

The value of urodynamics and bladder management in predicting upper urinary tract complications in male spinal cord injury patients

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A review of 160 male patients admitted to the Shepherd Spinal Center was completed to determine the influence of urodynamic findings and choice of bladder management program on the risk of developing upper urinary tract distress following acute spinal injury. Within the context of this investigation, upper urinary tract distress was defined as presence of hydronephrosis, febrile urinary tract infection, urolithiasis or vesicoureteral reflux. Three groups were identified according to the urodynamic findings and the bladder management program. Thirty-four subjects with preservation of detrusor function managed their bladders by spontaneous voiding. Seventy patients with detrusor areflexia managed their bladders via intermittent catheterization; and 56 males who had detrusor hyperreflexia on urodynamics were managed by a reflex voiding program with condom drainage. None of the subjects with preservation of spontaneous voiding function experienced upper tract distress. Seven percent of those on intermittent catheterization and 32% of those managed by a reflex voiding program experienced upper tract distress. The presence of detrusor hyperreflexia with or without vesicosphincter dyssynergia influenced the likelihood that subjects would experience upper urinary tract distress following spinal injury. While traditional urodynamics failed to distinguish patients managed by a reflex voiding program who experienced upper tract distress from those who did not, calculation of a new urodynamic variable, the urethral pressure gradient, was found to assist in this prediction.

Key words: urodynamics; urological complications; spinal injury; upper urinary tract.

Introduction

The relationship between bladder function and renal function compromise has been stressed by many authors since Bors described a mortality rate of 2% in those with a balanced bladder compared to 31% among individuals with unbalanced function.² Heckler's longitudinal survey of World War II and Korean War paraplegic veterans showed renal disease to be the leading cause of death accounting for 43% of the 49% overall mortality rate.³ More recently, however, in a large group of spinal cord injured patients followed from 1963 to 1976, only 14% of deaths were shown to be renal in origin.⁴

The reasons for this significant decrease in the death rate attributable to renal disease are varied. The use of clean intermittent catheterization as an alternative to indwelling catheters, improved ability to manage urinary tract infection and urinary calculi, establishment of specialized centers to care for spinal injured patients and improvements in long term urological surveillance have certainly contributed to a reduction in serious renal complications.⁵

The urological management of the spinal injured patient aims to achieve a program that prevents or adequately contains urinary leakage and prevents the deleterious effects of high pressure and its adverse effects on

renal function. Efficient bladder emptying and maintenance of low detrusor pressures during voiding are important. Detrusor pressures greater than 6 cm H₂O that persist for a period of longer than 10 seconds are thought to present a potential risk factor for upper urinary tract distress.⁶

Over the past decade urodynamic evaluation has become a major component in the urological care of the spinal injured patient via its role in defining lower urinary tract dysfunction and providing clues to appropriate treatment.¹ In contrast, the value of urodynamic studies in the prediction of upper urinary tract distress remains unclear.

Materials and methods

One hundred and sixty male patients who were consecutively admitted to Shepherd Spinal Center from 1983 to 1987 were included in the investigation. The median age of the study group was 31 years with a range of 21 to 82 years. The subject's level of injury ranged from C2 to L4. Initial evaluation of all subjects consisted of intravenous urography, voiding cystourethrography and urodynamics.

The majority of the initial urodynamic studies were completed using rapid fill gas cystometry with simultaneous urethral sphincter electromyography (EMG) and urethral pressure profilometry. The remaining subjects underwent rapid fill water cystometry with abdominal pressure measurement and urethral sphincter EMG. Long term surveillance of urinary system function consisted of yearly voiding cystourethrography and intravenous urography. Subsequent urodynamic studies were obtained when patients experienced febrile urinary tract infections, recurrent infections or a change in voiding behavior.

Seventy subjects were found to have detrusor areflexia on urodynamic evaluation or were converted to detrusor areflexia with anticholinergic medications. They were managed by intermittent catheterization. An additional 56 subjects were noted to have detrusor hyperreflexia and vesico-sphincter dyssynergia on urodynamics. They were managed by reflex voiding. Thirty subjects with incomplete spinal injury con-

tinued to void spontaneously and 4 subjects emptied their bladders by a combination of spontaneous and strain voiding. Seven subjects were excluded from the investigation due to death or transfer to another institution (Table 1).

