Symposium

Long-term outcomes of urinary tract reconstruction in patients with neurogenic urinary tract dysfunction

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ABSTRACT

The advent of specialized spinal units and better understanding of the pathophysiology of neurogenic urinary tract dysfunction has made long-term survival of these patients a reality. This has, in turn, led to an increase in quality and choice of management modalities offered to these patients including complex anatomic urinary tract reconstructive procedures tailored to the unique needs of each individual with variable outcomes. We performed a literature review evaluating the long-term outcomes of these reconstructive procedures. To achieve this, we conducted a world-wide electronic literature search of long-term outcomes published in English. As the premise of this review is long-term outcomes, we have focused on pathologies where evidence of long-term outcome is available such as patients with spinal injuries and spina bifida. Therapeutic success following urinary tract reconstruction is usually measured by preservation of renal function, improvement in quality-of-life, the satisfactory achievement of agreed outcomes and the prevention of serious complications. Prognostic factors include neuropathic detrusor overactivity; sphincter dyssynergia; bladder over distension; high pressure storage and high leak point pressures; vesicoureteric reflex, stone formation and urinary tract infections. Although, the past decade has witnessed a reduction in the total number of bladder reconstructive surgeries in the UK, these procedures are essentially safe and effective; but require long-term clinical and functional follow-up/monitoring. Until tissue engineering and gene therapy becomes more mainstream, we feel there is still a place for urinary tract reconstruction in patients with neurogenic lower urinary tract dysfunction.

Key words: Botulinum toxin, clam augmentation, clam cystoplasty, conduit urinary diversion, continent diversion, detrusor myomectomy, enterocystoplasy, ileocystoplasty, long-term outcome, neobladder, neurogenic, reconstruction, review, sphincterotomy, spinal cord injury, urethral stent, urinary tract dysfunction

INTRODUCTION

Neurological lesions resulting in lower urinary tract dysfunction include peripheral lesions such as myelomeningocele, sacral agenesis, diabetes and sacral/spinal injuries; spinal lesions such as spinal injuries, tumors and infarctions; progressive lesions such as multiple sclerosis and myelitis; and intracranial lesions such as cerebrovascular disease, trauma, dementia, encephalitis, Parkinson and Shy Drager syndrome. This list is not exclusive. As the premise of this review is long-term outcomes, we will concentrate on pathologies where evidence of long-term outcome is available and these include spinal injuries and spina bifida.

Spinal cord injury (SCI) has been mentioned in the Edwin Smith papyrus as "an ailment not to be treated" and this sentiment prevailed until after the second world war when, the advent of specialized spinal units by Guttmann in Britain; Bors in the US, made long-term survival a reality. Even then, it was realized that mortality in the spinal injured patient was directly related to bladder physiology. 2% of patients with "balanced bladders" compared with 31% with unsatisfactory bladders, die of renal failure.[1] Factors responsible for improved morbidity and reduced mortality include intermittent catheterization and catheter free management; infection control and judicial use of antibiotics; and the advent of urodynamics with a better understanding of bladder physiology. In the last three

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decades, there has also been a greater understanding of the dynamic pathophysiology of neurogenic lower urinary tract dysfunction.[2] This has in turn led to an increase in quality and choice of management modalities offered to these patients. With wide use of intermittent catheterization, these modalities also include complex reconstruction options. The treatment approach adopted in managing these patients is often multifaceted but tailored to the unique needs of each individual with variable outcomes.[3,4] Therapeutic success is usually measured by preservation of renal function, improvement in quality-of-life, the satisfactory achievement of the agreed outcome measures and the prevention of serious complications.[4,5] The primary goal in neuropathic bladder management is protecting the upper tracts and reducing complications; achieving continence is a secondary goal.

Prognostic factors include neuropathic detrusor overactivity; sphincter dyssynergia; bladder over distension; high pressure storage and high leak point pressures; vesicoureteric reflex, stone formation and urinary infections.

