Chapter 5

# Urinary Tract Infections in Neuro-Patients

Charalampos Konstantinidis and
Achilleas Karafotias

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.79690

**Abstract**

The majority of neurological diseases may have an impact on lower urinary tract function. High intravesical pressure, post-void residual and incontinence are the main consequences of this dysfunction. All the mentioned conditions are inductive factors for urinary tract infections (UTIs). In addition, the potential complications of neurogenic urinary disorders (reflux, stone formation, incomplete emptying of the bladder), and the methods of urine drainage (intermittent or indwelling catheters, urinary diversion) contribute even more to UTIs. In neuro-patients, all UTIs are considered as complicated ones and there is a different microbiology as compared to the general population. In this chapter, inductive factors for UTIs in neuro-patients will be analyzed and the potential solutions will be exposed. There is a special mention in asymptomatic bacteriuria, which is correlated to neurogenic urinary dysfunction and it is clinically total different from UTI. Asymptomatic bacteriuria should not be treated as the treatment has a negative final outcome for the patient.

**Keywords:** neurogenic low urinary tract dysfunction, UTIs

## 1. Introduction

The normal functioning of the urinary system is closely related to the functional integrity of the central nervous system (CNS). Neuro-urological symptoms may be caused by a variety of diseases and events affecting the nervous system controlling the lower urinary tract (LUT). The resulting neuro-urological symptoms depend predominantly on the location and the extent of the neurological lesion. There are no exact figures on the overall prevalence of neuro-urological disorders in the general population, but data are available on the prevalence of the underlying conditions and the relative risk of these for the development of neuro-urological

symptoms. The majority of the data show a very wide range of prevalence/incidence. This reflects the variability in the cohort (e.g. early or late stage disease) and the frequently small sample sizes, resulting in a low level of evidence in most published data. Spinal cord injury patients may be the most studied group among neurogenic patients.

Spinal cord injury (SCI) is a damage to the spinal cord from traumatic or nontraumatic etiology, as defined by the International Spinal Cord Society (ISCoS) [1]. It is difficult to accurately calculate the worldwide prevalence and incidence of SCI due to the lack of standardized methods of assessment across regions and limited information in the data collected. The incidence varies from 12 to more than 65 cases/million per year. Data from Olmsted County, Minnesota, United States, from 1975 to 1981, showed an age- and sex-adjusted incidence rate of 71 spinal cord injuries/million [2]. The annual incidence of SCI reported for the year 1991 was around 30.0–32.1 persons/million population in the United States, meaning 7500 and 8000 new cases per year at that time [3]. In 2016, the estimated annual incidence of SCI was approximately 54 cases/million population or 17,000 new SCI cases each year [4]. The annual incidence varies widely by country. From 27 per million persons in Japan, 8–13.4 in Switzerland, 12.7 in France, and 16.7 in South Africa [5]. A systematic review in 2010 by Van den Berg et al. showed up to threefold variation in incidence rates between developed countries. The highest rates reported in Canada and Portugal. Most traumatic SCI studies show a bimodal age distribution. The first peak was found in young men between 15 and 29 years of age and the second peak in older adults (mostly ≥65 years old and women) [6]. The National Spinal Cord Injury Statistical Center at the University of Alabama at Birmingham reported approximately 12,000 new cases each year, with 4:1 male-to-female ratio. The average age at injury was 40 years. The most common injury was incomplete tetraplegia at 30%, followed by 25.6% for complete paraplegia, 20.4% for complete tetraplegia, and 18.5% for incomplete paraplegia. In the past, the leading cause of death among SCI patients was the renal failure while nowadays, is pneumonia, pulmonary emboli, and septicemia supersede renal failure. SCI patients seem to have a higher prevalence of several comorbidities than the general population. It is reported high blood pressure (49% vs. 26%, respectively), high cholesterol (47% vs. 30%), and diabetes (19% vs. 7%). Obesity is also a significant problem for individuals with SCI (25%).

Spinal cord injury (SCI) patients clinically face urinary incontinence during the bladder filling phase and incomplete emptying during the micturition phase. The main aggravating factors are the increased intravesical pressure and the residual urine. These may result in vesicoureteral reflux, bladder diverticula, and urinary stones formation. These conditions also lead to an increased risk of urinary tract infection (UTI) [7, 8]. Despite improved treatment methods, UTI is considered the second leading cause of death in SCI patients [9]. It is known that UTIs are the most common hospital infections with known repercussions for the patient and the national economy. Approximately 5–10% of patients admitted to hospital are infected during their hospitalization and UTIs account for the highest (40–50%) [10, 11]. In addition, SCI patients usually have asymptomatic bacteriuria. In this way, positive urine culture is not the foundation stone for the diagnosis of urinary tract infection. The clinical signs and symptoms of urinary tract infection are differentiated in these individuals as the neural sensation is affected or absent. The review of the following literature aims to highlight the specificities of urinary tract infections in people with SCI or other neurogenic conditions in order to prevent and treat the infections and recognize asymptomatic bacteriuria without treatment necessity.

http://dx.doi.org/10.5772/intechopen.79690

The physiological function of the lower urinary tract is characterized by the central control of the urinary reflexes (inhibition or removal of reflex inhibition) from the upper cortical centers of the cortex. Urine concentration within the bladder results in an increase in intravesical pressure that causes stimulation of the thoracic-lymphatic sympathetic center (T10-L2) via transient and adductor nerve fibers. Adjacent nerve fibers transfer the stimulus to the breech centers of urination and from there to the upper centers of the cerebral cortex. Then, if there is no central depression, the urinary reflex is manifested through the contraction of the detrusor resulting in the sympathetic nerves. However, if urination is undesirable, this reflex is inhibited as cationic signals inhibit sympathetic stimulation at the level of the thoracic-lumbar sympathetic center and increase the muscular tone of the external sphincter by suture from the pelvic neural mesh formed by the S2–S4 level. From the above, it is clear that any damage at any level of SC results in disorders of lower urinary function. These disorders vary according to level [11, 12], the degree (complete or incomplete) [13] and the extent of the damage.

## 2. Associated risk factors

### 2.1. Increased intravesical pressures

Neurogenic urinary tract dysfunction characterized by increased intravesical pressures and/or urine residual [14]. These patients have decreased microorganism removal capacity [15]. Both incomplete emptying of the bladder [16] and high intravesical pressure [17, 18] are accompanied by an increased risk of UTI. Patients who have been using Credé maneuver for a long time to empty their bladder have had severe complications in the upper urinary tract (82% pyuria, 60% ureter dilation, 35% hydronephrosis, and 16% renal failure). Men appeared more susceptible to upper urinary tract damage than to women [19]. According to Esclarin De Ruz et al [20] in patients with SCI with detrusor overactivity, the coexistence of detrusor-sphincter dyssynergia duplicates the risk of urinary tract infections.

### 2.2. Vesicoureteral reflux

Under normal circumstances, the ureterovesical junction allows urine to enter the bladder but prevents urine from regurgitating into the ureter and the kidney. This results in the kidney being protected from high pressure in the bladder and from contamination by vesical bacteria. In this way, vesicoureteral reflux is considered to be an important factor in urinary tract infection [20]. It occurs in 10% of patients over 4 years of SCI [21]. Although the reflux is the result of high intravesical pressure, it must be controlled by another neurological mechanism since patients with a T10-L2 lesion exhibit more regressive effects than patients who have a level of damage above or below this level [22]. The damage at this level is probably related to the ureteral peristaltic mechanisms.

