Post-Traumatic Female Urethral Reconstruction

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Post-traumatic urethral damage resulting in urethrovaginal fistulas or strictures, though rare, should be suspected in patients who have unexpected urinary incontinence or lower urinary tract symptoms after pelvic surgery, pelvic fracture, a long-term indwelling urethral catheter, or pelvic radiation. Careful physical examination and cystourethroscopy are critical to diagnose and assess the extent of the fistula. A concomitant vesicovaginal or ureterovaginal fistula should also be ruled out. The two main indications for reconstruction are sphincteric incontinence and urethral obstruction. Surgical correction intends to create a continent urethra that permits volitional, painless, and unobstructed passage of urine. An autologous pubovaginal sling, with or without a Martius flap at time of reconstruction, should be considered. The three approaches to urethral reconstruction are anterior bladder flaps, posterior bladder flaps, and vaginal wall flaps. We believe vaginal flaps are usually the best option. Options for vaginal repair of fistula include primary closure, peninsula flaps, bilateral labial pedicle flaps, and labial island flaps. Outcomes are optimized by using exacting surgical principles during repair and careful postoperative management by an experienced reconstructive surgeon.

Introduction

Post-traumatic urethral damage can result in urethrovaginal fistula and urethral stricture. Both conditions, though rare, are increasing in incidence in industrialized countries due to the use of synthetic slings for the treatment of sphincteric incontinence. Nevertheless, such injuries are still much more prevalent wherever there is inadequate access to modern obstetrical techniques. Obstetric injuries to the urethra are predominately due to prolonged labor, particularly if maternal–fetal disproportion exists and the fetal head compresses the bladder neck and urethra against the undersurface of the pubis, causing pressure necrosis [1].

In industrialized countries, a more common cause of urethral damage is the scarring that occurs between the urethra and cervix from cerclage sutures or caesarean section. Urethrovaginal fistula is also commonly due to anti-incontinence surgery using synthetic slings [2–4,5•,6] and urethral diverticulectomy [7]. Synthetic slings can cause urethrovaginal fistula if they erode into the urethra after being applied under too much tension, become infected, or if the sling is placed in the wrong plane (ie, deep into the pubocervical fascia). Fistula after urethral diverticulectomy most likely occurs from failure to obtain a tension-free closure of the urethral defect after excision of the diverticulum. During bladder neck suspension, an inadvertent (and unrecognized) injury to the bladder or urethra may occur or an errant suture may result in fistula formation or tissue necrosis.

Less commonly, urethrovaginal fistulas may be caused by anterior colporrhaphy, vaginal hysterectomy, pressure necrosis from improperly managed long-term indwelling catheters, pelvic fracture injury causing laceration of the urethra, and local invasion from adjacent malignancies (primarily cervical or vaginal cancer) and radiation therapy.

Urethral strictures are most often caused by anti-incontinence operations, pelvic trauma, and pelvic radiation [8]. However, some appear to be due to vaginal atrophy secondary to estrogen deficiency and some are idiopathic [9].

Diagnosis

The rarity of urethrovaginal fistula and urethral stricture mandates a high index of suspicion for diagnosis. These injuries should be suspected in the following instances: 1) urinary incontinence after pelvic surgery, particularly synthetic sling, urethral diverticulectomy, anterior colporrhaphy, and Kelly plication; 2) urinary incontinence or other lower urinary tract symptoms (LUTS) after pelvic fracture; 3) urinary incontinence that occurs with a long-term indwelling urethral catheter; and 4) urinary incontinence or LUTS after pelvic radiation.

Although most patients with urethrovaginal fistula have urinary incontinence, they occasionally present with

overactive bladder or voiding symptoms. In patients who have undergone recent synthetic sling placement, urethral erosion should be suspected when the patient has intractable vaginal/urethral pain, recurrent urinary tract infections, vaginal discharge, and occasionally hematuria, even in the absence of incontinence.

