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# Urinary Catheters: A Review

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## Citation

K Ramakrishnan, J Mold. *Urinary Catheters: A Review*. The Internet Journal of Family Practice. 2004 Volume 3 Number 2.

## Abstract

The purpose of the article is to review the history, the indications for and methods of urinary catheterization, types of urinary catheters and ancillary devices used, and the adverse effects of the procedure.

Urinary catheters are used for diagnosing pathology in the lower urinary tract, to monitor urine output, and to relieve urinary retention. Their universal availability and ease of insertion too often leads to indiscreet and prolonged use. Condom catheters are a safer alternative in people able to void spontaneously. When prolonged catheterization is necessary, intermittent insertion minimizes irritation, local and ascending infection, and stone formation. Earlier catheter removals, use of smaller bore catheters and a closed drainage system and optimal hygienic techniques (hand-washing, sterile catheterization techniques) by health care workers are effective in minimizing the incidence of infection. Patient discomfort, catheter induced trauma to the lower urinary tract and abdominal wall, calculi, bladder spasms and contraction, and balloon problems are well known complications associated with catheter use. There is a growing trend towards avoiding routine peri-operative catheterization during laparoscopy, cesarean sections, and pelvic surgery.

With family physicians increasingly involved in the multidisciplinary care of complex patients, they need to be aware of the current recommendations associated with the use of urinary catheters, and the problems associated with their insertion and maintenance.

## KEY POINTS

- Because of the potential for complications (trauma, infection) use of urinary catheters should be restricted to when absolutely necessary.
- Condom drainage is preferable in men with the ability to void spontaneously.
- Intermittent self-catheterization minimizes the risks of bacteriuria and infectious complications, calculus disease, bladder spasms and leakage, blockage of the catheter, and renal damage associated with long-term catheterization.
- Early decanulation, using smaller bore catheters and closed drainage systems, and adopting optimal hygienic techniques are effective in minimizing infection.
- Asymptomatic bacteriuria in catheterized individuals requires treatment only in exceptional circumstances. Infections should be managed

aggressively.

- Perioperative catheterization is not required in diagnostic laparoscopies and in certain elective orthopedic and pelvic surgeries.

## INTRODUCTION

Urinary catheters include both indwelling as well as external (condom) catheters. An indwelling catheter may be either a urethral or a suprapubic catheter. They are widely used in the diagnosis and treatment of urological problems, and in the resuscitation and monitoring of patients in the hospital and emergency room settings. With family physicians increasingly managing patients with multiple and complex medical problems, and often in tandem with their specialist colleagues, it is important that they understand the indications for catheterization, the techniques available, potential problems associated with their use, and current controversies regarding their routine and long-term placement. This review focuses on the history of the urinary catheter, indications for and methods of urinary

catheterization, benefits of intermittent catheterization, types of urinary catheters and ancillary devices used, and the adverse effects of urinary catheter insertion and maintenance. An attempt has been made to address in some depth the issues associated with antibacterial-coated urinary catheters and catheter-associated infections. The recent trend in minimizing use of post-operative bladder drainage in extremity, back and pelvic surgeries is also emphasized.

**METHODS**

A search of the English language literature was performed using “PubMed” and the search engine “Google”. Key words used in the search were “urinary catheters,” “urinary catheterization”, and “complications of urinary catheterization”. A careful review of bibliographic references in the chosen articles including review articles on the subject since 1999 yielded earlier and more recent pertinent references including randomized controlled trials, cohort and case-controlled studies, other reviews and individual case reports, which form the basis of this manuscript. Attention was focused on works examining the history of bladder catheterization, indications for and present-day techniques of bladder drainage, advantages of intermittent urinary catheterization, types of catheters and ancillary devices, various complications of catheterization, and changing attitudes towards routine perioperative bladder catheterization.

**RESULTS**

**HISTORY**

The term catheter in Greek means to let or send down. Catheterization has been used to relieve painful retention of urine from time immemorial. Many materials have been utilized to form the tubular structure of the catheter including straw, rolled up palm leaves, long, thin dried leaves of Allium, gold, silver, copper, brass and lead.<sup>1</sup>

More malleable catheters were developed in the beginning of the eleventh century. For example the silver catheter could be bent to any desired shape and, having antiseptic function, became popular. Boring holes in the sides of the tube (fenestration) facilitated drainage.<sup>1</sup> Since catheterization with a straight metal catheter was found to be extremely difficult particularly in men, coude' and bicoude' catheters, with one or two bends near the tip respectively, were invented in the 18<sup>th</sup> and 19<sup>th</sup> centuries to negotiate the curvatures of the male urethra.<sup>2</sup> Rubber catheters were also produced in the 18<sup>th</sup> century but initially were weak and friable at body temperature, resulting in intravesical fragmentation.

