Surgical Therapy of Erectile Dysfunction in Men with Diabetes Mellitus

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1 Introduction

Diabetes mellitus is a metabolic disorder characterized by defect in insulin secretion, insulin action or the combination of both. As a result, the amount of glucose in the blood increases while the tissue cells are starved of energy (Kumar et al., 2004).

This uncontrolled hyperglycemia causes damage to both nerves and blood vessels, leading to serious myriad of complications such as ischemic heart disease, peripheral vascular disease and cerebral vascular disease which may ultimately result in death.

Sexual dysfunction including sexual drive, ejaculatory function and sexual satisfaction is undoubtedly one of the major health problems that impair the quality of life of diabetic patients at physical, psychological and social levels. Those have been well documented in the medical literature since 1978 (McCulloch et al., 1980). Erectile dysfunction (ED) is defined as the inability to achieve and/or maintain sufficient erection satisfactory for sexual intercourse (NIH Consensus Conference, 1993). A fair number of males with Type 2 diabetes may complain of ED at some stage in their lives. ED also tends to occurs at a younger age group in the Type 1 diabetes mellitus (Klein et al., 1996). There have been Substantial epidemiological studies which demonstrated that the odd ratio of developing ED in diabetics is 2–4 times more than the normal population (Lewis, 1996).

The treatment of ED compromises different modalities starting with first and second line measures which are minimally invasive in nature. Third line measures with surgical intervention are saved for patients’ refractory to minimally invasive approaches. The aim of this chapter is to shed light on the pathophysiology of ED in DM followed by discussion of the surgical measures applied in this patient population with special emphasis on penile implants.

2 Pathophysiology of ED in DM

Erectile function in essence results from intricate psychological, neurological, hormonal and vascular interactions. Centrally, coordination of penile erection involves many cerebral and supraspinal transmitters and the details of which remain incompletely understood and by in large have been based upon experimental animal models. Currently many studies are investigating the role of centrally acting drugs for ED particularly patients that are refractory for phosphodiesterase type 5 (PDE-5) inhibitor drugs. Peripherally, erection is triggered either by tactile, visual, olfactory, or imaginary stimuli. The ultimate peripheral response is mediated by coordinated signals from the autonomic and somatic nervous systems to the smooth muscles of the corpora cavernosa in the penis and the striated muscles of the perineum. Blood flow to the penis is controlled by the autonomic erection center, the source of parasympathetic (S2–S4) and sympathetic (T12–L2) input to the pelvic plexus, as well as the cavernous nerves innervating the trabecular smooth muscle (Taub et al., 1993).

The corpora cavernosa smooth muscles are two spongy cylinders which comprise the human penis. The penile muscles are highly specialized vascular structures which surrounds the penile urethra. In addition, the penile urethra traverses another spongy cylinder, the corpus spongiosum muscle at the glans of the penis. The vascular system within the penile tissues work in syncytium so that optimal erection occurs as a result of increased intracavernosal arterial inflow and reduced venous outflow. Those muscles become engorged during sexual activity. Neural stimulation is transmitted through the nervi erigentes, which release three important neurotransmitters: norepinephrine, acetylcholine and nitric oxide (NO).
Penile erection is predominantly mediated by parasympathetic neurotransmitters and NO and to a lesser extent by the other regulatory factors. For tumescence, intracavernosal oxygen and the enzyme NO synthase are both required essentially for the generation of nitric oxide. In turn, NO promotes the formation of cyclic GMP which causes smooth muscle relaxation and vasodilatation in the penile tissues. Sildenafil, Vardenafil and Tadalafil are drugs that act as (PDE-5) inhibitors and are widely used as first line treatment of patients with ED. The reverse is true during detumescence which occurs as a result of cyclic GMP metabolism via intracavernosal type 5 cyclic GMP phosphodiesterase. Norepinephrine pathways also play a lesser role in detumescence (Jeremy et al., 1997).

In DM, the role of NO has a significant therapeutic implication. In fact, suboptimal and low levels of nitric oxide synthase have been found in diabetic patients in addition to testosterone deficiency. Testosterone deficiency results have been implicated in the pathophysiology of ED. Testosterone is critical for, nocturnal erections, libido and the maintenance of intracavernosal nitric oxide synthase activity (Mills et al., 1992; Santen et al., 1973). Hypogonadism has also been associated with ED and diabetes. According to Corona et al. (2004), Hypogonadism was demonstrated in 24.5% of men with diabetes and ED vs. 12.6% in those with ED. Testosterone supplementation in human diabetics with ED receiving pharmacological treatment has been advocated in the diabetics that did not respond to PDE5 inhibitors (Kalinchenko et al., 2003).

