

## ORIGINAL ARTICLE

# The use of one-channel water cystometry in patients with a spinal cord lesion: practicalities, clinical value and limitations for the diagnosis of neurogenic bladder dysfunction

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**Study design:** Investigational technique evaluation.

**Objective:** To evaluate the clinical value and limitations of one-channel cystometry as a method for urodynamic testing in patients with spinal cord lesion (SCL).

**Setting:** Spinal Cord Injury Centers Asia.

**Methods:** Protocol, equipment and practical performance of the one-channel cystometry as used in Ho Chi Minh City and Chiang Mai were studied.

**Results:** One-channel cystometry permits to accurately evaluate bladder pressure development at constant filling speed. It shows detrusor muscle behaviour as detrusor overactivity and allows evaluating sensation of bladder filling. It can strongly suggest detrusor external sphincter dyssynergia. The need of bladder-relaxant drugs and their effectiveness can be evaluated. The major limitation is that the one pressure line will show changes of intravesical pressure independent of their cause, which makes a continuous thorough observation mandatory throughout the test. Other limitations are a filling rate higher than physiological and a filling solution at room temperature. As in more elaborate urodynamic testing, the observations do therefore not necessarily reflect the function of the lower urinary tract in daily life.

**Conclusion:** One-channel cystometry is easy to perform, cheap and clinically valid. The results need to be integrated in the overall knowledge of the patient's neurological situation. The method permits one to gather a lot of information on bladder function in persons with SCL. With proper interpretation and a clear understanding of the shortcomings, it is a good guide for bladder management. It is applicable everywhere.

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**Keywords:** cystometry; spinal cord injury; neurogenic bladder

## Introduction

Most persons with spinal cord lesion (SCL) develop a neurological bladder dysfunction. History has taught how important a proper bladder management is for life expectancy and quality of life. Optimal treatment requires a proper diagnosis. Patient history, signs and symptoms, physical and neurological examinations, urine and blood tests, bladder diary, observations by nurses are all important on this behalf. These data, combined with the level and severity of the SCL,

permit us to 'guess' the detrusor and sphincter dysfunction in around 80%.<sup>1</sup>

Pressure development during bladder filling and voiding has been recognized as an important criteria for a 'safe' urodynamic status.<sup>2</sup> Urodynamic testing is the only objective way to measure this pressure development.

Traumatic SCL is as prevalent in developing countries as in the western world,<sup>3</sup> and the vast majority need urodynamic testing to properly guide bladder management. A drawback of developing regions can be the cost of expensive equipment that runs on electricity and of the disposable material needed for the tests. The multichannel equipment permits without doubt a profound evaluation, but to be able to translate the different curves into a complete urodynamic

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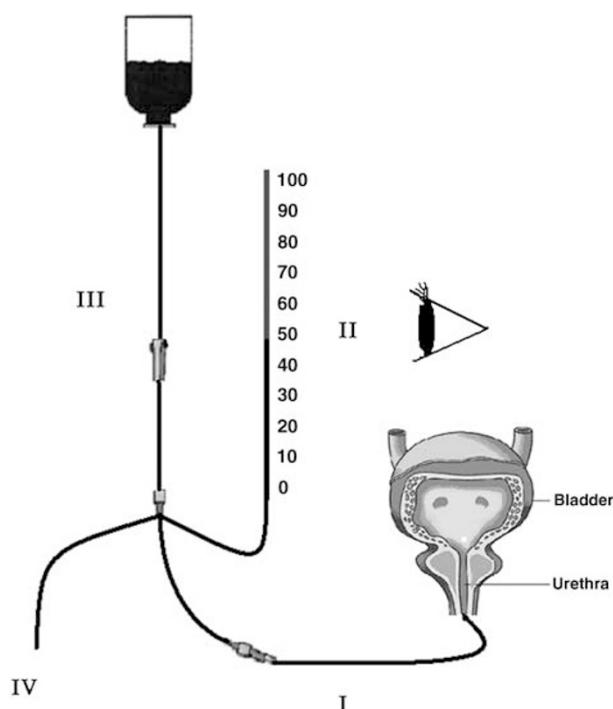
diagnosis of lower urinary tract dysfunction, the investigator needs a solid knowledge of the pathophysiology after spinal cord injury, of what all the generated data mean and of the pitfalls easily encountered in such complicated tests.

We describe the simple and practical equipment of a cheap one-channel water cystometry that could be used everywhere, for primary and follow-up testing. We evaluate its clinical value and shortcomings.