Vulcanization improved the firmness, flexibility and durability of rubber, and popularized catheter use. The earliest self-retaining catheters had flexible shoulders or were wing-tipped, and were tied to the male penis or sewn to the female urethra. Swaging of a self-retaining balloon (as in a Foley catheter) became practical with the availability of latex rubber in the 1930s.<sup>3</sup> In the 1950's, the “Kipper Bag” consisting of a condom sheath, a plastic connector and a short piece of rubber tubing pushed into the top of the bag, was developed and was probably the precursor of the condom catheter.

In the 19<sup>th</sup> and early 20<sup>th</sup> centuries patients with bladder outlet obstruction and urinary retention due to prostatic hypertrophy or urethral strictures catheterized themselves. The absence of aseptic precautions, led to “catheter fever” (systemic sepsis). Guttman introduced the concept of sterile, intermittent catheterization in spinal cord injured patients, and Lapides popularized clean, intermittent self-catheterization.<sup>4,5</sup>

**INDICATIONS FOR CATHETERIZATION (TABLE 1),,,,,,**

**Figure 1**

Table 1: Indications for urinary catheterization ,,,,,,

<b>Diagnostic Evaluation</b>
<ul style="list-style-type: none"> <li>o Obtaining sample of urine for evaluation</li> <li>o Bladder distention prior to transvaginal or abdominal ultrasound of the pelvis</li> <li>o Cystogram, cystourethrograms, assessing vesicoureteric reflux</li> <li>o Critically ill patients requiring accurate measurement of urinary output</li> </ul>
<b>Therapeutic short-term catheterization (&lt; 6 weeks)</b>
<ul style="list-style-type: none"> <li>Epidural anesthesia</li> <li>Urologic surgery, surgery on contiguous structures in the pelvis and lower abdomen.</li> <li>Acute urinary retention (due to infections, neurological disorders, cerebrovascular accidents, diabetic autonomic neuropathy, calculus disease, benign prostatic hypertrophy, fecal impaction and medications- antispasmodics, antihypertensives, narcotic analgesics, tricyclic antidepressants, lithium)</li> <li>Instillation of chemotherapeutic agents.</li> <li>Short-term urinary diversion in treating decubitus ulcers</li> </ul>
<b>Therapeutic long-term catheterization (&gt; 6 weeks)</b>
<ul style="list-style-type: none"> <li>Uncorrectable bladder outlet obstruction</li> <li>Recalcitrant decubitus ulcers caused or exacerbated by urinary incontinence</li> <li>Neurogenic bladder</li> <li>Palliative care in terminally ill or severely impaired incontinent patients to minimize frequent changing</li> <li>Patient preference following failure of medical or surgical intervention</li> </ul>

**DIAGNOSTIC USES**

Bladder catheterization facilitates obtaining a specimen for urinalysis or culture (e.g.in children), measuring post-void residual volume, and undertaking more extensive urodynamic studies to diagnose causes of urinary incontinence. Radiographic contrast may be instilled through a catheter to visualize bladder or urethral pathology, and document vesicoureteric reflux. The bladder may be distended with saline to form a sonoluscent structure, prior to a pelvic ultrasound.

### SHORT-TERM (0-2 WEEKS) OR INTERMEDIATE TERM (2-6 WEEKS) THERAPEUTIC USES

Indwelling catheters are used during labor following epidural anesthesia, and in the fluid management and tocolysis of patients with pre-eclampsia and eclampsia. An empty bladder facilitates pelvic dissection in patients undergoing hip and abdominopelvic surgical procedures. Catheterization enables measurement of intra- and post-operative urine output and eases post-procedure patient care. Cytotoxic drugs and BCG may be administered intravesically in treating bladder tumors, antibiotics (Amphotericin) in fungal cystitis, and Capsaicin and Resiniferatoxin in treating spastic bladder following spinal cord injury.<sup>7,8,9</sup>

Acute urinary retention may arise from a variety of causes (Table 1). Temporary decompression of the bladder through an indwelling catheter may be necessary until resolution of the primary cause of the retention. Short-term decompression of a distended bladder may also restore muscle tone.

Short term or intermittent catheterization may be required following urethropexy or a sling procedure for bladder neck obstruction, when swelling and pain may cause retention.<sup>10</sup> Other organic causes of obstructed voiding in women (neoplastic, inflammatory) may also be managed with clean intermittent or indwelling catheter drainage until the underlying condition is treated. Incomplete pelvic floor relaxation with resulting dysfunctional voiding may also be treated with catheterization.

Gluteal, sacral or trochanteric skin trauma or decubitus ulcers contaminated by urine in an incontinent patient will respond to temporary urinary diversion through catheterization to maintain a moisture and infection-free environment.<sup>11</sup>

### LONG-TERM THERAPEUTIC USES (> 6 WEEKS)

Any form of incontinence (stress, urge, overflow, mixed or functional) not responding to conservative measures or surgery may be managed by either continuous or intermittent bladder catheterization, though overflow incontinence is the most common reason for such treatment. This will maintain mobility and renal function, and minimize residual urine, infectious complications and calculus disease. Overflow incontinence resulting from a poorly contractile bladder is usually unresponsive to behavioral or pharmacologic therapy. Surgery is generally not indicated for men with this

condition, and in most cases, patients are required to perform clean intermittent catheterization. Obstructed voiding in patients, who are not surgical candidates (unwilling or unfit for surgery) need long-term intermittent or continuous bladder drainage.

