Neurogenic bladder dysfunction: surgical interventional approaches

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Introduction

The first-line management of neurogenic bladder dysfunction is based on conservative treatments, such as general measures, non-pharmacological approaches and pharmacological treatment. However, when these measures fail, are not well tolerated or the patient has complications, such as renal impairment or low bladder compliance, surgical treatment may be indicated. There are several different procedures which can be considered including electrical stimulation, bladder and urethral reconstructive surgery, bladder outlet obstruction management and the treatment of stress urinary incontinence. The choice of surgical treatment is based on a multidisciplinary assessment involving urologists, rehabilitation physicians, physiotherapists, specialist nurses and often neurologists, neurosurgeons and gastroenterologists and must be appropriate for the patient's disability, cognitive functions and hand functions.

The goals of surgical management of the neurogenic bladder are to preserve the upper urinary tract and renal function, to avoid urological complications and to improve quality of life by restoring continence and independence. Surgery is not commonly performed in patients with progressive neurological disease and bladder dysfunction, but may be the best option for those who have had a spinal cord injury (SCI), those with myelomeningocele and occasionally patients with multiple sclerosis. In those with non-progressive disease, surgery for neurogenic bladder disorders is often performed in young people with an otherwise near normal life expectancy and hence its benefits must be durable.

This chapter describes the different surgical procedures for managing neurogenic bladder.

Electrical stimulation

Electrical stimulation to manage bladder dysfunction in patients with neurological disorders has been used since the 1950s. Nowadays, electrical stimulation therapies include intravesical electrostimulation, sacral neuromodulation and sacral anterior root stimulation with selective sacral rhizotomy.

Intravesical electrostimulation

Intravesical electrostimulation was first described by Saxtorph in 1887 but reintroduced by Katona in 1959 [1, 2]. The bladder is filled with saline, a monopolar electrode (cathode) is inserted urethrally into the bladder and a second one attached to the abdominal wall (anode). Electrical stimulation is given for between 60 and 90 minutes for 5 days per week, usually using an intensity between 1 and 10 mA, a rate of 20 Hz and a pulse duration of 2 ms.

It is thought that this acts primarily by stimulating Aδ mechanoreceptor afferents [3] inducing bladder sensation and the urge to void, and consequently increasing the efferent output, with improvement of micturition and conscious control. Thus, patients with a hyposensitive and underactive detrusor may be offered intravesical electrostimulation [4, 5], especially in combination with intermittent self-catheterization, before invasive surgical procedures are considered. However, it should only be used in patients with at least some sensation in the sacral dermatomes indicating functioning afferent fibers and if the detrusor muscle is still able to contract.

This therapy has been used mainly in children with myelomeningocele but clinical studies have been limited and results remain controversial. The only

randomized, sham-controlled and blinded clinical study in fact failed to reveal any improvement in bladder capacity, development of detrusor contractions, improvement in detrusor compliance or acquisition of bladder sensation in the active treatment group [6].

Sacral neuromodulation

Sacral neuromodulation (SNM) was developed in the 1980s by Tanagho and Schmidt and it has now come to occupy the position of a second-line treatment for refractory non-neurogenic voiding dysfunctions such as urgency-frequency syndrome, urgency incontinence and non-obstructive chronic urinary retention [7].

The first use of neuromodulation on neurogenic voiding dysfunction was reported by Bosch and colleagues in 1996 [8] and since then a number of other studies have been reported [9–15]. There is now some evidence that sacral neuromodulation may have a place in treating bladder dysfunction in incomplete SCI, multiple sclerosis, cerebrovascular disease or myelomeningocele.

The exact mechanism of action of SNM is still not fully understood but in non-neurological patients it has been suggested that by using a continuous or cycling mode of electrical pulses, SNM stimulates sacral afferent nerves. In conditions of detrusor overactivity these may have an inhibitory effect on sacral efferent activity whereas in some causes of retention the afferent activity "re-informs the midbrain" (see Chapter 19). So in both types of disorder, SNM is effective by modulation of spinal cord reflexes or brain networks, rather than direct stimulation of the motor response of the detrusor or urethral sphincter [16–18]. The same inhibitory effect may operate in neurogenic DO although SNM has not been found to be very effective in neurogenic retention or incomplete bladder emptying.