Surgical intervention is usually considered after exhausting less invasive options or if the patient's condition precludes such measures. The main indication is to protect or preserve renal function and to reduce the complications like recurrent infections. A secondary indication is to treat intractable urinary incontinence. Although the past decade has witnessed a reduction in the total number of bladder reconstructive surgeries in the UK (due in part to the advent of effective minimally invasive therapeutic procedures as well as neuromodulator interventions), there is still a role for such operations.[6,7]

There is an ongoing debate on options in the surgical management of these patients.[7] The considered options range from relatively simple measures such as sphincterotomy to more complex operations like urinary diversion or bladder reconstruction depending upon the urodynamic assessment of bladder dysfunction and treatment goals. Surgical interventions usually involve anatomic reconstruction; these are often complex, potentially high risk operations.[4,5,7] Most reports detail short-term outcomes with reconstructive procedures among this cohort, but only a handful have published long-term outcomes. We present a review of the published long-term outcomes of urinary tract reconstruction in patients with neurogenic urinary tract dysfunction.

The objective of this review is to provide a comprehensive look at reported long-term outcomes after reconstructive surgery in patients with neurogenic urinary tract dysfunction and thereby identify optimal practice and common adverse outcomes.

METHODS

We conducted a world-wide electronic literature search of all English language publications using PubMed, MedLine, ovid and the reference list of relevant articles containing keywords: Reconstruction, urinary tract dysfunction, neurogenic, SCI, sphincterotomy, urethral stent, botulinum toxin, continent diversion, conduit urinary diversion, detrusor myomectomy, ileocystoplasty, clam cystoplasty, clam augmentation, enterocystoplasy, neobladder and long-term outcome. Initial review of 2103 results led to 102 full text articles meeting the selection criteria. Articles on children (<16 year); and those with a mean follow-up of less than 36 months were excluded.

Principles

In 2008, Neurourologists from the 11 spinal units in the UK published guidelines for the urological management of spinal injury patients.[8] Immediate, early, intermediate and long-term management was considered. Management follows one of three broad options; continence, contained incontinence or indwelling catheters/ostomy. Reconstruction of the neuropathic bladder should be the only long-term management option and; depends upon the nature of the lesion, on the abilities of the patient, on the time since the disability and most importantly should be tailored to the clinical picture, the social circumstances and the video urodynamics investigations.

Surgery is directed to the underlying problem. A failure to void could be helped by increasing detrusor contractions by sacral anterior root stimulator (SARS) or by reducing outlet resistance by sphincterotomy, stents or botulinum toxin. A failure to store can be helped by decreasing uninhibited detrusor contractions or increasing sphincter resistance or by bladder replacement surgery. Indications depend upon the clinical picture including holistic care, urodynamic pathophysiology and the choice of intervention as desired by the patients. Procedure options depend upon a multitude of factors.

Long-term reconstruction outcomes are analyzed in an anatomically retrograde fashion beginning with reconstructive operations on the urethra.

Trans urethral external sphincterotomy

This endoscopic procedure is usually performed to relieve bladder outlet resistance and facilitate effective bladder drainage in men.[9] Following sphincterotomy, an external urine collection device becomes necessary, achieved by condom catheterization and possible only in men. Sphincterotomy is considered a management indication in treating refractory detrusor sphincter dyssynergia (DSD) or severe autonomic dysreflexia (AD) in male patients with SCI or spina bifida. First employed therapeutically in paraplegic patients by Ross *et al.*;[9] a resecting loop, laser or endoscopic knife is used to destroy the striated urethral sphincter, the preferred site of incision is at 12 O'clock position;[10] this was first described by Madersbacher and Scott.[11]

Short-term outcomes were very encouraging in terms of improved vesical drainage and reduction of urinary tract infections (UTIs), but more recent articles describing long-term outcomes have been less impressive. Upper tract function preservation appears to be better when intervention is performed early, however reoperation rates can exceed 50%.[12-17] Laser sphincterotomy appears to have a better out come in this regard.

Perkash[13] reported long-term outcomes on 46 male patients with supra T6 SCI and frequent episodes of AD. These patients were followed-up for between 1 and 12 years. He was able to show a significant reduction in blood pressure ($P < 0.0001$) and this correlated with a subjective relief in episodes of AD; and a significant reduction in post-void resides.

