thus, much more difficult microsurgery must be performed to reverse this type of vasectomy. This greater pressure buildup from cautery also causes more postoperative pain. Nonetheless, cautery is very appealing because it so efficiently seals the vas that the chance for spontaneous recanalization (and thus failure of the sterilization procedure) is extraordinarily low. Another approach is to seal only the "receiving" end, leaving the testicular end of the vas open so that sperm can continue to leak and thus prevent pressure buildup (Fig. 2). This is the so-called "open-ended" approach.

Despite the fact that vasectomy is an extraordinarily simple operation, it is possible for some disastrous complications to occur if performed incorrectly. Several patients actually lost one of their testicles because the spermatic blood supply was accidentally tied off. This is a rare occurrence and is likely to happen only if the doctor is having difficulty locating the vas. This is such a rare complication because the vas has a characteristic "feel" to it that is unmistakably like a copper wire underneath the scrotal skin. The blood vessels to the testicle are always soft and pliable. That is why it is so easy to isolate the vas through a tiny little incision and not to have to visualize any of the other important structures in the scrotum when doing a vasectomy.

IV. DISAPPEARANCE TIME OF SPERM (AND RISK OF REAPPEARANCE)

The first ejaculate after vasectomy will normally have a sperm count of about 35% of what it was before the vasectomy. The next ejaculate after that will have a sperm count of about 35% of the previous ejaculate. After about 10–12 ejaculations there should be close to zero sperm in the ejaculate. For example, if one started with an average count of about 60 million per cubic centimeter, the first ejaculate after vasectomy would have a sperm count of about 21 million cm^2. The second ejaculate after vasectomy would have a sperm count of about 7 million cm^2. The third ejaculate after vasectomy would have a count of about 2.5 million sperm cm^2. The fourth ejaculate would have about 900,000 sperm cm^2. By the 10th to 12th ejaculate, it would be approaching zero. If spontaneous recanalization has not occurred by the 12th ejaculate, the vast ma-

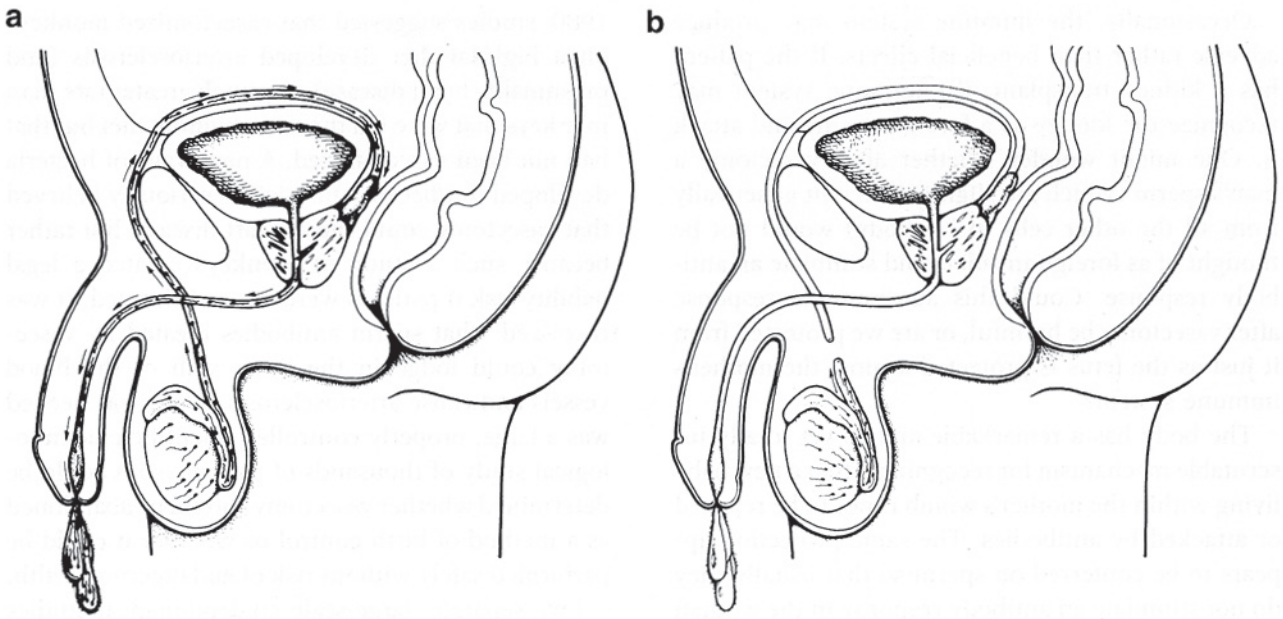

FIGURE 3 (Top) Before vasectomy. (Bottom) After vasectomy.