Surgical technique

The technique for SNM has undergone several modifications since its first introduction. The technique has always involved two steps, a test stimulation and a permanent implant, the test stimulation providing an opportunity to evaluate the possible outcome of the final implant. Nowadays, a two-staged percutaneous technique is carried out using the tined lead developed by Spinelli in 2003 [19]. Under fluoroscopic guidance, and local or general anesthesia,

Fig. 7.1. Pelvic x-ray showing a tined lead connected to a permanent implanted pulse generator.

the tined lead is implanted and attached to an external stimulator for up to a month, allowing a prolonged period of testing. If the first stage fails, the electrode can be removed. If the patient responds, a permanent implantable pulse generator (IPG) is implanted in the upper buttock region (Interstim® model) (Fig. 7.1) and connected to the tined lead already *in situ*. Buttock placement of the battery has been shown to decrease the incidence of postoperative and position-related pain, and infection [20]. The average battery life with Interstim® and Interstim II® is around seven and five years, respectively, but this varies with the settings used [21].

Results

Bosch reported the results of SNM in 6 patients with refractory urgency incontinence secondary to multiple sclerosis and, at a mean follow-up of 35 months, showed a reduction in incontinence episodes from 4 to 0.3 per day [8]. Chartier-Kastler then confirmed these findings in 9 women, including 4 from Bosch's series and 5 others with traumatic SCI or myelitis, and showed that the results remained stable with a long-term follow-up (43.6 months) [10]. By contrast, Hohenfellner reported that SNM was effective in 8 patients with neurogenic bladder dysfunction but for less than 54 months, after which all implants became ineffective [11]. No patients with MS were included in that series, which consisted of incomplete SCI, disc prolapse or surgical pelvic nerve damage.

The two largest series of SNM in neurogenic bladder disorders have been reported by Wallace and Lombardi respectively and demonstrated a degree of

efficiency [14, 15]. In a retrospective series of 33 patients with neurologic disease, Wallace reported that 28 patients (85%) underwent implantation. Thirteen of the 16 patients with MS, 4 of 6 with Parkinson disease and all 11 of those with various other neurologic disorders received a permanent implant. Incontinence episodes decreased by 68%, number of voids by 43%, nocturia by 70% and there was a 58% reduction in intermittent self-catheterization per 24 hours [15]. Lombardi reported on the outcome of 24 incomplete SCI patients with a follow-up of 61 months. He found that all subjects maintained a clinical improvement of more than 50% compared with baseline, although 4 subjects with urinary retention needed a new implant at the contralateral S_3 because of loss of efficacy [14].

In children, Guys reported a prospective, randomized, controlled study of 42 patients with neurological disease (mean age 11.9 years) including 33 with spina bifida [13]. Patients were randomized into the control group treated conventionally and an implant group treated with SNM. Some improvement was noted in the SNM group but the differences compared with the control group were not significant and furthermore it was observed that it could be difficult to identify the relevant sacral roots and place leads accordingly in some of the patients with spina bifida.

In two separate studies, Scheepens and Amundsen reported that a neurologic condition is associated with a reduced improvement rate in comparison to non-neurogenic patients [9, 12]. Furthermore, it appears to be less effective in improving urinary retention than reducing detrusor overactivity.

Recently, Van Rey has reported in a selected MS patient population that despite a 61% positive response rate to the first stage, at two years of follow-up neuromodulation remained efficient in only 18% of the implanted patients, the efficacy being lost with progression of the neurological disease in all cases [22]. The conclusion from this study therefore is that this costly intervention should probably not be undertaken in patients with MS. However the advent of effective disease-modifying drugs which slow or even halt the progression of MS may significantly alter the situation in the near future.

The impact of neuromodulation on DSD is not yet defined and currently neuromodulation should be proposed only in patients without DSD and with incomplete SCI. It appears that prospective studies are needed to determine the place of SNM as a treatment of neurogenic voiding dysfunction in children and adults.

Very recently, sacral neuromodulation has been used in the acute SCI setting, i.e. in the state of spinal shock, and been shown to prevent the development of neurogenic detrusor overactivity, reducing urinary infections as well as improving bowel function. Continence is maintained by clean intermittent self-catheterization (CISC). So far the benefit has been sustained for more than two years [23] and if this effect can be confirmed in a large scale trial, SNM may well transform the management of NDO in SCI patients.

Complications

SNM is not without a significant complication rate and need for revision surgery. Complications include lead migration, pain at the IPG site, leg pain, infection and failure of the device over time. The reported incidence of lead migration and lead breakages is 11% and 20% respectively [21, 24]. Siegel summarized the adverse events in 219 patients who underwent implantation of the Interstim® IPG and the most common complaint was pain at the IPG site in 15.3% of patients [25]. The surgical revision rate was 33%. Everaert reported a 34% device-related pain rate, with a 23% surgical revision rate [26]. Grunewald reported a revision rate of 30% over four years. Lead migration was noted as 5.4% and IPG site pain as 8.1% [27]. Recently authors have reported much higher long-term revision rates at 54% [28], 48.3% [21] and 43.9% [29] excluding battery changes. Similar results were obtained in a worldwide SNM clinical study in non-neurological voiding dysfunction, carried out by Van Kerrebroeck [30].

