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# Results of the Mitrofanoff procedure in urinary tract reconstruction in children

O. SÜZER, T.S. VATES, A.L. FREEDMAN, C.A. SMITH and R. GONZALEZ
*Department of Pediatric Urology, Children's Hospital of Michigan, Wayne State University, Detroit, Michigan, USA*

**Objectives** To evaluate the success and long-term complications associated with the use of continent catheterizable conduits based on the Mitrofanoff principle in children.

**Patients and methods** The records of 43 patients (21 female and 22 male) who underwent the construction of a continent catheterizable stoma based on the Mitrofanoff principle between 1987 and 1996 were reviewed retrospectively. The mean age at surgery was 10 years (range 3–21) and the mean follow-up was 3 years (range 0.5–6.5). Twenty-eight of the 43 children underwent augmentation cystoplasty in conjunction with the Mitrofanoff procedure, using ileum in 17, sigmoid in seven, caecum in two and stomach in one; detrusormyectomy was performed in one child. Fifteen patients had only a continent catheterizable stoma formed. The most common type of conduit was appendicovesicostomy (36 of 43 children); other conduits were constructed with ureter (four), tapered ileum (two) and fallopian tube (one).

**Results** Stomal continence was achieved in 42 of 43 patients (98%). The most common late complication was difficulty in catheterization, which occurred in 14 patients (32%). Stomal prolapse requiring revision occurred in one patient (2%). Conduit dilatation was initially attempted in all patients with difficult catheterization, although it failed in 11 who then required surgical revision. Therefore, the overall revision rate was 28% (12 of 43). The site of stomal placement (umbilical or abdominal) did not significantly influence the risk of difficulty with catheterization.

**Conclusion** The Mitrofanoff procedure can simplify catheterization in children who are dependent upon intermittent catheterization. The vermiform appendix appears to be the best source for constructing the conduit. While stomal continence is excellent, conduit stenosis remains a frequent complication regardless of stomal location.

**Keywords** Mitrofanoff principle, complications, urinary tract reconstruction, incontinence

## Introduction

The continent urinary stoma may provide improved access for catheterization when the urethra is inaccessible or difficult to catheterize. The Mitrofanoff principle, whereby the appendix or an alternative conduit is implanted in the urinary reservoir in a non-refluxing flap-valve technique, has been instrumental in the success of these conduits. The use of such stomata, particularly in children with severe physical anomalies or decreased motor skills, may improve accessibility such that clean intermittent catheterization (CIC) can be performed independently [1].

Herein we report our experience with continent stomata based on the Mitrofanoff principle, alone or in combination with bladder augmentation, and assess stomal continence and long-term complications.

## Patients and methods

The records of 43 patients (21 female and 22 male) who underwent urinary reconstruction based on the Mitrofanoff principle between 1987 and 1996 were reviewed. The mean age of the patients at surgery was 10 years (range 3–21) and the mean follow-up was 3 years (range 0.5–6.5). Most patients had a neurogenic bladder, PUV or bladder exstrophy (Table 1). Twenty-eight of the 43 children underwent augmentation cystoplasty in conjunction with the Mitrofanoff procedure (Table 2) and 15 patients did not require a bladder augmentation. The underlying conditions in these patients included myelodysplasia in five, Prune-Belly syndrome in two, PUV in two, exstrophy in two, Hinman syndrome in one and three with miscellaneous conditions.

