Management of the neuropathic bladder

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Neurological injury and disease are common, and intimately related to abnormalities of the urinary system. The prevention and treatment of urological sequelae in patients with neurological injury or disease requires a clear multidisciplinary management strategy.

The term 'neuropathic bladder' describes the condition of voiding dysfunction secondary to neurological disease, injury or dysfunction. The term is misleading as the pathology rarely involves the bladder in isolation; for a full appreciation of the disorder one must consider the interaction of the bladder, ureters, sphincters and urethra.

The urological complications of diseases of the nervous system were previously a major cause of mortality in patients with neurological injury (Frankel et al, 1998); however, advances in management of the neuropathic bladder have led to a decline in mortality in conditions such as spinal cord injury (SCI) (DeVivo et al, 1999).

Neurological disease is very common in both the hospital and community settings, therefore every member of the medical team associated with the care of these patients should have a basic understanding of the neuropathic bladder.

OVERVIEW OF PHYSIOLOGY

Normal functioning of the bladder and lower urinary tract relies on close synergy between the detrusor and the urethral sphincters. On one hand, the bladder must act as a highly compliant reservoir for urine storage; the two urethral sphincters (internal and external) prevent urinary leakage during this stage. On the other hand, voiding involves synchronous contraction of the detrusor preceded by a relaxation of the sphincters. This complex process involves interaction of the autonomic nervous system (both sympathetic and parasympathetic) and somatic nerves supplying the external urethral sphincter.

The parasympathetic innervation is derived from the sacral segments of the spinal cord (S2–S4). This constitutes the main motor innervation to the bladder, via the pelvic splanchnic nerves. The sympathetic innervation to the lower urinary tract originates from T10–L2 cord levels, and innervates the bladder neck, internal sphincter and proximal urethra. The role of sympathetic input to the bladder itself is debatable, but is probably both vasomotor and inhibitory. Somatic motor innervation (controlling voluntary external sphincter contraction) comes from the pudendal nerve (S2–S4). Both the parasympathetic and sympathetic nervous systems contribute to bladder sensation, via visceral sacral afferent nerves. Fullness of the bladder is detected by receptors in the detrusor wall. Less is known about the role of the brain and brainstem in the cycle of micturition. However, brainstem nuclei exert important excitatory and inhibitory input to the lumbosacral reflex pathways coordinating bladder and sphincter function.

From this brief overview one can begin to see how disruption of any of these pathways may lead to motor dysfunction (bladder and sphincters) and sensory dysfunction (from bladder and urethra).

COMMON PATTERNS SEEN WITH THE NEUROPATHIC BLADDER

The International Continence Society and its standardization of terminology (Abrams et al, 2002) has helped to simplify the description of the neuropathic bladder. The most common scenarios and their correct nomenclature are described below, and are based on data obtained from urodynamic studies.

One of the most useful urodynamic investigations is videocystometrogram. This involves recording the pressure changes attributable to detrusor contraction during active filling of the bladder by means of a solution containing radiopaque contrast. These findings are dynamically interpreted using radiographic screening.

Important information on vesicoureteric reflux, abnormalities in bladder contraction, sphincter dysfunction and incontinence can be obtained. The bladder may show characteristic appearances during contraction (the 'fir cone' or 'spinning top' bladder) (*Figure 1*).

Videocystometrogram may only be available at more specialist centres. Elsewhere, the measure-

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ment of urine flow rate (uroflowmetry) and residual volumes may be of use; however, this gives no indication of the associated detrusor pressure. Again, in more specialist centres urethral pressures may be measured using microtip transducing catheters, or electrical activity of the urethral sphincter may be monitored with electromyography.

Neurogenic detrusor overactivity

Neurogenic detrusor overactivity (NDO) (formerly known as detrusor instability) is one of the most common findings associated with the neuropathic bladder. As previously mentioned, the higher centres have an important role in inhibition of the micturition reflex. In the neurologically intact adult, these higher centres have an important role in preventing premature detrusor contraction and incontinence during the filling stage. When these pathways are interrupted, uninhibited detrusor contractions may occur, resulting in incontinence ('firing off') in the patient with complete suprasacral SCI, or urge and incontinence in the patient with an incomplete injury (*Figure 2*).

