Posterior urethral injuries and the Mitrofanoff principle in children

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OBJECTIVE

To report our experience of children with trauma causing posterior urethral injury who at some stage underwent a Mitrofanoff intervention, as post-traumatic urethral injuries can demand long-term treatment which (regardless of the surgical intervention) requires a period of dilatation of the reconstructed urethra.

PATIENTS AND METHODS

From 1992 to 2001, 14 patients with urethral injuries underwent a Mitrofanoff procedure. Thirteen had been run over by a motor vehicle and had severe hip injuries, and one had a direct non-penetrating perineal impact lesion (13 boys and one girl, aged 2–13 years at the time of the accident). In all cases the Mitrofanoff procedure involved interposing the appendix between the bladder and the umbilicus. Only one of the children (because of extremely high bladder filling pressures) also underwent an augmentation cystoplasty and closure of the bladder neck because there were bony fragments in the urethra.

RESULTS

The Mitrofanoff technique was considered useful in most cases. All patients during a given period used the Mitrofanoff conduit to empty their bladder every 3 h; 10 of the 14 are currently voiding urethrally, with an adequate flow, and four are not, but emptying the bladder periodically via the appendicovesicostomy. The only girl in the group has a major hip deformity and is unlikely to undergo urethroplasty; two patients are expecting definitive treatment and the other, although having a patent urethra, has no urinary flow. He is currently 19 years old and has no erections.

CONCLUSIONS

The treatment of posterior urethral injuries represents a challenge to surgical teams. Although primary suturing of the separated urethral ends is accepted as the best treatment, the construction of a temporary continent urinary diversion may be considered in the most severe cases.

KEYWORDS

urethral stricture, wounds, injuries, pelvis, fracture, catheterization

INTRODUCTION

Post-traumatic urethral injuries in childhood frequently occur as a result of pelvic fractures during vehicular accidents. While fractures with a low risk of urethral injury are more common in adults, high-risk fractures are more common in children [1]. As the membranous urethra is fixed to the tough perineal membrane, which is attached firmly to the pubic arch, any major force causing pelvic fracture leads the prostate to rise towards the abdominal cavity, stretching and straining the bulbous urethra. In boys, given the elasticity of the bulbous urethra and lower consistency of the prostate, the urethral disruption could affect the small prostate or the bladder neck, leading to a high incidence of incontinence and strictures [2]. The treatment of urethral disruption currently advocated for children is based on the Johanson principle, with a cystostomy at the time of the injury, postponing the reconstruction of urethral continuity [3]. The Johanson principle accepts the inevitable stricture formation after complete urethral disruption, but it has become widely accepted in the past three decades, as it avoids surgical interventions in the presence of major pelvic haematomas, therefore implying a greater risk of infection and excessive blood loss [3]. Repairing the urethra at a second procedure allows the clinician to determine whether the accident alone caused any possible impotence and/or incontinence [3].

In 1980, Mitrofanoff used the appendix as a catheterization route between the skin and the bladder [4], later defined as the Mitrofanoff principle. A narrow conduit (appendix or ureter) is brought to the skin as a catheterizable stoma to allow for continence and maintenance of a low-pressure urinary storage reservoir. Reflux to the kidney is prevented by an antireflux mechanism between the ureters and the urinary reservoir, and the use of intermittent catheterization to completely empty the reservoir at regular intervals [5]. Cendron and Gearhart [6] reported the major indications for constructing a Mitrofanoff diversion to be in patients with a low leak-point pressure and neurogenic bladder, an unreconstructable bladder (e.g. exstrophy), an unreconstructable urethral disease or the inability to catheterize the urethra in a neurogenic bladder. Extending the applications of the Mitrofanoff principle, we used it in a series of patients who had major urethral injury after accidents.

PATIENTS AND METHODS

From 1992 to 2001, 14 patients with urethral injury underwent the Mitrofanoff procedure; 13 had been run over by a motor vehicle, with severe hip fractures, and one had a direct non-penetrating perineal impact lesion (13 boys and one girl, aged 2–13 years at the time of the accident). All patients were first seen elsewhere, where they underwent laparotomy and cystostomy; one was referred to us with a urethral catheter, and another had undergone urethroplasty by the anterior sagittal transanorectal approach, with an interposed bovine pericardium graft that resulted in stricture. All underwent one or more procedures for urethral reconstruction, except for the only girl, whose hip injury was so