On the other spectrum, the pathology of ED in DM is certainly multi-factorial and not solitary in nature. ED is more prevalent than retinopathy or nephropathy (Lehman et al., 1983) in diabetic patients. According to a study by The Massachusetts Male Aging group, up to 75% of diabetic male patients have a predilection lifetime risk for developing ED (Feldman et al., 1994; Metro et al., 1999; Sarica et al., 1994). Moreover, the age of onset of ED in diabetics occurs earlier in those who suffered from diabetes within 10 years from the onset in more than 50% of patients (Whitehead et al., 1990). Interestingly, 12% of type 1 diabetic men had ED as the first diagnostic symptom (Koncz et al., 1970). In the same vein, ED in diabetics could herald fatal cardiovascular disease (Gazzaruso et al., 2004).

In the literature, the most common hypothesized mechanisms for developing ED in DM are as follows (Moore et al., 2006):

1. The impairment of NO synthesis and the reduction of cGMP in diabetes (Costabile et al., 2003).
2. The formation and accumulation of advanced glycation end-products (AGEs) in the corpus cavernosum leading to higher levels of oxygen free radicals and endothelia dysfunction (Cartledge et al., 2001; Costabile et al., 2003; Giuseppe et al., 2006; Sullivan et al., 1997).
3. Increased plasma serum and cavernosal levels of endothelin and the up regulation of endothelin-B receptor binding sites (Singh et al., 2001; Takahashi et al., 1990).
4. GTP-binding protein RhoA/Rho-kinase pathway and ET-1 induced vasoconstriction of the cavernosal smooth muscles (Park et al., 2002; Wang et al., 2002)
5. Autonomic, peripheral and central neuropathy (Agarwal et al., 2003)
6. Deficiency in the cGMP-dependent protein kinase-1 (PKG-1) causing cavernosal smooth muscle relaxation (Chang et al., 2004).

There have been several studies in the literature demonstrating a potential link between poor glycemic control and ED in diabetic patients. The increased levels of Hemoglobin (Hb)A1c has been associated with ED severity (Rhoden et al., 2005a; 2005b). Nevertheless, here have been controversial results exist regarding the beneficial effects of intensive glycemic control on erectile function (Lu et al., 2009).
The current evidence is scarce and many studies have failed to address whether ED would improve with intensive glycemic control. This is due to the fact that the vast majority was not specifically designed to test the hypothesis if intensive glycemic control would improve ED. Hence, this area remains a high priority for future research by utilizing objective questionnaires, large sample size and minimizing confounding factors.

3 Surgical Treatment of ED in DM

Surgical therapy for ED remains the gold standard surgical modality for patient's refractory to first and second line therapies. The surgical treatment with penile prosthesis was first described in the 1930s. Over the years significant developments were made to the prosthetic devices and materials leading to excellent functional and cosmetic results (Kim & Carso, 1993). On the other spectrum, penile arterial revascularization or venous surgery are other surgical treatment modalities for ED which tends to be effective only in a highly selected group of patients, mainly congenital or traumatic in nature and are being performed rarely.

3.1 Arterial Revascularization

Penile arterial bypass surgery was first described in the early 1970s (Michal et al., 1973; 1974), and has undergone many modifications since its early description. The risk factors in penile arterial insufficiency is strongly related to atherosclerosis such as is most frequently the result of general arteriosclerosis as hyperlipidemia, hypertension, cigarette smoking, and diabetes mellitus. The outcome of penile arterial revascularization in patients with such risk factors generally is unsatisfactory. According to the American Urological Association (AUA2005) guidelines, arterial reconstructive surgery could be offered as a treatment option only in healthy individuals with recently acquired ED secondary to a focal arterial occlusion and in the absence of any evidence of generalized vascular disease.

Several tests are available to confirm the diagnose such as Duplex ultrasonography of the penis with injection and stimulation test. In addition, selective penile or pudendal angiongram is essential prior to any surgical reconstruction.

Current surgical techniques for revascularization include anastomosis between the epigastric artery and the dorsal penile artery or the deep dorsal vein (Hauri et al., 1999; Virag et al., 1980). Young patients with arterial insufficiency due to pelvic trauma are generally ideal candidates for such procedures (Goldstein, 1988). Certain centers offer laparoscopic approach to minimize the morbidity and overall the long-term success is in the range of 34-80% spontaneous erections (Lund et al., 1995; Manning et al., 1988).