The first step in diagnosis is physical examination with a comfortably full bladder. It is incumbent on the physician to witness urethral leakage of urine before a definitive diagnosis of sphincteric incontinence is made. When incontinence is observed from the urethral meatus, if a fistula is suspected, the examination should be repeated with a finger occluding the meatus to observe leakage from the fistula itself. Conversely, asymptomatic women with an incidentally discovered distal fistula need no treatment. To visualize the fistula in the office, we use either the posterior blade of a vaginal speculum to depress the posterior wall of the vagina or a clear, plastic, disposable vaginal speculum that allows simultaneous retraction and visualization of the anterior vaginal wall. The next step in diagnosis is cystourethroscopy to evaluate the extent of the fistula and the remainder of the urethra, particularly the length, viability, and sphincteric function of the proximal urethra.

If a urethral injury is diagnosed, a concomitant vesicovaginal or ureterovaginal fistula or ureteral obstruction should be ruled out before surgery. Urethral damage may also compromise the bladder, causing low bladder compliance, impaired detrusor contractility, or detrusor overactivity; however, in most cases, this improves spontaneously after successful repair of the urethra.

Treatment Options

The two main indications for reconstruction are sphincteric incontinence and urethral obstruction sufficient to warrant surgery. A vesicovaginal fistula or ureteral obstruction should also be repaired at the same time.

The goals of surgical correction are to create a continent urethra that permits volitional, painless, and unobstructed voiding. The urethra should not be too short, causing vaginal voiding, or too long, leading to voiding over the toilet bowl because of the location of the meatus. We believe these goals can almost always be accomplished with a single transvaginal procedure. Urethral reconstruction is technically demanding and the patient may best be served by referral to a surgeon with expertise in this area.

When sphincteric incontinence is present, we prefer to construct a concomitant, autologous, fascial pubovaginal sling [10] with an interposed free labial (Martius) fat pad flap [2,5•,11] between the sling and the reconstructed vesical neck. In the past, transvaginal bladder neck suspension has been used, but in our experience, this has a nearly 50% failure rate. We do not recommend a synthetic sling because of the possibility of infection and erosion or an allograft or xenograft because of a lack of long-term follow-up and some early failures.

There are three generic approaches to urethral reconstruction: 1) anterior bladder flaps [12], 2) posterior bladder flaps [13], and 3) vaginal wall flaps [14]. These techniques appear comparable with respect to the creation of a neourethra, but in proximal injuries postoperative incontinence rates of nearly 50% are expected unless a concomitant anti-incontinence procedure is performed. We believe vaginal reconstruction is considerably easier and faster, more amenable to concomitant anti-incontinence surgery, and associated with much less morbidity than bladder flap operations [15,16].

General principles of surgical technique

In the past, it was recommended that surgery be delayed 3–6 months until the tissues had time to "mature," but with the judicious use of well-vascularized tissue flaps, we now believe that surgery can safely be performed once the tissues are free of infection and inflammation, unless there is urethral erosion of a synthetic sling, in which case it should be removed as soon as it is diagnosed. Regardless of sling composition, the sooner it can be removed, the easier it is from a technical standpoint. If the sling is macroporous and/or monofilamentous, the longer it remains in situ, the greater the tissue ingrowth and the harder it is to remove. Furthermore, excision of a sling that has become imbedded in the urethral wall leaves a much larger anatomic defect than one that is not imbedded.

Preoperatively, careful examination of the vagina is necessary to determine the extent of urethral tissue loss and to assess the availability of sufficient tissue in the anterior and/or lateral vaginal wall that can be mobilized and used for the reconstruction. Occasionally, it may be necessary to use an adjacent labial or thigh flap and, very rarely, a bladder flap technique [13,17].

In patients who sustain urethral erosions and/or urethrovaginal fistula after synthetic sling, when infection is present, attempts should be made to remove all synthetic material, including nonabsorbable mesh, sutures, and/or bone anchors. However, when infection is absent, bone anchors are exceedingly difficult to remove. We recommend their removal only when infected or if they pull out easily. In most instances, the urethra can then be reconstructed primarily.

