Endocrine, *vol. 23, nos. 2–3, 161–165, March–April 2004* 0969–711X/04/23:161–165/$25.00

Surgical Management of Erectile Dysfunction

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Since the introduction of sildenafil citrate, oral systemic therapy has become the first line of therapy for men with erectile dysfunction (ED). Men who are not candidates for or who fail treatment with an oral agent may choose second-line therapies such as intraurethral prostaglandins, penile injection therapy, sex therapy, or a vacuum erection device. These second-line therapies may be unpalatable or inadequate for some men, and these men constitute the candidates for surgical intervention for ED. This article reviews surgical management of vascular ED, surgical management of Peyronie's disease, and penile prosthesis implantation. At the current time, the appropriate candidate for penile revascularization is a young man with proven arterial insufficiency resulting from pelvic trauma. Results in other populations are disappointing. Peyronie's disease with curvature significant enough to interfere with intercourse may be managed with tunical lengthening or shortening procedures in potent men and with prosthetic implantation in men with ED. Modern three-piece penile prostheses are associated with excellent device reliability, high rates of patient satisfaction, and acceptably low complication rates.

Key Words: Sildenafil citrate; erectile dysfunction; Peyronie's disease; penile prostheses.

Introduction

The advent of sildenafil citrate (Viagra™) has revolutionized the management of erectile dysfunction (ED). Since the introduction of sildenafil citrate in 1998, oral systemic therapy has become the first line of therapy for men with ED. Men who are not candidates for or who fail treatment with an oral agent may select second-line therapies such as intraurethral prostaglandins, penile injection therapy, sex therapy, or a vacuum erection device. These second-line therapies are unpleasant or inadequate for some patients, and such patients are therefore the candidates for surgical intervention for ED.

Received September 15, 2003; Revised November 14, 2003; Accepted November 14, 2003.

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This chapter reviews the surgical management of ED including the implantation of penile prostheses, surgical management of Peyronie's disease, and surgical treatment of vascular ED.

Penile Prostheses

Device Selection

The ideal penile prosthesis would approximate the functional human penis as closely as possible. It would be completely flaccid in the nonerect state and expand in both length and girth in the erect state. The ability to achieve these qualities as well as maintain mechanical reliability are the key criteria involved in choosing a penile prosthesis. Prostheses may be categorized as rod or inflatable; inflatable prostheses may be one-, two-, or three-piece devices *(1)*.

Rod Prostheses

Rod prostheses consist of paired solid cylinders that are surgically implanted into the corpora cavernosa. These devices are associated with very low mechanical failure rates and are relatively easy to implant. Inasmuch as they are nonexpanding, they do not approximate normal flaccidity and are associated with an increased risk for device erosion. For these reasons, inflatable prostheses remain significantly more popular.

Inflatable Prostheses

One-Piece Device. One-piece prostheses are hydraulic devices that are implanted into the corpora cavernosa. These devices approximate flaccidity and erection somewhat better than the rod prostheses. However, they are associated with relatively high rates of mechanical failure. In 1996, Wilson et al. *(2)* reviewed the results of 295 patients with self-contained prostheses (Hydroflex and Dynaflex, one-piece prostheses manufactured by American Medical Systems [AMS]) and 1026 with multicomponent inflatable devices for up to 8 yr. They found that multicomponent inflatable prostheses were superior regarding mechanical reliability and patient satisfaction, with no differences in rates of infection. One-piece prostheses are no longer available in the United States.

Two-Piece Device. Two-piece prostheses have paired corporal cylinders connected to a scrotal pump. With the Ambicor prosthesis (AMS), the fluid "reservoir" is located in the proximal compartment of the cylinders and the scrotal pump serves to transfer fluid to the distal portion. The Mark II prosthesis (Mentor) contains a scrotal unit that func-

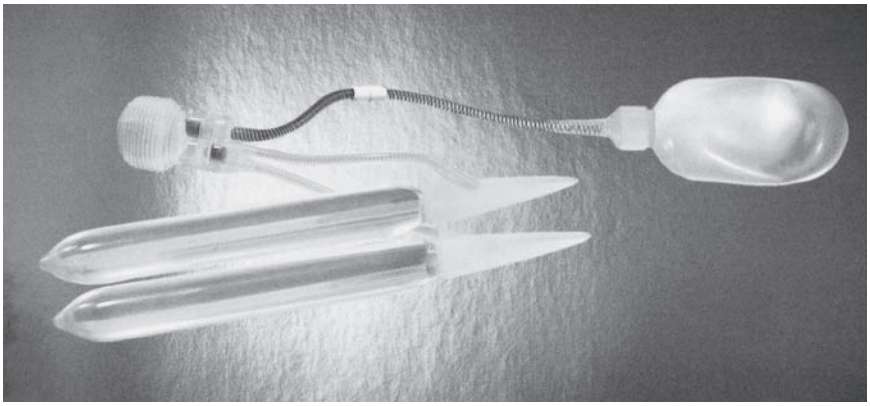

Fig. 1. Mentor Alpha I inflatable penile prosthesis.

