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Complications of the upper urinary tract in patients with spinal cord injury: a long-term follow-up study

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Abstract The aim of this study was to establish hazard ratios for the risk of complications of the upper urinary tract in relation to bladder management methods in patients with spinal cord injury. A total of 179 male patients were eligible for this investigation which was followed-up on a yearly basis until 2003. The average age at which the lesion occurred was 25.2 years (range 18–57). The average duration of follow-up since SCI was 29.3 years (range 10–53). During follow-up, the incidence of vesicoureteral reflux (VUR) was 15.1%. A total of 61 (34.1%) and 44 (24.6%) patients were diagnosed with pyelonephritis and renal stones, respectively. There were no significant differences in these complications among groups. Upper tract deterioration (UTD) was observed in 58 patients (32.4%). The incidence of UTD in the urethral catheter group (51.7%) was higher than that in other groups ($P = 0.008$). Using multivariate analysis, patients with VUR were shown to have a higher risk of pyelonephritis (odds ratio 2.78; 95% confidence interval 1.16–6.68), and UTD (odds ratio 22.10; 95% confidence interval 6.92–70.56). We also found that UTD was more common for patients with an indwelling urethral catheter than for patients using other methods. For other variables, no positive association was observed. In cases which cannot undergo intermittent catheterization, or when the bladder cannot empty spontaneously, a suprapubic catheter is better than a urethral catheter for reducing UTD in this population. These findings suggest that even at a late stage post injury, bladder management methods are still important.

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Introduction

The primary objective in the care of spinal cord injury patients is the prevention of complications by establishing effective urinary drainage, and the preservation of renal function. Long-term survival of patients with spinal cord injury is dependent on regular and close follow-up to detect complications and coexistent urologic conditions, combined with proper management. Since World War II, appropriate early bladder management in patients with spinal cord injury has been linked with a reduction in complications and preservation of renal function. Retrospective analyses of the urologic status of Vietnam War veterans with spinal cord injuries have consistently shown decreased renal death as compared with previous spinal cord injury populations, this being attributed to catheter-free status [1, 2]. However, since patients with spinal cord injury are prone to developing a variety of urologic complications [3], urologic care of these patients continues to be a challenge for urologists.

Clean intermittent catheterization is the safest bladder management method in spinal cord injury patients in terms of urological complications [4]. However, many factors should be considered when electing bladder management, including patient convenience, prevention of potential urologic complications and preservation of renal function. Since most studies have reported the results within several years after injury, it is not known whether bladder management methods contribute to the complications of upper urinary tract long after injury. In addition, the results have exhibited clinical differences from setting to setting among these patients. Furthermore, although clean intermittent catheterization is the preferred method, various alternatives are still widely used in this country. We therefore decided to establish,

using formal statistical analysis, hazard ratios for the risk of complications of upper urinary tract in relation to bladder management methods in spinal cord injury patients including Korean War veterans (1950–1953) with prolonged follow-up.

Materials and methods

Patients

We retrospectively reviewed the medical records of all patients with post-traumatic spinal cord injury who had received continuous long-term urologic care at our hospital up to 2003. Data were collected on demographic variables, injury-related characteristics, urologic complications and management, and laboratory findings at annual clinic visits. The criteria for inclusion in this study were: (1) male patients, (2) age at injury 18 years or above, (3) a discernible neurologic lesion, (4) traumatic spinal cord injury, (5) follow-up for 10 years or longer from the date of injury, and (6) follow-up until 2003. A total of 179 patients who were followed-up on a yearly basis were eligible for this investigation.

Levels of spinal cord injuries were categorized as cervical, lumber or thoracic, as modified from the description by Burke et al. [1]. A comprehensive chart review revealed that many patients had changed their bladder management method at least once since the injury occurred. To minimize confusion due to this necessary variable, patients were assigned a predominant method of bladder management based on the chart documented technique used for the majority of the time elapsed since the injury, as described by Weld and Dmochowski [4]. Bladder management methods included urethral catheter in 29 cases, intermittent catheter in 48, suprapubic catheter in 42, Crede maneuver or reflex voiding in 38, and condom catheter in 22. Those with an indwelling catheter (suprapubic cystostomy or urethral catheterization) underwent routine catheter exchange monthly.

