

# “Bladder Effect” - An Urodynamic Parameter to Distinguish Subtypes of Urinary Incontinence in Women

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## Abstract

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**BACKGROUND:** Urinary incontinence (UI) is defined by the International Continence Society (ICS) as the involuntary loss of urine that represents a hygienic or social problem to the individual. The aetiology is multifactorial. The diagnosis of UI is important because it can result in the application of appropriate therapy. Urodynamics is a golden standard, without which every UI diagnosis is insufficient.

**AIM:** The goal of this study was, based on urodynamic results, to prove the existence of evident differences between the subtypes of UI.

**METHODS:** Eighty patients with UI were evaluated (50 with urinary stress incontinence-USI and 30 with detrusor instability-DI) according to a standard evaluation protocol. Exclusion criteria were: mixed UI and diseases that simulated UI. All patients were 36-65 years of age (mean 56). The following parameters were measured: maximal and average flow, maximal and average voiding pressure. These parameters were compared between both groups, to determine the diagnostic significance of the parameter “Bladder Effect” (BE). It is a product of the urine flow and the pressure during voiding.

**RESULTS:** The results showed a significant difference with a high confidence interval. Mean BE<sub>max</sub> was 577 units in the patient group with USI, and 1014 in the DI group. Similarly, BE<sub>av</sub> was 313 units in the USI group, and 499 units in the DI group, with a significant difference and a high interval of confidence.

**CONCLUSION:** In conclusion, the results of the study suggested that BE could be a useful diagnostic parameter to distinguish between USI and DI.

## Introduction

Urinary incontinence (UI) is defined by the International Continence Society (ICS) as the involuntary loss of urine that represents a hygienic or social problem to the individual [1]. Urinary incontinence can be checked as one of the patient's symptoms, a sign which can objectively be demonstrated as a disorder. There is no specific aetiology for the appearance of this phenomenon. Most of the individual cases verify multifactorial nature of this entity. The aetiology of UI is still not completely understood. Each patient suffering from urinary incontinence must go through basic clinical evaluation which includes: anamnesis, gynaecological status and urine analysis. Additional investigations such as

voiding chart, pad-test, Marshall stress test, and measurement of residual urine, cystoscopy, urodynamics and methods of visualisation (ultrasonic or radiologic) can be performed to help define the type of UI. Video urodynamic studies are reserved for complex cases of urinary stress incontinence (USI). They combine radiologic results and multichannel urodynamics.

Of great interest are the two entities of transurethral urinary incontinence: Urinary stress incontinence (USI) associated with involuntary leakage of urine when the intra-abdominal pressure is suddenly increased, and Urgent (imperative) urinary incontinence (UUI) associated with the detrusor instability (DI). Some authors mention mixed urinary incontinence as a separate entity, but it is the same combination of USI and UUI. The success of the

applied therapy practically depends on the kind of therapeutic approach, which needs to be adequate for each UI, since different type of UI requires a different type of therapeutic approach.

Urinary incontinence, or involuntary micturition, is another disorder or deviation of the physiology of voiding [2]. The art of diagnosing a UI is to determine at what level a disorder of the physiology of voiding has occurred. This leads to proper therapy, and if adequate, it is indeed successful. The prognosis of UI is quite good in more advanced healthcare systems.

The term urodynamics dates from 1954, when David Davis used it while presenting his work in measuring the pressure of the upper urinary tract and renal injuries [3]. Not long after, Hodgkinson [4] [5] declared the urodynamic standards and differentiated USI from an unstable detrusor. Since then, our understanding of the urinary tract, the equipment used, even the width and definition of urodynamics has greatly been expanded. Today, the term "urodynamics" refers to a group of tests used to gather information about the function of the lower urinary tract, as well as the time needed for the bladder to be filled and emptied [6]. Urodynamics is used as a golden standard in the detection of a precise cause for occurrence of UI, in the absence of which, each diagnosis would be insufficient. It has been discovered that the symptoms of USI tend to have a weak correlation with specific urodynamic findings and a strong correlation with the unstable detrusor, which makes the urodynamic evaluation a superb diagnostic tool for identification of the signs of UI. Urodynamic studies in patients suffering from UI enable acquisition of a large amount of data of the lower urinary tract function. They can guide us toward determination of the adequate treatment. They could also point to the possible reasons of the previous treatment failure or help in foretelling the outcome of the recommended treatment [7].

