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Current Evidence Related to Intermittent Catheterization

A Scoping Review

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ABSTRACT

PURPOSE: The purpose was to summarize evidence related to adherence to intermittent catheterization (IC), complication rates, satisfaction with IC, and its effect on health-related quality of life.

PROBLEM: Intermittent catheterization is frequently used to manage lower urinary tract dysfunctions including urinary retention and urinary incontinence, but research suggests that care for patients using IC may not always be based on evidence.

METHODS: Scoping review.

SEARCH STRATEGY: We searched the PubMed, EMBASE, CINAHL databases, and the Cochrane Database for Systematic Reviews to identify studies published between January 2009 and March 2019. Seventy studies met inclusion criteria and were evaluated for adherence, complication rates, satisfaction, and health-related quality in adults and children using IC for bladder management.

FINDINGS: Recent research was variable in both quantity and quality. The evidence suggests that (1) most patients can successfully master IC and that functional status is likely the most important predictor of success; (2) adherence to IC probably decreases over time; (3) urinary tract infections (UTIs) are the most common complication of IC and that prophylactic antibiotic therapy may reduce the risk of recurrent UTIs; (4) urinary incontinence is also a common complication; and (5) other complications such as urethral strictures, bladder stones, hematuria, and urethral false passage do occur but are less prevalent than UTIs and incontinence between catheterizations. Our review also revealed multiple gaps in the evidence to support care for patients using IC.

CONCLUSIONS: Research priorities include a need for prospective studies of the epidemiology and risk factors for IC-related complications, along with intervention studies to determine how to improve outcomes for patients using IC to manage bladder function.

KEY WORDS: Adherence, Adults, Children, Complications, Intermittent catheterization, Satisfaction, Scoping review.

INTRODUCTION

Urinary catheters have been used for more than 3500 years to drain the bladder when it fails to empty.[1] Intermittent catheterization (IC) mimics normal bladder function by allowing the bladder to fill and then emptying it completely via regular insertion of a catheter that is removed when the bladder is drained of urine. Intermittent catheterization was employed on a limited basis during World War II using strict sterile technique that significantly limited its uptake in clinical practice. Lapides revolutionized IC by demonstrating its safe application using clean rather than sterile technique. This innovation led to widespread use of this intervention in the management of patients with urinary retention with or without urinary incontinence.

While IC has been shown to be effective for many patients with incomplete bladder emptying, a recent cross-sectional study of 210 nurses based in the United States who regularly teach IC as part of their daily practice found that almost two-thirds (66%) do not base their practice on clinical guidelines.[2] Many who reported using guidelines for IC identified guidelines focusing on assessment and management of indwelling rather than IC. Results also indicated significant variability in approaches to teaching IC including who should be taught the procedure (patient and significant other) and catheter selection (length and size).

Based on gaps in knowledge and evidence in this important nurse-led intervention, we conducted a scoping review and

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summarized evidence related to use of IC for (1) ability to perform IC, (2) adherence to IC, (3) satisfaction with IC, (4) its effect on health-related quality of life (QoL), and (5) development of complications.

METHODS

We selected the framework promulgated by Arksey and O'Malley[3] to guide the review. Based on this framework, we identified aims of our review, searched and retrieved potentially relevant studies, selected pertinent studies based on our aims and inclusion/exclusion criteria, extracted and charted data from these studies, and collated, summarized, and reported results in this article.

Study Identification

The literature search focused on articles published between January 2009 and March 2019. The start date for the review was selected based on the change in United States Center for Medicare and Medicaid policy coverage for IC from reusable catheters to single-use catheters. The search was conducted in PubMed, EMBASE, CINAHL, and the Cochrane Database for Systematic Reviews. These databases were selected to be comprehensive and to reflect a range of disciplines. Searches were conducted by a reference librarian who used a combination of Medical Subject Heading (MeSH) terms and free text terms provided by all of the authors. The terms used were intermittent urethral catheterization, urinary catheterization, intermittent catheterization, clean intermittent catheterization, sterile intermittent catheterization, self-catheterization, intermittent self-catheterization, urinary bladder, neurogenic, and spinal cord injuries. The search terms were adapted for each database. The reference lists of relevant studies were hand-searched to identify additional studies that met inclusion criteria.

Study Selection

Records were eligible for inclusion if they reported results of a quantitative research study (intervention or observational designs) or a systematic review with meta-analysis and if one of the following outcomes in relation to IC were reported: urinary incontinence, complications such as urinary tract infection (UTI) and hematuria, adherence/compliance to catheterization, health-related QoL, comfort/discomfort/pain, or satisfaction with IC. Studies were excluded if they were not published in English, did not report results separately for patients using IC, reported findings of a systematic review that did not include meta-analysis of pooled data (we nevertheless searched the reference lists of these reviews to identify additional potentially eligible studies), or the full-text article was not available.

A 2-stage screening process was used to determine study inclusion. All of the authors divided into pairs and reviewed each identified record. During stage 1, the title and the abstract were screened using the eligibility criteria. If either reviewer judged the article to be potentially eligible, it moved to stage 2, full-text review. During stage 2, both reviewers had to agree on the eligibility of the study and if excluded, the reason for exclusion. Any conflicts were resolved by discussion.

Data Extraction

During a face-to-face meeting of all authors, data were extracted from the included studies and summarized following group consensus about the study characteristics and findings. The data extracted were setting, sample, outcome(s), method used to measure the outcome, the comparison group (if applicable), and the findings. Findings were categorized by outcome.

RESULTS

Database searches identified 2256 records and 12 additional records were identified by reviewing the reference lists of studies included in the review. After duplicate records were removed, the titles and abstracts of 2248 records were reviewed and 2002 were excluded. Two hundred forty-six underwent full-text review and 71 articles reporting the results of 70 studies (1 study reported results in 2 articles) met the eligibility criteria (Figure). These studies examined predictors of ability to self-catheterize, adherence to IC, adverse events associated with IC including UTIs, urethral strictures, hematuria, bladder stones, false passage, discomfort, urinary incontinence, renal scarring, satisfaction with IC, and QoL in individuals using IC. The studies were conducted in multiple countries, used a variety of research designs, and included a variety of patient groups.

Ability to Self-catheterize

Four studies examined the patient's ability to self-catheterize and characteristics associated with successful mastery of this skill (Table 1). One study examined the ability of children with spina bifida 3 years or older to perform self-catheterization.[4] Forty-eight percent (48%) of participants were able to self-catheterize. Two factors, male sex and higher levels of independence in activities of daily living increased the likelihood of mastering self-catheterization. In contrast, having a thoracic lesion and intellectual disability (among children 5 years or older) decreased the likelihood of success in performing self-catheterization.

Three studies examined adult patients' ability to perform self-catheterization. Participants in one study were 65 years and older and used IC for a variety of reasons while the second study evaluated 23 participants with neurogenic bladder dysfunction caused by multiple sclerosis (MS).[5,7] In both studies, more than 80% of participants were able to self-catheterize and functional ability was a significant predictor of success. Better cognitive function predicted success in the study of older adults where the mean age was 74 years,[5] but it did not predict success in self-catheterization in the study that enrolled patients with MS where the mean age was 46 years.[7] In a study of 391 individuals being taught IC for a variety of indications, Parsons and colleagues[6] compared the proportion of males and females who were successful in mastering the procedure. They found that 88% of males and 76% of females were successful in performing IC.

Adherence to Intermittent Catheterization

Sixteen studies that examined adherence to IC were conducted in a variety of settings and varied in sample sizes and times frames over which adherence was measured (Table 2). Four studies (n = 41-3328 patients) examined adherence in patients using IC following spinal cord injuries. Reported adherence rates varied from 57.7% (n = 104 patients followed up a mean of 4.5 years) to 91.8% (n = 49 patients, follow-up time not reported).[8,9,16,19] The largest study to examine adherence to IC used data extracted from the National Spinal Cord Injury

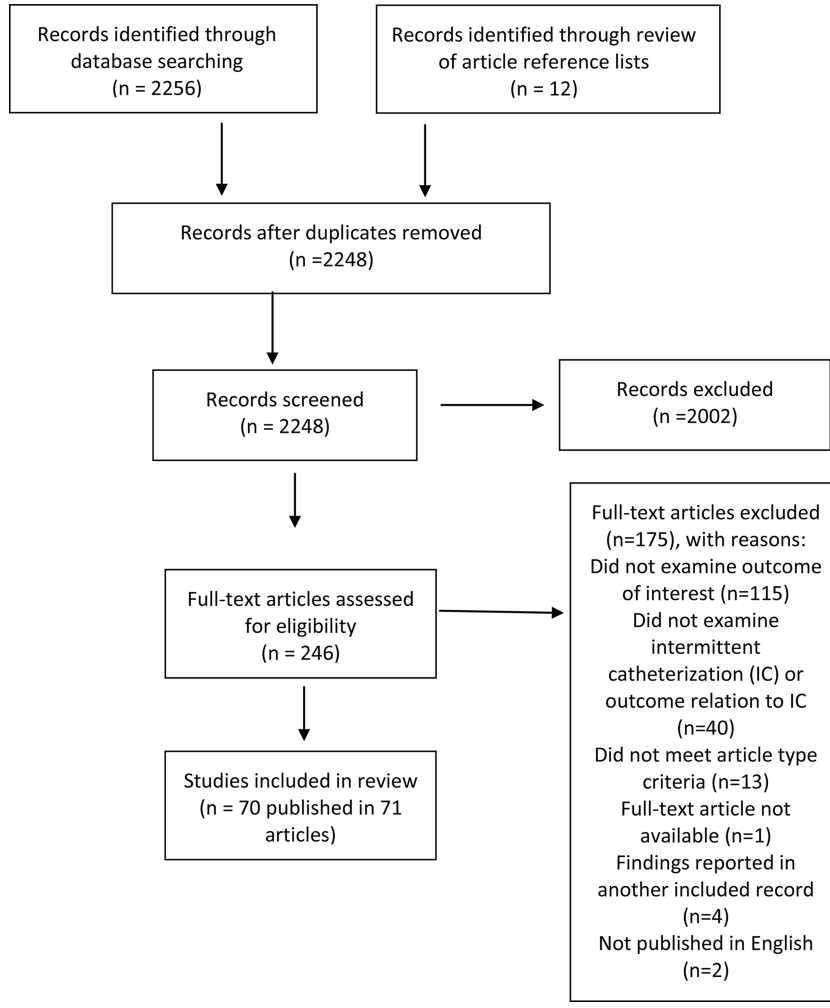

Figure. PRISMA flowchart of the study selection, screening, and inclusion.

Database in the United States in which adherence at 1-year following discharge from postinjury rehabilitation reported 78.6% of a group of 3328 participants were still using IC.[19] In this study, the only significant predictors of continued use of IC American Spinal Injury Association classes C versus A ($P = .003$) and D versus A ($P = .008$) impairment. Classes C and D spinal cord injuries are historically referred to as incomplete; both are characterized by preservation of motor function below the neurologic injury level with variable levels of muscle weakness. In contrast, a class A (complete) level spinal cord injury is characterized by loss of motor and sensory function below the neurologic injury level.[20]

We identified 5 studies that examined adherence to IC in samples of adults with varying types of lower urinary tract (LUT) dysfunction requiring IC.[6,10,14,15] Adherence was measured for a period between 6 weeks and 66 months; reported adherence rates varied from 52.7% in a group of 27 patients followed up from a mean of 23.5 months[10] to 84% in a group of 391 participants followed up for 6 weeks.[6] Three studies measured adherence at 12 months. Two reported similar adherence rates of 51.2% (n = 129) and 58% (n = 60).[12,14] In 1 of these studies, the authors reported that 50% of the patients who stopped IC did so because it was no longer indicated.[12] In a third study (n = 169), Hentzen and colleagues[15] reported a much higher adherence rate of 89.9%, but the study was limited to patients with a continued indication for IC such as neurogenic bladder dysfunction.

Parsons and colleagues[6] compared adherence rates in males versus females and in older versus younger adults (≥65 vs <65 years). A higher percentage of men (88%) than women (76%) were adherent 6 weeks after being taught to perform IC. Adherence rates were similar in those 65 years and older and younger than 65 years, 86% and 82%, respectively. Hentzen and colleagues[15] also compared adherence rates in patients older than 65 years and younger than 65 years and reported that those older than 65 years were significantly less likely to be adherent at 1-month follow-up ($P < .001$) but not at 6 to 12 months ($P = .38$). Two of the 5 studies in this group examined characteristics associated with adherence in multivariate analysis. In 1, males with nonneurogenic bladder dysfunction who were older than 60 years were less adherent to IC ($P = .003$), while females with neurogenic bladder dysfunction who were younger than 40 years were the most adherent group ($P = .04$).[14] Hentzen's group[15] identified no statistically significant predictors of adherence among participants older than 65 years.

