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# Impact of Clean Intermittent Catheterization on Renal and Lower Urinary Tract Outcomes in Spinal Cord Injury Patients

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## Abstract

Neurogenic bladder dysfunction following spinal cord injury (SCI) is a major source of morbidity, predisposing patients to recurrent urinary tract infections (UTIs), renal deterioration, and compromised quality of life. Clean intermittent catheterization (CIC) is widely recommended as the gold standard for bladder emptying in this population. This prospective real-world study evaluated the outcomes of CIC among SCI patients, focusing on urinary tract infection rates, renal function preservation, bladder compliance, and patient-reported satisfaction. A total of 180 SCI patients (mean age 39.6 ± 11.2 years) with documented neurogenic bladder were followed for 24 months after initiation of CIC. Clinical parameters assessed included frequency of UTIs, serum creatinine, estimated glomerular filtration rate (eGFR), bladder compliance (via urodynamics), and validated patient satisfaction scores. Results showed significant preservation of renal function (mean eGFR decline of 1.8 mL/min/1.73m² over 2 years), reduction in upper tract dilatation compared to baseline, and improved bladder compliance in 71% of patients. However, 44% of patients reported at least one UTI episode per year, with higher risk among females and patients with poor adherence to CIC schedules. Patient satisfaction remained high overall, with 82% reporting improved quality of life. This study supports CIC as an effective long-term bladder management strategy in SCI, though adherence and infection prevention strategies remain critical for optimal outcomes.

**Keywords**: neurogenic bladder, spinal cord injury, clean intermittent catheterization, urinary tract infection, renal preservation

## Introduction

Spinal cord injury (SCI) is a devastating condition that often results in permanent disability and significant long-term complications. Among these, neurogenic bladder is one of the most clinically challenging consequences, affecting both patient survival and quality of life. The neural pathways that regulate lower urinary tract function are disrupted, resulting in impaired bladder storage and emptying. This dysfunction predisposes patients to urinary tract infections, incontinence, hydronephrosis, and renal impairment, all of which can further complicate rehabilitation and social reintegration.1-4

Historically, chronic indwelling catheters were frequently used to manage bladder dysfunction in SCI patients. While effective in ensuring drainage, they were associated with high rates of infection, encrustation, stone formation, and progressive renal deterioration.5-7

This led to the search for alternative strategies that not only achieved adequate bladder emptying but also minimized complications and preserved renal health. Clean intermittent catheterization (CIC) emerged as a cornerstone of neurogenic bladder management, offering a balance between efficacy and safety.8-9

CIC is performed by the patient or caregiver at regular intervals, typically every 4–6 hours, to empty the bladder using a sterile or clean technique. The method aims to maintain low intravesical pressures, reduce residual urine volume, and thereby prevent upper urinary tract damage. Importantly, CIC allows for periods of catheter-free time, decreasing risks of chronic colonization and bladder wall trauma compared to indwelling catheters. It also promotes patient independence and improves quality of life by providing better continence control.10

Despite its widespread acceptance, CIC is not without challenges. Patients may struggle with adherence due to physical limitations, lack of motivation, or difficulties with manual dexterity. Additionally, urinary tract infections remain the most common complication, often linked to technique errors, suboptimal frequency of catheterization, or colonization with multidrug-resistant organisms. Psychological barriers, including embarrassment and anxiety, may also hinder consistent practice, particularly in newly injured patients adjusting to their disability.

The outcomes of CIC in SCI patients vary based on several factors, including level and completeness of injury, bladder dynamics, catheter type, and patient adherence. While controlled

trials have demonstrated its efficacy, real-world outcomes often differ, reflecting patient diversity and challenges in long-term adherence. In clinical practice, ongoing education, support, and monitoring are essential to optimize benefits and minimize complications.

This study was designed to evaluate the outcomes of CIC in a real-world SCI population with neurogenic bladder. Specifically, the objectives were to determine its impact on renal function preservation, bladder compliance, urinary tract infection rates, and patient-reported satisfaction. By focusing on these parameters over a two-year follow-up, this study provides insight into both the benefits and limitations of CIC in routine clinical practice, contributing to evidence-based recommendations for bladder management in SCI patients.

**Methodology**

This prospective observational study was conducted at Department of Nephrology, King Edward Medical University, Lahore. A total of 180 SCI patients aged 18–65 years with documented neurogenic bladder on urodynamic evaluation were enrolled. Patients with prior urological surgery, known malignancy, or severe renal failure requiring dialysis were excluded. CIC was initiated in all patients using single-use hydrophilic catheters, with instructions provided by specialized continence nurses. Patients were advised to perform CIC every 4–6 hours depending on bladder capacity and fluid intake.

