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ORIGINAL ARTICLE

The effect of appropriate bladder management on urinary tract infection rate in patients with a new spinal cord injury: a prospective observational study

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Abstract

Purpose This study aimed to determine the rate of urinary tract infection (UTI) in patients with a new spinal cord injury (SCI) and identify which bladder management technique is associated with the lowest rate of UTI.

Methods Adults admitted to the Victorian Spinal Cord Service with a new SCI from 2012 to 2014 were enrolled. Data collected included patient characteristics, SCI level, bladder management and diagnosis of UTI. Bacteriuria (≥ 102 colony-forming organisms/mL) with clinical signs of infection was used to define a UTI.

Results 143 patients were enrolled. 36 (25%) were female; the median age was 42 years. An indwelling urethral catheter (IUC) was placed in all the patients initially. 55 (38%) patients developed a UTI with an IUC, representing a UTI rate of 8.7/1000 inpatient days. Long-term bladder management strategies were initiated after a median of 58 days. IUC removal and initiation of any other alternative bladder management halved the UTI rate to 4.4/1000 inpatient days, $p < 0.001$. Intermittent self-catheterisation (ISC) and suprapubic catheter placement had lower UTI rates compared to IUC, 6.84 and 3.81 UTI/1000 inpatient days, $p = 0.36$ and $p = 0.007$, respectively. An IUC was re-inserted in 29 patients and resulted in a higher UTI rate of 8.33/1000 inpatient days.

Conclusion This study has identified a high UTI rate in new SCI patients with an IUC and reinforces the importance of early IUC removal and initiation of non-IUC bladder management in this cohort of patients.

Keywords Spinal cord injury · Urinary tract infection · Bladder management

Introduction

Patients with a spinal cord injury (SCI) are at an increased risk of developing urinary tract infections (UTIs) [1–3]. UTIs are the most common cause of emergency department presentation, re-admission to hospital and are the second most common cause of death in SCI patients [2]. When an SCI patient develops a UTI during their acute admission, it extends hospital stay and may delay the transfer to a rehabilitation centre. In rehabilitation, the development of a UTI often results in readmission to a hospital. These delays and setbacks lower patient's morale, disrupt participation in recovery, place increased demand on hospital bed capacity and extend the overall length of stay (LOS) [3].

Neurogenic bladder dysfunction and poor bladder management can increase the risk of UTI [4]. Choosing a method that minimises bladder foreign bodies, yet empties the bladder efficiently is the best means to reduce UTI risk [5]. The initial bladder management following SCI is an indwelling urethral catheter (IUC) [6]. Alternative bladder management options available include intermittent self-catheterisation (ISC), suprapubic catheterisation (SPC), reflex voiding and condom catheter drainage.

There is a relative dearth of data investigating bladder management and UTI rate in SCI patients. The highest level evidence to date consists of comparative cohort studies, and only four have compared all IUC, ISC and SPC [7–10]. Furthermore, there are only two systematic reviews of the topic

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[11, 12]. This study aims to examine the effect of bladder management on the prevalence of UTI in the early phase of an SCI and to compare the UTI rates of each bladder management method.

Methods

Patient population

In Australia, the Victorian Spinal Cord Service (VSCS) provides a service to the state of Victoria, Tasmania and southern New South Wales, providing specialist care to people who have sustained traumatic and non-traumatic spinal cord injuries. All the patients who suffer a new SCI in this catchment area (approximately 60 per year) are transferred to the VSCS for their initial inpatient management. In this study, patients were identified from the VSCS database. Primary outcomes were a comparison of UTI rates between different bladder drainage methods, measured as both total patients with UTIs and UTIs per 1000 inpatient days. Ethics approval was granted by the Austin Health Human Research Ethics Committee, reference LNR/14/Austin/585. The study was funded by a grant from the Institute for Safety, Compensation and Recovery Research (ISCRR).

Data collection

Eligible patients suffered a new SCI and were admitted to the VSCS during the period January 2012 to June 2014. Data were prospectively collected by a specially trained research assistant from medical records and included patient demographics and SCI characteristics, UTI episodes and bladder management. Bladder management was recorded at initial presentation, discharge and follow-up. Management options consisted of IUC, ISC, SPC, reflex voiding, condom drainage and voiding on sensation (VOS). VOS is defined as the return-to-normal micturition with complete emptying and no neurological defect. Reflex voiding was defined as the reliance on spontaneous bladder contractions for voiding. These contractions occurred with bladder filling or were induced with suprapubic tapping.