## Materials and methods

The experiences with a one-channel water cystometry used in different countries in South East Asia (Thailand, Cambodia, Vietnam and Nepal) were put together. The protocol is given in detail as used routinely after a pilot period in November 2004 in a specialized SCI unit in Ho Chi Minh City, where it has been performed in several hundreds of patients.

The equipment needed is an infusing stand, a bottle with infusion liquid (NaCl 0.9%, 500 ml) connected with a three-way connector. One way (I) is connected to a Nelaton catheter (FR 12–14) introduced transurethraly into the bladder. Another way (II) is connected with a glass (less frequently used) or plastic tube with open top, fixed against a 1 m measure, with divisions of 1 cm, put vertically against the stand. This is used for pressure measurement. The third way (III) is connected with the filling tube. If a fourth way (IV) is wanted, for emptying the bladder between tests, it can be added through an extra Y valve to the three-way valve (Figure 1). This last way can be useful when repeated fillings are performed.



**Figure 1** One-channel cystometry equipment. I: channel connected to bladder catheter; II: channel for pressure measurement; III: channel for filling the bladder; IV: channel (eventually added) for bladder emptying.

Patients are explained about the purpose and technique of the test. Level and completeness of the SCL are noted (ASIA Impairment Scale—AIS scale). Clinical neurological tests are performed related to the sacral cord: presence of touch and pin-prick sensation in the perineal dermatomes; bulbocavernosus, anal and, in male, cremasteric reflexes; voluntary anal contraction and evaluation of sphincter tone.

The patients are supine on a mattress. The equipment is installed, all tubes water filled, with the zero of the pressure line positioned at probable bladder level. A collecting device is put at the meatal area (urinal, bed pan) for eventual voiding or leakage.

Filling speed is determined beforehand by opening the roller valve of the filling line slowly and measuring the inflow with a stop watch and out flow volume measured in a container. When filling speed ( $20\text{--}50\text{ ml min}^{-1}$ ) remains stable when measured two to three times, the roller valve is fixed with a strip to make inflow speed fairly constant. Patient is instructed to report bladder-filling sensation and other nonspecific symptoms that may occur.

Before starting, the liquid in the pressure line, which has fallen to intravesical pressure, is checked on rising with coughing. The basic bladder pressure is measured and together with start time noted on the special log page. Inflow is started at the pre-set speed and the pressure noted every 30 s as presented in Figure 2. The estimated filling volume is calculated from filling time  $\times$  filling speed. Reported bladder-filling sensations and signs such as leakage, increased leg spasticity and signs of autonomic dysreflexia are recorded on the log. Filling is stopped at bladder sensation of fullness or strong desire to void. In patients without bladder sensation, the filling is stopped when leakage occurs due to bladder pressure rise, at 500 ml when no pressure rise is noticed or at pressure above 50–60 cm  $\text{H}_2\text{O}$ , if such pressure rise appears without leakage.

The test is reperformed after bladder emptying to check consistency. In case of voiding, post-void residual volume is measured; in case of no voiding, the volume in the bladder is measured to control the calculated volume infused (filling speed  $\times$  time filled).