Intermittent catheterization has become the standard of care in patients with spinal cord injuries.<sup>12</sup> Continuous or intermittent catheterization should be established immediately in a hypotonic bladder, to prevent over-distention, infection and detrusor muscle damage. Spastic bladder following spinal injury may require condom catheter or long-term suprapubic drainage.<sup>13</sup> Intermittent or continuous bladder drainage may also benefit the incontinent, immobile subject due to aging or terminal illness, in whom comfort care is the goal and toileting is unnecessarily burdensome. However, continuous drainage should be used rarely, and only as a last resort.

### CATHETERIZATION METHODS CONDOM CATHETERS

Condom catheters are indicated in men with functional disabilities such as restricted mobility or dementia plus incontinence, who are able to void spontaneously.<sup>14,15</sup> They are ideal for nighttime use and are more comfortable, less painful, and less restrictive than indwelling catheters.<sup>14</sup> Condom drainage may be associated with a lower risk of bacterial colonization and urinary tract infection (UTI) than indwelling urethral catheters.<sup>16,17</sup> However, a study in hospitalized patients reported that the risk of UTI was higher in those wearing condom catheters.<sup>18</sup>

Urinary leakage is a major drawback, increasing with patient mobility and ambulation. Skin breakdown over the penis and inner thighs is minimized by attention to tethering techniques, using barrier creams, and treating skin infections promptly. One analysis of inpatient resource consumption in the Veterans Affairs medical centers showed that catheter-related costs were 100-fold higher for condom catheter users than for those with indwelling catheters, almost entirely related to nursing time required for catheter care.<sup>19</sup> An external collecting device in women similar to an ostomy appliance has been used in nursing home settings to treat incontinence, minimize infections and skin breakdown.<sup>20</sup> However, this has not gained wide acceptance.

### URETHRAL CATHETERIZATION

In this method, the bladder is drained intermittently or continuously by means of a lubricated catheter placed

through the urethra. Sterile intermittent catheterization (SIC) implies the one-time use of a prepackaged and pre-lubricated sterilized catheter. In nursing home patients its annual cost (including nursing care) varied from \$3600 to \$7000.<sup>21</sup> Clean intermittent catheterization (CIC) involves the repeated use of washed and rinsed catheters. Its use is based on the assumption that most urinary tract infections are due to an underlying structural or functional abnormality, which compromises host resistance to infection, rather than due to the introduction of bacteria into the urinary tract by the catheterization procedure. Being more cost-effective, (annual savings of \$1460 per patient in nursing time and catheterization supplies), this technique needs to be more widely used.<sup>21,22</sup> More recent data continue to show that using a sterile catheter with each void was an unnecessary expense as it did not reduce the frequency of bacteriuria when compared with CIC, confirming that CIC with a reusable catheter remains an excellent method of prolonged bladder drainage.<sup>23,24</sup>

**SUPRAPUBIC CYSTOSTOMY (SPC)**

This is preferred in people with cervical spinal cord injury and other pathology that limits hand dexterity and where intermittent self-catheterization is not an option.

The catheter is inserted through a tract created from the bladder to the anterior abdominal wall, and drains urine into a bag. It can be irrigated intermittently if necessary and left in place for several weeks, prior to replacement. The cystostomy is also performed during bladder or prostate surgery, to irrigate the bladder or the prostatic bed in the post-operative period.

SPC has a lower incidence of UTI compared to urethral catheterization<sup>25,26</sup>, though it increases the incidence of bladder and renal calculi. One-third of patients on long-term SPC develop bladder stones over a 10-year period.<sup>27</sup> Other complications include recurrent catheter blockage with debris, persistent urinary leakage, abdominal wall and urinary infections associated with chronic use, and injury to adjacent viscera (small bowel) during insertion.<sup>28</sup> A lower incidence of bladder cancer in patients managed with an SPC compared to indwelling urethral catheters, has been suggested (0.39% over 5 years)<sup>29</sup>. Concomitant administration of Oxybutynin (Ditropan) decreases bladder spasms and vesicoureteral reflux, leakage and renal.