Results

Three groups were identified for analysis. The first group comprised subjects who managed their bladders by spontaneous voiding or strain voiding. A second group consisted of subjects with detrusor areflexia on initial urodynamic evaluation and subjects converted to detrusor areflexia by pharmacological manipulation. The third group comprised subjects who managed their bladders by a reflex voiding program.

None of the 34 subjects who continued to spontaneously or strain void following spinal injury experienced upper urinary tract distress. Follow up care for this group of patients ranged from 1 to 6 years with a mean of 3.0 years.

Of the 70 subjects managed by intermittent catheterization, 5 (7%) developed evidence of upper urinary tract distress including the presence of vesicoureteral reflux, hydronephrosis, and urinary calculi. The remaining 65 subjects (93%) remained free of signs of upper urinary tract distress over a mean surveillance period of 3.7 years with a range of 1 to 6 years. Among those subjects managed by intermittent catheterization, 50 (71%) were found to have detrusor areflexia on urodynamic evaluation and 20 were converted to areflexia by the long term administration of anticholinergic drugs. Twenty-one subjects were quadriplegics (30%) and 49 were paraplegics (70%).

Table I Bladder management program

	Number of patients
Intermittent catheterization	70
Reflex voiding	56
Self void	30
Strain void	4
Total	160

Among the 56 subjects noted to have detrusor hyperreflexia with or without vesicosphincter dyssynergia and maintained by condom catheter drainage, 18 (32%) experienced upper urinary tract distress including hydronephrosis, vesicoureteral reflux, urinary calculi and febrile urinary tract infection. Fourteen (25%) of these patients were paraplegics and 42 (75%) were quadriplegics. The mean follow up of this group was 2.4 years with a range of 1 to 6 years.

The 4 channel CMG/EMG was compared using subjects managed by reflex voiding program with and without upper urinary tract distress. Unfortunately, only 25% of these subjects (40) were evaluated with water cystometry while the remainder were followed with carbon dioxide CMG. In the group of reflex voiders with upper urinary tract distress 5 patients (27%) underwent 4 channel water cystometry. Their mean voiding pressure was noted 68 cm H₂O, mean compliance was 85 cc/cm and H₂O and 80% experienced dyssynergia. In contrast, 10 subjects with absent upper urinary tract distress were evaluated by 4 channel water cystometry. Among these subjects, the mean voiding pressure was 80 cm H₂O, the mean compliance was 49 cc/cm H₂O and dyssynergia was present in 9 subjects (90%) (Table II).

Discussion

As expected, those subjects who maintained spontaneous voiding function following spinal injury were least likely to experience upper urinary tract distress. In addition, only 7% of the 70 subjects who experienced detrusor areflexia or who were pharmacologically converted to areflexia and maintained on an intermittent catheterization program experienced upper urinary tract

distress. In contrast, 32% of the 56 subjects who experienced detrusor hyperreflexia with or without vesicosphincter dyssynergia experienced upper urinary tract distress.

While it may seem attractive to convert all subjects who experience spinal injury to a state of detrusor areflexia and institute an intermittent catheterization program, other factors must be considered in order to meet the needs of the individual and family who experience spinal injury. The majority of individuals who were maintained on an intermittent catheterization program were paraplegics or quadriplegics with adequate dexterity of their hands to self catheterize. In contrast, the majority of subjects maintained on a reflex voiding program were quadriplegics with poor hand function with inability to perform self catheterization. Therefore, since an alternative to intermittent catheterization is needed for certain spinal injured males, the use of urodynamic results to predict which patients will develop upper urinary tract distress, and which are likely to tolerate a reflex voiding program becomes clear.

Although the percentage of subjects who underwent water urodynamic evaluation is relatively small, the results indicate that the number of subject who experienced upper urinary tract distress was lower than those with normal upper tracts. In addition, subjects in both groups experienced a significant percentage of vesicosphincter dyssynergia (90% of subjects with normal upper tracts vs 80% of subject with distress). The compliance was adequate for both groups. From this series, the 4 channel water urodynamic evaluation failed to provide clear assistance in prediction of which subjects managed by reflex voiding program were at risk for upper urinary tract distress.