### 2.3. Intermittent catheterization

Intermittent catheterization (IC) during the recovery period appears to reduce the rate of urinary tract infections and substantially eliminate many of the complications associated with the use of an indwelling catheter [23, 24]. However, IC may also present certain

complications, such as traumatic urethral injury (immediate) or urethral restenosis and recurrent epididymitis (late). In one study, SCI patients, using pure intermittent catheterization for more than 5 years, showed urine stasis at 19% and epididymitis at 28.5% [23]. The appearance of the above complications appears to be increased according to the number of years of pure IC performed [23]. Research supports the use of sterile IC technique in the acute phase of the neurogenic bladder [25] and agrees with a study in which few cases of bacteriuria and urinary tract infection were observed using sterile intermittent catheterization as compared to using a non-sterile procedure [26]. On the other hand, Shekelle et al. reported contradictory results in the value of sterile techniques or techniques without direct catheter contact compared to pure intermittent catheterization, as there is insufficient evidence of risk associated with psychological, behavioral and hygienic factors [27]. Hydrophilic catheters for clean intermittent catheterization are associated with lower rates of long-term complications (urethral stenosis) and may cause a lower degree of bacteriuria [28]. Another type of catheter, with an insertion sheath, which bypasses the first 1.5 cm of the urethra, appears to reduce the incidence of urinary tract infections in hospitalized men with SC damage [29].

### 2.4. Permanent indwelling catheters

Permanent indwelling catheters are the greatest risk factor for complicated UTIs [30]. They are responsible for most in-hospital UTIs, 3–10% per day and with 100% bacteriuria in their long-term use [31]. Silver-coated catheters are more effective in preventing urinary tract infections in patients who require short-term catheterization and reduce the incidence of symptomatic urinary tract infection and bacteriemia compared to simple catheters [32, 33]. For short-term catheters not exceeding 2–3 weeks, the use of nitrofurazone, minocycline, and rifampin-impeded catheters reduce the risk of urinary tract infection [34, 35] due to antibiotic overlap.

### 2.5. Suprapubic catheters

The use of a permanent suprapubic catheter is an effective way of draining the bladder in SCI patients with a low rate of urinary tract infection [36, 37]. Suprapubic catheterization may be an alternative drainage method for female patients who cannot perform self-IC [38]. The disadvantage is the continuous presence of the catheter (foreign material) within the bladder associated with the formation of urinary lithiasis as compared to intermittent catheterization at rates of 9 and 4%, respectively, over a period of more than 9 years [39]. On the other hand, this chronic irritation from the catheter is accompanied by an increased incidence of bladder cancer as compared to intermittent catheterization [40]. Nomura et al. [41] reported that 25% of patients with long-term use of suprapubic catheter showed bladder stone formation, which was accompanied by a 7.24 urine pH. Suprapubic drainage in patients with neurogenic urinary disorders is preferred (against urethral catheterization) as it appears to reduce the risk of urethritis, orchiepididymitis, testicular abscess and urethral erosion as compared to permanent catheterization [42].

### 2.6. Condom catheter drainage

Condom catheters are used in male patients to manage incontinence but not bladder emptying. Their application is accompanied by the same degree of urinary tract infection as in the use of intermittent catheterization. However, condom catheters do not ensure complete bladder drainage and can (in cases of poor application) be considered a cause of occlusion [43]. It is recommended that the condom catheter is applied daily, although no increase in infections has been reported in non-daily applications [44]. In addition, although condom catheters are external, they appear to be related to colonization of the urethra by pathogenic microbes. They are accompanied by Pseudomonas [45] and Klebsiella [46] infections due to the colonization of the regions of the urethra, perineum, penis, and rectum by the above microorganisms. In addition, the urine trap is a very good reservoir of microorganisms. In male patients using condom catheter, urine culture was 73% positive for Pseudomonas, although the degree of bacteriuria was much lower [47, 48]. Also, the colonization of the urethra with Pseudomonas is combined with the presence of the condom catheter [49]. From the above, it can be seen that the chronic use of a condom catheter drainage and urine collector predisposes to the colonization of the patient and the upward introduction of microorganisms into the anterior urethra.

### 2.7. Biofilm (biomembranes)

According to their initial description, microorganisms are referred to as non-adherent "planktonic" cells [50] based on their developmental characteristics in enriched liquids and solids. Today, it is now known that bacteria in their natural environment are typically attached to some biological or non-surface area. It is also known that adhering microorganisms under suitable conditions form complex structures, biofilms (bio-membranes). These structures are formed as the microorganisms are surrounded by an extracellular exopolysaccharide (EPS) layer which themselves produce [50, 51]. Bacteria are the best-studied microorganisms regarding surface colonization and subsequent biofilm formation.

Fungi, protozoa, viruses, and algae have also been isolated from corresponding extracellular material in direct contact with organic or inorganic surfaces [52]. Stable microbial attachment to the underlying surfaces and the formation of biofilms creates significant and often insoluble problems both in the medical community and in the industry [53]. *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis* and *Pseudomonas aeruginosa* often colonize implanted medical devices [54] (such as pacemakers, intravenous catheters, urinary catheters, prosthetic implants, and heart valves) as well as pathological tissue structures (such as respiratory epithelium in patients with cystic fibrosis or cystic fibrosis mucosal in patients with neurogenic bladder) and create biofilms, thus causing chronic and often resistant to treatment infections.

Bacterial biomembranes are observed in 73% [55] patients with SCI using IC, and no relationship has been found between the presence of bio-membrane and symptoms [56]. However, the presence of at least 20 bacterial adherence in each bladder cell appears to be related to the symptomatology of the infection [57]. Bacterial cells are detached individually or in groups

from the upper layers of the biofilm circulating in the fluid medium, urine in this case, and attempting to adhere to a new substrate which is more conducive to their growth. These detachable bacteria can cause systemic infection [53, 58].

## 3. Clinical symptoms

The specificity of individuals with SCI is that asymptomatic bacteriuria is usually present and the sensory disorder results in the lack of a clear symptom of urinary tract infection. The clinician should carefully evaluate the patient to decide whether a positive urine culture reveals infection or is an asymptomatic bacteriuria. Additionally, fever should not be attributed to urinary tract infection if the only positive point is bacteriuria unless other possible causes of fever are excluded. Approximately 45% of feverish conditions in these patients are thought to be due to urinary tract infections [59]. Other causes are respiratory infections as well as thromboembolic events. The septic condition in quadriplegic patients may also occur as hypothermia [60]. Approximately 10% of febrile episodes may be the result of a temperature control malfunction and not an infection [61]. The coexistence of elevated CRP and routine serum test values should be considered. UTI is accompanied by a specimen of urine blisters with microbes above $10^5$ CFU/ml, and symptoms such as fever, back pain in the lumbar region of the kidney, upper urinary tract infection, and if the patient has a sensation at this level, urinary urgency and increased spasticity. A characteristic symptom is the reduction of cystic functional capacity and the aggravation of overactive bladder syndrome, in the case of a neurogenic overactive detrusor, or the discontinuation of response to previously well-regulated treatment for increased extravasation activity. The incidence of urinary tract infections in SCI patients is 2.5 episodes per patient per year. Bacteremia and sepsis occur in 1% of SCI patients [62]. The urinary system is considered to be the most common source of bacteremia [62, 63]. Bacteremia in SCI patients is accompanied by 90% fever, 17% hypotension, and death rate of about 15%. [62, 63]. Approximately 20–25% of episodes are characterized by polymicrobial infections. Bacteriemia is more common in quadriplegic patients and in patients with complete SCI [64]. Urogenital tube manipulations are considered as risk factors for bacteremia [65].

## 4. Microbiology—urine culture

Urinary tract colonization often follows colonization of the urogenital tract, perineum or urethra with enteropathogenic microorganisms [66, 67]. In a study of 15 adult men with SCI and other neurogenic urinary dysfunctions, the normal flora of the perineum, penis and urethra regions was compared with the flora of 10 control men without neurogenic urinary disorders [68]. The predominant microorganisms with respect to the control group were Gram-positive granules and diphtheroids. In the individuals with the neurogenic urinary disorder, the microorganisms isolated from the skin flora include species such as Enterobacteriaceae, Pseudomonas, Acinetobacter, and Enterococcus [68]. In addition, other studies of individuals with SCI as compared to non-injured patients, the presence of *E.coli* microorganisms

and Klebsiella spp. are less, and have a higher frequency of infections than Pseudomonas, Proteus, and Serratia. Esclarin De Ruz et al. [20] reported that *E. coli*, 36% enterobacteria, 15% *Pseudomonas aeruginosa*, 15% *Acinetobacter* spp., 12% Enterococcus, 6% other microorganisms, and 26% multiple strains were isolated in 45%. In another study in 43 of 50 individuals with SCI, the same types of microorganisms as those from various areas of the skin, including perineal, peripubic, and perinatal regions, were isolated in urine [69]. In 50% of the cases, the same microorganism was isolated from the anterior urethra and from the bladder [70]. Also, the catheter insertion mode is also considered to be significant, which appears to cause an increase of approximately 10 times the number of bladder colonies [70]. The above results demonstrate the important role of bacterial colonization of the skin and urethra as a source of vaccination, through the catheters, of the bladder with microorganisms.