It is important that patients are counselled regarding the possible failure of the procedure and the significant revision rate.

Sacral anterior root stimulation with sacral deafferentation

Sacral anterior root stimulation with sacral deafferentation was introduced by Brindley in 1970s [31]. Essentially this procedure involved section of the dorsal sacral roots to abolish detrusor overactivity and stimulation of the sacral anterior roots (S_2, S_3 and S_4) to produce detrusor contraction and bladder emptying. After a laminectomy to expose the nerve roots, the anterior roots were placed in special

stimulating electrodes and were tunneled to connect to a subcutaneous radio receiver positioned over the lower anterior chest wall. The patient placed a radio transmitter over the receiver and activated the device with settings as required for micturition, defecation and even erection. Bladder emptying was accomplished usually by stimulation of S_3 with a bladder emptying success rate of 70% [32].

This device could only be used in individuals with complete suprasacral SCI because those with incomplete lesions found even efferent root stimulation painful. But because of the posterior rhizotomy which was required to abolish detrusor overactivity, men lost reflex erections and it is probably because of this destructive component that this intervention is now little used.

Surgical technique

Two approaches have been described, the intradural and the extradural approaches, and a specific electrode has been developed for each [33].

The surgical technique for intrathecal implantation developed by Brindley [34] involves laminectomy of the fourth and fifth lumbar vertebrae and the first two segments of the sacrum, exposing 10–12 cm of dura. The dura and arachnoid are opened in the midline to expose the roots, the roots identified by their size, situation and by perioperative stimulation during which the bladder pressure is recorded and skeletal muscle responses observed. Stimulation of the S_2 anterior roots contracts the triceps surae, the glutei, and the biceps femoris, S_3 anterior roots the pelvic floor and the toe flexors, and S_4 anterior roots the pelvic floor. The sphincters (anorectal and urethral) are innervated predominantly by S_4 and to a lesser degree by S_3 and S_2. A detrusor response can almost always be obtained by stimulation of S_3 and S_4, and sometimes S_2. The roots need to be split into the anterior and posterior components and when the posterior roots are confirmed by an absence of a motor response to electrical stimulation, a segment measuring about 20–40 mm in length is removed. When the S_5 root is identified, it is resected if no bladder response is obtained.

The surgical technique for extradural implantation involves laminectomy of the first three segments of the sacrum. It may also involve laminectomy of the L_5 vertebra, depending on whether electrodes are to be placed on S_2 roots. A posterior rhizotomy is done at the level of the conus medullaris at the same operation through laminectomy of T_{12}, L_1 and, sometimes, L_2. At this stage it is straightforward to identify and to cut all posterior roots that enter the last 30 mm at both sides of the spinal cord.

Once the rhizotomy has been performed, electrodes are put on the motor fibers and a sleeve is fixed over the cables to prevent leakage of cerebrospinal fluid. After closure of the dura, the cables are tunneled to a subcutaneous pocket on the lower part of the thorax or on the abdominal wall and connected to the radio receiver block. Stimulation is started between days 8 and 14 after surgery according to the level of the spinal cord lesion.

Results

The results of implanting the Brindley stimulator are summarized in Table 7.1 [35–44]. Postoperative continence is achieved in between 80% and 90% of the cases. The goal of the posterior rhizotomy is to abolish detrusor activity and to normalize bladder compliance. Continuing urinary incontinence is related either to an incomplete rhizotomy or to sphincter incompetence. Bladder capacity increases and reaches more than 400 ml in all cases although it is recommended that bladder volumes be kept to less than 600 ml. Bladder emptying is complete in 69–100% of the cases. Use of the stimulator is associated with a decrease in complications, such as symptomatic urinary tract infections, vesico-ureteric reflux and autonomic dysreflexia.

Follow-up

Urodynamic studies are needed one month after the surgery to check electrical stimulation produces an efficient bladder contraction and thereafter at four months and one year, then every 2–3 years subsequently.

Urinary tract reconstructive surgery

The goal of urinary tract reconstructive surgery in neurological patients is to create a low-pressure urinary tract, to preserve the upper urinary tract and renal function and to improve patients' quality of life by restoring continence and independence.

The various urinary tract reconstructive operations for patients with neurogenic bladder dysfunction include bladder augmentation, cutaneous continent diversion and an ileal conduit.