Bladder management protocol

Immediately after the SCI, for bladder drainage, an IUC is placed. During this time, the level of the neurologic injury, hand function, patient preference and recovery progress are assessed to guide the selection of the most appropriate long-term bladder drainage method. At the earliest opportunity, alternative bladder drainage is commenced, and IUC is removed. Some patients will have no neurological defect and will be able to do VOS. Patients with high cervical spine injuries and no hand function are offered an SPC early. Patients with a neurogenic bladder and all other SCI patients will be initially trailed with ISC. Some patients may fail ISC and request an SPC or IUC placed, while a small number may use reflex voiding. Some patients may not be psychologically ready to accept an SPC and are offered an extended period of IUC.

Long-term IUC and reflex voiding are both discouraged. To prevent upper urinary tract damage, patients using VOS, reflex voiding and condom drainage must have demonstrated low post-void residuals to persist with this method. After 12 weeks, when the spinal shock phase has resolved, video urodynamic testing is carried out to determine if the patient has detrusor overactivity, detrusor sphincter dyssynergia, poor compliance, atonic bladder or a healthy bladder. This helps in advising the patient about the available choices for long-term bladder management. It is at this stage that the reflex voiders and patients still using IUC are converted to either ISC or SPC.

Diagnosis of UTI

A UTI is defined as bacteriuria plus symptoms or signs suggestive of UTI requiring antibiotic treatment. National Institute on Disability and Rehabilitation Research consensus criteria were used to determine significant bacteriuria, namely $\geq 10^2$ colony-forming organisms (CFU)/mL in an intermittent catheter specimen, $\geq 10^4$ CFU/mL for clean-void samples and any detectable bacteriuria from indwelling urethral or suprapubic catheters [13].

Symptoms or signs suggestive of UTI included fever, abdominal discomfort, urinary incontinence, increased spasticity, autonomic hyperreflexia for which no other cause could be identified, cloudy or malodorous urine, malaise and lethargy or sense of uneasiness. In all the cases, the determination of UTI was made by the attending doctor who based the diagnosis on positive urine culture and clinical signs.

For mild UTI, oral antibiotics are started, and for moderate-to-severe UTI, empirical parenteral antibiotic therapy is initiated. Empirical antibiotics are a third generation cephalosporin with or without an aminoglycoside. When urine cultures are available, antibiotic therapy is tailored to the bacterial sensitives. Care is also taken to choose the most suitable antibiotic with the lowest *C. difficile* infection risk. If the IUC has been in situ for more than 2 weeks, the IUC is changed. The patient should have received a minimum of 3-day treatment before IUC is changed.

Statistics

Unless otherwise stated, data are represented as median [interquartile range (IQR)], and *N* represents the number of patients included in the analysis. Differences in the

distribution of clinical data including UTI frequency were evaluated using a two-sided Fisher's exact test for categorical variables and the Mann–Whitney *U* test for continuous variables. Calculations were performed using STATA version 14 (StataCorp, College Station, TX, USA). All the analyses were two-tailed, and significance was assessed at the 5% alpha level.

Results

Patient demographics

Data were analysed on 143 patients and 36 (25%) were female. The median age was 42 years (IQR 27–61). The aetiology of the SCI was a fall in 49 (34%) patients, transport accidents in 42 (29%), sport or recreation injuries in 31 (22%), non-traumatic injury in 19 (13%) and assault in two (1%). Cervical cord injuries were the most common injury and occurred in 52% of the patients, thoracic in 37% and lumbar in 10%. The median primary hospital LOS before admission to the VSCS was 1 day (IQR 0–5). Upon arrival, the median duration of care in the VSCS, but outside the spinal ward, was 1 day (IQR 1–7); this is due to the primary treatment being in the intensive care unit. The median subsequent duration of care in the spinal ward was 15 days (IQR 7–30), with a further median rehabilitation centre LOS of 76 days (IQR 24–145). The median total hospitalised LOS was 104 days (IQR 47–181). Table 1 shows patient demographics, SCI level, mechanism of injury and admission duration data.

