Review Article

Review Article: Urethral Catheters and Catheterization Techniques

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Abstract

Background: The urethral catheter is an essential medical device that is used in everyday medical practice worldwide. The urethral catheter has evolved over the years with several modifications and improvements to overcome the shortcomings of previous productions. With several indications, it remains one of the most commonly used devices traversing almost all specialties in the field of medicine; however, the process of urethral catheterization is occasionally challenging and may result in injury to the urethra. The attendant complications following its passage far outweigh its cost and the required skills to necessitate appropriate insertion. Knowledge of the type of urethral catheter, training with regard to its insertion, care while *in situ*, and competency of the attendant caregivers are required for safe catheterization. **Aim:** This review aims to disseminate knowledge on urethral catheter types, insertion procedures, and its attendant complications so that doctors and other health-care professionals may safely perform this necessary procedure. **Materials and Methods:** A review of internatinal literature was conducted using PubMed database and goggle search using key words such as urethral catheter materials and types. **Result:** 105 articles were identified and found suitable for the study.

Keywords: Catheterization, catheters, technique, urethral

Introduction

Urinary catheters are one of the most commonly used medical devices in clinical practice.[1] They have been used for over 3500 years to drain the urinary bladder when it fails to empty or for other indications.[2] In the United States of America alone, an estimated 30 million indwelling urethral catheters are sold yearly, and about 20% of hospitalized patients have a urethral catheter inserted at any given moment.[3] A urinary catheter is a tube inserted from the external urethral meatus to the bladder to drain urine from the bladder.[4] It can be used for the short term, especially in the perioperative period. Still, it can also be used long term, especially when managing people with urinary incontinence or chronic urine retention.[4] Globally, the commonly used catheter is the Foley catheter invented by an American urologist named Frederic Foley.[5] However, there are several types of urinary catheters, and their use is determined primarily by the indication for urinary catheterization. Under ideal conditions, a urinary catheter that is 100% silicone can remain *in situ* for up to about 12 weeks. This, however, is often not feasible due to encrustation and bacterial infection that can block the catheter or result in a medical complication.[5] Although urethral catheterization is a standard procedure performed by many cadres of health workers, it may be associated with some complications and thus may be the cause of litigations and medical malpractice consequent on certain complications that may arise such as urethral stricture, urinary tract infection, urethral erosion, sepsis, and urethral injuries.[6]

Materials and Methods

A review of the international literature was conducted using PubMed database and Google Search, using keywords such as "urethral catheter materials and types," "catheterisation techniques and complications," "difficult urethral catheterizations," "retained urethral catheter," "catheter-associated urethral

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Access this article online

Quick Response Code:

Website: www.njmonline.org

DOI: 10.4103/NJM.NJM_99_21

How to cite this article: Agwu NP, Umar AM, Oyibo UE. Review article: Urethral catheters and catheterization techniques. Niger J Med 2022;31:497-508.

Submitted: 27-May-2021 **Revised:** 18-Jul-2022
Accepted: 08-Sep-2022 **Published:** 29-Nov-2022

stricture," and "catheter-associated urinary tract infection." We included review of only articles published in English and a total of 105 articles were identified, found suitable.

History of Urethral Catheters

The word "catheter" is derived from the Greek word *kathie'nai*, which means "to send down" or "to let down into."[2,7] It is attributed to Hippocrates describing an instrument used to dilate the uterine cervix and to drain empyema.[8] In the first-century medical writings of Galen, Erasistratus – a Greek physiologist and anatomist – is credited with treating urinary retention using a metal tube shaped like a roman letter S, which he termed "catheter."[8]

The process of emptying an overfilled painful bladder must have been among the problems of humanity since antiquity.[7] This was initially accomplished using rigid instruments, which required more extraordinary skills in manipulating them into the urinary bladder as against the insertion of a flexible catheter that follows the natural curves of the urethra.[8] In the 900s, a malleable silver tube with numerous side holes was used, making the insertion easier. In comparison, in the 1100s, the Chinese treated urinary retention by transurethral insertion of hollow leaves of onions (*Allium fistulosum*). Still, these were frequently difficult to pass, and rigid wood or metal tubes were used as alternatives.[2] The description of catheters made of silver, copper, brass, and horn was made by Fabricius of Acquapendente in the 16th century.

In the 20th century, there was a proliferation of different types of synthetic materials, including silicone which has been extensively used in the manufacture of urethral catheters.[8] With the development of catheters, it was necessary to devise a means of standardization, and this led Frederick Benoit Charriere, a French instrument maker to develop the French scale based on the metric system, which was adopted for use in 1799 by the French Academy of Sciences.[7] The initial indwelling catheters were not self-retaining, and therefore were mostly taped or tied to the phallus in men, while in women, they were sometimes sewn to the urethral orifice.[7] Reybard, in about 1842, designed a self-retaining catheter with one part held in place by a movable flange while the other part was fitted with a small inflatable balloon and was the prototype of the Foley catheter.[7]

Types of Urethral Catheters

Different medical device manufacturing companies that have produced urethral catheters have been trying to produce better quality catheters that can allow for good urine drainage while minimizing bacterial colonization and encrustation, thus reducing the incidence of catheter blockage.[9] Urethral catheters are generally differentiated by several criteria such as material make, length, diameter, size, tip configuration, number of channels, retainability, and types of coating.[10]

Catheter Material

The ideal catheter material should be soft, pliable, biocompatible, possess a high tensile strength, an inherent chemical resistance, and have the capacity to maintain adequate urine flow while retaining minimally invasive circumference.[11]

The material used in the production of catheters may be silicon [Figure 1], latex [Figure 2], polyvinyl chloride, polytetrafluoroethylene (PTFE), latex coated with hydrogel, or silicone elastomer. The particular type of catheter material has bearing on the duration of time the catheter can remain *in situ* in the body.