Methods

The categories of complications occurring in the upper tract included infection (pyelonephritis), stone disease (renal stones), and radiologic renal deterioration. The presence or absence of vesicoureteral reflux was determined by the video portion of urodynamic studies and/or voiding cystourethrography. Pyelonephritis was defined as microbiological confirmation of significant bacteriuria in the presence of relevant symptoms (flank pain, dysuria, fever and/or rigors), once other causes had been excluded, as described by Drake et al. [5]. Plain film radiographs of the kidneys, ureters, and bladder were routinely performed to check for the presence of stones at each annual evaluation and whenever stones were clinically suspected throughout the year. Renal stone cases were defined as patients who had an abnormal concretion in the kidney documented by radiography or ultrasound performed during annual surveillance. Radiographic complications were also assessed. Renal deterioration was defined as a parenchymal thinning, atrophy, renal scarring or decreased function of the kidney as determined by renal ultrasound and/or renal scan. Renal ultrasonography was considered abnormal when there was unilateral or bilateral renal scarring or renal size less than 8 cm. Renal scan was considered abnormal when there was a split renal function of 60% in one and 40% in the other renal unit or a more significant disparity [6].

Table 1 Clinical parameters. UC urethral catheter, IC intermittent catheterization, SPC suprapubic cystostomy, CM Crede menuever or reflex voiding, CC condom catheter, FU follow-up. *Kruskal-Wallis test, †Armitage test. Data presented are median (range) or number (%)

Parameter	UC	IC	SPC	CM	CC	*P*
No. patients	29	48	42	38	22	
Age at injury (years)	22 (19–39)	23 (18–57)	24 (18–50)	23 (18–46)	24 (19–36)	0.243*
Duration of FU (years)	35 (16–50)	29 (10–53)	27 (13–51)	30 (11–47)	32 (17–51)	0.137*
Completeness of injury						0.529†
Incomplete	23 (79.3%)	38 (79.2%)	31 (73.8%)	31 (81.6%)	15 (68.2%)	
Complete	6 (20.7%)	10 (20.8%)	11 (26.2%)	7 (18.4%)	7 (31.8%)	
Level of injury						0.214†
Cervical	6 (20.7%)	6 (12.5%)	16 (38.1%)	15 (39.5%)	5 (22.7%)	
Thoracic	16 (55.2%)	32 (66.7%)	21 (50.0%)	11 (28.9%)	14 (63.6%)	
Lumbar	7 (24.1%)	10 (20.8%)	5 (11.9%)	12 (31.6%)	3 (13.6%)	
Mechanism of injury						0.163†
Traffic accident	13 (44.8%)	26 (54.2%)	22 (52.4%)	19 (50.0%)	10 (45.5%)	
Fall	4 (13.8%)	9 (18.8%)	13 (31.0%)	16 (42.1%)	6 (27.3%)	
Gunshot wound	8 (27.6%)	10 (20.8%)	5 (11.9%)	2 (5.3%)	5 (22.7%)	
Others	4 (13.8%)	3 (6.3%)	2 (4.8%)	1 (2.6%)	1 (4.5%)	
Vesicoureteral reflux						0.666†
No	27 (93.1%)	41 (85.4%)	32 (76.2%)	32 (84.2%)	20 (90.9%)	
Yes	2 (6.9%)	7 (14.6%)	10 (23.8%)	6 (15.8%)	2 (9.1%)	

Statistical analysis

Clinical parameters were categorized by patient and injury characteristics, including age at injury, duration of the follow-up, lesion level, completeness of lesion, and methods of bladder drainage. Overall comparisons were conducted using the Kruskal-Wallis test (continuous variables) and the Armitage test (categorical variables) to determine differences among groups. Although complications differed in severity and morbidity, for statistical purposes all complications were given equal weight and the numbers of complications were determined for each group.

Multivariate logistic regression analysis was performed to examine the relation between each variable and complications of upper urinary tract, as measured by the adjusted odds ratio. The 95% confidence interval was calculated to indicate the precision of effect estimates. The final parsimonious model for complications of the upper urinary tract contained patient age at injury, duration of spinal cord injury, injury characteristics (level and completeness), vesicoureteral reflux, and types of bladder drainage. A probability of less than 5% was considered to be statistically significant and all statistical tests were two-tailed. Statistical analyses were performed using a commercially available analysis program, Statistical Package for Social Sciences, version 10.0 (SPSS, Chicago, Ill.).