After reconstruction of the urethra, a decision about whether or not to use a flap depends of the surgeon's assessment of tissue viability and technical aspects of the repair, including blood supply and wound tension. In the vast majority of patients, when a flap is needed, a labial fat pad (Martius) flap suffices (Fig. 1A, Fig. 1B, Fig. 1C) [18]. Other available flaps include rectus abdominal, gracilis, or thigh flaps.

The most important principles of surgical repair are: 1) clear visualization and exposure of the operative site; 2) creation of a tension-free, multiple layered closure;

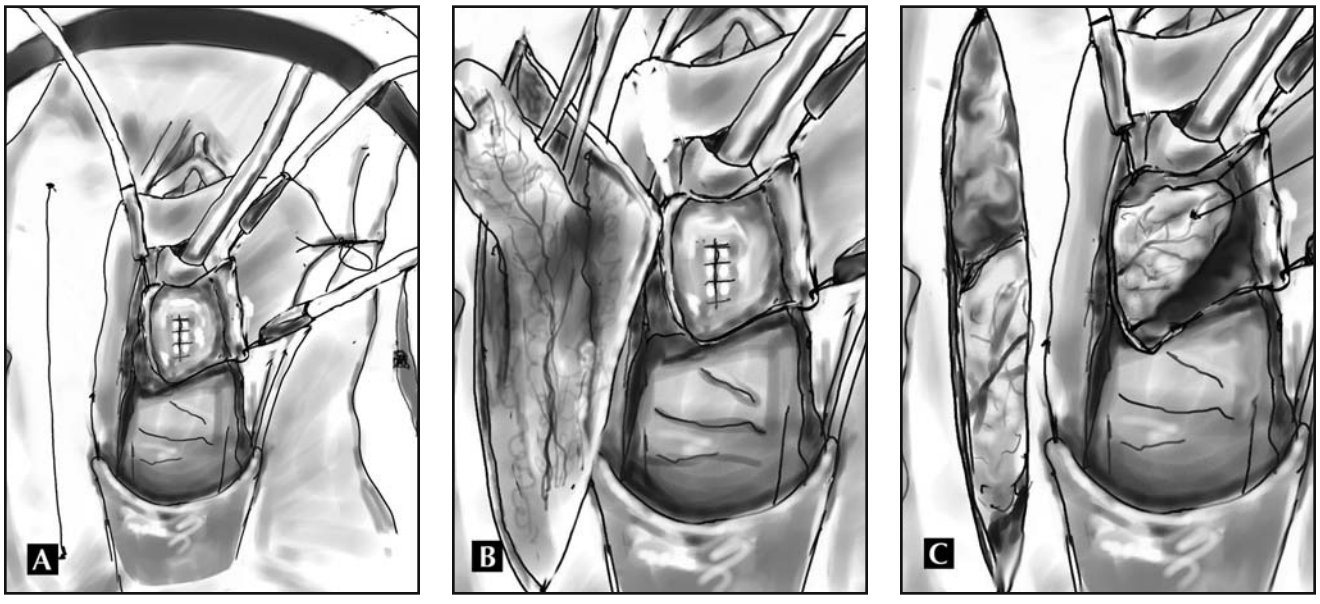

Figure 1. A, A longitudinal incision is made along the labia. The length of the incision is determined by the approximate length of flap needed. **B,** The incision is deepened through Scarpa's fascia; dissection superficial to this tissue can cause injury and bleeding of very broad, flat, thin-walled veins. **C,** A suture is planed on tip of flap and the flap is brought underneath the vaginal wall. Occasionally dense connected tissue underneath the vaginal wall necessitates sharp incision of this tissue. Note careful preservation of the vascular pedicle. We leave in a 0.25 inch Penrose drain in the dependent portion of the labial incision.