The main complication of external urethral sphincterotomy is a relatively high failure rate (36-49%) as reported by Yang and Mayo, and Santiago.[14,17] Their results were independent of selection criteria such as: age at operation, level of injury, previous bladder neck/sphincter operations, pre-operative maximum detrusor contraction pressures or time to maximum pressure. Reported reoperation rates can be as high as 66% often within the 1st year. Other long-term complications include chronic urine leakage and pressure sores.[18]

Following a mean follow-up of 11 years, Juma *et al*. found asymptomatic bacteriuria in 76%, impaired renal function in 3.2%, detrusor hyperreflexia (95%), DSD (54%), significant upper tract complications (30%) and lower tract complications such as bladder neck stenosis (48%).[19]

Others complications include bladder neck obstruction or urethral stenosis[13,17,20,21] (3-48%), risk of cutaneous skin breakdown and urethral fistula from long-term usage of a condom catheter.

Accounts of erectile dysfunction with the loss of reflex erections are reported in the short-term. This, as well as the advent of other reconstructive modalities, has resulted in a significant fall in the incidence of sphinterotomies in current neuro-urological practice.

Urethral stents

Urethral stents were first used to treat urethral strictures in the late 1980s.[22] Indications later expanded to include patients with bladder outlet obstruction that were unsuitable for surgery.[23]

In neuropaths with DSD, external sphincterotomy remains the gold standard for patients with high voiding pressures with, urethral stents used as an alternative measure.[24]

Reported outcomes are mostly short-term,[24-26] but some long-term studies report up to 13% reduction in AD episodes.[24] Complications include bladder neck obstruction/stenosis (3.5-42%), stent migration (5-33%), calculi (6-20%), and stent telescoping (16-25%).[24,26,27]

The attraction of urethral stents in neuropaths is its reversibility.[28] There appears to be an inverse relationship between the time from SCI to stent insertion and duration of stent tolerance.[23] Rarely employed stents for DSD are not recommended under the current EAU guidelines.[29]

Botulinum neurotoxin A

Botulinum toxin is produced by the microbe clostridium botulinum and was first isolated in 1897 by van Ermengem.[30] It is one of the most potent naturally occurring toxins known to man. Botulinum neurotoxin A is the most clinically relevant subtype.[31] It acts as a reversible inhibitor of neurotransmitter (mainly acetylcholine) release at the neuromuscular junction of both striated and smooth muscle. Indications include DSD, idiopathic and neurogenic detrusor overactivity (NDO).

When employed in patients with DSD, small amounts are injected transurethrally into the external striated urethral sphincter.[32] Long-term outcomes are unavailable, but short-term results are encouraging.[33]

In 2000, Schurch *et al*. performed the first intradetrusor injections to treat incontinence due to overactive bladder in adult SCI or multiple sclerosis patients[34] and short-term outcomes have been published by various groups advocating the efficacy of this treatment in maintaining sustained control of incontinence, protection of upper urinary tract and reduction of urinary infectious complications. The largest was from a European group in 2004.[35] Re-injections do not appear to reduce the efficacy and this modality has found favor both with patients and their treating clinicians. To the best of our knowledge, published long-term outcomes are still awaited.

SARS

Tanagho and Schmidt first described sacral neuro-modulation as a means of treating refractory voiding dysfunction in 1988.[36] The modern day technique consists of posterior sacral rhizotomy (S2-4) with implantation of an electrical stimulation device on the corresponding anterior sacral nerve roots. Various studies show improved bladder emptying and quality-of-life with symptom relief (reduction in UTIs, incontinence, AD) in patients with suprasacral SCI.

Published long-term outcomes involve a heterogeneous patient population with a paucity of outcomes for pure neurogenic patients. Available reports show improved continence (80-90%), decrease episodes of UTI (up to 81%) and improved quality-of-life (up to 90%). These effects continue in most cases unless there is device failure or neurological progression. Reported long-term complication rates are between 22% and 43%; and include infection, pain, mechanical faults or device failure, which appears to be time dependent; difficulty operating the implant and implant automaticity.[37-40] Reoperation rates are between 6% and 50%.[37,41,42]

SARS implantation remains a treatment option in a select group of patients, unwilling or unable to do intermittent self-catheterization (ISC) and willing to accept complications including sexual and bowel effects of the device.

Artificial urinary sphincter (AUS)

In patients with neurogenic sphincter weakness incontinence requiring surgery, the gold standard remains an AUS implantation. Pre-implantation exclusions are cognitive impairment or upper limb paresis.