Three studies were found that examined adherence to IC in individuals with MS. Adherence rates were 95.6% (mean follow-up = 9.3 months), 29% (mean follow-up varied with adherent patients followed a mean of 100.7 months) and 60%

TABLE 1.
Predictors of Ability to Perform Self-intermittent Catheterization

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Castillo and colleagues[4]	*Design*: Observational *Setting*: US *Sample*: Children age ≥3 y with spina bifida; n = 200	Self or caregiver reported	Ability (n = 96) vs inability (n = 104) to self-catheterize	75 participants were able to perform self-urethral IC by a mean age of 9.4 y and 21 were able to catheterize through a surgically created channel at a mean age of 9.8 y Characteristics associated with a higher rate of self-catheterization were male sex ($P = .047$) and independence in dressing, bathing, and performing skin checks ($P < .0001$); lower rates of self-catheterization were associated with having a thoracic level of lesion compared to other levels ($P = .041$) and intellectual disability for those ≥5 y of age ($P = .0005$)
Hentzen and colleagues[5]	*Design*: Retrospective cohort *Setting*: France *Sample*: Adults age ≥65 y (mean age = 74 y); n = 202	Medical record review	Ability (n = 169) vs inability to self-catheter (n = 33)	83.7% were successful in learning to self-catheterization In multivariate analysis, the characteristics associated with success were greater functional independence (OR = 1.04; 95% CI, 1.01-1.08) and better cognitive function (OR = 1.18; 95% CI, 1.03-1.37) measured by the Functional Independence Measure and ability to access the perineum (OR = 2.30; 95% CI, 1.32-4.42)
Parsons and colleagues[6]	*Design*: Retrospective *Setting*: UK *Sample*: 391 males and females (mean 63 y) taught IC with varying indication for use	Medical record review	None, IC only	88% of males and 76% of females were successful in learning to perform IC
Vahter and colleagues[7]	*Design*: Observational *Setting*: Estonia *Sample*: Individuals with multiple sclerosis; n = 23 (mean age = 46 y)	Determined by continence nurse advisor who trained participants	Ability (n = 20) vs inability to self-catheter (n = 3)	86.9% were successful at the end of the training Success in learning to self-catheterize was related to the number of lessons ($r = -0.50$, $P = .03$) and physical disability ($r = -0.43$, $P = .04$); it was not significantly related to disease course or cognitive function

Abbreviations: CI, confidence interval; IC, intermittent catheterization; OR, odds ratio.

(at 3-month follow-up).[7,11,17] The sample sizes in all 3 studies were small (n = 20-35). Although 2 of the studies examined bivariate relationships between select characteristics and adherence to IC (Table 2),[7,17] neither performed the multivariate analyses essential to determine which characteristics were independently associated with IC adherence.

We only identified 2 studies examining adherence to IC in children; they were conducted in France (n = 60) and Saudi Arabia (n = 44). Participants had varying reasons for IC and were followed up for a variable period; reported adherence rates were 77% (follow-up of at least 2 years) and 82% (mean follow-up of 9.9 years).[13,18]

Satisfaction With Intermittent Catheterization

We retrieved 7 studies that examined participants' satisfaction with IC (Table 3).[10,21-26] All evaluated adults performing IC and were conducted in a variety of countries. Only 2 examined satisfaction with IC regardless of catheter type. Both measured satisfaction on a 10-point scale, with higher scores representing greater satisfaction. They reported mean satisfaction scores of 6.0 (n = 27)[10] and 7.86 (n = 269) out of 10.[26] The remaining studies compared satisfaction with different types of catheters. One study compared hydrophilic (HC) to noncoated catheters (NC) with participants randomly assigned to the catheter type. Overall satisfaction was significantly higher in the group (n = 45) using HCs (mean score of 9.3 on a 0- to 10-point scale) compared to the group (n = 69) using NC (mean score 8.6) ($P = .007$).[21] Another study (n = 21) compared satisfaction scores with polyvinyl chloride (PVC), hydrophilic-coated, and gel-lubricated nonhydrophilic catheters with participants randomly assigned to the order of catheter use and using each type of catheter for 6 weeks. Satisfaction scores were highest when participants were using the gel-lubricated catheter.[25] A third study (n = 195) compared satisfaction with PVC and PVC-free catheters and reported no significant differences.[24] The final 2 studies compared compact catheters to standard length catheters.[22,23] There was no significant difference in satisfaction scores in 1 on the studies (n = 125),[22] and while the difference was statistically significant ($P = .04$) in the second study (n = 118), the actual difference in scores was small, 77 versus 71 on a 100-mm scale, respectively, for the compact versus standard length catheter.[23]

Quality of Life

Table 4 summarizes the findings of the 15 studies that examined health-related QoL in patients using IC. Quality of life was measured in a variety of patient samples using IC secondary to neurogenic and nonneurogenic causes of bladder dysfunction. The instruments used to measure QoL varied across studies. Four studies examined the effect of initiating IC on QoL and reported improvement of urinary-related QoL.[11,12,26,31] Kessler and associates (n = 92)[32] also examined IC-related QoL in relation to ease of insertion, interference with work or other activities, and pain and reported that most participants rated their QoL positively in relation to each of these domains. Three studies examined characteristics associated with poor urinary-specific and/or general health-related QoL. Chiappe and colleagues[29] examined the relationship between a variety of characteristics and bladder-specific and general health-related QoL in 119 patients using IC. While a history of UTI and urinary incontinence were significantly related to bladder-specific QoL on bivariate analysis, multivariate analysis revealed no characteristics that exerted a significant effect of QoL. Kessler and associates[32] reported that the

TABLE 2.
Adherence and Continuation of Intermittent Catheterization

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Afsar and colleagues[8]	*Design*: Retrospective *Setting*: Turkey *Sample*: Adults (mean age = 41 y) with SCI discharged from a rehabilitation center; n = 164; 104 (64%) were using IC at discharge	Medical record review	None, IC only	Patients were followed up a mean of 53.9 ± 27.67 mo, with 57.7% remaining adherent to IC 44 stopped IC and of these 21.4% reverted to using an indwelling catheter, 73.8% started using reflex voiding, and 4.8% were voiding normally The only factor related to adherence was catheter type and the correlations were weak
AlSaleh and colleagues[9]	*Design*: Cross-sectional *Setting*: Saudi Arabia *Sample*: Adults (mean age = 29.6 y) with SCI, n = 41, using IC at discharge	Self-report	None, IC only	By 3 mo postdischarge 73.2% of patients were adherent to IC 11 (26.8%) had stopped IC and switched to incontinence pads or an indwelling catheter
Batista-Miranda and colleagues[10]	*Design*: Observational *Setting*: Spain *Sample*: Adults (mean age = 54.3 y) performing IC for neurogenic and nonneurogenic reasons; n = 27	Self-report survey, n = 19 responses	None	Followed up for a mean of 23.5 mo (range = 2-66); 52.7% (n = 10) respondents were still practicing IC
Castel-Lacanal and colleagues[11]	*Design*: Prospective cohort *Setting*: France *Sample*: Adults (mean age = 49.3 y) with multiple sclerosis: n = 23	Self-report	None	95.6% (n = 22) continued to use IC; followed up a mean of 9.3 mo
Cobussen-Boekhorst and colleagues[12]	*Design*: Prospective multicenter observational *Setting*: The Netherlands *Sample*: Adults (mean age = 62 y) with a variety of diagnoses who had been performing IC at least once a day for ≥3 mo; n = 129	Self-report	None, IC only	At 3-mo follow-up, 69% of patients were adherent to IC; the percent dropped to 51.2% at 12-mo follow-up Of the 63 who stopped, 50% did so because their bladder function had recovered. The only characteristic related to adherence was age and the correlation was weak ($r = 0.214$, $P = .017$)
Faure and colleagues[13]	*Design*: Retrospective *Setting*: France *Sample*: Males (ages 1-18 y) with neurologic and nonneurologic reasons for IC; n = 60	Medical record review	None, IC only	82% adherence rate after a mean follow-up of 9.9 ± 4.3 y
Girotti and colleagues[14]	*Design*: Prospective observational *Setting*: Brazil *Sample*: Adults (mean age = 50.4 y) with neurogenic and nonneurogenic reasons for IC; n = 60	3-d bladder diary	None	61.7% (n = 37) were adherent at 6 mo and 58% (n = 35) were adherent at 12 mo Characteristics associated with adherence on multivariate analysis, males older than 60 y with nonneurogenic bladder dysfunction were less adherent ($P = .003$) and females younger than 40 y with neurogenic bladder dysfunction were the most adherent ($P = .04$)
Hentzen and colleagues[15]	*Design*: Retrospective *Setting*: France *Sample*: Patients >65 y (mean age = 74 y) with varying reasons for catheterization who successfully learned IC; n = 169	Medical record review	Patients over 65 y were matched to control patients younger than 65 y based on sex, body mass index, and pathology	Among patients with data available at follow-up and with continuing medical indication for IC, 72.9% (n = 113 of 153) and 89.9% (n = 80 of 89) of those 65 y and older were adherent at 1 and 6-12 mo, respectively, compared to 87.1% (n = 149 of 171) and 87.0% (n = 114 of 131) of those younger than 65 y, respectively Adults older than 65 y were significantly less likely to be adherent as 1-month follow-up ($P < .001$) but not at 6- to 12-mo follow-up ($P = .38$) compared to those <65 y Multivariate analysis: no predictors of adherence in older adults
Lopes and colleagues[16]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 40 y) with neurogenic bladder due to SCI who had undergone IC during rehabilitation; n = 49	Self-report	None, IC only	91.8% were adherent to IC (the follow-up time was not reported) The only characteristic examined in relation to adherence was social support and there was no significant relationship

(*continues*)

TABLE 2.
Adherence and Continuation of Intermittent Catheterization (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Motavasseli and colleagues[17]	*Design*: Prospective observational *Setting*: France *Sample*: Patients (mean age = 50 y) with multiple sclerosis prescribed IC; n = 35	Self-report measured at varying time points following initiation of IC	None, IC only	29% of the patients were adherent Via bivariate analysis, the intensity of voiding dysfunction ($P < .001$), a greater number of daily catheterizations ($P = .03$), and better functional status ($P = .02$) were associated with better adherence, while a greater number of spontaneous voids ($P < .001$), a blocking sensation when inserting the catheter, and higher anxiety ($P < .001$) and depression ($P < .001$) scores were associated with poorer adherence
Neel and colleagues[18]	*Design*: Retrospective observational *Setting*: Saudi Arabia *Sample*: Children (mean age = 6.5 y) with PUV or NNBSD who had been using IC for at least 2 y; n = 44	Medical record review	None, IC only	77% were adherent after at least 2 y of follow-up The adherence rate was higher in children 4 y and younger than those over 4 y among those with NNBSD There were no differences in the adherence rates for these 2 age groups when the child had PUV
Parsons and colleagues[6]	*Design*: Retrospective *Setting*: UK *Sample*: 391 men and women (mean age = 63 y) taught IC with varying indication for use	Medical record review	None, IC only	At 6-wk follow-up, 84% of the patients were performing IC, 88% of men and 76% of women; 86% of those younger than 65 y and 82% of those 65 y and older were adherent
Vahter and colleagues[7]	*Design*: Observational *Setting*: Estonia *Sample*: Adults (mean age = 46 y) with multiple sclerosis who were successful in learning to self-catheterize; n = 20	Self-report	None, IC only	At 3-mo follow-up, 60% of participants were still self-catheterizing None of the characteristics measured as the time of IC instruction (cognitive function, functional ability, disease course, or time required to learn IC) were significantly related to continued adherence to IC found by bivariate analysis
Zlatev and colleagues[19]	*Design*: Retrospective observational *Setting*: US *Sample*: Patients (median age = 35 y) with SCI; n = 3328 discharged from rehabilitation using IC	Data extracted from the National Spinal Course Injury (SCI) Database	None, IC only	78.6% were still using IC at 1-y follow-up Significant predictors of adherence to IC were American Spinal Cord Injury Scale classes C (OR = 0.62; 95% CI, 0.44-0.85, $P = .003$), and D (OR = 0.55, 95% CI, 0.36-0.86, $P = .008$) (incomplete impairment) relative to class A (complete impairment) Significant predictors of nonadherence: older age (OR = 1.02; 95% CI, 1.01-1.03, $P < .001$) and limitations in upper extremity function compared to able function $P < .001$ for each measure of limited function with ORs varying from 4.01 to 6.33

Abbreviations: CI, confidence interval; IC, intermittent catheterization; NNBSD, non-neuropathic bladder sphincter dysfunction; OR, odds ratio; PUV, posterior urethral valve; SCI, spinal cord injury.

only predictor of poor QoL was severe pain while performing IC odds ratio (OR) = 20.9; 95% confidence interval (CI) 1.7 to 259.9; $P = .02$. Girotti and coworkers[14] (n = 60) reported that patients who were adherent to IC had better overall QoL in psychological ($P = .04$) and social relationships ($P = .02$) domains than were nonadherent patients.

Several studies compared QoL in patients using IC to those using a variety of other methods of bladder evacuation. In 2 studies (n = 1193 and 42), QoL did not differ significantly by bladder-emptying methods.[30,34] In 2 studies (n = 195 and 142), patients with spinal cord injuries who voided spontaneously reported better QoL than those who used IC to empty their bladders.[27,33] In 1 of these studies, QoL was also compared in participants who self-catheterized and those whose IC was performed by a caregiver and reported that caregiver IC was associated with worse QoL in most domains compared to other bladder management methods.[27]

We found only 1 study that evaluated the effect of IC on QoL in children with urethral sensation. Alencar and colleagues[28] compared urethral (n = 51) and continent urinary stoma (n = 19) catheterization and reported that urethral catheterization was associated with significantly worse QoL in physical and social domains than stoma catheterization.

Two studies compared QoL in patients using shorter (sometimes referred to as compact) catheters versus catheters of regular length; both employed a randomized cross-over trial design. In 1 (n = 118), use of the compact catheter was associated with significantly better IC-specific QoL compared to the standard catheter ($P < .001$).[23] In the other study (n = 125), use of the compact catheter was associated with significantly better general QoL related to daily activities ($P = .03$), but not in overall QoL (P value not reported).[22]

Only 1 study was identified that examined the effect of an intervention on QoL in patients using IC. Wilde and colleagues[35] completed a single-group, pre-/poststudy in patients using IC following spinal cord injuries (n = 26). The intervention was a web-based self-management program; it did not result in a significant improvement in IC-related QoL.