A pure (100%) silicone catheter appears to be superior to a latex-based catheter as it induces less cellular reaction by the patient's body and it is not toxic.[12,13] However, it is more expensive and not readily available in some poor rural and urban communities in developing countries.[14] Pure silicone catheters are relatively more rigid than latex-based catheters and this enables for easier, smoother passage through the urethra, although the rigidity may be associated with more patient discomfort.[15] However, silicone catheters are more prone to premature failure because the retention balloon may deflate more rapidly than that of latex brands.[15] Latex-based catheters are the most abundant, especially in developing countries as they are relatively cheap; however, they do not have very smooth surfaces, thus making them prone to encrustation.[15] In addition, the latex catheter absorbs moisture with the resultant swelling of the device and this increases its external diameter while reducing the internal diameter of the lumen.[15] To improve the quality of latex catheters, they may be coated with materials such as silicone, silicone elastomer, and PTFE to provide for smooth surfaces and minimize the risk of urethral injury and irritation.[14] Latex-based catheters are usually used for short-term catheterization as they are generally associated with a higher risk of cellular reaction and catheter-associated urethral stricture resulting from latex allergy and toxicity.[14,15]

In summary, the material from which the catheter is made strongly determines how long it may be left *in situ*. Long-term catheters may be left in the bladder for up to 12 weeks, while short-term catheters are changed at an interval of 14–28 days.[15] The ideal catheter for long-term catheterization is the pure silicone catheter, and they are also ideal for patients with latex allergy.[15]

Catheter length

Urethral catheters are available in three different lengths, namely standard length (40–44 cm), female length (23–26 cm),

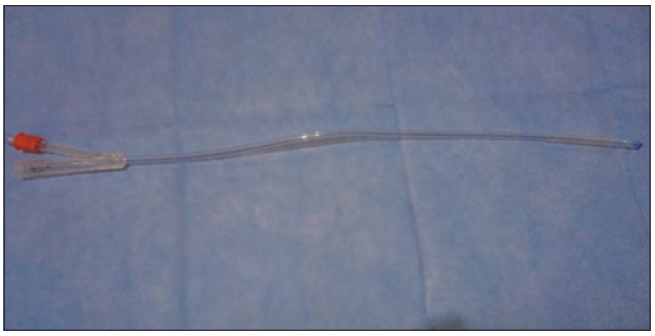

Figure 1: Pure silicone catheter (two-way Foley)

and paediatric length (30 cm).[9] Adult male patients should always be catheterized using the standard catheter length due to the longer urethra in men. This is to avoid the risk of inflating the catheter retention balloon in the urethra, which may result in urethral injury and subsequent stricture formation. Obese female patients may experience pressure symptoms and discomfort in the groin region when a female-length catheter is used.[9] As such, some female patients have a preference for the standard-length catheter.

Catheter size

The size of urethral catheters is measured using the French (F) unit, which indicates the external diameter of the catheter, with each French unit equivalent to 0.33 mm.[9] The higher the French unit, the wider the drainage eye of the catheter. The walls of a silicone catheter are thinner than that of latex-based urethral catheters, which means that silicone catheters have relatively larger lumen concerning their external diameter.[15] However, because the lumen is crescent shaped in cross-section, the silicone catheters are prone to internal encrustation and obstruction.[15] The sizes of the catheters may be indicated by colour code with green, orange, red, and yellow corresponding to 14F, 16F, 18F, and 20F, respectively. This colour coding enables rapid identification of the appropriate catheters that will effectively drain the bladder. For drainage of normal urine in an adult, a 12–16F catheter will suffice, but in the presence of debris, sizes 16–18F should be used for adequate drainage.[15,16] However, for the drainage of haematuria and thick pyuria, a relatively stiff, wide lumen catheter will be required, and sizes larger than 20F are usually employed.[16]

In paediatric patients, a 6–10F catheter is generally used.[14] The use of urinary catheters larger than 18F, especially for a long duration in the adult male, is generally discouraged because they, in addition to causing discomfort to the patient, may result in obstruction of the periurethral glands leading to retention of urethral secretion, infection, periurethral abscess, and urethral erosion.[17]

Urethral catheter tip configuration

Urethral catheters have varying tip designs, such as a blunt straight tip, which is the most typical variety, whereas others may be curved or coudé shaped.[18,19] A coudé tip catheter such as the Carson coude tip [Figure 3] has a curved tip which facilitates its by-pass of obstruction such as scar tissue and an enlarged prostate further maneuvering difficult urethral catheterization.[20]

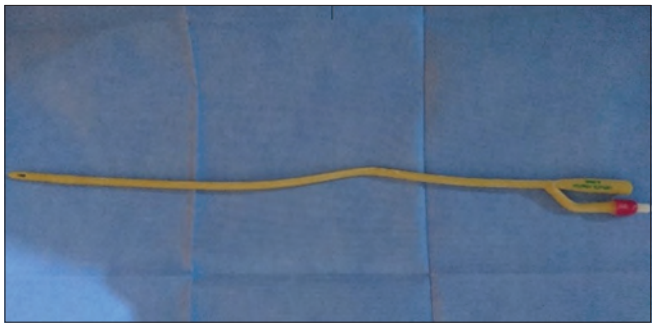

Figure 2: Silicone-coated latex catheter (two-way Foley)

The coudé tip Tiemann urethral catheter [Figure 4] has a bent tip that is longer, thinner, and more flexible than the standard coudé tips. These features make it helpful in navigating obstructions in the male urethra, such as tight strictures and obstructive prostatic enlargement.[21]

Number of channels

Urinary catheters can be two-way with two lumens: one lumen serves for drainage of urine and the second for inflating the balloon.[18] These are the most commonly used catheters for indwelling catheterization. The second type is the three-way urinary catheter with three channels: one for inflating the balloon, one for irrigating the bladder, and the third channel for draining the bladder.[22] The three-way urinary catheters are commonly used for bladder irrigation in the presence of haematuria, blood clot, debris, or pus.