The commonest complications of the procedures are infection, bleeding, thrombosis of anastomosis and hyperemia in the glans of the penis.

3.2 Venous Surgery

Venogenic cause for ED is considered when sub-optimal erectile response to intracavernosal injection occurs despite a normal arterial response on duplex ultrasonography.

When venous leak is suspected in ED, cavernosometry and cavernosography can be used to delineate its location and the severity (Puyau et al., 1983; Rudnick et al., 1991; Wespes et al., 1986). Venous surgery should be contemplated only when cavernosography demonstrates visual evidence of penile venous leak.
Penile prostheses surgery tends to be more superior to venous surgery as venous surgical ligation has been associated with significant obliterations of arterial inflow in many cases. Hence penile venous surgery has been limited to patients under the age of 50. Venous surgery is relatively contraindicated in diabetics, and in patients refusing to quit smoking. Recognizable complications of venous surgery include numbness of the skin, shortening of penile length, penile curvature and hematoma formation.

The poor prognostic factors that affect the long term outcome and may also explain the high incidence of failure rate include increasing age, duration of ED, multiple leak sites, crural venous leak site, and the existence of arteriogenic insufficiency (Kim et al., 1995; Motiwala et al., 1993).

3.3 Prosthetic Surgery

Penile implants were first introduced to clinical practice almost 30 years ago (Scott et al., 1974; Small et al., 1975). It is estimated that one-third of patients with ED will not respond to contemporary medical treatments such as PDE-5 inhibitors and intracavernosal injection therapy. Moreover, half of the patients with ED have severe and irreversible damage; making those patients ideal candidates for penile prosthesis surgery (Moncada et al., 2004).

Penile prosthesis is an irreversible surgery in the erectile corporal tissues which in essence means that any previous degree of normal physiological erections will be permanently lost. In other words, if there is an indication for the prosthesis to be removed such as infection or mechanical failure; complete ED will ensue.

There are three major classes of penile prosthesis which are semi-rigid, two-piece and three-piece inflatable implants. The semi-rigid prosthetic implants are technically easier to insert and have minimal mechanical failure rate. They are made of two cylinders. Their insertion is indicated in Patients with limited mentation or restricted manual dexterity. However, they are generally inferior to the inflatables; as the penis remains unable to achieve complete rigidity or flaccidity. The semirigids also have higher rate of prosthetic erosions. The two-piece inflatable prostheses have a pair of cylinders connected to a scrotal pump. The prosthesis cylinders are deflated by bending the middle part of the shaft of the penis. These two-piece is disadvantaged by less rigidity than the three-piece and less girth expansion. The two-piece also does not have better flaccidity than the three-piece upon deflation. The three-piece inflatable prosthesis is composed of a pair of cylinders which are implanted in the penis, a pump that is inserted in the scrotum and a reservoir that is placed in the extra peritoneal region of abdomen. The scrotal pump has a small button that allows inflation and deflation of the cylinders.

3.3.1 Inflatable Three-Piece Penile Prosthesis Operation

The insertion of a three-piece penile prosthesis is considered the gold standard and provides the best option for patients due to its optimal rigidity and flaccidity as well as patient satisfaction. Hence in this part of the chapter, we have elected to focus on the surgical techniques and the management of pitfalls that are commonly encountered during the procedure.

Both large and small penises have been best served by the three-piece inflatable implants because semi-rigid and two-piece implants are difficult to conceal in such patients. Preoperative counseling of prospective patients is mandatory about the different methods available for treatment and explanation of how prosthesis works. Patients must be fully informed that any preexisting natural erection will be lost and that the procedure is irreversible. Another important fact that the patient must be aware of is that the length of the fully stretched flaccid penis preoperatively will be the maximal length obtained with a penile prosthesis.
3.3.2 Preoperative Preparations

Diabetic patients with better blood sugar control and HbA1C are less susceptible to infection than those with poorly controlled HbA1C (Bishop et al., 1992). On average, the presence of diabetes increases the infection rate in penile prosthesis from 3 to 8% (Wilson et al., 1998).