TABLE 3.
Satisfaction With Intermittent Catheterization

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Batista-Miranda and colleagues[10]	*Design*: Observational *Setting*: Spain *Sample*: Adults (mean age = 54.3 y) performing IC for neurogenic and nonneurogenic reasons; n = 27, followed up for a mean of 23.5 mo	Telephone interview using a 1- to 10-point scale, where 0 = fully dissatisfied and 10 = very satisfied	None	Mean = 6.0 with 63.2% of scores >5
Cardenas and colleagues[21]	*Design*: RCT *Setting*: Inpatient or SCI rehabilitation units and community (postdischarge); US and Canada *Sample*: Adults (mean age = 37 y) with SCI; n = 224	0- to 10-point scale (very dissatisfied to very satisfied)	Hydrophilic-coated catheter (n = 45) vs noncoated catheter (n = 69)	The overall satisfaction with the hydrophilic-coated catheter was significantly higher than for the uncoated catheter: Mean score = 9.3 (1.4) vs 8.6 (1.3), $P = .007$
Chartier-Kastler and colleagues[22]	*Design*: Randomized cross-over *Setting*: Europe *Sample*: Adults (mean age = 43 y) with SCI; n = 125	General satisfaction with IC measured using a 10-cm VAS	Hydrophilic compact telescoping catheter vs standard coated catheter	There were no differences for general satisfaction
Chartier-Kastler and colleagues[23]	*Design*: RCT 2-way cross-over *Setting*: Europe *Sample*: Adults (mean age = 54 y) with neurogenic reasons for IC; n = 118	Satisfaction measured by a 100-mm VAS, where 100 = highly satisfied	Discreet compact catheter vs standard catheter	Mean VAS for compact catheter = 77 mm vs 71 for standard coated catheter, $P = .037$
Witjes and colleagues[24]	*Design*: Multicenter RCT *Setting*: 6 European countries and 12 centers *Sample*: Adults (mean ages = 51 and 52 y) neurogenic and urologic reasons for IC; n = 195	Measured by "questionnaire"	PVC-free catheter vs continuing to use their PVC catheter	80% of patients using the PVC catheter and 78% of those using the PVC-free catheter were satisfied; no significant difference
Sarica and colleagues[25]	*Design*: RCT *Setting*: Turkey *Sample*: 21 men (mean age = 37 y) with SCI within the past 6 mo who were able to perform IC	Satisfaction measured by a 10-point VAS and 5 questions asking about satisfaction with time needed to empty bladder, urine flow rate, ease of use, overall comfort, and overall satisfaction, with 0 = very much, 1 = moderately, 2 = a little, and 3 = not at all	Participants randomized to order of using 3 catheter types: PVC, hydrophilic-coated, and gel-lubricated nonhydrophilic; each type was used for 6 wk	VAS score was significantly higher when using the gel-lubricated catheter ($P < .05$) The gel-lubricated catheter was also significantly superior to the PVC and hydrophilic catheter in relation to satisfaction with bladder-emptying time, handling ease, and comfort ($P < .05$)
Yilmaz and colleagues[26]	*Design*: *Setting*: Turkey *Sample*: Adults (mean age = 41.1 y) with SCI; n = 269	Measured by a 0- to 10-point VAS	None; only IC examined	Mean score = 7.86 with a statistically significant difference between men (mean = 8.07) and women (mean =7.2). Overall 66.6% of patients were satisfied with the catheter they were using

Abbreviations: IC, intermittent catheterization; PVC, polyvinyl chloride; RCT, randomized controlled trial; SCI, spinal cord injury; VAS, visual analog scale.

Complications

Our search revealed a variety or potential complications associated with IC. These included UTI, urethral strictures, hematuria, bladder stones, false urethral passage, pain or discomfort, and renal scarring.

Urinary Tract Infections

Urinary tract infection was the most commonly studied IC complication. We retrieved 13 studies that reported UTI rates in patients using IC. The method used to diagnose a UTI varied as did the time frame over which UTIs were assessed (Table 5). In 3 studies, participants were adults with neurogenic bladder dysfunction secondary to a spinal cord injury[8,16,41] while 4 studies evaluated UTI in patients with neurogenic and nonneurogenic LUT disorders.[10,29,36,38] Four studies (n = 104-649) reported the 1-year incidence of UTI, which varied from 62% to 77%.[8,29,38,41] Two studies reported the number of UTIs over a 1-year period; both reported similar rates (2.6 and 2.7).[29,41] Woodbury and associates[41] compared the annual prevalence of UTIs in males and females and reported significantly more UTIs in females versus males (3.2 vs 2.4, $P < .05$). In contrast, Batista-Miranda and coworkers[10] reported that more males than females had a UTI during a longitudinal study with a mean follow-up of 23.5 months.

Four studies examined the occurrence of UTIs in children with LUT dysfunction managed by IC. Faleiros and

TABLE 4.
Intermittent Catheterization: Quality of Life

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Akkoç and colleagues[27]	*Design*: Observational *Setting*: Turkey *Sample*: Adults (mean age = 38 y) with SCI; n = 195 with 144 using IC	King's Health Questionnaire	Self-IC and caregiver-IC, spontaneous voiding, assisted maneuver voiding, indwelling catheter	Participants whose IC was performed by a caregiver had worse QoL than other groups in most domains; those performing self-IC had significantly worse QoL-related incontinence impact scores and symptom severity than those voiding spontaneously (*P* values not reported)
Alencar and colleagues[28]	*Design*: Observational *Setting*: Brazil *Sample*: Children (mean age = 12 y); n = 70	Pediatric Quality of Life Inventory	Urethral (n = 51) vs stoma (n = 19) catheterization	Urethral catheterization was associated with significantly worse quality of life in physical and social domains than stoma catheterization
Castel-Lacanal and colleagues[11]	*Design*: Prospective cohort *Setting*: France *Sample*: Adults (mean age = 49.3 y) with multiple sclerosis, n = 22	Urinary problem-related QoL: Qualiveen (a bladder problem-specific quality of life questionnaire) administered prior to and at least 6 mo postinitiation of IC General health-related QoL: SF-36	None—measured pre- and postinitiation of IC	Significant improvement from pre to post ($P = .004$) No significant change in any domain
Chartier-Kastler and colleagues[23]	*Design*: RCT 2-way crossover *Setting*: Europe *Sample*: Adults (mean age = 54 y) with neurogenic reasons for IC; n = 118	Intermittent Self-Catheterization Questionnaire	Discreet compact catheter vs standard catheter	Use of the compact catheter was associated with significantly better quality of life than the standard catheter ($P < .001$)
Chartier-Kastler and colleagues[22]	*Design*: Randomized crossover *Setting*: Europe *Sample*: Adults (mean age = 43 y) with SCI; n = 125	Overall quality of life and quality of life related to daily activities measured using a 10-cm VAS, where higher scores indicate better quality of life in the domain assessed	Hydrophilic compact telescoping catheter vs standard coated catheter	Use of the compact catheter was associated with significantly better quality of life in relation to daily activities ($P = .03$) than the standard catheter, but there were no differences in overall quality of life
Chiappe and colleagues[29]	*Design*: Observational *Setting*: France *Sample*: Adults (mean age = 54 y) with various reasons for IC; n = 119	Qualiveen QoL (urinary disorder-specific measure) and SF-12 (general health-related) questionnaires	None, IC only	Bivariately, UTI history, and UI were significantly related to poorer disease-specific QoL; multivariate analysis showed neither were significantly related Neither were related to general QoL (SF-12)
Cobussen-Boekhorst and colleagues[12]	*Design*: Prospective observational *Setting*: The Netherlands *Sample*: Adults (mean age = 62 y) referred for IC instructions; n = 129	10-point VAS (where higher scores indicated that urinary problems have less impact on quality of life) and King's Health Questionnaire (a bladder function-specific quality-of-life measure where lower scores indicate better quality of life)	Continuing and stopping IC	Although QoL measured by the VAS improved in all patients over the year of follow-up, the change was not statistically significant Scores improved the most in those who stopped IC. Based on King's Health Questionnaire scores, there was a decrease in the impact of the patients' bladder problem in daily life ($P < .0001$), limitations in daily activities ($P = .002$), and negative emotions ($P = .006$) over time for all participants Over the course of the study, 49% of the participants stopped IC and 50% of those who stopped did so because IC was no longer indicated. King's Health Questionnaire results were not reported separately by whether or not IC was still indicated
Girotti and colleagues[14]	*Design*: Prospective observational *Setting*: Brazil *Sample*: Adults (mean age = 50.4 y) with neurogenic and nonneurogenic reasons for IC; n = 60	WHOQoL BREF—measure of overall quality of life	Compared in patients adherent and nonadherent to IC	Adherent patients had significantly better psychological and social relationships domains of QoL than nonadherent patients (*P*s = .04 and .02, respectively)
James and colleagues[30]	*Design*: Retrospective observational *Setting*: North America *Sample*: Adults (mean age = 55 y) with multiple sclerosis; n = 1193	Impact of catheter use on QoL; method used to measure was not reported	Indwelling and suprapubic catheter	Impact of catheter use on QoL did not differ by method used ($P = .63$): *IC* (n = 727): positive impact = 53.2%, negative impact = 26.4%, and no impact = 20.4% *Indwelling catheter* (n = 169): positive impact = 51.5%, negative impact = 23.7%, and no impact = 24.9% *Suprapubic catheter* (n = 169): positive impact = 59.8%, negative impact = 20.1%, and no impact = 20.1%

(*continues*)

TABLE 4.
Intermittent Catheterization: Quality of Life (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Jhanwar and colleagues[31]	*Design*: Prospective cohort *Setting*: India *Sample*: Males (mean age = 37.7 y) treated for urethral stricture who performed CIC posttreatment; the etiology of the structure varied; n = 97	Investigator developed a 10-point VAS measuring domains of QoL: (1) how the individual would feel if he had to do IC rest of life (overall QoL), (2) interference of IC with daily activities, and (3) pain associated with IC (higher scores = greater impact of QoL)	QoL was measured at 3- and 6-mo follow-up	QoL domain scores improved significantly between 3 and 6 mo: overall QoL—from mean = 5.16 (1.25) to mean = 3.57 (0.95), $P = .0001$; interference with daily activities—from mean = 3.11 (1.63) to 1.38 (0.52), $P = .0001$; pain associated with IC—from mean = 3.76 (1.39) to mean = 2.56 (1.05), $P = .0001$
Kessler and colleagues[32]	*Design*: Observational (cross-sectional) *Setting*: Switzerland *Sample*: Adults starting IC (at mean age = 61 y) for neurogenic and nonneurogenic bladder dysfunction; n = 92	Investigator-developed a 0- to 10-point VAS, with higher scores indicating worse QoL in the domain measured	Single group	78% (n = 72) reported that IC was easy or very easy (VAS: 0-3) with 3% (n = 3) reporting it was difficulty or very difficult (VAS = 7-10) 83% (n = 76) reported that it did not or only a little interfered with work or other daily activities; 14 (15%) reported that is interfered quite a bit or extremely 87% (n = 8) reported no or minimal pain during IC, 9 (10%) reported moderate pain and 3 (3%) reported severe pain 87% (n = 80) reported that IC-related pain had little or no impact on work or daily activities, 2% (n = 2) reported moderate interference and 10% (n = 10) reported quite a bit or extreme interference 32 (35%) reported that IC resulted in extreme improvement in their QoL, 24 (26%) reported improvement, 25 (27%) reported no change, 7 (8%) reported deterioration in the QoL, and 4 (4%) extreme deterioration The only predictor of poor QoL was severe pain while performing IC (OR = 20.9; 95% CI, 1.7-259.9; $P = .02$)
Liu and colleagues[33]	*Design*: Observational (cross-sectional) *Setting*: UK *Sample*: Adults (mean age = 45 y) with SCI; n = 142	SF-36 and King's Health Questionnaire	Compared QoL across bladder-emptying methods with individual methods only compared if the overall comparison was significant	SF-37: Physical and mental health component scores significantly were higher (better QoL) in the normal voiders than IC Kings Health Questionnaire: Scores were lower (indicating better QoL) for all domains for normal voiders than for other methods of bladder emptying including IC The only statistical comparisons were for the physical, personal, and emotions subscales and scores were significantly better in those who voided normally than those who used IC
Liu and colleagues[34]	*Design*: Observational (cross-sectional) *Setting*: US *Sample*: Adults (mean age = 32 y) with spina bifida; n = 42 used IC	SF-36 and I-QoL	Bladder management methods were compared	Across the bladder management techniques, there were no significant differences in QoL measured by I-QoL or SF-36 except for the SF-36 general health rating subscale ($P = .03$) The highest score (reflected better QoL in this domain) was in the normal voiding group (n = 12) followed by the IC group (n = 42) and lowest in the indwelling catheter group (n = 4)
Wilde and colleagues[35]	*Design*: Pre-post single-group quasiexperimental design *Setting*: US *Sample*: Adults (mean age = 44 y) with SCI; n = 26	Intermittent Self-Catheter Questionnaire	Prior to and following a web-based self-management intervention focusing on fluid management and activities, IC intervals, catheter supplies, travel, preventing incontinence, and identifying symptoms of UTIs	No significant change in QoL
Yilmaz and colleagues[26]	*Design*: Observational *Setting*: Turkey *Sample*: Adults (mean age = 41.1 y) with SCI; n = 269	5-point Likert-type scale (1 = much better to 5 = much worse)	None; only IC examined	128 (47.9%) reported that IC made their QoL somewhat better; 3% reported it made their QoL much worse

Abbreviations: CI, confidence interval; CIC, clean intermittent catheterization; IC, intermittent catheterization; I-QoL, Incontinence Quality of Life Scale; OR, odd ratio; QoL, quality of life; SCI, spinal cord injury; RCT, randomized controlled trial; UI, urinary incontinence; UTI, urinary tract infection; VAS, visual analog scale.

