ORIGINAL ARTICLE

A novel technique to achieve cutaneous continent urinary diversion in spinal cord-injured patients unable to catheterize through native urethra

G Karsenty¹, E Chartier-Kastler¹, P Mozer¹, A Even-Schneider², P Denys² and F Richard¹

¹Department of Urology, Pitié-Salpêtrière Hospital, Pierre et Marie Curie School of Medicine (Paris VI), Paris, France and ²Department of Physical Medicine and Rehabilitation, Garches Hospital, Paris Ouest School of Medicine (University Versailles Saint Quentin-en-Yvelines), Boulogne, France

Study design: Description of a technique and prospective follow-up study.

Objectives: To present and assess a perioperative strategy associated with a single-procedure surgical technique for continent cutaneous diversion in spinal cord injury (SCI) patients requiring self-catheterization and unable to do it through the native urethra.

Setting: University hospital, Paris, France.

Methods: We considered SCI patients suffering from urinary incontinence related to neurogenic detrusor overactivity and/or poor bladder emptying for more than 1 year and inability to perform self-catheterization through the native urethra. These patients including quadriplegics underwent selection for surgery by occupational therapists and neurorehab to assess the ability to self catheterize through an abdominal stoma and to determine the optimal site to place the stoma. The surgical technique included a single procedure: aponevrotic sling in women requiring stress continence reinforcement, supratrigonal cystectomy, preserved detrusor wall flap (original description), enterocystoplasty, a catheterizable tube using either the Mitrofanoff or Young-Monti principle and Politano–Leadbetter anti-reflux technique. A prospective follow-up study of consecutive patients reviewed initial condition, indication, surgical technique, complications, continence, catheterizing difficulties, functional bladder capacity and serum creatinine.

Results: Thirteen consecutive patients were selected for surgery. Median follow-up was 44 months. Stoma location was variable from one patient to another. All patients had a catheterizable continent stoma at last follow-up. Kidney function was preserved.

Conclusion: Given these results, a multidisciplinary approach including neuro-rehabilitation practitioners and urologists performing appropriate technical solutions in highly selected SCI patients unable to catheterize native urethra provides upper urinary tract protection and continence after a single procedure.

Spinal Cord (2008) 46, 305–310; doi:10.1038/sj.sc.3102104; published online 14 August 2007

Keywords: spinal cord injury; quadriplegia; urinary diversion; incontinence; urinary catheterization; urinary bladder

Introduction

Spinal cord lesions induce severe dysfunction of the bladder and the urethral sphincter, which impair both micturition and urine storage.¹ Urological management aims to prevent life-threatening complications, and to improve patient autonomy and quality of life.² Clean intermittent self-catheterization has been demonstrated to

be the most-effective way to empty the bladder in spinal cord injury (SCI) patients. To prevent upper urinary tract damage and achieve continence, one must obtain a low-pressure bladder of adequate volume. When validated conservative treatment of neurogenic detrusor overactivity fails, enterocystoplasty (ECP) has been demonstrated to be a safe and effective alternative.^{3,4}

However, urethral catheterization can be impossible or unacceptable in some SCI patients. Upper limb dysfunction, difficulty in transferring or undressing oneself, inability to reach the urethra, or urethral lesions are the usual reasons that an SCI patient is unable to catheterize. In such

Correspondence: Dr G Karsenty, Department of Urology, Pitié-Salpêtrière Hospital, Pierre et Marie Curie School of Medicine (Paris VI), 47 Bd de l'Hôpital, 75013 Paris, France.
E-mail: gilles.karsenty@ap-hm.fr
Received 4 February 2007; revised 29 May 2007; accepted 3 June 2007; published online 14 August 2007

situations, a cutaneous continent diversion (CCD) composed of an abdominal continent stoma (ACS) combined with ECP can facilitate self-catheterization.

We describe and analyze our perioperative strategy and technique for CCD in SCI patients requiring self-catheterization and unable to do it through the native urethra.

Patients and methods

Patient selection

ECP combined with ACS was considered in selected SCI patients with urinary incontinence related to neurogenic detrusor overactivity, and/or poor bladder emptying for over 1 year.

Selection criteria in paraplegic patients included poor bladder emptying owing to detrusor sphincter dyssynergia or bladder acontractility and inability to perform self-catheterization through the native urethra.