Active infection therefore anywhere in the body should be excluded, but especially in urine and skin. Patient should be encouraged to brush the genitalia with strong soaps for few days prior to the procedure. Preoperative antibiotics targeting gram-positive bacteria are recommended before skin incision. In addition, the following are vital:

- Shaving immediately before the procedure
- Alcohol-based skin preparation and a minimum of 10 minutes scrubbing should take place prior to the formal prepping and draping
- Draping for scrotal incision should be with extremity drape and self adhesive special drapes if possible
- Face masks, disposable gowns, and double-gloving are mandatory
- Traffic in and out of the operating room should be minimized and there must be laminar air flow if possible

3.3.3 Special Equipments

- Scott retractor, transverse penile strap, and hook retractors
- Small Deaver or similar retractors
- Brook’s cavernosal dilators or Hegar dilators
- Rosello cavernotomes for cases of corporal fibrosis
- Furlow inserter with Keith needles
- DeBakey forceps and Metzenbaum scissors
- Long-blade nasal speculum
- Absorbable sutures for corporotomy, dartos fascia and skin closures

3.3.4 Surgical Steps

A Foley catheter is first inserted into the urethra and the bladder is emptied. A spigot is applied. A Scott retractor is then placed below the penis. A transverse skin incision is made at the penoscrotal junction. The incision can be modified to an inverted T-shape and extended when better corporal exposure is needed during difficult surgery, e.g., when there is corporal fibrosis (Figure 1). The dartos fascia is exposed and incised. Skin hooks are placed. The tunica albuginea of both corporas are exposed and the urethral catheter is palpated in the midline. This facilitates urethral exposure and minimizes its potential damage. A stab wound is made with a scalpel into each corpora and, using Metzenbaum scissors, a 2-cm vertical corporotomy is performed between two nonabsorbable 2-0 stay sutures (Figure 2).
Figure 1: A Foley catheter is inserted to empty the bladder. A transverse skin incision is made at the penoscrotal junction. The incision can be modified to an inverted T-shape.

Figure 2: Skin hooks are in place. A stab wound is made into each corpora and a 2-cm vertical corporotomy is performed between two nonabsorbable 2-0 stay sutures.

Corporal dilatation is performed and directed laterally to avoid urethral injury. The corporal space is dilated with Brook’s dilators or Hegar dilator from 10 mm up to 14 mm. proximally the dilator can be felt to hit on the ischiopubic ramus. An equal depth of the dilators should be achieved when performing proximal dilatation; this ensures that proximal perforation is highly unlikely. Both corporas are irrigated with antibiotic solution. Distally, the glans of the penis is palpated until maximal limit of dilatation is achieved by feeling the tip of the dilator bilaterally. At each side, a measurement is recorded proximally and distally each towards approximately mid-point of the corporotomy incision and, added together which determines the final length of the cylinder implant. There should be no more than 1 cm discrepancy between the two sides. Cycling of the connected corporal cylinders and pump is performed two or
three times using sterile saline. This ensures the removal of any air bubble. The connecting tubes are gently clamped with rubber-shod clamps. The same preparatory steps are repeated for the reservoir.

The rear tip extenders of the cylinders are attached at this stage when needed. The proximal part of the corporal cylinder/rear tip extender is inserted first, and the back of a DeBakey forceps may be used to facilitate a gentle pushing into the corporal space.

The Furlow instrument is then inserted distally and laterally to avoid any ‘crossover’ into the contralateral corporal space. The Furlow is used to pass the Keith needle at the tip on each side to facilitate the distal placement of the cylinders. The corporotomies are closed using the 2-0 absorbable stay sutures (Figure 3).

![Figure 3: The Furlow is used to pass the Keith needle at the tip on each side to facilitate the distal placement of the cylinders.](image)

A subdartos pouch is made for the pump in the middle of the scrotum or the hemiscrotum. A small incision is made through the dartos fascia and a long-blade nasal speculum or ring forceps is used to create the space. The pump is inserted into the subdartos pouch, ensuring that the deflation button lies anteriorly and inferiorly.

The tubing from the pump is preferably passed through separate stab incisions in the dartos fascia to emerge from the posterior aspect of the pouch. The opening of the top part of the pouch is closed with 2-0 nonabsorbable suture. Connection between the tubing of the pump and the cylinders is made. The reservoir tubing from the pump remains intact at this stage. A 50-ml syringe filled with normal saline is attached to the reservoir tubing. This allows testing of the prosthesis cylinders to ensure the function and quality of erection. In preparation for the reservoir placement, the spigot is removed from the Foley
catheter and the bladder is fully drained. The size of the reservoir depends upon the surgeon’s preference. However, a previous surgery on one side would make placement on the contralateral side preferable.