TABLE 5.
Intermittent Catheterization and Urinary Tract Infections

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
UTI incidence				
Afsar and colleagues[8]	*Design*: Observational *Setting*: Turkey *Sample*: Adults (mean age = 41 y) with SCIs discharged from a rehabilitation center; n = 104	Medical record documentation	None	68% incidence annually
Batista-Miranda and colleagues[10]	*Design*: Observational *Setting*: Spain *Sample*: Adults (mean age = 54.3 y) performing IC for neurogenic and nonneurogenic reasons; n = 27, followed for a mean of 23.5 mo	Not reported	None	33% (n = 9), 2 women and 7 men with all occurring during the first month performing self-IC
Bolinger and Engberg, 2013[36]	*Design*: Observational *Setting*: US *Sample*: Adults (mean age = 54.3 y) with neurogenic and nonneurogenic reasons for IC; n = 44	Self-report	None	77% (time frame not reported)
Chiappe and colleagues, 2016[29]	*Design*: Observational *Setting*: France *Sample*: Adults (mean age = 54 y) with neurogenic and nonneurogenic reasons for IC; n = 171	Health care provider competed questionnaire	None	63% during the prior year Annual mean number of UTIs = 2.66 ± 0.46
Faleiros and colleagues[37]	*Design*: Observational *Setting*: Germany and Brazil *Sample*: Children (median age = 11 y) with spina bifida; n = 94	Bacteriuria (>100,000 colonies/mL) with one or more predefined signs or symptoms	UTI rates compared 1 y prior to and 1 y after beginning IC	Mean = 2.8 ± 3.0 episodes in the year before starting IC vs 1.1 ± 1.7 in the year postinitiation of IC
Håkansson and colleagues[38]	*Design*: Observational *Setting*: Sweden *Sample*: Adults (mean age = 55 y) with neurogenic and nonneurogenic reasons for IC using hydrophilic-coated catheters; n = 391	Self-report based on antibiotic use	None	62% incidence during the prior year
Li and colleagues[39]	*Design*: Retrospective observational *Setting*: China *Sample*: Children with neurogenic bladder, n = 78	Not reported	Early IC (<1 y of age), n = 40 vs late IC (>3 y of age), n = 36	15% of patients in the early IC group compared to 38.9% in the late CI at 3 y follow-up (P = .04) and 25.0% and 52.8%, respectively, at 6-y follow-up (P = .02)
Lopes and colleagues[16]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 40 y) with SCI; n = 49	Self-report	None	20.0% reported UTIs
Uyar and colleagues[40]	*Design*: Retrospective observational *Setting*: Turkey *Sample*: Children diagnosed with UTIs over a 4-y period. Children with UTI due to extended spectrum beta-lactamase producing bacteria (ESBL+, n = 154) were matched 1:2 with children with ESBL− UTIs (n = 308) by age ± 20% and sex	Risk factors for ESBL+ UTIs; measured by medical record review	ESBL+ vs ESBL− UTIs	IC was a significant independent risk factor for ESBL+ UTIs (OR = 2.70; 95% CI, 1.25-5.84)
Woodbury and colleagues[41]	*Design*: Observational *Setting*: Canada *Sample*: Adults (mean age = 50 y) with SCIs; n = 649	Self-reported symptomatic	None	77% during prior year with a mean of 2.6 UTIs; significantly more common in women (mean = 3.2) than in men (mean = 2.4), P = .003

(*continues*)

TABLE 5.
Intermittent Catheterization and Urinary Tract Infections (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Yildiz and colleagues[42]	*Design*: Observational *Setting*: Turkey *Sample*: Children (mean ages = 8.2 and 7.9 y) with myelodysplasia using IC who had significant bacteriuria (n = 71)	IC patients who had a change in the pattern of symptoms, urine color or odor, evidence of a systematic inflammatory response (increased WBC count, CRP, and/or ERS) without another explanation for infection were diagnosed with a symptomatic UTI	None	15 patients (21%) had symptomatic UTIs, 84.5% were receiving prophylactic antibiotic treatment (UTI rates were not compared in those who were and were not receiving prophylactic antibiotics)
UTI incidence: IC compared to other bladder-emptying methods				
Anderson and colleagues[43]	*Design*: Observational *Setting*: Switzerland *Sample*: Adult (age 16 to >76 y) with SCI participating; n = 344 (73 using IC)	Positive culture with symptoms	Indwelling catheter Spontaneous voiding	No significant difference in adjusted incidence rates for indwelling and IC groups ($P = .82$) Significantly lower adjusted incidence rates than indwelling catheter and IC groups
Krebs and colleagues[44]	*Design*: Observational *Setting*: Switzerland *Sample*: Adults (mean age = 46 y) with neurogenic reasons for IC; n = 1104 with 427 using IC	Self-report	Spontaneous voiding	70% incidence rate during prior year; odds of UTI = 3.54 (95% CI, 1.79-7.00) and 2.66 for recurrent UTIs (95% CI, 1.05-7.76) in the IC group compared to spontaneous voiding
Singh and colleagues[45]	*Design*: Observational *Setting*: India *Sample*: Adults (mean age = 49 y) with SCI; IC n = 180	Positive urine culture with fever and at least 2 other symptoms of UTI	Indwelling catheter n = 224, suprapubic catheter n = 24, reflex voiding n = 32, normal voiding n = 40	UTI per 100-person d: • 2.68 for indwelling catheter • 0.34 for IC • 0.34 for condom catheter • 0.44 for reflex voiding • 0.56 for suprapubic catheter • 0.32 for normal voiding
Shen and colleagues[46]	*Design*: Prospective cohort *Setting*: China *Sample*: Adults (mean age = 45.7 y) with SCIs more than 1 y prior; n = 67	Number of UTIs during the 2-y follow-up period measured by monthly clean-catch of catheterized urine specimen with bacterial count $\geq 10^2$ on catheter specimen or 10^4 on clean-catch specimen. The number of UTIs was reported as none, 1, 2 or 3, or more	CI: n = 15, reflex voiding/crede: n = 26, indwelling catheter: n = 12, normal voiding: n = 14	*IC group*: n = 5 (33.3%) with no UTIs, n = 7 (46.7%) had 1 UTI, 1 (6.7%) had 2 UTIs; *crede/reflex voiding*: no patients with no UTIs, n = 9 (34.6%) had 1 UTI, n = 9 (34.6%) had 2 UTIs, and n = 8 (30.8%) had 3 or more UTIs; *indwelling catheter*: no patients with no UTIs, n = 2 (16.7%) had 1 UTI, n = 4 (33.3%) had 2 UTIs, and n = 6 (50.0%) and 3 or more UTIs; and *normal voiding*: n = 8 (57.1%) had not UTIs, n = 5 (35.7%) had 1 UTI, n = 2 (7.1%) had 2 UTIs, and no patients had 3 or more UTIs. The only significant differences in relation to the IC group were that significantly fewer patients had no infections than in the reflex voiding and indwelling catheter groups ($P < .05$)
Stillman and colleagues[47]	*Design*: Observational *Setting*: US *Sample*: Adults (mean age = 49 y) with SCI discharged from inpatient rehabilitation; IC n = 31	Self-report	Indwelling catheter (n = 47-42 at 3- to 12-mo follow-up) Spontaneous voiding n = 58-63 (3- to 12-mo follow-up)	3-mo prevalence rates of UTIs varied from 48% to 81% among individuals using indwelling catheters, 31% to 61% among those using IC, and 4% to 10% among those voiding spontaneously
UTI incidence: Compared by catheter type				
Cardenas and Hoffman[48]	*Design*: RCT *Setting*: US *Sample*: Adults (mean ages = 42 and 40 y) with SCI; n = 45	Symptomatic UTI (significant Bacteriuria, $\geq 10^5$ CFU/mL, with at least 1 sign or symptom suggestive of UTI)	HC (n = 22) vs NC (n = 23)	54% of individuals in the HC group had at least 1 UTI during the 12 mo of follow-up compared to 61% of those in the NC group ($P = .67$) with the mean total UTIs = 1.18 ± 1.3 and 1.00 ± 1.0, respectively ($P = .61$), and the mean total antibiotic-treated UTIs = 0.77 ± 0.87 and 1.65 ± 1.46, respectively ($P = .02$)

(*continues*)

TABLE 5.
Intermittent Catheterization and Urinary Tract Infections (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Cardenas and colleagues[21]	*Design*: RCT *Setting*: Inpatient or SCI rehabilitation units and community (post-discharge); US and Canada *Sample*: Adults (mean age = 37 y) with SCI; n = 224	*Clinical definition*: Antibiotic treatment prescribed *Strict definition*: Bacteriuria (≥10^2 CFU/mL), at least 1-7 identified UTI symptoms, dipstick positive for leukocyte esterase and antibiotic treatment prescribed	HC (n = 79) vs NC (n = 82)	During inpatient/rehabilitation admission, UTIs/mo (number of UTIs/number of months) = 0.539 vs 0.683 based on clinical definition (P = .04) and 0.189 vs 0.295 based on the strict definition (P = .20) in the HC and NC groups, respectively; during the entire study period, there were no significant differences in UTI rates based on either definition
DeFoor and colleagues[49]	*Design*: RCT *Setting*: US *Sample*: Children (mean age = 13 y) with neurogenic reasons for IC; n = 78	Positive urine culture (>50,000 CFU/mL of a single dominant organism), at least 1 of the measured UTI symptoms and antibiotic treatment	HC (n = 37) vs NC (n = 41)	UTIs/person year: 2 of 22 (9.1%) in the HC group vs 17 out of 33 (51.5%) in the NC group (P = .003)
Li and colleagues[50]	*Design*: Systematic review with meta-analysis *Setting:* US and Spain *Sample*: RCTs, 2-group quasiexperimental (including cross-over designs) or prospective cohort studies (5 studies)	Method used to diagnose UTI not reported	HC (n = 230) vs NC (n = 232)	OR = 0.36 (95% CI, 0.24-0.54) favoring HC over NC
Prieto and colleagues[51]	*Design*: Systematic review with meta-analysis *Setting*: Varied *Sample*: Randomized controlled or cross-over trials comparing catheter types in relation to UTIs (n = 6)	Method of measuring UTI varied across studies	Coated vs noncoated catheters	No significant difference in UTIs
Rognoni and Tarricone[52]	*Design*: Systematic review with meta-analysis *Setting*: Varied *Sample*: RCTs, n = 6 studies	Method varied across studies	Hydrophilic catheter (HC, n = 247) vs noncoated catheter (NH), n = 259)	Relative risk of UTI = 0.84 (95% CI, 0.75-0.94) in HC compared to NH group
Sarica and colleagues[25]	*Design*: RCT *Setting*: Turkey *Sample*: 21 men (mean age = 37 y) with SCI within the past 6 mo who were able to perform IC	Positive urine culture (bacterial colony count of ≥100,00 CFU) and at least 1 UTI symptom	Participants randomized to order of using 3 catheter types: PVC, hydrophilic-coated, and gel-lubricated non-hydrophilic; each type was used for 6 wk	4 UTIs when using the PVC catheter, 1 when using the hydrophilic and 1 when using the gel-lubricated catheter (not significantly different)
Witjes and colleagues[24]	*Design*: Multicenter RCT *Setting*: 6 European countries and 12 centers *Sample*: Adults (mean ages = 51 and 52 y) neurogenic and urologic reasons for IC; n = 195	Not reported	PVC-free catheter vs continuing to use their PVC catheter	7 UTIs in the PVC group and 3 in the PVC-free group (statistical comparison not reported)
UTI incidence: Compared by antibiotic use				
Akil and colleagues[53]	*Design*: Single group cross-over *Setting*: Turkey *Sample*: Children (mean age = 13 y) with neural tube defects, n = 22	Presence of ≥10^5 colonies of the same microorganism in a urine sample taken by catheter along with UTI symptoms	Continuous prophylactic antibiotic therapy (y 1) followed by discontinuation of the antibiotic (y 2)	There were 28 symptomatic UTIs during the prophylactic antibiotic period and 26 during the antibiotic-free period (P = .65)
Cox and colleagues[54]	*Design*: Retrospective observational *Setting*: US *Sample*: Adults (mean age = 38 y) with neurogenic bladders for various reasons using IC; n = 22	UTI symptoms combined with positive leukocyte esterase and/or nitrates or a positive culture and antibiotic treatment	Prophylactic gentamicin bladder instillations—data on UTI collected pre and post	At baseline patients had a median of 4 UTIs during the prior 6 mo, which decreased to a median of 1 postintervention (P < .004); the median courses of antibiotic decreased from 3.5 (baseline) to 1 (postintervention), P = .01; 27.3% of patients had emergency department visits or hospitalizations for UTIs at baseline, which decreased to 10% postintervention (P = .32)

(*continues*)

