6

Catheters and Infections

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1. Introduction

Catheters are used for effective drainage of the bladder, either temporally or permanently, in the presence of physiological and anatomical defects or obstruction of the lower urinary tract. Catheters are used for a variety of reasons, as follows, to maintain bladder drainage during and following surgery or epidurals anesthesia for minimizing and prevention of the risk of distension injuries; investigations, for accurate urine output measurement, and measurement of post-micturition residuals; treatments, to relieve urinary retention or for chemotherapy instillation; intractable incontinence, as the final option for containment.

2. Urethral catheterization

Urethral catheterization is a routine medical procedure that allows direct drainage of the urinary bladder into an attached bag or container. It consists in the insertion of a catheter into a patient's bladder.
Urinary catheterization is employed in hospital and nursing home settings to maintain urine output in patients who are undergoing surgery, or who are confined to the bed and physically unable to use a bedpan. Critically ill patients who require strict monitoring of the urinary output are also frequently catheterized. Urethral catheterization may be performed as either a therapeutic or a diagnostic procedure. Therapeutically, catheters may be placed to decompress the bladder in patients with acute or chronic urinary retention. In addition, catheters may be placed to facilitate bladder irrigation in patients with gross hematuria. Diagnostically, urinary catheters may be placed to obtain an uncontaminated urine sample for microbiologic testing, to measure urinary output in critically ill patients or during surgical procedures, or to measure post-void residuals. The only absolute contraindication to urethral catheterization is known or suspected urethral injury, usually in the setting of a pelvic fracture.
Surely these interventions were performed already long time before recorded history. Although in the most ancient medical writings, such the code of Hammurabi -1700 B.C.- (1), there is no clear mention of catheterism, the condition of urinary retention is well described in an ancient Chinese medical text, the Huang Ti Nei Chingh Su Wen (mentioned in the Annals of the Former Han Dinasty- 206 B.C. to 25 A.C., but referred to a much earlier origin). It is a sort of dialogue where the emperor (Huang Ti) poses questions to a minister, whose answers convey a clear sense of organ-based pathology: "(…) When the bladder does not function efficiently, it causes retention of urine; when it functions without restraint, it causes copious urination" (2). If urinary retention was so specifically identified and

described, it is likely that it was treated with catheterization: the technology was available. For instance, hollow leaves of Allium Fistolosum, an onion plant, coated with laquer, were used as catheters in China around 100 B.C (3). The Sushruta Samhita, an early Indian surgical text dated approximately around 1000 B.C: describes tubes of gold, silver, iron and wood smeared with ghee (liquid butter) for evacuation of urine, management of strictures, instillation of medication and for assistance in lithotomy. Sushruta suggest also that "wine should be used before operation to produce insensibility to pain" (4).

Urethral catheterization is then always well described among the medical writings of the first millennium and the Renaissance, even if it was not even mentioned by one of the most famous scientists ever, Leonardo da Vinci. During this period the main factor driving the need for diagnostic and therapeutic catheterization was the bladder stone. Even Benjamin Franklin, in a letter written on December 8th, 1752, described a flexible silver catheter he designed for his older brother John, who suffered from bladder stone. This device was made from a flat silver wire, wound spirally and then covered with waxed threadbound parchment (5). In 1756 Heuermann provided a good description of catheter therapy for benign prostatic hypertrophy, and during the next 150 years, according to Laurisden, this method was "absolutely Paramount" (6).

Industrialization brought about the manufacturing ability to make better surgical instruments as well as the scientific means to fit the tool to the task: the configuration of the catheter was investigated by anatomical studies, and the designs of past millennia were for the most part found appropriate. The Goodyear patent for moldable hard rubber in 1851 permitted faster and cheaper production of catheters: Auguste Nelaton, physician to Napoleon III, introduced a flexible rubber catheter in 1860 (7). Mercier the coudé catheter in 1836 and the bicoudé in approximately 1841, with one or two bends near the tip respectively. By the late 19th century a wide armamentarium of catheters was available to the practitioner. George Tiemann's catalogue of surgical instruments listed nearly 80 different types of catheters. Special types were used for various purposes in cases of urethral strictures, stones or foreign bodies, and for evacuation of urinary retention, irrigating and distending the bladder (8). The development of the balloon catheter has been documented by Zorgniotti, who traced it back to Reybard's device in 1853. Foley (1891 to 1966), an ingenious American urologist, devised a balloon catheter for haemostatis in prostatic surgery (9). He demonstrated the first production model at the annual meeting of the AUA in 1935. Although a different company (the Davol Rubber Company) retained the rights to the balloon catheter after applying a key patent five months later, the "Foley" name has become universally synonymous of self-retaining balloon catheter.