Table 1 Spinal cord injury patient demographics

	Total
Patients	143
Male	107 (75%)
Female	36 (25%)
Age (years), median (IQR)	42 (27–61)
Spinal cord injury level	
Cervical cord	75 (52%)
Thoracic cord	53 (37%)
Lumbar/cauda	15 (10%)
Mechanism of injury	
Fall	49 (34%)
Transport	42 (29%)
Sport/recreation	31 (22%)
Non-traumatic	19 (13%)
Assault	2 (1%)
Admission (days), median (IQR)	
Pre-VSCS	1 (0–5)
VSCS non-spinal ward	1 (1–7)
VSCS Spinal ward	15 (7–30)
Rehabilitation ward	76 (24–145)
Total admission	104 (47–181)

IQR interquartile range, *VSCS* Victorian spinal cord service, % percentage

Bladder management and UTI

All the patients had a trial removal of catheter (TROC) when it was clinically appropriate. The median time to TROC was 58 days (IQR 30–117). During this initial phase of early bladder management, 93 separate UTIs occurred in 55/143 (38%) patients. After the TROC, 36 (25%) patients had no symptoms or signs of a neurogenic bladder, had low PVRs and voided normally. Healthy bladder function in this group was later confirmed with video urodynamics. In patients with signs of a neurogenic bladder, ISC was initiated in 74 (51%) patients. ISC was successful in 45 (31%) patients, but 29 (20%) patients failed ISC. These patients deferred getting an SPC, and an IUC was reinserted. 24 (17%) patients had an SPC inserted, 8 (6%) patients used reflex voiding, and 1 patient used a condom catheter.

From the time of TROC to discharge, 40 UTI episodes occurred in 35/143 (24%) patients. In the decreasing order of frequency, UTI occurred in 29% with SPC, 27% with ISC, 25% with reflex voiding and 6% with VOS, with none in the patient with condom drainage. The UTI rate for patients who had a catheter re-inserted after failing ISC was 38% (Table 2). When measured proportional to LOS, the UTI rate before TROC was 8.7 UTI/1000 inpatient days. After the TROC, all the non-IUC bladder management options were 4.38 UTI/1000 inpatient days. Non-IUC bladder management post-TROC compared to IUC pre-TROC had a statistically significant UTI risk reduction, incident rate ratios (IRR) 1.99 [95% confidence interval (CI) 1.31–3.09], < 0.001 (Table 3). The UTI rate for patients performing ISC or with an SPC sited were 6.8 and 3.8 UTI/1000 inpatient days,

Table 2 Bladder drainage methods and urinary tract infection rate

	Total	UTI (%)	LOS	UTI/1000 days
Pre-TROC	143	55 (38%)	58	8.72
Post-TROC	114	23 (20%)	43	4.38
ISC	45	12 (27%)	44	6.84
Voiding on sensation	36	2 (6%)	16.6	1.12
IUC re-inserted	29	11 (38%)	102	8.33
Suprapubic catheter	24	7 (29%)	105	3.81
Reflex voiding	8	2 (25%)	74	5.59
Condom drainage	1	0 (0%)	106	–

IUC indwelling urethral catheter, *LOS* length of stay, *ISC* intermittent self-catheterization, *TROC* trial removal of catheter, *UTI* urinary tract infection, % percentage

Table 3 UTI rate/1000 inpatient days for main bladder management strategies

	UTI rate/1000 inpatient days	*p* value
Pre-TROC	8.72	
Post-TROC	4.38	
IUC vs other IRR	1.99 (95% CI 1.31–3.09)	< 0.001
IUC vs ISC	6.84	
IRR	1.28 (95% CI 0.76–2.28)	0.36
IUC vs SPC	3.81	
IRR	2.29 (95% CI 1.19–4.93)	0.007

TROC trial removal of catheter, *UTI* urinary tract infection, *IUC* indwelling urethral catheter, *ISC* intermittent self-catheterization, *IRR* incident rate ratios, *CI* confidence interval

respectively. Placement of an SPC significantly reduced the risk of UTI compared to IUC, IRR 2.29 (95% CI 1.19–4.93), $p = 0.007$. However, patients doing ISC did not have a statistically significant reduction in UTI compared to IUC, IRR 1.28 (95% CI 0.76–2.28), $p = 0.36$ (Table 3). The re-insertion of the IUC post-TROC in those patients who failed ISC resulted in a significant increase in the UTI rate (Table 2). Figure 1 shows the UTI rate and rate/1000 inpatient days for each bladder management option.

