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ICS-SUFU standard: Theory, terms, and recommendations for pressure-flow studies performance, analysis, and reporting, Part 2: Analysis of PFS, reporting, and diagnosis

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ABSTRACT

Aims: The Working Group (WG), initiated by the International Continence Society (ICS) Standardisation Steering Committee and supported by the Society of Urodynamics, Female Pelvic Medicine and Urogenital Reconstruction, has revised the ICS Standard for pressure-flow studies of 1997.

Methods: Based on the ICS standard for developing evidence-based standards, the WG developed this new ICS standard in the period from May 2020 to December 2022. A draft was posted on the ICS website in December 2022 to facilitate public discussion and the comments received have been incorporated into this final release.

Results: The WG has recommended analysis principles for the diagnosis of voiding dysfunction for adult men and women without relevant neurological abnormalities. New standard terms and parameters for objective and continuous grading of urethral resistance (UR), bladder outflow obstruction (BOO) and detrusor voiding contraction (DVC) are introduced in this part 2 of the standard. The WG has summarized the theory and recommendations for the practice of pressure-flow study (PFS) for patients in part 1. A pressure-flow plot is recommended for the diagnosis of every patient, in addition to time-based graphs. Voided percentage and post void residual volume should always be included in PFS analysis and diagnosis. Only parameters that represent the ratio or subtraction of pressure and synchronous flow are recommended to quantify UR and only parameters that combine pressure and flow in a product or sum are recommended to quantify DVC. The ICS BOO index and the ICS detrusor contraction index are introduced in this part 2 as the standard. The WG has suggested clinical PFS dysfunction classes for male and female patients. A pressure-flow scatter graph including every patient's p_{det} at maximum flow ($p_{detQmax}$) with maximum flow rate (Q_{max}) point should be included in all scientific reports considering voiding dysfunction.

Conclusion: PFS is the gold standard used to objectively assess voiding function. Quantifying the dysfunction and grading of abnormalities are standardized for adult males and females.

1. Introduction

An earlier International Continence Society (ICS) subcommittee (ICS-ST97) [1] revised and expanded diverse sections of the earlier and later updated ICS terminology (ICS-ST02) [2] and defined parameters with the preferred abbreviations to depict pressure-flow study (PFS) results. The procedure [3], motivation, and scope of developing this new standard are explained in part 1 which also includes theory, lower urinary tract (LUT) physiology and clinical practice, this part 2 contains the working group's (WG's) recommendations on PFS-analysis, diagnosis and reporting and has the aim to renew analysis and further standardize reporting of PFS.

Analysis and reporting of PFS are specifically discussed in this standard, but for individual clinical diagnosis these cannot be separated from the results of the cystometry and all other tests and clinical

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[1] In remembrance, Prof. Phillip Smith who contributed until his death mid April 2022.

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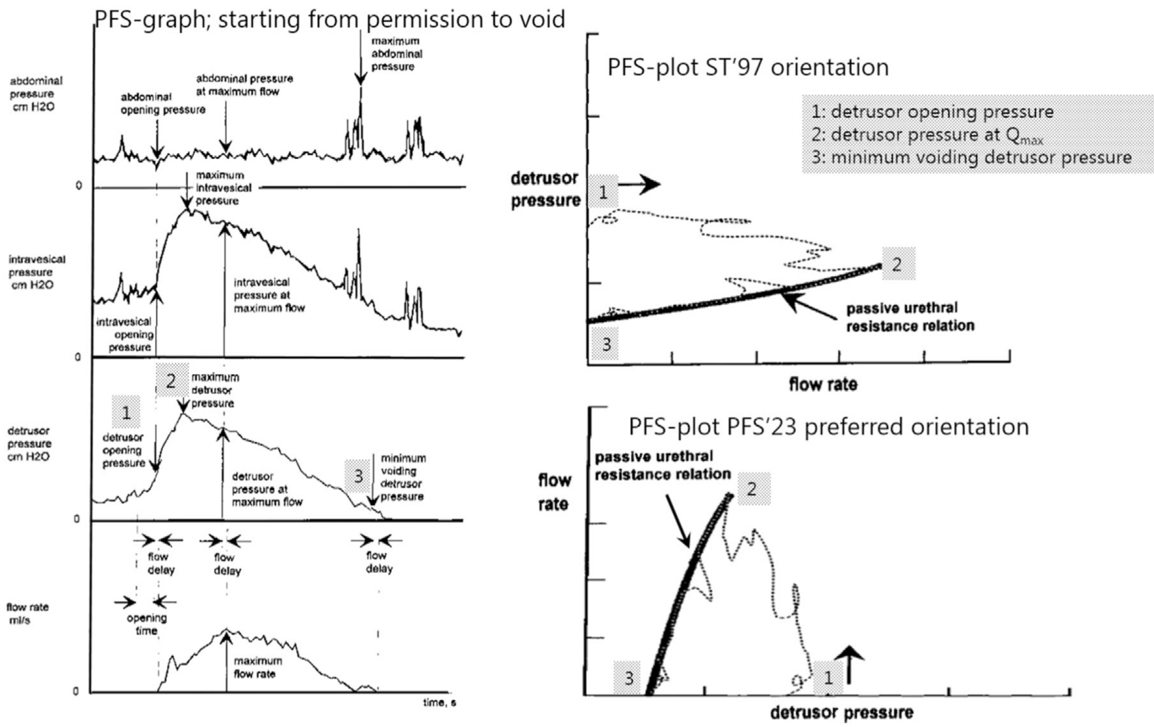