By these times, lacking the scientific justification of the germ theory, medical practitioners, except for a few ones, had little interest in cleanliness around wounds. Joseph Lister experimented with urine putrefaction, and found out that was normally sterile and had an uncanny sense of host resistance (10). After his studies and the similar ones performed by Roberts, clean techniques and antiseptic principles became standard practice, and urethral catheterization thereby achieved another degree of safety (11).

3. 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 a saline solution to form a sonoluscent structure, prior to a pelvic ultrasound.

4. 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. Moreover urethral catheterization enables measurement of intra- and post-operative urine output and eases post-procedure patient care. Intermittent or short-term catheterization may be helpful in treating bladder neoplasms (Cytotoxic drugs and BCG may be administered intravesically), and mycotic infections (Amphotericin in fungal cystitis).

Surely the primary care of any patient with acute urinary retention (that may arise from a variety of causes) is urethral catheterization: temporary decompression of the bladder through an indwelling catheter may be necessary until resolution of the primary cause of the retention.

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. 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 moist and infection-free environment.11

5. Long-term therapeutic uses (> 6 weeks)

In selected cases of urinary incontinence not responding to conservative treatments Clean Intermittent Catheterization (CIC) may be carried out. This will maintain mobility and renal function, and minimize residual urine, infectious complications and calculus disease. In this setting another application of CIC is represented by the presence of a poorly contractile bladder that 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 CIC.

During the last ten years CIC has become the standard care in patients with spinal cord injuries. 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. In these cases CIC or continuous bladder drainage may also be helpful for incontinent patients, immobile subjects due to aging or finally in cases of terminal illness. However, continuous drainage should be used rarely, and only as a last resort.

6. Catheter characteristics

Urethral catheterization is the most frequent retrograde manipulation performed on the urinary tract. Catheters are placed to drain the bladder during and after surgical procedures,

to assess urinary output in critically ill patients, to collect reliable urine specimen and to assess post voiding residual urine. Such catheters can be left indwelling with a self-retaining balloon or used for clean intermittent catheterization procedure.

The choice of a specific type of catheter depends upon the reasoning of catheterization. Large-caliber catheters are used to evacuate potential blood clots or to assess urinary output. Other catheter variables include balloon size and construction materials. In this way large balloons can be inflated to help hemostasis after transurethral resection of the prostate or in case of open prostatectomy. Sometimes the standard latex catheter can result in severe reactions in patients with latex allergies and silicone varieties are good alternatives in such situations. In particular the silicone catheters are usually manufactured with several grooves placed on the surface of catheter itself to allow an interface between the catheters and the urethra and thus avoiding the possibility of infection in the short term (1). Therefore the catheters can be distinguished by the shape of the tip, the characteristics, the diameter, the number of ways and the materials.

Straight rubber or latex catheters often referred to as Robinson catheters, are straight catheters used for short-term catheterization, as in measurement of residual urine and instillation of medication chemotherapeutic agents or in case of radiological evaluation of the bladder. The tip of the Robinson catheter is rounded, with one or two drainage ports along the side. Self-retaining catheters like the Pezzer and Malecot catheters, are shaped in such a way that after placement at open surgery the catheter configuration maintains the catheter within a hollow viscus (Fig.1a). The advantage of these catheters include the excellent urinary drainage and the tip design, which make them ideal for use as cystostomy or nefrostomy tubes. Foley-types catheters are most often used for long-term urethral catheterization.

The catheters are often named according to the characteristics of the proximal tip as follows:

1. The Nelaton catheter is the standard catheter and has a rounded and straight proximal end. It has two lateral eyes for drainage (Fig.1b).
2. The Mercier catheter has a rounded and angular (30-45°) tip. The angle helps the introduction of the catheter in the membranous or prostatic urethra (Fig.1c).
3. The Tiemann catheter can have a cone shaped tip, which can be straight (olive-tip catheter) or angular (Fig.1d).
4. Couvelaire catheter is used in case of bladder hemorrhage or after a urologic surgical intervention because it guarantees an efficient drainage. The structure can be rigid or semi-rigid and it has one drainage eye at the end and two lateral eyes (Fig.1e).
5. Dufour catheter (semi-rigid, self-retaining) has three ways. The tip has a 30° curve, is open and with two staggered drainage eyes. It is used in case of gross haematuria (Fig.1f).

External diameter is sized by Charrièr (1CH=1/3mm). The size of the catheter is selected according to specific clinical use. The length of catheter is usually 420mm for male, 260mm for female and a shorter for pediatric patients. In clinical use the size of the catheter should guarantee a safe urine drainage without damaging the urethral mucosa and avoiding infections, stricture or scarring causing stenosis. The use of smaller than 14Ch is recommended in contrast with large catheter that increases the risk of blockage of paraurethral glands causing urethritis or other ascending infection. Silicon or silicon-coated catheters produce less tissue reaction and less encrustation than rubber catheters(2). They also have a larger lumen diameter than catheters made of rubber and thus are preferred by some for long-term indwelling catheterization.