Retainability

Catheters can either be indwelling or intermittent urinary catheters. Intermittent urinary catheters are inserted into the bladder temporarily and removed once the bladder is drained, and an example of such a catheter is the Nelaton catheter[22] [Figure 5]. In contrast, indwelling urinary catheters are left *in situ* for several days to weeks and are usually self-retained in place by a water-filled balloon resting inside the bladder.[22] These catheters are known as Foley. However, a Malecot catheter can also serve this purpose. Indwelling catheters can be introduced into the bladder transurethrally or through the percutaneous suprapubic route.[23]

Self-retaining urethral catheters are kept in place by various retention mechanisms depending on the manufacturer's design and the make of the device. A Foley catheter is retained by incorporating a balloon which, when fully inflated, allows the tip of the device to be located symmetrically at the bladder neck.[24] The maximum and instilled volume of the catheter varies from 2.5 ml to 40 ml depending on the manufacturer's design, size, and indication of the device insertion. The small caliber catheters in children contain 2.5 ml to 5.0 ml balloon volume. The recommended balloon volume is usually indicated on the catheter. Inflation with a high fluid volume into the balloon may result in catheter-related bladder discomfort and pain caused by bladder spasms.[25-27]

The Malecot catheter and its modification is a self-retaining, radiopaque catheter made of latex or silicone. The catheter tip has four wings that provide adequate drainage and device retention, thus reducing the risk of slippage and dislodgment.[28,29] Malecot catheters are not used for urethral catheterization; instead, they are inserted for suprapubic bladder drainage.

The Pezzer catheter is a self-retaining device with a bulbous umbrella end for retention. It allows for continuous bladder drainage or irrigation in children and adult females and is less prone to failure of the retention mechanism.[19]

The Madduri urethral catheter [Figure 6] is used for contrast imaging of the urethra. It is used to instill contrast medium into the urethra and to provide drainage of the urinary bladder. Its retention mechanism includes a balloon and retention plug. The silicone balloon occludes the bladder neck while the retention plug prevents the backflow of the contrast.[19]

Urethral catheter coating modifications

The common problems associated with the clinical use of urethral catheters such as infections, encrustation, and blockage have led to the search and design of certain modifications of these devices such as the incorporation of slow-release polymers, disinfectants, antibacterial agents, and surface coatings to reduce the incidence of urethral mucosal trauma and this involves alteration of surface properties of the device with various coating agents such as silver, PTFE, hydrogels, and silicone.[11,30,31]

Hydrogel, antibiotic, and antiseptic coating

Hydrogels are a three-dimensional network of hydrophilic polymers that swell when in contact with water while at the same time maintaining the structure of the molecule as a result of the chemical and physical cross-linking of the individual polymer chains.[32] Hydrogels have been incorporated in the manufacture of urethral catheters to reduce biofouling while increasing lubricity, thus improving patient comfort and safety.[33,34] Various types of antibiotics and antiseptics have been incorporated into Foley catheters to achieve easier, smoother, atraumatic urethral passage as well as minimize the occurrence of catheter-associated urinary tract infection (CAUTI).[35-38]

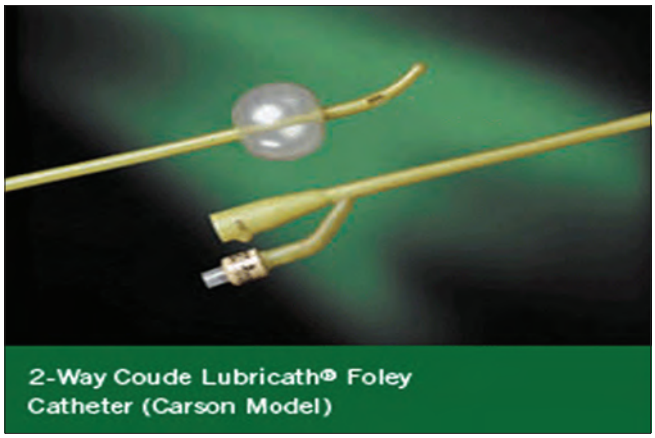

Figure 3: Carson catheter (Copyright© 2022 Mountainside Medical Equipment, New York)

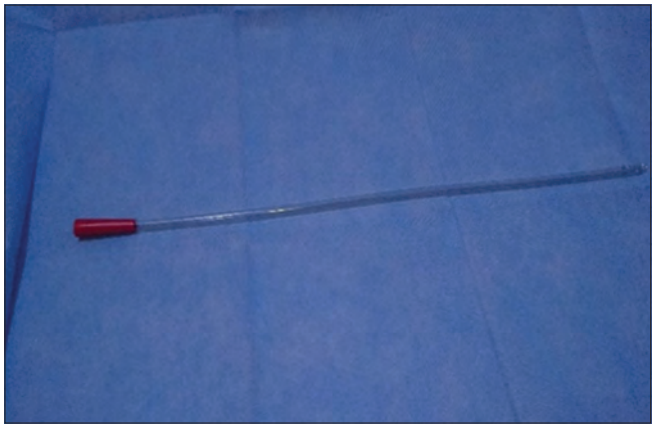

Figure 5: Nelaton catheter for intermittent catheterization

Types of urethral catheterization

Urinary catheterization may be classified as indwelling which may include urethral or suprapubic catheter insertion, external catheterization such as the use of condoms, short-term catheterization including intermittent catheterization (IC) as well as long-term catheterization.