When a UTI is suspected, it is important that the urine specimen is obtained in an appropriate manner in order to prevent contamination and a potential false-positive result. For patients with indwelling catheters (either the urethral catheter or suprapubic), the indwelling catheter should be changed to a new catheter, and the specimen should be obtained from the new catheter after capping the catheter for a few minutes to allow a small amount of urine to collect in the bladder. The urine specimen should then be collected by uncapping the catheter. For patients with external catheters or those who perform IC, the specimen should be collected by catheterization with a new sterile catheter.

## 5. Pyuria

The significance of pyuria in neurogenic patients in combination with the use of intermittent catheterization or permanent catheter is often difficult to assess. Changing the Foley catheter in symptomatic patients causes an increase in the leucocytes without affecting the microbial strain or the number of colonies [71]. Positive urine culture ($10^5$ CFU/ml colonies), with the presence of >50 leucocytes per field of vision, is associated with an increased risk of fever. In addition, Gram-positive microorganisms such as *Staphylococcus epidermidis* and *Streptococcus faecalis* are accompanied by a small number of leukocytes despite the occurrence of a large number of colonies, while Gram-negative microorganisms are accompanied by significant pyuria [72]. According to the above significant pyuria is associated with the presence of catheters, infection with Gram-negative microorganisms, as well as bacterial tissue filtration.

## 6. Bacteriuria

Comparative studies are difficult to perform in these patient groups due to different definitions of bacteriuria and urinary tract infection, different urinary tract drainage methods, as well as the severity of acute, subacute, chronic, or total and partial lesions. In 1992, according to the National Institute on Disability Rehabilitation Research, severe bacteriuria is defined as the number of colony counts of $10^2$ CFU uropathogenic micro granules per ml of urine in samples taken by catheterization, $10^4$ CFU/ml urine samples under pure micturition and any

detectable uropathogenic concentration in samples from permanent catheter or supraventricular puncture. Other researchers continue to regard the concentration of $10^5$ CFU/ml in urine as a criterion for significant bacteriuria even in samples after catheterization [73]. Waites et al. reported that patients with 10 CFU/ml in urine have a 10% risk of a febrile episode, while the presence of pyuria is more associated with fever and shivering [73]. In patients receiving 40% IC, the source of bacteriuria was the upper urinary tract, while in 60%, the source was the lower urinary tract [74]. Pyuria was much higher in patients with upper urinary tract infection [75].

## 7. Asymptomatic bacteriuria

Asymptomatic bacteriuria is defined as the presence of a significant number of urine microbes ($10^5$ CFU/ml) in patients without clinical symptoms or signs of infection. The incidence varies depending on the age of the patients, the sex and the presence or absence of functional or anatomical urinary tract abnormalities. Bladder catheterization is the most important predisposing factor for asymptomatic microbial growth. In hospitalized catheterized patients with an open urine collection system, the incidence of the asymptomatic microbial disease is 100% of the patients within 3–4 days.

Microorganisms most commonly isolated in bladder catheterized patients are *Escherichia coli*, Klebsiella, Proteus, Enterococcus, Enterobacter, Pseudomonas, Serratia, and Candida. Most are part of the microbial flora of the bowel colonizing the anterior part of the urethra. In patients with a bladder catheter for a short or long period of time, urine specimen collection should be taken by catheter puncture after meticulous antisepsis of the puncture site and not through the catheter's mouth. The presence of leucocytes with or without hematuria is taken into account but does not necessarily require the diagnosis of active infection. Asymptomatic bacteriuria in individuals with SCI requires treatment only in cases where symptomatic urinary tract infection develops [76, 77].

## 8. Skin colonization

As mentioned, bacterial colonization of the skin and the urethra is an important source of bladder infection using catheters. Differences in microbial species and their presence in normal skin flora of SCI patients and other neurogenic urinary disorders in relation to individuals without neurogenic disorders may result from the use of antibiotic therapy, use of condom catheters, pH and skin temperature in the area, personal hygiene, or fecal contamination. Pseudomonas colonizes the perineum, in addition to the high pH of the skin of the area appears to contribute positively to the high risk of colonization [78, 79]. The meticulous soap wash of the perineum area only has temporary effects in reducing its colonization by Gram-negative microorganisms, whereas the use of antiseptics, such as chlorhexidine and povidone-iodine, has no effect [80, 81].

## 9. Bladder catheterization

Efforts to eliminate bacteriuria due to the use of permanent or intermittent catheterization have no effect. Intensive or continuous catheterization is a frequent but not documented method of treatment to prevent sedimentation, bacteriuria, urinary tract infection and/or bacteremia. Intravenous administration with neomycin/polymyxin has no effect. Spinal hygiene, perineal wash, and frequent catheter changes have found ineffective methods in reducing urinary tract infection due to catheterization [82]. In addition, it is important for both coating and catheter composition. Prevention of *P. aeruginosa* biofilm formation is observed using silver-coated catheters [83].

## 10. Biofilm management

As mentioned above, a general feature of the microorganisms that form the bio-membranes is their resistance to various antimicrobial substances, as opposed to free-flowing cells. The main objective should prevent biofilm formation by the prophylactic administration of antibiotics and strict adherence to antisepsis rules when attaching any prosthetic material and in this case a catheter. It is also proposed to incorporate antimicrobial agents into the material to be implanted and to modify the physical or chemical properties of the material so as not to favor biofilm formation.

To achieve satisfactory penetration of antimicrobial drugs into the bio-membrane, experimentally liposomal forms of drugs have been tested with encouraging results. Reid et al. claimed that the daily use of cranberry helmet juice drastically reduced the formation of biofilm and reduced the adhesion of Gram-negative and -positive microorganisms to bladder cells [84]. Respectively, in more recent studies and post-analysis, the clinical benefit of using cranberry juice to reduce urinary tract infections appears to be limited to recurrent urothelial infections in women without neurogenic urinary disorders of young and middle age [85, 86].

The use of antimicrobial drugs for the prevention of UTIs in people who have intermittent catheterization or carry an indwelling bladder catheter has some positive results. In some studies, prophylactic antibiotics are reported to be effective. The use of methenamine orally and intake of acidic substances contributes to the reduction of urinary tract infection in the case of intermittent catheterization [87]. A low dose of ciprofloxacin appears to be more effective than placebo in preventing urinary tract infection [88]. In a study, administration of the 500 mg twice daily dose for 10 days reduced the incidence of Gram-negative organisms in the perineum and urethra but ciprofloxacin-susceptible microorganisms were replaced by resistant microorganisms such as staphylococci, including methicillin-resistant *S. aureus*, Enterococci and Acinetobacter spp. [89]. In contrast to the above, comparative studies of prophylactic administration of ascorbic acid, TMP-SMX, nalidixic acid, methenamine hippurate, or nitrofurantoin microcrystals to prevent urinary tract infection in patients with SCI did not provide statistically significant results. In a daily use of TMP-SMX study compared to placebo as a prophylaxis for urinary tract infections in SCI patients, the use of TMP-SMX did not reduce the incidence of symptomatic bacteremia while there was an increase in TMP-SMX resistance in asymptomatic patients [90].