The AUS has undergone various developmental modifications since Scott first introduced it in 1973.[43] The current version is the (American Medical Systems) 800 which consists of a urethral/bladder neck cuff, an inflation/deflation bulb and a pressure regulating balloon reservoir. The tubing is kink resistant, the connectors are suture-less and the cuff is flattened for added comfort and ease of implantation.[44,45] Careful patient selection is mandatory as is post implantation surveillance. Detrusor over activity, as high as 47%, has been reported in some series.[46]

Long-term results are very satisfactory. Chartier Kastler *et al*. reported 74% continence rate in a multicenter study involving 51 patients with an average follow-up time of 83 months (6-208).[47] Other groups report continence rates between 77% and 92% at 4-5 years.[48,49]

Complications include infection, (6-24%);[47-49] cuff erosion (5-8% over a 5 year follow-up period). Erosion is more common within the 1st year of implantation and with the new flat back cuff the incidence appears reduced.[47,48,50] Infection and erosion inevitably lead to device explanation.

As with all implanted devices, mechanical failure remains a threat. The frequency of mechanical device failure appears to be more than that seen in non-SCI patients and increases with time. Reported incidence is 10-57% within 5 years.[47,48,50] Reoperation rate can be high (28-50% revision within a 5 year follow-up period);[48,51,52] and tend to increase with longer follow-up.

Voiding dysfunction post implant is common (incidence 73.8-78%)[52-54] and intermittent catheterization should be learnt pre-implantation. Anticholinergics may also be required to control unmasked detrusor overactivity or reduce high detrusor pressure post-implantation. Singh and Thomas reported 78.9% of their patients required anticholinergic post AUS implantation.[48] In the Neuropath cystoplasty could either be performed simultaneously with AUS cuff implantation with good outcome and no increase in infection or erosion; or become necessary later to treat hypo compliance and preserve upper tract integrity. Studies show up to 79% of neurogenic patients may require this additional intervention.[48,55]

Bladder neck reconstruction

Some patients with neurogenic dysfunction may require bladder neck reconstruction to manage urinary incontinence if diagnostic video urodynamic studies point to an incompetent bladder neck. Bladder neck reconstruction may also be performed in conjunction with augmentation cystoplasty.[53] Treatment needs to be individualized and some authors believe that good outcomes are solely due to bladder augmentation.[54,56-58]

Numerous reconstructive techniques have been described. These include urethral bulking procedures, colposuspensions, transvaginal/mid urethral tapes (autologous or synthetic), flap valve reconstruction or AUS implantation. The precise technique chosen has to fit the patient's presentation and expectations after careful investigation and frank discussion with the patient. With the exception of an AUS, most published long-term outcome data involving bladder neck reconstruction in neuropaths are in the pediatric age group.

Bladder neck closure

Bladder neck closure needs to be combined with reconstruction with a catheterizable stoma. Shpall and Ginsberg reported one of the largest series reporting long-term results following bladder neck closure and lower urinary tract reconstruction in 39 patients with neurogenic voiding dysfunction.[59] The average follow-up period was 36.9 months and nearly half of their patients had concomitant augmentation enteroplasty with continent cutaneous stoma construction. All patients had good preservation of upper tract status. The most common post-operative complication was the formation of a vesicourethral fistula in 15% of patients. They concluded that bladder neck closure with simultaneous urinary diversion was a highly effective, well-tolerated treatment in neuropaths with an acceptable complication rate and current practice appears to support this with the exception of synthetic slings that have a higher erosion rate.

Continent diversion

Zommick *et al*.[5] reported results of continent urinary diversion in 28 patients (average follow-up 59.5 months). Nearly, 95% required long-term post-operative catheterization either by self or by a caregiver. Among the 21 patients who responded to their survey questionnaire, 80% reported a high level of satisfaction and an improved quality-of-life due to a post-operative improved sense of body image and freedom from urinary drainage bags.

Success following these procedures requires a dedicated team working in specialized centers.

Suprapubic cystostomy

As with permanent urethral catheters, long-term management of the neuropathic bladder with a suprapubic cystostomy is fraught with problems. A Bristol (UK) group performed transvaginal urethral closure with concomitant suprapubic cystostomy in 50 women with multiple sclerosis and reported 79% continence after a follow-up period of 6.5 years (average). Secondary revision was attempted in 10%. Urinary diversion was performed in 4% and a return to urethral catheterization in 2%. The main complication was from recurrent bladder calculi and catheter encrustation[60] Nomura *et al*. reported stone free rates of 77% and 64%, 5 and 10 years post cystostomy.[61] Colli and Llyod achieved 97% continence (8.6% requiring a second operation) and 17% overall complication rate.[62] In conclusion, indwelling catheterization through suprapubic approach has the potential for controlled continence with some increase in long-term morbidity.