3) assurance of an adequate blood supply; and 4) adequate bladder drainage, ideally through a suprapubic catheter. We use a urethral catheter as a stent postoperatively and suture it to the anterior abdominal wall in a gentle curve to minimize tension on the suture line.

Surgical technique

There are five basic techniques for urethral reconstruction: 1) primary closure; 2) lateral random peninsula flaps; 3) proximal random peninsula advancement flaps; 4) labia minora random peninsula flaps; and 5) labial island flap. The choice of incision depends on the local anatomy of the tissue loss and whether or not a pubovaginal sling or other anti-incontinence procedure is planned. If a pubovaginal sling is planned, we complete the urethral reconstruction before placing the sling.

Before incising the vaginal wall, it is important to select the site and shape of the initial incisions for urethral reconstruction. If an inverted U-shaped incision is made in the anterior vaginal wall in anticipation of advancing it to cover the reconstruction, that tissue can no longer be used as an advancement flap for urethral reconstruction if necessary. If two parallel incisions are made along the intended site of the urethra to roll the flaps into a tube graft, the distance between the two incisions must be sufficient so the flaps cover the entire circumference of the catheter and can be sutured together over the catheter without any tension. Tissue lateral to the incisions should not be undermined until it is clear that a lateral-based flap is not needed to cover the wound. The five reconstruction techniques are outlined below.

Primary closure

For small defects with tissue pliable enough to achieve a loose, tension-free closure over a 16F catheter, primary closure should be considered (Fig. 2A, Fig. 2B, Fig. 2C, Fig. 2D). We prefer chromic catgut to longer-acting synthetic absorbable sutures for urethral closure because, in our experience, the latter often make subsequent voiding and/or urethral instrumentation painful. After the repair is complete, a decision is made regarding how to cover the wound. In some instances, it is possible to elevate lateral-based flaps and suture them in the midline over the wound, but when this is not possible a U or inverted U flap usually suffices. If a Martius labial fat pad graft is needed, it is prepared before closure of the wound (Fig. 1A, Fig. 1B, Fig. 1C). If a pubovaginal sling is also necessary, the fat pad graft is placed between the sling and urethra.

Lateral random peninsula flaps

If there is insufficient urethral tissue for primary closure, it may be possible to use a lateral-based random peninsula flap using one of two techniques. In the first, a rectangular incision is made lateral and around the urethral defect and advanced from lateral to medial so the vaginal surface of the flap becomes the posterior urethral wall. In the second technique, two such flaps are raised on either side of the urethra and sutured together in the midline to form a tube. In both instances, the mucosal surface of the urethral remnant forms the anterior part of the urethra and the posterior surface is formed by vaginal epithelium of the flap. In some instances, it may be