## 11. External sphincterotomy

The efficacy of the sphincterotomy has been well documented since Emmett JL and Dunn JH described the trans-urethral resection of the bladder neck and prostate in SCI patients with outlet obstruction. Ross JC introduced the resection of the external urinary sphincter. Large series have shown that sphincterotomy is successful in the treatment of vesical outlet obstruction in certain male patients with quadriplegia, in order to reduce detrusor leak point pressure, followed by condom catheter drainage. Patients who develop UTIs after sphincterotomy are should undergo assessment of PVR to ensure adequate bladder emptying. Urodynamic testing should also be considered to assess the efficacy of the sphincterotomy. If there is evidence of urethral obstruction, repeat sphincterotomy may be indicated. Sphincterotomy can also be indicated when patients use Credé or Valsalva to empty their bladder, but first, surgeons must have assessed that the lower urinary tract is urodynamically safe and that the upper urinary tract is not damaged [91].

## 12. Bladder augmentation

The aim of bladder augmentation is to reduce detrusor overactivity (DO), improve bladder compliance and reduce the pressure effect of DO [92, 93]. Complications associated with these procedures are recurrent infection, stone formation, perforation or diverticula, possible malignant changes, metabolic abnormality, mucus production and impaired bowel function [94–96]. Special attention should be paid to patients with preoperative renal scars since metabolic acidosis can develop [97]. Several different techniques have been published [98–106]. Bladder substitution, even by performing a supratrigonal cystectomy [93], is also indicated in patients with a severely fibrotic bladder wall. IC may become necessary after this procedure.

## 13. Urinary diversion

Following supravesical urinary diversion, pyelonephritis may occur, usually accompanied by fever, chills, leukocytosis, nausea and vomiting. Upper tract imaging should be performed, due to possible urinary obstruction. If there is an obstruction, the system should be drained via percutaneous nephrostomy. In this case, urine culture should be obtained from the nephrostomy tube.

### 13.1. Continent diversion

It is the first choice for urinary diversion. The continent urinary reservoir is indicated when the native bladder and urethra are severely devastated functionally or anatomically, as well as bladder neck closure and ureteral re-implantation are not avoidable. All of the different techniques have complications such as leakage or stenosis. The short-term continence rates are >80% and good protection of the UUT is achieved [107–119].

### 13.2. Incontinent diversion

If catheterization is impossible, incontinent diversion is indicated. The ileal conduit is the most common form of incontinent urinary diversion used. It could be considered in patients who show intractable and untreatable incontinence, in patients with LUT dysfunction, when the upper urinary tract is severely compromised and in patients who refuse other therapy [119]. An ileal segment is used for the deviation in most cases [120–124] and patients gain better functional status and quality of life [125]. Incontinent diversion has also an acceptable rate of complications. Especially in children, there are concerns about long-term effects on renal function, and while conduit diversion may be considered in this population, alternative methods may be preferable.

### 13.3. Undiversion

Long-standing diversions may be successfully undiverted or an incontinent diversion changed to a continent one with the cause of better techniques for control of detrusor pressure and incontinence [120]. The patient must be carefully counseled and must comply with the instructions [120]. Only then successful undiversion can be performed [126].

## 14. Continent catheterizable channel

Some patients with spinal cord injury have difficulty or are unable to perform IC through a native urethra. In such cases, the creation of an abdominal stoma using a continent catheterizable channel (CCC) should be considered. A CCC is particularly helpful in women because their ability to access their urethra is more difficult than in men [127–129]. A concomitant bladder neck closure with a CCC becomes an option when urethral dysfunction or destruction does not result in acceptable continence over anti-incontinence surgeries.

The majority of patients with bladder augmentation or continent urinary diversion will have mucus production that can act as an incubation material for infection. Irrigation of the bladder or pouch at regular intervals with normal saline decrease the incidence of symptomatic urinary tract infection.

## 15. Treatment

Generally, asymptomatic bacteriuria does not require treatment because the microorganism cannot be eliminated or will recur after the treatment is complete. In addition, antimicrobial therapy will lead to resistant strains of microorganisms [130, 131]. Therefore, there is no indication that treatment reduces virulence or mortality. Systemic antimicrobial therapy for asymptomatic bacteriuria is recommended only in special cases such as:

- patients who undergo urological surgery or prosthetic graft
- treatment may be a part of the control of a hospital infection due to a particular prevalent virulent microorganism

- patients belonging to high-risk groups (immunosuppressed)
- strains of microorganisms suspected of bacteremia such as Serratia marcescens [132–135].

Symptomatic UTI in the neurogenic patient is defined as a urinary culture with $\geq 10^2$ CFU bacteria/mL and symptoms including, but not limited, to LUTS, urinary incontinence, increased spasticity, autonomic dysreflexia, pelvic discomfort, fever, and decreased energy level. Moreover, it has not been shown that the type of microbe isolated in urine culture of an asymptomatic patient is the cause of infection when a symptomatic episode occurs. In 30–50% of cases, urinary catheter removal is accompanied by urinary tract purification by the microorganism [40, 134]. People with symptomatic bacteriuria—UTI should be treated with the most specific antibiotic treatment for the shortest but sufficient period. Since the urinary catheter surface, due to biofilm formation becomes a source of bacterial growth, it is justified and important to remove it and replace it with a new one before treatment of symptomatic infection [40, 136–139]. The guidelines for choosing the right antimicrobial treatment are the same as those of the general population. They include the identification of the microorganism, antimicrobial susceptibility, the location of the infection, its complexity, and the risk factors.

Although there are insufficient clinical studies on the duration of treatment for urinary tract infections in neurogenic patients, the duration of treatment varies from 3 to 21 days depending on the microorganism, the accompanying factors of infection and the condition of the patient [138, 140, 141]. When oral treatment is sufficient, it is usually given for a period of 5–7 days, and when intravenous treatment is required, it remains from 7 to 14 days depending on the clinical and laboratory findings [142]. In the appearance of fungi in urethral cultures, treatment is unnecessary. In this case, either local (intravesical) or systemic antifungal treatment [143, 144] is not recommended, and it is recommended to replace the catheter with a new one. If the infection is accompanied by symptoms of the urinary tract or the presence of fungus is a symptom of systemic infection, then antifungal treatment is necessary [145].

## 16. Conclusion

Urinary tract infections are a grade issue for medical doctors and patients. It is even more difficult to diagnose and treat neurogenic patients rather than general population. The higher frequency of recurrent infections in these patients and resistant microorganisms remain the main problems as for this specific population. In summary, based on the criteria of evidence-based medicine, there is currently no preventive measure for recurrent urinary tract infections in neurogenic patients that can be recommended without limitations. Individualized concepts, including immunostimulation, phytotherapy, and complementary medicine, should be taken into consideration [146]. Prophylaxis is important to pursue, but there are no data favoring one approach over another. In this case, prophylaxis is essentially a trial and error approach. Nowadays, the quality of life of the neurogenic patients is the primary concern. Antibiotics, catheterization techniques and urinary diversions are the main features of treatment applied. The medical community contributes in this direction with the proper diagnosis of the diseases

in this group of patients. Personalized physician and patient collaboration and the timely recognition of symptoms by the patient remain the cutting edge of early symptoms relief. The proper and efficient control of the "neurogenic bladder" is essential for the prevention and the management of the UTIs. The controlled bladder pressure and its complete periodical evacuation under a low-pressure environment can ensure that the UTIs will be less frequent and less severe.