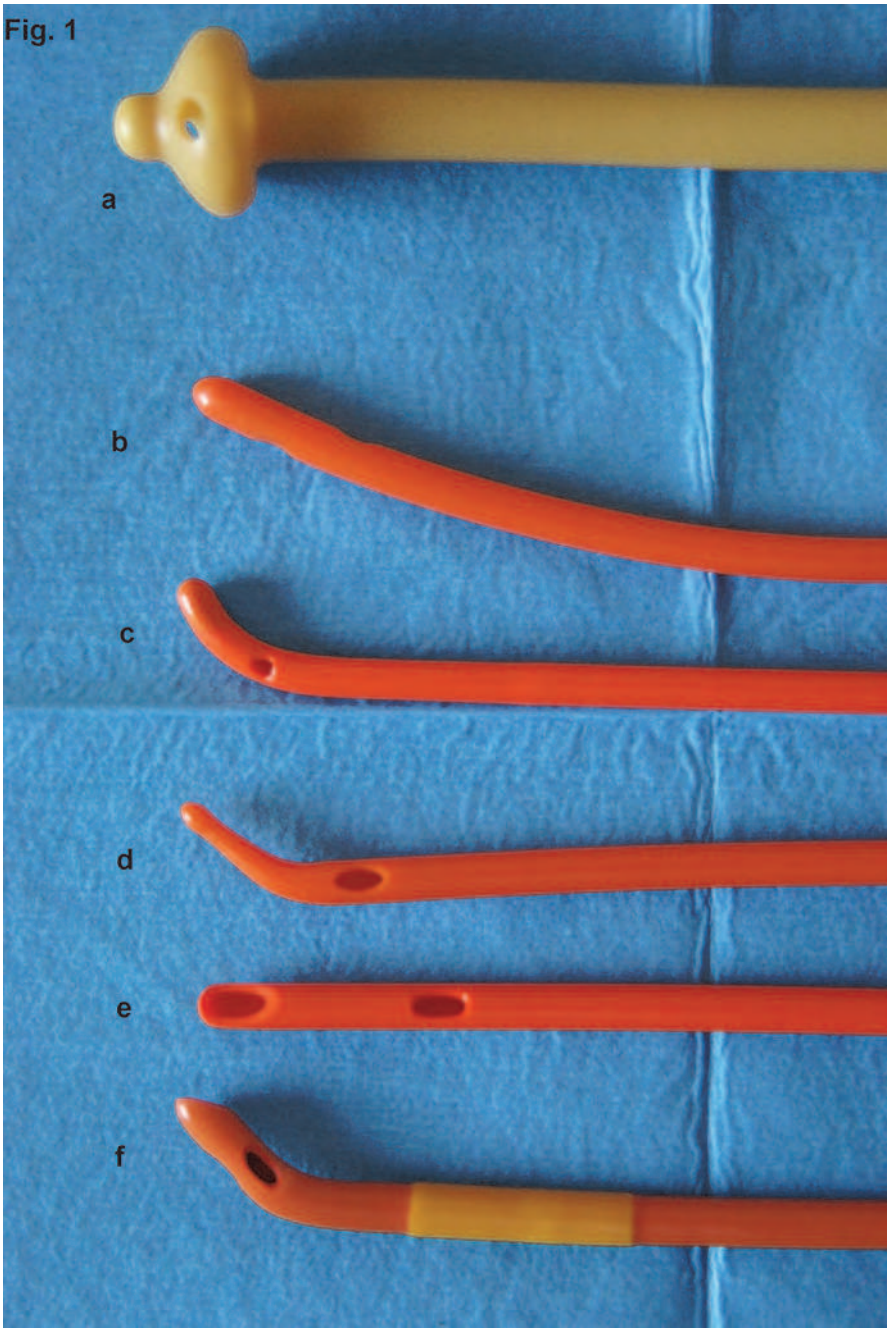

Fig. 1. Types of urinary catheters : a) Pezzer self-retaining catheter; b) Nelaton catheter; c) Mercier catheter; d) Tiemann catheter; e) Couvelaire catheter; f) Dufour catheter.