Incontinent ileovesicostomy

Smith and Hinman introduced the incontinent ileovesicostomy in the 1955[63] and in the mid-1990s McGuire popularized this as a surgical option for patients with neurogenic voiding dysfunction who were unable to perform clean catheterization due to body habitus, limited manual dexterity, cognitive impairment or other reasons.[64] Long-term indwelling catheterization is considered an alternative last resort in these patients.[65] Also named the bladder chimney operation, studies reporting long-term outcomes are scarce. Leng *et al*. and others published long-term reviews suggested low morbidity outcomes with an overall improvement in renal morphology and function.[65-68]

However later reports[69,70] suggest higher morbidity; with 50-54% requiring further surgical intervention and 54-83% infection or stoma problems. Stomal stenosis rates as high as 15% have been reported.[64]

It is generally agreed that incontinent ileovesicostomy may be useful in neuropaths who are unable to perform clean intermittent catheterization or when their general health precludes major reconstruction and, after exhausting more conservative options. Among these patients, long-term problems often arise from either the neurogenic voiding dysfunction and/or the constructed ileovesicostomy; hence close long-term surveillance is advocated.

Conduit urinary diversion (Ileal conduit)

Conduit urinary diversion remains a good option for the management of neurogenic voiding dysfunction where problems such as hypocompliance with upper tract deterioration or total urinary incontinence may be prevalent. The ileal conduit, introduced by Bricker[71] has stood the test of time due to its relatively shorter construction time and familiarity among urologists.[72,73] The conduit allows for low-pressure urinary drainage. Very early published long-term outcomes from the 1970s were poor.[74] Moeller and Comarr reported good to a fair outcome in only about 50% of patients with 25% mortality mainly from urinary tract complications.[74,75] Koziol and Hachler also reported 25% mortality most of which occurred several years after the procedure and attributable to recurrent UTIs.[76] More recent studies though have published better outcomes with satisfactory renal function preservation in up to 100% in some series.[64,68,77,78] Patient satisfaction recorded at 88-100%.[78] These excellent results are however not reproducible across the board and long-term outcome review indicate a high complication and reoperation rate. Some of the major long-term complications encountered with ileal conduit diversion in neuropaths include:

Pyocystis

As high as 52% in cases where a concomitant cystectomy was not carried out.[75-79] This was managed by periodic bladder irrigation, iatrogenic vesicovaginal fistula formation and cystectomy were conservative methods had failed to treat the condition adequately.

Stomal problems

Long-term stoma problems were reported among 6-37% of patients. The most common complications reported include bleeding, skin irritation, parastomal hernias, incisional hernias, prolapse, stenosis, ileo-ureteric anastomotic stricture and retraction of stoma.[76,78-80] Conduit obstruction may result in upper tract dilatation and earlier series had a reoperation rate as high as 65%.[76] More recent studies however, report much lower reoperation rates (3-8%);[77,78] due to improved technique, imaging at follow-up and general perioperative fitness of patients.

UTI/pyelonephritis

This has been reported as a major concern in up to 12-60% of patients not only in the short-term; but also as a long-term complication.[77-80]

Metabolic acidosis

This is an inevitable outcome in cases where bowel is harvested and used as a bladder substitute. In ileal conduits, acute hyperchloremic acidosis is rare, but chronic metabolic acidosis has been reported in up to 20% of patients.[81]

Urolithiasis

Calculi formation has been reported in 28-43% of patients.[76,80,81] These are often located in the kidney, but may form anywhere along the renal tract including the conduit. Predisposing factors include UTI, ureteric dilatation, urine stasis and metabolic acidosis.

Sekar *et al*. studied the renal function of over 1,000 SCI patients pre and post ileal conduit formation and noted that there were no clinically meaningful differences in the change in renal function over time among persons using different bladder management methods.[82] Renal function was adequately preserved in the great majority of neuropathic patients and did not appear to be influenced to any great extent by methods employed in bladder management.