## Author details

Charalampos Konstantinidis[1]* and Achilleas Karafotias[2]

*Address all correspondence to: konstantinidischaralampos@yahoo.com

1 Urology and Neuro-Urology Unit, National Rehabilitation Center, Athens, Greece

2 Urology Department, General Hospital "Asklepieio Voulas", Athens, Greece

## References

[1] New PW, Sundararajan V. Incidence of non-traumatic spinal cord injury in Victoria, Australia: A population-based study and literature review. Spinal Cord. 2008;**46**(6):406-411

[2] Griffin MR, Opitz JL, Kurland LT, et al. Traumatic spinal cord injury in Olmsted County, Minnesota, 1935-1981. American Journal of Epidemiology. 1985;**121**(6):884-895

[3] National Spinal Cord Injury Statistical Center (NSCISC). Spinal cord injury facts and figures at a glance. The Journal of Spinal Cord Medicine. 2010;**33**(4):439-440

[4] National Spinal Cord Injury Statistical Center (NSCISC). Spinal Cord Injury (SCI) Facts and Figures at a Glance. 2016. Available from: https://www.nscisc.uab.edu/Public/Facts%202016.pdf [Accessed: May 1, 2016]

[5] Key AG, Retief PJ. Spinal cord injuries. An analysis of 300 new lesions. Paraplegia. 1970;**7**(4):243-249

[6] van den Berg MEL, Castellote JM, Mahillo-Fernandez I, de Pedro-Cuesta J. Incidence of spinal cord injury worldwide: A systematic review. Neuroepidemiology. 2010;**34**(3):184-192

[7] The prevention and management of urinary tract infections among people with spinal cord injuries. National Institute on Disability and Rehabilitation Research consensus statement. The Journal of the American Paraplegia Society. 1992;**15**(3):194-204

[8] Carderas DD, Hooton TM. Urinary tract infection in persons with spinal cord injury. Archives of Physical Medicine and Rehabilitation. 1995;**76**:272-280

[9] Frankel HL, Coll JR, Charlifue SW, Whiteneck GG, Gardner BP, Jamous MA, Krishnan KR, Nuseibeh I, Savic G, Sett P. Long-term survival in spinal cord injury: A fifty-year investigation. Spinal Cord. 1998;**36**:266-274

[10] Noreau L, Proulx P, Gagnon L, Drolet M, Laramee MT. Secondary impairments after spinal cord injury: A population-based study. American Journal of Physical Medicine & Rehabilitation. 2000;**79**:526-535

[11] Siroky MB, Krane RJ. Neurologic aspects of detrusor-sphincter dyssynergia, with reference to the guarding reflex. The Journal of Urology. 1982;**127**:953-957

[12] Weld KJ, Dmochowski RR. Association of level of injury and bladder behavior in patients with post-traumatic spinal cord injury. Urology. 2000;**55**:490-494

[13] Pikov V, Wrathall JR. Coordination of the bladder detrusor and the external urethral sphincter in a rat model of spinal cord injury: Effect of injury severity. The Journal of Neuroscience. 2001;**21**:559-569

[14] Hansson S, Hjalmas K, Jodal U, Sixt R. Lower urinary tract dysfunction in girls with untreated asymptomatic or covert bacteriuria. The Journal of Urology. 1990;**143**:333-335

[15] Merritt JL. Residual urine volume: Correlate of urinary tract infection in patients with spinal cord injury. Archives of Physical Medicine and Rehabilitation. 1981;**62**:558-561

[16] MacMillan RD. Complicated urinary tract infections in patients with voiding dysfunction. The Canadian Journal of Urology. 2001;**8**(Suppl 1):13-17

[17] Ruutu M. Cystometrographic patterns in predicting bladder function after spinal cord injury. Paraplegia. 1985;**23**:243-252

[18] Chang SM, Hou CL, Dong DQ, Zhang H. Urologic status of 74 spinal cord injury patients from the 1976 Tangshan earthquake, and managed for over 20 years using the Credé maneuver. Spinal Cord. 2000;**38**:552-554

[19] Foley SJ, McFarlane JP, Shah PJ. Vesicoureteric reflux in adult patients with spinal injury. British Journal of Urology. 1997;**79**:888-891

[20] Esclarin de Ruz A, Garcia Leoni E, Herruzo Cabrera R. Epidemiology and risk factors for urinary tract infection in patients with spinal cord injury. The Journal of Urology. 2000;**164**:1285-1289

[21] Lamid S. Long-term follow-up of spinal cord injury patients with vesicoureteral reflux. Paraplegia. 1988;**26**:27-34

[22] Suzuki T, Ushiyama T. Vesicoureteral reflux in the early stage of spinal cord injury: A retrospective study. Spinal Cord. 2001;**39**:23-25

[23] Firlit CF, Canning JR, Lloyd FA, Cross RR, Brewer R Jr. Experience with intermittent catheterization in chronic spinal cord injury patients. The Journal of Urology. 1975;**114**:234-236

[24] Perrouin-Verbe B, Labat JJ, Richard I, Mauduyt de la Greve I, Buzelin JM, Mathe JF. Clean intermittent catheterisation from the acute period in spinal cord injury patients. Long-term evaluation of urethral and genital tolerance. Paraplegia. 1995;**33**:619-624

[25] Matsumoto T, Takahashi K, Manabe N, Iwatsubo E, Kawakami Y. Urinary tract infection in neurogenic bladder. International Journal of Antimicrobial Agents. 2001;**17**:293-297

[26] Prieto-Fingerhut T, Banovac K, Lynne CM. A study comparing sterile and nonsterile urethral catheterization in patients with spinal cord injury. Rehabilitation Nursing. 1997;**22**:299-302

[27] Shekelle PG, Morton SC, Clark KA, Pathak M, Vickrey BG. Systematic review of risk factors for urinary tract infection in adults with spinal cord dysfunction. The Journal of Spinal Cord Medicine. 1999;**22**:258-272

[28] Hedlund H, Hjelmas K, Jonsson O, Klarskov P, Talja Ml. Hydrophilic versus non-coated catheters for intermittent catheterization. Scandinavian Journal of Urology and Nephrology. 2001;**35**:45-53

[29] Bennett CJ, Young MN, Razi SS, Adkins R, Diaz F, McCrary A. The effect of urethral introducer tip catheters on the incidence of urinary tract infection outcomes in spinal cord injured patients. The Journal of Urology. 1997;**158**:519-521

[30] Biering-S¢rensen F, Bagi P, H¢iby N. Urinary tract infections in patients with spinal cord lesions: Treatment and prevention. Review of aetiology, bladder management, treatment and prevention related to UTI in SCL individuals. Drugs. 2001;**61**:1275-1287

[31] Nicolle LE. A practical guide to antimicrobial management of complicated urinary tract infection. Drugs Ageing. 2001;**18**:243-254

[32] Saint S, Elmore JG, Sullivan SD, Emerson SS, Koepsell TD. The efficacy of silver alloy-coated urinary catheters in preventing urinary tract infection: A meta-analysis. The American Journal of Medicine. 1998;**105**:236-241

[33] Saint S, Veenstra DL, Sullivan SD, Chenoweth C, Fendrick AM. The potential clinical and economic benefits of silver alloy urinary catheters in preventing urinary tract infection. Archives of Internal Medicine. 2000;**160**:2670-2675

[34] Guay DR. An update on the role of nitrofurans in the management of urinary tract infections. Drugs. 2001;**61**:353-364

[35] Maki DG, Tambyah PA. Engineering out the risk for infection with urinary catheters. Emerging Infectious Diseases. 2001;**7**:342-347

[36] MacDiarmid SA, Arnold EP, Palmer NB, Anthony A. Management of spinal cord injured patients by indwelling suprapubic catheterization. The Journal of Urology. 1995;**154**:492-494

[37] Sheriff MK, Foley S, McFarlane J, Nauth-Misir R, Craggs M, Shah PJ. Long-term suprapubic catheterisation: Clinical outcome and satisfaction survey. Spinal Cord. 1998;**36**:171-176

[38] Grundy DJ, Fellows GJ, Gillett AP, Nuseibeh I, Silver JR. A comparison of fine-bore suprapubic and an intermittent urethral catheterisation regimen after spinal cord injury. Paraplegia. 1983;**21**:227-232

[39] Mitsui T, Minami K, Furuno T, Morita H, Koyanagi T. Is suprapubic cystostomy an optimal urinary management in high quadriplegics? A comparative study of suprapubic cystostomy and clean intermittent catheterization. European Urology. 2000;**38**:434-438

[40] West DA, Cummings JM, Longo WE, Virgo KS, Johnson FE, Parra RO. Role of chronic catheterization in the development of bladder cancer in patients with spinal cord injury. Urology. 1999;**53**(2):292-297