jority of patients no longer have any sperm whatsoever in their ejaculate (Fig. 3).

V. POSTOPERATIVE COMPLICATIONS

A. Scrotal Swelling

The most terrifying-looking complication after vasectomy is a swollen scrotum, or "hematoma." Because the vasectomy is performed through a tiny incision, in most cases there will be virtually no sign of any surgery having been performed. However, if one is unfortunate enough to have a hematoma, the scrotum will swell up to the size of a grapefruit or possibly even a football. Despite the grim appearance, it is eventually harmless and will heal with no residual problems, but very slowly.

The scrotal tissue is unique compared to that of any other part of the body. It is loose and incredibly expandable. In most areas of the body, the rigidity of the tissue itself stops the bleeding and minimizes the swelling. In the scrotum the tiniest little "bleeder" that would be inconsequential in many other parts of the body keeps on bleeding, and the scrotum keeps on expanding as it fills with as much as a pint of blood.

Despite the painful image that a scrotal hematoma presents, it is truly not a dangerous complication and, if left alone, it eventually will resolve completely over the next 3 months, and the scrotum and testicles will look and feel normal.

What can the doctor do to minimize this risk? He or she should be a good technical surgeon and should make sure to stop all bleeders. The doctor should not put the patient on pain killers such as aspirin that act as anticoagulants. He or she should leave the tiny incision in the scrotum open because if the little incision is closed with a stitch, there is no escape route for blood to drain if bleeding should develop.

B. Sperm Antibodies

There has been a great deal of publicity about the so-called "autoimmune" consequences of vasectomy.

Autoimmune diseases are common. They occur when an immune response to something foreign creates a peculiar type of chronic allergic reaction, and the antibodies so produced actually damage one's own tissue.

Occasionally, the immune system may produce adverse rather than beneficial effects. If the patient has a kidney transplant, the immune system may recognize the kidney as a foreign enemy and attack it. One might wonder whether after vasectomy a man's sperm (which are slightly different genetically from all the other cells in his body) would not be thought of as foreign invaders and stimulate an antibody response. Could this autoimmune response after vasectomy be harmful, or are we protected from it just as the fetus is protected against the mother's immune system?

The body has a remarkable and as yet totally inscrutable mechanism for recognizing that a new baby living within the mother's womb is not to be rejected or attacked by antibodies. The same protection appears to be conferred on sperm so that usually they do not stimulate an antibody response in the woman with each episode of intercourse.

How sure can we be that the rare case of illness occurring after vasectomy might not in truth be caused by it? The only way to find the answer is to have large-scale population studies involving hundreds of thousands of people, some of whom have been vasectomized and some of whom have not, to see whether there is any difference in their health. There is no cause for alarm if a percentage of men get arthritis or heart attacks after their vasectomy if the same percentage of men get arthritis or heart attacks after they start using a condom. The fact that a man may have had a vasectomy prior to developing a health problem does not mean that the vasectomy caused it. Rather, it simply means that a certain percentage of men in any population at any time, whether or not they have had a vasectomy, are going to develop heart disease, arthritis, or other diseases.

