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Original Article

Long-term urological outcomes in paediatric spinal cord injury

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Study design: Retrospective review.
Objective: This retrospective review observes the evolution of bladder management by time and reports adult urological outcomes and complications in paediatric onset spinal cord injury (SCI).
Setting: Spinal Injuries Unit RNOH Stanmore.
Method: In total, 10 traumatic SCI patients with mean age at injury of 13.6 years underwent treatment, for a mean period of 13.1 years. Characteristics of injury were noted. Two diagnostic subgroups, neurogenic detrusor overactivity (NDO), and acontractile detrusor were made. Complications, treatment changes, operative procedures with follow-up were noted.
Results: In group 1 (6/10 patients) with NDO, five had DSD. Initial bladder management was reflex/urge voiding ($n=4$), suprapubic catheterisation (SPC), ($n=1$) and self-intermittent catheterisation (SIC), ($n=1$). Two patients had multiple upper tract complications with decreased renal function, two recurrent symptomatic urinary infections and one; bladder calculus. In total, 12 operative procedures were performed to treat complications and change bladder management to, SIC + oxybutynin ($n=3$), ileal conduit ($n=1$), sacral anterior root stimulator implant (SARSI), ($n=1$), voiding on urge ($n=1$). In group 2 (4/10 patients) with a-contractile detrusor two had low compliance. Initial bladder management was SIC ($n=3$) and voiding on urge/straining ($n=1$). Two patients converted from SIC to permanent catheter drainage and reported complications. Incidental kidney stone was diagnosed in one. A total of four interventions were carried out with final management of SIC ($n=2$), voiding on urge/straining ($n=1$) and Mitrofanoff + ileocystoplasty ($n=1$).
Conclusion: Bladder management in paediatric SCI is dependent on neurological level and type of injury; it changes with growth and is affected by changes in bladder management.
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Keywords: paediatric; long term; spinal cord injury; urological complications

Introduction

Spinal cord injury (SCI) predominantly affects young adults between the age group of 16 to 30 years, with average age at injury of 32.6 years.[1] SCI in young children is rare and accounts for 5% of spinal cord injuries.[2] Motor vehicle accidents, sport, violence, medical and surgical complications are some of the causes of SCI in children, adolescents and teenagers. The low incidence of SCI in paediatric age group is attributed to flexibility of the spinal column.[3] The neurological characteristics and level of bony injury also differ in pre-teens, teens and adults.[2] Younger adults although less likely to have SCI have higher incidence of neurological trauma and cervical cord injury.[4] Nonetheless, 18% of all paediatric injuries and 23% of paediatric traumatic deaths are due to neurological injury.[5]

Children are not 'small adults'[6] and rehabilitation of a child with SCI requires specialised care including psychological and social issues. Literature detailing long-term urological complications in paediatric SCI population is quite scanty but neurourological complications in spina bifida and meningomyelocele (MMC) patients are well documented.[7] The dismal picture of urinary incontinence, multiple urinary infections and subsequent renal failures in spina bifida patients underwent a change firstly, with the introduction of ileal conduit in the 1950s followed by clean intermittent catheterisations (CSIC) in 1970s. Fanciullacci *et al* have reported urinary tract infections, upper tract changes and renal deterioration in paediatric SCI population, which is not dissimilar to complications seen in MMC

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patients followed up to adulthood.[7–9] In a recently published study in paediatric SCI patients 42 children were followed up for a mean of 5.5 years. The authors conclude that with early introduction of CSIC and anticholinergic medications the upper tract changes could be minimised.[10]

The aim of this retrospective review is to observe evolution of management over time, report adult urological outcomes and complications in paediatric onset SCI.

Materials and methods

Clinical records of 10 adults with a mean age of 28 years (range 18–37 years) with paediatric onset spinal cord injuries were retrospectively reviewed. The range of age at injury was from 6 to 16 years with a mean age at injury of 13.6 years. Six male and four female subjects, all with traumatic SCI were followed for a mean duration of 13.1 years (range 6–31 years). The level of injury was confirmed with neurological testing and magnetic resonance imaging. Six injuries were classified as complete and four were incomplete. Urodynamics and ultrasound studies (USS) were performed at regular intervals ranging from once a year to once in 2 years. Based on initial urodynamic and video-urodynamic (VCMG) results, the patients were divided into two diagnostic subgroups: (1) neurogenic detrusor overactivity (NDO) with or without detrusor sphincter dyssynergia (DSD) ($n=6$) and (2) a-contractile detrusor with or without low bladder compliance ($n=4$) as shown in Table 1.