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**Table 1** Aetiology of bladder dysfunction

| *Aetiology* | *Number of patients* |
|---|---|
| Myelodysplasia | 13 |
| Posterior urethral valves | 7 |
| Neurogenic bladder | 5 |
| Cloacal exstrophy | 4 |
| Bladder exstrophy | 4 |
| Prune-belly syndrome | 3 |
| Miscellaneous | 7 |

**Table 2** Source of Mitrofanoff conduit and augmentation

| | *Number* |
|---|---|
| *Conduit* | |
| Appendix | 36 |
| Ureter | 4 |
| Ileum | 2 |
| Fallopian tube | 1 |
| *Augmentation* | |
| Ileocystoplasty | 17 |
| Sigmoidocystoplasty | 7 |
| Caecocystoplasty | 2 |
| Gastrocystoplasty | 1 |
| Autoaugmentation | 1 |
| Native bladder | 15 |
| *Location of stoma* | |
| Umbilical | 28 (all appendix) |
| Cutaneous | 15 (8 appendix) |

*Operative procedure*

Following abdominal exploration and preparation of the bladder for augmentation if necessary, the appendix is mobilized, preserving its blood supply. The appendix is divided from the caecum, maintaining a small cuff at its base. If the appendix is unusually short, a strip of caecum can be left attached and tubularized to provide additional conduit length. A submucosal tunnel is created in the bladder or intestinal segment and the appendix implanted. Usually, the bladder adjacent to the entrance of the appendix is secured to the abdominal wall to ensure a short, straight conduit. The bladder should be catheterized both empty and full, to test for ease of catheterization and leakage. The anastomosis of the conduit to the skin is performed to the umbilicus or abdominal wall. Currently, stomata are constructed using the V-flap technique, whereby a V-shaped incision is made at the base of the umbilicus and the skin flap is rotated posteriorly to join with the apex of the spatulated conduit. When the appendix is not available, tapered ileum, distal ureter or fallopian tube may be used to construct the conduit.

Post-operatively, a latex-free catheter and cystostomy tube were left as drainage for 3–6 weeks, after which patients were instructed in CIC and bladder irrigation. Patients were maintained on suppressive antibiotics while the catheters were indwelling.

## Results

Of the 43 patients, 42 had a continent stoma 6 months to 6.5 years after surgery (mean 3 years). One patient, with a history of PUV, developed stomal incontinence following renal transplantation.

Fourteen patients experienced difficulty in catheterizing the conduit, caused by angulation of the conduit in four cases, stricture at the skin anastomosis in three, stricture below the skin anastomosis in six and stricture at the bladder level in the patient in whom the fallopian tube was used (Table 3).

Initially, all patients with difficulty catheterizing were treated with dilatation and prolonged catheterization; three improved and needed no further therapy, all with appendicular conduits. Eleven required revision of the conduit (Table 4), five of whom had non-appendicular conduits (ureter in two, tapered ileum in two and fallopian tube in one) and six of whom had appendicular conduits. Thus, the revision rate for appendicular conduits was 17% (6/36) and was five of seven for non-appendicular conduits. Including the revision for stomal prolapse, the overall revision rate was 28% (12/43) and the mean time from surgery to revision was 15.4 months (range 2–71). Other complications are listed in Table 4. The revision rate for appendicular conduits placed in the umbilicus was slightly less than for those placed in the abdominal wall (14% and 25%, respectively).

## Discussion

During the past two decades there has been a tremendous advance in the treatment of the incontinent child. Following the demonstration by Lapides *et al.* that CIC is a safe and acceptable method for bladder emptying, augmentation cystoplasty and CIC in combination has become a common method for achieving continence in children with neurogenic bladders [2]. However, there are limitations to the successful use of CIC. Some children are unable to catheterize independently through their native urethra. Severe congenital or orthopaedic anomalies, wheelchair dependence, leg braces and obesity can impair catheterization. A recent innovation is the use of catheterizable abdominal stomata whose conduit is re-implanted to create a continent flap-valve, known as the Mitrofanoff procedure. Mitrofanoff initially reported

**Table 3** Location of obstruction

| | *Location of obstruction* | | | |
|---|---|---|---|---|
| *Material for Mitrofanoff* | *Skin anastomosis* | *Between skin and fascia* | *Bladder anastomosis* | *Angulation below fascia* |
| Appendicovesicostomy ($n=36$) | 3 | 6 | | |
| Ureteric Mitrofanoff ($n=4$) | | | | 2 |
| Ileal Mitrofanoff ($n=2$) | | | | 2 |
| Fallopian Mitrofanoff ($n=1$) | | | 1 | |