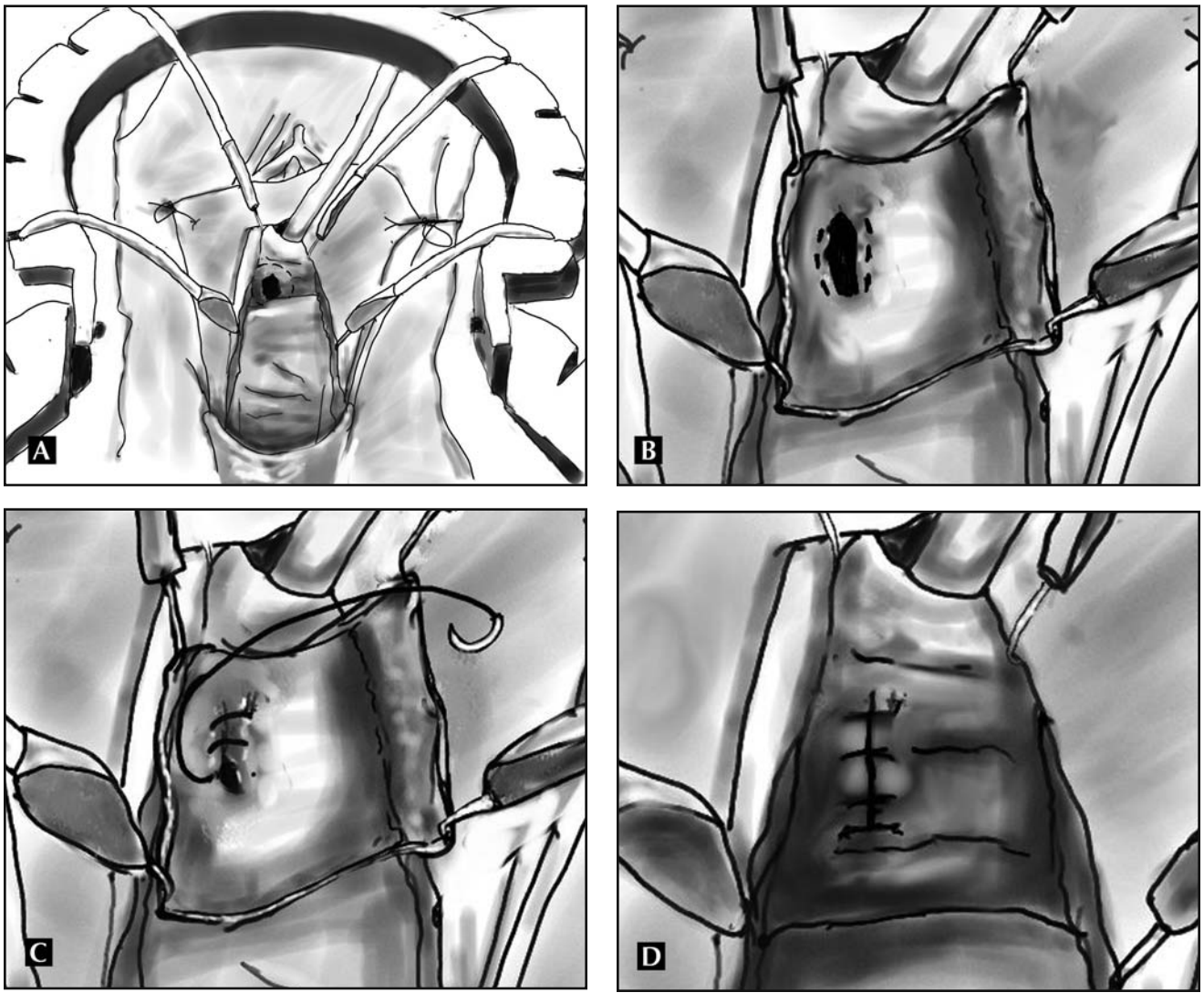

Figure 2. A, The fistula is circumscribed. **B,** Wide skin flaps are developed. **C,** The wound is closed with 3′0 chromic catgut sutures. We prefer chromic to longer-acting suture material because the longer-acting sutures can cause persistent postoperative dysuria.

possible to cover the wound by suturing the lateral edges of the wound in the midline. If not, it is usually possible to cover the repair with an advancement flap from the anterior vaginal wall.

Proximal random peninsula flap

If there is insufficient tissue lateral to the urethra, a proximal random peninsula flap should be considered. This is a straightforward technique in which a U-shaped incision is made and rotated so the proximal edge of the flap becomes the most distal part of the repair.

Bilateral labia minora pedicle flap

When there is insufficient local vaginal wall tissue, a bilateral labia minora pedicle flap may be possible. In this technique, the labia minora are mobilized and sutured together in the midline over a 16F urethral catheter to create a neourethra.

Labial island flap

In this technique, an oval-shaped incision is made in an adjacent hair-free portion of the vaginal wall minora as close to the site of the urethra as possible (Fig. 3A, Fig. 3B, Fig. 3C, Fig. 3D). The size of the incision should be large enough to be used as a patch around a 16F catheter. The incision is deepened around the labial incision and a pedicle is raised on an anterior- or posterior-based blood supply. The flap is passed beneath the vaginal wall and rotated so that the mucosal surface forms the inner wall of the reconstructed urethra. For patients in whom extensive scarring prohibits creation of a tunnel for passage of the graft, an incision is made in the vaginal wall between the site of the new urethra and the graft and flaps elevated to cover the graft.

