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A METHOD FOR DETERMINING INCOMPLETE URINARY BLADDER EMPTYING BY UROFLOWMETRY

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Aim. This article aims to assess the effectiveness of uroflowmetry in detecting residual urine and to investigate the relationship between the sensation of incomplete bladder emptying, as measured by the IPSS questionnaire, and the presence of residual urine.

Materials and methods. A cohort of patients treated at the Urination Pathology Centre (Vladivostok) for benign prostatic hyperplasia was observed and data were collected. Patients ranged in age from 50 to 73 years (with an average age of 60.5 ± 8.2 years) and were observed during from 2 to 24 months (with an average of 8.4 ± 5.5 months).

Results. The analysis of ultrasound data and uroflowmetry results demonstrates convincingly that the SIGMA uroflowmeter can reliably detect residual urine with a high degree of accuracy ($p < 0.01$). However, during the study, no consistent correlation was found between the symptom of feeling of incomplete bladder emptying, as assessed by the IPSS questionnaire, and the presence of residual urine detected by the SIGMA uroflowmeter.

Conclusion. Uroflowmetry conducted with the SIGMA uroflowmeter reliably identifies instances of incomplete bladder emptying, as evidenced by comparison with ultrasound data. At the same time, clinical assessment using the IPSS charts, particularly for the symptom of incomplete bladder emptying, does not adequately indicate the presence of residual urine. Uroflowmetry offers a means to identify incomplete bladder emptying and measure residual urine volume without requiring specialised equipment or medical personnel, thus broadening the diagnostic scope for both conservative and surgical treatment approaches.

Keywords: residual urine, incomplete bladder emptying, benign prostatic hyperplasia, uroflowmetry, ultrasound examination of residual urine

Conflict of interest: The authors declare no conflict of interest.

Introduction

The increase in life expectancy leads to an ageing population and, consequently, a growing number of patients with lower urinary tract dysfunctions. Recent studies have found that 90 % of men aged 45 and older experience some level of urinary dysfunction [1]. These conditions are caused by various factors, not always related to prostate diseases [2]. However, benign prostatic hyperplasia (BPH) is found in approximately 50 % of men over 50 years old, and this percentage steadily increases with age, reaching 80–100 % in patients aged 80 and older [3–6]. It should be noted that one-third of men with BPH experience progressive bladder dysfunction, characterised by chronic urinary retention, increased intravesical pressure, subsequent development of ureterohydronephrosis, and chronic renal failure [7]. Assessing postvoid residual urine volume (PVR) in routine clinical practice helps identify patients at risk of acute urinary retention and prevents complications associated with prolonged urinary retention.

Aim and objectives

The objective of this article is to examine the potential of uroflowmetry in identifying residual urine and evaluate the reliability of incomplete bladder emptying detection by ultrasound. It also explores the feasibility of subjective assessment of incomplete urinary bladder emptying, using the IPSS questionnaire and compare these evaluations with the results of residual urine detection by uroflowmetry.

Materials and methods

For observation and data collection, a group of patients diagnosed with BPH was selected. These patients had been receiving treatment and undergoing monitoring at the Urinary Pathology Centre in Vladivostok. The group comprised patients aged between 50 and 73 years, with an average age of 60.5 ± 8.2 years. They were observed over a period ranging from 2 to 24 months, with an average observation duration of 8.4 ± 5.5 months.

The inclusion criteria for the group were as follows:

1) presence of BPH;

2) absence of previous surgical interventions related to BPH;

3) absence of oncological or psychiatric disorders.

The following parameters were chosen for evaluation:

1) the severity of lower urinary tract symptoms measured using the IPSS questionnaire;

2) data from two-day in-home uroflowmetry;

3) ultrasonographic examination with the determination of residual urine volume.

The instrumental examinations were conducted using the following equipment:

1) Sigma uroflowmeter (Registration Certificate RZN № 2020/11522 dated of 5 August 2020, manufactured by Urovest, Vladivostok, Russia);

2) Mindray DC-8 Exp ultrasonography device (Mindray, China).

Data processing was carried out using Urovest 8.1 software (Urovest, Vladivostok, Russia) and Microsoft Excel.

The primary objective of the study was to assess the feasibility of verifying residual urine using uroflowmetry. This involved comparing data on instances of incomplete bladder emptying detected by ultrasonography with the results of uroflowmetry for the same patients.

The secondary objective was to evaluate the correlation between the symptom of incomplete bladder emptying (estimated based on the IPSS questionnaire) and verified residual urine detected by uroflowmetry.

χ^2 test was used to analyse the data obtained.

Results

While processing uroflowmetry and ultrasound data on residual urine, a null hypothesis was formulated, stating that the frequency of residual urine detection by ultrasound does not correlate with cases identified through uroflowmetry (Table 1).

Table 1. Initial data for the verification of residual urine as determined by uroflowmetry

Factor	Effect		*Total*
	Residual urine is detected by uroflowmetry	Residual urine is not detected by uroflowmetry	
Residual urine is detected by ultrasound	10	6	16
Residual urine is not detected by ultrasound	0	20	20
Total	10	26	36

Comment. The degrees of freedom are 1; the value of χ^2 test is 17.308; the critical value of χ^2 at the level of significance $p = 0.01$ is 6.635. The correlation between the independent and dependent variables is statistically significant at a significance level of $p < 0.01$.

The level of significance is $p < 0.01$.

