Author, Year Country Study Design Sample Size	Population Intervention Outcome Measure	Results
(Patki et al., 2006) United Kingdom Observational N=10	**Population**: *Pediatric-onset SCI*: Mean age: 28 (18-37) yr; Age at injury: 13.6 (6-16) yr; Time since injury: 13.1 (6-31) yr; Severity of injury: complete=6, incomplete=4. *Group 1*: neurogenic detrusor overactivity (NDO) with or without detrusor sphincter dyssynergia (DSD) (*n=6*), *Group 2*: acontractile detrusor with or without low bladder compliance (*n=4*). **Intervention**: None. Review. **Outcome Measures**: Urodynamics and ultrasound studies (USS), video-urodynamic (VCMG).	*Group 1: NDO* 1. 2 patients, 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 underwent sphincterotomy and memokaths 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. 2. Upper tract changes with bilateral renal scarring and reduced glomerular filtration rate (GFR) were reported in 2 patients. In the patient (C3 complete) 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 patient (T5 complete), 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. 3. During the follow-up, complications involving upper and lower urinary tracts were reported in 5/6 patients with NDO all of whom also had DSD. The single patient (C3 incomplete) with NDO without DSD has remained complication free on urge/reflex voiding for 13 yr. 4. Overall, at the last follow-up, 4 patients were continent with normal renal functions and 2 patients have stable renal function with ileal conduit and SARSI. *Group 2: acontractile detrusor* 5. 2 patients had low compliance on initial VCMG. A kidney stone was detected incidentally in one of them (T12 incomplete) and was treated with extracorporeal shockwave lithotripsy (ESWL). The other patient (T12 complete) changed management from CSIC to indwelling urethral catheter (IDUC). 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. 6. A small noncompliant bladder was seen in a patient (T12 complete) who on initial VCMG had no loss of compliance. The loss of compliance seen subsequently was secondary to long-term suprapubic catheterisation (3 yr) and noncompliance with SPC clamping routine. The patient required ileocystoplasty and Mitrofanoff procedure for good capacity and low-pressure storage. 7. During the follow-up, a total of 16 urological interventions were performed. 12/16 (75%) were carried out in NDO + DSD group. 7/12 interventions (58%) in this group were for change of management. In acontractile detrusor group, 2 interventions changed management and 2 were for treatment of complications. Apart from occasional 'firing off', continence and renal function was well maintained in all.
(Tanaka et al., 2006) USA Observational N=22	**Population**: *Pediatric patients with transverse myelitis*: Age at injury: 8.8 yr (3 mo-18yr); Gender: males=15, females=7; Time since injury: 7.1 yr (6 mo-22 yr); Level of injury: cervical=7, thoracic=9, lumbar=6; Severity of injury: complete=9, incomplete=13. **Intervention**: None. Review. **Outcome Measures**: American Spinal Injury Association Impairment Scale (AIS), urinary and bowel continence, urodynamic studies, augmentation cystoplasty, upper tract imaging studies, CIC and anticholinergics.	1. At last follow-up, 19 patients (86%) had persistent bladder dysfunction. Of these patients, 16 (73%) used CIC and 14 (64%) took anticholinergic medications. 3 patients continued to have urinary incontinence despite CIC and anticholinergics. 1 patient with urinary incontinence refractory to medical therapy was successfully treated with detrusor botulinum toxin injection. 2. All patients with complete injury remained on CIC. When evaluated continence status, they did not significantly correlate with neurological level of lesion (p=0.58). 3. 17 patients (77%) had persistent bowel dysfunction. Of these patients, 15 (68%) followed a daily bowel program, including stool softeners, digital stimulation, suppositories and/or enemas. Of the 7 patients not on a bowel program, only 5 had complete bowel control. Fecal incontinence refractory to medical management resolved with the Malone antegrade continence enema procedure in 1 case. 4. Urodynamics were performed in 17 patients. Detrusor overactivity was present in 10 of these patients (59%), DSD in 7 (41%), low compliance in 8 (47%) and detrusor leak point DLPP >40 cm water in 2 (12%). Detrusor overactivity, DSD, low compliance and increased DLPP did not significantly correlate with lower extremity tone (p=0.48, p=0.16, p=0.37 and p=0.40, respectively) or ambulatory status (p=0.58, p=0.58, p=0.60 and p=0.26, respectively). 5. No patient with complete injury had increased DLPP. When patients with complete injury were evaluated the presence of detrusor overactivity, DSD and low compliance did not significantly