Surgery should be performed in departments which are used to managing neurological patients.

Table 7.1. Results of sacral anterior root stimulation and sacral posterior rhizotomy in complete spinal cord injured patients

| Authors (year) | n | Sex | | Mean follow-up (years) | Continence | | Mean bladder capacity | | Post-void residual volume < 50 ml (%) | AD | | UTI | |
		Men	Women		Preop (%)	Postop (%)	Preop (ml)	Postop (ml)		Preop (%)	Postop (%)	Preop (%)	Postop (%)
Barat (1993) [35]	40	26	14	2.5	2.5	90	210	463	82	–	–	100	30
Brindley (1994) [36]	500	271	229	4	–	–	–	–	82	–	–	–	–
Van Kerrebroeck (1996) [37]	52	29	23	3.5	–	81	285	592	87	14	4	4.2/an	1.4/an
Schurch (1997) [38]	10	3	7	3.4	0	80	160	>500	100	60	60	80	30
Egon (1998) [39]	96	68	28	5.5	1	88	200	565	89	22	0	100	32
Van der Aa (1999) [40]	37	33	4	6	–	84	75% <400	95% >400	91	–	–	–	–
Creasey (2001) [41]	23	16	7	1	65	87	243	>400	69	35	7	82	78
Bauchet (2001) [42]	20	6	14	4.5	0	90	190	460	90	15	0	100	–
Vignes (2001) [43]	32	–	–	8	0	90	220	550	80	18	2	100	30
Kutzenberger (2005) [44]	464	224	220	6.6	–	83	173	470	81	–	–	6.3/an	1.2/an

Preop = preoperative; Postop = postoperative; AD = autonomic dysreflexia; UTI = urinary tract infections

There should be suitable infrastructure and environment including adapted patients' alarms, beds, toilets and bathrooms and an adequate number of specially trained nurses [45].

Bladder augmentation

Detrusor myectomy

Detrusorotomy was proposed by Mahony and Laferte, in the 1970s, as an alternative to enterocystoplasty [46], the technique being subsequently modified by Cartwright and Snow who proposed a partial detrusor excision [47]. These procedures have been used mainly in children.

Surgical technique

The principle of detrusor myectomy is to excise detrusor muscle over the entire dome of the bladder, leaving the urothelium intact. Bladder pressure gradually dilates the excised area and a large diverticulum appears. It was initially performed using an open approach, but nowadays it can be performed laparoscopically or with robotic assistance [48, 49].

Results

The level of evidence for efficacy for either procedure is low. Most series report poor results and failure of this technique with time [50–53]. Bladder volume increases in most of the cases but it may take 3–12 months to reach full capacity and then a secondary retraction frequently occurs. Furthermore, detrusor overactivity often persists so that the improvement in symptoms may be small. Kumar reported a failure rate of 83% with a mean follow-up of 79 months. A retrospective study comparing detrusor myectomy and enterocystoplasty found enterocystoplasty to be more effective [54]: whereas urodynamic improvement was 50% in detrusor myectomy, it was 100% in enterocystoplasty and symptom improvement was 42% vs 94%, respectively. However, detrusor myectomy avoids the digestive complications which may occur following enterocystoplasty (20% vs 3%, respectively). Bladder autoaugmentation by detrusor myectomy is rarely carried out now.

Bladder augmentation enterocystoplasty

Bladder augmentation enterocystoplasty was first performed by Von Mickulicz in 1889 [55] to manage chronic tuberculosis cystitis. Nowadays, bladder augmentation is mainly for SCI patients and patients with myelomeningocele who have low bladder capacity, a reduced bladder compliance and detrusor overactivity which is resistant to all conservative treatments including oral antimuscarinics, intradetrusor botulinum toxin injections and possibly sacral neuromodulation. Bladder augmentation is contraindicated in severe inflammatory bowel disease such as Crohn's disease, hemorrhagic colitis, irradiation related bowel damage, short bowel syndrome, compromised renal function, and in patients who refuse to perform CISC.

Surgical technique

Before performing a bladder augmentation enterocystoplasty, the patient is cystoscoped to exclude bladder cancer, kidney function is checked and gastrointestinal tract function evaluated. The patient must be able and willing to perform CISC [56].

Several techniques have been proposed according to the type of bowel segment to be used and the state of the bladder. The principal two methods of bladder augmentation are bivalving the bladder and performing a subtrigonal cystectomy. The choice is generally based on the bladder wall thickness. Hence, if there is significant loss of viscero-elastic properties, it is better to perform a subtrigonal cystectomy. Nowadays, it constitutes the most frequent condition because reduced bladder compliance without bladder wall fibrosis is most often managed with botulinum toxin injections.