The external ring is identified using a small Deaver retractor and the index finger is used to palpate the spermatic cord, pushing it medially to protect it. A closed Metzenbaum scissors is then used to puncture the transversalis fascia. This permits access to the retropubic space. The index finger is inserted again to create a space. The retropubic location of the space is confirmed by feeling the back of the pubic bone, the symphysis pubis and the Foley balloon inside the bladder (Figure 4).

![Figure 4](image)

**Figure 4:** The external ring is identified using a small Deaver retractor. A closed Metzenbaum scissors is used to puncture the transversalis fascia allowing access to the retropubic space. The index finger is inserted again to create a space.

Through the same wound, a long-blade nasal speculum is inserted in the created transversalis fascia defect, the blades are pulled upward and lateral to gain access to this defect. The blades are gently spread apart, and the reservoir is inserted into the newly created retropubic space (Figure 5).

Alternatively, a Deaver can be placed to expose the space to permit placement of the reservoir. The reservoir is then filled with normal saline up to 5 mls above its manufactured capacity. With the tubing to the filling syringe left open, the syringe should spontaneously fill to 5 ml. If it fills more than this, the position of the reservoir space needs to be checked again to ensure that there is no pressure around the reservoir. Some reservoirs have lockout valves to prevent autoinflation. The correct position of the reservoir is confirmed again by palpation and it is ensured that the reservoir tubing is exiting through the transversalis fascia defect.

The final connection between the pump and the reservoir is completed and a last check is made of the connections between the three tubes. The rubber-shod clamps are removed and inflation and deflation of the prosthesis is carried out few times to make sure that it is functioning properly (Figure 6).
**Figure 5:** A long-blade nasal speculum is inserted in the created transversalis fascia defect. The blades are pulled upward and lateral to gain access to the defect. The blades are gently spread apart, and the reservoir is inserted into the newly created retropubic space.

**Figure 6:** Once the final connection between the pump and the reservoir is completed and a last check is made of the connections between the three tubes, inflation and deflation of the prosthesis is carried out few times to make sure that it is functioning properly.
We prefer not to leave a drain routinely unless there is a particular concern, e.g., bleeding. If needed, a drain may be left *in situ* through a separate stab wound incision. The wound is then closed in two layers. The dartos fascia is closed with 2-0 absorbable suture and the skin is closed with 3-0 absorbable suture.

### 3.3.5 Post Operative Care

**Antibiotics**

Antibiotics are usually continued for 48 hours postoperatively. Some surgeons prefer to maintain antibiotics for a week after surgery and a longer period of time after revision surgery or in special circumstances, e.g., previous penile prosthesis infection.

**Urinary catheter**

The catheter facilitates identification of the urethra and the corpus spongiosum. It can be removed at the end of the procedure or retained for 24 hours after surgery.

**Drain**

Some surgeons prefer to use a drain to reduce the edema and to facilitate drainage of hematoma when it occurs. These drains are usually removed on postoperative day 1 or day 2 (Sadeghi-Nejad *et al.*, 2005).

**Wound care**

The penis is positioned over the suprapubic region pointing toward the umbilicus. The wound is covered with gauze and Mefix® tape is applied. The patient is reviewed in the outpatient clinic after 2 weeks to check the wound and to rule out autoinflation.

**Pain**

Pain following placement of a penile prosthesis is subjective and variable. It may be aggravated by preexisting conditions. For most patients, pain is no longer bothersome by 4–6 weeks.

**Using the prosthesis**

The cylinders are kept inflated for 24 hours and then partially deflated. This facilitates corporal hemostasis. At 4 weeks, the patient is advised to cycle the prosthesis. Patients are taught to operate the inflatable prosthesis at about 6 weeks. Other clinicians may prefer to leave the cylinders inflated for few weeks to allow creation of an adequate capsule, since keeping the prosthesis deflated after surgery for few weeks might result in prosthetic tip retraction under the glans and the creation of a capsule that is too short. A reasonable method is to leave the prosthesis partially (50%) inflated at the conclusion of the procedure; this will encourage proper modeling of the penis and also maintain good hemostasis.