Catheters can have one, two or three ways. In two ways catheters, one way provides urine drainage, the other way which is provided with a valve allows the inflation of a balloon that is inserted in the bladder to keep the catheter securely in place. Three-way catheters have a small lumen inflating the balloon mechanism, a lumen for instilling irrigant and a larger lumen for bladder drainage. Silicone, PVC and latex are the most used materials to produce catheters. Latex and PVC are mostly used for short-term catheters or in intermittent catheterization. Silicone is more used for long-term catheters because it is considered to be biocompatible and it is recommended for patients who are allergic to latex. Different catheter surfaces, such as latex, silicone, or Teflon, have not been shown to alter the frequency of urinary infection. Silicone catheters may be less likely to become blocked by encrustations due to prolonged use (3,4). In this way it seems to be evident that the use of silicone catheters are less prone to infections. Thus, silicone catheters, which tend to be more expensive, should be reserved for residents shown to have a consistent problem with repeated catheter obstruction. In this context P aeruginosa had a higher rate of adherence to Teflon or silicon catheters than other gram-negative species. (5) Conflicting results describing the effectiveness of antimicrobial-coated catheters, including silver-coated catheters, in preventing infection for short-term catheters have been reported. These materials are likely to be less effective for long-term catheters, because duration of catheter use is such an overwhelming determinant for infection. Catheters available today have a roughly engineered surface that is extremely vulnerable to blockage by crystalline biofilms and therefore we hope that in the future new biomaterials, which limit biofilm formation, will be developed.

7. Urethral catheter and related infections

7.1 Epidemiology

The catheterization is widely used to relieve anatomic or physiologic obstructions, to provide a dry environment for comatose or incontinent patients, and to permit the accurate measurement of urine output in severely ill patients. Unfortunately, when catheters are used inappropriately or when left in place too long they increase the risk of asymptomatic bacteriuria and urinary tract infection (UTI). The catheter-associated urinary infections (CAUTIs) have been reported to increase mortality and have a considerable economic impact. For these reasons catheter should be removed as soon as possible in order to prevent the risk of infection. Urinary tract infections account for 20 to 40% of hospital-associated infections, and an estimated 80% are associated with urinary catheter. The majority of studies say that 10 to 30% of people who are catheterized for a short period develop bacteriuria (often asymptomatic) and that after 30 days of catheterization bacteria can be found in the urine of all patients. The infections provoked by the use of a short-term catheter may prolong hospitalization by 2.4 to 4.5 days, and are likely to be associated to an increase in nosocomial mortality. Asymptomatic bacteriuria converts to symptomatic in approximately 24% of patients(7). Long-term urinary catheters are a leading cause of morbidity in acute care settings, accounting for up to 40% of hospital-associated infections (8,9). Within the hospital environment, the intensive care unit has the highest prevalence of nosocomial infections with estimated rates of 8–21% for nosocomial UTI of which 95% are catheter-associated(10). The daily incidence of bacteriuria in catheterized patients is approximately 3–10%. Among patients with bacteriuria, up to 25% will develop symptoms of local UTI, and about 3% will develop bacteremia (11). Catheter-associated UTI is the

second most common cause of nosocomial bloodstream infection. Patients who develop nosocomial UTI have their hospital stay extended by approximately 3 days and are nearly three times more likely to die during hospitalization than patients without such an infection. The case-fatality rate from UTI-associated bacteremia is approximately 13% within severely ill patients at highest risk (12,13).

It Deserves a mention the CIC has emerged as the most practical to ménage urinary emptying dysfunction and reduces significant lower urinary tract infection. CIC has been effective in managing patients with spinal cord injury, diabetes, multiple sclerosis, outlet obstruction and continent urinary diversion. This management technique is not without complications, including urethral trauma, increased urinary infection, stone disease and even progression of the upper urinary tract deterioration that the management technique is attempting to prevent. A controversy has surrounded the concept of CIC vs. sterile technique from the beginning of its use. Regarding bacteriology and urinary tract infections and even for CIC most authors conclude that in the still existing light of many controversies in bacteriology and management of infections, CIC is an acceptable way of voiding a neuropathic bladder, enabling a voluntarily induced balanced micturition within a shorter period of bladder training, having less aggressive urinary tract infections by reducing the residual urine volume and last but not least assisting continence and avoiding unaesthetic leg-bags, aggressive indwelling catheters or irritating external urine collecting devices such as diapers. In his publication Kuhn observe that after CIC, in 13 out of 46 patients (28%) the type of bacteria in the urine did not change from that of the first bacteriological control. Antibiotic prophylaxis is probably ineffective in preventing symptomatic urinary tract infections. Recent Cochrane library reviews conclude that the current strength of evidence is weak and well-designed studies are strongly recommended. Based on the current evidence, it is not possible to state that any catheter type, technique or strategy of self-catheterization is better than another in prevention of infections. The sterile versus clean technique question is of relatively low importance because in community settings (where most IC takes place) a sterile technique is not practical. In hospital settings rising concerns about infection control indicate that a sterile technique would be needed for safety (14,15) In any case intermittent catheterization is a commonly recommended procedure for people with incomplete bladder emptying not satisfactorily managed by other methods.

