Renal Tract Ultrasonography for Routine Surveillance in Spinal Cord Injury Patients

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Objectives: To report the efficacy of a urinary tract surveillance regime based on annual renal tract ultrasound without routine use of urodynamic testing (UDS) in our population of spinal cord injury (SCI) patients managed with clean intermittent catheterization (CIC). **Methods:** Data was gathered retrospectively from the records of 48 SCI patients (40 males and 8 females). After establishing a safe system with initial urodynamics, renal ultrasonography was done annually for surveillance. UDS was repeated only when patients presented with new symptoms. The primary endpoint was the report of ultrasound findings at last follow-up. Findings of dilatation, calculi, scarring, and reflux were noted. **Results:** Mean follow-up was 6.8 years. By final follow-up, pelvicaliectasis was present in 4 (8%) subjects. Mild-moderate hydronephrosis was present in 3 (6%) subjects: 1 stable and 2 (4%) new compared to initial assessment. No severe cases of hydronephrosis were noted. Six (13%) subjects had renal/ureteral calculi. No new cases of renal cortical scarring or thinning were noted. One (2%) subject had high-grade reflux on UDS secondary to a double J stent. **Conclusions:** Data relating to the efficacy of sequential surveillance studies in SCI patients are scarce, thus there is great variability in urologic surveillance methods worldwide. Upper tract abnormalities detected in our patients were early consequences of acute obstruction rather than late manifestations of detrusor changes and could not have been prevented with more regular urodynamic testing. These results suggest that annual ultrasound monitoring without routine urodynamic testing is an effective surveillance strategy in SCI patients managed with CIC. **Key words:** intermittent catheterization, neurogenic bladder management, renal tract surveillance, spinal cord injury, urinary tract deterioration, urodynamic testing

Approximately 11,000 new cases of spinal cord injury (SCI) occur in the United States each year.¹ Although advances in urologic management are credited for the improved survival of injured individuals over the recent decades,² urologic complications remain a major source of morbidity in this population.³ As such, life-long urologic follow-up is a central component in the routine care of the SCI patient. The ultimate goals of neurogenic bladder treatment following SCI are to maintain urinary continence and preserve upper tract function with low intravesical pressure. Although there is no disagreement on these treatment goals, there is a lack of consensus on the evaluation and management of the urinary tract.⁴

Bladder management in SCI patients is established based on the findings of urodynamic testing (UDS).⁵ Initial management with clean intermittent catheterization (CIC) is safe and effective⁶ and has become the standard of care in these patients.⁷ After urodynamic findings are used to guide an individualized management regime, routine evaluation and surveillance of the urinary tract is recommended to ensure upper tract and bladder stability.⁸ However, data relating to the

value of sequential ultrasonography or urodynamic testing are scarce, thus there is great variability in urologic management of these patients in the United States and around the world.⁹⁻¹¹ A 2002 survey of 160 US Society of Urodynamics, Female Pelvic Medicine & Urogenital Reconstruction (SUFU) members by Razda and colleagues revealed that 80% of respondents performed annual ultrasound for upper tract surveillance. Up to 65% of respondents performed urodynamics annually or every other year for lower tract monitoring.¹¹ However, it is the position of this study that the annual use of urodynamics for urinary tract surveillance is not necessary. The objective of this study is to report the efficacy of a renal tract surveillance method based on annual retroperitoneal ultrasonography without the use of routine UDS in our population of SCI patients managed with long-term intermittent catheterization.

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Table 1. Patient characteristics

Characteristics	n (%)
Age, years	44.8 (range, 13-84)
Sex	
Male	40 (83)
Female	8 (17)
Injury level	
Cervical	22 (46)
Thoracic	16 (33)
Lumbar	10 (21)
Catheterization method	
Self cath	32 (67)
Care provider cath	16 (33)
Mean duration of follow-up, years (SD)	6.8 ($\pm$ 3.7)
Mean duration of U/S follow-up, years (SD)	5.2 ($\pm$ 2.6)

Note: Data are presented as n (%), unless noted otherwise. Cath = catheterization; U/S = ultrasound.

Methods

This study was approved by the institutional review board at Yale University School of Medicine. Subjects were selected from SCI patients who were followed by one physician at the Yale Urology Medical Group. Subjects with neurogenic bladder secondary to spinal SCI who were managed with long-term intermittent catheterization were included in the study. Subjects were excluded if they were not managed with CIC, had undergone urinary diversion, or had not been followed for at least 1 year.