### 3.3.6 Pitfalls and Specific Considerations

**Infection**

Despite the use of antibiotics and meticulous sterile environments and improved surgical techniques, infection rates remained relatively stable over decades till the introduction of antibiotic-coated implants. *Staphylococcus epidermidis*, *Staphylococcus aureus*, *Pseudomonas*, and *Candida albicans* are the most common skin-colonizing microorganisms implicated (Mulcahy *et al.*, 2008; Sausville *et al.*, 2009).
It has also been demonstrated that the incidence of infection is doubled (18.8%) in re-operation cases and in secondary implantation, uncontrolled diabetes, and paraplegia, as well as in the hands of inexperienced surgeons (Henry et al., 2005; Lotan et al., 2003). Overall, infection rates are generally 1.8%–10% for first-time prostheses and 7%–21% for replacements (Jarow et al., 1996; Lane et al., 2007).

Regardless of the microbiologic agent involved, it is advisable to remove the infected implant if the patient has not responded to antibiotic therapy. In such cases, all components of the infected implant should be removed to prevent a recurrence of infection. Also, the absence of clinical and microbiological evidence of infection must be ensured before embarking on any further surgery for penile prosthesis. It is essential to advise patients to use physiotherapy with a vacuum device in order to prevent excessive shrinkage of cavernosal tissue and consequent penile shortening.

An alternative to removal of all components and later reimplantation has been described by Mulcahy (Mulcahy et al., 2003) who calls it the ‘salvage or rescue’ procedure. This involves removal of all prosthetic parts and irrigation of the wound with a series of antiseptic solutions, followed by replacement of the prosthesis during the same procedure. It is also demonstrated that the use of systemic antibiotics for 48–72 hours prior to the salvage improves the chances of success, with improvement or resolution of cellulitis suggesting that the chance of the salvage procedure succeeding would be higher. The advantage of the salvage procedure is that most of the length of the penis will be maintained. In addition, it is easier to place cylinders while the cavities in the corpora cavernosa are still open, rather than returning at a later date to create new cavities in the scar tissue.

**Type of incision**

The penoscrotal approach avoids possible injury to the dorsal sensory nerves, provides easier and more complete corporal exposure, and allows the pump to be anchored in the scrotal pouch. In a review by Montague and Angermeier (Montague et al., 2000) for most primary penile prosthesis patients, the AMS Ultrex® prosthesis is recommended because it produces expansion in both girth and length of the penis. In primary patients with long penises and in men with Peyronie disease, the AMS 700CX® prosthesis is recommended. For secondary implants (penile prosthesis reimplantation), the urologist can still offer most of patients the AMS Ultrex® device. However, in men with previous urethral erosion or cylinder crossover complications, the recommendation is to use the AMS 700CX® prosthesis. When corporal dilation is limited because of cavernosal fibrosis, for instance after removal of an infected penile prosthesis, the smaller size AMS 700CXM® cylinders are a better option (Wilson et al., 1994).

**Cavernosal fibrosis**

The multicomponent inflatable penile prosthesis has undergone sequential modifications that have afforded important functional advantages and have greatly reduced the potential for mechanical failure. This was made possible by the introduction of the Ultrex® cylinder, which consists of bi-directionally woven Dacron™ and Lycra™ layers situated between inner and outer layers of silicone. This allows expansion in girth from 12 mm to 18 mm, while resisting any possible aneurysmal bulge. However, oversizing and deformity maybe encountered.

Montague and Angermeier described a cylinder measurement technique that avoids the problem of oversizing that may occur particularly in the case of the length-expanding Ultrex® penile prosthesis, when cylinders that are too long can result in an S-shaped cylinder deformity. These types of deformities are sometimes difficult to diagnose. Wilson and Delk published an outstanding review describing the newer tools and techniques to enhance placement of an inflatable device in patients with severe fibrosis...
This includes the use of specially designed cavernotomes for dilating fibrotic corpora, the use of downsized prosthetic cylinders, alternative procedures to fix cylinders in the face of perforation (as opposed to primary closure of the perforation), and replacing the original cylinders 1 year after the modified cylinders have served as tissue expanders. The cylinder sizing is of great importance (Wilson et al., 1994).

**Corporal sizing**

A 2-cm corporotomy incision is used and the distal measurement is from the distal end of the corporotomy and the proximal measurement is from the proximal end of the corporotomy as outlined earlier within the surgical steps. The two measurements added together determine the total cylinder size. The aim is to insert a cylinder that extends to each end of the corpus cavernosum and lies comfortably inside the open corporotomy. With the cylinder completely filled with normal saline it will be possible to ascertain the final appearance. The use of a cylinder that does not match the length of the corpus cavernosum may result in the so-called S-shaped cylinder deformity.