Indwelling urethral catheterization

Short-tern indwelling urethral catheterization is usually performed as part of patient monitoring during the perioperative period, in the treatment for acute urine retention,

Figure 4: Tiemann tip coudé urethral catheter

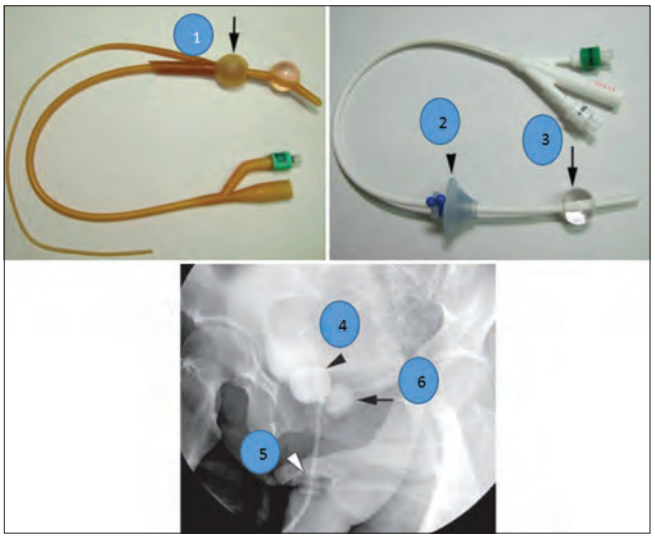

Figure 6: 1. Second (Proximal) balloon. 2. Retention plug at the urethral meatus prevents the backflow of contrast agent. 3. Silicone balloon occludes the bladder neck. 4. Double-balloon urethrogram obtained with a Madura catheter shows the urethral lumen is occluded distally by the second balloon. 5. Proximal retention plug. 6. Diverticulum with posterior extension

Figure 7: Trolley with minimum materials needed for catheterization. 1. Surgical gloves 2. Sterile gauze. 3. 2% Xylocaine Jelly 4. Povidone iodine solution. 5. Penile Clamp. 6. 100% 2-way Silicone catheter 7. 10ml Syringe. 8. Spigot. 9. Sterile water for injection. 10. Urine bag

in the acutely ill patient and following urological procedures and the duration of the *in situ* catheter is usually <24 days.[12,39]

Intermittent catheterization

IC is an accepted procedure in the management of chronic urine retention for patients with neurogenic bladder following spinal cord injury.[40-42] It has been a very valuable procedure in reducing the incidence of upper tract deterioration and subsequent renal failure in patients with spastic neurogenic bladder following spinal cord injury.[41] It may be performed as a sterile (nontouch), or clean technique depending on the place and the involvement of health personnel. When patients are being managed in the emergency rooms, health institutions, or rehabilitation hospitals in which it is aseptic IC while when performed by self or third parties, it is referred to as clean IC.[40] Sterile or clean IC may be performed using different catheter types such as red rubber, Lofric catheter, hydrogel coated, or prelubricated devices, which may be used singly or re-used several times.[43,44] However, a single-use intermittent catheter device is safer and offers a better quality of life to the patient.[45] A study, however, has demonstrated that single-use IC is more expensive; however, in poor-resource countries, the catheters may be re-used severally, and this has been documented not to pose significant adverse outcomes to the patients.[46]

Male external catheterization

The complications of long-term indwelling urethral catheterization, especially CAUTIs, occur as a result of the disruption of the normal anti-bacterial, anti-colonization mechanisms of the urethral mucosa as a result of the presence of the urethral catheter, and this has necessitated the need for external continence devices in men who do not have evidence of urinary outlet obstruction.[47,48] The external urine collecting devices are applied on the external genitalia or pubis for urine collection. These devices differ from urethral catheters, which are inserted into the urinary bladder, and these may be classified as condom catheters, re-usable body-worn urinals, or as a nonsheath, glans-adherent appliances.[49] The male external catheter is a simple rubber or synthetic sheath that is placed over the penis similar to a condom except that it has a plug to which a drainage tube is attached for urine collection.[50]

Indications for Urethral Catheterization

Urinary catheterization can be indicated for the following reasons:

Monitoring

Urethral catheterizing can be used to monitor urine output in patients in shock, patients in the perioperative period, and patients in the intensive care unit.[15,51] Monitoring the hourly urine output in these patients indicates the degree and adequacy of tissue perfusion in these states of hypovolemia.