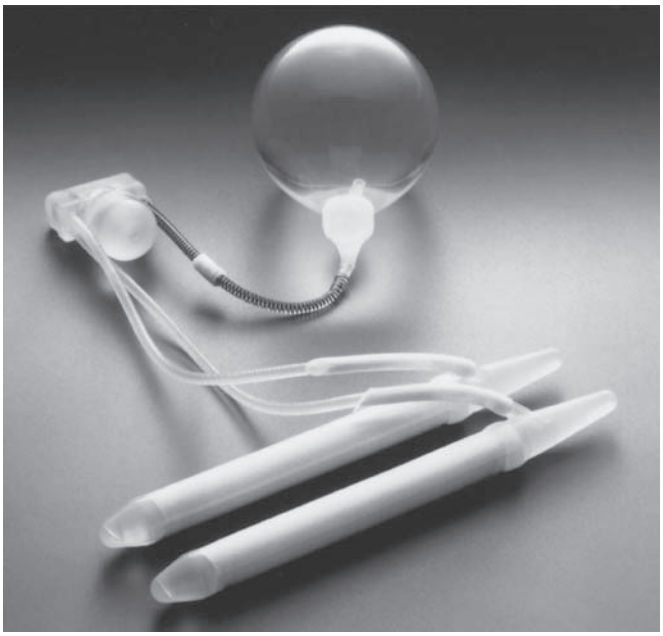

Fig. 2. AMS Ultrex inflatable penile prosthesis.

tions as both a pump and a reservoir. The scrotal device holds 25 mL. The chief advantage of these devices (compared with the three-piece devices) is that they avoid entry into the pelvic cavity. This may be of benefit in patients who have had multiple lower abdominal surgical procedures, particularly vascular surgery in which there may be grafts crossing the implant site (femoral-femoral bypass). In general, these devices do not have the capability of moving large amounts of fluid to and from the cylinders, and, therefore, the difference between the flaccid and erect state cannot be as great as with the three-piece devices. The Mentor Mark II two-piece inflatable prosthesis is currently not available.

Three-Piece Device. Three-piece prostheses consist of paired corporal cylinders, a scrotal pump, and a large volume reservoir that is implanted into the abdomen. The pump transfers fluid from the reservoir to the cylinders to achieve an erect state. Of all currently available devices, these most closely approach the functioning penis with respect to flaccidity and erection. Currently available three-piece devices include the Mentor Alpha I (Fig. 1), the Mentor Alpha I Narrow-base, the Mentor Titan,™ the AMS 700CX, and the AMS 700CXM. The AMS 700CXM is a smaller version of the 700CX. Because of the large volume of fluid that is stored in the reservoir available for transfer to the cylinders, these cylinders exhibit significant girth expansion.

However, the nondiseased penis expands in both length and girth. In 1990, AMS produced the Ultrex penile prosthesis (Fig. 2), a three-piece prosthesis with both length and girth expansion. The AMS CX cylinders consist of three layers, with the middle layer controlling only girth expansion. With the Ultrex cylinders, the middle layer is converted from a unidirectional weave to a bidirectional weave, thereby permitting both length and girth expansion. Unfortunately, the early Ultrex cylinders were associated with less mechanical reliability. We previously reported 5-yr Kaplan-Meier cylinder survival estimates of 79.7% for the Ultrex cylinders, compared with 92.4% for the CX/CXM cylinders ($p = 0.0292$) *(3)*. In 1993, the cylinders were modified with subsequent improvement in mechanical reliability. A recent analysis found that the 5-yr Kaplan-Meier cylinder survival rates were 80.2% for the premodification devices and 96.2% for the postmodification devices *(4)*. The survival rate of the postmodification cylinder is similar to that of the other available three-piece devices. Because of this equivalence in mechanical reliability and length and girth expansion, we favor the Ultrex prosthesis for most first-time implantations. Exceptions include men with Peyronie's disease *(5)*, men with significant fibrosis, and men with very long penises. For secondary implantation, we use the Ultrex device if the preoperative physical examination reveals a 2-cm or more difference between nonstretched and stretched penile lengths *(4)*.