Based on the results obtained (see Table 1), the null hypothesis was rejected. Residual urine can be determined with high accuracy using a Sigma two-sensor uroflowmeter and Urovest software (Vladivostok, Russia) with artefact and wag-effect mitigation capabilities.

Table 2 presents a comparison of results obtained using the IPSS questionnaire with cases where residual urine was detected. The correspondent null hypothesis is formulated as follows: there is no correlation between the severity of the symptom of incomplete bladder emptying and the volume of residual urine.

Table 2. Initial data obtained using uroflowmetry for the verification of residual urine and the feeling of incomplete emptying of the bladder

IPSS (sensation of incomplete bladder emptying)	Result		*Total*
	Residual urine is detected by uroflowmetry	Residual urine is not detected by uroflowmetry	
Values 1–5	9	16	25
Value 0	1	10	11
Total	10	26	36

Comment. The degrees of freedom are 1; the value of χ^2 test is 2.757; the critical value of χ^2 at the level of significance $p < 0.05$ is 3.841. There is no statistically significant correlation between the dependent and independent variables at the level of significance $p > 0.05$.

The level of significance is $p = 0.097$.

The results presented in Table 2 indicate that the null hypothesis cannot be rejected. Therefore, there is no correlation between the symptom of incomplete bladder emptying sensation and the detection of residual urine verified by uroflowmetry. These findings are consistent with several studies [8; 9].

Discussion

The factors contributing to the formation of residual urine are extensively discussed in the literature. These include conditions such as detrusor sphincter dyssynergia, decreased detrusor contractility, bladder outlet obstruction (BOO), BPH, urethral stricture, urethral valves and meatal stenosis [10; 11]. However, even in the presence of a pathological process, detecting residual urine is not always possible [12; 13].

Currently, there is ongoing interest in methods to identify cases of residual urine, determine residual volumes and establish correlations between residual urine volume and existing urinary voiding disorders [14].

One of the widely recognised methods for determining residual urine is using equipment for ultrasound diagnostics, including portable bladder ultrasound scanners. Invasive catheterisation also remains relevant for residual urine detection. Although each method has its advantages and disadvantages, the results of residual urine determination may not consistently fulfil clinicians' requirements [10; 15–22].

Over the last two decades, the literature has paid particular attention to in-home uroflowmetry as a promising method for the examination of urological patients [23]. It should be noted that attempts to use uroflowmetry as an alternative non-invasive method for verifying residual urine have not yet been successful [10; 11; 13; 26].

The unclear significance of residual urine in diagnosing urinary tract disorders has been highlighted in several works attributing this ambiguity to the high variability of symptoms throughout the day, fluctuations in the amount of residual urine depending on various factors and the absence of distinct boundaries between 'health' and 'disease' [8; 13]. However, determining residual urine does have merit, as uroflowmetry monitoring offers new avenues for interpreting the data obtained. This approach allows for long-term non-invasive monitoring of patients with subclinical urination disorders, assessing the functional state of the urinary tract during conservative therapy, refining indications for surgical treatment and predicting the development of conditions such as urinary tract infections, cystolithiasis or detrusor dysfunction [24; 25].

Various devices are available for in-home uroflowmetry, which, as reported in the literature, offer more dependable results than tests conducted in urodynamic laboratories. Yet, the use of simple uroflowmetry does not yield the desired results, as it attempts to statically assess a highly variable system [23]. Analytical urodynamics (AU) holds great promise, with its main methods including monitoring, modelling and forecasting. AU makes it possible to obtain a more comprehensive picture of the state of this highly variable system.

In this study, a Sigma in-home two-sensor uroflowmeter was used alongside Urovest software, the latter employing a unique algorithm for mathematical processing of individual uroflowgrams (Russian patents № 2303397 and 2598055). This measurement system offers several advantages, including high immunity to artefacts, which ensures the accuracy of the results, the ability to obtain universally accepted data when performing uroflowmetry and precise determination of incomplete bladder emp-

tying cases. The data obtained from this hardware-software system, when compared with the traditional ultrasound method for assessing residual urine, suggests the emergence of a new tool for non-invasive diagnosis of incomplete emptying. This tool can detect residual urine with a probability of at least 0.95.

Yet another question is why, despite the high reliability of measurements, we did not obtain identical results when using different methods. It is worth noting that determining residual urine by ultrasound has several drawbacks. The variability of residual urine volume is influenced by various factors, including bladder filling, the time of day and the environmental [15]. Therefore, a significant advantage of the Sigma uroflowmeter is that it can be used both in urodynamic laboratories and by patient at home at any time of day. Additionally, the design features of the device and the capabilities of the built-in software allow mitigating the influence of artefacts while maintaining high metrological characteristics.

In conclusion, the study built on the principles of analytical urodynamics, which essentially represents an evolutionary development of elementary urodynamics. Analytical urodynamics enables the prediction of the urinary tract's response to conservative therapy, the identification of indications for surgical treatment and long-term monitoring of the functional state of the urinary system.

Conclusions

Uroflowmetry performed using a Sigma uroflowmeter make it possible to reliably identify cases of incomplete bladder emptying, as confirmed by comparing the data obtained by ultrasound data in a patient group.

The clinical assessment using IPSS tables (symptom of incomplete bladder emptying sensation) inadequately reflects the presence of residual urine in the patient.

Uroflowmetry enables the determination of incomplete bladder emptying and residual urine volume without requiring specialized equipment or medical personnel., thereby expanding the diagnostic capabilities of the method in conservative therapy and surgical treatment.

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