Detrusor–sphincter dyssynergia

Detrusor–sphincter dyssynergia (DSD) is another feature of the neuropathic bladder, and in some ways the most important. Again, this is seen mainly in injury above the sacral spinal cord (which is anatomically located at the T12/L1 vertebral level). Following the initial injury, an episode of spinal shock usually ensues. This involves a loss of response of striated and smooth muscle, resulting in an acontractile detrusor and urinary retention, and possibly overflow incontinence.

Following the period of spinal shock (which may last many months), NDO usually develops, associated with DSD. This results essentially in an uninhibited high-pressure bladder contracting against a closed outlet. High intravesical pressures may lead to ureteric reflux, and the bladder typically becomes trabeculated and low volume, and diverticuli may form. Ureteric reflux combined with the common problem of infected urine leads to the downward spiral of reflux nephropathy and renal failure. This is the reason why renal failure was, until fairly recently, the most common cause of death in SCI patients.

While trauma is the commonest cause of suprasacral SCI, other causes such as multiple sclerosis, myelomeningocele, transverse myelitis or vascular disruption to the cord may result in the same problems.

Acontractile detrusor

Lesions affecting the sacral spinal cord (T12/L1 vertebral levels) are relatively uncommon. They may be associated with disruption and injury to the cell bodies innervating the bladder, and a common consequence is the acontractile bladder. This is usually associated with a reduction in external urethral sphincter tone and control. Damage to the cord below this (medullary cone) or the cauda equina will have the same effect as a result of trauma to both efferent and afferent nerves.

Neuropathies such as diabetic neuropathy may affect afferent nerves, resulting in absent detrusor sensation and a similar urodynamic effect. The most common pathologies affecting these levels are trauma, prolapsed intervertebral discs and multiple sclerosis.

Figure 1. A radiograph taken during a videocystometrogram demonstrating characteristic features of the neuropathic bladder.

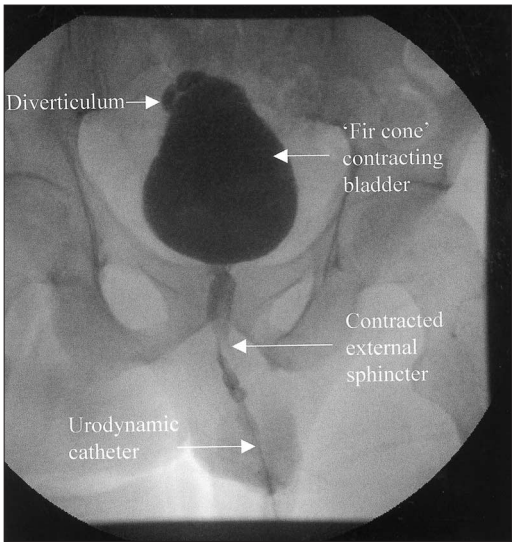
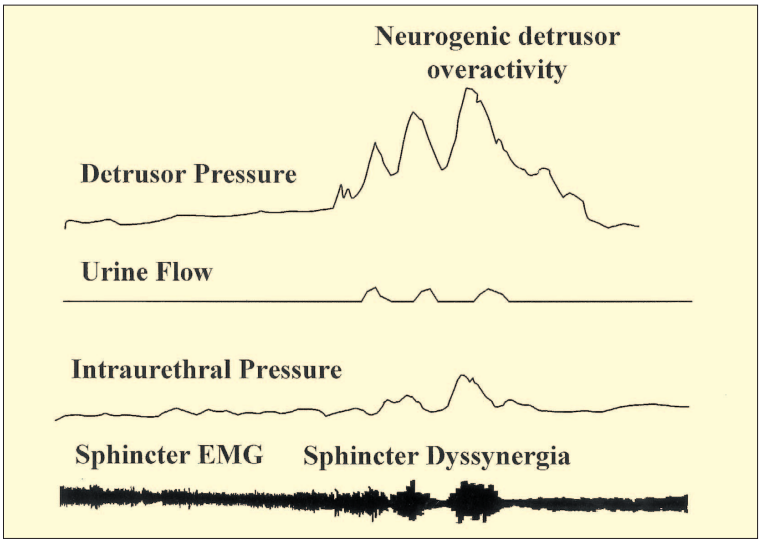