Medical complications, changes in treatment plans and the reasons for these changes and operative procedures with follow-up were noted. The final aim of treatment changes was preservation of upper tract function by maintaining low bladder pressures during storage with continence, near normal bladder pressures during emptying, and prevention of urinary tract infections.

Results

In group 1 with NDO (6/10 patients) five patients also had DSD. The characteristics of injury, age at injury and follow-up in years with number of urological interventions were as shown in Table 2. Two patients (numbers 2 and 5), each on urge/reflex voiding (T2 complete and T5 incomplete) with sheath drainage reported 2–3 urinary tract infections (symptomatic bacteriuria) per month. The patient with T5 incomplete injury (number 5) under-

Table 1 Group and injury classification

Diagnosis	*Patient no.*	*Injury level*	*Complete/ incomplete*	*ASIA (current)*	*DSD*
Neurogenic detrusor	1	T5	Complete	A	DSD
Overactivity ± detrusor	2	T2	Complete	A	DSD
Sphincter dyssnergia	3	T12	Complete	A	DSD
	4	C3	Complete	A	DSD
	5	T5	Incomplete	B	DSD
	6	C3	Incomplete	C	NO DSD
Acontractile	7	T12	Complete	A	–
detrusor ± low	8	T12	Complete	A	–
compliance	9	L3/4	Incomplete	C	–
	10	T12	Incomplete	B	–

ASIA = American spinal injuries association classification, DSD = detrusor sphincter dyssynergia

Table 2 Neurogenic detrusor overactivity – group 1: 6/10 patients

Age/sex	*Patient no.*	*Injury level*	*C/I ± DSD*	*Age at injury*	*F/U years*	*Initial bladder management*	*No. of procedure*	*Final bladder management*
35:M	1	T5	C + DSD	14	20	Urge/reflex void	5	SARSI
37:F	2	T2	C + DSD	6	31	Urge/reflex void	0	CSIC + oxybutynin
21:F	3	T12	C + DSD	14	7	CSIC + oxybutynin	1	CSIC + oxybutynin
18:F	4	C3	C + DSD	12	6	SPC + oxybutynin	4	Ileal conduit
36:M	5	T5	I + DSD	15	21	Urge/reflex void	2	CSIC + oxybutynin
29:M	6	C3	I	16	13	Urge/reflex void	0	Urge void + alpha blockers

C = complete; I = incomplete; DSD = detrusor sphincter dyssynergia; SARSI = sacral anterior root stimulator implant; SPC = supra pubic catheter; CSIC = clean self intermittent catheterization

went sphincterotomy and memokath® stent insertion. The stent had to be removed due to malposition within a year. Subsequently CSIC and oxybutynin was instituted in both patients leading to control of recurrent infections.

Upper tract changes with bilateral renal scarring and reduced glomerular filtration rate (GFR) were reported in two patients. In the patient (C3 complete, number 4) managed with supra pubic catheter (SPC) and oxybutynin, the changes were secondary to recurrent bilateral reflux with small, contracted, poorly controlled neuropathic bladder. The upper tract deterioration was stabilised with ileal conduit diversion. In the second (T5 complete, number 1) uncontrolled NDO, kidney stone and recurrent pyelonephritis were responsible for upper tract changes. Sacral anterior root stimulator implant (SARSI) with posterior rhizotomy resolved the NDO and emptying, and the kidney stone was treated with lithotripsy with no further complications. Incidental bladder stone was picked up on routine ultrasound in the remaining patient with DSD. The stone was treated with cystolitholapaxy with no change in management.

During the mean follow-up of 16.3 years (range 6–31 years), complications involving upper and lower urinary tracts were reported in five out of six patients with NDO all of whom also had DSD (Table 3). The single patient (C3 incomplete, number 6) with NDO without DSD has remained complication free on urge/reflex voiding for 13 years. Overall, at the last follow-up (in group 1), four patients were continent with normal renal functions and two patients have stable renal function with ileal conduit and SARSI.