TABLE 1 Patients' general data, operative procedures and outcome

Patient no. (date of birth)	Trauma†	Mitrof. surgery	Urethral interventions	Associated procedures	Follow-up (condition in 2001)
1 (12/82)	09/92	10/98	12/92 U, 12/93 U 1/98 RUF resection 10/98 RUF resection (stones)	12/92 colostomy	No UF; MC
2 (5/87)	04/94	7/95	12/94 U, 7/95 U, 7/96 EU, 9/98 EU	–	Adequate UF
3 (10/93)	12/95	11/98	6/96 Up, 2/97 Up, 11/99 U	–	Adequate UF, variable residual, SI
4 (10/87)	06/96	7/97	2/97 Ue, 7/97 U, 11/97 Up 8/98 UD resection	2/97 colostomy	Adequate UF, SI
5* (10/89)	8/97	1/00	–	8/97 femur prosthesis 11/00 neovaginoplasty + colostomy	No UF, MC
6 (11/87)	03/98	11/98	11/98 Up	3/98, skin flaps	Adequate UF, no residual
7 (2/91)	03/98	03/99	12/99 U	–	Interrupted UF, residual
8 (7/90)	07/98	8/98	3/99 Urethral closure, 2/01 U	3/99 AC + bladder neck closure	Interrupted UF, no erection
9 (8/91)	10/98	2/99	2/99 Up, 12/99 U	–	Extended flow time
10 (11/88)	11/98	3/99	3/99 U	–	Adequate UF
11 (9/96)	8/99	11/99	10/99 U	8/99 scrotoplasty	Adequate UF
12 (12/95)	12/99	04/01	10/00 U	–	Adequate UF
13 (08/86)	02/00	5/00	5/00 U, 11/00 U	–	No UF, MC
14 (11/87)	11/87	03/01	3/01, 3/01 U	–	Inadequate UF, MC

**The only girl; †trauma and laparotomy + cystostomy; U, anastomosis between the urethral ends; Ue, urethroplasty elsewhere; Up, urethroplasty with preputial flap; RUF, recto-urethral fistula; EU, endoscopic urethrotomy; UD, urethral diverticulum; UF, urinary flow; SI, stress incontinence; AC, augmentation cystoplasty; MC, Mitrofanoff catheterization.*

severe that there was complete avulsion of the urethra and vagina.

In all patients the Mitrofanoff procedure comprised interposing the appendix between the bladder and the umbilicus. Only one child (because of extremely high bladder-filling pressures) also underwent bladder augmentation with ileum and closure of the bladder neck, as there were bony fragments in the urethra. The Mitrofanoff procedure was the only surgery in five children, in seven it was accompanied by urethroplasty and in two accompanying other procedures.

Of the 13 patients who underwent urethroplasty the anastomosis between the urethral ends was the last procedure in 12, and one had a preputial flap interposed between the urethral ends. A preputial flap was also interposed between the urethral ends in another two patients, but in these cases the patients presented with stricture and were re-operated, with an anastomosis between the urethral ends. The only girl also had a colostomy and vaginal reconstruction, with no urethral reconstruction attempted.

All patients who had urethroplasty underwent weekly urethral dilatations, initially under general anaesthesia and then as outpatients; in three the procedure was eventually administered by the family, with a urethral dilator of a calibre appropriate for each case. After the urethroplasty the patients were given three daily doses of oxybutynin, and after removing the catheter, usually by 15 days, they were given 1 mg doxazosin daily, regardless of their weight, until they no longer required urethral dilatation. During this period the patients systematically catheterized the bladder via the appendicovesicostomy every 3 h, even when their urinary flow was suitable, to empty any possible residual urine. The patients' general data are summarized in Table 1.

RESULTS

For varying periods, all patients used the Mitrofanoff conduit to empty their bladder every 3 h. There were no complications, e.g. stenosis or bleeding, as a result of the procedure. Of the 14 patients, 10 are currently voiding urethrally with adequate flow, including the patient who underwent bladder augmentation with ileum. He catheterizes the urinary reservoir only at the end of voiding and is currently awaiting urinary undiversion. Only one patient has regular diurnal urinary leakage, although curiously he has no nocturnal urine loss. All patients have adequate renal function, although some have a thick bladder wall apparent on ultrasonography. Only two patients no longer require urethral dilatation.

