Characteristics of Urinary Incontinence in Elderly Patients Studied by 24-Hour Monitoring and Urodynamic Testing

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Summary
Characteristics of urinary incontinence have been studied in 100 elderly incontinent patients using invasive video-urodynamics and noninvasive 24-h monitoring of incontinence, fluid intake, voiding and residual urine. Incontinence was of the urge type in 51 patients, including 24 with reduced bladder sensation. Noninvasive 24-h monitoring showed satisfactory reproducibility and high sensitivity (88%) for detecting urine loss. Urodynamically proven urge incontinence, especially in combination with reduced sensation, and recent bacteriuria were associated with severe urine loss on 24-h monitoring. On 24-h monitoring, urine output was significantly larger at night and nocturia was common. In urge incontinence urine loss was predominantly nocturnal and the amount depended significantly on the previous evening's fluid intake and on nocturia.

Noninvasive 24-h monitoring showed that post-void residual was common and was often largest in the early morning. It also yielded many free-voiding flow curves. Normal flow curves with small residual urine make dysfunction of voiding itself unlikely. Thus noninvasive monitoring provides information about incontinence and voiding that is suitable for designing intervention and management strategies. Invasive testing may be necessary however to confirm the urodynamic type of incontinence or suspected voiding dysfunction.

Introduction
Urinary incontinence is common among elderly people and has serious social and economic consequences [1]. Various urodynamically defined types of incontinence have been identified but the causes are usually multifactorial [2]. Established incontinence is difficult to treat and manage. Any single approach has limited success and careful selection and combination of different approaches is necessary [3].

We have conducted a study of established urinary incontinence among patients being assessed in a geriatrics unit for rehabilitation. Our objectives were to determine the clinically important characteristics and the predominant types of incontinence and to compare different methods of investigation.

Methods
Elderly patients with a history of established urinary incontinence or urgency and frequency of micturition were referred from a geriatric assessment facility. Bedridden patients, patients with an indwelling catheter that could not be removed and those with a...
recent (<6 weeks) cerebrovascular accident were excluded. Impaired mobility or poor cognitive status was not a reason for exclusion. Written informed consent was obtained from the patient and from a relative or guardian if necessary. Urinalysis and culture were performed and any infection or other possible cause of transient incontinence was treated. Medication prescribed for urinary tract dysfunction was discontinued 5–7 days before the initial investigation. Other medications were continued. Urodynamic methods, definitions and units conform to the standards recommended by the International Continence Society (ICS) [4] except where noted.

On admission, a physical examination and a medical history were carried out by a certified geriatrician or trainee. Ability to perform the activities of daily living was assessed on the Katz ADL scale [5] by a rehabilitation medicine professional. Twenty-four-hour monitoring was then started on a nursing unit with trained staff, using a patient room with a private toilet fitted with an automatic flowmeter (Wiest 4150). Patients continued to perform their normal hospital activities and voiding routine. All fluid intake was recorded. To record urine loss, preweighed absorbent briefs ('pads') were worn; during waking hours they were changed and reweighed every 2 h (sooner if obviously saturated), using a Mettler PJ 4000 balance; during the night they were checked every 2 h and changed if damp. The automatic flowmeter gave a recording of all voids, including the flow curves and the volumes voided.

Post-void residual urine was estimated three times with a Pie Medical 1100 ultrasound scanner, in the early afternoon, the evening and the early morning. Residual urine was calculated by combining the dimensions of a transverse and a sagittal scan of the bladder [6]. The method was validated by comparison with catheter determinations of urine volume in a separate study of 21 patients.

In assessing urine loss, a gain in pad weight of 8 g in 24 h [7] or 2 g in 1 h [4] is the upper limit of normal. We have conservatively adopted a weight gain of 3 g or more in any one pad together with a total 24-h weight gain of at least 10 g as representing measurable urine loss.

A detailed voiding and incontinence history was taken and the Mini-mental State Examination (MMSE) [8] was administered. Video-urodynamic testing was carried out using a Laborie UDS-500 urodynamics analyser, a Philips BV 22 fluoroscope and a specially designed investigation table/chair. Fluid-filled urethral and rectal catheters (5 and 10 French gauge) were connected to external pressure transducers. With the patient supine above a flowmeter, the bladder was filled through a second urethral catheter (8 French gauge) with room-temperature radiographic contrast material (Conray 30) at a medium rate (70 ml/min). The patient was questioned repeatedly about bladder sensation. The patient coughed, under fluoroscopy, to provoke possible incontinence. Filling was continued until there was uninhibited voiding or a strong urge to void or the detrusor pressure rose by more than 15 cmH$_2$O. The patient then voided in the sitting position. Filling, coughing and voiding were repeated in this position.