Figure 2. A urodynamic tracing during filling of the neuropathic bladder. Neurogenic detrusor overactivity is demonstrated, along with detrusor sphincter dyssynergia. EMG = electromyogram.



UROLOGICAL SYMPTOMS OF THE NEUROPATHIC BLADDER

Symptoms experienced by the patient will depend on both the completeness and the level of injury (*Figure 3*). NDO is common in patients with complete SCI. Their main untreated urinary symptom will thus be uncontrolled and frequent voiding, known as 'firing off'. A normal bladder sensation will be lacking; however, bladder fullness may be perceived because of stretching of the reflected peritoneum over the bladder. DSD may simultaneously be occurring during NDO without the patient being aware of it. Patients with acontractile bladders will have painless retention of urine, associated with overflow incontinence if the bladder is not emptied by catheterization.

Patients with incomplete neurological lesions may complain of a wide range of lower urinary tract symptoms, which are not always correlated to the severity of injury. Symptoms such as urgency, frequency, poor stream with variable incontinence may be reported. Importantly, some patients with the most minor neurological symptoms may demonstrate gross urodynamic abnormalities.

Figure 3. The approximate relationship between level of neurological injury and urological sequelae.

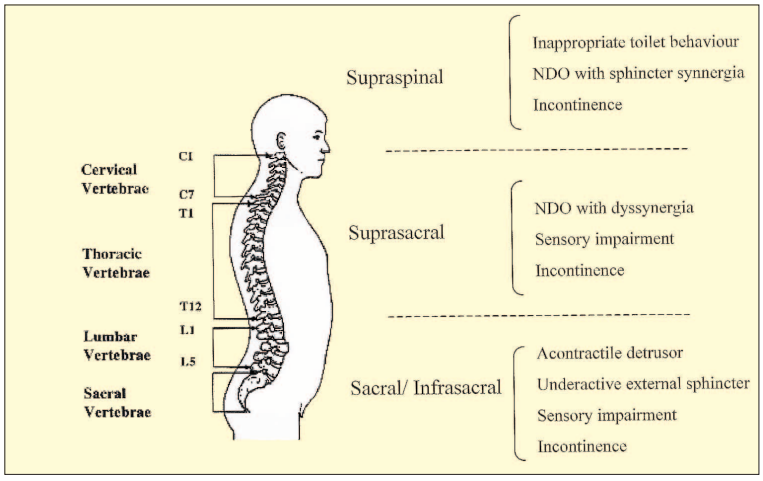


TABLE 1.
Objectives in the management of the neuropathic bladder

Patient oriented	Socially acceptable
	Simple to perform
	Avoidance of drainage device
	Personal control
Medically oriented	Avoidance of urinary tract infection
	Low pressure filling
	Low pressure voiding
	Renal preservation

Conditions above the spinal cord

Conditions affecting the brain and brainstem, such as cerebrovascular accidents, multiple sclerosis and dementia, typically result in NDO with synergia of the external urethral sphincter. Patients will therefore complain of urgency and incontinence.

In males, such symptoms may be inseparable from those of benign prostatic hypertrophy. Acute events may be associated with a period of 'cerebral shock' and an acontractile bladder, which is usually of shorter duration than spinal shock. Detailed urodynamic studies are mandatory in patients with Parkinson's disease before considering surgery for benign prostatic hypertrophy, in order to correctly identify the source of lower urinary tract symptoms. Prostatectomy may markedly worsen symptoms if not correctly indicated.