[41] Nomura S, Ishido T, Teranishi J, Makiyama K. Long-term analysis of suprapubic cystostomy drainage in patients with neurogenic bladder. Urologia Internationalis. 2000;**65**:185-189

[42] Konstantinidis C, Kalokerinou K, Siatelis A, Kartsaklis P, Nikolia A, Karyotis I, Gekas A, Delakas D. Urethral erosion after long-term urethral catheterization. Urology. 2007;**70**(Suppl 3A):287

[43] Pidde TJ, Little JW. Hydronephrosis due to improper condom catheter use. The Journal of the American Paraplegia Society. 1994;**17**:168-170

[44] Stelling JD, Hale AM. Protocol for changing condom catheters n males with spinal cord injury. SCI Nursing. 1996;**13**:28-34

[45] Montgomerie JZ, Morrow JW. Long-term pseudomonas colonization in spinal cord injury patients. American Journal of Epidemiology. 1980;**112**:508-517

[46] Montgomerie JZ, Gilmore DS, Graham IE, Schick DG, Ashley MA, Morrow JW, Bruce SK. Klebsiella pneumoniae colonization in patients with spinal cord injury. Diagnostic Microbiology and Infectious Disease. 1987;**7**:229-235

[47] Gilmore DS, Schick DG, Young MN, Montgomerie JZ. Effect of external urinary collection system on colonization and urinary tract infections with Pseudomonas and Klebsiella in men with spinal cord injury. The Journal of the American Paraplegia Society. 1992;**15**:155-157

[48] Gilmore DS, Bruce SK, Jimenez EM, Schick DG, Morrow JW, Montgomerie JZ. Pseudomonas aeruginosa colonization in patients with spinal cord injuries. Journal of Clinical Microbiology. 1982;**16**:856-860

[49] Montgomerie JZ, Morrow JW. Pseudomonas colonization in patients with spinal cord injury. American Journal of Epidemiology. 1978;**108**:328-336

[50] Donlan RM. Biofilms: Microbial life on surfaces. Emerging Infectious Diseases. 2002;**8**: 881-890

[51] Donlan RM, Costerton JW. Biofilms: Survival mechanisms of clinically relevant microorganisms. Clinical Microbiology Reviews. 2002;**15**:167-193

[52] Lindsay D, von Holy A. Bacterial biofilms within the clinical setting: What healthcare professionals should know. The Journal of Hospital Infection. 2006;**64**:313-325

[53] Kierek-Pearson K, Karatan E. Biofilm development in bacteria. Advances in Applied Microbiology. 2005;**57**:79-111

[54] Davey ME, O' Toole GA. Microbial biofilms: From ecology to molecular genetics. Microbiology and Molecular Biology Reviews. Dec 2000;**64**:847-867

[55] Reid G, Charbonneau-Smith R, Lam D, Kang YS, Lacerte M, Hayes KC. Bacterial biofilm formation in the urinary bladder of spinal cord injured patients. Paraplegia. 1992;**30**:711-717

[56] Reid G, Kang YS, Lacerte M, Tieszer C, Hayes KC. Bacterial biofilm formation on the bladder epithelium of spinal cord injured patients. II. Toxic outcome on cell viability. Paraplegia. 1993;**31**:494-499

[57] Reid G, Dafoe L, Delaney G, Lacerte M, Valvano M, Hayes KC. Use of adhesion counts to help predict symptomatic infection and the ability of fluoroquinolones to penetrate bacterial biofilms on the bladder cells of spinal cord injured patients. Paraplegia. 1994;**32**:468-472

[58] Jain A, Gupta Y, Agrawal R, Khare P, Jain SK. Biofilms—A microbial life perspective: A critical review. Critical Reviews in Therapeutic Drug Carrier Systems. 2007;**24**(5):393-443

[59] Montgomerie JZ, Guerra DA, Schick DG, Gilmore DS, Tabatabai MF, Morrow JW. Pseudomonas urinary tract infection in patients with spinal cord injury. The Journal of the American Paraplegia Society. 1989;**12**:8-10

[60] Ohry A, Heim M, Rozin R. Peculiar septic responses in traumatic tetraplegic patients. Paraplegia. 1983;**21**:318-321

[61] Colachis SC III, Otis SM. Occurrence of fever associated with thermoregulatory dysfunction after acute traumatic spinal cord injury. American Journal of Physical Medicine & Rehabilitation. 1995;**74**:114-119

[62] Bhatt K, Cid E, Maiman D. Bacteremia in the spinal cord injury population. The Journal of the American Paraplegia Society. 1987;**10**:11-14

[63] Montgomerie JZ, Chan E, Gilmore DS, Canawati HN, Sapico FL. Low mortality among patients with spinal cord injury and bacteremia. Reviews of Infectious Diseases. 1991;**13**:867-871

[64] Waites KB, Canupp KC, Chen Y, DeVivo MJ, Moser SA. Bacteremia after spinal cord injury in initial versus subsequent hospitalizations. The Journal of Spinal Cord Medicine. 2001;**24**:96-100

[65] Faarvang KL, Muller P, Lomberg B, Biering-S¢rensen F. Screening for bacteriuria in patients with spinal cord lesion: Dipstick test, microscopic examination and urine culture. Spinal Cord. 2000;**38**:106-108

[66] Moloney PJ, Doyle AA, Robinson BL, Fenster H, McLoughlin MG. Pathogenesis of urinary infection in patients with acute spinal cord injury on intermittent catheterization. The Journal of Urology. 1981;**125**:672-673

[67] Montgomerie JZ, McCary A, Bennett CJ, Young M, Matias B, Diaz F, Adkins R, Anderson J. Urethral cultures in female patients with a spinal cord injury. Spinal Cord. 1997;**35**:282-285

[68] Taylor TA, Waites KB. A quantitative study of genital skin flora in male spinal cord-injured outpatients. American Journal of Physical Medicine & Rehabilitation. 1993;**72**:117-121

[69] Hamamci N, Dursun E, Akbas E, Aktepe OC, Cakc A. A quantitative study of genital skin flora and urinary colonization in spinal cord injured patients. Spinal Cord. 1998;**36**:617-620

[70] Barnes DG, Timoney AG, Moulas G, Shaw PJ, Sanderson PJ. Correlation of bacteriological flora of the urethra, glans and perineum with organisms causing urinary tract infection in the spinal injured male patient. Paraplegia. 1992;**30**:851-854

[71] Ho CH, Kirshblum S, Linsenmeyer TA, Millis SR. Effects of the routine change of chronic indwelling Foley catheters in persons with spinal cord injury. The Journal of Spinal Cord Medicine. 2001;**24**:101-104

[72] Anderson RU, Hsieh-Ma ST. Association of bacteriuria and pyuria during intermittent catheterization after spinal cord injury. The Journal of Urology. 1983;**130**:299-301

[73] Waites KB, Canupp KC, DeVivo MJ. Epidemiology and risk factors for urinary tract infection following spinal cord injury. Archives of Physical Medicine and Rehabilitation. 1993;**74**:691-695

[74] Hooton TM, O'Shaughnessy EJ, Clowers D, Mack L, Cardenas DD, Stamm WE. Localization of urinary tract infection in patients with spinal cord injury. The Journal of Infectious Diseases. 1984;**150**:85-91

[75] Newman E, Price M. Bacteriuria in patients with spinal cord lesions: Its relationship to urinary drainage appliances. Archives of Physical Medicine and Rehabilitation. 1977;**58**:427-430

[76] Nicolle LE, Bradley S, Colgan R, Rice J, Schaeffer A, Hooton TM. Infections Diseases Society of America Guidelines for the diagnosis and treatment of asymptomatic bacteriuria in adults. Clinical Infectious Diseases. 2005;**40**:643-654

[77] Zhanel GG, Harding GK, Guay DR. Asymptomatic bacteriuria. Which patients should be treated? Archives of Internal Medicine. 1990;**150**:1389-1396