About one-half to two-thirds of men will develop sperm antibodies following vasectomy. Widespread publicity concerning this finding created almost hysterical fears that vasectomized men would not only develop autoimmune disease but also have no possibility for restoration of fertility. Both of those notions have been disproven. We can return fertility to the great majority of men who have had a vasectomy, and epidemiological studies have proven that vasectomy results in no autoimmune disease such as arthritis. What about the monkey scare? In 1978 and in 1980, studies suggested that vasectomized monkeys on a high-fat diet developed arteriosclerosis (and presumably heart disease) at a much greater rate than monkeys that were fed the same high-fat diet but that had not been vasectomized. A new wave of hysteria developed not because physicians seriously believed that vasectomy could cause heart disease, but rather because such a study in monkeys created a legal liability risk if patients were not so informed. It was theorized that sperm antibodies created by vasectomy could lodge in the inner wall of the blood vessels and cause arteriosclerosis. What was needed was a large, properly controlled scientific epidemiological study of thousands of patients so it could be determined whether vasectomy should be abandoned as a method of birth control or whether it could be performed safely without risk of endangering health.

Five separate, large-scale epidemiological studies were undertaken. The results showed that vasectomized men had absolutely no increased risk of heart disease, arteriosclerosis, strokes, arthritis, or any other major health disorder. Why did those monkeys get sick? One possibility is that monkeys may be different from humans. The other possibility is that these monkey studies were done with very small numbers, and since the "control" monkeys were not randomly alternated with the vasectomized monkeys to ensure that all other factors were the same, it could very well be that the vasectomized group was at greater risk for other reasons, such as diet or even lifestyle in the cage.

C. Failure of Vasectomy

The major risk of vasectomy is, of course, that it will fail. If there is even a small number of sperm in the ejaculate, there is a risk of pregnancy, and so the operation has failed unless it reduces the sperm count absolutely and unquestionably to zero. Urologists are literally terrified of this complication. It is the largest single cause of lawsuits against urologists, particularly if a defective child is born as a result. This is the so-called "wrongful birth" lawsuit.

The major cause of failure is that sperm manage to leak out of the testicular end of the vas and grind their way through the small amount of scar tissue to get to the other side. When it occurs, this "sponta-

neous recanalization" almost always happens within 6 months after vasectomy. Different vasectomy techniques have different rates of recanalization. For example, if the doctor simply cuts the vas and ties it off with a suture, 3% of the patients will still have sperm postoperatvely because of recanalization. If the doctor takes out a large segment of vas; adding space between the two cut ends will reduce the risk of recanalization to <0.5%. If the doctor seals the inside opening of the vas by burning it with an electrocautery needle rather than "tying it off," this is much more secure and leads to a recanalization rate of <1/1000. Therefore, the recommended approach to having permanent sterilization with no spontaneous recanalization is to seal the inside of the vas with cautery, with no need to remove a large section.

VI. OPEN-ENDED VERSUS CONVENTIONAL VASECTOMY

There are two reasons to perform an open-ended vasectomy. One is to reduce the occasional risk of long-term aching scrotal pain caused by the inevitable pressure buildup that occurs after regular vasectomy. The other is to increase the ease of subsequent reversibility.

The continual production of fluid from the testicle, with no place to escape, causes a gradual pressure buildup within the vas and the microscopic epididymal tubule. Eventually, there are blowouts and perforations in this delicate epididymal tubule, and this relieves some of the pressure. It is this dilatation and "blowing up" of the epididymis that results in the mild but aggravating pain that occasionally bothers a small percentage of men who have had a vasectomy.

Epididymitis (i.e., inflammation and dilation of the epididymis) occurs in virtually every patient who undergoes vasectomy but usually produces no symptoms. Pain from epididymitis occurs in only about 8% of patients. In a very small percentage of these men the discomfort can be extremely irritating and aggravating.

Vasectomy produces no change in hormone or sperm production of the testicle. The testicle continues to produce fluid and sperm that are transferred into the epididymis and from there into the vas deferens, which is now completely blocked and unable to let any of the fluid out. The question should not be why a small number of patients have pain after vasectomy, but rather why everybody does not have constant, chronic pain after vasectomy.

The reason is that with complete blockage, the tubules of the epididymis dilate quickly, and the muscle wall thins out. As it becomes thinned out and more able to expand, there is less pain from pressure within it. The initial pain is masked by the pain that the patient feels because of the surgery, and within a week the epididymis has dilated so much that it no longer hurts. However, for 8% of the patients it does hurt.