Detrusor instability during bladder filling was diagnosed from involuntary phasic changes in detrusor pressure characteristic of detrusor contraction. Incontinence was regarded as urodynamically proven only if actual leakage was detected during the test. Thus urodynamic proof of the condition (motor) urge incontinence required that leakage be detected during an unstable detrusor contraction, with the sensation of urgency. (Only the symptom of urge incontinence is defined by the ICS [4].) Patients who failed to appreciate that their bladder was being filled, or felt it only after a detrusor pressure rise of at least 15 cmH$_2$O had occurred prior to voluntary or involuntary voiding, were classified as having reduced sensation of bladder fullness.

On the basis of the history, physical examination and 24-h monitoring, the geriatrician instituted an intervention, such as oxybutynin chloride, referral for surgery or conservative management by exercises, voiding routine or fluid restriction. Twenty-four-hour monitoring and video-urodynamics were repeated 2–6 weeks later.

Results

Characteristics of the patient sample: Sixty-two women and 38 men were studied. Their ages ranged from 60 to 91 (median 79.5) years. MMSE scores ranged from 7/30 to 30/30 (median 23/30). ADL scores ranged from 1/8 to 8/8 (median 3/8). Twenty-two patients had a history of cerebrovascular diseases; 19 had a diagnosis of Alzheimer's disease; eight of multi-infarct dementia; 12 of parkinsonism and 13 of diabetes. Seven patients had disc prolapse problems. Fifty-four patients gave a history of incontinence lasting more than one year. Ninety-six of the 100 patients were incontinent on history and/or on testing. Twenty-five patients had bacteriuria (>100 000 colony-forming units/ml) immediately prior to entry to the study. At the first investigation, fewer than a quarter of these patients still had infected urine
but a sixth of those previously free of infection had developed it (see [9]).

Characteristics of incontinence and lower urinary tract function: Twenty-four-hour monitoring showed that the severity of the incontinence, as judged by the total gain in weight of all pads, covered a wide range (Figure 1). The median value was $80 \text{ g}$. There was measurable urine loss in all but five of the patients.

Video-urodynamic testing demonstrated urge incontinence in $51/100$ patients, genuine stress incontinence in $3/100$, overflow incontinence in $1/100$, reflex incontinence in $1/100$ and incontinence of mixed or questionable type in $9/100$. In $35$ patients, no actual urine loss was demonstrated on video-urodynamics, although detrusor instability without urine loss was observed in $12$ of them.

Patients with urodynamically proven urge incontinence leaked more urine during 24-h monitoring than those with other urodynamic findings ($p < 0.0002$) (Figure 2). Twenty-two of the $51$ urge-incontinent patients had predominantly nocturnal urine loss. Twenty-four of the $51$ urge-incontinent patients had reduced bladder sensation. These $24$ leaked even more than those with urge incontinence and normal bladder sensation (Figure 2).

Among the patients with pre-entry bacteriuria, $12$ had urge incontinence and in five no incontinence was demonstrated on video-urodynamics. There was no significant association between the urodynamic finding of urge incontinence and pre-entry bacteriuria. However, patients with pre-entry bacteriuria leaked more urine than those without bacteriuria (Figure 3). Statistical analysis of variance showed that urodynamically proven urge incontinence and pre-entry bacteriuria contributed independently (and significantly) to the severity of urine loss.

Figure 1. Histogram showing the wide range covered by the amount of urine lost in 24 h.

Figure 2. Relation of 24-h urine loss to presence of urodynamically proven urge incontinence and bladder sensation. The differences between the columns are significant ($p < 0.0005$ by Friedman’s non-parametric analysis of variance). In this figure and Figure 3, the columns and vertical bars represent median values and 25th and 75th percentiles. Nocturnal urine loss shows similar significant relations.