Results

The baseline clinical characteristics are summarized in Table 1. The average age at which the lesion occurred was 25.2 years (median 23; range 18–57). The average duration of follow-up since injury was 29.3 years (median 30; range 10–53). A total of 41 lesions (22.9%) were complete while 138 (77.1%) were incomplete. An equal proportion of patients with set injury levels was included in each group. The incidence of vesicoureteral reflux was 15.1% [urethral catheter group 6.9% (2/29); intermittent catheter group 14.6% (7/48); suprapubic catheter group 23.8% (10–42); Crede meneuver or reflex voiding group 15.8% (6/38), and condom catheter group 9.1% (2/22), $P = 0.666$].

During the follow-up, 61 patients (34.1%) were diagnosed with pyelonephritis. Although there was a trend for the incidence of pyelonephritis in patients on urethral catheter or intermittent catheter to be higher than that in other groups, no statistical significance was observed. A total of 44 patients (24.6%) were diagnosed with renal stones. There was no significant difference among groups. Upper tract deterioration was observed in 58 patients (32.4%). The incidence of upper tract deterioration in the urethral catheter group was higher than that in other groups ($P = 0.008$) (Table 2).

Using multivariate analysis, patients with vesicoureteral reflux had a 2.8-fold higher risk (odds ratio 2.78; 95% confidence interval 1.16–6.68) of pyelonephritis than those without vesicoureteral reflux. In another model, vesicoureteral reflux was associated with a greater risk of upper tract deterioration (odds ratio 22.10; 95% confidence interval 6.92–70.56). We also found that upper tract deterioration was more common in patients with an indwelling urethral catheter than in patients using other methods. For other variables, no positive association was observed. The results of the logistic regression analyses for complications of upper urinary tract are presented in Table 3.

Discussion

The incidence of vesicoureteral reflux in the spinal cord injury population has been shown to range from 17% to 25% [7]. Some have contended that the presence of a suprapubic catheter could cause edema of the trigone and actually initiate vesicoureteral reflux. However, in our study, although vesicoureteral reflux was noted in 23.8% of the suprapubic catheter group, its incidence in this group was not statistically higher than that in the other groups.

Patients with spinal cord injury are at increased risk of systemic infection because of their neurologic condition. Reflux of urine from the bladder to the kidney has long been recognized as a risk factor for pyelonephritis. In the present study, we confirm such an association. It is well known that clean intermittent catheterization involves a lower incidence of urinary tract infections than indwelling catheterization. However, the incidence of pyelonephritis was not significantly different among our cohort. Preventive measures to reduce pyelonephritis associated with bladder management include an optimal catheter, catheterization hygiene, and early recognition and treatment of infections.

Table 2 Incidence of the complications of upper urinary tract according to bladder management methods. UC urethral catheter, IC intermittent catheterization, SPC suprapubic cystostomy, CM Crede menuever or reflex voiding, CC condom catheter. *Armitage test. Data presented are number (%)

Parameter	Bladder management methods					
	UC	IC	SPC	CM	CC	*P**
Pyelonephritis	12 (41.4%)	20 (41.7%)	13 (31.0%)	10 (26.3%)	6 (27.3%)	0.086
Renal calculi	6 (20.7%)	6 (12.5%)	15 (35.7%)	13 (34.2%)	4 (18.2%)	0.224
Upper tractdeterioration	15 (51.7%)	18 (37.5%)	11 (26.2%)	9 (23.7%)	5 (22.7%)	0.008