Selection criteria in male quadriplegic patients included poor bladder emptying and inability to perform self-catheterization through the native urethra and refusal of sphincterotomy (endoscopic surgery or urethral stent) or Brindley neurostimulator. Sphincterotomy is never considered in tetraplegic women. In both genders, a creatinin clearance lower than 40 ml/min was considered as a contraindication because of increased risk of morbid hyperchloremic acidosis due to ionic reabsorption through the intestinal mucosa of a continent urinary pouch.⁵ Selected patients were evaluated for both motivation and the ability to self-catheterize through an abdominal stoma while sitting. Patients were asked to catheterize a fake stoma on the lower abdominal wall. Optimal stoma location was chosen according to the time and ease of self-catheterization. Time to handle the catheter as well as to undress and dress up again was taken into account. Motivation was evaluated with the patient, family and occupational therapist only after 1 week of such trial. Patients who successfully completed this evaluation were offered surgery.

Surgical technique

In female patients with mixed urinary incontinence, open bladder neck or low maximum urethral pressure (MUP < 30 cm H₂O), a bladder neck aponeurotic sling anchored to Cooper's ligaments was first performed to reinforce stress continence mechanisms (Figure 1). Supratrigonal cystectomy to remove pathological detrusor was performed first in men. Ureteric stents were placed at the time of the surgery and removed before augmented bladder closure. A long posterolateral bladder wall flap of 2.5–3 cm width and full wall thickness was preserved (Figure 2). Coloration and bleeding from the distal part of the flap were carefully verified to detect local ischemia before the catheterizable tube was implanted in the flap. A maximal flap length of 16.5 cm was obtained. The flap was preserved from the right or left hemi-bladder according to the location of the stoma. In this patient series, all flaps came from the right hemi-bladder. The bladder neck and urethra were left open to preserve a pop-off mechanism and for easy access to the

Figure 1 Reinforced stress continence mechanism in women. Aponeurotic sling anchored to Cooper's ligament supports the bladder neck to reinforce stress continence mechanisms.

bladder in case of catheterization difficulty. The excised part of the bladder was replaced by a 55-cm ileal segment 30 cm from the ileo-caecal valve, detubularized according to Hautmann's technique,⁶ then anastomosed to the trigone. The efferent catheterizable tube was constructed using either the Mitrofanoff⁷ or Yang-Monti⁸ principle according to surgical history, appendix length and patency (Figure 3). The capacity of the efferent tube to reach the planned stoma site without tension was verified at this time. The proximal efferent tube was implanted into the detrusor flap using the Politano–Leadbetter⁹ anti-reflux technique (Figure 2). The absence of kink and the direct route of catheterization were verified before the efferent tube was sutured to the skin with a V-shaped skin flap. A 14-French Foley catheter was left in the efferent tube and a 20- or 22-French urethral catheter was placed to drain the ECP (dedicated to ECP with large holes and additional holes below the balloon). Closure of the peritoneal sheet maintained the augmented bladder and efferent tube close to the inner face of the abdominal wall outside the peritoneum.

Peri-operative care

All patients were admitted 48 h before the procedure to receive two enemas and 2 l of an oral polyethylene glycol solution.

Naso-gastric tube was removed when bowel movements resumed and then oral feeding was slowly re-introduced. Early post-operative mobilization (median: third day) was implemented to promote faster intestinal transit

Figure 2 Enterocystoplasty (ECP) combined with abdominal continent stoma (ACS). Supratrigonal cystectomy sparing a long posterolateral bladder wall flap that respects bladder blood supply. The mobile part of the bladder is replaced by a 55-cm ileal segment detubularized according to Hautmann's technique. Implantation of the proximal efferent tube into the detrusor flap using the Politano-Leadbetter technique (from left to right).

Figure 3 Technical principles of Monti (a) and Mitrofanoff tubes (b).

resumption. Saline irrigation through urethral and stomal catheters started postoperatively (three times a day) to prevent mucus build up. The urethral catheter was removed 2 days before starting self-catheterization. Self-catheterization education started progressively after 14-French catheter removal at the 21st day and was optimized at the neuro-rehabilitation department using the urinary diary to monitor time between catheterization (initially 3 h). Saline irrigation, twice a week, was maintained during 8 weeks.