[78] Montgomerie JZ, Gilmore DS, Ashley MA, Schick DG, Jimenez EM. Long-term colonization of spinal cord injury patients with Klebsiella pneumoniae. Journal of Clinical Microbiology. 1989;**27**:1613-1616

[79] Montgomerie JZ, Schick DG, Gilmore DS, Graham IE. pH and water content of Pseudomonas aeruginosa- and Klebsiella pneumoniae-colonized perineal skin of men with spinal cord injuries. Journal of Clinical Microbiology. 1983;**18**:844-848

[80] Gilmore DS, Aeilts GD, Alldis BA, Bruce SK, Jimenez EM, Schick DG, Morrow JW, Montgomerie JZ. Effects of bathing on Pseudomonas and Klebsiella colonization in patients with spinal cord injuries. Journal of Clinical Microbiology. 1981;**14**:404-407

[81] Gilmore DS, Montgomerie JZ, Graham IE, Schick DG, Jimenez EM. Effect of antiseptic agents on skin flora of the perineum of men with spinal cord injury. Infection Control. 1984;**5**:431-434

[82] Muncie HL Jr, Hoopes JM, Damron DJ, Tenney JH, Warren JW. Once-daily irrigation of long-term urethral catheters with normal saline. Lack of benefit. Archives of Internal Medicine. 1989;**149**:441-443

[83] Liedberg H, Ekman P, Lundeberg T. Pseudomonas aeruginosa: Adherence to and growth on different urinary catheter coatings. International Urology and Nephrology. 1990;**22**:487-492

[84] Reid G, Hsiehl J, Potter P, Mighton J, Lam D, Warren D, Stephenson J. Cranberry juice consumption may reduce biofilms on uroepithelial cells: Pilot study in spinal cord injured patients. Spinal Cord. 2001;**39**:26-30

[85] Guay DR. Cranberry and urinary tract infections. Drugs. 2009;**69**(7):775-807

[86] Jepson RG, Craig JC. Cranberries for preventing urinary tract infections. Cochrane Database of Systematic Reviews. 2008;**1**:CD001321

[87] Krebs M, Halvorsen RB, Fishman IJ, Santos-Mendoza N. Prevention of urinary tract infection during intermittent catheterization. The Journal of Urology. 1984;**131**:82-85

[88] Biering-Sorensen F, Hoiby N, Nordenbo A, Ravnborg M, Bruun B, Rahm V. Ciprofloxacin as prophylaxis for urinary tract infection: Prospective, randomized, cross-over, placebo-controlled study in patients with spinal cord lesion. The Journal of Urology. 1994;**151**:105-108

[89] Waites KB, Canupp KC, Brookings ES, DeVivo MJ. Effect of oral ciprofloxacin on bacterial flora of perineum, urethra, and lower urinary tract in men with spinal cord injury. The Journal of Spinal Cord Medicine. 1999;**22**:192-198

[90] Sandock DS, Gothe BG, Bodner DR. Trimethoprim-sulfamethoxazole prophylaxis against urinary tract infection in the chronic spinal cord injury patient. Paraplegia. 1995;**33**:156-160

[91] Reynard JM, Vass J, Sullivan ME, Mamas M. Sphincterotomy and the treatment of detrusor-sphincter dyssynergia: Current status, future prospects. Spinal Cord. 2003;**41**(1):1-11

[92] Vainrib M et al. Differences in urodynamic study variables in adult patients with neurogenic bladder and myelomeningocele before and after augmentation enterocystoplasty. Neurourology and Urodynamics. 2013;**32**:250. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22965686

[93] Krebs J, Bartel P, Pannek J. Functional outcome of supratrigonal cystectomy and augmentation ileocystoplasty in adult patients with refractory neurogenic lower urinary tract dysfunction. Neurourol Urodyn. 2016 Feb;**35**(2):260-266. DOI: 10.1002/nau.22709. (Epub 2014 Dec 18)

[94] Gough DC. Enterocystoplasty. BJU International. 2001;**88**:739. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11890246

[95] Greenwell TJ et al. Augmentation cystoplasty. BJU International. 2001;**88**:511. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11678743

[96] Vajda P et al. Histological findings after colocystoplasty and gastrocystoplasty. The Journal of Urology. 2002;**168**:698. Available from: https://www.ncbi.nlm.nih.gov/pubmed/12131353

[97] Mitsui T et al. Preoperative renal scar as a risk factor of postoperative metabolic acidosis following ileocystoplasty in patients with neurogenic bladder. Spinal Cord. 2014;**52**:292. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24469144

[98] Chapple CR et al. Surgery for detrusor overactivity. World Journal of Urology. 1998;**16**:268. Available from: https://www.ncbi.nlm.nih.gov/pubmed/9775426

[99] Comer MT et al. Reconstruction of the urinary bladder by auto-augmentation, enterocystoplasty, and composite enterocystoplasty. Advances in Experimental Medicine and Biology. 1999;**462**:43. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10599412

[100] Cranidis A, Nestoridis G. Bladder augmentation. International Urogynecology Journal and Pelvic Floor Dysfunction. 2000;**11**(1):33-40. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10738932

[101] Leng WW, Blalock HJ, Fredriksson WH, English SF, McGuire EJ. Enterocystoplasty or detrusor myectomy? Comparison of indications and outcomes for bladder augmentation. The Journal of Urology. 1999;**161**(3):758-763. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10022679

[102] Niknejad KG, Atala A. Bladder augmentation techniques in women. International Urogynecology Journal and Pelvic Floor Dysfunction. 2000;**11**(3):156-169. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11484743

[103] Oge O, Tekgul S, Ergen A, Kendi S. Urothelium-preserving augmentation cystoplasty covered with a peritoneal flap. BJU International. 2000;**85**:802. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10792156

[104] Siracusano S, Trombetta C, Liguori G, De Giorgi G, d'Aloia G, Di Benedetto P, et al. Laparoscopic bladder auto-augmentation in an incomplete traumatic spinal cord injury. Spinal Cord. 2000;**38**:59. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10762200

[105] Westney OL, McGuire EJ. Surgical procedures for the treatment of urge incontinence. Techniques in Urology. 2001;**7**:126-132. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11383990

[106] Zhang F, Liao L. Sigmoidocolocystoplasty with ureteral reimplantation for treatment of neurogenic bladder. Urology. 2012;**80**:440-445. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22857763

[107] Khavari R, Fletcher SG, Liu J, Boone TB. A modification to augmentation cystoplasty with catheterizable stoma for neurogenic patients: Technique and long-term results. Urology. 2012;**80**:460-464. Available from: https://www.ncbi.nlm.nih.gov/pubmed/22704181

[108] Hadley D, Anderson K, Knopick CR, Shah K, Flynn BJ. Creation of a continent urinary channel in adults with neurogenic bladder: Long-term results with the Monti and Casale (Spiral Monti) procedures. Urology. 2014;**83**:1176. Available from: https://www.ncbi.nlm.nih.gov/pubmed/24612618

[109] Leslie B, Lorenzo AJ, Moore K, Farhat WA, Bägli DJ, Pippi Salle JL. Long-term follow up and time to event outcome analysis of continent catheterizable channels. The Journal of Urology. 2011;**185**:2298-2302. Available from: https://www.ncbi.nlm.nih.gov/pubmed/21511280

[110] Duckett JW, Lotfi AH. Appendicovesicostomy (and variations) in bladder reconstruction. The Journal of Urology. 1993;**149**:567-569. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8437267

[111] Kajbafzadeh AM, Chubak N. Simultaneous Malone antegrade continent enema and Mitrofanoff principle using the divided appendix: Report of a new technique for prevention of stoma complications. The Journal of Urology. 2001;**165**:2404-2409. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11371987

[112] Kawai K, Hattori K, Akaza H. Tissue-engineered artificial urothelium. World Journal of Surgery. 2000;**24**:1160-1162. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11071451

[113] Liard A, Séguier-Lipszyc E, Mathiot A, Mitrofanoff P. The Mitrofanoff procedure: 20 years later. The Journal of Urology. 2001;**165**:2394-2398. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11371985