Several intestinal segments such as colon, ileum or stomach can be used, most commonly the ileum. After preparation of the bladder or a supratrigonal cystectomy, a 15–45 cm detubularized intestine segment is isolated and stitched in the defect (Fig. 7.2). Several approaches have been reported including open (Pfannenstiel or midline incision), laparoscopic and robotic. If the patient has difficulty performing CISC via the urethra, a cutaneous diversion can be fashioned at the same time (see below) [57, 58]. Usually, no ureteric reimplantation is required as even in the case of vesico-ureteric reflux before surgery, this is corrected in more than 90% of cases by the decrease in pressure associated with the bladder augmentation.

An indwelling catheter is left *in situ* following surgery and 10 days later a check cystogram is
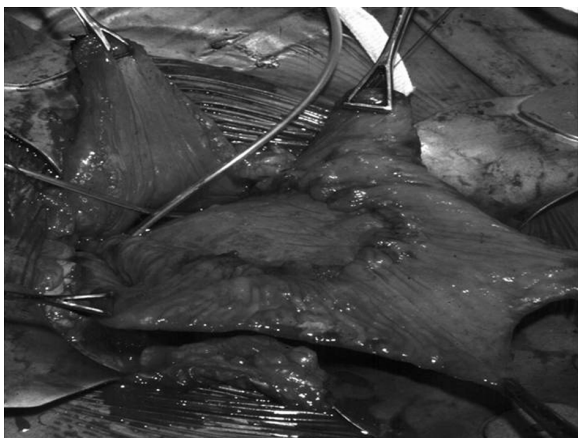
Fig. 7.2. Bivalved bladder with intestinal segment stitched to the posterior wall.

performed and the catheter removed. The patient then starts CISC and, for the first few months, catheterizes three-hourly. The bladder usually reaches its definitive capacity about three months after the surgery and patients then catheterize every four hours at daytime and every eight hours during the night.

Results

The perioperative mortality rate is between 0 and 3.2%. The early post-operative morbidity rate is between 3% and 28%. Ileus is the most frequent complication with a rate up to 11.7%. Late morbidity is mainly related to the type of intestinal segment used and includes mucus production, stones (10–50%), persistent asymptomatic or symptomatic bacteriuria (up to 70%), hyperchloremic metabolic acidosis (0–15%), deterioration of renal function, bowel disturbances and bowel patch cancer (1%) [59–64]. However, the most serious complication is the spontaneous rupture which occurs in 5–13% of patients and requires emergency surgery [65]. It is usually related to bladder overdistension but sometimes to a traumatic catheterization.

The long-term results are very good with excellent control of overactivity and incontinence [66]. Furthermore, quality-of-life studies report an improvement of over 90% [66]. Continence is achieved in more than 90% for night-time and between 91% and 100% during the day [59, 60, 67]. If incontinence remains, intradetrusor botulinum toxin injections to treat persistent detrusor overactivity can be

Fig. 7.3. Sagittal view of a cystogram performed one year after subtrigonal cystectomy and enterocystoplasty in a T12 ASIA A paraplegic patient.

performed or an artificial urinary sphincter or sling can be placed in case of sphincter incompetence.

Follow-up

The follow-up of patients who have had a "clam" cystoplasty should be life-long, as a variety of problems can develop (see above). Kidney and bladder ultrasound and renal function assessment should be performed at one and six months after the surgery and yearly thereafter. Cystogram (Fig. 7.3), cystoscopy and urodynamics are usually performed one year after the surgery and then on an as-required basis.

Future possibilities

New bladder augmentation techniques have been proposed which may be developed in the future, using biomaterials such as extracellular matrix of the small intestinal submucosa (SIS, Cook®) [68] or porcine xenograft acellular matrix (Pelvicol, Bard®) [69] for "clam" cystoplasty. An alternative approach may be to use tissue that has been engineered using selective cell transplantation [70].

Cutaneous urinary diversions

Cutaneous continent diversion

Cutaneous continent diversions may be performed in neurological patients, mainly in the young myelomeningocele patient or those with SCI who cannot perform CISC via the urethra because of congenital abnormalities, urethral pain, obesity, strictures or poor hand mobility. Cutaneous continent diversions are contraindicated in patients who simply refuse to perform CISC, have permanent severe cognition dysfunction (brain injury) or have severely limited manual dexterity through a quadriplegic injury. However, a tendon transfer, such as extensor carpi radialis longus to flexor digitorum profundus, facilitates apposition of the thumb and first finger and so enables such a patient to perform CISC.