7.2 Pathogenesis

Indwelling urinary catheters are used for short-term (<14 days mainly in hospitals) and long-term (>30 days mainly in nursing homes and home care) urinary drainage (16). Short-term catheterization usually results in bacteriuria that rapidly clears after removal of the catheter, especially with antibiotic therapy. Symptomatic urinary infection or febrile episodes are more commonly associated with long-term catheterization. An indwelling catheter impairs normal host defenses both by promoting increased access of microorganisms to the bladder and by compromising complete voiding. Generally, infection is introduced via two routes after catheterization: the intraluminal route via the inside lumen of the catheter, or the trans-urethral route between the catheter and the urethra. The infections that arise with catheterization are caused by bacteria from patient's body or colonic flora and by bacteria found in the hospital setting. Bacteria can invade the lower urinary tract along the surface of the catheter or by its lumen. Bacteriuria that occurs during short-term catheterization is usually caused by a single organism. The most commonly isolated pathogen its *Escherichia-coli* and *enterococci*, *pseudomonas*, *enterobacter*, *staphylococcus*

aureus or *epidermidis, klebsiella* and *serratia*. In the long-term catheterization common urophatogens include *Escherichia-coli, Pseudomonas aeruginosa* and *proteus mirabilis(17,18)*. Many of these pathogens develop a multiple antibiotic resistance and they could adhere to the catheter surface, in these case the catheter becomes a reservoir for the pathogens. The reason why bacteria migrate through the catheter into the bladder without being expelled by the urine is still not clear. Urine has a cleaning action that protects the bladder from backwards invasion of skin pathogens, which is why healthy subjects do not get an infection if bacteria is injected in the bladder. Most probably the reason why bacteria are not expelled in UTIs associated with catheterization is the adhesion of bacteria to the bladder urothelium. Epithelial cells in the bladder usually are coated with Lactobacillus that are not invasive nor virulent but can prevent virulent organisms from sticking to the bladder wall (19). When the coat of the cells is missing, colonization of bacteria and infections of the lower urinary tract begin. The mechanism is therefore strictly related to the adhesion of bacteria to the bladder during catheterization. Analysis with electron microscope of the surface of catheters show that indwelling catheters are rapidly colonized by a thick layer of microorganisms included in a protein matrix of the host, and by polysaccharides produced by bacteria that form a biofilm (20).

The risk of urinary tract infection is related to the length of time that the catheter is in place. Most patients catheterized for a week or less should escape infection, but for the elderly and disabled patients who are catheterized for several months or years, bacteriuria is inevitable (21). Risk factors other than the duration of catheterization include contamination of the drainage-bag, diabetes mellitus, female patient, antibiotic usage and a compromised status of renal function. The risk of CAUTIs is increased in patients who are in urinary retention, in patients catheterized peripartum, in debilitated patients (22). In this case organisms that colonize the periurethral skin can migrate into the bladder through the mucoid film that forms between the epithelial surface of the urethra and the catheter. In addition, contamination of the urine in the drainage bag can allow organisms to access the bladder through the drainage tube and the catheter lumen (23). The initial bacteria that cause the urinary tract infections are usually *Staphylococcus epidermidis*, *Escherichia coli* or *Enterococcus faecalis*. As time goes by, other species appear in the residual bladder urine, including *Pseudomonas aeruginosa, Proteus mirabilis*, *Providencia stuartii, Morganella morganii* and *Klebsiella pneumoniae*.(8,23). Biofilms containing 5 × 109 viable cells per centimeter can be found on long-term indwelling catheters removed from patients.(20) The biofilm populations, therefore are often outnumber than those in the urine. The most common species present in the mixed-population biofilms are *E. faecalis, P. aeruginosa, E. coli, and P. mirabilis*. The biofilms formed are generally sparse, and because the catheter is removed within a few days, they cause few problems. By contrast, long-term catheters become colonized by extensive biofilms, which can have profound effects on the health of the patient. By far the most troublesome biofilms are those that become crystalline in nature (24,25). These biofilms may be present on the outer surface of the catheter around the balloon and catheter tip, and can cause trauma to the bladder and urethral epithelia. The crystalline deposits on catheters have a similar composition to infection-induced kidney and bladder stones. Struvite (magnesium ammonium phosphate) and a poorly crystalline form of apatite (a hydroxylated calcium phosphate, in which a variable proportion of the phosphate groups are replaced by carbonate) are the principle crystalline components (23,26). Urease is the driving force of crystallization: it hydrolyzes urea, leading to the formation of ammonium and carbonate ions and an increase in urinary pH. As the urine