The ICS recommends the urodynamic studies to be carried out in the investigation of UI in women. The urodynamic evaluation, as a necessary step, should include bladder pressure tests (cystometry), flow measurement of the urine (flowmetry), urethral pressure profile, and pressure measurement during micturition (voiding cystometry). The part of urodynamics that analyses the evacuation of the urine from the bladder is known as voiding cystometry. Voiding cystometry can objectively be achieved when the measurements of voiding parameters are taken with the bladder at its full capacity. Western authors interpret this analysis as pressure/flow studies.

During this examination, pressures are measured during voiding. Micturition is examined with the same catheters used to fill the bladder. This phase helps in grading two critical parameters related to bladder voiding: detrusor contractility (normal versus damaged) and urinary flow (uninterrupted versus

interrupted) [8].

The most widespread use of voiding cystometry is determining the presence of a urethral obstruction, commonly found in men. With the beginning of 1960 [9], nomograms were developed to standardise the definitions of obstruction and contractility of the bladder [2] [10] [11]. These nomograms are well established and widely accepted in diagnosing urinary obstruction in benign hyperplasia of the prostate in men. However, the nomograms did not achieve the expected results in women, and as such, never gained widespread use in clinical practice [8] [12] [13] [14] [15].

The goal of this study was to identify, based on urodynamic measurements, differences between subtypes of UI. The fact that part of the UI results (i.e. voiding cystometry) provide an abundance of unclassified information was a motive to find a correlation between them. It was perceived that particular segments of the findings, which were routinely done in UI patient investigation, could increase their capacity and their usage, especially the parameter Pressure x Flow = BE (bladder effect) and to assess its diagnostic value.

## Material and Methods

This study included a total of 80 female patients, divided into two groups: a group of 50 patients with USI and a group of 30 patients with DI.

Inclusion criteria of the study were: female individuals with diagnosed USI (according to the UI investigation protocol); female individuals with diagnosed DI (according to the UI investigation protocol).

Exclusion criteria were the presence of urinary tract infection; diabetes; conditions that lead to polyuria; neurologic disease (cerebrovascular insult, spinal cord injury, multiple sclerosis, peripheral neuropathy); urogenital fistula; and other states that could influence voiding and its parameters (i.e. urolithiasis).

All patients were between 36-65 years of age, with an average age of 56 years for both groups. All of them underwent the standard diagnostic procedure during their examination, according to the UI investigation protocol. Each patient went through: an interview, examination of the urine sediment and urine culture, urogynecology exam, USI verifying tests and urodynamic tests which included: urethral pressure profile (UPP), cystometry, flowmetry and voiding cystometry.

In order to execute voiding cystometry (after measuring the UPP, flowmetry and cystometry) the patients were placed on a voiding collector in a sitting

position, with a pressure measuring catheter in the bladder. Then the patient was asked to void the previously filled fluid in the bladder to its maximum capacity. During the act of voiding, urine flow and pressure parameters were noted. From the flow curve, using interpolation, the pressure was plotted on the pressure curve at any moment of interest during the voiding. All patients signed informed consent, and the study was approved by the Ethics committee.

The average and maximum flows were measured (which the urodynamic system presented automatically) and according to them, the pressure during maximal voiding flow (calculated by interpolating it at the moment of maximal flow), as well as the average voiding pressure (the average of maximal and minimal voiding pressures). These parameters were compared between both groups, to determine the diagnostic significance of their nominal values. Special attention was given to the BE parameter, which was a product of urine flow and pressure during voiding. The data were processed using statistical methods and procedures for comparing numeric values. (The SPSS Statistics package version 23).

## Results

The obtained results of each patient for the maximal and average "bladder effect" (BEmax and BEav) were the product of maximal urine flow (Fmax) and the pressure at that time point (Ppf) and the average urine flow (Fav) with the average voiding pressure (Pav) respectively, according to the formula  $BEmax = Ppf \times Fmax$  and  $BEav = Pav \times Fav$ .