What exactly is a sperm granuloma? It is a lump at the vasectomy site caused by sperm leakage. More than 15 years ago, sperm granuloma occurred in 33% of men after vasectomy. It represents continual sperm leakage at the vasectomy site, thus preventing pressure buildup in the epididymis. If leakage at the vasectomy site were ever to stop, the sperm granuloma would disappear within weeks. The presence of this lump at the vasectomy site does not represent a permanent glob of scar tissue but rather a dynamic pressure-releasing valve. It was present in literally millions of men who had vasectomies in the 1960s and 1970s when the vasectomy was performed with suture only. Over the past 20–40 years these granulomas have caused no harm.

Why did sperm granulomas occur more frequently in vasectomies performed with older techniques than they do now? The common technique in the past was to divide the vas and put a tie of surgical string, or suture, around each end. This tie was meant to seal the two ends of the vas to prevent sperm from leaking out of the testicular side. In case sperm did manage to leak out of the testicular side, the tie on the other side would prevent the sperm from getting into the end of the vas going toward the ejaculate. However, this method of sealing the vas proved to be very poor. Once the vas is tied off, there is no longer a blood supply going to the stub of vas on the other side of the tie. Thus, the little stub on the other side of the tie withers away and falls off, leaving behind a raw end of vas that is able to leak sperm freely. The modern method of sealing the vas with cautery burns the lining of the canal so that it fills

up solidly with scar, forming a permanent block. Using this technique, sperm granulomas almost never occur.

The presence of sperm leakage at the vasectomy site does not increase the likelihood of having sperm antibodies. The incidence of sperm antibodies in patients with or without sperm granuloma is about the same. This is because once one has a vasectomy, one physically must have sperm leakage somewhere. The leakage is going to occur either at the vasectomy site, forming the sperm granuloma, or from blowouts in the epididymis. Therefore, no matter how one does the vasectomy, the risk of formation of sperm antibodies is the same.

In summary, a sperm granuloma represents a continual tiny leakage of sperm from the vasectomy site that protects against pressure buildup that would automatically occur after vasectomy. The presence of a sperm granuloma would result in a decreased risk of pain from pressure buildup and would make subsequent reversal of vasectomy much easier to perform.

VII. REVERSAL OF VASECTOMY

For reversal of vasectomy, obstruction is either at the site of the vas reconnection (vasovasostomy) or in the epididymis from blowouts that have been caused by the pressure buildup. If the patient has obstruction at both sites, then reconnection of the vas deferens alone would not restore fertility.

The length of vas removed at the time of vasectomy and the area of vas that was cut should have no effect on success rate. If a large segment of vas has been removed, the gap can be bridged by making the incision larger and freeing up a large enough segment of vas. The success rate should not be any lower in cases in which large portions of the vas have been removed.

In patients undergoing vasectomy reversal with no damage in the epididymis, more than 98% have adequate postoperative sperm counts, and 88% are able to eventually impregnate their wives. This statistic is not significantly different from a normal population of couples trying to get pregnant. The results are certainly not as good when there is epididymal damage. Of patients who have had previous failures of vasectomy reversal who come to our clinic for reoperation, 81% have impregnated their wives. Many of these patients impregnate their wives with a moderately low sperm count.