Table 3 Multivariate risk factors for complications of the upper urinary tract

Parameters	Adjusted odds ratio (95% confidence interval)		
	Pyelonephritis	Renal calculi	Upper tract deterioration
Age (years)	0.982 (0.934–1.032)	1.012 (0.958–1.069)	1.049 (0.992–1.109)
Duration of follow-up (years)	0.993 (0.961–1.027)	0.991 (0.954–1.030)	0.969 (0.932–1.008)
Completeness of injury			
Incomplete	1.000	1.000	1.000
Complete	1.608 (0.760–3.403)	1.871 (0.836–4.184)	0.893 (0.365–2.186)
Level of injury			
Cervical	1.000	1.000	1.000
Thoracic	1.243 (0.551–2.805)	0.661 (0.288–1.517)	0.787 (0.310–1.999)
Lumbar	1.402 (0.538–3.650)	0.503 (0.175–1.442)	0.911 (0.298–2.789)
Vesicoureteral reflux			
No	1.000	1.000	1.000
Yes	2.781 (1.158–6.678)	0.840 (0.304–2.323)	22.100 (6.922–70.558)
Bladder management			
Urethral catheter	1.000	1.000	1.000
Intermittent catheter	0.930 (0.352–2.455)	0.526 (0.147–1.888)	0.330 (0.114–0.958)
Suprapubic catheter	0.532 (0.186–1.519)	1.827 (0.581–5.745)	0.097 (0.026–0.359)
Crede menuever orreflex voiding	0.464 (0.158–1.366)	1.856 (0.579–5.955)	0.123 (0.035–0.428)
Condom catheter	0.502 (0.148–1.704)	0.746 (0.177–3.137)	0.200 (0.051–0.780)

It is estimated that approximately 7% of patients with spinal cord injury develop a kidney stone within 10 years of injury [8]. It is clear that struvite stones are more common in patients with spinal cord injury than in the general population. In previous studies of the chemical components of spinal cord injury related stones, the ratio of struvite to carbonate apatite tended to increase with time after injury [9]. Therefore, long-term catheterization may be associated with a higher risk of urinary stone. However, no differences in risk between patients with and those without indwelling catheters have been found in other studies [3, 10, 11]. Therefore, there is still considerable debate about the efficacy of different management methods with respect to urinary stone formation. Furthermore, because these studies focused on the first occurrence of a urinary stone, it is not known whether risk factors are the same for recurrent stones. In the present study, long-term catheterization was not associated with a substantially increased risk of renal stone formation in these patients.

Upper tract preservation is the most important objective of urinary tract management in the patients with spinal cord injury. Contrary to our results, Hackler [12] showed that suprapubic catheters were more destructive to the upper tracts than urethral drainage, with suprapubic catheters utilized for 5 years causing renal deterioration comparable to that caused by urethral catheters utilized for more than 20 years. However, data suggest that patients using external appliance drainage have a better prognosis than those using indwelling catheters. Catheterized patients showed considerably greater evidence of progressive upper tract deterioration, demonstrated radiographically, with parenchymal thinning and renal wasting [13]. In our study, although no patients progressed to renal insufficiency or failure during the follow-up period, a urethral catheter was an independent risk factor for upper tract deterioration.

To date, because many studies have reported results within a few years after injury, we still do not known which factors contribute to the development of complications of upper urinary tract long after injury. In addition, since various causal elements may play different roles in the causal pathway, depending on the duration after injury, the factors that control the development of these complications after spinal cord injury remain uncertain.

To our knowledge, this study included patients with the longest duration of spinal cord injury yet considered in the investigation of risk of complications of upper urinary tract. However, due to the retrospective nature of our study subjects, it has several limitations. First, because of the constraints of our existing database, we were unable to address the influence of other factors, including bladder characteristics. Second, we were unable to control for the fact that initial bladder management methods after injury could have influenced variables used as outcome measures in the analysis. Third, the issue of urinary tract infection was not addressed in this study, since there is no consensus on the definition of a symptomatic urinary tract infection, or when or which urinary tract infections should be treated in spinal cord injury patients [14]. However, because methods of urinary drainage were considered, and such methods are important risk factors for urinary tract infection, the potential impact of urinary tract infection is likely to have been appropriately adjusted. Finally, our study is limited because each patient was categorized by a predominant bladder management method, defined as the method used for the majority of time since injury. Most likely, the strict categorization of patients into a single predominant bladder management group

introduced an experimental error. However, a short period of non-dominant bladder management relative to the overall follow-up interval helped to minimize the influence of this variable [4].

Conclusions

Clean intermittent catheterization is an established technique for managing neuromuscular dysfunction of the lower urinary tract in patients with spinal cord injury. Unfortunately, in some patients, urethral trauma from repeated catheterizations or mechanical problems related to manual dexterity may preclude the use of clean intermittent catheterization. In cases which cannot undergo intermittent catheterization, or when the bladder cannot empty spontaneously, a suprapubic catheter is better than a urethral catheter for reducing upper tract deterioration in this population, although bladder management methods are not associated with a substantially increased risk of pyelonephritis or renal stone formation. These findings suggest that, even at a late stage post injury, bladder management methods are still important.

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