**Table 1: BEmax values in USI and DI**

	N	Mean $\pm$ Std. Deviation	p-value
BEmax DI	30	1014.04 $\pm$ 673.34	P < 0.0001
BEmax USI	50	576.80 $\pm$ 174.73	

BEmax-maximal bladder effect; USI – urinary stress incontinence; DI-detrusor instability.

The mean values of the parameters above, for the two different patient groups, were presented in Table 1 and Table 2.

**Table 2 – BEav values in USI and DI**

	N	Mean $\pm$ Std. Deviation	p-value
BEav DI	30	498.94 $\pm$ 333.47	P < 0.0001
BEav USI	50	313.27 $\pm$ 118.16	

BEav-- average bladder effect; USI – urinary stress incontinence; DI-detrusor instability.

The results presented in Table 1 and Table 2 indicated a significant difference between the USI and DI groups. The mean value for the BEmax parameter in the USI group was 577 units, and for the DI group,

it was 1014 units. Statistical analysis showed that the difference was significant, with a high interval of confidence. The values of the BE parameter (also in a variant of maximal values and average values), were lower in the USI group compared to the DI group.

Both groups showed a statistically significant difference of the average values of both parameters, with  $p < 0.001$  and a high 95% Confidence interval.

## Discussion

Voiding cystometry is a rich source of bladder function data, which is processed by a wide group of medical and scientific staff, but until today without visible, tangible evidence that can be transformed into parameters that could distinguish UI subtypes or indicate prognosis or success in therapeutical procedures. Given how patients are closed about their difficulties, urodynamics check-ups are valuable during female patient screening, especially in patients that hide their symptoms, have masked UI or simulate certain symptoms in order to receive some formerly suggested treatment, which they perceive as the solution to their problem.

Several pressures and flows exist in voiding cystometry, and statistical analysis by many authors regarding these values was performed in the past. Several authors found significant differences between certain pressures or flows or both, while others disputed those findings. The situation is similar in estimating the correlation between pressures and flows at a certain time during voiding. Due to the diversity that emerged near the end of the 20<sup>th</sup> century, a fundamental analysis of all the data was made, which showed that the significant parts of the studies were mostly based on a subjective estimate of the results. Because of that, in 1998 the International Continence Society (ICS) recommended ending the pressure-flow studies with the goal of receiving a diagnostic or scientific interpretation of incontinence. About 20 years later, the observations that DI has a larger flow compared to USI and voiding pressures are larger in DI compared to USI, still, pertain. Although this cannot be correlated to something of significance, the opinion that voiding cystometry can be a good diagnostic tool persists. The analysis of pressure and urine flow at the same time, as their mathematical product, leads to a mathematical result which shows the effect of voiding urine, out of the bladder, in the physical sense. Hence, the bladder effect parameter imposed itself as the imperative in studying and its possible use in diagnosing UI subtypes.

The study showed a difference in the values of the given parameters in each group. The statistical sample was small, and it could be the reason for the

high standard deviation. It deviated by 30.3 % from the mean value in the USI group, and 62.8 % in the DI group for the BEmax values, and 37.7 % from the mean in the USI group and 66.8 % in the DI group for the BEav values. Despite this, the unpaired t-test analysis showed a significant difference. This is of great importance due to the partial overlapping of the curves of distribution between the two groups, thanks to the standard deviation, especially in the DI examined group. It is unclear how the BE values would change in patients with mixed UI (USI + DI), i.e. whether they would incline towards a certain group, or remain somewhere in between, and given that, become unable to be classified in either group. The lack of research by which this parameter could be compared complicates analysis further. Most of the published papers covering this area included men and the closest parameter to the BE would be the contraction index parameter, which was based on a formula for voiding flow [10].

Based on the results of this study, we believe that the BE parameter is a new promising tool for differentiation of the subtypes of UI, not previously described by other authors. Statistical analysis showed that this parameter is worth exploring further, on a larger female patient population.

In conclusion: 1) the BEmax parameter in USI patients was significantly lower about DI patients; 2) the BEav parameter in USI patients was significantly lower when compared to DI patients, and the results of our study suggested that BE could become a valuable diagnostic parameter to distinguish USI from DI.

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