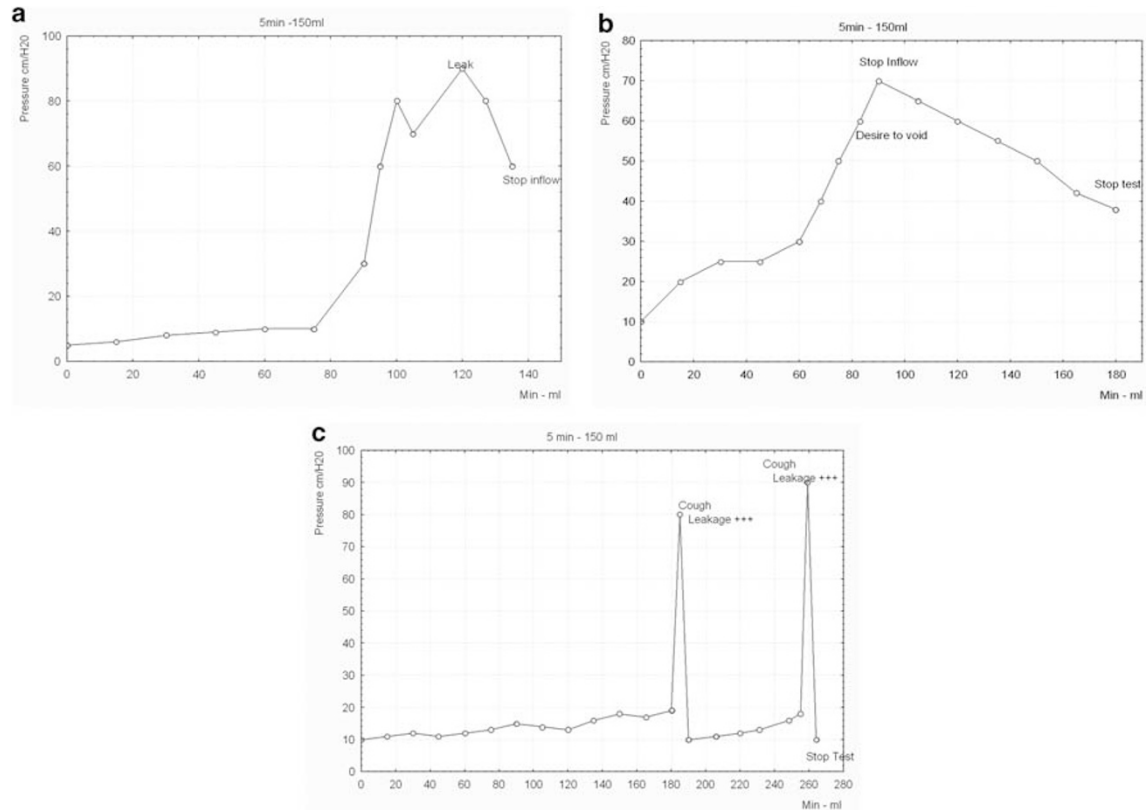
## Results

The equipment proved easy to use and the application of the test easy to learn. Examples of curves are given in Figure 2.

The following parameters could be measured: intravesical pressure at the start and at the end of filling, at leakage and at sensation. Cystometrical capacity at first overactive contraction, at leakage and at sensation could be calculated from infusion time and inflow speed. Residual volume when voiding or leakages had occurred could be measured.

Observations included aspect of urine at start, difficulty to introduce the catheter, skin lesions from incontinence, leakage, signs of autonomic dysreflexia and type of stream when voiding occurred (continuous or interrupted).

Problems encountered were rare: blocking of the filling and pressure lines, expulsion of the pressure line during



**Figure 2** Examples of curves obtained with a one-channel cystometer. Filling at 30 ml min<sup>-1</sup>. Pressure measured every 30 s. (a) a 22-year-old man with paraplegia T7, AIS A, 6 weeks after injury, cystometry showing bladder overactivity with high pressure leakage. (b) a 32-year-old man with paraplegia T5, AIS B, 6 months with indwelling catheter shows low-compliance bladder with high pressure at low volume. (c) a 57-year-old woman with paraplegia L1, AIS A, 3 months after injury. Leakage despite self-catheterization: stress urinary incontinence demonstrated without bladder contraction. The bladder-filling volume is calculated from filling speed  $\times$  filling time and does not necessarily present the exact volume in the bladder at that time.

involuntary contraction or cough despite fixation on the outside of the body.

The cost of material for one test was on an average 5 US dollars (value 2008).

## Discussion

There is little doubt that measuring what happens in the bladder after a neurological lesion is important to determine and follow bladder management and safeguard the kidneys.

The goals of proper bladder management in paralysed patients are to keep the lower urinary tract at good capacity, low pressure, without infection and without incontinence.<sup>2</sup>

The urological treatment was based for decades mostly on clinical data as level and completeness of the lesion, bladder diary, renal function and imaging. The development of urodynamic equipment has offered the possibility to measure specific components of function during bladder filling and during voiding. The first cystometers had one channel and were used for research purposes.<sup>4</sup> Despite the poor technical equipment, neurophysiologic observations in the 19th century were impressive pioneering investigations of bladder pressure and studies in bladder motility.

Continuously recordable filling cystometry was developed as early as the end of the 19th century.

The Lewis one-channel cystometer was one of the first applied on a wide scale in neurourological practice.<sup>5</sup> Bors and Comarr<sup>6</sup> described its use in their textbook stating that the most important is not the equipment itself but that the examiner knows it well and is able to make a proper interpretation of the findings. As such, it gave a good idea of how the lower urinary tract activity developed in the individual paraplegic or tetraplegic patient. Some consider it still an important tool for nurses and doctors. It permits early and repeated evaluation in patients with SCL, avoiding sometimes long waiting lists for elaborate urodynamic evaluation and lowering the cost.