**INTRAURETHRAL CATHETERS**

These self-retaining devices that are totally contained within

the urethra are introduced with a cystoscope. They offer continued relief of urinary retention in high-risk patients with benign prostatic hypertrophy. Early reports suggest low incidences of bacteriuria and symptomatic infection over weeks and months of use.<sup>30,31</sup> An extension of this concept is the more recent use of temporary bio-degradable and permanent intraurethral stents in men with BPH, and in women with acontractile bladders and chronic urinary retention. Studies suggest that these stents are an attractive and simple alternative to conventional catheterization.<sup>32,33,34</sup>

**INTERMITTENT VS. CONTINUOUS BLADDER DRAINAGE**

Patients with neurogenic or obstructive bladder problems who are at risk for incontinence and chronic renal failure due to recurrent pyelonephritis, benefit from intermittent drainage.<sup>35</sup> Improvement in bladder emptying mitigates the risk of ascending UTI, improves self-esteem and quality of life.<sup>35</sup> Though the majority of patients have bacteriuria with both CIC (69%) and SIC (61%), UTI is much more frequent following CIC (44%- 1 every 3-6 months vs.17%-1 every 12-16 months for SIC) and more than 25% have serious infections (pyelonephritis, prostatitis) with CIC.<sup>36,37</sup> Intermittent catheterization following abdominal surgery leads to earlier return of normal voiding (5.1 days versus 9.4 days) and minimizes the risk of bacteriuria, at the risk of increased post-operative urinary retention.<sup>38,39</sup> The sequela associated with both techniques, are outlined in Table 2.

**Figure 2**

Table 2: Intermittent vs. Continuous bladder drainage,,,,, ,,,

<u>Complication</u>	<u>Continuous bladder drainage (Urethral/Suprapubic)</u>	<u>Intermittent catheterization</u>
Infection	Infection (urethritis, cystitis, abdominal wall)	Minimized by SIC
Encrustation, Calculi	Catheter calculus, Vesical calculus	Rare
Catheter blockage, leakage around catheter	Present	Absent
Loss of vesical tone	Contributory	Vesical tone maintained
Loss of bladder capacity, contraction	Present	Absent
Urethral and bladder trauma	Due to insertion, traction on catheter	Due to insertion
Abdominal wall trauma	May result from suprapubic insertion	Non-existent
Injury to intra-abdominal structures	May result from suprapubic insertion	Rare
Urethral stricture	More common (Due to trauma, recurrent urethritis, false passage)	Rare
Sexual dysfunction	Present with urethral catheterization	Rare
Bladder cancer	Rare	Rare

SIC= Sterile intermittent catheterization

**CATHETER MATERIAL, TYPES, TIPS, VALVES AND BAGS**

Indwelling urethral catheters, were originally made of natural latex rubber, which is flexible and inexpensive, but more prone to infection and toxicity. Hypersensitivity to

latex and anaphylaxis are also being increasingly recognized.<sup>40</sup> Silicone catheters have a wider lumen and urethritis following short-term catheterization may be significantly reduced.<sup>41</sup> Latex catheters, with similar outcomes, but lower cost are preferred for long-term catheterization.<sup>15</sup> Silastic catheters have decreased incidences of urethritis and, possibly, urethral stricture and can also be used long-term.<sup>41</sup> Polyvinylchloride and polyethylene catheters have a wide lumen enabling a rapid flow rate, are recommended for short-term post-operative use, but cause greater patient discomfort.<sup>42,43</sup> Pre-lubricated, sterile non-latex catheters coated with polyvinylpyrrolidone, are water absorbent, cause 90%-95% less urethral friction trauma to the urethra, and are also indicated long-term.<sup>21</sup>

Catheter size is expressed in Charrière (Ch) units, which reflects the catheter's diameter in millimetres (1Ch=0.33mm diameter) or French units (F= circumference in millimeters). The smallest size of the catheter consistent with effective drainage is used.<sup>44</sup> In the presence of infection or if post-operative bleeding is expected, a larger bore catheter minimizes catheter obstruction. Most urethral catheters are 41-45 cm. long; a shorter catheter (20-25 cm) is more discreet and comfortable in women.

Anti-microbial coated urinary catheters may offer significant benefit for hospitalized patients undergoing short-term bladder catheterization.<sup>45</sup> A meta-analysis of four randomized controlled trials showed that silver coating prevented bacterial colonization and growth and the use of silver-hydrogel urinary catheters resulted in reduction in catheter-associated UTIs and a modest cost saving.<sup>46,47,48</sup> However, one large randomized study on hospitalized patients showed a significantly increased incidence of bacteriuria in male patients and a significantly increased occurrence of staphylococcal bacteriuria.<sup>49</sup> Coating the catheter with antibiotics (minocycline-rifampin) or connecting them to electrodes are expensive and may diminish bacteriuria temporarily, but may not have long-term benefit.<sup>15,50</sup> Minocycline-rifampin coated catheters have low activity against Gram-negative rods, enterococci and candida, the main organisms causing UTI.<sup>51</sup> Nitrofuraxone-impregnated catheters were found to reduce UTIs in postoperative orthopedic and trauma patients.<sup>52</sup> It is unclear whether reduction in bacteriuria and UTI due to antibiotic or silver impregnation also translates into decrease in catheter-related bacteremia and mortality, though one study by Karchmer et al suggests this.<sup>47</sup>