Alternative closures

If the vaginal incision cannot be closed primarily, alternatives include creating an inverted U or lateral

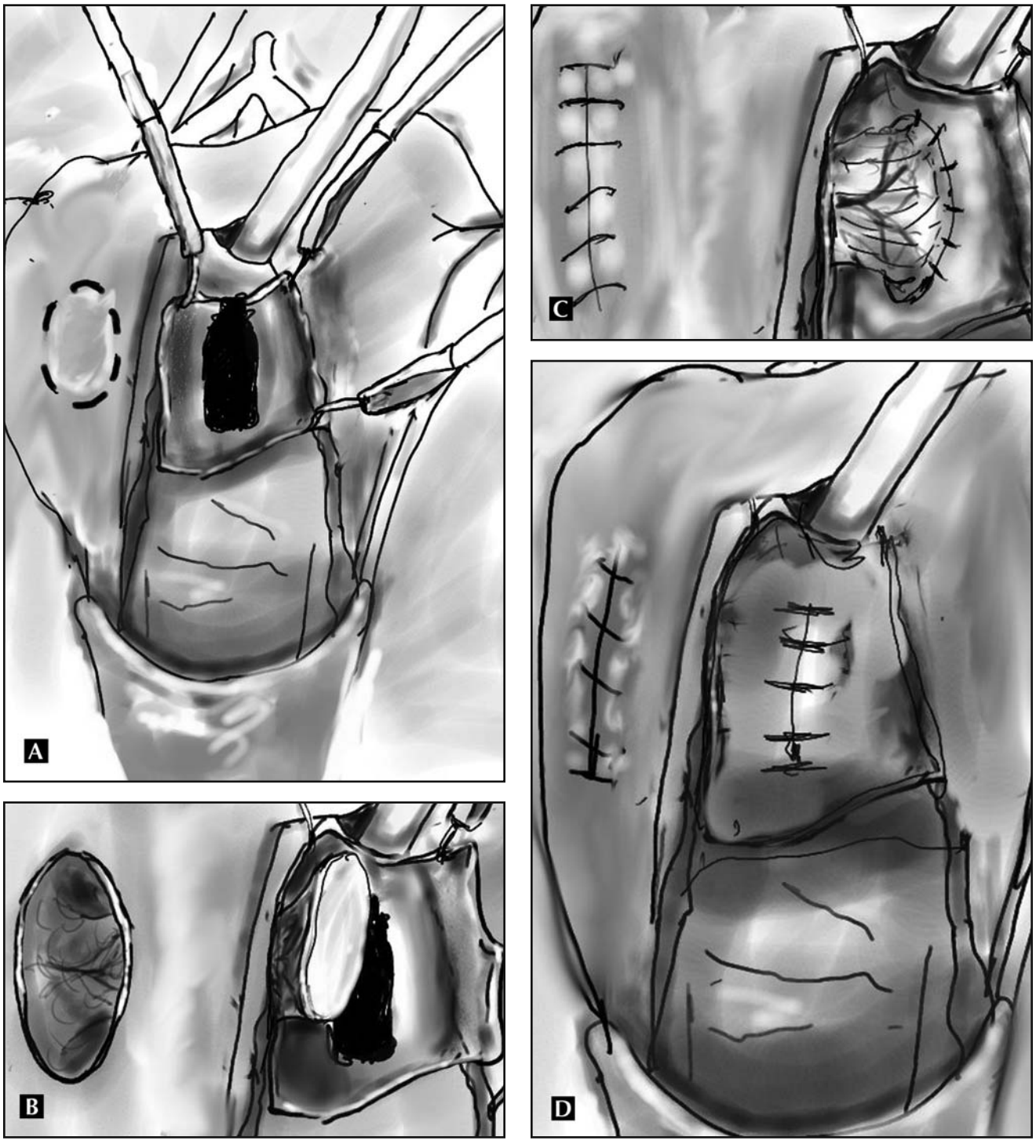

Figure 3. A, For patients with insufficient vaginal tissue, we use an island skin flap by making an ovoid labial skin incision corresponding to the size of the defect. **B,** The island flap is tunneled beneath the vaginal wall into the wound taking care to preserve the blood supply. **C,** The flap is rotated so the labial skin surface becomes the posterior wall of the urethra and sutured in place with interrupted 3′0 chromic catgut sutures. **D,** The wound is closed with chromic sutures.

broad-based flap (as described above for neourethral reconstruction); creating a flap of the inner surface of the labia, which may be taken as described above and rotated so that the skin is on the outside; or creating a modification of the Martius flap using full-thickness vaginal wall. Other techniques include gracilis myocutaneous, rectus pedicle, and Singapore grafts, but in about 100 cases, we have only found these to be necessary three times.

At the procedure's conclusion, the Foley catheter is sutured to the anterior abdominal wall with a gentle loop to minimize tension on the urethra. Failure to maintain a

correct position of the catheter may result in necrosis of the urethra.

Postoperative care

If a Martius flap is used, the Penrose drain is removed as soon as there is minimal drainage, usually on the first or second postoperative day. A voiding cystourethrogram is performed though the suprapubic catheter on day 14. If the patient voids satisfactorily and without extravasation, the suprapubic tube is removed. If not, the tube is left in place and another voiding trial is undertaken in about 2 weeks.

Results

Because of the rarity of the condition, there have been few studies concerning reconstruction of the severely damaged urethra. Combining all series, we could find fewer than 500 patients in the English literature. Successful anatomic reconstructions were reported in 67%–100% of women. Most authors emphasize the need for a well-vascularized pedicle flap to ensure a successful