Four patients are not currently voiding urethrally; the only girl has a significant hip deformity and will probably be unable to undergo urethroplasty. One patient had a significant stricture after primary suturing of the separated urethral ends by the perineal approach. The family refused urethral dilatation and even a new urethroplasty. One patient, who had primary suturing of the separated urethral ends by a combined perineal and perineal-abdominal (transpubic) approach, had a traumatic disruption of the urethra during urethral dilatation under general anaesthesia, and since then has been unable to void urethrally. One patient, despite having a completely patent urethra, with no resistance to the introduction of a 16 F

catheter, has no urinary flow. He is currently 19 years old and has no erections. These four patients catheterize the bladder regularly via the appendicovesicostomy.

Four patients had at least one episode of UTI before treatment, but only one has had an infection after the Mitrofanoff procedure. Two patients had fungal infections while they still had a cystostomy, which seriously delayed the definitive repair. In no patient was there formation of renal scarring on DMSA scintigraphy. The general results are also summarized in Table 1.

CASE HISTORY

A 7-year-old boy sustained injuries in a motor vehicle accident, including pelvic fracture and urethral bleeding. He underwent laparotomy and a cystostomy after stabilization of the pelvic fracture. He was referred to us 16 days after the accident. Physical examination with the patient under general anaesthesia showed extensive ecchymosis in the perineal region. Cystoscopy showed loss of continuity of the bulbous urethra. A ureterogram with contrast medium injected through the urethra and the cystostomy showed extravasation. The patient then underwent urethroplasty by the combined perineal and abdominal-perineal (transpubic) approach. Given the large gap between the urethral ends, a preputial flap was interposed (Fig. 1); he also had a simultaneous Mitrofanoff procedure. After removing the urethral catheter (15 days after surgery) the patient voided well urethrally, with an apparently adequate flow. An antegrade cysto-urethrogram with injection of contrast medium through the appendicovesicostomy showed a urethra of adequate calibre (Fig. 2).

The patient underwent urethral dilatations, initially under general anaesthesia every week, but eventually it was not possible to pass the dilators. The urinary flow deteriorated (Fig. 3); the patient started voiding urine only through the appendicovesicostomy. Ten months after the initial procedure the patient underwent urethroplasty via the anterior sagittal transanorectal approach. The preputial flap was then resected and the urethral ends anastomosed. After removing the urethral catheter (15 days) the boy started voiding urethrally with apparently adequate flow, although uroflowmetry showed a maximum flow rate of 2.4 mL/s, with an elongated curve and pressures of 40 cmH_2O (Fig. 4).

FIG. 1. Transpelvic urethroplasty: ***a,*** *arrows showing the distance between the urethral ends;* ***b,*** *the tubularized preputial flap interposed between the urethral ends.*

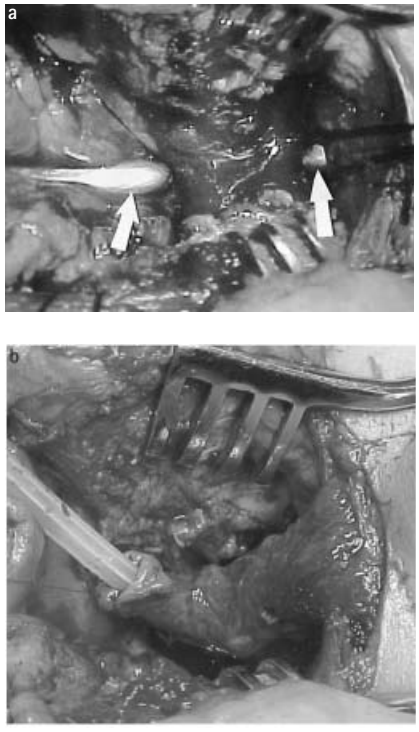
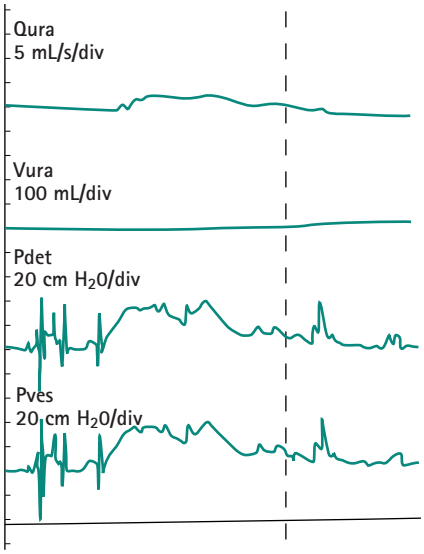


FIG. 2. A cysto-urethrogram showing adequate urethral calibre.