		correlate with the neurological level of the lesion (p=0.58, p=0.58 and p=0.58, respectively). 6. Augmentation cystoplasty was performed in 4 patients for worsening compliance, incontinence and upper tract changes. 1 male patient had placement of an artificial urinary sphincter during augmentation for a Valsalva leak point pressure of <40 cm water, 1 patient underwent an antegrade continence enema for stool incontinence refractory to medical therapy, and 1 patient with incontinence and detrusor overactivity refractory to anticholinergics underwent endoscopic detrusor botulinum toxin injection. 7. Of the 19 patients with upper tract imaging studies, 5 (26%) had upper tract changes, consisting of hydronephrosis in 3, reflux in 1, and hydronephrosis and reflux in 1. Chronic renal insufficiency developed in 1 patient during the study period. The patient presented for rehabilitation 2.7 yr after disease onset with a complete thoracic level lesion and no increased lower extremity tone. Initial imaging studies showed hydronephrosis and vesicoureteral reflux; initial urodynamics revealed low compliance. Although CIC and anticholinergics were started, detrusor compliance continued to decrease. The patient ultimately underwent augmentation cystoplasty and bilateral ureteral reimplantation. 8. 5/6 patients in the early CIC group and all of those in the delayed group underwent urodynamic testing. Low compliance was found in 7 of 10 patients in the delayed CIC group and no patient in the early group. Bladder compliance was significantly worse in the delayed CIC group (p=0.02). 9. None of the 6 patients in the early CIC group had development of upper tract changes. Conversely, 4/10 patients in the delayed group had development of upper tract changes. Renal deterioration correlates with time elapsed between disease onset and institution of CIC (p=0.1, 90% confidence limit). However, standard statistical significance (p≤0.05, 95% confidence limit) was not reached by Fisher's exact test.
(Johnston et al., 2005) USA Post Test N=3	**Population:** Age: 17-21 yr; Gender: males=3; Time since injury: 1.0-1.5 yr; Level and Severity of injury: Motor complete T3-T8. **Intervention:** Praxis system consists of a 22-channel implant stimulator, extension leads and epineural electrodes. Leads emanating from the stimulator are configured in three tresses: two tresses of nine leads each for stimulation of lower extremity muscles and one tress of four leads for	1. Just one subject demonstrated positive neuromodulation effects of the bladder; stimulation suppressed reflex bladder contractions acutely thereby reducing vesical pressure.

	stimulation for bladder and bowel function (parameters: 0.2–8 mA amplitude, 25–600 ms pulse duration, 2–500 Hz pulse frequency per channel). After implantation and immobilization participants completed exercise phase (FES strengthening) followed by lower extremity conditioning, standing and upright mobility training (13 wk). **Outcome Measures:** Completion of eight upright mobility activities, scored based on completion time and level of independence: donning, stand and reach, high transfer, bathroom, floor to stand, 6m walk, stair ascent, stair descent.	
(Generao et al., 2004) USA Observational N=42	**Population:** Age at injury: 5.3 yr (1 day-14 yr), Age at follow-up: 5.5 (1-15.5) yr; Gender: males=19, females=23; Level of injury: cervical=10, thoracic=26, lumbar=6. **Intervention:** None. Retrospective review. **Outcome Measures:** Bladder management, infection history, anticholinergic and antibiotic usage, continence, renal ultrasounds, video-urodynamics.	1. Bladder management included clean intermittent catheterization (CIC) in 40 of 42 patients and antispasmodics in 37. 2. No patient had reflux, hydronephrosis or renal scarring. 3. In patients with cervical injuries, safe bladder capacity was less than the expected capacity in 80% but all patients undergoing multiple urodynamics had increasing capacity with time. 4. In patients with thoracic injuries, 58% had a safe bladder capacity less than expected and 76% of those undergoing multiple urodynamics had increasing capacity. 5. In patients with lumbar injuries, 50% had a safe bladder capacity less than expected and 67% of those undergoing multiple urodynamics had increasing capacity.