The self-retaining Foley catheter is the most common type in use. (Table 3) A balloon at its tip inflated after insertion facilitates its retention in the bladder. A size 12 F is sufficient to relieve urinary retention in most adults.<sup>53</sup> Using a smaller balloon (5 ml balloon), and restricting inflation minimize bladder irritation, though underinflation may cause blockage of the drainage ports by the balloon. The DePezzler (mushroom catheter) has triangular tips designed for suprapubic catheterization or to drain urine from the renal pelvis (continuous use). The triple lumen indwelling catheter is used for continuous bladder irrigation after surgery on the bladder or prostate, the fenestrated catheter with multiple bores on the shaft enables drainage of urethral secretions and minimizes urethritis and stricture (intermittent or continuous use), and the red-rubber or plastic disposable urethral catheter enables straight catheterization of the bladder. The Tiemann coude catheter (intermittent or continuous use) has a curved tip with one to three drainage openings designed to negotiate the membranous and prostatic urethra in patients with prostate enlargement. The Whistle-tipped catheter has openings laterally and above the balloon to provide a large drainage area to drain debris and blood clots. The Roberts catheter has an eye above and below the balloon to facilitate the drainage of residual urine.<sup>6</sup>

Catheter valves eliminate the need for drainage bags, allow the bladder to fill and empty intermittently, maintaining bladder volume and minimizing contraction. Left insitu for 5-7 days, they are appropriate for patients with good cognitive function, manual dexterity and an adequate bladder capacity, requiring long-term catheterization. Uncontrolled detrusor overactivity, ureteric reflux and renal impairment are contraindications.<sup>54</sup> Nocturia is a drawback. There is greater patient acceptance, less restriction of activity during catheterization, and the one-way flow is not associated with increased UTI.<sup>55</sup> The UroCycler® is a small, anti-reflux valve attached directly to the catheter that permits the natural function of cyclical filling and drainage of the bladder. It functions as a precision, magnetically coupled valve actuated by the pressure build up of urine in the bladder. It may be of value in those both cognitively and/or neurologically impaired, though its long-term benefits are unknown.<sup>56</sup>

Urine collection bags may be changed weekly, and are reusable after thorough cleaning and drying. Leg bags are advantageous for their discretion, and allow ambulation and normal wear. A variety of supports are available for use with bags, including waist belts, leg holsters, and leg straps.

**ADVERSE EFFECTS/ COMPLICATIONS OF CATHETERIZATION (TABLE 3)**

**Figure 3**

Table 3: Potential complications of catheterization

<p><b>Urethral/ Penile/Scrotal/Prostatic</b></p> <p>Urethritis                  Urethral stricture                  Urethral diverticulum/ false passage                  Paraphimosis and gangrene of the glans penis if uncircumcised                  Funiculitis, Epididymitis, Epididymoorchitis                  Prostatitis</p>	<p><b>Renal/Ureteral</b></p> <p>Vesicoureteric reflux                  Pyelonephritis                  Renal/ ureteric calculus                  Obstructive hydronephrosis                  Chronic renal failure</p>
<p><b>Bladder</b></p> <p>Asymptomatic bacteriuria                  Cystitis                  Vesical calculi                  Catheter calculi                  Bladder spasms                  Decrease in bladder capacity, atony                  Bladder cancer (transitional cell carcinoma, Squamous cell carcinoma)- rare                  Extraperitoneal perforation of the bladder- rare</p>	<p><b>General</b></p> <p>Hematuria                  Pain                  Urine leakage around the catheter                  Abdominal wall infections- in SPC                  Systemic sepsis                  Retained catheter- rare                  Knotted catheter- rare                  "Fractured catheter"- rare                  Injury to adjacent organs (small bowel)-SPC- rare                  Hypersensitivity, anaphylaxis (Latex catheter)</p>

**DISCOMFORT**

Urinary catheterization is an uncomfortable procedure. Anesthetizing the urethra with topical lidocaine gel instilled through a pre-loaded syringe, minimizes discomfort. In males external massage moves the gel down the urethra, and the catheter tip is lubricated prior to its passage. The absence of lubricating glands in the female urethra dictates a greater need for a lubricant. One prospective study of common emergency department (ED) procedures found that the most painful procedures in descending order were nasogastric intubation, abscess drainage, fracture reduction, and urethral catheterization.<sup>57</sup> Other procedures such as anesthetic infiltration, venous and arterial punctures, suturing, suture removal, lumbar puncture and intramuscular injections were all considered to be less painful.<sup>57</sup>

**TRAUMA**

Trauma from catheterization causes urethral strictures and false passages. Traction on the catheter either inadvertently or by the patient traumatizes the bladder neck and the prostatic bed, accounting for most episodes of hematuria. Intraurethral balloon distention on the Foley catheter may lead to pressure necrosis and urethral rupture and even rectal wall perforation.<sup>58</sup> Intra or extraperitoneal bladder perforation is rare and is due to pressure necrosis from contraction of the bladder on the catheter tip.<sup>59</sup> Patients on long-term catheterization may present with unexplained lower abdominal pain or mental status changes. Imaging studies such as retrograde cystourethrography, abdominal ultrasound, computed tomography or magnetic resonance

imaging are useful in diagnosing trauma to the bladder or proximal urethra, and ruling out associated lower abdominal or pelvic pathology.<sup>60</sup> Recurrent paraphimosis develops in uncircumcised elderly patients needing frequent bladder catheterization, and occasionally causes ischemia and gangrene of the glans. Circumcision minimizes this risk.<sup>61</sup>