TABLE 5.
Intermittent Catheterization and Urinary Tract Infections (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Fakas and colleagues[55]	*Design*: Quasiexperimental *Setting*: Greece *Sample*: Adults (mean age = 44-44.9 y) with multiple sclerosis; 3 groups—group A: those with indications for IC who were trained and elected to use; group B: patients with an indication for IC but who refused to use; and group C: patients with no indication for IC. No significant group differences in sociodemographic characteristics or history of UTI within the prior 3 y (20.5%, 15.1%, and 9.3%, respectively); n = 167	Patients in all 3 groups received either nitrofurantoin or norfloxacin prophylaxis for 6 mo. UTIs were measured by monthly urine culture and diagnosis was based on bacteriuria plus fever	The IC group (group A) was compared to patients with indication for IC but who refused to use it (group B) and patients with no indication for IC	14% (5 of 35) of patients in group A placed on long-tern prophylaxis had symptomatic UTIs. There were no episodes of UTI in group B or group C patients placed on long-term prophylaxis
Fisher and colleagues[56]	*Design*: RCT *Setting*: UK *Sample*: Adults (mean ages = 59 and 60 y) using IC with a history of recurrent UTIs, n = 404 of whom 361 had 12-mo outcome data	Self-report of at least 1 of the predefined UTI symptoms and a prescription for antibiotics	Antibiotic prophylaxis (n = 181) vs no prophylaxis (n = 180)	The incidence of symptomatic UTIs was 1.3 per person year in the prophylactic antibiotic group compared to 2.6 in the no prophylaxis group ($P < .0001$); there were also significantly ($P < .0001$) fewer microbiologically confirmed UTIs (0.74 vs 1.5, respectively) but no statistically significant difference in febrile UTIs (0.11 vs 0.16, $P = .24$)
Huen and colleagues[57]	*Design*: Retrospective observational *Setting*: US *Sample*: Children (mean age = 14.5 y) with neurogenic reasons for CI and a history of symptomatic UTIs and treated with daily intravesical antibiotic installation; n = 52	Positive urine culture with >10,000 CFU/mL with 1 or more predefined symptoms and a physician decision to treat with antibiotics	Neomycin polymyxin or gentamicin bladder instillations: UTIs measured pre- and postintervention	58% reduction in symptomatic UTIs after antibiotic instillation started ($P < .001$); 54% reduction in emergency department visits ($P < .001$) and 39% reduction in hospital admissions ($P = .04$) for UTIs
Michau and colleagues[58]	*Design*: Retrospective observational *Setting*: France *Sample*: Pregnant women (mean age = 30 y) using IC for neurogenic and nonneurogenic reasons; n = 25 women and 30 pregnancies	Medical record documentation of UTIs	WCA (n = 13 pregnancies) vs non-WCA (n = 17 pregnancies)	There were 5 UTIs during pregnancy in the WCA group (15.4%) vs 14 during pregnancy (82.4%) in the non-WCA group, $P = .02$
Pickard and colleagues[59]	*Design*: RCT *Setting*: UK *Sample:* 361 men and women (mean age = 59.6 y) using IC for ≥12 mo and a history of at least 2 symptomatic UTIs during the prior year or 1 UTI requiring hospitalization	Symptomatic, antibiotic-treated UTI defined as the presence of at least 1 patient-reported or clinician-documented symptom (from a predefined list of symptoms)	12 mo of antibiotic prophylaxis (daily dose of nitrofurantoin, trimethoprim, or cefalexin) compared to no antibiotic prophylaxis	IRR for symptomatic UTIs over the 12 mo in the prophylactic antibiotic group compared for the nonprophylaxis group, adjusted for days followed; IRR = 0.52 (95% CI, 0.44-0.61)
Poirier and colleagues[60]	*Design*: Observational *Setting*: France *Sample*: SCI patients (mean age = 51 y) with a history of >4 UTIs/y who were treated with WCA; n = 50	UTI was defined as 1 or more clinical symptoms with bacteriuria (≥10^5 of at least 1 bacterial species)	UTIs compared prior to and following initiation of WCA	The mean number of nonfebrile UTIs decreased from 9.45 ± 6.40/y prior to WCA to 1.57 ± 2.12/y post-WCA ($P < .001$). Febrile UTIs decreased from 5.25 ± 7.29/y prior to WCA to 0.18 ± 0.66/y post-WCA ($P < .001$). Hospitalizations per patient/y decreased from 0.86 to 0.02 ($P = .002$) and hospital length of stay decreased from 5.37 d per patient/y to 0.16, $P = .001$). Total days of curative antibiotic treatment per patient per year decreased from 92.83 to 34.5 ($P < .0001$).

(*continues*)

TABLE 5.
Intermittent Catheterization and Urinary Tract Infections (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Previnaire and colleagues[61]	*Design*: Retrospective observational *Setting*: SCI rehabilitation unit in France *Sample*: Patients (n = 50, mean age = 49 y) with SCI self or nurse catheterized with prescription for 5-d course of antibiotics for asymptomatic bacteriuria (prior to a procedure) or symptomatic UTI; n = 57 patients with 111 courses of antibiotics	*Microbiologic cure*: Eradication of bacteria on culture *Clinical cure*: Complete resolution of symptoms *Relapse*: Recurrence of UTI due to similar bacterial species *Reinfection*: Recurrence of UTI due to different bacterial species	None	Microscopic cure in 91 of 97 urine cultures (93.8%) with 5 of the 6 positive cultures contaminated with a different bacteria (99% eradication rate for the original bacteria); 100% clinical cure; average UTI-free days postprescription of UTI was 53.7 d (UTI rates = 16% at wk 3, 30% at wk 6, and 50% at wk 9) and 45.5 d after prescription of asymptomatic bacteriuria (UTI rate = 20% at wk 3, 35% at wk 6, and 44% at wk 9)
Zegers and colleagues[62]	*Design*: RCT *Setting*: Belgium *Sample*: Children (mean age = 9 y) with spina bifida; n = 176	Positive urine culture, leukocyturia, and clinical symptoms	Discontinuation (n = 88) of vs continuation (n = 88) of low-dose prophylactic antibiotics	The rate of symptomatic UTIs was significantly higher in the discontinuation group (4.58/person year) than in the continuation group (3.64/person year, $P = .002$) as were the number of febrile UTIs/person year (2.52 vs 1.07, $P = .003$) but there were no significant differences in the absolute number of febrile UTIs in the 2 groups (4 vs 2, respectively, $P = .42$)
UTI incidence: Compared by other interventions				
Prasad and colleagues[63]	*Design*: Single-group quasiexperimental *Setting*: US *Sample*: Adults (mean age = 56 y) with neurogenic bladder due to SCI and a history of at least 1 UTI during past year; n = 13 with 19 insertions of study catheter	Urine cultures and self-reported UTI symptoms; cultures and symptom assessments weekly for 28 d and then monthly until *Escherichia coli* 83972 disappeared from the urine	Insertion of a urinary catheter preinoculated with *Escherichia coli* 83972; catheter left in place for 3 d and then removed; successful colonization was defined as ($\geq 10^2$ CFU/mL) of *E. coli* 83972 in urine cultures for 43 d after catheter removal	8 patients (62%) were successfully colonized; following colonization the rate of UTIs/patient-year was 0.77 compared to the rate of 2.27 prior to enrollment in the study
Prieto and colleagues[51]	*Design*: Systematic review with meta-analysis *Setting*: Varied *Sample*: Randomized controlled or cross-over trials comparing catheter types in relation to UTIs; n = 5 studies	Method of measuring UTI varied across studies	Aseptic vs clean technique to insert catheter (n = 5 studies)	No significant difference in incidence of UTIs
Radojicic and colleagues[64]	*Design*: 2-group quasiexperimental *Setting*: Serbia *Sample*: Children (mean age = 10 y) with spina bifida and confirmed overactive bladder, detrusor sphincter dyssynergia, and constipation; n = 72	Symptomatic UTI confirmed by urine culture	Anticholinergic plus bowel management regimen (n = 35) vs only anticholinergic medication (control group, n = 35)	Prior to the intervention children in the bowel management group have a mean of 3.2 ± 1.2 UTIs during the prior 12 mo, which decreased to 0.3 ± 0.5 during the 12 mo following the intervention. while in the control group, the mean number of UTIs was 3.1 ± 1.1 at baseline and decreased to 1.1 ± 1.0 during the 12-mo follow-up period ($P < .001$)
Wilde and colleagues[35]	*Design*: Single-group quasiexperimental *Setting*: US *Sample*: Adults (mean age = 44 y) with SCI; n = 26 (23 with 3-mo follow-up data)	Self-reported	Prior to and following a web-based self-management intervention focusing on fluid management and activities, IC intervals, catheter supplies, travel, preventing urinary incontinence, and identifying symptoms of UTIs	At baseline 11 participants (42%) reported having a UTI during the prior 3 mo with a mean of 0.65 ± 0.94 infections; at 3-mo postintervention 7 (30%) reported a UTI (mean = 0.45 ± 0.74 infections) with no significant pre- to postdifferences

Abbreviations: CFU, colony-forming unit; CI, confidence interval; CRP, C-reactive protein; ERS, erythrocyte sedimentation rate; ESBL, extended-spectrum β-lactamases; HC, hydrophilic catheter; IC, intermittent catheterization; IRR, incidence rate ratio; NC, noncoated catheter; NH, nonhydrophilic catheter; OR, odds ratio; PVC, polyvinyl chloride; RCT, randomized controlled trial; SCI, spinal cord injury; UTI, urinary tract infection; WBC, white blood cell; WCA, weekly cyclic antibiotic therapy.

colleagues[37] evaluated a group of 94 children with myelomeningocele and neurogenic bladder and compared the number of UTI episodes during the year prior to and following the initiation of IC and reported that the mean number decreased from 2.8 to 1.1. Li and colleagues[39] compared the incidence of UTI in children with neurogenic bladders (n = 78) who had IC initiated prior to 1 year of age (early IC adopters) and after 3 years of age (late IC adopters). At both 3 and 6 years of follow-up, a significantly higher proportion classified as late IC adopters experienced UTIs (38.9% and 52.8%, respectively) when compared to early IC adopters (15.0% and 25.0%, respectively).[39] Uyar and colleagues[40] (n = 462) reported that IC was a significant independent risk factor for UTI secondary to extended β-lactamase-producing bacteria (OR = 2.70, 95% CI, 1.25-5.84). Yildiz and colleagues[42] (n = 71) reported that 21% of children with myelodysplasia using IC had symptomatic UTIs (time frame not reported). Most of the children (84.5%) in this study were being treated with prophylactic antibiotics.[26]

We identified 5 studies[43-47] conducted in adults that compared the incidence or prevalence of UTI in IC to other bladder-emptying methods (n = 110-1104). Four of the 5 were conducted in adults with neurogenic bladder dysfunction following spinal cord injury.[43,45-47] With the exception of 1 study,[45] UTIs were more common in patients using IC than among spontaneous voiders. Singh and colleagues[45] compared UTIs per 100 patient days and reported similar rates for IC (0.34) and normal voiding (0.32).

We identified 5 studies that compared UTI rates in patients using IC versus indwelling catheters. Anderson and colleagues[43] evaluated 344 spinal cord-injured adults and reported no significant differences (P = .82) in adjusted incidence rates of UTIs among patients managed with IC versus indwelling urethral catheters. The findings of this study differ from the 3 studies that reported UTIs were more common in patients with indwelling catheters than those using IC.[45-47] Two studies compared the incidence of UTIs in IC and reflex voiding (a bladder management strategy where males with neurogenic detrusor overactivity and detrusor sphincter dyssynergia spontaneously void into a condom catheter). In both studies, UTI rates were higher in patients managed by reflex voiding into a condom catheter; unfortunately, neither study reported whether the differences were statistically significant.[45,46] The 4 studies comparing UTI rates in patients using IC and those voiding spontaneously all reported higher rates in the IC group.[43,44,46,47]

We retrieved 8 studies that compared UTI rates based on the type of catheter being used for IC.[21,24,25,48-52] Six compared HCs to NCs.[21,48-51] Three of the studies were randomized controlled trials (RCTs) (n = 45-224) and 2 of them reported no significant differences in UTI occurrences in patients using HCs versus NCs.[21,48] In contrast, 1 study in children reported significantly fewer UTIs per person year in the HC group compared to the NC group.[49] We also identified 3 systematic reviews with meta-analysis that compared UTIs in patients (not restricted to adults) using HC and NC. Meta-analysis of pooled data from 1 systematic review found no significant differences in UTI rates.[51] This finding differed from the other 2 meta-analyses that reported the odds of experiencing a UTI were significantly lower in the HC group compared to the NC group.[50,52]

We retrieved 10 studies (n = 22-361) that evaluated the influence of prophylactic (suppressive) antibiotic use on UTI rates.[53-62] We found variability in the antibiotic regimen and method of administration limiting our ability to compare findings across studies (Table 5). Three studies examined the effect of continuous prophylactic antibiotic therapy in adults using IC. Two compared UTIs in adults with a history of IC use and recurrent UTIs; participants were randomized to a prophylactic antibiotic or no antibiotic group.[56,59] Both reported significantly lower UTI occurrences in the group receiving prophylactic antibiotics. In the third study, all participants using IC were treated with prophylactic antibiotics for 6 months; 14% of patients using IC had a symptomatic UTI during treatment.[55]

We identified 2 studies that evaluated the effect of discontinuing prophylactic antibiotics therapy in children. There was no significant difference in UTI rates in 1 study,[53] while the rate was significantly higher in the discontinuation group in the other study.[62] Two studies examined the effect of weekly cyclic antibiotic therapy (WCA) on UTI rates. One study was conducted in adults with a history of spinal cord injury and compared UTI rates before and after initiating WCA. There was a significant reduction in UTIs following initiation of WCA.[60] The other study evaluated WCA in pregnant females using IC for neurogenic or nonneurogenic causes of bladder dysfunction. Analysis revealed significantly fewer UTIs in the WCA group than in the non-WCA group.[58]

We identified 2 studies that evaluated the effect of prophylactic antibiotic bladder instillations of UTI rates.[54,57] One study, conducted in adults, compared rates prior to and following initiation of gentamicin instillations and reported a significant reduction in UTIs.[54] The other study was conducted in a pediatric sample and reported a significant reduction in the UTIs following initiation of neomycin-polymyxin or gentamicin bladder instillations.[57]