Data were gathered retrospectively from the medical records of 48 subjects (40 males and 8 females) who were included in the study (**Table 1**). The inclusion criteria were neurogenic bladder secondary to SCI, a minimum of 1 year follow-up at our institution, neurogenic bladder management with CIC, and annual upper tract surveillance with retroperitoneal ultrasound. The primary endpoint was the presence or absence of abnormal ultrasound findings at the time of last renal tract surveillance. Specifically the finding of hydronephrosis, pelvicaliectasis, renal/ureteral calculi, renal cortical scarring, and reflux were noted. Ultrasound findings were recorded based on final radiology reports with reflux noted by findings on UDS report. The notation of mild/

Table 2. Baseline urodynamic testing findings

Bladder function	n (%)
DH	25(58)
DA/DU	8 (19)
DH and DSD	10 (23)
Decreased bladder compliance ^a	8 (19)

Note: DA = detrusor areflexia; DH = detrusor hyperreflexia; DSD = detrusor sphincter dyssynergia; DU = detrusor underactivity.

^aDecreased bladder compliance = <20.0 mL/cm H₂O.

moderate/severe hydronephrosis was recorded as stated on radiology reports. The duration of ultrasound follow-up, degree of disability, and baseline ultrasound and urodynamic findings were also noted. Fifteen (31%) subjects were fully compliant with annual ultrasonography, without missing a single appointment throughout the duration of follow-up. An additional 11 (23%) subjects missed just 1 appointment throughout follow-up. Twenty-two (46%) subjects had missed 2 or more annual ultrasound evaluations during follow-up. Subjects included in the study had received initial video-UDS to guide their pharmacologic and catheterization regimen. Video-UDS was performed according to the International Continence Society (ICS) protocol with EMG, cystometography (CMG), and subtracted pressures. Baseline UDS findings for 43 (90%) subjects are listed in **Table 2**. After a safe system had been established, routine upper tract surveillance was done annually with ultrasonography of the renal tracts and bladder to monitor urinary tract stability. A safe system in this case is defined as patients in the stable phase of SCI receiving indicated bladder management with CIC with or without anticholinergics as guided by their initial UDS results. UDS was repeated only when patients presented with new symptoms such as recurrent unexplained urinary tract infections, increased incontinence between catheterization, or with alarming findings on ultrasonography. Using these criteria, UDS was repeated 22 times in 19 (40%) subjects during the study period (**Table 3**). Indications for repeating UDS were recurrent unexplained urinary tract infection in 8 (36%) cases, increased incontinence in 5 (23%) cases,

Table 3. Findings on repeat urodynamic testing

Bladder function	n (%)
DH	16 (73)
DA/DU	3 (14)
DH and DSD	3 (14)
Decreased bladder compliance ^a	6 (27)

Note: DA = detrusor areflexia; DH = detrusor hyperreflexia; DSD = detrusor sphincter dyssynergia; DU = detrusor underactivity.

^aDecreased bladder compliance = <20.0 mL/cm H₂O.

Table 4. Indications for and regimen modifications due to repeat urodynamic testing

Indication	n (%)
UTI	8 (36)
Incontinence	5 (23)
Improved skeletal muscle	1 (5)
Stone	1 (5)
Scheduled	7 (32)
Regimen modification	
No regimen change	14 (64)
Anticholinergic increase/change	7 (32)
Augmentation cystoplasty	1 (5)

Note: UTI = urinary tract infection.

increased skeletal muscle activity in 1 subject, and scheduled follow-up of previous concerning UDS results in 7 (32%) cases (**Table 4**).

All statistical analyses were done with Statistical Package for Social Sciences, version 17.0 (SPSS, Inc, Chicago, Illinois). Data were represented as counts and percentages for categorical variables. Means and standard deviations were used for continuous variables.

Results

The mean age of all subjects was 44.8 years (range, 13-84 years) (**Table 1**). Subjects had been followed for a mean duration of 6.8 years (± 3.7) (range, 2-16 years). Thirty-two (67%) subjects performed self-catheterization, whereas 16 (33%) subjects with poor hand function were catheterized by a care provider. Thirty-four (71%) subjects were on anticholinergic agents at baseline. During follow-up, type or dose of

anticholinergics was changed or increased in 7 (15%) subjects. On average, subjects were followed with ultrasonography for 5.2 years (± 2.6) (range, 1-9 years). At the time of last follow-up, 9 (19%) subjects were managed with CIC alone, 33 (69%) with CIC plus anticholinergics alone, and 6 (13%) with CIC and augmentation cystoplasty. After repeat UDS for new onset of symptoms during study period, bladder management was not changed in 14 (64%) cases. The dose or type of anticholinergic was increased or changed in 7 (32%) cases, and 1 subject received bladder augmentation. In 4 other subjects, regimen was modified based on symptoms without repeating UDS. These changes include increased dose of anticholinergics in 1 subject and augmentation cystoplasty in 3 subjects.