Because of the lack of predictive value in 4 channel urodynamic evaluation, we identi-

Table II Results of H₂O urodynamic evaluation in reflex voiders

	Mean voiding pressure (cm H ₂ O)	Mean compliance (dV/dP)	Dyssynergia (no. of patients)
Upper tract distress	68	85	5 (80%)
Normal upper tracts	80	49	10 (90%)
	<i>p</i> = 0.67	<i>p</i> = 0.59	<i>p</i> < 0.01

fied a group of 15 spinal injured males with documented detrusor hyperreflexia and vesicosphincter dyssynergia who were managed by a reflex voiding program for at least 6 months prior to evaluation. Exclusion criteria for the study included any subject who had obstruction noted on videourodynamics arising from a source other than a dyssynergic sphincter (such as prostate or stricture) and history or surgery to the bladder outlet.

All subjects underwent videourodynamic evaluation. A pilot study group of 15 spinal cord injured males with documented detrusor hyperreflexia and dyssynergia managed by a reflex voiding program was also evaluated. These patients underwent urodynamics with an additional variable of continuous urethral pressure monitoring. The urethral pressure study was used to generate a urodynamic variable we have identified as the maximum urethral pressure gradient (MUPG).

The MUPG is determined by placing a 3 lumen catheter into the bladder allowing simultaneous measurement of intravesical and urethral pressures. The urethral pressure is measured at the point of maximum urethral closure pressure located at the mid-membranous urethra (rhabdosphincter) in the male. The gradient is determined by calculating the difference between intravesical and urethral pressure during detrusor contraction. In each instance the pressure is measured from the baseline established immediately prior to contraction and the difference calculated during maximum contraction pressure. This variable allows quantification of the pressure gradient that exists across the sphincteric mechanism during detrusor contraction.

The prevalence of upper urinary tract distress among subjects in the pilot series was similar to the main study group. Five of 15 subjects (33%) developed upper urinary tract distress and 10 subjects (67%) maintained normal upper urinary tracts. Among the 5 subjects with distress, the maximum voiding pressure was 109 cm H₂O and the compliance was noted to be adequate (mean 49 cc/cm H₂O). Dyssynergia was present in all affected subjects and the mean urethral pressure gradient was 87 cm H₂O (Table III). In contrast, the group with normal upper tracts experienced an average maximum voiding pressure of 75 cm H₂O and adequate compliance (60 cc/cm H₂O). Nonetheless, while all subjects who were spared upper tract distress also experienced vesicosphincter dyssynergia, their mean urethral pressure gradient was 35 cm H₂O.

Comparison of the results between these subjects revealed a difference in maximum voiding pressure not noted in the main study group. Of greater interest is the marked difference in the MUPG. The urethral pressure gradient measures pressure loss over the sphincter mechanism produced by obstruction. While the sphincter EMG provides a qualitative analysis of the presence or absence of dyssynergia, calculation of the urethral pressure gradient permits quantification of the magnitude of obstruction produced by detrusor-sphincter incoordination. Even though the pilot group is too small to draw definitive conclusions, clear trends are present. Subjects managed by reflex voiding with a urethral pressure gradient of 80 cm H₂O or greater are at risk for upper urinary tract distress. Subjects with a urethral pressure gradient of 50–79 cm H₂O exhibited a greater risk of febrile urinary

Table III Maximum urethral pressure gradient (MUPG) added to standard CMG/EMG

	Maximum voiding pressure (P _{det} , max cm H ₂ O)	Compliance (cc/cm H ₂ O)	Dyssynergia	Maximum urethral pressure gradient (MUPG)
Upper tract distress	109	49	5 (100%)	87
Preserved upper tracts	75	60	10 (100%)	35

tract infection than reflex voiders with gradients below 50 cm H₂O. Subjects with urethral pressure gradients less than 50 cm H₂O remain at low risk for upper urinary tract distress despite the presence of vesicosphincter dyssynergia. Investigation of a larger group is indicated to explore the predictive values of the urethral pressure gradient.

Conclusion

Both urodynamic data and choice of bladder management program influence the risk of

upper urinary tract distress following spinal injury. The presence of detrusor hyperreflexia and vesicosphincter dyssynergia and bladder management as reflex voider indicate higher risk than presence of detrusor areflexia and intermittent catheterization management program. Videourodynamics with calculation of urethral pressure gradient provides data to identify those persons managed by reflex voiding who represent increased risk for upper urinary tract distress. Early intervention may prevent unnecessary urological complications.

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