The final study in this group examined the effect of a 5-day course of antibiotics on cure, relapse, and reinfection rates in patients using IC following spinal cord injury. While cure rates were high, by week 9 posttreatment, the relapse or reinfection rates were 50% and average posttreatment UTI-free days were 53.7.[61]

Four studies examined the effects of nonantibiotic-based interventions on UTI rates (Table 5). Prasad and colleagues[63] examined the effect of a urinary catheter preinoculated with *Escherichia coli* 83972 (inserted for 3 days and then removed) on bladder colonization and, among patients who were successfully colonized, on UTI rates. Eight of 13 patients were successfully colonized and during colonization the UTI rate/patient year was reduced from 2.27 to 0.77. In a systematic review with meta-analysis comparing aseptic and clean technique during catheter insertion, there was no significant difference in the incidence of UTI.[51] Wilde and colleagues[35] examined the effect of a web-based self-management intervention on UTI rates in 26 adults with a history of spinal cord injury. While fewer participants (n = 7, 30%) reported having a UTI in the 3 months following the intervention compared to the 3 months prior to the intervention (n = 11, 42%), the difference was not statistically significant. The last study in this group compared the effect of a combined antimuscarinic and bowel management regimen (intervention group) versus an antimuscarinic-only regimen in decreasing the rates of UTI over 12 months. The sample comprised 72 children with spina bifida and urodynamic confirmed neurogenic overactive bladder with detrusor sphincter dyssynergia and constipation. The

rate of UTIs decreased significantly more in the intervention group (from a mean of 3.2 to 0.03) than in the control group (from a mean of 3.1 to 1.1).[64]

Urethral Stricture

The relationship of IC and urethral stricture is complex. Repeated in-and-out (1-time) catheterization may be used to maintain urethral patency in patients with a urethral stricture. However, the act of repeated catheterization also may result in inflammation and formation of secondary urethral strictures.[65] Our scoping review focused on formation of secondary urethral strictures in patients using IC to manage LUT dysfunction.

We identified 4 studies that examined the development of secondary urethral strictures in patients using IC to manage bladder dysfunction (Table 6).[45,65-67] Two studies measured the incidence of strictures. Batista-Miranda and colleagues[10] investigated 27 patients using IC secondary to neurogenic and nonneurogenic causes of bladder dysfunction and reported that 16.7% developed strictures over the mean 23.5 months of follow-up. In a study of 333 adults with a history of spinal cord injury, 4.2% (all males) developed a urethral stricture a mean of 19.8 months after starting IC.[67] Greenwell and associates[66] examined the incidence of recurrent strictures in patients who did (n = 31) and did not (n = 95) use IC during follow-up (mean = 25 months). Recurrence rates were similar in the 2 groups, 42% of patients using IC and 49% of those who did not ($P = .46$). Krebs and coworkers[65] compared the incidence of strictures in males who used IC (n = 415) versus other bladder evacuation methods (n = 629) and reported that a significantly higher percentage of patients using IC (25%) than those using other methods (trigger reflex voiding, suprapubic catheter, physiologic voiding, suprapubic catheterization, abdominal straining, spontaneously voiding, sacral anterior root stimulation, or indwelling catheter) to empty their bladder (14%) developed strictures ($P = .0001$). Singh and colleagues[45] reported that strictures were significantly less common when IC was used (n = 180) than when patients were managed by an indwelling urethral catheter (n = 224, $P = .04$).

Hematuria

Nine studies examined hematuria in individuals using IC to manage bladder emptying; all but one was conducted in adult participants (Table 6).[21,36,38,45,49,50,52,68,69] We identified 2 studies that reported the prevalence of hematuria. Both studies enrolled participants with various indications for IC; 1 (n = 391) reported a low prevalence rate (2.2% annually) among individuals using HCs.[38] In contrast, participants in the other study (n = 44) used a variety of catheter types and reported a hematuria prevalence rate of 23%; the time frame for this measurement was not reported.[36] Singh and colleagues[45] compared rates of hematuria in patients using IC to patients (n = 180) with indwelling urethral catheters (n = 224). Significantly fewer of the patients using IC (4%) than patients with indwelling catheters (12%) had hematuria ($P = .005$).

The remaining studies compared hematuria in patients using different types of catheters for IC. Two were RCTs and 2 were systematic reviews with meta-analysis that compared HCs and NCs. One of the RCTs measured microhematuria during hospitalization in an inpatient rehabilitation unit and reported that significantly fewer of the dipstick tests were positive in the HC group (23% of n = 79) than in the NC group (n = 34% of n = 82) ($P < .0001$).[21] The other study examined self-reported hematuria in children using HCs (n = 37) and NCs (n = 41) and reported no hematuria in either group.[49] One of the systematic reviews reported a significant reduction in the odds of hematuria in subjects using HCs (n = 230) versus NCs (n = 232), OR = 0.57 (95% CI, 0.35-0.92).[50] In contrast, the other systematic review found no significant differences in the risk of hematuria in subjects using HCs (n = 247) versus NCs (n = 258).[52] In a small study (n = 36) comparing compact and standard length catheters in males with a history of spinal cord injury, 2 patients in the compact group experienced hematuria compared to none in the standard length catheter group.[68] In an RCT using a single-group, cross-over design (n = 104), comparing hematuria when patients used PVC and PVC-free catheters, 4% of patients experienced hematuria when using the PVC-free catheter compared to 10% when using PVC catheter (significance was not reported).[69]

Bladder Stones

We identified 5 studies that investigated the incidence of bladder stones in patients using IC (Table 6). Bartel and colleagues[70] compared the occurrence of stones in patients using different methods to empty their bladder. Two percent of patients using IC had bladder stones documented on endoscopy or imaging studies. This rate was lower than patients managed with suprapubic catheters (11%) and indwelling urethral catheters (6.6%). In contrast, the rate of bladder stones in patients managed with IC was slightly higher than that documented in males managed by reflex voiding into a condom catheter (1.1%). The time to occurrence of stones was also much longer in patients using IC (mean = 116 months) compared to suprapubic (mean = 59 months) and indwelling urethral (mean = 31 months) catheters.[70] The remaining 4 studies reported the rates of bladder stones only in patients using IC. Hakansson and associates[38] reported an annual rate of bladder stones was .6%. The other 3 studies reported rates between 10% and 28.2%; none reported the time frame over which these stones occurred.[16,36,67]

Urethral False Passage

A false passage in the urethra is formation of an epithelialized tract created when the catheter is inserted against the urethral wall rather than guided through the urethral lumen and into the bladder vesicle.[38,45] We identified 2 studies that measured rates of urethral false passage formation (Table 6). Hakansson and colleagues[38] reported that 2.2% of the 391 participants reported this complication annually. Singh and colleagues[45] evaluated urethral false passage formation in a longitudinal study of patients with neurogenic bladder managed by IC (n = 180) or an indwelling urethral catheter (n = 224); the rate of false passage formation was 5% in the IC group and 4% in the indwelling catheter group.

Pain

Table 7 summarizes the findings of the 5 studies that examined pain or discomfort associated with IC.[14,35,49,68,69] Girotti and colleagues[14] compared self-reported anticipated pain measured prior to initiation of IC and actual pain following initiation of IC (n = 60). Anticipated and actual pain intensity was measured using a 10-point visual analog scale, where 0 indicates no pain and a score of 10 indicates worst imaginable pain. The mean anticipated pain scores (mean = 5.47 out of 10) was significantly higher than actual pain scores (mean = 2.34

TABLE 6.
Urethral Stricture, Hematuria, Bladder Stones, False Passages, and Intermittent Catheterization

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Urethral strictures				
Greenwell and colleagues[66]	*Design*: Retrospective observational *Setting*: UK *Sample*: Patients (mean ages = 62.5 y). For IC and 50.4 for non-IC with a history of urethral stricture; 31 practiced self-IC while 95 did not	Medical record review	IC patients (n = 31) compared to non-IC patients (n = 95)	IC patients: 42% had a recurrent stricture (mean of 2.6 per patient) while 49% of the *non-IC patients* (mean of 3.4 per patient) had recurrence
Cornejo-Dávila and colleagues[67]	*Design*: Retrospective observational *Setting*: Mexico *Sample*: Adults (age not reported) with SCI; n = 333	Medical record review: narrowing of the urethral lumen confirmed by urethroscopy	None	14 patients (4.2%) developed a urethral stricture a mean of 19.8 mo after beginning to use IC; all were men
Krebs and colleagues[65]	*Design*: Retrospective observational *Setting*: Switzerland *Sample*: Men (age not reported) with SCI who underwent routine video-urodynamics, n = 415 using IC	Medical record review of video-urodynamics	Other bladder-emptying methods (n = 629): trigger reflex voiding, suprapubic catheter, physiologic voiding, suprapubic catheterization, abdominal straining, spontaneously voiding, sacral anterior root stimulation, or indwelling catheter	105 men (25%) developed strictures a median of 5.9 y after starting IC; the proportion of patients who developed strictures was significantly higher than the proportion of patients using other methods to empty their bladder (14%, $P = .0001$)
Singh and colleagues[45]	*Design*: Observational *Setting*: India *Sample*: SCI patients (mean age = 35 y); IC n = 180	Cystoscopy	Indwelling catheter; n = 224	Stricture occurred in 18% of patients using indwelling catheters compared to 10% using IC ($P = .04$)
Hematuria				
Bolinger and Engberg[36]	*Design*: Observational *Setting*: US *Sample*: Adults (mean age = 57 y); with neurogenic and nonneurogenic reasons for IC; n = 44	Self-report	None	23% reported bleeding associated with IC
Cardenas and colleagues[21]	*Design*: RCT *Setting*: Inpatient or SCI rehabilitation units and community (postdischarge); US and Canada *Sample*: Adults (mean ages = 37.2 and 35.1 y); with SCI; n = 224	Microhematuria measured daily by erythrocyte dipstick test during wk 3 and 4 while inpatient (measured an average of 10 times/patient)	HC (n = 79) vs NC (n = 82)	Proportion of positive dipstick tests was 23% in the HC and 34% in the NC groups ($P < .0001$)
DeFoor and colleagues[49]	*Design*: RCT *Setting*: US *Sample*: Children (mean age = 13 y) with neurogenic reasons for IC; n = 57	Self-reported	HC (n = 37) vs NC (n = 41)	No bleeding reported in either group
Domurath and colleagues[68]	*Design*: Single-group RCT *Setting*: Germany *Sample*: Men (mean age = 40 y) with SCI performing self-IC who had used hydrophilic catheters for a least 1 mo; n = 36	Self-reported	THC vs SLC—subjects randomized to order of intervention	Reported by 2 in the THC group and none in the SLC group
Håkansson and colleagues[38]	*Design*: Observational *Setting*: Sweden, the Netherlands, Germany, Italy, Norway, US *Sample*: Adults (mean age = 55 y) with neurogenic and nonneurogenic reasons for IC and using hydrophilic-coated catheters; n = 391	Self-report	None	2.2% reported annually
Johansson and colleagues[69]	*Design*: RCT, single-group cross-over *Setting*: Sweden *Sample*: Men (mean age = 72 y) with neurogenic and nonneurogenic reasons for using IC; n = 104	Self-reported	PVC-free catheter vs PVC catheter	Reported by 4% in the PVC-free group and 10% in the PVC group (significance not reported)
Li and colleagues[50]	*Design*: Systematic review with meta-analysis *Setting:* US and Spain *Sample*: RCTs, 2-group quasiexperimental (including cross-over designs) or prospective cohort studies (5 studies)	Method used to diagnose UTI not reported	Hydrophilic catheter (n = 230) vs NC (n = 232)	OR = 0.57 (95% CI, 0.35-0.92) favoring HC over NC

(*continues*)

TABLE 6.
Urethral Stricture, Hematuria, Bladder Stones, False Passages, and Intermittent Catheterization (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Rognoni and Tarricone[52]	*Design*: Systematic review with meta-analysis *Setting*: Varied *Sample*: RCTs, n = 5 studies	Self-report	Hydrophilic catheter (n = 247) vs NH (n = 212)	No significant difference in risk in the hydrophilic vs nonhydrophilic group: IRR = 1.10 (95% CI, 0.66-1.84)
Singh and colleagues[45]	*Design*: Observational *Setting*: India *Sample*: SCI patients (mean age = 35 y); IC n = 180	Self-report	Indwelling catheter (n = 224)	Reported by 4% of the IC group vs 12% of the indwelling catheter group ($P = .005$)
Bladder stones				
Bartel and colleagues[70]	*Design*: Retrospective observational *Setting*: Switzerland *Sample*: Patients (mean age = 50 y) with SCI; n = 1315 using IC	Medical record review	Indwelling catheter (n = 75), suprapubic catheter (n = 453), reflex voiding (n = 982)	Bladder stones documented in 2% of IC users (occurred a mean of 116 mo postinitiation of IC), 6.6% of indwelling catheter patients (mean time to stone = 31 mo), 11% of suprapubic catheter patients (mean time to stone = 59 mo), and 1.1% of reflex voiders (mean time to stone = 211 mo); proportions not compared statistically
Bolinger and Engberg[36]	*Design*: Observational *Setting*: US *Sample*: Adults (mean age = 57 y) with neurogenic and nonneurogenic reasons for IC; n = 44	Self-report	None	11% reported (time frame not reported)
Cornejo-Dávila and colleagues[67]	*Design*: Retrospective observational *Setting*: Mexico *Sample*: Adults (age not reported) with SCI; n = 333	Medical record review	None	10% (time frame not reported)
Håkansson and colleagues[38]	*Design*: Observational *Setting*: Sweden, the Netherlands, Germany, Italy, Norway, US *Sample*: Adults (mean age = 55 y) with neurogenic and nonneurogenic reasons for IC and using HC, n = 391	Self-report	None	0.6% reported/year
Lopes and colleagues[16]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 40 y) with SCI; n = 49	Self-report	None	28.2% reported stones (time frame not reported)
Urethral false passage				
Håkansson and colleagues[38]	*Design*: Observational *Setting*: Sweden, the Netherlands, Germany, Italy, Norway, US *Sample*: Adults (mean age = 55 y) with neurogenic and nonneurogenic reasons for IC and using hydrophilic-coated catheters; n = 391	Self-report	None	0.5% reported/year
Singh and colleagues[45]	*Design*: Observational *Setting*: India *Sample*: SCI patients (mean age = 35 y); IC n = 180	Self-report	Indwelling catheter (n = 224)	Reported by 5% of the IC group and 4% the of indwelling catheter group; no significance difference

Abbreviations: CI, confidence interval; HC, hydrophilic catheter; IC, intermittent catheterization; IRR, incidence rate ratio; NC, noncoated catheter; NH, nonhydrophilic catheter; OR, odds ratio; PVC, polyvinyl chloride; RCT, randomized controlled trial; SCI, spinal cord injury; SLC, standard length hydrophilic catheter; THC, telescoping compact hydrophilic-coated catheter; UTI, urinary tract infection.