outcome. Continence, however, was achieved in only 55%–92% after a single operation, and postoperative urethral obstruction was reported in 2%–17%. In the great majority of studies, the criteria for incontinence and urethral obstruction were not specified and, especially in view of the lack of follow-up, the results cited above should be considered overly optimistic. It does seem evident, however, that it is important to perform an anti-incontinence procedure at the same time as the urethral reconstruction. Failure to do so resulted in incontinence rates varying from 50%–84%. Most series indicated that secondary procedures to correct incontinence are successful in most patients.

In 1969, Hamlin and Nicholson [19] published the first large series on female urethral reconstruction. An excellent anatomic result was achieved in 49 of the 50 childbirth injuries in West Africa, but eight patients (16%) had severe incontinence and many more had lesser degrees of incontinence, which was usually cured after a second procedure. Symmonds and Hill [20] described 50 women undergoing neourethra using tubularized vaginal wall. Follow-up ranged from 1–15 years. Using an independent examiner, 37 of 50 patients considered the operation successful even though they had "some" stress incontinence.

To date, we have operated on more than 100 women with extensive anatomic vesical neck and urethral defects, of whom 74 have been recently reported [15]. All but one patient underwent a vaginal reconstruction (one patient had a Tanagho anterior bladder flap, which failed). Overall, in our series, a successful anatomic outcome was achieved in 93% and continence was achieved in 87% of patients who had preoperative incontinence, and no patient developed de novo incontinence. Early in our series [21], we did not routinely perform concomitant pubovaginal slings and 50% of the women who underwent a modified Pereyra procedure had persistent sphincteric incontinence. All patients were subsequently cured or improved by an autologous fascial pubovaginal sling. No patient required intermittent catheterization except for anatomic failures requiring continent urinary diversion.

