Residual urine following intermittent catheterisation in patients with spinal cord injuries

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Residual urine following catheterisation was studied using ultrasonography (Ultramark II Scientific Medical System) in 12 patients with spinal cord injury, for an average of 4 months (range 3–7 months) after the time of injury. All of the patients were examined on three occasions. Urinary tract infections were also registered, and the functional type of the urinary bladder was identified by a cystometric examination. Ultrasonography showed residual urine volumes after 25 of a total of 36 catheterisations (70%). In seven of these catheterisations the residual urine volume exceeded 50 ml, and in two patients was more than 100 ml. None of the patients had a residual urinary volume of more than 50 ml after all three catheterisations, but in all but two patients, some residual urine volume was found after at least one of the catheterisations. Low and non-significant correlations were found between residual volume and frequency of urinary tract infections. It is possible that even small residual urine volumes after catheterisations may predispose to urinary tract infections in these patients

Keywords: residual urine; intermittent catheterisation; spinal cord injury; ultrasonography

Introduction

Intermittent catheterisation of the bladder in patients with paresis following traumatic injuries to the spinal cord was, to our knowledge, first described by Guttman in 1949.¹ The method was introduced in order to reduce urological complications due to insufficient bladder emptying. Comarr² introduced sterile self-catheterisation in paraplegic patients in 1972, and Lapides *et al*³ introduced non-sterile 'clean' catheterisation for patients suffering from excessive residual urine and recurrent urinary tract infections.

Intermittent catheterisation reduces the frequency of urinary tract infections (UTI), calculus formation, epididymitis and hydronephrosis in patients with spinal cord injuries compared to permanent indwelling catheters.^{1–8} The method is now used as a routine in patients with spinal cord injuries, and if finger/hand function is intact the patients are usually instructed to perform self-catheterisation.

Despite adequate technique with expected sufficient bladder emptying, many of these patients nevertheless have repeated UTI. Different causes for such infections have been proposed.^{3,5,7,8} One possible reason is that intermittent catheterisation does not empty the bladder sufficiently.

Materials and methods

Twelve patients suffering from spinal cord injuries, consecutively admitted to Sunnaas Rehabilitation Hospital for primary rehabilitation were included

(Table 1). Patients in the spinal shock phase (five) were not included. The time from injury to examination was on average 4 months (range 3–7 months). Before starting the study, all patients performed intermittent self-catheterisation according to a given procedure at our hospital. The frequency of the catheterisations varied between 1 and 5 times daily, depending on the amount of residual urine. Patients with UTI and/or bladder calculus were not examined during the presence of these complications. All patients included in the study had normal pyelograms and normal levels of serum creatinine.

In this study, two members of the staff performed the catheterisations of the 12 patients. These members of the staff were the same persons during the whole study and had a long experience and training in the procedure. The residual urine following catheterisation was measured by another experienced member of the staff three times for each patient. All measurements were carried out at 1 o'clock during the following 3 days.

The catheterisation was carried out according to a standard procedure. The patients were lying in a supine position, and no movements or manipulations were performed. The procedure lasted at least 5 min, and the catheter was slowly retracted 2 min after the last amount of urine had passed. The catheters used were identical in all patients (Lofric No. 12, Astra Meditec, Sweden).

Immediately after catheterisation all patients were examined with ultrasonography (Ultramark II Scientific Medical System, USA), and the examination was

Table 1 Level of injury, given according to the lowest intact cordal segment, of the 12 patients included in the study. The injury was either complete (no medullary connection over and below level of injury), scored as (+), or incomplete (variable degree of medullary connection over and below level of injury), scored as (–)

Patient	Sex	Age (years)	Completeness of injury	Time since injury (months)
1	F	17	–	4
2	M	20	–	3
3	M	72	–	6
4	M	23	+	4
5	M	32	–	5
6	M	21	+	3
7	M	33	–	4
8	M	23	+	7
9	M	28	+	4
10	M	66	+	4
11	M	21	+	4
12	M	46	–	3

C: cervical; T: thoracic; L: lumbar

carried out by the same examiner for all patients. The residual urine present in the urinary bladder was calculated using the formula: 'sagittal height $\times$ sagittal depth $\times$ transverse width',⁹ as this formula was reported to be the most accurate one in determining residual urine with ultrasonography.¹⁰ This examination was chosen as the 'gold standard' for the measurement of residual urine. However, for the present discussion an error margin of 15–25% is calculated for this procedure.¹¹

All patients had urethrocystometry with anal sphincter EMG, installing CO₂ gas in the bladder at a rate of 50 ml min⁻¹. Urinary bladder function was classified into two main groups: neuropathic hyperactive bladder (reflex bladder) and neuropathic hypoactive bladder (atonic bladder).^{5,12,13}

Results

Table 2 shows the classification of the urinary bladders, effect of percussion, residual urine and number of

urinary tract infections during the hospital stay for 12 patients. We registered residual urine following 25 out of total 36 catheterisations. In seven patients the residual urine was found to be between 50 and 100 ml, and in two cases the residual urine was above 100 ml (150 and 153 ml, respectively). No patients exceeded 50 ml in residual urine following all three measurements. All but two patients had some residual urine after at least one catheterisation.

Table 3 shows the average and maximal residual urine in patients with hyperactive and hypoactive neuropathic bladders, respectively. The difference between maximal residual urine in the two groups almost reached statistical significance ($P = 0.06$). The average residual urine and the number of urinary tract infections were not statistically different in the two groups of bladder disorders studied.