He started urethral dilatations, initially weekly, and currently, at 1.5 years after the last operation, no longer has dilatations, and for 2 months has not used the appendicovesicostomy. He has had no UTIs. While practising urethral dilatation he often found it difficult to void urethrally on the same day or even subsequent days, and then emptied his bladder only through the appendicovesicostomy.

FIG. 3. Urinary flow a few months after urethroplasty with interposition of a preputial flap.

FIG. 4. Uroflowmetry showing elongation of the flow curve with pressures of 40 cmH_2O at the maximum flow rate (2.4 mL/s).



DISCUSSION

Posterior urethral injuries in childhood are highly debilitating, and pose a very high risk of developing stricture, incontinence

and impotence [7]. Even when treated successfully, the child should always undergo a period of systematic dilatation of the reconstructed urethra, when the maintenance of a cystostomy to avoid renal damage is required [3]. Although not so frequent in girls, when accompanied by severe hip fractures, urethral injuries can lead to complete loss of the urethra and major vaginal injury [8]. Although the pelvis represents a formidable protective structure that must be disrupted before the posterior urethra can be injured, with severe fractures children nearly always have a long hospital stay. Although in some cases the urethral ends can be realigned primarily, in patients with a large gap between the urethral ends (when an endoscopic approach is impossible) any procedure at the time of trauma should be avoided, when the risk of infection is high [9].

Different approaches can be used but there appears to be a consensus that the best management, when possible, is primary suturing of the separated urethral ends after resecting fibrous tissue [3,10,11]. Boone *et al.* [7] followed 24 boys, who had sustained simultaneous pelvic fracture and posterior urethral disruption, from the time of injury to puberty. They showed that the clinical course depended on the site of injury, with 75% of those having proximal urethral injuries being impotent, 75% having untreatable stenoses and 25% incontinence. Elliot and Barret [12] followed 56 patients with posterior urethral disruptions who underwent primary urethral realignment within 6 h of injury; the pelvis was fractured in 52, and 53 were available for the long-term follow-up. In all, 36 patients (68%) had strictures after re-alignment and 13 (25%) had more significant strictures that required a repeat procedure under general anaesthesia.

The present 14 patients had severe urethral disruption, for which many procedures were used through different approaches. Currently, with a more critical view, we would attempt an anastomosis of the urethral ends, without interposing grafts, in all patients. However, more important when comparing the development of these patients was the utility of the Mitrofanoff principle in those periods when the patients often found it difficult to void. Appendicovesicostomy replaced cystostomy, with the advantage that the diversion is continent, with a low rate of infection, and is highly accepted by the children; when they have the potential to catheterize either the Mitrofanoff channel or the urethra they choose to catheterize the former. Three children were already dilating the urethra at home, sometimes with reduced urinary flow and significant episodes of dysuria. In such cases catheterization of the appendicovesicostomy enabled them to empty their bladder with no effort, no residual volume and all the advantages of clean intermittent catheterization. The present case history shows that after the second procedure, when the preputial graft was resected and the separated urethral ends sutured, although the urinary flow was apparently good while the child was voiding, uroflowmetry showed a low maximum flow rate, a long voiding time and excessive voiding pressures (Fig. 4). The appendicovesicostomy enabled the use of urethral dilatation that improved the urinary flow, without the child having to empty his bladder through the urethra, potentially traumatized by the dilatation. The only girl in the series had a very severe hip injury that caused great deformity. In an attempt to perform the urethroplasty, we considered using bladder flaps, as described by Hemal *et al.* [8], but found that it would be impossible to expose the neourethra in the perineal region, being badly positioned because of the trauma. We tried to reconstruct the vagina, with unsatisfactory results, and maintained the Mitrofanoff channel as the definitive route for this patient's voiding. The patient is currently well adjusted to the situation.

The other three patients, for different reasons, have no urethral flow and are well adjusted to catheterization by the Mitrofanoff channel. Although in these patients a definitive repair might mean they can eventually void urethrally, with catheterization, their renal function was protected, and they remained continent with no UTI.

Obviously we are not proposing that the Mitrofanoff principle be the definitive treatment for posterior urethral injuries. However, in patients with more severe injuries this form of temporary urinary diversion was useful for prolonged periods and, when no longer useful, required no other procedure.

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