The results of initial and final ultrasonography exams are illustrated in **Figure 1**. At the time of initial retroperitoneal ultrasound, renal calculi were present in 2 (4%) subjects, 6 (13%) subjects were noted to have cortical scarring, and no cases of reflux were noted. Moderate to minimal hydronephrosis was present in 1 (2%) subject, and mild to moderate pelvicaliectasis was present in 4 (8%) subjects. At the time of last follow-up, final ultrasound demonstrated small renal/ureteral calculi in 6 (13%) subjects: Two cases were stable and 4 (8%) cases were new compared to the initial exam (**Table 5**). No new cases of renal cortical scarring were noted. Three cases of scarring were stable compared to the initial, whereas the other 3 cases that were previously noted on initial ultrasound were not reported in the final ultrasound readings. One (2%) subject had high-grade reflux on UDS at the time of final ultrasound due to presence of a double J stent.

Table 5. Resolved, stable, and new cases on final ultrasound

	Resolved	Stable	New
Pelvicaliectasis	2	2	2 (4)
Hydronephrosis	0	1	2 (4)
Stone	0	2	4 (8)

Note: Data are presented as counts; data in parenthesis are percentages.

Figure 1. Bar graph illustrating the changes in renal tract ultrasound findings between the initial ultrasound at the beginning of follow-up and the final ultrasound at the time of last follow-up. One case of hydronephrosis and another case of pelvic ectasia were due to presence of stone. U/S = ultrasound.

Mild to moderate hydronephrosis was present in 3 (6%) subjects at the time of the final surveillance. Of these, 1 case was stable and 2 (4%) cases were new compared to the initial assessment (Table 5). Four (8%) cases of pelvic ectasia were also present at the time of final ultrasound. Of these, 2 cases were stable and 2 (4%) were new compared to initial ultrasound. Two of the 4 cases of pelvic ectasia present on initial ultrasound had resolved by the final evaluation. One of the 2 new cases of mild hydronephrosis was secondary to obstruction by ureteral calculi and the second was due to refractory bladder pressures in a noncompliant patient. Of the 2 new cases of pelvic ectasia, 1 was due to bladder fullness so it did not prompt any intervention, but the other was due to a small obstructing stone. Both cases of hydronephrosis and pelvic ectasia resulting from obstructing calculi were treated with laser lithotripsy and extracorporeal shockwave lithotripsy, respectively, with resolution of the abnormalities in follow-up imaging. No cases of severe hydronephrosis occurred.

The 2 initial cases of pelvic ectasia that were absent on final evaluation resolved after 1 year and 5 years of management, respectively. The 2 new cases presented after 2 years and 8 years, respectively. Of the 4 new cases of stone formation, 2 cases presented after 3 years, and the others

presented after 4 years and 8 years of management, respectively. UDS was only repeated for 1 case of abnormality on ultrasound in a subject with increased incontinence and a small nonobstructing stone. In this case, UDS results prompted the addition of another anticholinergic medication.

Discussion

Renal disease has historically been the leading cause of death in individuals with SCI. The decision to create special spinal injury units within selected hospitals during the Second World War prompted the modern era of treatment of spinal cord-injured persons.¹² These regional specialized treatment units played an important role in studying and developing a better understanding of the needs of injured patients.¹³ Subsequent advances in urologic management are credited for the improved survival in this population,¹⁴ therefore life-long urologic follow-up is critical to maintain quality of life and to minimize urinary tract-associated morbidity. The improved life expectancy in SCI patients makes long-term complications of the urinary tract more pertinent and mandates continued research related to urinary tract dysfunction.

Long-term bladder management strategy should be determined by the findings of urodynamic

testing after the patient is beyond the spinal-shock phase,⁵ because the most important predictor of the urologic outcome is UDS to define the type of neurogenic dysfunction and for planning management strategy.¹⁵ The standard first-line therapy in patients with neurogenic detrusor overactivity is intermittent catheterization along with oral anticholinergic treatment for detrusor relaxation.¹⁶ In this study, subjects with detrusor overactivity reporting incontinence or those with inadequate storage pressures were managed initially with oral anticholinergic medications to prevent urinary incontinence and to protect the upper tracts from high pressures. The clinical value of urodynamics was in guiding management modifications when patients presented with new onset of symptoms. UDS was repeated if patients presented with new symptoms including recurrent unexplained urinary tract infections, incontinence, or increased frequency of catheterization; management was modified as indicated by UDS results. Bladder augmentation was performed based on symptoms in 3 subjects without repeating UDS. Of the 22 cases where UDS was repeated, results prompted changes in bladder management in 8 (37%) cases. Management strategies included increasing the dose of anticholinergics, adding another anticholinergic, or intervening surgically with augmentation cystoplasty (**Table 4**). There are no standard guidelines for the routine monitoring in these patients. Most urological centers prefer annual monitoring of upper and lower urinary tract function with either an upper tract study or a compliance test.⁴ The European Association of Urology guidelines for neurogenic bladder dysfunction recommend video-UDS investigation every 2 years for patients with normal bladder compliance and without detrusor overactivity and annually for patients with detrusor overactivity and/or low bladder compliance.¹⁷ However, there is little data relating to the value of sequential urodynamic testing, thus there is currently a wide variability in the management strategies amongst specialists.^{10,11} Nossair and colleagues retrospectively investigated the long-term results of 80 SCI patients managed at their institution with a strictly urodynamic-based treatment regime and determined that physiologic changes in bladder

function can occur in the absence of changes in overall symptoms, thus they recommended annual urodynamic testing in patients with detrusor overactivity.¹⁸