Fig. 1. PFS-graph and PFS-plots. The dotted line represents the urethral resistance relation; the pressure with corresponding flowrate during the entire voiding. The URR forms a loop from opening to Q_{max} and closing of the outflow tract. In all graphs: flow begins at 1 and continues to 2, which is Q_{max} and continues further to 3; end of voiding. The phase between 1 and 2 is the outlet distension phase; detrusor (or intravesical) pressure opens the outflow tract. Point 2 is Q_{max} representing the maximum opening of the outflow tract and between 2 and 3 is the (elastic) collapse phase. UR is measured through analysis of this phase (between 2 and 3) representing the lower pressure border of the URR (see Section 2.1.1). Point 3 is the pressure when Q stops. ST97 has presented the PFS plot with flowrate on the X-axis. This standard has recommended that the projection with pressure on the X-axis is preferable (see Section 3.2). PFS, pressure-flow study; URR, urethral resistance relation.
Source: Adapted from Griffiths et al. [1].

information and the WG recommends integrating the PFS diagnosis with all other information.

ICS-ST97 recommended terms, methods, and parameters for PFS-analysis and also recommended presentation of PFS flow rate (mL/s) with the synchronous detrusor pressure (p_{det}, cmH_2O) in a pressure-flow plot, in addition to the time-based graphs [1] (see Fig. 1). The ICS good urodynamic practices and terms standard of 2016 (ICS-GUP16) repeated this recommendation [4]. The WG further explains LUT physiology with regard to voiding relevant to PFS in this part 2, and updates recommended terms, parameters, analysis methods and, graphic display of PFS. This standard may be referred to (ICS-PFS23) in scientific manuscripts in addition to a reference to the ICS-GUP16, when appropriate. The WG refers to part 1 of the standard for standard terms, symbols and qualifiers also used in this part.

The WG considered that the treating physician is responsible to establish a diagnosis and is also responsible for the validity of this diagnosis. A urodynamic diagnosis is made on the basis of what is known about normal LUT physiology (of bladder storage and voiding). UDS and PFS can show deviations from the normal physiology and the categorization and grading of these are used to establish a urodynamic diagnosis.

2. Clinical physiology, pathophysiology, and terms

2.1. Physiology of voiding

Detrusor contraction follows relaxation of the pelvic floor muscles (PFM) with autonomic reflex relaxation and funnelling of the smooth muscle bladder outlet as is explained in part 1 of this standard. The WG discusses detrusor contraction during voiding and bladder outflow physiology in further detail in this part of the standard. Part 1 has defined that the PFS begins after permission to void. The WG thus uses pressure and flow events after permission to void while reporting PFS in this part of the standard.

Detrusor contraction during voiding follows the Hill equation that, in general, describes the relation between the force generated by the contracting muscle and its shortening velocity [5,6]. For a given muscle, a shortening velocity of zero when contracting against maximum (infinite) load will, when the muscle is maximally stimulated, lead to an isometric force of contraction that is its maximum value. Reducing the load will allow increasing velocity of shortening and has the consequence of diminishing of load; the force will reach zero at a maximum shortening velocity [6]. For a circumferential muscle, the Hill equation can be converted to the bladder output relation (BOR), which relates p_{det} (resulting from detrusor muscle force) to flow rate (resulting in volume decrease, representing muscle shortening velocity) at a given bladder volume (representing muscle length or, bladder surface area) [7,8]. Urethral resistance (UR), as will be explained in more detail here below (Section 2.1.1) dictates the way that detrusor energy is divided between contraction force and velocity of shortening which, in the case of voiding, means between p_{det} and Q [8].