As expected we mainly found hyperactive neuropathic bladders in patients with cervical or thoracic lesions, while hypoactive patterns were found in lower lesions. There was no significant correlation between

Table 2 Type of bladder, reflex response, residual urine, and urinary tract infections in 12 patients with spinal cord injury

Patient	Type of bladder	Reflex response	Residual urine (ml) following three (intermittent) catheterisations			Number of urinary tract infections
1	Reflex bladder	Poor	30	63	46	1
2	Reflex bladder	Yes	75	25	32	0
3	Reflex bladder	No	0	0	88	0
4	Reflex bladder	Yes	44	40	48	4
5	Reflex bladder	No	0	0	0	1
6	Reflex bladder	Yes	78	153	28	1
7	Atonic bladder	No	44	10	41	1
8	Reflex bladder	No	0	9	0	2
9	Reflex bladder	Yes	0	56	150	4
10	Atonic bladder	No	0	0	0	2
11	Atonic bladder	No	25	27	23	0
12	Atonic bladder	No	37	11	9	1

Table 3 Mean and maximal residual urine and number of urinary tract infections among SCI patients with hyperactive and hypoactive neuropathic bladder. Values are scored $\pm$ SE

	Average residual urine (ml)	Max scored retention (ml)	Urinary tract infections (n)
Hyperactive neuropathic bladder ($n = 8$)	40 ± 11	73 ± 20	1.6 ± 0.6
Hypoactive neuropathic bladder ($n = 4$)	19 ± 7	27 ± 10	1.0 ± 0.4
Statistical significance (Student's unpaired t test)	$P = 0.21$	$P = 0.06$	$P = 0.49$

the number of UTI and the amount of residual urine (Figure 1); correlation coefficients were low and not significant (0.19 and 0.16, respectively).

Nine of the patients had one or more UTI. In two of these there was no residual urine following catheterisation.

Discussion

This study shows that bladder emptying by means of IC in patients with spinal cord lesions is often incomplete. Ten out of 12 of the patients had residual urine in at least one out of three catheterisations. If a residual urine less than 50 ml is a criterium of satisfactory bladder emptying, five out of 12 patients had unsatisfactory emptying in one or more catheterisations.

IC is considered to be the best method of estimating residual urine, but ideally the procedure should be carried out with the patient standing.¹⁰ Our investigation shows that residual urine can be demonstrated even in many patients when catheterisation is finished with the patient in the supine position. This has been verified by ultrasonography also in other patients.¹⁴ Catheterisation in the supine position in patients with spinal cord injury therefore should not be used as the 'gold standard'.

Using catheterisation as the 'gold standard', the error margin compared to ultrasonography measurements is reported to be between 15 and 25%.^{11,15} One study

reports an error margin of $49 \pm 32\%$ (SD) if the residual urine is less than 150 ml.¹⁰

Several studies report difficulties in estimating the residual urine with ultrasonography if the volume is less than 50 ml.^{10,15} In such cases there are several false negative results, but no false positive results.¹⁴ No separate studies have been carried out for the reproducibility of measurements done by ultrasonography, but reports from comparable studies state about 9%.¹⁵ Some of the variations in the test results found in the same patients in our study may be accounted for by methodological errors. Varying positioning of the openings of the catheter may be another reason.

In our department we often exert pressure over the bladder region or turn the patient round during the procedure of catheterisation. We suppose that this results in more complete emptying, like catheterisation in the upright position.¹⁰ This has, however, not been verified by ultrasonography studies. In self-catheterisation the patient is often instructed to do this in a sitting position. In some patients this appears to result in more complete emptying.¹⁶ For some time after the injury, many patients are unable to maintain the sitting position.

The type of bladder paresis may also influence the amount of residual urine. Patients with a reflex type of bladder have a greater tendency for larger amounts of residual urine following catheterisation than do patients with an atonic type of bladder (Table 3). The degree of detrusor sphincter dyssynergia will influence the degree of emptying on spontaneous micturition, but this does not explain the increased residual urine following catheterisation. Our material is too small to be able to say anything about the relationship between the type of bladder paresis and the residual urine following catheterisation.

Our patients had rather frequent UTI (Table 2). In this study there was a low correlation between the average or maximal residual urine following catheterisation and the frequency of UTI (Figure 1). The prevailing opinion is that a residual urine of 100 ml or less does not predispose for UTI. According to our results even smaller amounts of residual urine are no guarantee against UTI. We, therefore, recommend efforts to optimise the catheterisation technique in order to reduce the amount of residual urine to nil. Factors other than the residual urine may also be of importance in the development of UTI in patients with spinal cord injuries. Lapides *et al*^{3,8} have shown that overstretching of the bladder causes reduced blood flow in the parenchyma and uroepithelium. This may

Figure 1 Frequency of urinary tract infections correlated to the residual urine (mean and max values) following (intermittent) catheterisation. The figure includes regression lines, regression equations and correlation coefficients

facilitate invasion of gram-negative organisms from the patients' own bacterial flora. Frequent IC will prevent overstretch of the urinary bladder, and hence reduce the danger of infection.

Conclusions

This study shows that IC carried out in SCI patients in a supine position does not often empty the bladder completely. If less than 50 ml residual urine is defined as satisfactory, our study shows insufficient bladder emptying in 20% of catheterisations. The question is, however, if even smaller amounts of residual urine will predispose for UTI, which is what our study may indicate.

The study also shows that residual volume of urine measured by means of catheterisation in the supine position cannot be considered as an indisputable 'gold standard' in judging the residual volume in patients with spinal cord injury.

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