The principle is to fashion a drainage channel between bladder and umbilicus or lower abdominal wall, through which the patient can completely empty their bladder.

Surgical techniques

Nowadays, two procedures are used. The first, which uses the appendix, is called a Mitrofanoff procedure [71], and the second, which uses the ileum, is known as a Yang-Monti procedure [58]. If the appendix is available, it is preferable to use this, so that the Yang-Monti procedure is reserved for the patients in whom an appendectomy has previously been performed or those in whom the appendix does not look suitable or is already in use [72]. The fashioned tube is inserted into the bladder wall via an at least 4 cm submucosal tunnel [73].

In case of reduced bladder compliance or neurogenic detrusor overactivity, a bladder augmentation is usually performed at the same time. Usually, the bladder neck is left open as a "safety mechanism." If the native bladder cannot be preserved, for example because of bladder cancer, a substitution cystoplasty using ileum or colon can be performed with the complications the same as those described above for cystoplasty. Nowadays, the most popular substitution cystoplasty performed is the "Florida pouch" which uses a low-pressure detubularized colonic reservoir with a tapered ileum and a purse string suture around the ileocecal valve as its continent mechanism [74].

During the surgery, an indwelling catheter is left through the native urethra and another into the stoma. These are usually removed 21 days after performing a cystogram, and the patient then starts CISC. For the first months, patients have to catheterize themselves every three hours in daytime and at night. About three months after the surgery, the bladder reaches its definitive capacity and patients catheterize every four hours during the day and eight-hourly during nights.

Results

Morbidity and mortality are comparable to those reported above for bladder augmentation enterocystoplasty. However, specific stoma complications occur in 16–60% with a follow-up between 30 and 240 months. The main complication, which has an incidence of 3.5–45%, is stomal stricture preventing catheterization attempts. Other complications include tube necrosis, diverticulae, tube traumatism and mucosa prolapse. Stoma complications require a second intervention in 5–38% of cases [75].

Continence is achieved in 70–98% of the patients. Furthermore, an improvement of the quality of life has also been reported, as a result of better patient independence, continence and sex life [76].

Follow-up

Follow-up must be similar to that of patients with bladder augmentation enterocystoplasty (see above).

Ileal conduit

An ileal conduit is a non-continent diversion, performed for patients with severe motor or cognitive disability or with urological complications such as deteriorating renal function, usually in the context of advanced MS or complicated myelomeningocele or SCI. The procedure is regarded as an "end of line" management option for the neurogenic bladder. A cystectomy may be performed simultaneously, although adding to postoperative morbidity, as there is a risk of bladder cancer or pyocystis if the defunctioning bladder remains.

Surgical techniques

After removing the bladder, a segment of ileum is anastomosed to the ureters at the proximal end, the distal end being inserted through the right side of the abdominal wall. Two ureteral stents are left for several days and then removed. An ileal conduit can be performed using an open, laparoscopic (Fig. 7.4) or robotic approach [77–79].

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Fig. 7.4. Post-operative view of an MS patient managed with a laparoscopic assisted ileal conduit (the upper stents are ureteral).

The role of the ileum segment is to conduct, not to collect, urine through the abdominal wall into a bag attached to the skin. An important point is the localization of the stoma, which must be determined before the surgery and adapted to the patient's anatomy and disability. In a wheelchair-bound patient, the stoma should be placed higher on the abdomen than in someone who is ambulant.

Results

The perioperative mortality rate is between 1.3% and 3.1%. The early postoperative morbidity rate is between 3.8% and 33.4%, related mainly to the development of an ileus or transient impairment of respiratory function in a very disabled patient [78, 80, 81]. Late complications are mainly related to uretero-ileal anastomosis (stenosis: 2–7.8%), stomal hernia and pyelonephritis (6–32%) [81, 82]. Long-term renal function in patients with ileal conduit has been studied in children and although this may remain stable for the first few years it may subsequently deteriorate [81].

Nevertheless an ileal conduit may be a means of preventing urinary tract damage and infections, or preventing progressive renal function impairment, and may be able to improve patients' quality of life [83].

Sphincter surgery

The aim of sphincter surgery is to relieve bladder outlet obstruction due to external urethral sphincter contraction. It can be performed only in men because patients become incontinent and need a condom to collect urine. In men who cannot perform self-catheterization and who have no detrusor contractility impairment, especially quadriplegics or men with advanced MS, it can improve bladder management considerably. Several procedures have been proposed such as sphincterotomy or urethral stenting.