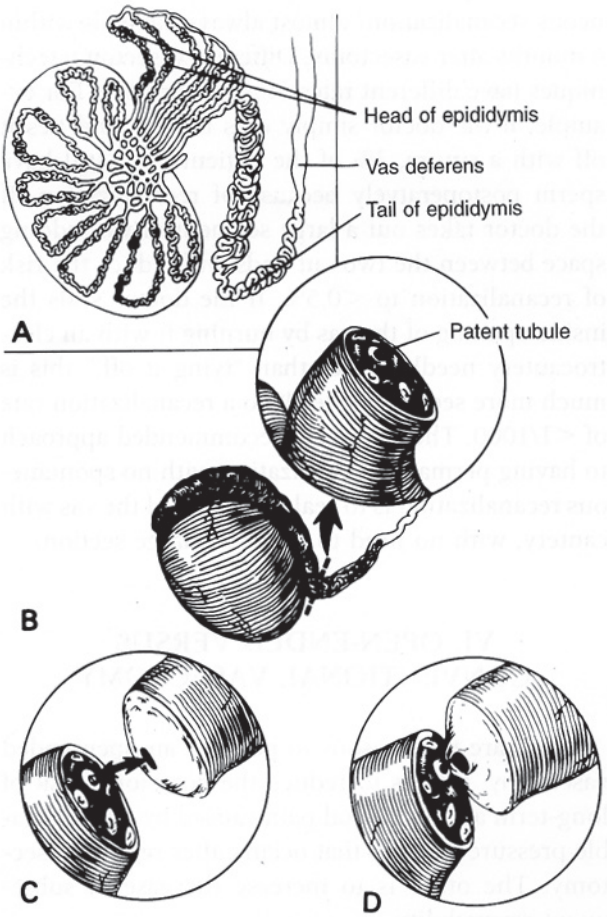

FIGURE 4 Reversal of vasectomy.

To reestablish fertility after vasectomy, the tiny, delicate duct must be microsurgically reconnected with extreme accuracy. If there are epididymal blowouts causing blockage in the ductwork closer to the testicle, the operation becomes 10 times more difficult (Fig. 4). The delicate wall of the epididymis is a thin, filmy membrane $\frac{1}{1000}$ in. thick. The diameter is $\frac{1}{300}$ in., or roughly one-third the size of a pinpoint. If there is blockage in the epididymis caused by pressure-induced blowouts, the vas deferens must be microsurgically reconnected to this much more delicate epididymis, bypassing the blowouts. This

means stitching together a $\frac{1}{1000}$-in.-thick tubule. With this sort of very fine microsurgery, most vasectomies can be reversed, despite the secondary epididymal obstruction.

See Also the Following Articles

CONTRACEPTIVE METHODS AND DEVICES, MALE; EPIDIDYMIS; FAMILY PLANNING; FEMALE STERILIZATION

Bibliography

Silber, S. J. (1978). Vasectomy and vasectomy reversal. *Fertil. Steril. Mod. Trends* **29**, 125–140.

Silber, S. J. (1979a). Epididymal extravasation following vasectomy as a cause for failure of vasectomy reversal. *Fertil. Steril.* **31**, 3098–3015.

Silber, S. J. (1979b). Open-ended vasectomy, sperm granuloma, and postvasectomy orchialgia. *Fertil. Steril.* **32**, 546–550.

Silber, S. J. (1980). *How to Get Pregnant*. Scribner, New York.

Silber, S. J. (1987). *How Not to Get Pregnant*. Warner, New York.

Silber, S. J. (1989a). Pregnancy after vasovasostomy for vasectomy reversal: A study of factors affecting long-term return of fertility in 282 patients followed for 10 years. *Hum. Reprod.* **4**, 318–322.

Silber, S. J. (1989b). Results of microsurgical vasoepididymostomy: Role of epididymis in sperm maturation. *Hum. Reprod.* **4**, 298–303.

Silber, S. J. (1991). *How to Get Pregnant with the New Technology*. Warner, New York.

Vitellogenins and Vitellogenesis

Gary J. LaFleur, Jr.

Brown University

The increase in size of egg-laying (oviparous) animals has long been a simple indicator of reproductive health. On a molecular scale, most of this size increase is due to an increase of yolk content in growing oocytes. Thus, the formation of yolk or vitellogenesis represents one of those physiological processes that was likely to have been studied since the earliest days of biological observation, even before recorded time. As early as 300 BC it was realized that the yolk of an egg was not part of the embryo proper but rather acted as nourishment for the developing embryo. Aristotle (as quoted in Peck, 1990) offered the following insight while considering the differences in viviparous and oviparous transfer of nutrition to embryos:

> The nourishment for the young of viviparous animals, what we call milk, is formed in breasts, a different part of the body altogether; but for birds Nature provides this inside their eggs.... It is not the white of the egg that is the milk, but the yolk, because it is the yolk that is the nourishment for the chicks. (p. 287)

It was not until 21 centuries later that the mechanisms responsible for yolk formation were begun to be truly understood. In recent years vitellogenesis has received attention both from researchers interested in yolk formation per se and from researchers who have chosen vitellogenesis as a model system to study other biological processes, such as protein evolution, hormonal regulation of transcription and translation, and receptor-mediated endocytosis.