The more elaborate the equipment has since become, the more data became available. A proper interpretation of the multiple curves and the lists of data that a multichannel equipment automatically delivers is not easy and many pitfalls exist. A solid knowledge is needed to make this modern urodynamic testing reliable and clinically valuable. Multichannel urodynamic equipment is not cheap and many areas of the world cannot as yet afford it. It has become evident that a lot of information can be gained with a cheap system, as described here, that is easy to use even in places without electricity.

The one-channel cystometry permits, when correct interpretation is done, to investigate many functional parameters described in the recently published International Urodynamic Basic Spinal Cord Injury Data Set.<sup>7</sup>

Increased or reduced bladder sensation and absent bladder sensation, as one of the signs of complete neurologic lesion, can be noted. Normal detrusor function, neurogenic detrusor overactivity and detrusor acontractility can be diagnosed. To determine the bladder compliance with the International Continence Society,<sup>8</sup> recommended calculation between two standard points is possible with a one-channel investigation. Normal detrusor function during voiding will show a voluntarily initiated continuous pressure rise, with voiding and complete bladder emptying noted. The magnitude of the recorded pressure rise will give some indication of the degree of outlet resistance. Detrusor sphincter dyssynergia can be suspected from the postponement of urine outflow despite high bladder-contraction pressure and by repeated interruption of the stream during voiding alternating with peaks of intravesical pressure. Leak-point pressure, maximum vesical pressure during filling cystometry, cystometric bladder capacity and post-void residual volume can all be evaluated.

A one-channel cystometry can also record the strength of abdominal strain.<sup>6</sup> Cystometry cannot be interpreted by just reading the graph at the end of the test or afterwards. The examination must be interpreted at the time of the study by maintaining close verbal contact with the patient. When changes in intravesical pressure are noted, it must be determined whether the observed changes are due to a detrusor contraction, an increase in intra-abdominal pressure or a loss of elasticity of the bladder wall. If a bladder pressure rise is observed, it must be ascertained whether it is voluntary or involuntary, if the patient is aware of it and if he/she is able to inhibit it.

The shortcomings of a one-channel cystometry are several. The lack of simultaneous bowel pressure measurement makes interpretation of sharp pressure rises tricky, but this can be counteracted by a close patient observation. Small pressure changes cannot be measured but are seldom important clinically. It is not always easy to differentiate between pressure rise from involuntary contraction and that from lack of elasticity of the bladder wall (low compliance). The speed of pressure increase during filling as well as of pressure drop after stopping the inflow may help an experienced examiner. There is no imaging, making the diagnosis of vesicoureteral reflux, bladder neck pathology and diverticula impossible. Calculating the filling volume from filling speed and filling time can be unreliable. By a strong increase of vesical pressure, the inflow can get slower or even stop. Reading the amount run out of the infusion bottle and measuring the volume catheterized at the end of the test can help.

In the technique described here, a 12- to 14-FR catheter was used, because it was easily available where the testing was performed. Mostly, a much smaller catheter would be advisable to prevent an obstructive effect during the voiding phase.

Several studies in literature compared one-channel with multichannel measurements, but to our knowledge, not in

patients with neurogenic bladder. Sutherst and Brown<sup>9</sup> evaluated the abilities of a single-channel cystometry and a standard multichannel cystometry to diagnose bladder instability in 100 women in a single-blind crossover trial. In 93 of the women, both tests yielded the same result. In seven, suggested detrusor contractions were not evident on multichannel cystometry, probably due to changes in abdominal pressure. Scotti and Myers<sup>10</sup> and Wall *et al.*<sup>11</sup> found the simplified method of the cough stress test and the single-channel cystometry as accurate and predictive for the diagnosis of genuine stress incontinence as the multichannel method. Sand *et al.*<sup>12</sup> demonstrated that when multichannel urodynamics are not available in a high-prevalence population of non-neurogenic female patients, retrograde incremental water cystometry performed on two occasions may offer the physician an accurate alternative for the diagnosis of detrusor instability. Similar results were found by Ouslander *et al.*<sup>13</sup> and Fonda *et al.*<sup>14</sup> in a comparison between the simple and the multichannel cystometry in incontinent geriatric patients. Simple bedside cystometry was also advocated by incontinence nurses.<sup>15,16</sup>

## Conclusion

A one-channel cystometry permits one to gather a lot of information on bladder function in persons with SCL. With proper interpretation and a clear understanding of the shortcomings, it is a good guide for bladder management. It is easy to perform, not expensive and applicable everywhere.

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