Ensuring patient education and compliance, using proper material and good catheterization techniques minimizes urethral trauma. Once inserted, the catheter should be anchored to prevent traction. In men, the penis may lie over the lower abdomen with the catheter taped to the abdomen. In both sexes the catheter may be secured to the anteromedial thigh.<sup>62</sup>

**MINERAL DEPOSITS/STONES, CATHETER BLOCKAGE**

Under alkaline conditions minerals precipitate on the outside of the inserted portion of the catheter, especially the tip, causing recurrent blockage in around 40-50% of long-term catheterized patients. This is distressing to patients and costly to health services in both time and resources.<sup>63</sup> Catheter obstruction also results from precipitated mucus, protein, crystals, blood clots and bacteria, and increases with the duration of catheterization. Infection with *Proteus Mirabilis* alkalizes the urine by splitting urea, causing precipitation of crystals. Occasionally the encrustations congregate over the catheter tip and form the nidus for development of a vesical calculus. Increasing fluid intake, acidification of the urine with instilled citric acid or oral mandelic acid, ascorbic acid or cranberry juice (reduce colony count and dissolves crystals), treating infection, using larger bore catheters and saline irrigation reduce the risk of blockage.<sup>64,65</sup> Inflating the balloons with an anti-bacterial Triclosan causes it to be impregnated throughout the catheter material inhibiting the formation of crystalline *Proteus Mirabilis* biofilm, minimizing blockage.<sup>66</sup> Replacing catheters periodically also reduces blockage, and blocked catheters should be replaced promptly.

**CATHETER-ASSOCIATED INFECTION**

Indwelling catheters initiate the accumulation and prevent drainage of urethral and prostatic secretions, causing prostatitis, urethritis and, eventually urethral stricture. Catheterized patients are also seven times more likely to develop pyelonephritis.<sup>67</sup> Choosing the smallest effective size catheter, and early removal minimizes these risks.<sup>68</sup> Fenestrated catheters drain urethral secretions, but are more expensive and not widely used. Retrograde flow of infected

urine into the seminal vesicles and the vas deferens leads to seminal vesiculitis, funiculitis and epididymoorchitis.

Every day approximately five percent of catheterized patients develop bacteriuria and up to 50% over one week, and virtually all patients requiring indwelling urinary catheters for longer than a month become bacteriuric.<sup>67,69</sup> Most episodes of bacteriuria associated with short-term catheters are asymptomatic. As the catheter remains in place the bacteriuria becomes complex, polymicrobial, and dynamic.<sup>70</sup> *Escherichia coli* is the dominant pathogen accounting for most UTIs followed by *S. epidermidis*, *S. saprophyticus*, and *Enterococcus* species. Less common organisms, such as *Gardnerella vaginalis*, *Mycoplasma* species, and *Ureaplasma urealyticum* may also infect patients with intermittent or indwelling catheters.<sup>71</sup> Constitutional symptoms suggestive of UTI occur in a third of catheterized patients, though less than five percent develop bacteremia.<sup>72</sup>

A prospective study carried out by Platt and associates identified many factors increasing catheter related infection, and several steps in catheterization technique and subsequent care are effective in reducing bacteriuria and ascending infection.(Table 4)<sup>73, 15</sup> Silicone catheters and antibiotic impregnated catheters postpone bacteriuria and have the potential to minimize catheter related infection and morbidity.<sup>47,50</sup> Urethral meatus disinfectants are of little help in reducing infection.<sup>62</sup> Monitoring for time-to- catheter obstruction, and changing the catheter just before the patient would be expected to obstruct, minimizes catheter changes, and thus infection.<sup>74</sup>

**Figure 4**

Table 4: Catheter related infection,,,

Factors associated with catheter-related infection	Factors minimizing bacteriuria and ascending infection
<ul style="list-style-type: none"> <li>Duration of catheterization</li> <li>Female gender</li> <li>Diabetes mellitus</li> <li>Lack of systemic antibiotics during short catheterization,</li> <li>Not incorporating a urinometer (a measuring device incorporated to measure hourly urine output)</li> <li>Microbial colonization of the drainage bag</li> <li>Serum creatinine greater than 2 mg/dl at the time of catheterization</li> <li>Use of catheters with sealed collection junctions when no antibiotic is administered</li> </ul>	<ul style="list-style-type: none"> <li>Early catheter removal</li> <li>Using a closed drainage system</li> <li>Intermittent catheterization (every 4 hours)</li> <li>Smaller bore catheters</li> <li>Optimal hygiene techniques (hand-washing, sterile catheterization techniques)</li> <li>Silicone, antibiotic impregnated catheters</li> <li>Catheter removal when infection suspected</li> </ul>