Sphincterotomy

Endoscopic sphincterotomy was developed for the treatment of DSD in the 1950s. It has been demonstrated to be effective for both the treatment and the prevention of genitourinary complications. However, this technique is associated with a failure rate of 15–50%, erectile dysfunction in 4–40% of cases, perioperative complications such as septicemia and hemorrhage in 5% of cases, and is irreversible [84]. Balloon dilatation of the striated sphincter was also described, but subsequently abandoned owing to the high failure rate.

Stents

Urethral sphincter stents were developed in the 1990s. There are two types: temporary (Memokath®, Diabolo®) or permanent (Urolume®, Memotherm®) (Fig. 7.5). Temporary stents can be used as a therapeutic test to ensure adequate continence control in combination with a condom catheter, to check that a stent does not induce troublesome autonomic dysreflexia, to assess acceptability of the bladder drainage method, to verify bladder emptying will be achieved, to study bladder emptying in the sitting position, to improve the patient's independence and give the patient time to think about a definitive management strategy. Temporary stents can also be used as a reversible treatment in patients with transient problems or who cannot do CISC or in patients during the initial period following the injury whilst awaiting recovery or rehabilitation of the upper limbs. In neurological patients, temporary stents can be used to help determine whether or not urinary symptoms are related to benign prostatic hyperplasia (BPH): if urinary symptoms mimicking BPH are relieved by placing a stent in the prostatic part of the urethra, prostate surgery should be considered [85].

After a temporary urethral sphincter stent, 70% of patients choose a permanent one as the preferred management of their bladder dysfunction [86]. Complications with temporary stents include a higher rate
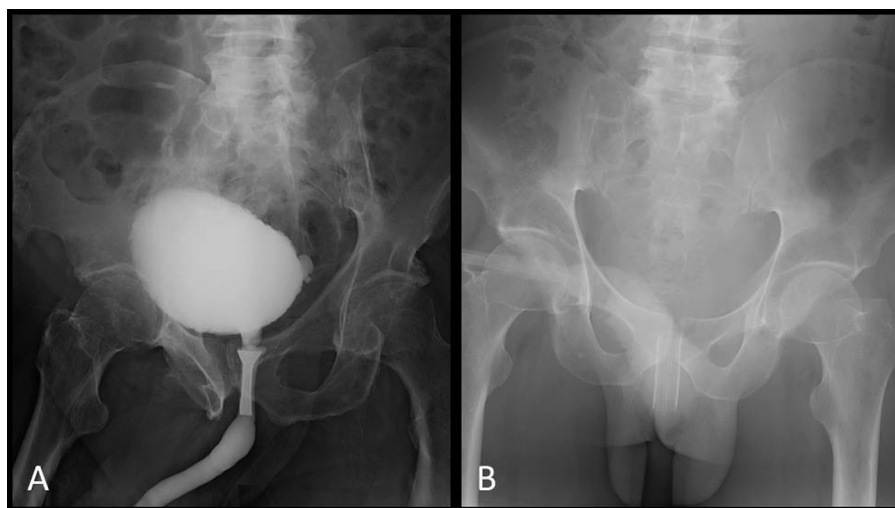
Fig. 7.5. Quadriplegia patients with a temporary urethral sphincter stent (A) and a permanent urethral sphincter stent (B).

of stent migration, stent blockage with stone or calcification, and recurrent urinary tract infections [87].

Temporary and permanent stents may ensure effective bladder emptying and lower bladder voiding pressure, thus reducing autonomic and infectious complications and minimizing the risk of renal damage [88]. Rivas found no significant differences in terms of efficacy between urethral stents and endoscopic sphincterotomy, but stents were associated with less blood loss and earlier discharge from the hospital [89]. The long-term complications with permanent stents are stent encrustation, migration, bladder neck obstruction and, if required, difficult stent removal [90].

Stress urinary incontinence management

Urinary incontinence in neurological patients is mainly due to detrusor overactivity but in some cases coincidental striated sphincter incompetence, or urethral hypermobility in women, can lead to stress urinary incontinence.

Slings

Slings are mainly used in women and are made either from autologous tissue (rectus fascia) or synthetic material (polypropylene mesh). The sling is placed vaginally under the mid urethra or under the bladder neck. With a follow-up of 27 months, an efficacy of up to 83% has been reported [91]. In neurological patients who are already performing CISC (SCI or MS patients or patients with peripheral neuropathy causing impaired detrusor contractility), the sling can be placed somewhat more tightly to increase the chance of achieving continence. However, in women who void spontaneously, preoperative urodynamics are mandatory to check bladder contractility since urinary retention after sling surgery requiring CISC may be due to detrusor hypocontractility. Apart from urinary retention, complications include urethral and bladder erosion, difficulty in self-catheterization and development of de novo detrusor overactivity.