[114] Moreno JG, Chancellor MB, Karasick S, King S, Abdill CK, Rivas DA. Improved quality of life and sexuality with continent urinary diversion in quadriplegic women with umbilical stoma. Archives of Physical Medicine and Rehabilitation. 1995;**76**:758-762. Available from: https://www.ncbi.nlm.nih.gov/pubmed/7632132

[115] Sekar P, Wallace DD, Waites KB, DeVivo MJ, Lloyd LK, Stover SL, et al. Comparison of long-term renal function after spinal cord injury using different urinary management methods. Archives of Physical Medicine and Rehabilitation. 1997;**78**:992-997. Available from: https://www.ncbi.nlm.nih.gov/pubmed/9305274

[116] Stein R, Fisch M, Ermert A, Schwarz M, Black P, Filipas D, et al. Urinary diversion and orthotopic bladder substitution in children and young adults with neurogenic bladder: A safe option for treatment? The Journal of Urology. 2000;**163**:568-573. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10647686

[117] Sylora JA, Gonzalez R, Vaughn M, Reinberg Y. Intermittent self-catheterization by quadriplegic patients via a catheterizable Mitrofanoff channel. The Journal of Urology. 1997;**157**:48-50. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8976213

[118] Van Savage JG, Yepuri JN. Transverse retubularized sigmoidovesicostomy continent urinary diversion to the umbilicus. The Journal of Urology. 2001;**166**:644-647. Available from: https://www.ncbi.nlm.nih.gov/pubmed/11458110

[119] Karsenty G, Chartier-Kastler E, Mozer P, Even-Schneider A, Denys P, Richard F. A novel technique to achieve cutaneous continent urinary diversion in spinal cord-injured patients unable to catheterize through native urethra. Spinal Cord. 2008;**46**(4):305-310. Epub Aug 14, 2007

[120] Drake M et al. Conservative management in neuropathic urinary incontinence. In: Abrams P, Cardozo L, Khoury S, Wein A, editors. Incontinence. Plymouth: Health Publication; 2013. pp. 827-1000

[121] Atan A, Konety BR, Nangia A, Chancellor MB. Advantages and risks of ileovesicostomy for the management of neuropathic bladder. Urology. 1999;**54**:636-640. Available from: https://www.ncbi.nlm.nih.gov/pubmed/10510920

[122] Cass AS, Luxenberg M, Gleich P, Johnson CF. A 22-year follow up of ileal conduits in children with a neurogenic bladder. The Journal of Urology. 1984;**132**:529-531. Available from: https://www.ncbi.nlm.nih.gov/pubmed/6471190

[123] Hald T, Hebjøorn S. Vesicostomy—An alternative urine diversion operation. Long term results. Scandinavian Journal of Urology and Nephrology. 1978;**12**:227-231. Available from: https://www.ncbi.nlm.nih.gov/pubmed/725543

[124] Schwartz SL, Kennelly MJ, McGuire EJ, Faerber GJ. Incontinent ileo-vesicostomy urinary diversion in the treatment of lower urinary tract dysfunction. The Journal of Urology. 1994;**152**:99-102. Available from: https://www.ncbi.nlm.nih.gov/pubmed/8201699

[125] Sakhri R, Seigle-Murandi F, Jacqmin D, Lang H, Saussine C. Laparoscopic cystectomy and ileal conduit urinary diversion for neurogenic bladders and related conditions. Morbidity and better quality of life. Progrès en Urologie. 2015;**25**:342-347. Available from: https://www.ncbi.nlm.nih.gov/pubmed/25726693

[126] Herschorn S, Rangaswamy S, Radomski SB. Urinary undiversion in adults with myelodysplasia: Long-term follow up. The Journal of Urology. 1994;**152**:329-333

[127] Herschorn S, Thijssen AJ, Radomski SB. Experience with the hemi-Kock ileocystoplasty with a continent abdominal stoma. The Journal of Urology. 1993;**149**(5):998-1001

[128] Hakenberg OW, Ebermayer J, Manseck A, Wirth MP. Application of the Mitrofanoff principle for intermittent self-catheterization in quadriplegic patients. Urology. 2001;**58**(1):38-42

[129] Perrouin-Verbe MA, Chartier-Kastler E, Even A, Denys P, Roupret M, Phé V. Long-term complications of continent cutaneous urinary diversion in adult spinal cord injured patients. Neurourology and Urodynamics. 2016;**35**(8):1046-1050

[130] Darouiche RO, Hull RA. Bacterial interference for prevention of urinary tract infection: An overview. The Journal of Spinal Cord Medicine. 2000;**23**:136-141

[131] Stover SL, Lloyd LK, Waites KB, Jackson AB. Neurogenic urinary tract infection. Neurologic Clinics. 1991;**9**:741-755

[132] Rutala WA, Kennedy VA, Loflin HB, Sarubbi FA Jr. Serratia marcescens nosocomial infections of the urinary tract associated with urine measuring containers and urinometers. The American Journal of Medicine. 1981;**70**:659-663

[133] Maki DG, Hennekens CG, Phillips CW, Shaw WV, Bennett JV. Nosocomial urinary tract infection with Serratia marcescens: An epidemiologic study. The Journal of Infectious Diseases. 1973;**128**:579-587

[134] Schaberg DR, Weinstein RA, Stamm WE. Epidemics of nosocomial urinary tract infection caused by multiply resistant gram-negative bacilli: Epidemiology and control. The Journal of Infectious Diseases. 1976;**133**:363-366

[135] Kumon H. Management of biofilm infection in the urinary tract. World Journal of Surgery. 2000;**24**:1193-1196

[136] Raz R, Schiller D, Nicolle LE. Replacement of catheter improves the outcome of patients with permanent urinary catheter and asymptomatic bacteriuria. In: Abstracts of the 38th Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC). American Society for Microbiology; 1998. pp. 532-537

[137] Zimakoff JD, Pontoppidan B, Larsen SO, Poulsen KB, Stickler DJ. The management of urinary catheters: Compliance of practice in Danish hospitals, nursing homes and home care, to national guidelines. Scandinavian Journal of Urology and Nephrology. 1995;**29**:299-309

[138] Nicolle LE. The chronic indwelling catheter and urinary infection in long-term-care facility residents. Infection Control and Hospital Epidemiology. 2001;**22**:316-321

[139] Harding GK, Nicolle LE, Ronald AR, Preiksaitis JK, Forward KR, Low DE, Cheang M. How long should catheter-acquired urinary tract infection in women be treated? A randomized controlled study. Annals of Internal Medicine. 1991;**114**:713-719

[140] Nicolle LE. Catheter-related urinary tract infection. Drugs & Aging. 2005;**22**:627-639

[141] Everaert K, Lumen N, Kerckhaert W, Willaert P, van Driel M. Urinary tract infections in spinal cord injury: Prevention and treatment guidelines. Acta Clinica Belgica. 2009;**64**(4):335-340

[142] Sobel JD, Kauffman CA, McKinsey D, Zervos M, Vazquez JA, Karchmer AW, et al. Candiduria: A randomized, double-blind study of treatment with fluconazole and placebo. The National Institute of Allergy and Infectious Diseases (NIAID) Mycoses Study Group. Clinical Infectious Diseases. 2000;**30**:19-24

[143] Jacobs LG, Sidmore EA, Freeman K, Lipschultz D, Fox N. Oral fluconazole compared with bladder irrigation with amphotericin B for treatment of fungal urinary tract infections in elderly patients. Clinical Infectious Diseases. 1996;**22**:30-35

[144] Sobel JD, Lundstrom T. Management of candiduria. Current Urology Reports. 2001;**2**:321-325

[145] Hamory BH, Wenzel RP. Hospital-associated candiduria: Predisposing factors and review of the literature. The Journal of Urology. 1978;**120**:444-448

[146] Pannek J et al. Usefulness of classical homoeopathy for the prevention of urinary tract infections in patients with neurogenic bladder dysfunction: A case series. Indian Journal of Research in Homoeopathy. 2014;**8**:31

IntechOpen