Risk factors for UTI

The relationship between UTI frequency, patient factors and LOS was assessed. UTI was significantly more common in male patients; this may be due to the fact that 75% of the patients were male. A protracted admission and long interval until TROC were also associated with an increased risk of UTI. The median duration of an IUC for those who developed a UTI was 98 days, IQR (57.3–138.8), compared to 41 days, IQR (13–76), for those that did not get a UTI, $p = 0.0094$. Patients who developed a UTI with an IUC before the TROC were also at increased risk getting further UTI post-TROC. 22/55 (40%) patients who had a UTI pre-TROC later developed a UTI. Only 13/89 (14.5%) patients who did not get a UTI before TROC got a subsequent UTI, $p = 0.0008$.

Discussion

Up to 80% of the patients with a spinal cord injury will have some degree of bladder dysfunction and will be at increased risk of UTI [1–3, 14]. In this study, we examined the effect of bladder management on the rate of UTI following the SCI and during the early rehabilitation phase. Following the SCI, all the patients will have an IUC placed to drain their bladder and measure their urinary output. In this study, 38% of the patients developed a UTI during this initial phase of urethral catheterisation. Adjusted for LOS, the UTI rate is 8.7/1000 inpatient days. Removing the patients' IUC and commencing any alternative bladder management resulted in a statistically significant reduction in the UTI rate. By purely removing the catheter, the UTI rate is halved to 4.38/1000 inpatient days.

ISC and SPC are well-accepted long-term bladder management strategies [15–17]. In this study, both bladder management options are associated with reductions in the UTI rate. However, interestingly, only SPC was associated with a statistically significant reduction in UTI rate compared to IUC. The higher rate of UTI seen in ISC patients may be due to a combination of the learning curve, unfamiliarity with aseptic technique and a spectrum of neurological deficit, with some patients struggling to catheterise with sterility. This rate we believe will decrease over time as patient skill

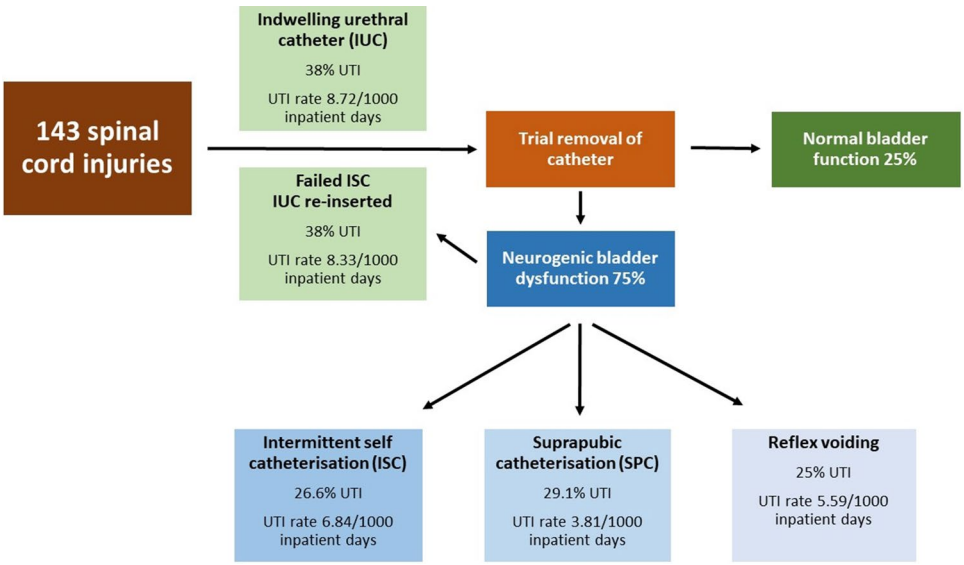

Fig. 1 Effect of bladder management on urinary tract infection rate in spinal cord injury patients. *N* number, *UTI* urinary tract infection

improves. The results of this study are reassuringly similar to the majority of existing studies of bladder drainage methods in patients with SCI. Like our findings, these studies have reported significantly higher rates of UTI in patients utilising IUC compared with non-invasive methods and a reduction in UTI in non-IUC bladder management [7, 18, 19].