TABLE 7.
Intermittent Catheterization: Pain, Urinary Incontinence, Impaired Upper Urinary Tract Function, and Squamous Cell Carcinoma

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Pain, burning, or discomfort				
DeFoor and colleagues[49]	*Design*: RCT *Setting*: US *Sample*: Children (mean age = 13 y) with neurogenic reasons for IC; n = 57	Self-reported	HC (n = 37) vs NC (n = 41)	*Pain*: 3 patients in the HC group and none in the NC group ($P = .06$)
Domurath and colleagues[68]	*Design*: Single-group RCT *Setting*: Germany *Sample*: Men (mean age = 40 y) with SCI performing self-IC who had used hydrophilic catheters for a least 1 mo; n = 36	Self-reported	THC vs SLC—subjects randomized to order of intervention	*Pain*: 3 of 36 (8.3%) when using the THC vs 2 of 36 (5.6%) when using the SLC ($P = .44$) *Stinging*: 5 of 36 (23.9%) when using the THC compared to 2 of 36 (5.6%) when using the SLC ($P = .50$)
Girotti and colleagues[14]	*Design*: Prospective observational *Setting*: Brazil *Sample*: Adults (mean age = 50.4 y) with neurogenic and nonneurogenic reasons for IC, n = 60 who had been using IC for 12 mo	10-point VAS	Anticipated pain associated with IC was assessed prior to starting IC and actual pain was assessed after the patient was trained and able to perform IC	*Anticipated pain*: mean = 5.47 ± 2.90 vs *actual pain* mean = 2.34 ± 1.64, $P < .001$. Actual pain scores were not significantly different in patients who were and were not adherent to IC at follow-up
Wilde and colleagues[35]	*Design*: Single-group quasiexperimental *Setting*: US *Sample*: Adults (mean age = 44 y) with SCI, n = 26 (20 with 3-mo follow-up data)	Self-reported measured on a 1-to 10-point scale	Prior to and following a web-based self-management intervention focusing on fluid management and activities, IC intervals, catheter supplies, travel, preventing incontinence, and identifying symptoms of UTIs	*Pain*: No significant difference pre- to post intervention; 5 reported pain at baseline (2 rated as 2 or 3, 1 as 6, and 2 as 8-10) and at 3-mo postintervention 3 reported pain (rated as 4 or 5)
Johansson and colleagues[69]	*Design*: RCT, single-group cross-over *Setting*: Sweden *Sample*: Men (mean age = 72 y) with neurogenic and nonneurogenic reasons for using IC; n = 104	Self-reported	PVC-free catheter vs PVC catheter	*Discomfort*: 14% in PVC-free and 28% when using PVC catheter (significance not reported) *Burning*: 13% in PVC-free and 23% when using PVC catheter (significance not reported)
Urinary incontinence				
Chiappe and colleagues[29]	*Design*: Observational *Setting*: France *Sample*: Adults (mean age=54 y) with neurogenic and nonneurogenic reasons for IC; n = 119	Patient competed questionnaire	None	55.1% of patients reported UI
Lopes and colleagues[16]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 40 y) with SCI; n = 49	Self-report	None	33.0% reported UI
Mazzo and colleagues[71]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 53 y) with neurogenic bladder for various reasons; n = 108	Self-report	None	64.3% reported UI
Radojicic and colleagues[72]	*Design*: Two-group quasi-experimental *Setting*: Serbia *Sample*: Children (mean age = 10 y) with spina bifida and confirmed overactive bladder, detrusor sphincter dyssynergia, and constipation being treated with IC and anticholinergic medication; n = 72	Mean dry interval—parents checked diaper every 15 min for eight 3-h intervals during the day	Anticholinergic plus bowel management regimen (n = 35) vs only anticholinergic medication (control group, n = 35)	Mean dry interval: The bowel management group increased from 28.9 ± 11.10 to 150.0 ± 36.4 min while the control group mean increased from 29.8 ± 12.1 to 101.3 ± 51.6 min ($P < .001$)

(*continues*)

TABLE 7.
Intermittent Catheterization: Pain, Urinary Incontinence, Impaired Upper Urinary Tract Function, and Squamous Cell Carcinoma (*Continued*)

Study	Design/Setting/Sample	Measurement	Comparison Group(s)	Findings
Singh and colleagues[45]	*Design*: Observational *Setting*: India *Sample*: SCI patients (mean age = 35 y); IC n = 180	Self-report	Indwelling catheter: n = 224, condom catheter: n = 45, reflex voiding: n = 32, suprapubic cystostomy: n = 24, normal voiding: n = 40	Significantly higher percent of IC patients (8%) reported UI than those using an indwelling catheter (1%, $P \leq .001$); significantly more patients using condom catheters (38%) reported UI than those using IC ($P < .001$); no significant differences between percentage of IC patients and patients in other bladder management groups that reported UI
Stillman and colleagues[47]	*Design*: Observational *Setting*: US *Sample*: Adults (mean age = 49 y) with SCI discharged from inpatient rehabilitation; IC n = 31 to 39 (3- to 12-mo follow-up)	Self-report UI ≥ once per month	Spontaneous voiding n = 58-63 (3- to 12-mo follow-up)	36% (3 mo) to 44% (12 mo) of IC patients reported UI compared to 9% (3 mo) to 16% (6 and 12 mo) of those voiding spontaneously
Wilde and colleagues[35]	*Design*: Single-group quasiexperimental *Setting*: US *Sample*: Adults (mean age = 44 y) with SCI, n = 26 (20 with 3-mo follow-up data)	3-d bladder diary	Prior to and following a web-based self-management intervention focusing on fluid management and activities, IC intervals, catheter supplies, travel, preventing incontinence, and identifying symptoms of UTIs	89% at baseline and 74% at 3 mo postintervention
Impaired upper urinary tract function				
Elzeneini and colleagues[73]	*Design*: Retrospective observational *Setting*: Ireland *Sample*: Children (age 5-18 y) with spina bifida; n = 214	Renal scan	IC starting between 1 and 3 mo of age (early IC, n = 113) vs IC initiated only if clinical or radiological deterioration, significant video urodynamic abnormalities, renal scarring or very poor bladder emptying (late IC, n = 126)	18.8% incidence in early IC vs 39% in delayed IC ($P = .002$)
Woo and colleagues[74]	*Design*: Retrospective observational *Setting*: US *Sample*: Children (mean age = 5 y) with spina bifida, n = 100	Renal scan	IC started at birth, early IC (n = 17) vs IC started later (median age: 5 y), late IC (n = 83)	Early IC increased the likelihood of renal scarring (OR = 9.26; 95% CI, 1.99-43.18, $P = .005$)
Li and colleagues[39]	*Design*: Retrospective observational *Setting*: China *Sample*: Children with neurogenic bladder, n = 78	Vesicoureteral reflux: urodynamics	Early IC (<1 y of age), n = 40 vs late IC (>3 y of age), n = 36	20.0% of patients in the early IC group compared to 50.0% in the late IC group at 3-y follow-up ($P = .04$) and 17.5% and 41.7%, respectively, at 6-y follow-up ($P = .04$)
Lopes and colleagues[16]	*Design*: Observational *Setting*: Brazil *Sample*: Adults (mean age = 40 y) with SCI; n = 49	Hydronephrosis or ureteral dilatation: self-report	None	18.4% of participants
Adverse events examined in 1 study				
Casey and colleagues[75]	*Design*: Case study *Setting*: Ireland *Sample*: One 80-y old women combined with 7 other cases (ages 19-69 y) reported in the literature; reasons for IC varied	Squamous cell cancer: biopsy	None	Across all reported cases: • Duration of IC varied from 4 to 23 y • 6 or 8 patients were women • All had asymptomatic bacteriuria • Presenting symptoms included hematuria (n = 3 frank and n = 1 microhematuria), bladder stones (n = 2), suprapubic pain (n = 2), and recurrent UTIs (n = 1)

Abbreviations: CI, confidence interval; HC, hydrophilic catheter; IC, intermittent catheterization; NC, noncoated catheter; OR, odds ratio; PVC, polyvinyl chloride; RCT, randomized controlled trial; SCI, spinal cord injury; SLC, standard length hydrophilic catheter; THC, telescoping compact hydrophilic coated catheter; UI, urinary incontinence; UTI, urinary tract infection; VAS, visual analog scale.

out of 10). DeFoor and coworkers[49] compared pain in patients (n = 36) randomly assigned to use either an HC or NC (participants used both types of catheters and were randomized to the order of use). They found that 3 out of 37 patients (8.1%) in the HC versus 0 out of 41 patients (0%) in the NC group reported pain; this difference was not statistically significant ($P = .06$). Domurath and colleagues[68] compared self-reported pain and stinging in 36 patients using a shorter (compact) versus standard length catheter (both were HC). They found no significant differences in pain intensity with IC. Johansson and coworkers[69] compared self-reported discomfort and burning in 134 patients using PVC or PVC-free catheters. The proportion of patients reporting discomfort and burning was higher when catheterizing with the PVC catheter (28% and 23%, respectively) as compared to the PVC-free catheter (14% and 12%, respectively). The remaining study examined the effect of a web-based self-management intervention on self-reported pain related to IC and reported no significant differences in pain scores pre- and postintervention.[35]

Urinary Incontinence

We identified 7 studies that examined urinary incontinence among patients using IC to manage their LUT dysfunction.[16,29,35,45,47,64,71] Findings of these studies are summarized in Table 7. Three studies examined the prevalence of urinary incontinence in adults with neurogenic and/or nonneurogenic LUT dysfunction; the rates were 33.0% of 49 patients,[16] 55.1% of 119 patients,[29] and 64.3% of 108 patients,[71] respectively. Singh and colleagues[45] compared incontinence rates in patients using IC (n = 180) versus an indwelling urethral catheter (n = 224) and reported that a significantly higher proportion of those using IC (8%) reported urinary incontinence than those managed with an indwelling urethral catheter (1%). Incontinence rates among IC users were also compared to males using a condom catheter (n = 45) and showed incontinence was significantly lower in the IC group (8% vs 38%). Stillman and colleagues[47] compared the rates of self-reported incontinence occurring at least once monthly in patients using IC (n = 31 and 39) versus patients who retained the ability to void spontaneously (n = 58 and 63). At 3- and 12-months follow-ups, 36% and 44% of patients respectively performing IC reported urinary continence compared to 9% and 16% of those who voided spontaneously. Wilde and colleagues[35] reported the proportion of patients (n = 26 at baseline and 20 at 3 months) who reported urinary incontinence prior to participating in a web-based self-management intervention was 89%, which decreased to 74% 3 months postintervention. As described earlier, Radojicic and coworkers[72] compared outcomes in a group of 72 children with myelomeningocele and neurogenic bladder dysfunction who were managed by IC and an antimuscarinic or IC and a combined antimuscarinic and structured bowel elimination regimen. They found that the combined regimen was more effective in increasing mean dry intervals than the anticholinergic medication alone ($P < .001$).

Impaired Upper Urinary Tract Function

Evidence concerning the effects of IC on upper urinary tract function is mixed. Based on the pioneering work of Stuart Bauer, children with myelomeningocele may be started on IC before showing signs of upper urinary tract distress such as trabeculation of the bladder wall, ureterohydronephrosis, reduced glomerular filtration rate or serum creatinine, febrile urinary infection or renal scarring in order to prevent these adverse effects.[73,74] Two studies conducted in children with spina bifida evaluated renal scarring, comparing the effects of starting IC early (between 1 and 3 months in 1 study and at birth in the other) to starting IC later in life, after signs of upper urinary tract distress.[73,74] Elzeneini and colleagues[73] compared early-onset IC to IC initiated only when there was a clinical or diagnostic indication that IC was needed. Results showed significantly higher rates of scarring in the late IC group (39.0%) when compared to the early IC group (18.8%).[73] In contrast, Woo and associates[74] compared early-start IC (1-3 months of age) to IC started at a median age of 5 years. They reported that early-start IC significantly increased the odds of renal scarring (OR = 1.99) when compared to starting IC only when diagnostic findings indicate the need for IC.