Results

Thirteen consecutive SCI patients (11 females, 2 males), underwent ACS combined with ECP from July 2001 to January 2004. Patient characteristics and indications for surgery are summarized in Table 1.

All patients had a preserved posterolateral detrusor flap. The efferent tube was constructed according to Monti in six cases and according to Mitrofanoff in seven cases. All were

Table 1 Patient characteristics

Number of patients	13
Male	2
Female	11
Median age at surgery (min–max)	42 (18–63)
Median duration of SCI (min–max)	12.2 years (1.6–32)
Level and etiology of SCI	Cervical: 5 (C5 ASIA B–C7 ASIA A), traumatic (3), myelitis (2) Thoracic: 5 (T6–T10), traumatic (4), myelitis (1) Sacral: 1 (conus medularis), traumatic Cauda Equina: 1, traumatic Other: 1 multiple sclerosis 10 years without progression
Bladder dysfunction	NDOI + DSD 12 Acontractile bladder 1
Indication for CCD ^a	Upper limb disability 6 Inability to reach or find urethra 4 (all women) Urethral lesion (fistula ± stenosis) 4
Median BMI (min–max)	20 kg/m ² (17–27)
Median creatinine at baseline (min–max)	52 µmol/l (38–97)
Upper urinary tract lesion	One patient (grade 2 hydronephrosis) Six had more than three pyelonephritis

^aOne patient had urethral stenosis after post-traumatic urethral fistula and upper limb inability due to brachial plexus lesion resulting in a monoplegia. Abbreviations: BMI, body mass index; CCD, cutaneous continent diversion; DSD, detrusor sphincter dyssynergia; NDOI, neurogenic detrusor overactivity incontinence; SCI, spinal cord injury.

re-implanted in the detrusor flap according to Politano–Leadbetter. Stoma were made at the umbilicus (7), on the midline between umbilicus and pubis (2), on the right iliac fossa (2) or in a right paraumbilical site (1). All patients had stoma at the site proposed before surgery. All female patients except one had a bladder neck sling. The duration of surgery was 250–386 min (median 355 min) and blood loss was 150–1200 ml (median 386 ml).

Median follow-up was 44 months (range 20–56) and one patient was lost to follow-up.

There were no postoperative deaths. One patient was reoperated for pelvic abscess and another underwent small bowel resection for occlusion 4 months after surgery. Seven patients had documented postoperative infection (five urinary, two pulmonary), which were all successfully treated with antibiotics.

At last follow-up, the catheterizable stoma was continent in all 12 patients. All patients were performing 4–6 self-catheterizations a day on voiding diary. One patient initially had difficulty in catheterizing, but finally succeeded with a different catheter (bend tip). Three women had stress urine leakage through the native urethra despite a large bladder capacity. One was treated with a peri-urethral bulking agent, and the remaining two required secondary bladder neck closure.

Median functional bladder capacity was 180 ml (range: 70–445 ml) and 540 ml (range: 380–800 ml) before surgery and at last follow-up, respectively. There was no change in serum creatinine level or in renal ultrasound after surgery.

Discussion

This comprehensive technique of urinary diversion preserved kidney function and provided a catheterizable and continent stoma in all patients at last follow-up. There were no specific re-operation or self-catheterization problems. Continent lower urinary tract reconstruction in SCI patients who require bladder augmentation and cannot perform self-catheterization via the native urethra has been reported to be effective in protecting the upper urinary tract, and enhances patient independence, self-esteem and quality of life.^{10–14} In accordance with Zommick *et al.*,¹⁴ we consider preoperative selection of patients to be the key point for successful outcomes. Patients were selected based on their performance and satisfaction in self-catheterization in a fake stoma positioned at different sites on the abdomen wall. We found that the optimal stoma site was patient-specific and not always at the umbilicus. Moreover, wheelchair-bound patients often need higher placement of the stoma. An efferent tube to connect the augmented bladder to any site of the lower abdomen without length limitation was therefore necessary.

The posterolateral detrusor flap first described herein provided enough length for a single efferent tube to reach the site chosen for the stoma preoperatively in all cases. This flap appears to be very useful owing to the pelvic bone rotation related to SCI, increasing the anatomical distance from pubic bone to the umbilicus by 1.5–2 times.