Therapeutic indications

Urethral catheterization can be used to relieve urinary retention in patients with benign prostatic enlargement (BPE), following spinal or epidural anaesthesia, and in patients with neurogenic bladder. It is also used to empty the bladder during labour to facilitate delivery.[22,23] Retained blood clots can also be evacuated through urethral catheterization. It also allows for bladder irrigation in patients with haematuria.[15] Intravesical chemotherapy and immunotherapy are also administered through urethral catheterization.[15,22] It is also inserted to drain the urinary bladder and thus prevent any skin damage due to irritation by urine in patients with urinary incontinence.[52]

Diagnostic indications

Urethral catheter is used during the urodynamic investigation, retrograde urethrogram, micturating cystourethrogram, and videocystourethrography.[22,23] Furthermore, it can be used to obtain uncontaminated urine specimens and measure postvoid residual volume.[23,53]

Contraindications for Catheterization

Urethral catheterization should not be attempted in patients with priapism as this may lead to fracture of the corpus cavernosum, laceration, and bleeding.[16] It is also contraindicated in patients with urethral injury as it can convert a partial tear to a complete tear and create a false urethral passage.[16] Attempts at passing urethral catheter should not be made in patients with urethritis due to the possibility of transferring bacteria from the lower to the upper urinary tract and subsequent septicemia.

Selection of Urethral Catheters

The choice of the catheter to be inserted into a patient depends on age, sex, intended duration of indwelling (intermittent self-catheterization, short term or long term), nature of the fluid to be drained, availability and cost as well as the history of allergies to the catheter materials, especially to latex. The urethral catheter used in children may be the straight, nonretaining, or balloon self-retaining type, and the sizes range from 4.0 F to 14.0 from the newborn to 12 years of age.[54,55]

Techniques of Urethral Catheterization

Urethral catheters may be inserted and retained as an indwelling catheter or intermittently by the patient (intermittent self-catheterization) or the caregiver, depending on the indication for the procedure. Intermittent self-catheterization is the passage of a catheter to drain the bladder and the immediate of the catheter after the procedure.[56] On the other hand, indwelling catheters are inserted in acute settings or for long-term care situations for bladder drainage.[45]

Informed consent

Urethral catheterization is an invasive procedure, and thus informed consent must be obtained from all patients, including all consenting adults and children, unconscious, demented, or intellectually disabled adults from legal guardians.[18,52,57] This entails a detailed explanation by the physician or a qualified designee familiar and knowledgeable of the procedure, the nature of the medical problem, the benefits and probable risks/complications of and alternatives to the procedure as well as postcatheterization care.[58]

Urethral catheter insertion

Insertion of a urethral catheter may be challenging, and hence, an assistant is needed.[18] Due to the anatomic variation between males and females, different techniques are required during the catheterization of either gender.[51] Catheterization is an aseptic procedure, and therefore, some form of training is needed. Indwelling urethral catheterization should only be considered after considering alternative forms of patient management, and the indication for catheterization and care should be documented.[58] The choice of the catheter will be based on the indication for the procedure, the anticipation of how long the catheter will remain in place, and the clinical experience of the physician or nurse.[58] The following are needed for a successful catheterization: trolley two pairs of surgical gloves, gauze pack, normal saline, povidone-iodine or other suitable antiseptics, appropriate size catheter and urine bag, water for injection, drape, penile clamp, anaesthetic gel such as 2% lignocaine, 20 ml and 10 ml syringes, adhesive tape, gallipot or small kidney dish, and sharp box container [Figures 7 and 8]. A sterile field with good illumination is set up with the male patient lying supine (however frog-leg position in females) on a firm flat surface. Hand hygiene and gloving are performed, and the patient is draped to expose the penis in the male patient.[51] It is important to test the integrity of the catheter balloon and the balloon port by inflating and deflating the balloon and looking out for any leaks. Using a one-hand technique, the nondominant hand holds the penis at 90° while the dominant hand that only makes contact with the sterile field is used to clean the urethral meatus and the glans penis. Sterile normal saline can be used to clean the meatus/glans penis. Still, we routinely use povidone-iodine for that purpose.[18,52,58] The urethra is then generously lubricated and anaesthesized with anaesthetic jelly. The jelly is introduced into the urethra via the meatus using a syringe or the funnel cap attached to some of the jelly tubes.[18] The jelly is then milked proximally down the urethra while occluding the glans.[30] The use of at least 20 ml of 2% lignocaine jelly is recommended to ensure that it reaches the prostatic urethra, which is often the most difficult portion to negotiate and often the tightest segment.[18] A penile clamp is then applied to the glans penis to maintain the gel in the urethra for at least 15 min. Where a penile clamp is not available, the dominant hand is used to maintain the distal urethra occluded for the said duration. To insert the urethral catheter, the first set of sterile gloves is discarded, and the second set is now put on.[16,18] The penis is then held with the nondominant hand at about 90° in an upright position in line with the normal anatomical curve of the urethra so that the pathway for the catheter is straight.[16] When manipulating the catheter, the catheter is grasped near the tip and looped back over the gloved hand, holding the distal end of the catheter between the palm and the tips of the fourth and fifth fingers to prevent contamination of the sterile catheter.[16] The end of the sleeve covering the catheter is gradually removed while gently advancing the catheter into the urethra. Asking the patient to cough may help relax the sphincter momentarily to allow smooth passage of the catheter.[18] Our experience has shown us that asking the patient to breathe deep also serves a similar purpose. If any resistance is encountered while advancing the catheter, gently lower the penis from its vertical position instructing the patient to cough which will facilitate its passage through the curve of the bulbar urethra.[16,18] The catheter is advanced into the bladder until the "Y" junction of the catheter reaches the urethral meatus. When the catheter is advanced 7–12 cm, the phallus is lowered to the level of the anterior abdominal wall. Once urine flows through the catheter, the urine bag is attached to the catheter. The catheter balloon is inflated with an amount of sterile water indicated on the catheter channel. The catheter is then drawn backward until there is resistance; at this point, the balloon is resting on the bladder neck. The colour and volume of urine drained should be noted. A urine sample should be sent for microbiological and chemical analysis in two separate sample bottles.[16,18] Occasionally, urine does not flow upon reaching the "Y" junction of the catheter, and this may be due to kinking of the catheter within the urethra, jelly blocking the catheter eyes, false passage, or occlusion of the catheter bag valve.[52] On reaching the "Y" junction of the catheter, if no urine flows, the operator should