Clinical epidemiology shows that the detrusor can compensate for slowly increasing UR in men with a growing prostate over many years of time, by muscle contraction force adaption [8–10]. As a consequence of a growing prostate, the patients "move" to diminished flow rates (slower contraction) and higher pressures (with higher force). Incomplete voiding may develop when the detrusor is unable to further compensate or loses the ability to contract sufficiently, which is commonly referred to as decompensating [11,12]. Incomplete voiding may be regarded as a sign of insufficient compensation or of decompensation or inability to maintain force. A sudden increase in UR, caused e.g., by surgery or (acute) inflammation around the bladder outlet, however, does not give the detrusor time to compensate and, may directly lead to incomplete voiding or complete urinary retention [13].

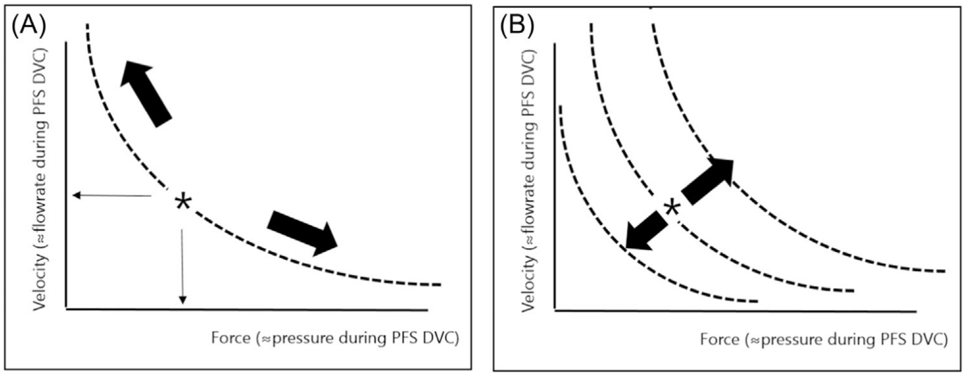

Fig. 2. Muscle force—velocity relation during PFS. At any point during the detrusor voiding contraction there is a "balance" between contraction force and contraction shortening velocity (see Section 2.1). A point is given here with the asterisk. (A) The asterisk represents a combination of force and muscle shortening velocity (thin arrows). PFS pressure and flowrate are representatives of, respectively, force and velocity, and in PFS the asterisk will be a "Q with p_{det}." The curved line represents the Hill muscle contraction force velocity equation, which is an exponential, therefore curved. The thick arrows indicate that for this given muscle increasing velocity is possible at the cost of force (arrow upward) and increasing force at the cost of velocity (arrow downward). (B) Shows that the muscle of (A) can train or adapt; both velocity as well as force increase, the force velocity curve shifts away from the graph's origin (thick arrow upward). A muscle can lose power and velocity, with downward shift of the curve as a result. Of note: Specific—deliberate-muscle training (sporting) can cause relatively more gain in force (weightlifting) or velocity (sprinting). PFS, pressure-flow study.