With the hypothesis that annual UDS is unnecessary, we retrospectively assessed our population of SCI patients managed with CIC to report the efficacy of a surveillance regime based on annual renal tract ultrasonography without annual UDS. UDS was repeated only if patients presented with new symptoms. Our series demonstrated that compared to initial ultrasonography, only 2 (4%) new cases of moderate or minimal hydronephrosis and 4 (8%) new cases of small renal/ureteral calculi occurred. The finding of a lower incidence of scarring at final ultrasound compared to initial was due to an inconsistency of reporting by the radiologist and did not provide clinically useful information. No cases of severe upper tract dilatation or large stone burden were observed in any of our patients.

One of the cases of moderate hydronephrosis was caused by an obstructing stone. The subject had been followed with ultrasonography for 6 years, with baseline UDS showing detrusor hyperreflexia with detrusor sphincter dyssynergia. Initial regimen included CIC and multiple anticholinergics. The obstruction and hydronephrosis presented in the sixth year of follow-up. He had been fully compliant with ultrasound surveillance until the year prior to presentation with moderate hydronephrosis. He underwent laser lithotripsy and basket extraction with subsequent resolution of hydronephrosis on follow-up imaging. UDS was not repeated in this patient. The second case of mild hydronephrosis was due to progression of inadequate bladder pressures in a noncompliant patient who had been monitored for 7 years. He presented with mild hydronephrosis in the seventh year of follow-up but was noncompliant with ultrasound surveillance in the 2 years prior. His baseline UDS was notable for hyperreflexia refractory to maximal doses of 2 anticholinergics; he refused surgical bladder augmentation.

The 1 patient with reflux due to double J stent was a 78-year-old male with hyperreflexia refractory to high doses of multiple anticholinergics. He had a solitary kidney from previous renal cell carcinoma

and was a poor candidate for surgical augmentation. He was noncompliant with surveillance in the 19 months prior to presentation until he was treated at an outside hospital for flank pain, increased creatinine, and mild hydronephrosis that resolved after the stent was placed. The stent was in place on his follow-up UDS. Management was continued with increased anticholinergics.

In SCI, renal deterioration leading to renal failure is principally caused by vesicoureteral reflux, chronic pyelonephritis, renal stone formation, and hydronephrosis.¹⁹ Efforts to preserve adequate urinary tract function must maintain adequate detrusor pressures. McGuire and colleagues in 1983 determined that high detrusor leak point pressure was related to upper tract deterioration.²⁰ Outlet obstruction associated with detrusor leak point pressure greater than 40 cm is considered the major risk factor for upper tract deterioration.^{21,22}

In our series, patients were followed with annual ultrasonography alone; UDS was reserved for patients presenting with new onset of symptoms. Only 8% of our subjects developed new cases of mild upper tract dilatation. Most of these cases, however, were early manifestations of acute obstructive processes rather than late manifestations of inadequate bladder pressures. Bladder pressures progressed to moderate hydronephrosis in 2 poorly compliant subjects in whom bladder augmentation could not be performed. It is therefore unlikely that a more frequent bladder UDS surveillance regime would have prevented upper tract changes in these subjects.

Although both ultrasound and UDS are critical components in the surveillance of SCI patients, we propose that after the initial treatment regime is implemented and a safe system is established, SCI patients managed with intermittent catheterization can be monitored effectively with annual ultrasonography. UDS can be reserved for modification of regimen when patients present with new onset of symptoms.

Some limiting factors in this study include the noncentralized ultrasound reader and variation in urodynamic interpretation. Outcomes could also be confounded by the use of anticholinergic medications and the change in medications over time. Future studies are necessary to directly compare ultrasound-based surveillance with a UDS-based regime as well as to determine the optimal interval for surveillance.

Conclusions

SCI patients with neurogenic bladder will often require a variety of treatment modifications and interventions in long-term follow-up to prevent upper tract deterioration.²² This retrospective report of patients monitored with annual renal tract ultrasound without frequent use of urodynamics demonstrates that an ultrasound-based surveillance approach was efficacious in our SCI patients and suggests that annual UDS may not be necessary. These findings contribute to the little data available dealing with the value of sequential surveillance methods. Future studies are needed to determine the optimal surveillance interval.

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