Figure 8: 2% Xylocaine jelly (local anesthetic and lubricant)

wait for five minutes to see if any drainage occurs or ask the assistant to apply gentle pressure on the suprapubic region to open up the catheter eye, which the jelly may have blocked.[16] If urine fails to drain, most often arising from the generous lubricant jelly occluding the eye of the catheter which can be resolved using a 20-ml syringe loaded with normal saline to flush the catheter. If urine fails to drain despite this maneuver, the position of the catheter balloon can be ascertained with the aid of an ultrasound scan if a bedside ultrasound is available; otherwise, the catheter should be removed and attempt at re-catheterization done. The balloon should not be inflated without seeing urine flowing through the catheter. This may inflate the balloon within the urethra, thus causing an iatrogenic urethral rupture and the consequent trauma, stricture formation, or posterior urethral stenosis. The use of fluids other than sterile water to inflate the balloon should be avoided. The use of Savlon® (cetrimide + chlorhexidine gluconate) to inflate the retention mechanism of the catheter is strongly discouraged as this may lead to chemical cystitis should the balloon be ruptured during removal of a retained catheter. Furthermore, using normal saline or other crystalloids to inflate the balloon is discouraged. These liquids can crystalize within the balloon and make deflating the balloon difficult, especially when used for long-term indwelling catheterization.

Documentation

Following successful urethral catheterization, details of the procedure should be documented, including the date and time of catheterization. Other information to be documented include the type of catheter, size of catheter, batch number, expiry date, amount of fluid used to inflate the balloon, indication for catheterization and identity of the health worker and that of the assistant, and whether urine microscopy, culture, and sensitivity were requested.[16,18]

Female urethral catheterization

The slight variations in female catheterization are that the female patient is placed supine (frog-leg position) with the knees flexed while the hips are flexed and externally rotated.[18] The labia majora, labia minora, clitoris, urethral meatus, and vagina are cleaned using a water-based antiseptic such as chlorhexidine.[18] This is done with an antiseptic-soaked gauze which is swiped from up downward and discarded. The use of anesthetic jelly is not mandatory as the female urethra is short.[18,23] Therefore, a water-based lubricant such as KY jelly can be applied to the tip of the catheter. The labia are spread apart using the thumb and the index finger of the nondominant hand to expose the urethral meatus, which is located between the clitoris and the vagina. It is important to note that the urethral meatus may be displaced slightly behind the pubic bone in older patients with vaginal atrophy and resorption of supporting retropubic fat, and this maneuver makes the urethra better appreciated in the full lithotomy position.[18]

Urethral catheterization in children

Urethral catheterization is indicated in children, whether male or female, for various diagnostic, therapeutic, and monitoring indications as having been previously documented in this article.[15,22,23,52,53,59] Appropriate informed consent must be obtained from the parents or legal guardians for the younger children and from the patient in those who can understand the implications.[54] The presence of the parents or legal guardian during the catheterization procedure is essential as it relieves the child's anxiety, thus providing a more conducive atmosphere.[60] The appropriate catheter size must be selected based on the age and weight of the patient, as has been documented in the literature.[61,62]

The child should be made comfortable in the presence of a caregiver/parent, supine position for girls and the legs in frog-leg position while an assistant restrains the legs gently and firmly.[60] The external genitalia is cleansed with soap and povidone-iodine solution, after which there is the installation of 10 ml of 2% lidocaine jelly through the external meatus of boys while in the perimeatal area of the girls.[54,60,63] The use of local anaeshetic jelly has been found to reduce patient discomfort during the procedure.[64] In the uncircumcised male, the prepuce is retracted to expose the external meatus however if it is still difficult then the catheter can be inserted gently through the opening on the foreskin.[65] In the female child, after identifying the urethral meatus, the distal end of the catheter is lubricated, gently introduced, and advanced into the bladder.[66,67]

Complications of Urethral Catheterization and Prevention

Inserting and maintaining indwelling urethral catheters though for therapeutic, diagnostic, or monitoring value may be associated with certain infectious and noninfectious complications that may impair the subjects' quality of life.[3] These complications may arise from the technique of insertion, trauma of passage through the urethra, and the body's response to the foreign material of the catheter. The impairment of regular filling and flushing out of urine and the disruption of the integrity of the standard defense mechanisms of the urinary system against the adhesion and proliferation of microbes may be responsible for the infectious complications of urethral catheterization.[68] In addition, complications may arise from catheter malfunction, changes in the urothelium as well as the psychosexual reaction to the presence of the urethral catheter by the patients.[3,69,70]

Difficult and failed urethral catheterization

Urethral catheterization may be performed on both male and female subjects smoothly without difficulties. However, in some subjects more commonly in males, it is associated with difficulty. DUC is characterized by the failure to insert the catheter into the urinary bladder after multiple attempts and the consequent onset of certain complications.[66,67] The aetiology of DUC may be a result of the existence of certain normal, abnormal anatomic variations in the patient as well as technical factors in the male such as urethral stricture, bladder neck contracture, benign prostatic hyperplasia, buried penis,

penile edema, phimosis, meatal stenosis, and tightening of the sphincter in anxious patients.[71,72] In female subjects, DUC may result from previous vaginal surgeries, childbirth, pelvic organ prolapse, obesity, and postmenopausal vaginal atrophy.[73]

Several guidelines and approaches have been devised for the management of patients with DUC.[20,74,75] These approaches consist of a brief urologic history and physical examination to determine the probable cause of DUC and to rule out trauma to the urethra, which is a contraindication to further attempt at urethra catheterization.