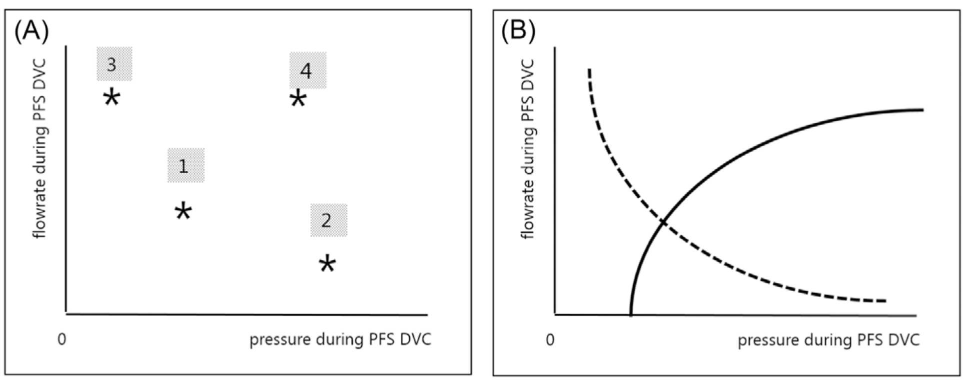

Fig. 3. Differences observable in the PFS-plot. (A) Shows 4 pressure flow points. Point 2 has higher pressure and lower flowrate than point 1; point 3 has lower pressure and higher flowrate. The difference between 2 and 1 represents more outflow obstruction and more forceful, but slower shortening velocity. The difference between 3 and 1 shows a higher contraction velocity and lesser force. Point 4 shows stronger contraction and higher velocity. The 4 points may represent e.g., Q_{max} points of different PFS studies, but comparing this with the PFS23 oriented plot in Fig. 1 learns that the entire voiding is a continuous series of Q -with -$p_{(det)}$—points (the URR) each representing a certain balance between p and Q. (B) Shows the (dotted line) contraction force velocity equation of a given muscle together with a line of UR (also an exponential relation representing the two dimensional flow controlling zone, Section 2.2.2). The detrusor contraction curve in combination with the UR determines the voiding—the flowrate. PFS, pressure-flow study; UR, urethral resistance; URR, urethral resistance relation.

2.1.1. UR, UR pattern, and bladder outflow obstruction (BOO)

The ICS-ST97 introduced and defined UR [1,14] as well as UR relation during voiding as a measure of the degree to which the bladder outlet opposes flow through the urethra. This WG recommends continuing the use of the term UR with this definition when bladder outflow resistance during voiding is measured with PFS, despite the potential confusion attached to the term. The ICS-ST97 has also recommended that UR is quantified by the lowest pressure part of the UR relation and suggests a one point ($p_{detQmax}$) classification as the provisional ICS method to specify UR (see Figs. 1–4, based on Griffiths et al. [1]).

ICS-GUP16 introduced the term bladder outflow obstruction for a cut-off value that is considered clinically relevant within the continuum of UR [4]. The WG recommends ignoring the definition for bladder outlet obstruction in a later standard (sub-paragraph Section 3.8) [15] with the argument provided in ICS-GUP16 [4].

The WG considers that the urodynamically measured UR is (despite its name) not solely dependent on the anatomically defined urethra. The periurethral or other anatomical structures, e.g., striated muscle, prostate, urethral valves, stricture, bladder neck, a diverticulum, or e.g., a sub-urethral tape can also cause changes in UR. The WG thus recommends bearing in mind that UR refers to a physiological observation only, and not to any specific anatomical entity. Abandoning the word urethral (being an anatomical entity) from the terms referring to LUT-function, and recommending bladder outlet function only, would, however, have too many consequences for all terms that are in use e.g., urethral pressures and is therefore not recommended. The WG recommends and will use bladder outlet function in clinical context not directly referring to quantification of UR.

When one single voiding is analysed, the distensible-collapsible tube hydrodynamics paradigm becomes relevant as the physiological model of voiding [7,8,16,17] (see also Fig. 1). This paradigm of voiding predicts that at the start of the voiding, the bladder outlet is opened by the energy that the pressure on the urine delivers. From Q_{max} to the end of voiding the outlet gradually closes again by its elasticity and by the repositioning (and contraction) of the PFM. After the point of Q_{max}, which represents maximum of bladder outlet distension (opening), the Q and the p_{det} decline together in an "uro(hydro-)dynamic equilibrium," until the bladder is emptied which is accompanied by collapse of the bladder outflow tract, in the normal situation [6,18,19]. These physiologic features are recognizable in the urethral resistance relation (URR) loop in the PFS-plot (see Fig. 1).

When, in a given patient the UR is high, the beginning of flow requires a higher pressure and a longer opening time, and a longer time to Q_{max} after the start of the voiding. Q_{max} is also lower and at a higher pressure this is the distension phase. Both phases of voiding (pressure and incline and decline) take place at higher pressures when compared to voiding with low UR.