becomes alkaline, magnesium and calcium phosphate crystals are precipitated. Aggregates of this crystalline material accumulate in the urine and in the biofilm that develops on the catheter surfaces. The continued accumulation of crystalline bacterial biofilm blocks the flow of urine through the catheter (2) causing bladder over-distension and damaging the urothelium aiding the attachment of bacteria to epithelial surface. *P. mirabilis* is not usually a pioneer colonizer of the catheterized urinary tract, and is not commonly found in patients undergoing short-term catheterization(26). *P. mirabilis* is considered to be an ingenious organism capable of initiating crystalline biofilms. Microorganisms that grow in biofilm are less likely to respond to antibiotic treatments. The majority of catheters removed within the seventh day of catheterization are already colonized by a bacterial biofilm. The presence of a urinary catheter impairs the normal protective mechanisms of the bladder. The duration of catheterization is the important factor of bacteriuria (27) but important risk factors are also the microbial colonization of the periurethral area and perineum providing a route for bacterial entry along both the internal and the external surfaces. In addition, urine often pools in the bladder or in the catheter itself and urinary stasis encourages bacterial multiplication.

8. Fungal urinary tract infections

Fungal urinary tract infections (funguria) are rare in community medicine, but common in hospitals where 10 to 30% of urine cultures isolate Candida species Funguria, or candiduria, may develop as early as the first 2 weeks of hospitalization. An indwelling urinary catheter is a known risk factor for funguria. Candida albicans is the most commonly isolated fungal species (40–65%) from the urine, but other species such as Candida glabrata and Candida tropicalis, also may occur. Candida as well as staphylococci can reach the hub site via the hands of health personal (26) . Non-pharmacologic measures, such as removing unnecessary antibiotics, and removing the urinary catheter, are typically beneficial but generally inadequate without additional pharmacologic therapy. The most serious complication of untreated asymptomatic funguria is candidemia, which occurs in less than 10% of cases. (28).

8.1 Diagnosis

Patients with CAUTIs are usually asymptomatic. The presence of bacteria in the urine does trigger an inflammatory response in terms of pyuria and urinary interleukins. The most common presentation of symptomatic infection is fever often associated with haematuria. Symptomatic bacteriuria is characterized by the presence of dysuria, urgency, frequency and hematuria (28). Symptomatic UTI occurs when bacteriuria leads to either local symptoms of infection, or systemic symptoms. Urinary catheter-related bacteremia is diagnosed when the same organism is isolated from both the urine and the blood cultures in the absence of other likely sources of infection. The risk of asymptomatic bacteriuria to bacteremia conversion is approximately 3–4%, and the estimated attributable mortality of urinary tract-related bacteremia is approximately 13%. Catheter associated UTI is diagnosed at a lower level of bacteriuria (>102 or >103 CFU/ml) for asymptomatic infections, plus associated symptoms for the symptomatic infections (29,30). The wide spectrum of potential infecting organism and increased likelihood of resistance means microbiological confirmation of the infecting organism and susceptibility testing are essential for determining optimal therapy. A positive urine culture supports a diagnosis of UTI but it is not sufficient to distinguish symptomatic

from asymptomatic infection. Thus, urine culture result must always be interpreted in the clinical context. In patients with short term indwelling catheter the specimen should be obtained by sampling through the catheter port. In patients with chronic indwelling catheter the preferred specimen is obtained from a new catheter placed immediately prior to initiating antimicrobial therapy (26). The urine specimen obtained through the new placed catheter reflects the bacteriology of the urine, rather than the biofilm.

9. Prevention and treatment of catheter-associated urinary infections

Prevention of UTI is therefore one of the most important tools in the treatment of catheterized subjects. The procedure of catheterization has to be done in order to avoid contamination of the intra or extra lumen drainage system. In accordance with the 2009 guidelines of the English Department of Health to prevent urinary tract infections in catheterized subjects, it is well know that closed drainage is infection free for the first 15 days and that after this period bacteria begin to spread in the bladder. In this context it seems that there are no differences in the infection rate between short-term sterile and short-term clean catheterization techniques based on recent literature reviews(31,32). The first review compared sterile catheterization with clean catheterization. No difference was shown between the two groups of patients, even if the sample was too limited to show any possible differences. The second review based on 436 women in labor compared genital cleaning before catheterization using chlorhexidine with the one using tap water alone showing also in this case no significant differences. The conclusion was that antiseptics do not reduce the bacteriuria rate. On the contrary open catheter drainage systems lead to bacteriuria in virtually all patients in few days, and this system is not recommended. (Grade of recommendation: A)(33).