In the acontractile detrusor group (group 2: 4/10 patients), the mean follow-up was 11.5 years (range 7–18 years). Two patients had low compliance on initial VCMG. A kidney stone was detected incidentally in one of them (T12 incomplete, number 10) and was treated with extracorporeal shockwave lithotripsy (ESWL). The other patient (T12 complete, number 7) changed management from CSIC to indwelling urethral catheter (IDUC). The reason for change was personal choice based on inability to comply with CSIC timings owing to hectic social lifestyle. After 10 months of long-term catheter drainage he developed urethral fistula, which was subsequently excised. He is currently managed on CSIC and oxybutynin without further complications (Table 4). Similarly, a small noncompliant bladder was seen in a patient from group 2, who on initial VCMG had no loss of compliance (T12 complete, number 8). The loss of compliance seen subsequently was secondary to long-term suprapubic catheterisation (3 years) and noncompliance with SPC clamping routine. The patient required ileocystoplasty and Mitrofanoff procedure for good capacity and low-pressure storage (Table 5).

During the follow-up, a total of 16 urological interventions were performed. Twelve of 16 (75%) were carried out in NDO + DSD group. Seven of 12 interventions (58%) in this group were for change of management. In acontractile detrusor group, two interventions changed management and two were for treatment of complications. Apart from occasional 'firing off' continence and renal function was well maintained in all.

Discussion

In our retrospective review of urological follow-up in adults with paediatric onset SCI, changes were required over time in majority of patients to optimise urological management. The ideal goals of urological management in adults, of achieving low-pressure urinary storage in

Table 3 Complications and operative procedures: group 1

Patient no.	*Injury level*	*Initial bladder management*	*Complications*	*Operative procedures*	*Final bladder management*
1	T5	Urge/reflex void	Lt. renal scarring ↓ GFR (84 ml/min) Bilat hydronephrosis Lt. Pylonephritis Kidney stone Function: Lt 20%, Rt 80%	Sphincterotomy + Memokath® stent (1998) Memokath® removal (1999) SPC (May 1999) Lithotripsy SARSI (July 1999)	SARSI
2	T2	Urge/reflex void	Recurrent UTI	None	CSIC + oxybutynin
3	T12	CSIC + oxybutynin	Bladder stone	Cystolitholapaxy	CSIC + oxybutynin
4	C3	SPC + oxybutynin	Small contracted bladder Recurrent VUR Bilateral renal scarring ↓ GFR (67 ml/min) Pylonephritis	 Bilateral STING x 3 Ileal Conduit (2003)	Ileal conduit
5	T5	Urge/reflex void	Recurrent UTI	Sphincterotomy + Memokath® stent (1996) Memokath® removal (1997)	CSIC + oxybutynin

GFR = glomerular filtration rate; VUR = vesico ureteric reflux; UTI = urinary tract infection; STING = submucosal injection of macroplastique®; CSIC = clean self intermittent catheterization; SPC = supra pubic catheter

Table 4 Acontractile detrusor – group 2: 4/10 patients (+low compliance 2/4 patients)

Patient no.	*Age/ sex*	*Injury level*	*C/I*	*Age at injury*	*F/U years*	*Initial bladder management*	*Complications*	*Operative procedures*	*Final bladder management*
10	21 M	T12	I	14	7	Urge (strain) void	Kidney stone	Lithotripsy	Urge (strain) void + alpha blockers
7	28 M	T12	C	15	13	CSIC IDUC (10Mth)	Urethral fistula	Cystoscopy + excision of urethral fistula	CSIC + oxybutynin

C = complete; I = incomplete; IDUC = indwelling urethral catheter; CSIC = clean self intermittent catheterization

Table 5 Acontractile detrusor – group 2: 4/10 patients (−low compliance 2/4 patients)

Patient no.	*Age/ sex*	*Injury level*	*C/I*	*Age at injury*	*F/U years*	*Initial bladder management*	*Complications*	*Operative procedures*	*Final Bladder management*
8	33 F	T12	C	15	18	CSIC SPC (3 Years)	Small contracted bladder	SPC (2000) Mitrofanoff + CLAM Ileocystoplasty (2003)	Mitrofanoff + CLAM Ileocystoplasty
9	23 M	L3/4	I	15	8	CSIC	None	None	CSIC

C = complete; I = incomplete; CSIC = clean self intermittent catheterization; SPC = supra pubic catheter

bladder with continence, efficient and complete emptying with normal pressures and preservation of kidney function and preventing urinary tract infections also apply to paediatric SCI population. Medical issues and individual choice drive the changes in management for the adult SCI population. In the paediatric SCI population this is also complicated by other issues like body image, physical growth, social, psychological and emotional circumstances all of which form a major part of decision-making process.