Asymptomatic bacteriuria should not be treated with antibiotics in catheterized patients, as it promotes resistance, and does not improve outcomes.<sup>75</sup> Exceptions include pregnancy (increased incidence of pyelonephritis and

premature labor), impending urologic surgery and recent renal transplantation.<sup>45</sup> Fever greater than 38.3°C lasting over 24 hours, mental status changes, hypotension, unusually cloudy urine, more frequent blockage, and new or increased detrusor spasms suggest infection. (Table 5) When infection is suspected, the catheter should be removed. If continued catheterization is needed, a new catheter is inserted and a fresh urine sample obtained and cultured to more accurately determine the source of infection.<sup>15</sup> Gram stain analysis of urine aids in the choice of initial antibiotic therapy. Suspicion of bacteremia indicates blood cultures. Clinical and bacteriological outcomes are improved when long-term indwelling catheters are replaced before initiating treatment for symptomatic UTI.<sup>76</sup> The optimal duration of antibiotic treatment ranges from 5-14 days, or longer.<sup>77</sup> Patients who are not critically ill and in whom infection with multiple organisms are not suspected are treated with oral or parenteral trimethoprim-sulfamethoxazole or a second generation cephalosporin. Antibiotic options in seriously ill patients or in the presence of sepsis include ampicillin with a third generation cephalosporin, a fluoroquinolone, aminoglycoside or aztreonam. <sup>77</sup> (Table 5)

**Figure 5**

Table 5: Diagnosis and treatment of catheter related infection,

Diagnosis	Antibiotic treatment choices
<ul style="list-style-type: none"> <li>Clinical- (Fever greater than 38.3°C [100.9°F] lasting over 24 hours, mental status changes, hypotension, unusually cloudy urine, more frequent blockage, and new or increased detrusor spasms)</li> <li>Urinalysis- (&gt; 5-10 WBC/hpf, positive leukocyte esterase and nitrite tests, Gram-stain analysis of urine)</li> <li>Blood cultures if bacteremia suspected</li> <li>Urine cultures</li> </ul>	<ul style="list-style-type: none"> <li>TMP-SMX 160/800 mg PO every 12 hours or 8-10 mg/kg IV every 12 hours</li> <li>Nitrofurantoin (Macrobid) 100 mg PO twice daily for 10 days.</li> <li>Ampicillin or Amoxicillin 500 mg PO or 1-2 G IV every 6-8 hours</li> <li>Cephalexin 500 mg every 6 hours</li> <li>Ceftriaxone 1-2 g daily</li> <li>Ciprofloxacin 500 mg PO or 400 mg IV every 12 hours</li> <li>Levofloxacin 250-750 mg PO or IV every day.</li> <li>Gentamicin 5-7 mg/kg every day</li> <li>Aztreonam 1-2 G IV every 6-8 hours</li> </ul>

**BLADDER CANCER**

Histological changes such as papillary and polypoid cystitis, follicular cystitis squamous metaplasia and urothelial dysplasia are seen in patients with long-term indwelling catheters.<sup>78</sup> One retrospective analysis showed an association between indwelling catheters and bladder cancer (transitional and squamous cell carcinomas).<sup>29</sup> Another study showed an in-dwelling catheter to be a factor, significantly increasing the risk of and mortality from bladder cancer.<sup>79</sup> Indwelling catheters, may cause bladder cancer, possibly by increasing urinary tract infections and by irritating the bladder wall. Annual cytology studies with subsequent

cystoscopy and biopsies if any suspicious finding may improve its detection in spinal cord injured patients with chronic (longer than 5 years) indwelling catheters.<sup>80</sup> Some have even recommended annual cystoscopy with biopsies of any suspicious areas in patients with a Foley catheter longer than 5 or an external appliance drainage longer than 10 years.<sup>81</sup> Bladder cancer, however, is rare and a growing body of literature, does not support this invasive monitoring.<sup>82</sup>

**BLADDER SPASMS, CONTRACTION**

Bladder spasms cause frequent urinary leaks around the tube and reflux of infected urine into the renal pelvis, increasing the risk of pyelonephritis, renal scarring, renal failure and hypertension.<sup>70</sup> In-dwelling catheters lead to contraction of the bladder, decreasing its capacity and tone and making bladder rehabilitation after catheter removal more difficult. Intermittent clamping of the Foley or suprapubic catheters initially for 1-2 hours, gradually lengthening to 4-6 hours and instituted several days or weeks prior to catheter removal (bladder retraining), or the addition of catheter valves in selected patients, enables the bladder to retain or maintain its capacity and tone.

**OTHERS (KNOTTING, FRAGMENTATION, FRACTURE, BALLOON PROBLEMS)**

Urethral catheter knotting is rare (0.2 per 100 000 catheterizations).<sup>83</sup> Catheters become knotted if an excessive length is inserted into the bladder and forms a loop. Subsequently, on withdrawal a knot can form and tighten. Removal is complex, may require general anesthesia and surgery, and may cause transient hematuria and complications such as stricture formation.<sup>84</sup>

Retained catheter fragments result from balloon rupture, and may cause recurrent UTI, irritative voiding symptoms and form a nidus for a stone.<sup>85</sup> Wear and tear due to excessive kinking, bending or stretching increases the potential for disruption, resulting in retention of larger sections of the catheter and endoscopic removal.