Ileal-conduit formation is safe, relatively well-tolerated and can be cautiously considered as an option in the urinary management of patients with neurogenic dysfunction, particularly when more conservative management strategies have proved unsuccessful.

Auto-augmentation (detrusor myectomy/myotomy)

The introduction of detrusor myectomy or bladder auto-augmentation, by Cartwright and Snow, offered an innovative alternative for managing refractory detrusor overactivity.[83] By excising a disc of detrusor muscle to create a large diverticulum of the bladder dome, bladder storage function could be appreciably improved. Since its introduction, several modifications in technique have emerged with variable results. Most of the published series are in children with very few among the adult population and less so among the neurogenic or SCI cohort.[84-88] McDougall *et al.* were among the earliest to perform this procedure laparoscopically in a SCI patient and publish the short-term outcome demonstrating urodynamic evidence of improvement.[89] Some patients may show signs of improvement post-operatively, but this is not always backed up by objective urodynamic changes.[90]

The time lapse between auto-augmentation and functional rehabilitation of the bladder (substantial increase of capacity and detrusor compliance) is difficult to determine but may take up to 6 months.[86] The long-term physiologic condition of the mucosal diverticulum is unknown, but it has been speculated that ultimately the diverticulum will undergo fibrosis or that muscular regrowth may occur.[91] Up to 60% of SCI patients will require ISC post-operatively. Bladder rupture was reported in 2% of patients undergoing autoaugumentation. The predisposing factor for the rupture was thought to be the presence of an AUS.[86]

Results are not durable and further adjunct operations may be needed in up to 50% of cases.[86,91] Most series with a relatively long mean follow-up period (±6 years) do not appear enthusiastic about auto-augmentation, concluding that it is urodynamically and symptomatically inefficacious in the long run when managing patients with neurogenic voiding dysfunction.[92] The attractiveness of auto augmentation lies in the fact that it has comparatively less morbidity than enterocystoplasty and it does not preclude performance of an enterocystoplasty if required in the future.

Augmentation cystoplasty/enterocystoplasty

Von Mikulicz described the first human augmentation ileocystoplasty in the latter part of the 19th century.[93] A 100 years later, Bramble published his experience using the procedure to treat adult enuresis and urge incontinence.[94] With recent improvements in both laparoscopic and robot assisted techniques, augmentation cystoplasty has been performed in selected centers using these methods.[95-98]

The vast majority of procedures are through the standard open technique and for these, long-term results have been published. Where available, ileocystoplasty appears to be the most popular bladder augmentation procedure in this cohort. Linder *et al.*[99] were amongst the earliest to report intermediate to long-term results of reconstructive surgery (caecocystoplasty/ileocystoplasty) in patients with neurogenic bladder dysfunction. Eighteen patients were followed-up post-operatively for between 12 and 120 months (mean 38 months). Of this number, 5 had AUSs in addition to enterocystoplasty to aid continence. At the end of the follow-up period, 82% of the patients were continent.

Gurung *et al.*[100] reported outcomes post augmentation ileocystoplasty in 19 patients (mean follow-up 14 years) with refractory NDO due to suprasacral SCI. These were relatively young patients with a mean age of 28.9 years. A single surgeon performed all operations. Evaluation was conducted using results of pre- and post-operative videocystometrogram and patient satisfaction was surveyed with a validated questionnaire. This group reported significant post-operative improvement in bladder capacity and a decrease in intravesical pressures ($P < 0.001$). Long-term complications were found in 57.9%. Nearly half of these were bladder stones ($n = 4$); others include urosepsis ($n = 2$); vesico-ureteric reflux ($n = 2$), ureteric re-implantation due to reflux ($n = 1$); NDO ($n = 1$); and laparatomy for bowel obstruction ($n = 1$). No patient developed bladder neoplasia during the follow-up period. Fourteen patients responded to the questionnaire with 93% indicating a high level of satisfaction. No patient reported any significant change in either bowel habit or sexual function. These are excellent long-term results in, possibly, a small series done in a regional center. Quek and Ginsberg[101] also reported a high level of patient satisfaction post enterocystoplasty in 26 patients with neurogenic voiding dysfunction after a mean follow-up of 8 years. Functional outcome was evaluated via urodynamics. Around 96% demonstrated near or complete resolution of their pre-operative urinary incontinence as well as a significant increase in bladder capacity ($P < 0.001$) with a mean maximum detrusor pressure reduction of 61 ± 12 cm H_2O ($P < 0.01$). Nearly 88% experienced no significant alteration in bowel habit and almost all reported extreme satisfaction with urological outcome. Of the 26 patients treated, 12 (46%) required a secondary procedure 4.4 years after the initial surgery. Similar reintervention rates (30% to 59%) were reported by Mast *et al*.,[102] Herschorn and Hewitt[103] and Andrew and Lloyd.[104]