Although none of our patients was obese (median body mass index (BMI) 20 kg/m²), overweight and obesity are frequent among SCI patients.¹⁵ The thickness of the abdominal wall and short, fat mesentery could restrict the feasibility of this technique in obese patients. Therefore, BMI or better waist circumference, which is thought to be a more accurate visceral adiposity predictor,¹⁶ should be taken into account in the eligibility checklist for surgery.

A double Monti tube, implanted in the detrusor flap, would make it possible to reach any point of the lower abdominal wall in those patients. Shifting the small bowel opening away from the anti-mesenteric line also shifts the location of mesentery insertion in the re-tubularized segment and provides a longer mesentery-free part at both ends of the double tube (Figure 4). The tube is therefore easier to re-implant in its proximal end and to pass through the abdominal wall in its distal end. The absence of tension and compression on the mesentery reduce the chance to compromise tube blood supply. According to the report of higher complication rate with double Monti¹⁷ (stenosis at the anastomosis of the two hemi-tubes and difficulty to catheterize), we believe that if a single tube was too short, the modification of the double Monti without anastomosis proposed by Casale¹⁸ (Figures 5a and b) would be the alternative choice.

Although the continence of such reservoirs largely depends on their physical qualities (capacity and compliance), re-implanting the tube according to the Politano–Leadbetter anti-reflux technique avoids urine leakage. Re-implanting the efferent tube in a preserved piece of bladder wall avoids implantation in the small bowel and provides a strong and

Figure 4 Technical principles of double Monti tube.

Figure 5 (a) and (b) Technical principles of Casale tube.

resistant posterior wall for self-catheterization. Whether or not the nature of the tube (appendix or detubularized ileum) affects the frequency of stoma stenosis remains controversial.¹⁹ We had no cases of severe stenosis requiring surgical revision with either tube. This could be explained by the systematic use of a V-shaped skin flap to enlarge the circumference of the stoma. The absence of tension on the tube avoiding local ischemia at its extremities could also play a role in avoiding stenosis. However, the rate of stenosis should be re-evaluated with longer follow-up and more patients.

Supratrigonal cystectomy was performed owing to the poor quality of the bladder wall observed at the time of surgery in all of our patients following the long period

between spinal lesion and surgery. We believe that leaving such tissue could decrease compliance of the augmented bladder. This choice and the choice of an ileal detubularized segment to build the ECP were supported by the long-term successful outcomes we obtained with this technique in SCI patients.³

All except one of our female patients had a history of prolonged indwelling urethral catheter. Subsequent urethral and bladder neck damage could explain the frequency of mixed urinary incontinence, low MUP or the opening bladder neck we observed. As recently reported by Castellan *et al.*,²⁰ we associated a bladder neck fascial sling to prevent the persistence of the stress component of urinary incontinence through the native urethra. Despite this procedure, three patients required additional treatment for persistent stress urinary incontinence by the native urethra. Interestingly, they had the lowest preoperative MUP of the series and 2/3 had an opened bladder neck. Castellan *et al.*²⁰ also reported seven patients with mixed neurogenic incontinence that failed after bladder neck sling associated with bladder augmentation. Continence of native urethra remains a challenging situation in female para- or quadriplegic patients, especially with a long-standing indwelling catheter. In these women with risk factors of urethral leakage, the risk/benefit ratio of an ECP combined with ACS that includes the chance of re-interventions for bladder neck closure has to be carefully assessed. Heterotopic continent diversion bearing the potentially severe long-term morbidity of uretero-digestive re-implantation²¹ can be discussed in such cases.

In this patient series, morbidity was acceptable²² and an increase in bladder capacity and ability to empty the bladder was achieved in 12 patients, including 5 quadriplegics. Although improvement in quality of life was not evaluated with specific tools, patients reported satisfaction and improved independence.

Such results support that an association of appropriate surgical technical solutions in carefully selected SCI patients

can provide upper urinary tract protection, continence and a high degree of independence regarding lower urinary tract function after conservative options have failed. To meet patients' expectations and reach physicians goals, this comprehensive strategy is based on a multidisciplinary approach involving urologist and neuro-rehabilitation practitioners.