**Difficult corporal closure**

Straightforward corporotomy closure can be attained using horizontal mattress sutures or simple closure with absorbable stay sutures pre-placed on each side of the corporotomy before corporal dilatation. This prevents possible damage to the cylinders. When severe intracorporal fibrosis is encountered, corporal dilatation to accommodate the cylinder and subsequent closure over the prosthesis is usually challenging. Various materials have been utilized to cover the cylinders when primary closure of the tunica albuginea is not possible. These include synthetic graft, tunica vaginalis flaps, processed cadaveric dura mater, processed cadaveric skin, and processed cadaveric pericardium (Alter et al., 1998; Fallon et al., 1990; Herschorn et al., 1995; Landman et al., 1999; Reddy et al., 1999; Smith et al., 1998).

**Corporal perforation and urethral injury**

If corporal fibrosis is anticipated, wider transverse incisions or vertical penoscrotal incisions are the best approach for proximal exposure of the tunica albuginea. With careful dilation of the corpora cavernosa, the majority of the complications can be avoided.

If distal corporal perforation is identified during dilation (e.g., a distally placed dilator comes out the meatus or, when irrigating the distal corpora, the fluid emerges out of the meatus), the safest course of action is to terminate the procedure. An injured urethra should be repaired over a Foley catheter. Another procedure can be rescheduled after 6 weeks. However, another option in cases of urethral perforation is urethral mobilization and sutting of the albugineal and urethral defect, followed by continuation with the procedure for prosthesis insertion. If the patient has a previous history of distal perforation or severe distal corporal fibrosis and previous urethral erosion, the urethra should be repaired through a circumcision incision. In addition, the patient should be warned about the possible need for temporary urinary diversion such as suprapubic catheter, vesicostomy, or perineal urethrostomy (Wang et al., 2000).

The patient should receive broad-spectrum antibiotics for 3–4 weeks and a retrograde urethrogram should be performed before the catheter is removed. If distal perforation occurs during the dilatation of the second corpora cavernosum, the injury should be repaired and then either the cylinder can be inserted on the non-perforated side with concomitant urinary diversion or the procedure should be abandoned and both corpora irrigated with antibiotics. Proximal laceration of the urethra during scrotal exposure can be repaired, and insertion of the prosthesis may continue. Care must be taken to avoid contacting the suture lines when closing the urethral and albugineal defects before continuation with prosthesis implantation.
Correction for proximal perforation has also been attempted with the use of synthetic graft material to form a ‘windsock;’ however, this technique has been associated with significant postoperative graft infection (Carson & Noh, 2002).

For proximal perforation of the corporal body during implantation into scarred corporal tissues, a sling of nonabsorbable suture through the rear tip extender has been demonstrated to effectively keep the cylinder base out of the damaged tunica albuginea. When this sling is used most authorities advocate that the prosthesis should not be used for 3 months (Henry & Wilson, 2007); This minimizes trauma and early pressure on the prosthesis during the healing process.

**Crossover**

Crossovers are rarely complete, i.e., with the tip of both cylinders in one corporal body. The corporal septum tends to have windows, and the typical crossover is indicated by an over-and-back movement. Using the scrotal incision and placing the penis on stretch in the Scott retractor helps the surgeon to avoid this over-and-back movement. If crossover is suspected, both cylinders should be removed, and the corpora cavernosa should be re-dilated proximally and distally with a size 11 or 12 Hegar dilator in the opposite corpora. If the active dilator hits the opposite stationary Hegar, a crossover situation exists and needs to be managed accordingly. One of the techniques is to place the Hegar dilator on the side in which one of the cylinders resided as a reference point, whether proximal or distal. The surgeon then gently rechannels the crossover side, staying lateral and using the stationary Hegar as the reference point. The cylinder is inserted with the stationary Hegar in place. When the cylinder goes in correctly, the stationary Hegar is removed and the contralateral cylinder is inserted. It is not necessary to repair the crossover because the septum of the corpora is variable, has windows, and occasionally is filamentous.

**Pump and reservoir problems**

There are three reservoir sizes available with the AMS three-piece inflatable penile prostheses: 50 mls, 65 mls, and 100 mls. The 50-mL reservoir is used for the CXM prosthesis. The 65-mL reservoir is used for the prosthesis and for the two smaller cylinder sizes of the Ultrex® prosthesis. The 100-mL reservoir is designated for the two largest cylinder sizes of the Ultrex® prosthesis. Correct placement of the reservoir into the retropubic space and a back pressure test are mandatory to prevent the problem of autoinflation of the prosthesis.