ISC is currently the preferred bladder management method for patients with a neurogenic bladder [15–17, 20]. ISC is associated with improved self-care and independence, and fewer urological complications, need for equipment and barriers to intimacy and sexual activities [15]. However, compliance and maintaining long-term ISC use is problematic. Several studies have shown that some patients with ISC revert to an IUC or SPC. In this study, 29 patients who could not do ISC and were not psychologically ready for an SPC are offered an extended period of IUC. This action resulted in a statistical increase in UTI in these patients, with a UTI rate of 8.33 infections/1000 inpatient days. Similarly, Afsar et al. [21] reported that ISC use fell by 50% in one SCI cohort. Other reasons for this included sufficient improvement of bladder function to permit reflex voiding, recurrent UTI, incontinence, nephrolithiasis, dependence on caregivers and urethral strictures.

When ISC is not possible, placing an SPC is in most cases better than re-inserting an IUC. With an SPC, hygiene can be easier to maintain, and catheter changes can be more comfortable. SPC eliminates the risk of urethral stricture and erosion and results in high levels of patient satisfaction. Iatrogenic hypospadias is also prevented with an SPC [19]. In this study, SPC was associated with fewer UTIs compared to both IUC and ISC. However, there are drawbacks to long-term SPC placement such as bacterial colonisation, antibiotic resistance, inflammatory pseudopolyps, bladder stones, reduction in bladder capacity, and most importantly the development of bladder cancer [22–24].

Some patients in this study emptied their bladder with reflex voiding, compression/straining or used a condom catheter. Reflex voiding is bladder emptying by stimulating detrusor contractions by squeezing the penis, scrotum or tapping the suprapubic area. Reflex voiding is not advocated as a long-term option, and we anticipate that these patients will change their long-term bladder management at a later date. Condom catheters are suitable for male patients with lower motor neuron injuries who can change the catheter daily.

We identified potential risk factors for UTI; this includes male sex, prolonged admissions, and delays in time to TROC and UTI before TROC. Extended admission and catheterisation likely increase the risk of UTI, because the longer the patient is on the ward, the longer they are exposed to pathogens and are more closely monitored increasing the chances of having a UTI diagnosed. UTI pre-TROC likely increases the risk of UTI due to bacterial colonisation of the catheter and ascension to the bladder [25]. Bacteria on catheters undergo phenotypic changes that lead to the formation of biofilms. These biofilms are composed of a mixture of exopolysaccharides, proteins and urinary salts [26]. Biofilms protect the bacterial colonies and facilitate seeding of sites within the bladder and aid bacterial antimicrobial resistance, due to genetic material exchange within the biofilm [26]. Consequently, early catheter removal and initiation of alternative bladder management could reduce the risk of bladder colonisation.

There are some limitations to this study. The design of this study is not ideal for determining causation, and patient numbers are relatively small. The ideal design for determining causation is either a randomised controlled trial or a large cohort study with prospectively collected data in which all possible confounders are identified prior to data collection through directed acyclic graphs [27]. However, randomised control trials in SCI patients are not possible, and there are relatively few new SCIs each year limiting the recruitment. Despite this, the findings of the study add to the body of evidence advocating for early urinary catheter removal in SCI patients, with the initiation of alternative long-term bladder management as soon as possible. Both ISC and SPC placements offer good long-term options. We discourage the use of an IUC for long-term bladder management for SCI patients.

Conclusion

The incidence of UTI in SCI patients is related to bladder drainage method. IUC is the typical initial method but has a high rate of UTI. The IUC should be removed as soon as possible, and alternative long-term bladder management should be initiated. In this study, changing to an alternative bladder drainage method halved the UTI rate. ISC is the preferred method, but SPC placement is a practical alternative for those unable to self-catheterise.

Author contributions DH wrote the paper and did the statistical analysis. NK helped to write the paper and did the statistical analysis. LM did data collection and statistical analysis and helped to refine the final manuscript. CB did data collection and helped to refine the final manuscript. JG assisted in analysis and helped to refine the final manuscript. AN created the report concept and helped to refine the final manuscript.

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Compliance with ethical standards

Conflict of interest No potential conflict of interest relevant to this article was reported.

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