Figure 3. Relation of 24-h urine loss to bacteriuria determined in the month before entry to the study (CFU = colony-forming units). The differences are significant ($p < 0.01$ by Friedman’s analysis of variance). Nocturnal urine loss shows a similar relation ($p < 0.0002$).
Table I. Diurnal variation of characteristics of lower urinary tract function

<table>
<thead>
<tr>
<th>Weight of urine leaked (g):</th>
<th>Median values and 25th and 75th percentiles</th>
<th>Significance of difference (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>Time 24 h 00-08 h 00</td>
<td>Time 08 h 00-16 h 00</td>
</tr>
<tr>
<td>Urge incontinence</td>
<td>15 (2-193)</td>
<td>12 (5-65)</td>
</tr>
<tr>
<td>Total urine output</td>
<td>108 (8-277)</td>
<td>25 (6-141)</td>
</tr>
<tr>
<td>Number of voids</td>
<td>532 (328-770)</td>
<td>394 (217-652)</td>
</tr>
<tr>
<td>Fluid intake (ml)</td>
<td>3 (1-4)</td>
<td>4 (3-6)</td>
</tr>
<tr>
<td>Residual urine (ml)</td>
<td>94 (54-162)</td>
<td>57 (29-115)</td>
</tr>
</tbody>
</table>

p values give overall significance of differences between times by Friedman's non-parametric analysis of variance.

loss. Surprisingly, current bacteriuria was not significantly associated with urine loss (p > 0.2).

On average, more urine was leaked during the night (midnight to 08 h 00) than during the day or the evening (Table I). Among urge-incontinent patients this tendency was especially pronounced (Table I) and the wettest pad was most often changed between midnight and 08 h 00 (26/51 cases). Nocturia was also common: the median for all patients was three (Table I). On average, the total urine output (voids plus incontinence) was greater during the night than during the day or the evening (Table I). Fluid intake was unevenly distributed over the 24 h, but quite large amounts were drunk in the evening (Table I).

Among patients with urge incontinence, the amount of nocturnal urine loss depended significantly on the fluid intake during the previous evening and on the number of nocturnal voids (multiple coefficient of correlation R = 0.49, p < 0.002). Multiple regression analysis showed that, on average, nocturnal urine loss increased by 30 (± 10 SD) g for each 100 ml of evening intake (p < 0.005; Figure 4) and decreased by 37 (± 13 SD) g for each nocturnal void (p < 0.01).

Overall, the median post-void residual urine was 70 ml. However, there was diurnal variation: residuals were significantly larger in the early morning (Table I).

Reproducibility of 24-h measurements: Because both oxybutynin chloride and surgery had a marked effect on urine loss and residual urine, reproducibility has been examined for the 31 patients who received conservative management rather than these interventions (Table II). Good reproducibility implies that the coef-
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Table II. Reproducibility of measurements made during 24-h monitoring

<table>
<thead>
<tr>
<th></th>
<th>Mean value in first 24-h period</th>
<th>Standard error of regression*</th>
<th>Slope of regression line*</th>
<th>Correlation coefficient*</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-h fluid intake</td>
<td>1729 ml</td>
<td>404 ml</td>
<td>1.07</td>
<td>0.98 (p &lt; 0.0001)</td>
</tr>
<tr>
<td>Evening fluid intake</td>
<td>704 ml</td>
<td>245 ml</td>
<td>1.16</td>
<td>0.97 (p &lt; 0.0001)</td>
</tr>
<tr>
<td>Maximum volume voided</td>
<td>296 ml</td>
<td>93 ml</td>
<td>0.79</td>
<td>0.95 (p &lt; 0.0001)</td>
</tr>
<tr>
<td>Nocturnal urine loss</td>
<td>65 g</td>
<td>147 g</td>
<td>0.62</td>
<td>0.57 (p = 0.005)</td>
</tr>
<tr>
<td>24-h urine loss</td>
<td>112 g</td>
<td>252 g</td>
<td>0.83</td>
<td>0.61 (p = 0.002)</td>
</tr>
<tr>
<td>Wettest pad weight</td>
<td>44 g</td>
<td>88 g</td>
<td>0.64</td>
<td>0.54 (p &lt; 0.01)</td>
</tr>
<tr>
<td>Number of voids in 24 h</td>
<td>10.1 g</td>
<td>3.1 g</td>
<td>0.86</td>
<td>0.95 (p &lt; 0.0001)</td>
</tr>
<tr>
<td>Nocturia</td>
<td>2.8 g</td>
<td>1.5 g</td>
<td>0.81</td>
<td>0.88 (p &lt; 0.0001)</td>
</tr>
<tr>
<td>Mean post-void residual urine</td>
<td>118 ml</td>
<td>61 ml</td>
<td>0.91</td>
<td>0.92 (p &lt; 0.0001)</td>
</tr>
</tbody>
</table>

* Correlation and regression are between values measured in first and second 24-h periods. All regression lines pass through the origin.