**Table 4** Complications after the Mitrofanoff procedure

| | (*n*/total [%]) |
|---|---|
| *Difficulty with catheterization through Mitrofanoff* | 14/43 (32) |
| Success with dilatation | 3/14 |
| Revision of Mitrofanoff (including stomal prolapse) | 12/43 (28) |
| *Other complications (%)* | |
| UTI with a sepsis or pyelonephritis ($n=5$) | 12 |
| Stone in neobladder ($n=2$) | 5 |
| Stomal prolapse ($n=1$) | 2 |
| Foreign body reaction in neobladder ($n=1$) | 2 |
| Haematoma and cloth retention ($n=1$) | 2 |
| Pancreatitis ($n=1$) | 2 |
| Pelvic fluid collection and deep venous thrombosis ($n=1$) | 2 |

successful results using the appendix in 1980 [3]. Others have confirmed the effectiveness of Mitrofanoff's concept, using not only the appendix but also other narrow tubular materials, including tapered ileum, ureter and the fallopian tube [4–6].

In the present series, the major complication was difficulty in catheterization of the conduit (14 of 43, 32%). This problem was less common when the conduit was made with the appendix (25%) than when the appendix was not used (86%). Initial attempts at conservative treatment with dilatation failed in 11 of 14 patients. While the exact aetiology of the strictures in the appendicular conduits is unknown, we suggest that ischaemia, recurrent trauma, body habitus or uneven growth rates between the Mitrofanoff conduit and the abdominal wall may be factors. Andreou *et al.* noted increased appendiceal fibrosis, decreased appendiceal lymphoid tissue and decreased appendix luminal diameter with increasing age of the patient [7].

In the non-appendicular conduits, the most frequent cause of difficulty in catheterization was related to excessive angulation of the conduit. Although this is probably a technical fault caused by the excessive extravesical length of the conduit, we nevertheless believe the appendix to be the best choice because the complication rate is lower. In addition, Marshall and Bissada showed that the appendix has a leak-point pressure up to 50 $cmH_2O$ [8] and this can contribute to the continence mechanism of the Mitrofanoff conduit. In the present series, there was no relationship between the rate of stomal stenosis and the stomal location, either umbilical or abdominal.

The continence rate in the present series was excellent (98%) and similar to that reported by others [9–11]. In the present patients, the conduit was anastomosed to the bladder or neobladder using an anti-refluxing method, in the most accessible location. In some cases, a caecal extension was used to mobilize the stoma up to the umbilicus.

Another common complication seen in patients with bladder augmentation and continent catheterizing stoma is urolithiasis [12]; daily irrigation of the bladders to avoid excessive mucus accumulation and stone formation has been shown to be effective [13]. All of the present patients used daily irrigation with water in an attempt to reduce calculus formation but despite this, two patients developed calculi in the neobladder; these patients were also having difficulty catheterizing.

We conclude that the Mitrofanoff procedure provides excellent continence and can simplify catheterization in children with physical anomalies. The appendix appears to be the best source for constructing the conduit. Stomal placement does not appear to significantly affect the rate of stenosis, the most frequent complication, and non-appendicular stomata have a high rate of stenosis. We favour placing the stoma at the umbilicus because it is cosmetically superior and facilitates finding the stoma, especially in obese patients. When catheterization is difficult, initial treatment with dilatation may be successful, although most patients will require surgical revision.

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## Authors

O. Süzer, MD, Fellow, Wayne State University and Assistant Professor of Urology University of Kocaeli, Turkey.
T.S. Vates, MD, Fellow.
A.L. Freedman, MD, Fellow.
C.A. Smith, MD, Assistant Professor.
R. Gonzalez, MD, Professor, Chief of Pediatric Urology.
Correspondence: Dr R. Gonzalez, Department of Pediatric Urology, CHM 3901 Beaubien, Detroit, MI 48201–2196, USA.