Implantation

Three-piece inflatable penile prostheses may be inserted via a penoscrotal or an infrapubic approach. The chief advantage of the latter approach is that it allows for reservoir placement under direct vision. However, this approach allows limited exposure of the corpora cavernosa and may be associated with dorsal nerve injury, especially during revision procedures *(1)*. For these reasons, we favor a penoscrotal approach. A transverse penoscrotal incision is used to access the corpora cavernosa. The paired cylinders are placed through 2-cm corporotomies. Via the same incision, the scrotal pump is placed in a midline subdartos pouch between the testes. In most cases, the abdominal reservoir may be safely placed via the same incision. The reservoir is positioned deep to the transversalis fascia in the retropubic space. In the case of the patient with prior bilateral lower abdominal surgeries, it may be prudent to render a second incision in the lower abdomen and place the reservoir under direct vision. The Mentor reservoirs include a Lock-out™ valve, which is intended to minimize autoinflation of the prosthesis with increases in intraabdominal pressure. We believe that autoinflation is frequently a consequence of overfilling the reservoir and may be minimized by applying pressure to the lower abdomen prior to securing the final attachments of the reservoir, thereby releasing excess fluid. For the interested reader, details of the implantation may be found elsewhere *(1)*.

Outcomes

Inflatable penile prostheses were first introduced in 1973 and early devices were associated with high (62%) 5-yr malfunction rates *(6)*. With the introduction of the controlled expansion cylinders in 1986, device malfunction rates dropped to 5–15% *(6)*. A recent, large multicenter study found a 5-yr mechanical reliability for the AMS 700CX device of 86% *(7)*. Most contemporary studies have demonstrated long-term device survival for three-piece devices ranging from 85 to 95% *(8–10)*. Patient satisfaction is usually high, with most studies reporting 80–90% satisfaction rates *(4,7,11)*. In our experience, the most common reason for dissatisfaction is disappointment with penile length. Most men receiving a penile prosthesis report that their penile length is shorter than it was when they had functional erections. We believe that it is critically important to detail this during the informed consent discussion prior to implantation of the prosthesis.

Complications

Aside from device failure, the most common complication of penile prosthesis implantation is infection. In large series, overall infection rates range from 1 to 4% *(7,8,11)*. Infection rates may be as much as seven times higher with redo implantation *(12)*. There are conflicting data regarding diabetics and increased risk for infection, with some studies showing a greater risk and others showing no increased risk *(13–16)*.

In at least one-third of infections, *Staphylococcus epidermidis* is the causative organism *(17,18)*. Most infections are presumed to be acquired at the time of surgery and are diagnosed within several months of the surgery. The classic management of device infections is explantation with staged reimplantation at a later time if the patient remains a candidate and chooses reimplantation. Mulcahy *(19)* has pioneered the salvage operation for an infected device in which explantation and reimplantation are performed at the same time. In appropriately selected patients, success rates of 82% have been reported *(19)*. This approach minimizes the significant fibrosis of the corpora cavernosa that occurs following device explantation for infection.

In an attempt to further minimize the infection rate, AMS recently released penile prostheses coated with InhibiZone™, a surface impregnation of minocyclin and rifampin. Mentor has also introduced Resist™, a hydrophilic coating for its penile prosthesis that may prolong the effect of intraoperative antibiotics. To date, no randomized controlled trials of these coated and noncoated devices have been published.

The subject of prosthetic infections has been exhaustively reviewed elsewhere *(20)*. Other complications of penile prosthesis implantation include erosion, migration, pain, device malfunction, and curvature/aneurysm of the shaft.

Peyronie's Disease

Fibrous plaques within the tunica albuginea of the corpora cavernosa characterize Peyronie's disease. While these plaques may initially be associated with pain, the most significant potential sequella is penile curvature with erections and, in some men, inability to obtain erections. Medical management of Peyronie's disease has been well detailed elsewhere; this section focuses on surgical management *(21)*.

For patients with significant ED in addition to penile curvature, the treatment of choice is implantation of a penile prosthesis. As already mentioned, the non-length-expanding cylinders (700CX, 700CXM, and the Alpha I) are preferred for this indication. For men with significant plaques, a modeling procedure may be performed during implantation *(22)*. In our experience, tunical plaques are usually amenable to fracture over an inflated cylinder at the time of implantation. In the rare case of plaques that are not amenable to fracture, implantation of a penile prosthesis may be combined with plaque incision and grafting (see below).