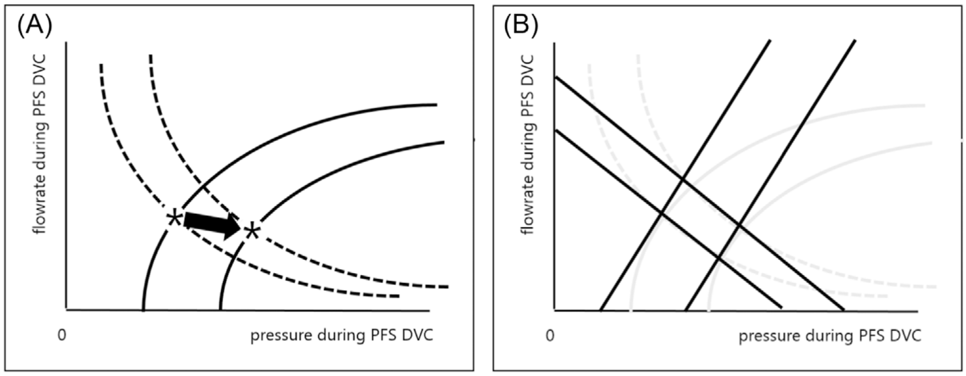

Fig. 4. Combination of UR and DVC and differences. (A) Shows how a patient moves (arrow) to more UR while "maintaining" flowrate, by a more forceful contraction. This (the two asterisks) can, however, also be seen as two people; one patient (asterisk at the right hand side in the plot) with a higher grade of UR and a more forceful detrusor voiding contraction. (B) Indicates that the curved lines can be replaced with straight lines (ignoring the fact that contraction as well as UR are exponential functions). Two lines representing detrusor voiding contraction and two lines (connecting the axes) representing UR. These lines are also used (including the slopes) to develop the indices (see par. 4). The indices DCI as well as the BOOI (and BOOIf) are linearized adaptations of exponential functions and thus allow single point analysis of DVC and UR, with the $p_{detQmax}$ point. BOOI, bladder outflow obstruction index; DVC, detrusor voiding contraction; UR, urethral resistance.

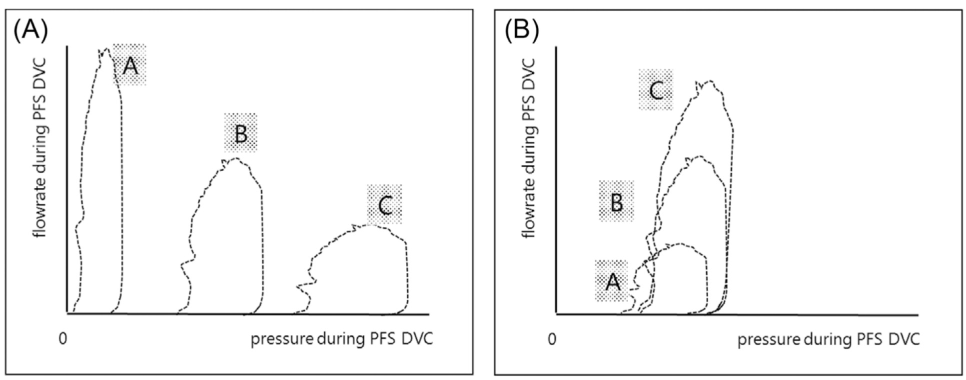

Fig. 5. The figure shows three PFS URR loops (compare with Fig. 1) here without precise grading. In Fig. 5A; —**A**: lower UR, **B**: UR, and **C**: higher UR (see also Fig. 1); the PFS-URR loop runs counterclockwise in time and the left hand side of each loop represents the lower pressure border. In Fig. 5B (Also, without precise grading); **A**: weaker detrusor voiding contraction; **B**: detrusor voiding contraction; **C**: stronger detrusor voiding contraction. Note that UR is (lower pressure—left hand side border of the loop) almost identical for A, B and C in this graph, but also not quantified. Note also that voiding time, PVR or Void% are not visible in the PFS-plot. PFS, pressure-flow study; PVR, Postvoid residual urine; UR, urethral resistance.

PFS-analysis—UR is quantified, by depicting the lower pressure border of the PFS-plot [1], (see Section 3.2 and Fig. 1) usually the second phase of the voiding (Q_{max} and following phase) as will be explained in Section 4.1. A reason for this is that during the first phase, before Q_{max}, a higher grade of UR exists, because distension of the outlet, including PFMs distension during relaxation, takes place that does usually not represent passive, or the lowest, UR.