Tanello et al. [22] reported success using a pedicle skin flap from the labia minora. Bruce et al. [23] demonstrated success with a pedicled rectus abdominus flap interposed between the fistula closure and the vaginal suture line. Amundsen et al. [24] reported on nine patients who presented with urethral erosion following a midurethral sling placement. All were repaired primarily with a multilayer closure, followed by a Martius flap in two patients, and 66% of patients with preoperative urge urinary incontinence or stress urinary incontinence had continued incontinence. Others have reported results with similar rates of incontinence, prompting some authors to perform concomitant anti-incontinence procedures with interposed vascularized tissue, such as a Martius flap.

Bladder Flap Techniques

We believe that bladder flap reconstructions are almost never necessary. The single patient in whom we performed this procedure failed because of refractory detrusor instability. There are two basic techniques, anterior and posterior bladder flaps. In the most recent and extensive series, Elkins et al. [25] reported their experience with a Tanagho-like procedure in 20 West African women who had extensive urethral damage subsequent to obstructed labor. These patients all had large vesicovaginal fistulas, and because of extensive scarring, were not suitable for vaginal flap techniques. The procedure was performed entirely through the vaginal approach. The anterior and lateral fistula edges are dissected sharply away from the pubic bone beneath the arch of the pubic ramus, thus entering the retropubic space from the vagina. The anterior bladder wall is then dissected free of surrounding tissues to the level of the peritoneal reflection. After the anterior bladder is mobilized, a 3 × 3–cm flap is raised and rolled into a tube over a 16F catheter. The new urethra is sutured to either the remaining distal urethra or at the site of the new meatus. The posterior edges of the vesicovaginal fistula are approximated and "fixation sutures are placed through the top portion of the neourethra to reattach the urethra to the base of the pubic periosteum" [25]. In the final three patients, a modified Pereyra procedure was performed instead. A Martius fat pad graft was then placed beneath the suture lines. Eighteen of the 20 women treated in this manner had a satisfactory anatomic repair of the fistula, but 4 of these 18 had persistent stress incontinence requiring further surgery. Two others had refractory detrusor instability or low bladder compliance.

Other Techniques

Park and Hendren [26] reported a series of seven girls with severely fibrotic urethras. Urethral reconstruction

was accomplished with a 2 × 4–cm, full thickness, buccal mucosa graft after splitting the pubis and excising the fibrotic urethra. The etiology of the urethral pathology included complications from operations for cloacal exstrophy and other cloacal malformations. The authors reported that five of seven patients were continent and two were being treated with periurethral bulking agents. Follow-up is 12–58 months (mean, 34.7 months). All seven were continent and two required additional procedures for continence.

Subsequently, Huang et al. [13] reported their experience with 40 girls with urethrovaginal fistula, 35 of whom underwent transpubic reconstruction of the urethra using a modified Young–Dees–Ledbetter procedure, with simultaneous repair of the urethrovaginal fistula. Eight of the 35 (23%) required multiple operations; with a mean follow-up of 3.5 years, 29 (73%) regained normal urinary control.

Conclusions

Reconstruction of the severely damaged urethra is technically challenging and requires considerable surgical expertise. The vast majority of women with traumatic injuries have sufficient vaginal tissue for a vaginal flap reconstruction. We believe that the vaginal approach offers the best chance for a successful outcome. However, for those with extensive vaginal scarring that precludes a local tissue repair, bladder flap techniques may prove useful.

The most important principles to keep in mind are: 1) clear visualization and exposure of the operative site; 2) careful selection of the initial vaginal incision to be sure that there is adequate blood supply should pedicle flaps prove necessary; 3) removal of all foreign material; 4) creation of a tension-free, supple, multiple-layered closure; 5) assurance of an adequate blood supply and soft tissue base with a Martius flap; 6) concomitant autologous pubovaginal sling when anti-incontinence surgery is indicated; 7) adequate bladder drainage; and 8) suturing the urethral catheter to the anterior abdominal wall and meticulous attention to catheter care to prevent pressure necrosis.

Disclosures

Dr. Blaivas is a consultant for Novartis and a stockholder of Endogun. No further conflicts of interest relevant to this article were reported.

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