Baseline assessments included demographic characteristics, SCI level and completeness, bladder compliance (urodynamics), renal function (serum creatinine and eGFR), and renal ultrasound. Patients were followed at 6, 12, and 24 months. Outcomes assessed included frequency of UTIs (defined as symptomatic episodes with positive urine culture), renal function trajectory, bladder compliance, and patient-reported satisfaction using a validated 5-point Likert scale. Statistical analysis was performed using paired t-tests and chi-square tests, with $p < 0.05$ considered significant. Ethical approval was obtained, and informed consent was taken from all participants.

**Results**

**Table 1. Baseline Characteristics of Patients**

| **Variable** | **Value (n=180)** |
|---|---|
| Mean age (years) | 39.6 ± 11.2 |
| Gender (male/female) | 124 / 56 |
| Level of injury (paraplegia) | 62% |

| **Variable** | **Value (n=180)** |
|---|---|
| Level of injury (tetraplegia) | 38% |
| Baseline eGFR (mL/min/1.73m²) | 96.2 ± 14.3 |
| Baseline bladder compliance | 18.7 ± 6.4 mL/cm $H_2O$ |

**Table 2. Outcomes at 24 Months**

| **Parameter** | **Baseline** | **24 Months** | **p-value** |
|---|---|---|---|
| eGFR (mL/min/1.73m²) | 96.2 ± 14.3 | 94.4 ± 15.2 | 0.04 |
| Bladder compliance (mL/cm $H_2O$) | 18.7 ± 6.4 | 26.3 ± 8.2 | <0.001 |
| Hydronephrosis (%) | 14% | 6% | 0.01 |

**Table 3. Complications and Satisfaction**

| **Outcome** | **Value** |
|---|---|
| ≥1 UTI episode/year (%) | 44% |
| Hospitalization for UTI (%) | 9% |
| Patient satisfaction ≥4/5 (%) | 82% |

Brief commentary: CIC preserved renal function, improved bladder compliance, and reduced hydronephrosis, though UTIs remained common. Satisfaction levels were high overall.

**Discussion**

This study provides real-world evidence supporting CIC as the most effective bladder management method for SCI patients with neurogenic bladder. Over a two-year period, renal function was largely preserved, confirming its protective effect on the upper urinary tract. The modest decline in eGFR observed was clinically acceptable and may reflect factors beyond bladder management, including comorbidities and aging.11-13

Bladder compliance improved significantly, underscoring the role of CIC in maintaining low-pressure storage and reducing risks of hydronephrosis. This is consistent with the physiological rationale of preventing chronic overdistension and elevated intravesical pressures. Notably, the incidence of hydronephrosis declined by more than half, highlighting the preventive value of CIC in long-term renal outcomes.14-15

Urinary tract infection remained the most frequent complication, affecting nearly half of the patients annually. This underscores the challenge of balancing effective bladder emptying with infection control. Contributing factors may include poor adherence, technical errors, female anatomy, and colonization with multidrug-resistant organisms. Preventive strategies such as patient re-education, use of hydrophilic catheters, and prophylactic regimens may be necessary in recurrent cases.16-18

Patient satisfaction was encouragingly high, with the majority reporting improved continence and quality of life. This finding is important, as psychological and social well-being are often under-recognized outcomes in bladder management. CIC provided autonomy and dignity for many patients, reinforcing its value beyond clinical metrics.19-20

The real-world design of this study enhances its generalizability, capturing the diversity of SCI patients encountered in daily practice. Unlike controlled trials, adherence challenges, comorbidities, and psychosocial factors were integral to the outcomes, reflecting the true complexity of neurogenic bladder care.

Limitations include the single-center design, reliance on self-reported UTI episodes in some cases, and lack of comparison with alternative methods such as indwelling catheters or surgical interventions. Future multicenter studies with longer follow-up are needed to better understand the long-term trajectory of renal function and optimize infection prevention strategies.

Overall, this study reinforces CIC as the preferred method of bladder management in SCI patients with neurogenic bladder, balancing safety, efficacy, and quality of life. While challenges remain, particularly regarding infection, adherence to structured follow-up and patient support can maximize outcomes.

## Conclusion

CIC in SCI patients with neurogenic bladder effectively preserves renal function, improves bladder compliance, and enhances quality of life. Although UTIs remain common, overall outcomes support CIC as the gold standard management strategy in real-world practice.

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