In the female patient, the inability to identify the meatus as a result of obesity and postmenopausal vulva atrophy will require adequate visualization and access to the introitus by the better placing of the patient in the Trendelenburg position, use of a vaginal speculum, use of head-lamp for lighting, and the physician placing a finger into the vagina below the clitoris to enable placement of the urethral catheter.[72,76]

In the males with DUC, due to difficulty in accessing the meatus as may occur in penile edema, phimosis may be managed by application of Coban dressing around the penis, thus exposing the meatus, application of lubricating jelly, and extension of the foreskin, to allow for urethral catheterization.[77] DUC and failed urethral catheterization occurring due to the inability of the catheter to gain entry into the bladder are managed by generous lidocaine jelly installation, lubrication, and administration of mild sedatives. When there is a failure of the above, the passage of 16F or 18F coude tipped catheter may be done.[76]

Other techniques that may be instituted for the management of DUC involve such nonendoscopic procedures consisting of the use of guidewires introduced into less rigid small 12F, 14F catheters, such as the Liss maneuver and its modifications.[78-81]

Attempts at a blind passage of urethral catheters for DUC may be associated with injuries, and for this, a variety of endoscopic techniques have evolved that allow for direct visualization of the location, source, and type of obstruction.[20,76] The endoscopic techniques enable visually directed placement of the catheter and reduction in the incidence of urethral injuries in patients with DUC.[82,83]

Urethral trauma

The length of the urethra, its tortuosity, and the presence of pathological conditions such as BPE, and urethral stricture, among others, make the male urethra prone to injury during catheterization.[84] Therefore, a wrong technique of catheterization together with the challenges of the anatomy of the male urethra and BPE are the significant reasons behind traumatic catheterization by nonurologic staff.[84] Urethral trauma can occur during the insertion or removal of a catheter. Accidental inflation of the balloon inside the urethra is a common cause of trauma. This leads to pressure necrosis with subsequent bleeding when the catheter is removed. It may occur due to balloon inflation before reaching the "Y" junction of the catheter and seeing urine flow out of the catheter. Trauma can also occur when the catheter is pulled out of the urethra without deflating the balloon intentionally by an anxious patient or accidentally by stepping on the urine bag. Furthermore, the application of too much force during catheter insertion can create a false passage, usually at the bulbar or prostatic urethra level.[84] Another cause of urethral trauma is biofilm encrustation of the catheter, which makes the surface of the catheter rough and sharp edged, which can cause abrasion or laceration of the urethra during removal.[85]

Bladder spasms

This is more common when the balloon is overinflated, resulting in irritation of the bladder trigone. It is advisable to reduce the balloon volume or replace the catheter with a smaller size catheter and balloon. If spasms persist, anticholinergics such as tolterodine or oxybutynin can be used to control spasms.[25,27,52]

Catheter blockage

One of the most familiar problems patients face with an indwelling urinary catheter is an encrustation of the catheter, which leads to catheter blockage and sometimes pericatheter leak.[15] This can cause significant discomfort and anxiety for the patient and the caregiver. Catheter encrustation occurs due to the precipitation of calcium phosphate and magnesium ammonium phosphate salts in alkaline urine.[15] Therefore, the acidification of urine is an essential preventive strategy. This includes using acidic bladder washouts (citric acid solutions) or systemic agents such as Vitamin C.[15] The urethral catheter may also be blocked by occlusion of the catheter eyes by the bladder mucosa due to hydrostatic suction. Gentle instillation of 20–30 ml of sterile water or saline into the catheter may unblock the catheter, or the urine drainage bag can be transiently raised above the bladder level to minimize the level of suction and free the mucosa.[15] Patients on the urethral catheter are also advised to drink a lot of fluid to wash out any debris in the bladder.

Catheter-associated urethral stricture

The mechanism by which a catheter causes urethral stricture is multiple. The size of the catheter is one of the factors implicated as large-sized catheters can cause occlusion of the periurethral glands, thereby causing retention of urethral secretions, which may become infected, and this may result in stricture formation.[86] Another mechanism thought to be responsible for stricture formation is a latex allergy, as it has been observed that some individuals develop urethral stricture even following a brief period of catheterization. Most of these strictures from latex allergy are long segments involving both the penile and bulbar urethra (pan urethral strictures).[86] The third mechanism is trauma due to either poor catheterization technique or an inappropriate large-size catheter. Most of these injuries occur in the bulbar urethra close to the penoscrotal angle.[86] The use of small-sized pure silicone catheters, and good insertion techniques, including generous use of local anesthetic lubricating jelly, can minimize the onset of iatrogenic urethral injury.