We identified 2 studies that reported dilation of the ureter or renal pelvis. In addition to comparing UTI rated in children with spina bifida and neurogenic bladders who initiated IC prior to 1 year of age versus those who started IC after 3 years of age, Li and colleagues[39] evaluated vesicoureteral reflux, which has been linked to an increased risk of febrile UTI and upper urinary tract scarring, and reported that a higher proportion of children in the late-start IC group had vesicoureteral reflux at both 3 (50%) and 6 (41.7%) months of follow-up as compared to the early-start IC group whose rates were 20.0% and 17.5%, respectively. Lopes and colleagues[16] reported that 18.4% of a group of 49 adults with spinal cord injuries and neurogenic bladder dysfunction using IC at the time of data collection had evidence of hydronephrosis or ureteral dilation in imaging.

Other Adverse Events

Casey and colleagues[75] investigated cases of squamous cell carcinoma in patients using IC. The risk for squamous cell carcinoma is higher in spinal cord-injured patients whose neurogenic bladder dysfunction is managed by indwelling urinary catheterization; however, evidence concerning the risk in patients managed by IC is lacking. In Casey's study, the results of 1 case were combined with 7 others reported in the literature showing the duration of IC prior to diagnosis varied from 4 to 23 years. All patients had a history of asymptomatic bacteriuria, and that most (75%) were females.

DISCUSSION

This scoping review examined evidence published between 2009 and 2019 on a variety of intermittent catheterization-related issues. Specifically, we reviewed data from 70 eligible studies (reported in 71 articles) that examined adherence to IC, complication rates, satisfaction with IC, and its effect on health-related QoL. The amount and quality of evidence available for the outcomes was variable. In addition, we found variability in study designs, samples, operational definitions of specific outcomes, methods of measurement, and data collection time frames. This variability often made it difficult to draw definitive conclusions about the influence of IC on specific outcomes.

The first outcome we examined was adherence to IC. The World Health Organization (WHO) defined adherence as the extent to which a person's behavior corresponds with recommendations from a health care provider.[76] As discussed in the WHO document, willingness and ability to learn a self-care skill is essential to adherence. We found only 4 studies that evaluated the individual's ability to perform self-catheterization,

and predictors of IC uptake and adherence.[4-7] Two studies investigated adults, 1 enrolled adults older than 65 years, and the other enrolled middle-aged adults with MS. Most adult participants were able to learn to self-catheterize. Functional ability emerged as a significant predictor of successfully learning to perform IC in both studies, age did not.[5,7]

We identified a single study that enrolled 200 children with spina bifida (a congenital anomaly associated with profound motor and cognitive effects) in which findings indicated that only 48% of 92 children were able to perform catheterization during the time frame they were followed up. Consistent with the adult samples, functional ability was a significant predictor of ability to successful learn to self-catheterize.[4] Faleiros and colleagues[77] published a study following completion of this scoping review that evaluated bladder management in 90 adolescents and young adults (age range 13-29 years) with spina bifida and neurogenic bladder dysfunction; participants lived in Brazil (n = 27), Germany (n = 36), or the United States (n = 27). Multivariate analysis revealed that age at which IC was begun was a significant predictor of self IC among participants 18 years or older.

A more robust body of research was found (n = 16 studies) that examined adherence to IC over time. Studies were conducted in a variety of countries and target populations and in which adherence was measured primarily by self-report. Nevertheless, the reported time frames over which adherence was measured varied from 6 weeks following successfully learning to perform IC to more than 60 months, making it difficult to compare findings across studies. Based on these studies, adherence appears to decrease over time with rates between 50% and 79% in most studies. Only one of the studies examining adherence rates reported that it was measured only for patients with continued indication for IC.[15] In this study the adherence rate at 12 months was 89.9% for patients 65 years and older and 87% for those younger than 65 years. Another study reported that half of the nonadherent patients in their study had stopped because IC was no longer indicated.[12] Adherence rates were not reported separately for the patients with a continued indication for catheterization. Other studies did not address whether IC was still indicated when reporting adherence. Based on these data, we recommend that future studies qualify reports of adherence to differentiate persons who stop IC because of changes in LUT function that nullify the need for IC. Clinical experience strongly suggests that a proportion of patients taught IC no longer require IC for bladder management after a period of time. Such changes occur in patients experiencing urinary retention following a surgical procedure. No longer requiring IC also applies to multiple groups of patients with neurogenic bladder dysfunction. Examples include cessation of IC as spinal shock subsides and some patients are able to resume voluntary spontaneous voiding or involuntary reflex voiding, and patients with remitting-relapsing MS whose bladder function changes based on the natural history of this chronic condition.

We also found sparse research aimed at identifying predictors of adherence or nonadherence, and we did not identify any studies examining the effect of interventions designed to improve adherence. There is a need for research addressing both of these issues. Finally, we found very little research examining adherence in children and adolescents with LUT dysfunction requiring IC and urgently recommend additional research focusing on adherence in this population.

We hypothesize that satisfaction with IC may be a predictor of long-term adherence, but we found little research examining patient satisfaction with this intervention or the characteristics associated with satisfaction. We only identified 2 studies that examined satisfaction in a sample of patients using IC—one was conducted in Spain and one in Turkey. Both reported levels of satisfaction were moderate (mean = 6 and 7.86 out of 10) in both studies.[10,26] The remaining studies compared satisfaction with different types of catheters, but sample sizes of these studies were too small to draw definitive conclusions about patient satisfaction in relation to catheter type. There is a need for additional research focusing on patient satisfaction with IC and the characteristics that influence satisfaction including catheter type.

We identified 15 studies that examined health-related QoL in patients using IC and all but one focused on adults.[28] Our ability to reach conclusions by evaluating results of multiple studies in this area was significantly impaired by the use of a variety of instruments to measure QoL. Evidence suggests that initiation of IC is likely to improve bladder-specific QoL in patients with a variety of problems impairing bladder emptying. Limited research suggests that urinary incontinence, UTIs, pain during catheter insertion, the need for a caregiver to perform the IC, and poorer adherence to IC may predict poor bladder-specific QoL in patients using IC, but additional research is needed to confirm these findings. The number of studies comparing QoL in patients using different methods to empty their bladders was limited and findings varied indicating a need for additional research in this area.

Research comparing QoL in patients using compact and standard length catheters was sparse and results were mixed.[22,23] We only identified 1 small, single-group quasiexperimental study that examined the effect of any other intervention on QoL and that intervention was not associated with a significant improvement in QoL.[35] We recommend additional research examining the effect of interventions on QoL in patients using IC.

Evidence related to complications of IC was more robust. The complication examined most often was UTI. While the time frame over which UTI rates were measured varied and was not reported in some studies, evidence suggests that UTIs are common in adult patients using IC. We found limited research examining sex-related differences in UTI rates and findings were mixed. More studies compared UTI rates in IC and other bladder-emptying methods.[43,44,47] All of these studies compared IC to spontaneous voiding and most found that UTIs were more common in those using IC.[43,47] Unfortunately, the utility of this finding in clinical practice is limited since IC is only indicated in patients who are unable to manage their bladders spontaneously. Evidence also suggests that UTIs are less common in patients with LUT dysfunction managed by indwelling urinary catheters[45,47]; however, the utility of this difference is more apparent, particularly when patients, caregivers, and providers must choose between the apparent ease of inserting an indwelling catheter versus the greater commitment required for IC. Our search identified 6 studies including 3 systematic reviews with meta-analysis that compared UTI rates in patients using HCs and NCs.[21,48,52] While there is some evidence to suggest that HCs may be associated with lower UTI rates, findings were mixed pointing to the need for additional well-designed studies.

Ten studies were retrieved that examined the effect of some type of preventive antibiotic therapy on UTI rates.[53-62] While,

overall, the evidence for effectiveness of continuous prophylactic antibiotics is mixed, there is some evidence to suggest that this therapy may reduce the rate of UTIs. Weekly cyclic antibiotic therapy, a relatively new approach to preventing recurrent UTIs currently undergoing investigation, was reported to significantly reduce the rate of UTIs in 2 studies.[58,60] While findings from these studies support the potential benefit of this intervention, both used weak observational designs increasing the likelihood of bias. Well-designed RCTs are needed to evaluate the effectiveness of this intervention in preventing recurrent UTIs in patients using IC. There is a registered RCT examining a WCA program on Clinical Trials.gov although no results are posted.[78]

Evidence supporting instillations of antibiotics into the bladder vesicle was sparse. Two studies (1 enrolled adults and 1 enrolled children) were retrieved that reported reductions in symptomatic UTIs.[54,57] Our collective experience indicates that the relative lack of research in this area is matched by its comparatively uncommon use in clinical practice. We recommend additional research evaluating not only the efficacy of intravesical instillation of solutions with antimicrobial or antiseptic properties, combined with evaluation of its acceptability to persons managing LUT dysfunction with IC.

We identified a single study that evaluated the effect of purposeful colonization of the LUT with *E. coli* 83972 on reduced symptomatic UTI occurrences.[63] We assert that findings from this study, along with studies of vaccinations designed to reduce symptomatic UTI recurrence in persons with normal LUT function,[79] should undergo further study, particularly given the rise in multidrug-resistant organisms in clinical medicine combined with the limited availability of newer antibiotics to eradicate these virulent bacterial strains.

We found less research examining other complications associated with IC. Five studies of secondary urethral stricture formation in patients using IC were conducted in a variety of countries and the method used to determine the presence of a stricture varied.[10,45,65-67] The reported stricture rate varied from 4.2% to 40%. We only identified 2 studies comparing stricture rates in patients using IC versus other bladder emptying methods and their findings were inconsistent.

Of the 9 studies examining hematuria, most compared rates in relation to the type of catheter used and most of these compared HCs to NCs (2 RCTs and 2 systematic reviews with meta-analysis), the results were mixed across types of studies.[21,36,38,45,49,50,52,68,69] We recommend additional research in examining these complications and potential interventions to prevent them.

Evidence concerning formation of bladder stones and urethral false passages was sparse possibly due to the relative scarcity of these adverse side effects of IC. We identified one study that reported a low annual rate of bladder stone formation (0.6%).[38] Similarly, rates of urethral false passage formation among patients using IC was 2.2% to 9% annually.[38,45]

Among patients with intact or partially preserved urethral sensation, pain or discomfort during IC may act as a barrier to adoption or adherence. Nevertheless, we found relatively little research examining its prevalence and few intervention trials aimed at alleviating pain with catheterization.[14,35,49,68,69] One study suggested the pain that patients experience when performing IC may be less than the magnitude of pain patients anticipate when faced with the need for IC.[14] Evidence concerning the effect of different types of catheters on pain or discomfort was also limited. We identified a single study that showed significantly more patients reported pain and burning when using PVC catheters than when using PVC-free catheters.[69] Clearly, there is a need for more research examining the effect of interventions, including different types of catheters, on pain and discomfort during IC.

Although there was variability in reported prevalence rates of urinary incontinence in patients using IC for bladder management, recent research suggests that it is prevalent.[16,29,35,45,47,71,72] Limited evidence suggests urinary incontinence is more common among IC users than in individuals managed with an indwelling catheter. We believe this observation must be carefully weighed against the multiple serious urologic complications associated with long-term indwelling catheterization for management of neurogenic bladder or other forms of LUT dysfunction.[80] One intervention study found that a self-management intervention decreased the prevalence of urinary incontinence compared to baseline.[35] While 15% fewer patients reported urinary incontinence postintervention, the difference was not statistically significant although the sample was small limiting the power to detect differences. One study in children supports the importance of bowel management in patients with concurrent bladder dysfunction and constipation.[72] There is a need for research focusing on interventions to reduce urinary incontinence in patients using IC to manage bladder function, along with studies evaluating the effect of IC as a means of complete bladder emptying on rates of urinary incontinence.

We found evidence of multiple uncommon to rare complications associated with IC such as urethral stricture, bladder stones, changes in upper urinary tract function, and squamous cell carcinoma. Fortunately, rates of these complications varied from uncommon to rare and additional research is needed to determine whether some of the most serious potential complications, particularly changes in upper urinary tract function and squamous cell carcinoma, can be directly linked to IC versus the sequalae of neurogenic or other forms of chronic and serious LUT dysfunctions requiring IC.

Limitations

There are several limitations that need to be considered. While we searched 4 major electronic databases, we did not search psychology or social science databases (eg, PsychINFO) or the gray literature. We also limited our search to studies published in English. As a result, we may have missed relevant articles. In addition, while we provided justification for selecting the start date for our search, we may have missed earlier evidence published in relation to some of our outcomes. Many of the studies used observational designs, which limit the ability to make causal inferences in relation to the outcomes.

CONCLUSIONS

In this scoping review, we examined recently published evidence about a number of outcomes related to IC. The amount and quality of evidence available for many of the outcomes makes it difficult to draw conclusions. There is, however, some evidence to suggest that most patients can successfully master IC and that functional status is probably the most important predictor of success; adherence to IC probably decreases over time; that UTIs are the most common complication of IC and that prophylactic antibiotic therapy may reduce the risk of recurrent UTIs; that urinary incontinence is also a common complication; and that other complications such as urethral

strictures, bladder stones, hematuria, and urethral false passage do occur but less commonly than UTIs and urinary incontinence. This review also revealed many gaps in the evidence to support care for patients using IC. The wide variation in the rates of many complications suggests the need for well-designed prospective studies to provide better evidence about how commonly they occur and who is at risk to develop them. There is a general lack of recent research on IC in the pediatric population. Finally, there is an urgent need for well-designed intervention studies to determine how to improve outcomes for patients using IC to manage bladder function. These studies need to consider both the risks and benefits of interventions and include patient-specific outcome measures such as QoL, satisfaction, and perceived treatment burden.

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