Patients with adequate erectile function but significant curvature may be best served by surgical treatment targeted to the plaques. These surgeries can be broadly divided into two categories: tunical shortening procedures ("shortening the long side") and tunical lengthening procedures ("lengthening the short side"). In either case, careful preoperative assessment of erectile function and counseling to avoid unrealistic expectations are essential. We instruct patients to provide us with Polaroid or digital pictures of the erect penis to confirm the presence of adequate erectile function

and independently assess the degree and location of the curvature.

Tunical shortening procedures involve shortening of the tunica albuginea on the convex side of the penis, opposite the plaque. This is a reasonable consideration in men with adequate penile length. The procedure may be performed by excising an ellipse of tunica (Nesbit procedure) or by incising the tunica albuginea in a vertical direction and closing the incision in a horizontal fashion. Good results with these procedures have been reported in 80–95% of patients *(21)*. Alternatively, the tunica albuginea may be plicated on the convex side of the penis without incising the tunica albuginea. Gholami and Lue *(23)* reported their results in 132 patients who underwent plication in such a fashion. Ninety-three percent of the patients reported straight erections and 7% reported almost straight erections at 6 mo. With a mean follow-up of 2.6 yr, 15% of patients reported recurrent curvature. Only 4% of the patients reported worsening erectile function following the procedure.

Men with marginal penile length may be better served by tunical lengthening procedures. These procedures involve either excision or incision of the plaque with grafting. Available graft materials include saphenous vein, autologous fascia or dermis, cadaveric tissue such as pericardium, and synthetic materials such as Gore-Tex. Plaque excisions have been associated with higher rates of ED and graft contracture with subsequent recurrence of the curvature. For these reasons, plaque incision has become more popular. In one of the largest series to date, El-Sakka et al. *(24)* reported a 96% technical success rate (defined as straight erections) with a 12% decrease in potency in 113 patients undergoing plaque incision with saphenous vein graft. Yurkanin et al. *(25)* specifically examined penile length in 22 men before and after plaque incision with grafting and found that mean penile length was increased 2.1 cm. The interested reader is referred to a thorough review of Peyronie's disease *(21)*.

Surgery for Vascular ED

Vascular ED may be subcategorized into arterial insufficiency and venoocclusive disease. In the former, arterial insufficiency results in inadequate blood flow for erectile function. In the latter, the normal venoocclusive mechanism required for the trapping of blood in the corpora cavernosa and subsequent erection does not function.

Arterial revascularization for arterial ED has been well detailed in the literature. The results are poor in unselected men *(26)*. Nonetheless, in young men who suffer traumatic pelvic injuries, acceptable results have been reported *(27)*. In a series of 50 men undergoing microsurgical penile revascularization, with or without a combined procedure to correct cavernosal venous leakage, 48% had "an excellent postoperative result" and an additional 40% were "improved" *(28)*. Revascularization may be performed by anastomosing the inferior epigastric artery to the corpus cavernosum (Michal I), to the dorsal penile artery (Michal II), or to the deep dorsal vein. Numerous other procedures have been described with contemporary success rates ranging from 25 to 80% depending on patient selection *(26)*. Recent evidence suggests that coexisting neural injuries may explain the not insignificant failure rate even in well-selected patients *(29)*.

Venoocclusive disease may be treated with venous ligation; often ligation of the dorsal, cavernous, and crural veins is required. Again, numerous procedures have been described with long-term success rates ranging from 14 to 77%. Similar to arterial insufficiency, careful patient selection may identify a small group of patients who stand to benefit from penile venoocclusive surgery. Excellent reviews of vasculogenic ED are available *(26,30)*.

Conclusion

Sildenafil citrate has revolutionized the treatment of ED. Nonetheless, surgical management of ED remains an important part of the treatment algorithm, particularly for patients failing or ineligible for first- or second-line therapies. At present, the appropriate candidate for penile revascularization is a young man with proven arterial insufficiency resulting from pelvic trauma. Results in other populations are disappointing. Peyronie's disease with curvature significant enough to interfere with intercourse may be managed with tunical lengthening or shortening procedures in potent men and with prosthetic implantation in men with ED. Modern three-piece penile prostheses are associated with excellent device reliability, high rates of patient satisfaction, and acceptably low complication rates.

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