(Vogel et al., 2002b) USA Observational N=216	**Population:** Age at interview: 28.6±3.4 yr; Age at injury: 14.1±4.0 yr; Gender: males=150, females=66; Time since injury: 14.2±4.6 yr; Level of injury: tetraplegia=123, paraplegia=93. Severity of injury: C1-4 ABC=41, C5-8 ABC=67, T1-S5 ABC=82, tetra/para D=26. **Intervention:** None. Survey. **Outcome Measures:** Prevalence of urinary tract infections (UTI), hospitalizations, urinary stones, orchitis or epididymitis, bladder incontinence, dysreflexia.	1. Most (160/216) of the study subjects experienced at least 1 UTI in the year before their interview. 2. Among those who had a UTI, the mean number of infections per year was 3.9, and 41 (26%) of these individuals experienced UTIs that required intravenous antibiotics or hospitalization (severe UTI). 3. Compared with those who did not have UTI, individuals who experienced UTI had significantly lower ASIA motor scores ($p<0.001$) and were less likely to have AIS scores of D ($p<0.001$). 4. Both the ASIA Motor score ($p=0.003$), ASIA Impairment Scale scores of D ($p=0.009$), and both the total ($P = .013$) and motor ($P = .017$) FIM scores were significantly lower among individuals who experienced severe UTI. 5. Urinary stones affected 25% of the subjects. 6. Compared with those without stones, those with stones had significantly more severe neurologic deficits, with a lower mean ASIA Motor score ($p=0.007$), and lower total ($p=0.001$) and motor ($p<0.001$) FIM scores.

		7. Frequency of urinary incontinence greater than monthly was reported by 25% of the subjects; there were no significant associations between bladder incontinence and the demographic, impairment, or functional limitation variables. 8. Urinary incontinence was not more common in those who experienced UTI (or severe UTI) compared with those who did not have UTI (or severe UTI). 9. Of the male subjects, 15 (10%) reported having orchitis or epididymitis; those who had experienced either orchitis or epididymitis were older at follow-up (p=0.018), had been injured longer (p=0.04), and more likely to have had severe UTI (p=0.049). 10. Compared with those with normal bladder function, UTI (but not severe UTI) was more commonly experienced by subjects who performed intermittent catheterization, had indwelling catheters, or who used external collection devices (p<0.001). 11. Urinary stones were more common in individuals with indwelling catheters compared with those with normal bladder function, and those who were performing intermittent catheterization or using external collection devices (p=0.004). 12. Bladder incontinence was statistically associated with bladder management, with incontinence most common in those with external collection devices and least common among those with normal bladder control (p=0.050). 13. There was no significant association between the type of bladder management program and the development of orchitis or epididymitis.
(Anderson et al., 1997) USA Observational N=37	**Population:** *Females with Pediatric-onset SCI:* Injured Before Menarche (n=22): Age at injury: 5.8 (0-13 yr); Age at interview: 16.4 (12-25) yr; Level of injury: tetraplegia=3, paraplegia=10; Injured After Menarche (n=15): Age at injury: 14.6 (12-16) yr; Age at interview: 17.6 (16-22) yr; Level of injury: tetraplegia=9, paraplegia=6. **Intervention:** None. Survey. **Outcome Measures:** Menstrual onset, regularity, frequency, duration, dysmenorrhea, dysreflexia, menstrual flow management and age of menarche of the patients' mothers.	*Injury Before Menarche Group* 1. Mean age of menarche was 12.3 (10-15) yr which was not significantly different from their mother's age of menarche or the age of menarche of females in this study who were injured after menarche. 2. The average age of menarche for those injured prior to menarche is comparable to the standard for North American females (12.5 yr). 3. There was no significant association between age of menarche and age at injury or level of injury. 4. Characteristics of menstruation included regular cycles, within a normal range of 20-36 days, for 14 of the 22; remaining eight showed a variety of irregularities in their cycles. 5. Six subjects occasionally miss a month of their cycle or their periods come one to two weeks early or late; for example, one has a sixty-day cycle and another started menstruating immediately after her

		injury (age 11 yr) but then stopped until she turned 14 yr. 6. Seven reported having minor dysmenorrhea. 7. None experienced dysreflexia during their menstrual cycles. *Injury After Menarche* 8. Of the 15 females who were injured after menarche, seven reported no interruption in menses while eight had an interruption ranging from one to seven months. 9. There was no association between length of time until resumption of menstruation and level of injury. 10. Comparing the characteristics of menstruation pre- and post-injury, 12 females reported no changes in regularity or flow and three reported minor changes including one who became more regular and two less regular after injury. 11. Six reported changes in dysmenorrhea, including two who had less discomfort and four who had more discomfort; in all cases, dysmenorrhea was mild and none reported dysreflexia or any other complications. *Menstrual Flow Management* 12. Of the 36 with SCI who were menstruating at the time of interview, 16 used pads, 11 used tampons, 7 used both; 2 used diapers for menstrual flow management. 13. Most women reported no medical problems with either pads or tampons, although one person who had initially used pads switched to tampons because she felt she experienced more urinary tract infections with pads. 14. Another individual switched from tampons to pads because she felt that reduced urinary tract infections. 15. Five females who had used tampons prior to injury stopped using them after injury because they found them inconvenient; four of those five were tetraplegic. 16. Five other females with tetraplegia use tampons by choice.