References

- 1 de Groat WC. Mechanisms underlying the recovery of lower urinary tract function following spinal cord injury. *Paraplegia* 1995; **33**: 493–505.
- 2 Elliott DS, Boone TB. Recent advances in the management of the neurogenic bladder. *Urology* 2000; **56**: 76–81.
- 3 Chartier-Kastler EJ, Mongiat-Artus P, Bitker MO, Chancellor MB, Richard F, Denys P. Long-term results of augmentation cystoplasty in spinal cord injury patients. *Spinal Cord* 2000; **38**: 490–494.
- 4 Herschorn S, Hewitt RJ. Patient perspective of long-term outcome of augmentation cystoplasty for neurogenic bladder. *Urology* 1998; **52**: 672–678.
- 5 Mills RD, Studer UE. Metabolic consequences of continent urinary diversion. *J Urol* 1999; **161**: 1057–1066.
- 6 Hautmann RE, Egghart G, Frohneberg D, Miller K. [The ileal neobladder]. *Urol A* 1987; **26**: 67–73.
- 7 Mitrofanoff P. [Trans-appendicular continent cystostomy in the management of the neurogenic bladder]. *Chir Pediatr* 1980; **21**: 297–305.
- 8 Castellan MA, Gosalbez Jr R, Labbie A, Monti PR. Clinical applications of the Monti procedure as a continent catheterizable stoma. *Urology* 1999; **54**: 152–156.
- 9 Politano VA, Leadbetter WF. An operative technique for the correction of vesicoureteral reflux. *J Urol* 1958; **167**: 1055–1061; discussion 1062, 2002.
- 10 Hakenberg OW, Ebermayer J, Manseck A, Wirth MP. Application of the Mitrofanoff principle for intermittent self-catheterization in quadriplegic patients. *Urology* 2001; **58**: 38–42.
- 11 Moreno JG, Chancellor MB, Karasick S, King S, Abdill CK, Rivas DA. Improved quality of life and sexuality with continent urinary diversion in quadriplegic women with umbilical stoma. *Arch Phys Med Rehabil* 1995; **76**: 758–762.
- 12 Sutton MA, Hinson JL, Nickell KG, Boone TB. Continent ileocecal augmentation cystoplasty. *Spinal Cord* 1998; **36**: 246–251.
- 13 Sylora JA, Gonzalez R, Vaughn M, Reinberg Y. Intermittent self-catheterization by quadriplegic patients via a catheterizable Mitrofanoff channel. *J Urol* 1997; **157**: 48–50.
- 14 Zommick JN, Simoneau AR, Skinner DG, Ginsberg DA. Continent lower urinary tract reconstruction in the cervical spinal cord injured population. *J Urol* 2003; **169**: 2184–2187.
- 15 Gupta N, White KT, Sandford PR. Body mass index in spinal cord injury—a retrospective study. *Spinal Cord* 2005; **44**: 92–94.
- 16 Buchholz AC, Bugaresti JM. A review of body mass index and waist circumference as markers of obesity and coronary heart disease risk in persons with chronic spinal cord injury. *Spinal Cord* 2005; **43**: 513–518.
- 17 Narayanaswamy B, Wilcox DT, Cuckow PM, Duffy PG, Ransley PG. The Yang-Monti ileovesicostomy: a problematic channel? *BJU Int* 2001; **87**: 861–865.
- 18 Casale AJ. A long continent ileovesicostomy using a single piece of bowel. *J Urol* 1999; **162**: 1743–1745.
- 19 Koyle MA, Mingin GC, Furness III PD, Malone PS. The Mitrofanoff (flap valve principle): Application in contemporary continent urinary and gastrointestinal reconstruction. *AUA Update Ser* 2004; **23**: 273–279.
- 20 Castellan M, Gosalbez R, Labbie A, Ibrahim E, Disandro M. Bladder neck sling for treatment of neurogenic incontinence in children with augmentation cystoplasty: long-term followup. *J Urol* 2005; **173**: 2128–2131; discussion 2131.
- 21 Madersbacher S, Schmidt J, Eberle JM, Thoeny HC, Burkhard F, Hochreiter W et al. Long-term outcome of ileal conduit diversion. *J Urol* 2003; **169**: 985–990.
- 22 Khoury JM, Timmons SL, Corbel L, Webster GD. Complications of enterocystoplasty. *Urology* 1992; **40**: 9–14.