Since as biofilm is the central factor in the pathogenesis of CAUTI, strategies designed to prevent biofilm formation with novel catheter material or coating are currently being investigated as shown in randomized trials reporting antimicrobial-impregnated catheters containing either nitrofurazone (34) or the combination of the broad-spectrum antibiotics minocycline and rifampin (35). This report demonstrated significant reductions in bacterial CAUTIs even if these results need further confirmations. In this way the advantage from the use of coated urinary catheters is not clear. In fact clinical trials have shown conflicting results as to the efficacy of silver oxide-coated catheters compared with uncoated catheters. In a prospective clinical trial involving hospitalized patients, silver oxide-coated catheters reduced the incidence of UTI only among women without antimicrobial agents administration compared with a control silicone catheter (36). A randomized study of 1,309 patients catheterized longer than 24h failed to demonstrate the effectiveness of a silicone catheter coated externally with silver oxide compared to a standard silicone coated latex catheter. However, these silver oxide catheters showed a significantly increased incidence of bacteriuria (37). With regard to this, literature on silver alloy latex catheters has failed to resolve the controversy over their efficacy and at present there is insufficient evidence to recommend the use of silver alloy catheters (Grade of recommendation: B)(33). Therefore it is evident that the use of indwelling urinary catheters, due to their complications, should be strictly related to specific and inalienable clinical conditions. Current data do not support the treatment of asymptomatic bacteriuria, either during short-term catheterization or during long-term catheterization, because it will promote the emergence of resistant strains (33). In short-term catheterization, antibiotics may delay the onset of bacteriuria, but do not

reduce complications (33). A symptomatic complicated UTI associated with an indwelling catheter is treated with an agent with as narrow a spectrum as possible, based on culture and sensitivity results. The optimal duration is not well established. Treatment durations that are both too short as well as too long may cause the emergence of resistant strains. A 7-day course may be a reasonable compromise (33).
Finally in case of treatment of fungal urinary tract infection we know that it is recommended only when funguria is symptomatic or in cases of fungal colonization when host factors increase the risk of fungemia. The antifungal agents used for funguria are mainly fluconazole and amphotericin B deoxycholate, because other drugs have extremely low concentrations in urine. Intravesical amphotericin B and oral fluconazole therapy are each effective in treatment of funguria (28).

10. Antibiotic prophylaxis and invasive urodynamics in female

Invasive urodynamics involving catheterization of the lower urinary tract is an essential part in the evaluation of detrusor filling and voiding phase in patients needing assessment of bladder function(1).
Urinary tract infections (UTI) are a recognized complication of urodynamic study. The natural history of bacteriuria after urodynamics is not completely known. The overall incidence of bacteriuria after urodynamic studies is not yet clear. In fact bacteriuria occurs in 1-5% of hospitalized patients after single short-term catheterization and in ambulatory ones lower than 1%. After cystometry, the reported incidence of bacteriuria varies from 1.5% to 30%, showing that the incidence of UTI in patients who underwent invasive urodynamics is present in most cases (2,3). In this context, the opinions on the safety of urodynamic studies differ among the authors. At present, published data on prophylaxis in urodynamics have showed contradictory results with a limited predictive value. Some investigators concluded that antibiotic prophylaxis seems to reduce the incidence of urinary tract infections and to protect patients from the risk of bacterial contamination from urethral catheterization, especially for those with high risk of infection(4). In this setting it was reported an overall infection rate of 15%, so concluding that antibiotic prophylaxis should be considered(5). Subsequently other authors reported that after invasive urodynamics the patients had UTI in 4% of cases, recommending the use of antibiotic before the procedure(4). In this way others reported an incidence of significant bacteriuria in less than of 1% of patients with antibiotic prophylaxis, so this approach is considered useful (6,). Similarly it was described that invasive urodynamics in postmenopausal female subjects are safe procedures without the necessity to perform it(1).
Antimicrobial prophylaxis entails treatment with an antimicrobial agent before and for a limited time after a procedure to prevent local or systemic postprocedural infections. For most procedures, prophylaxis should be initiated between 30 minutes and 120 minutes before the procedure. Efficacious levels should be maintained for the duration of the procedure and, in special circumstances, a limited time (24 hours, at most) after the procedure(7).
In this scenario several conditions are associated with a major risk of UTI with particular regard to women. In this setting many studies have revealed that for women presenting urogynecologic units to undergo an invasive urodynamic examination, there is a relatevely low incidence of bacteriuria (8%) after few days(8,9). Other series of a comparable number of women have shown incidences ranging from 1.6% to 17%(3). These discrepancies may be due