TREATMENT OPTIONS FOR THE NEUROPATHIC BLADDER

The main objectives regarding management of the neuropathic bladder are listed in *Table 1*.

Storage failure/NDO

The favoured management of patients with NDO is a combination of anticholinergic medication (such as tolterodine or oxybutynin) with intermittent self-catheterization (ISC) (Jamil, 2001). The medication helps to prevent NDO via its effect on the parasympathetic nervous system, and serves to increase bladder capacity and compliance. Side effects, such as dry mouth, constipation and dizziness, are common. A high level of patient education allows for successful ISC. Permanent catheterization (urethral or suprapubic) should be avoided if at all possible, owing to the high incidence of infection, encrustation, blockages and potential risk of the development of bladder tumours secondary to chronic irritation associated with this procedure (*Table 2*).

Patients who maintain poorly compliant, high-pressure, low-volume bladders, despite these interventions, are best served by procedures to circumvent the bladder, such as continent catheterizable diversion (Mitrofanoff procedure) or ileal conduit. A popular alternative is the clam ileocystoplasty. This involves suturing a piece of bowel to the edges of an opened bladder to increase capacity. Overall, the final outcome of surgical reconstruction of the lower urinary tract is very satisfactory (Robertson et al, 1991).

Further solutions to the overactive neuropathic bladder include sacral rhizotomy (division of the posterior sacral nerve roots) and simultaneous insertion of a sacral anterior root stimulator device (Brindley, 1995; van Kerrebroeck et al, 1996). For patients with a suprasacral SCI, this

allows bladder emptying on demand (via a small external control box) and reduces urinary tract infections and residual volumes. Rhizotomy increases bladder compliance and capacity; however, this is at the expense of reflex erections and ejaculations in males.

Rhizotomy may, however, be obviated by configuring the system as a sacral posterior and anterior root stimulator, whereby low-level current applied to posterior nerve roots between voiding increases capacity and decreases overactivity by a process known as 'neuromodulation'(Kirkham et al, 2002). The InterStim™ device (Medtronic, Minneapolis, USA) has also been used to neuromodulate the neuropathic overactive bladder, using permanent sacral foraminal electrodes to apply current to nerve roots.

Detrusor–sphincter dyssynergia

NDO and DSD in combination are responsible for many of the complications of the neuropathic bladder. DSD produces a high resistance to the bladder outlet, resulting in abnormally high bladder pressures (and subsequent renal damage), and increased residual volumes of urine.

Traditionally, DSD is prevented by performing a surgical sphincterotomy, whereby the sphincter is incised longitudinally via an endoscope. This is a destructive process, and should only be used in cases that are refractory to standard management, such as anticholinergics and ISC. Surgical sphincterotomy is only practical in males, where a condom catheter is used to collect urine (patients will be incontinent, and no equivalent urine collection device is available for females).

Alternatives to sphincterotomy include either permanent or temporary urethral stents (Shah et al, 1997), or botulinum toxin injections to the external sphincter (de Seze et al, 2002).

The incompetent sphincter

Neurological lesions may also affect continence by reducing the outlet resistance at the level of the external sphincter. To prevent incontinence in such cases there are several potential therapies. First, an artificial urinary sphincter may be surgically implanted, whereby patients manually control their own urethral pressure (Singh and Thomas, 1996). Other options involve either vaginal sling operations in females, or injection of peri-urethral substances such as collagen to increase outlet resistance.

The acontractile bladder

The acontractile bladder may be considered 'safe', in that high-pressure contractions and DSD will not occur. However, patients will generally rely on ISC to empty their bladders. Emerging alternatives include the latissimus dorsi muscle flap technique, whereby free flaps of muscle are attached to acontractile bladders using microvascular techniques (Stenzl and Ninkovic, 2001).