Inflation valve malfunction, clamping, crushing or kinking, or obstruction by solute crystallization when fluids other than sterile water are utilized for balloon inflation may cause balloon problems (Table 6).<sup>86</sup> The catheter is advanced to ensure its position in the bladder and the balloon over-inflated to cause rupture. If unsuccessful, the inflation port is cut to drain the fluid and deflate the balloon. Injecting mineral oil through the balloon port to rupture the balloon (85% -90% success rate with no adverse effects) and

percutaneous puncture under sonographic guidance are also available.<sup>87,88</sup> Mineral oil is a mild rubber solvent and about ten ml is instilled through the inflation port, and if required, an additional ten ml can be injected in 15 minutes with the expectation that the balloon will rupture within 30 minutes.<sup>86</sup> The bladder is first distended with 150-200 ml. of saline to dilute the chemical and minimize chemical injury. The catheter is inspected after removal to ensure that it is complete.

**Figure 6**

Table 6: Catheter balloon problems- Causes and remedies, ,

Causes	Treatment
<ul style="list-style-type: none"> <li>○ Inflation valve can malfunction (prevents return of the fluid filling the balloon).</li> <li>○ External clamping, crushing, or kinking (damages inflation channel).</li> <li>○ Obstruction by solute crystallization when fluids other than sterile water are utilized for balloon inflation.</li> </ul>	<ul style="list-style-type: none"> <li>○ Advancing catheter to ensure its position in the bladder and balloon over-inflated to rupture the balloon.</li> <li>○ Inflation port cut to drain the fluid and enable deflation.</li> <li>○ Injection of mineral oil through the balloon port to rupture the balloon (85% -90% success rate with no adverse effects)</li> <li>○ Percutaneous puncture under sonographic guidance using transabdominal, transvaginal, transperineal, and transrectal routes (trans-vaginal in women).</li> </ul>

**POST-OPERATIVE URINARY CATHETERIZATION**

Infection risk of routine post-operative catheterization is leading to a more selective approach during laparoscopy, orthopedic and pelvic surgery. One prospective study showed that the majority of diagnostic laparoscopies or laparoscopic sterilizations can be completed without catheterization by asking the patient to void immediately prior to surgery and ensuring the bladder is empty prior to trocar placement.<sup>89</sup> A retrospective study of 329 patients also showed a significant absence of urinary infections in patients undergoing cesarean sections and hysterectomies, who were not catheterized.<sup>90</sup> In patients undergoing back and lower limb surgery under spinal anesthesia good correlation existed between ultrasound estimate of urinary bladder volume and post-void residue.<sup>91</sup> It is suggested that in patients in whom retention following surgery is a possibility as after lower extremity or back surgery, bladder ultrasound is useful in monitoring accumulating residual urine volumes, guiding the more judicious use of catheterization.<sup>91</sup>

**CONCLUSIONS**

Urinary catheterization is a simple and valuable technique that can be performed by the patient, physician, or nurse. Because of a variety of potentially serious complications, it should be done only when absolutely necessary. Condom catheters are preferred in patients able to void spontaneously

and may be associated with a lower risk of bacterial colonization and infection. Silastic catheters have a decreased incidence of urethritis and stricture and are indicated for short-term canulation. Latex catheters cost less and may be used for long-term catheterization. Non-latex catheters coated with polyvinylpyrrolidone minimize urethral trauma and may also be used long-term. Silver impregnation delays bacterial colonization and development of UTI. If long-term catheterization is required, intermittent self-catheterization minimizes the risks of bacteriuria and infectious complications, calculus disease, bladder spasms and leakage, blockage of the catheter, and renal damage. If intermittent catheterization is impractical, monitoring the time-to-obstruction and changing the catheter just before the patient would be expected to obstruct minimizes catheter changes. If urethral catheterization is not practical, suprapubic cystostomy is a favored option.

Early decanulation, using a closed drainage system, using smaller bore catheters, and adopting optimal hygienic techniques by health care workers are effective in minimizing the incidence of bacteriuria and ascending urinary infection. Asymptomatic bacteriuria in catheterized individuals does not require anti-bacterials, and treatment encourages the emergence of resistant strains. Infection in a catheterized patient may be due to atypical organisms and needs early and aggressive management to minimize the risk of ascending infection and systemic sepsis.

Intra-operative and post-operative catheterization is no longer considered routine in laparoscopy, cesarean sections and pelvic surgery. Patients can be followed either clinically or using bladder ultrasound to monitor residual urine in the post-operative period and the bladder catheterized when required.

As family physicians continue to manage patients with multiple and complex medical problems, they need to be aware of the role of urinary catheters, the current recommendations regarding their proper use, and the problems associated with their insertion and maintenance.

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