Slings have been used in boys with spina bifida when they have been placed around the bladder neck using either an abdominal or abdomino-perineal approach. The success rate of slings in spina bifida boys is up to 75% [92] with complications similar to those in women.

Adjustable continence therapy (ACT)

ACT was developed for the treatment of post-prostatectomy incontinence, and in men and women for recurrent stress urinary incontinence resulting from sphincter incompetence. Two balloons are implanted under the bladder neck or close to the prostatic apex in men and attached to an injectable port which is located in the scrotum in men and in the labia majora in women. The port allows post-operative adjustment of balloon pressure and volume.

Fig. 7.6. Laparoscopic view of the retropubic space showing the anterior part of cuff around prostate and the reservoir in laterovesical position.

Bastien has suggested this may be a new alternative treatment option for managing stress urinary incontinence in neurological patients [93]. This procedure appears to be safe and completely reversible but in patients performing CISC, ACT was associated with high rate of urethral erosion.

Bulking agents

The injection of bulking agents to increase urethral resistance and leak point pressures is a minimally invasive endoscopic technique. Initially collagen-based beads were implanted but these were found to degrade over time so that now, silicone-based substances (Macroplastique-polydimethylsiloxane) are used. In non-neurological patients, they are effective in 60–80% of cases although the effects last for only about two years or so and quite often more than one injection is required to achieve the desired results. Importantly, their use does not preclude any further treatment. In neurological patients, studies are limited but it is known that this intervention is contraindicated in patients performing CISC.

Artificial urinary sphincter (AUS)

The AUS is an excellent device for achieving continence. Although more commonly used in men, it can be used in both sexes. However, the results in neurogenic patients are not as satisfactory as in the non-neurogenic group. The reason for this is not known but pressure on the perineum sustained from sitting in a wheelchair and self-catheterization may be contributing factors.

The device has three components, a cuff which is placed around the bulbar urethra or prostate, a balloon which is placed in the prevesical space and a pump which is located in the scrotum. In women, the cuff is placed around the bladder neck and the pump is installed in the labia. Its use in patients with neurological disorders has mainly been in those with SCI, myelomeningocele or cauda equina damage.

The early postoperative morbidity rate is 25% but at 10 years the success rate is up to 82%, although the average AUS life is 8 years. Late complications include mechanical failure, erosion of the cuff or infection requiring removal of the implant. It is claimed that the incidence erosion is less with bladder neck cuff placement than with bulbar urethra in men [94]. The AUS can be placed using an open, laparoscopic or robotic approach (Fig. 7.6) [95].

Suprapubic catheter (SPC)

An indwelling catheter use should be limited for patients without a long life expectancy and as an "end-line" treatment. An SPC is generally considered the preferred management option in advanced MS, disabled patients with MSA or quadriplegics who become unable to perform CISC. An SPC is preferred to a urethral catheter as the latter can cause pressure necrosis with cleavage of the urethra in males and that of bladder neck in females and is also hygienically superior.

An SPC is placed percutaneously directly into the bladder through the abdominal wall. Because of the small bladder size and thickness of the wall of neurogenic bladders, its placement in neurological patients requires endoscopic control and sometimes a short general anesthetic. A relative contraindication is severe abdominal adhesions from previous surgery. Precautions are necessary to prevent complications such as bowel perforation or epigastric artery injury. In the UK between September 1, 2005 and June 30, 2009, 259 incidents were reported to the National Patient Safety Agency's Reporting and Learning System relating to the insertion and management of SPCs. Of these, nine were the result of bowel perforation – three deaths and six cases of severe harm.

The specific problems of long-term catheters are:

- recurrent urinary tract infections: a foreign body is frequently colonized with bacteria

- blockage of catheters: the catheters become blocked by matrix-crystal complex formed by the interaction of bacterial biofilms with magnesium and phosphate crystals, leading to incontinence. However, if the catheter blocks and there is outlet resistance, the bladder can distend and lead to autonomic dysreflexia in those with SCI. Indeed, catheter blockage is one of the most common causes of autonomic dysreflexia. Some patients require regular bladder washouts and frequent catheter changes and an increase in size of the catheter may be helpful. It is also thought that cycling the bladder with a flip flow value helps preserve the bladder capacity and decreases the chances of catheter blockages
- bladder stones: about 25% of patients with long-term catheters will form stones. The mechanism is thought to be an extension of the one described above for catheter blockages
- bladder cancer: the chronic inflammatory process can lead to squamous metaplasia leading to cancer. This is generally a squamous cell carcinoma with a poor prognosis and is thought to occur in 8% of those with a long-term catheter.

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