(Fanciullacci et al., 1988) Italy Observational N=18	**Population**: Age at injury: 5.7 yr (*n=18*), Age at follow-up: 7.7 yr (*n=14*); Gender: males=16, females=2; Level of injury: cervical=2, thoracic=8, lumbar=8; Severity of injury: complete=13, incomplete=5. **Intervention**: None. Review. **Outcome Measures**: Urodynamic studies (UDS), intermittent catheterisation (IC), upper urinary tract (UUT) condition, urinary tract infection (UTI) rate, detrusor/sphincter balance.	1. Generally, the bladder recovered its emptying quite easily. 2. Spinal shock was shorter in those with upper motor neuron lesions compared to the 4-6 wk period seen in adults. 3. Urological data at the initial evaluation following spinal shock (2 mo-1.5 yr after trauma) showed that UUT was normal in 13 patients, slight dilation in 2, vesico-ureteral reflux in 2 (ureteral stone in 1), and renal stone in 1 patient. UTI was present in 15/18 (83%) patients. 4. UDS showed that 12 had hyperreflexia. Of the 12 patients, 6 had bladder/sphincter

		dyssynergia. 3 had areflexia with denervation of the perineal floor. 3 were not evaluated. 5. 2 children with stones were operated on. One of the 2 patients with reflux later developed a urethrocele and vesical stones (had an indwelling catheter for 1 year). Incontinence was not diagnosed until the child was 5 yr old. Continence was partial in all cases. Only 2 children were given oxybutynin + IC, in 1 case for initial ureteroidronephrosis and in the other to try to obtain good continence. 6. Follow-up of the conservative management of the neuropathic bladder was carried out in 14 children. UUT was normal in 8/11 patients. Slight dilation in 1, and vesico-urethral reflux in 2 with normal IVP. UTI was present in 7/14 patients (50%). 12 patients had a residue of <200 0 of the bladder capacity (balanced bladder). 7. 2 children who had reflux, have a UUT in good conditions, as shown by IVP. Of the 3 children where the condition of their UUT was not checked, 2 are free of UTI, 1 has asymptomatic bacteriuria and 2 have no residue. 8. The UUT of the boy managed by IC + oxybutynin, because of initial ureteroidronephrosis, improved. 9. For all the children, the control of urinary continence is a problem. 10. UTI was generally asymptomatic except for 2 children.
(Burke, 1974) US Observational N=29	**Population:** *Injury at birth (N=5):* Gender: males=2, females=3; Level of injury: cervical=4, thoracic=1; Severity of injury: complete=3, incomplete=2. *Injury post birth (N=24):* Gender: males=11, females=13; Level of injury: cervical=9, thoracic=14, lumbar=1; Severity of injury: complete=22, incomplete=2. **Intervention:** None. Chart review. **Outcome Measures:** Prevalence of scoliosis, urodynamic management.	1. No patients have died of renal complications, and none had a raised serum creatinine, but 6 patients had serious urological problems which could reduce their life expectancy. 2. In the group with a survival period of 0-5 yr (N=14), 1 patient died after a few months, another had bilateral vesico-ureteric reflux, but a normal pyelogram after 4.5 yr; one patient had a Leadbetters operation for left-sided vesico-ureteric reflux. 3. In the group with a survival period of 5-10 yr (N=6), 1 patient had multiple renal and bladder stones, but a normal pyelogram and normal blood chemistry 9 yr after injury; 1 had an early left nephrectomy for hydro-nephrosis, was drained by a suprapubic catheter for some yr, and had a right nephrostomy 9 yr after injury. 4. In the group with a survival period of 10-15 yr (N=3), all patients had renal damage, infected urine, 1 patient had a suprapubic catheter and 1 had bilateral cutaneous ureterostomies. 5. In the group with a survival period of more than 15 yr (N=3), 2 had poor function of one kidney, 1 had a U tube draining both suprapubically and through a peno-scrotal fistula.

		6. None of the 6 longest survivors had any elevation of blood urea nitrogen or serum creatinine.