Catheter-associated urinary tract infections

This is an important cause of patient morbidity, mortality, health-care cost, and length of hospital stay.[17] About 25% of hospitalized patients have a Foley catheter, and CAUTIs represent the highest number of infections in hospitalized patients.[17] According to the National Healthcare Safety Network, CAUTI is defined as the presence of an indwelling urinary catheter for at least two days associated with bacteriuria with not more than two organisms, at least one of which is >100,000 CFU/ml (excluding yeast) and one of the following: fever (≥37.3°C), suprapubic tenderness, costovertebral angle pain/tenderness, or urinary frequency, urgency, and dysuria in patients whose catheter has been removed in the previous 24 h.[87] Catheters are frequently colonized by bacteria, but patients do not continually develop symptoms. Therefore, treatment should only be instituted in symptomatic patients.[18] The bacteria responsible for CAUTIs are found on the catheter in biofilm, which provides them with protection and less accessibility to antimicrobial therapy.[88] There is no proven strategy to prevent CAUTIs; however, one of the best options is the proper handling of the catheter and observing strict asepsis. Other recommendations are avoiding unnecessary use of catheters and their removal once they are no longer needed.[88]

Several efforts have also been made to reduce biofilm formation, including impregnating the catheters with antibiotics/antifungals, chlorhexidine coating, and the use of the silver-alloy coating.[88,89]

Retained urethral catheter

The inability to deflate a self-retaining balloon catheter is one of the recognized complications of urethral catheterization. The urethral catheter balloon may fail to deflate and becomes retained due to malfunction of the balloon valve. Furthermore, the encrustation of the balloon and occasionally forming stone around the balloon may prevent the balloon from deflating.[90] Blockage of the inflation channel with blood-contaminated fluids or physiologic saline can also result in a retained catheter.[91,92] Many approaches have been described to remove a retained catheter; however, whichever technique that is chosen by the physician should not cause additional discomfort or morbidity to the patient.[91] Bypassing the valve by using a syringe and needle to withdraw the fluid or cutting off the valve to allow the fluid within the balloon to spontaneously egress is a commonly performed method. Occasionally the deflation of the balloon is slow and gradual and may take some time. Furthermore, the stylet of a ureteric catheter can be passed up the balloon inflation channel to re-establish the patency of the channel or rupture the balloon.[91,93] The catheter balloon can also be ruptured or deflated by puncturing the balloon through the suprapubic, transvaginal, transurethral, or transrectal route under appropriate ultrasound guidance.[91,94] In the past, physicians have used the method of overinflating the balloon to rupture it. However, this method is discouraged as it can cause discomfort to the patient, and the balloon fragments can serve as a nidus for the formation of a stone. The fragments are often too large to be evacuated by bladder irrigation, and cystoscopic intervention may be required.[91] Another method that has been employed is the use of chemicals to disrupt the balloon. Various chemicals have been used to disrupt the balloon, such as ether, liquid paraffin, chloroform, and mineral oil, instilled into the balloon through the inflation channel.[91] These agents disrupt the balloon by forming multiple small balloon fragments, which can be cleared either by spontaneous voiding or bladder irrigation.[91] It has been reported that following the instillation of ether *in vitro*, the bursting time is between 3.88 and 8 s. Similarly, chloroform disrupts the balloon within a short time.[21] However, both chemicals produce gas and liquid spillage, resulting in pain and discomfort, especially in patients with a blocked catheter.[91] Rarely, ether can cause severe chemical cystitis with subsequent contracture of the bladder.[91] When liquid paraffin is used, about 20–30 min is needed for the balloon to rupture. It is recommended to instill 10 ml of mineral oil and instill an additional 5–10 ml if the balloon fails to deflate after 15 min for 30 min.[91] Mineral oil might be preferred due to its safety profile and availability.[91] However, in some instances, the catheter will fail to come out despite all maneuvers, and surgical removal of the retained catheter will be warranted. This is especially true when a stone has formed around the catheter balloon.

Psychosexual complications of urethral catheterization

Sexual function impairment following indwelling urethral catheters may arise due to the disease process, such as spinal cord injury that necessitated the procedure or maybe due to the psychological response to the presence of the urethral catheter.[95] Urethral catheter can be disabling affecting the sexual esteem, masculinity or feminity with the associated pain and discomfort in those who desire to have sex despite been insitu.[70] Some subjects with urethral catheters report the feeling of shame, embarrassment, stigmatization, vulnerability, and loss of body image.[96]

Bladder cancer

Prolonged use of indwelling urethral catheters is a causative factor in bladder cancer, and this is more common in patients with spinal cord injury as well as nonspinal injured catheterized patients.[97-99] Pathogenesis of bladder cancer consequent on prolonged urethral catheterization is due to the synergistic effects of chronic urothelial irritation, recurrent urinary tract infections, chronic inflammation, and the body's immunologic response to the presence of urethral catheter, which is a foreign material.[100,101] The urothelial response to the prolonged presence of the catheter includes eosinophilic inflammation, focal, diffuse lymphocytic infiltration, diffuse eosinophilic polymorphonuclear infiltration, which macroscopically appears as papillary mucosal polypoid cystitis, and the degree of severity depends on the duration of catheterization.[102] The above processes result in squamous epithelial metaplasia, leading to squamous and transitional cell carcinoma of the urinary bladder.[103]

The prevention of the complications of urethral catheterization should focus on training of health workers with a view at

proper techniques of catheter insertion, adherence to procedural asepsis, proper choice of appropriate size catheter, product specification, adequate lubrication, avoidance of prolonged indwelling times and the use of antimicrobial and antifouling modified catheters.[36,37,104,105]

Conclusion

Urethral catheterization is a frequently performed procedure carried out by different cadres of health workers for a variety of therapeutic, monitoring, and diagnostic indications. Selection of appropriate size, type, design, and commensurate training of the medical staff are necessary to prevent complications associated with the procedure. Recent modifications of catheter design, including coatings, impregnation with antiseptics, and antibiotics, have resulted in a smoother passage, better patient comfort, and a reduction in CAUTIs.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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