COMPLICATIONS OF THE NEUROPATHIC BLADDER

The most important objective in management of the neuropathic bladder is avoidance of permanent renal damage. The mechanism of renal failure associated with the neuropathic bladder is complex, but usually arises from a combination of the following:

Urinary tract infection

Urinary tract infection is almost inevitable in patients with a neuropathic bladder. It is caused by a combination of incontinence, increased intravesical pressure, reflux of urine and calculi (Siroky, 2002). The high bladder pressures associated with the neuropathic bladder may render the vesicoureteric junction (VUJ) incompetent, resulting in reflux. The combination of reflux and infected urine lead to pyelonephritis and renal injury. In men, epididymitis and prostatitis are other manifestations of an infected urinary tract.

Treatment of urinary tract infection should be prompt and aggressive and be adjusted according to antibiotic sensitivities where these are available.

Hydronephrosis

Hydronephrosis results mainly from the combination of NDO, DSD and incompetence of the VUJ. Alternatively, the VUJ may become obstructed as a result of muscular hypertrophy. In cases of reflux and hydronephrosis, changes in management of the NDO or DSD must be made, and ultimately surgical revision may be

TABLE 2.
Benefits and drawbacks of different methods of catheterization

Method	Benefits	Drawback
Intermittent catheterization	Patient independence Sterility not required Reduced complications	Manual dexterity required Requires high motivation Good teaching essential
Suprapubic catheterization	Easy to change Protects urethra Easy to care for Reduced expulsion	Morbidity of insertion Blockage Urinary infection Stones and encrustation
Urethral catheterization	Convenient for some	Urinary infection Blockage Stones and encrustation Urethral injury long term Bladder neoplasia

necessary. The last resort in such cases is urinary diversion in the form of an ileal conduit, or continent reservoir formation such as the Mitrofanoff procedure.

Calculi

Bladder, ureteric and renal stones are common in patients with neurological impairment. The factors responsible for their high incidence are thought to include hypercalciuria resulting from skeletal demineralization and chronic urinary infection. Management is similar to that of patients without neurological impairment. Open surgery is rarely indicated, and most calculi may be dealt with either endoscopically or with extracorporeal shock-wave lithotripsy.

OTHER PROBLEMS ASSOCIATED WITH THE NEUROPATHIC BLADDER

Erectile dysfunction

Male patients with complete suprasacral lesions may experience reflex erections and ejaculations, but have no control over these. Patients with sacral level injuries may not experience any erections. The standard methods for treating erectile dysfunction, such as oral medication, intracavernosal and intraurethral injection, vacuum pumps and penile prosthesis, may be used in these patients. If oral medication is indicated, lower doses should be tried in neuropathic patients in the first instance to prevent priapism occurring.

Male fertility

SCI is associated with poor quality sperm and infertility in males. Semen may be obtained in patients with SCI via vibrators applied to the glans penis in individuals with suprasacral injuries or via transrectal stimulation (in those with lower injuries). If these techniques are used, patients and doctors must be aware of the possibility of precipitating an episode of autonomic dysreflexia.

KEY POINTS

- The neuropathic bladder is a multidisciplinary concern.
- Neurological disease or injury commonly results in dysfunction of the urinary tract.
- It is important to evaluate such patients thoroughly, including urodynamic studies.
- A basic understanding of the physiology of the urinary tract and nervous system promotes understanding of the neuropathic bladder.
- Urological symptoms are not an accurate predictor of underlying dysfunction (the bladder is 'a poor witness').
- Appropriate management following diagnosis prevents complications and reduces morbidity and mortality.

Autonomic dysreflexia

Autonomic dysreflexia is commonly caused by urinary stimuli, such as a blocked urethral catheter, and is a result of the intense autonomic overactivity produced by afferent stimulation.

The condition mainly affects patients with lesions above the mid-thoracic level. Patients experience headache, flushing and sweating. The main problem is severe life-threatening hypertension (Karlsson, 1999). Treatment involves removing the cause (e.g. draining the bladder), sitting the patient upright, and administering sublingual nifedipine.

CONCLUSION

In assessment of patients with neurological impairment a high index of suspicion should be maintained with regard to urological dysfunction. Appropriate investigations using available resources and clear management strategies will minimize urological complications and future renal impairment. HM

Conflict of interest: none.

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