to variability in age of patients, kwowing well that advancing age is associated with a higher rate of UTI, or with different catheterization techniques (the trauma caused by catheterization itself may leave the lower urinary tract more susceptible to a later infection)[10]. Recently it showed that the low vascularization of soft tissues in bladder and urethra in postmenopausal female is associated with a higher risk of UTI perhaps because this condition could delay or prevent the effect of an antibiotic prophylactic drug, which probably cannot reach these tissues in an adequate manner and concentration[11].
Recently some authors revealed that in postmenopausal women there is a slightly higher incidence rate of UTI after invasive urodynamics compared to the studies previously published in literature and this trend is not affected by the administration of an antibiotic prophylaxis. Urodynamic testing however remains a safe investigative procedure with low morbidity and infection rate in postmenopausal women when performed by sterile catheterization, even without any antibiotic prophylaxis[5].
In conclusion, we could stop administering antibiotic prophylaxis to postmenopausal patients undergoing invasive urodynamics

11. Conclusions

Urinary tract infections represent the second most often observed infectious diseases in community, following the respiratory tract infections. In nosocomial setting, UTIs represent the most frequent diseases, whose incidence equates 40% of nosocomial infections overall considered; about 80% of UTIs is related to urinary catheterization. Therefore it is strongly suggested the opportunity to increase any prevention strategy able to reduce the incidence of infections related to urinary catheterization and its consequences, as a more rational length and modality of catheterization, in addition to the use of innovative catheters: recently the use of newborn materials, such as antibiotic-impregnated catheters or silver-coated ones has started. By now, though, there was not enough evidence to suggest whether or not any standard catheter was better than another in terms of reducing the risk of urinary tract infection in hospitalised adults catheterised short-term. Siliconised catheters may be less likely to cause urethral side effects however, these results should be interpreted with some caution as the trials were small and the outcomes are still under investigation.

12. Appendix: standard catheterization procedure

1. Gather equipment.
2. Explain procedure to the patient.
3. Assist patient into supine position with legs spread and feet together.
4. Open catheterization kit and catheter.
5. Prepare sterile field, apply sterile gloves.
6. Check balloon for patency.
7. Generously coat the distal portion (2-5 cm) of the catheter with lubricant.
8. Apply sterile drape.
9. If female, separate labia using non-dominant hand. If male, hold the penis with the non-dominant hand. Maintain hand position until preparing to inflate balloon.
10. Using dominant hand to handle forceps, cleanse peri-urethral mucosa with cleansing solution. Cleanse anterior to posterior, inner to outer, one swipe per swab, discard swab away from sterile field.

11. Pick up catheter with gloved (and still sterile) dominant hand. Hold end of catheter loosely coiled in palm of dominant hand.
12. In the male, lift the penis to a position perpendicular to patient's body and apply light upward traction (with non-dominant hand).
13. Identify the urinary meatus and gently insert until 1 to 2 inches beyond where urine is noted.
14. Inflate balloon, using correct amount of sterile liquid (usually 10 cc but check actual balloon size).
15. Gently pull catheter until inflation balloon is snug against bladder neck.
16. Connect catheter to drainage system.
17. Secure catheter to abdomen or thigh, without tension on tubing.
18. Place drainage bag below level of bladder.
19. Evaluate catheter function and amount, color, odor, and quality of urine.
20. Remove gloves, dispose of equipment appropriately, wash hands.
21. Document size of catheter inserted, amount of water in balloon, patient's response to procedure, and assessment of urine

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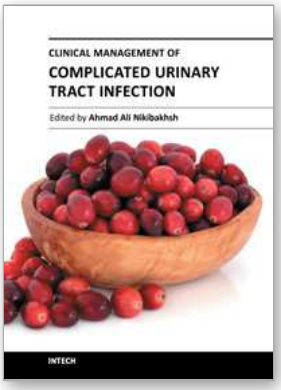

Clinical Management of Complicated Urinary Tract Infection

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Complicated urinary tract infections (cUTIs) are a major cause of hospital admissions and are associated with significant morbidity and health care costs. Knowledge of baseline risk of urinary tract infection can help clinicians make informed diagnostic and therapeutic decisions. Prevalence rates of UTI vary by age, gender, race, and other predisposing risk factors. In this regard, this book provides comprehensive information on etiology, epidemiology, immunology, pathology, pathogenic mechanisms, symptomatology, investigation and management of urinary tract infection. Chapters cover common problems in urinary tract infection and put emphasis on the importance of making a correct clinical decision and choosing the appropriate therapeutic approach. Topics are organized to address all of the major complicated conditions frequently seen in urinary tract infection. The authors have paid particular attention to urological problems like the outcome of patients with vesicoureteric reflux, the factors affecting renal scarring, obstructive uropathy, voiding dysfunction and catheter associated problems. This book will be indispensable for all professionals involved in the medical care of patients with urinary tract infection.

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