The most commonly experienced complications in adults with paediatric onset SCI have been reported as UTI (74%), bowel incontinence (63%), pressure ulcers (44%), autonomic dysreflexia (42%) and respiratory complications (33%).[11] Out of all these complications severe UTI, spasticity and pressure ulcers had the greatest impact on adult outcomes and greatly influenced life satisfaction.[12] The reduction in mortality rates with renal failure is most likely secondary to introduction of urodynamics, CSIC and anticholinergic medications.

In our series, even though the end point of treatment was to maintain urological management principles it was not always possible to maintain ideal status and complications were not uncommon. Overall patients with NDO and DSD appear to be at higher risk of developing complications. Also, those who opt for reflex voiding and SPC were found to be worst affected owing to multiple problems requiring hospitalisations and interventions. Four out of six patients in this group had a change of bladder management; two to CSIC. Augmentation cystoplasty, ileal conduit and SARSI are also viable options when conservative treatment fails.

In two patients with NDO and DSD, initially a sphincterotomy and subsequently a urethral stent was inserted to improve bladder emptying and achieve optimal voiding. In both these patients, the Memokath® urethral stents had to be later removed within a year of insertion. Similarly, in acontractile detrusor group two patients experienced complications as a direct result of their choice of change in treatment. In these four patients, additional urological interventions had to be carried out to treat complications owing to change in treatment advised by treating physicians and treatment preference of the patients. The psychological and social make up of individual patients have to be taken into account especially in adolescent population. Therefore, ideal urological treatment is individualised and tailored to suite a specific patient's medical and social needs, like in patient with high cervical cord injury. Ideal management has to account for realistic implementation possibilities taking account of patient compliance and choice. This is more so in the adolescent population.

The changing neuro-urological presentation of an adolescent with SCI, over a period of time requires follow-up for many years. This is due to a high probability of change in bladder management seen even at a late stage post injury.[13] Careful observation is needed through the peripubertal growth spurt. NDO with DSD in cervical and thoracic SCI patients appears to require frequent management changes. Although infrequent, owing to patients' choice and changing social circumstance, 'Safe Bladders' also are subject to changes in treatment. Patients considered having low pressure, good capacity bladders can present with kidney or bladder calculi. This makes regular follow-up with up to date investigations of significant importance. Even though we accept the small number of patients in this study, to our knowledge it is the longest (mean 13.1 years) reported in the literature. 'Regular' remains the key word in deciding follow-up routines in these patients.

Preservation of renal function is the most important objective of any long-term treatment plan in children with SCI or MMC. Even after adjusting for long-term changes in renal function secondary to an ileal conduit, the incidence of renal damage appears to double after puberty in children with MMC.[14] Similarly, in SCI population, increasing age and time since injury were significantly associated with deterioration of renal function.[13] This trend appeared to be independent of neurological injury category but variations were significant with different bladder management choices. Lack of predictive value of neurological injury category, changes in bladder management required at later stage in injury and variation of renal deterioration with different bladder managements make a strong case for regular and long-term follow-up of paediatric SCI population.

Similar to paediatric SCI population, more than 90% children with MMC have neurogenic bladder disturbance with risk to upper tracts. This has made a routine follow-up a necessity in this population at intervals from 6 months to 5 years.[9] In paediatric SCI population, in cases of upper motor neuron type injuries with NDO and DSD, it might be advisable to do ultrasound scan and VCMG yearly till stable bladder status is reached. Then VCMG could be deferred to once in 2 years but USS could be preformed yearly. Similarly, yearly studies may be advisable for first 2–3 years in lower motor neuron-type presentations and once stable status is achieved they also could be deferred to once in 2–3 years or when the patient becomes symptomatic.

Conclusion

Changing bladder neurology, natural growth and changes in psychology of growing children make regular follow-up of paediatric SCI patients a necessity. Rehabilitation process in SCI patients is a multidisciplinary and goal directed endeavour. The final aim of the process is to prevent life threatening complications, restore function and allow the patients a fruitful reintegration into society. In paediatric SCI patients several additional aspects of care have to be included. Long-term bladder management in paediatric SCI is dependent on neurological level and type of injury; it changes with growth and is affected by changing trends in urological treatments. Complications can be minimised by regular follow-up and management based on up to date investigations.

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