Chartier-Kastler's group performed their urodynamic assessment on a cohort of 17 patients after a mean follow-up of 5.4 years. 15 (88.5%) patients had a Hauntmann enterocystoplasty and the remainder a clam cystoplasty. Both groups reported very similar urodynamic and clinical outcomes.[105] Maximum cystometric capacity (MCC) increased from 174.1 ± 103.9 to 508.1 ± 215.8 ml ($P < 0.05$). Only two patients continued to have stress urinary incontinence. More recently, Gobeaux *et al*.[106] published single center data detailing urodynamic and clinical outcomes from a similar procedure (± concomitant urinary incontinence surgery) among a larger group (61 patients) of SCI patients with NDO related urinary incontinence and/or sphincter weakness incontinence.[106] With a mean follow-up of 5.84 years (range 1-20.5), an improved or total continence rate was achieved in 89.7% and 74.1%, respectively. Surgery failed (incontinence persisted) for 6 (10.3%) patients, three of whom had a simultaneous procedure for stress incontinence. On urodynamics, MCC increased from 305.2 ml to 509.4 ml ($P < 0.05$), mean compliance (ml/cm H_2O) increased from 15 to 42.7 ($P < 0.05$) and mean detrusor pressure at MCC (cm H_2O) fell from 54.1 to 19.1 ($P < 0.05$). Persistent NDO occurred in 20.7% compared with 59% pre-operatively ($P < 0.05$). The overall complication rate was 37.7% but ≤ Clavien Grade 2 in 82.6%. Notably, the incidence of bowel dysfunction, namely diarrhea and/or fecal incontinence was 27.5%. Concomitant outlet surgery was associated with increased morbidity as three (17.6%) complications led to re-intervention.

Robertson *et al*.[107] agreed that bladder augmentation or substitution has a role in managing patients with neuropathic bladder dysfunction after publishing their post-operative urodynamic (conventional and ambulatory) and clinical outcomes on 25 patients followed up over an average of 4 years. All patients had a detubularized reservoir made of an ileal or ileocecal segment. An artificial sphincter was fitted in 24% of patients treatedand 8% underwent colposuspension. 40% reporting complete success and 52% excellent improvement. An honest report with good long-term results and showing that combining a colposuspension and an AUS insertion does not create additional problems.

Although minimally invasive procedures are gaining in popularity and acceptance, augmentation cystoplasty remains the gold standard in treating patients with refractory neurogenic voiding dysfunction, detrusor overactivity, hypocompliance and high resting intravesical pressure. The evidence indicates a high level of success with manageable long-term morbidities. Lifelong surveillance is advocated.

The new frontier

Long-term outcomes are beginning to emerge from exciting new alternatives in reconstructive surgery. Atala *et al*. reported recently on 3.8-year (mean) outcomes following bladder tissue reconstruction using autologous bioengineered bladder tissue in seven patients with myelomeningocele.[108]

Autologous urothelial and smooth muscle cells were seeded on a bladder shaped collagen scaffold *in vitro* in preparation for later reconstruction and implantation. Overall improvement in urodynamic parameters were reported as well as preservation of renal function and absence of commonly reported long-term complications.

CONCLUSION

There have been a lot of advances in reconstructive urological surgery since the days of 19th century pioneers like von Mikulicz. Though minimally invasive procedures are becoming mainstream, there is still a place for reconstructive procedures whether open, laparoscopic or robot assisted.

Advances in tissue and genetic engineering and stem cell research hold the key to future exciting new developments in the field of reconstructive urological surgery. Such a rich plethora of reconstructive procedures affords this unique cohort of patients' greater choice and ultimately potentially improved long-term care with better long-term survival and improved quality-of-life.

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