All results are for 31 patients who did not receive oxybutynin chloride or prostatic surgery.

Sufficient of correlation between repeated measurements should be high, that the slope of the regression line should be about one and that the standard error of regression should be small compared with the mean. By these criteria, all the variables examined are reasonably reproducible.

Accuracy of residual urine estimation by ultrasound: Figure 5 shows the relation between the bladder volumes estimated by ultrasound and those measured by catheterization, in a separate study of 21 patients. The coefficient of correlation between the two sets of results is 0.97 (p < 0.0001), the slope of the regression line through the origin is 1.02 and the standard error of the regression estimate is 48 ml. Thus the bladder volume estimated by ultrasound is close to the volume determined by catheterization.

Table III. Sensitivity and specificity of diagnosis of urge incontinence from the weight gain of the wettest pad

<table>
<thead>
<tr>
<th>Critical weight (g)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Percentage correct</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>76</td>
<td>63</td>
<td>65</td>
</tr>
<tr>
<td>20</td>
<td>73</td>
<td>66</td>
<td>67</td>
</tr>
<tr>
<td>40</td>
<td>67</td>
<td>69</td>
<td>68</td>
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<tr>
<td>60</td>
<td>67</td>
<td>71</td>
<td>66</td>
</tr>
<tr>
<td>80</td>
<td>67</td>
<td>74</td>
<td>66</td>
</tr>
<tr>
<td>100</td>
<td>66</td>
<td>74</td>
<td>64</td>
</tr>
<tr>
<td>120</td>
<td>61</td>
<td>73</td>
<td>61</td>
</tr>
</tbody>
</table>

The table gives the sensitivity, specificity and accuracy of the diagnosis, as judged against the results of video-urodynamic testing, if it is assumed that patients whose wettest pad showed a weight gain of more than the specified critical value have urge incontinence.

Figure 5. Scatter diagram showing the relation between the bladder volume estimated by ultrasound and that measured by catheterization in a separate study of 21 patients.
Sensitivity of 24-h monitoring and video-urodynamics for urine loss: Of the 96 incontinent patients, 85 had measurable urine loss during the 24-h study, so that the sensitivity is 85/96 = 88%. Video-urodynamic testing demonstrated incontinence in 65 of the 96 incontinent patients, corresponding to a sensitivity of 67%. Thus 24-h testing was more sensitive than video-urodynamics for objective demonstration of urine loss.

Type of incontinence suggested by 24-h monitoring: Urge incontinence often showed a pattern of severe urine loss, especially at night. The assumption that patients whose wettest pad showed a large weight gain were urodynamically urge-incontinent, yielded the sensitivities, specificities and accuracies shown in Table III.

Discussion

The characteristics of incontinence and urinary-tract function demonstrated in this study are potentially important for nursing management. For example, the most common type of incontinence—urge incontinence—is also the most severe and tends to occur at night. The observation that the nocturnal urine loss depends on evening fluid intake and nocturia suggests simple ways of managing the problem. One factor contributing to nocturnal urine loss is increased urine output at night, which occurs even in healthy elderly people [10, 11]. If this could be prevented then the incontinence might be easier to manage. The observation that severe urine loss during the study is associated with previous but not current bacteriuria suggests that the irritative effect of urinary infection may persist after infection has cleared.

The two methods of investigating incontinence that we have used are complementary. Twenty-four-hour monitoring is noninvasive but lengthy; it is a sensitive detector of urine loss and provides reproducible information about timing and severity that is suitable for making decisions about nursing management and pharmacological or behavioural treatment. A short incontinence pad test cannot give this information, and is in any case less reliable than a 24-h test [12]. Twenty-four-hour monitoring gives some indication of the type of incontinence: urge incontinence is probable if the wettest pad contains more than 80 g of urine. The sensitivity and specificity of this measurement are not very high, but invasive urodynamics also has quite low sensitivity for urge incontinence. Twenty-four-hour monitoring provides reliable values for post-void residual urine, including the larger residual urine that usually occurs in the early morning. It yields a large number of free-voiding flow curves. If most of these have the normal, peak-shaped form and there is little residual urine, then voiding is probably normal. (See reference [13] for a discussion of this problem in children.) A large volume voided in any single micturition rules out a small bladder capacity.

Urodynamics on the other hand can be quickly carried out, even in the frail and cognitively impaired elderly patient. It is invasive but is the only way of objectively identifying the type of incontinence or specific voiding dysfunction, for example before undertaking an irreversible intervention such as surgery.

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References


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