In special situations, the retroperitoneal space can be extremely fibrotic and the transversalis fascia thickened. This is often caused by previous surgery, such as cystectomy or renal transplantation, or it may be the result of radiation. The surgeon may elect to insert a two-piece inflatable device, make a separate incision for placement of the reservoir, or consider another location for reservoir placement. Paravesical or abdominal placement of the reservoir may be a better option in previously operated patients. The pump should be placed in a dependent and easily palpable scrotal position. Particular care should be taken to not dissect or tear small vessels in this region as a scrotal hematoma can easily develop.

When replacing the three-piece prosthesis for malfunction the best way to manage the reservoir of the original prosthesis is still a matter for debate. Removing a reservoir is far more difficult than its initial placement; a self-retaining long-blade nasal speculum may be used for removal of the reservoir utilizing an extended diathermy tip to cut down on the tubing, which is placed on gentle traction. Some surgeons leave the reservoir of the original three-piece device behind after removing the penile cylinders and the scrotal pump of the malfunctioning device. Rajpurkar et al. (2004) found that retained reservoirs are not susceptible to infection or erosion and can therefore be left behind.
Revision

Antiseptic washout and mechanical debridement of the bacterial biofilm within the corporal space are the mainstay techniques during revision prosthetic surgery. It is theoretically advisable to remove reservoirs at the time of revision surgery. Alternatively, new reservoirs may be placed in different locations if the surgeon decides to leave the old one behind because of the daunting task involved in removing some of them.

Peyronie disease

When penile curvature is present, whether due to Peyronie disease or other causes, CX prosthesis cylinders have more straightening properties than Ultrex® cylinders. The formercylinders are used in conjunction with ‘modeling’ of the penis as described by Wilson and Delk (1994). Correcting the curvature deformity can be attained without the need for plaque incision or excision. It is necessary during modeling to initially clamp the cylinder input tubes to protect the pump from back-pressure flow. The prosthetic cylinders are inflated to high pressure, the input tube is clamped with rubber-shod clamps, and the penis is grasped with both hands and bent over the inflated cylinders at the region of maximum curvature. Bending is maintained for 90 seconds and then relaxed. It is worth noting that simple prosthesis insertion can produce complete straightening in up to 30% of patients. The rest of the patients may require additional procedures for residual curvatures (Ralph et al., 2004; Pryor et al., 2004).

A recent retrospective study by Garaffa et al. (2011) reported that modeling alone achieved more straightening on inflatable prosthesis (84%) than on a malleable prosthesis (54%) and procedures such as tunical plication or incision, with or without graft, can be used for any ventral curvature that persists after modeling.

In another study, Levine et al. (2010), reported a single center experience with IPP and straightening maneuvers as necessary in 90 men with medication-refractory ED and Peyronie disease. Additional intraoperative maneuvers used to straighten the penis following placement of the prosthesis included manual modeling, plaque incision and, if the defect created with incision was greater than 2 cm, an off-the-shelf human processed pericardial graft. In their study, IPP placement allowed reliable and satisfactory coitus for the great majority of men (91%). Mechanical failure was reported in 7%.

Patients with special conditions

For patients with complicated backgrounds such as kidney transplant or a neobladder, a simpler prosthesis should be contemplated than the three-piece inflatable penile prosthesis, for example, the two-piece or semi-rigid implant. Another solution is to place the reservoir outside the usual location (outlined above). In such cases, the surgeon makes a second incision and places the reservoir intra-abdominally or in the retroperitoneal space beneath the kidney. Three months after implantation, a tissue capsule would have formed around the reservoir and this will prevent increase in abdominal pressure from causing autoinflation.

Cold-glans syndrome

A common complaint after the insertion of a penile prosthesis is lack of glans engorgement after inflation. In the majority of patients this is due to inadequate sexual stimulation. In some patients, however, the glans is soft and cold despite proper sexual stimulation. Mulhall et al. (2004) found that most patients responded to sildenafil and reported higher satisfaction than with an implant alone. Lledo et al. (2011) have also reported similar results.
4 Future Research

There has been a tremendous enthusiasm in advancing further research ED in two main areas, first-line medical therapy and gene therapy. In medical therapy, the search for a drug which combines PDE5 inhibitory and NO-releasing properties aim to address the effect of multiple peripheral intracellular targets. On the other hand gene therapy for ED in diabetes and other conditions such as hypercholesterolaemia is still evolving as a therapeutic option.

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References