When UR is low, flow starts immediately after PFM and bladder outlet relaxation, with little or no pressure increment; Q is high after a steep increment and the rapid decay of Q is not accompanied with much decay of pressure (because the pressure was already low) (Fig. 5). A low UR will require only little, or no p_{det} increase to void completely with a high Q (representing a high muscle shortening velocity), as is frequently observed in women (or men after radical prostatectomy). One of the earliest ICS standardisations has introduced that: [citation] "For a given detrusor contraction, the magnitude of the recorded pressure rise will depend on the degree of outlet resistance" [20] which the WG accepts also as the physiological basis for the common observation that a proportion of women with very low UR, can void completely, without rise in detrusor pressure. In these women, the abdominal pressure on top of the bladder provides, even without straining, enough energy to drive the voiding. The detrusor muscle follows the expelled volume with a fast—maximum of detrusor contraction shortening velocity—, but not forceful contraction.

An enlarged prostate may require high pressure distension, occurring in combination with high pressure collapse. A stricture is a typical example of a nondistending bladder outflow resistance; when a stricture is present, pressure increment (stronger contraction) will have no or only very limited effect on Q [7,8,19]. The minimum pressure ($p_{det.min.void}$) that is able to generate flow will, however, be low in those cases since a stricture distends relatively easy up to its limit and also has a limited elasticity. Derived from these archetypes [21], it was proposed that a PFS loop with a low $p_{det.min.void}$ and a relatively constant, but reduced Q_{max} because of the limitation of distension, is named constrictive and the PFS loop that shows distension and collapse as is to be expected from a prostate is named compressive [1,21–24]. Although these terms and principles are adopted and explained in one of the recent ICS glossaries [15], the WG does not, without better evidence about the relevance and specificity of these qualifiers, recommend these as standard for PFS-analysis. The terms may seem to suggest a cause for the BOO, which may be confusing, and any specific voiding can show a pattern somewhere in between constrictive and compressive [1,6,21,25,26].

The consequence of the urethra's and surrounding tissues' extensibility or distensibility and elasticity [22,24] is that the bladder outlet distends and collapses as explained hereabove [1,7,8]. The WG suggests that a regular distending and collapsing bladder outflow pattern is referred to as the **normal urethral resistance pattern** during voiding [7,8,19] (see also Figs. 1 and 5). The WG cannot further quantify "regular" and we use the word normal here to include that no accessory signs of distension and collapse are visible in the pattern during the

PFS. A normal UR pattern can be present within the full spectrum of UR-BOO grades.

Based on the principles of the URR throughout the voiding [1,7,22], the ICS-ST97 [1] had introduced overactive urethral function during voiding as a term. This WG suggests, however, to use (new) **abnormal urethral resistance pattern** as a more descriptive term. Also, an abnormal UR pattern can be present within the full spectrum of UR-BOO grades [7,9,22,23]. The WG considers that evidence exists that further sub-classification of abnormal UR patterns has physiological face validity in men [7,9,21,24] but cannot give recommendations to clinically relevant demarcate abnormal from normal UR pattern.

The WG suggests that a normal UR pattern with high pressure (and low Q) is consistent with BOO as it can be diagnosed in men with an enlarged prostate. The WG acknowledges that an abnormal UR pattern in either sex can, in general, be associated with p_{det} variations or, especially in women also with p_{abd} variations as well as exist with anatomical, functional, and neurological abnormalities. The WG does not give further recommendations to unravel the cause of an abnormal UR pattern.

As a consequence of female anatomy, not only bladder outlet distension is usually possible at very low pressures and collapse occurs at the same low pressure but also the UR pattern includes intrinsically more variability throughout one voiding. Especially when compared to men with prostate enlargement and higher UR where the prostate acts as a stable nozzle, the Q variations in women are usually larger. This variable UR pattern usually exists against a background of very low UR with high Q and the limit for a clinically relevant abnormal UR pattern will be at a much higher, but currently still to be determined, level compared to UR patterns of men. The WG awaits further research that quantifies limits of physiologically normal outlet behaviour, i.e., the limits of normal UR patterns during voiding, of both sexes.

The WG prefers that **bladder outlet function** is used for the voiding function when referring to the anatomical function, contrasting the term bladder outflow function referring to physiology and UR to quantify this [1,2,4].

The WG recognizes, regarding UR and bladder outlet function [1,2,4], that some clinical definitions of "dysfunctional voiding" (of patients without neurological abnormalities) are published with variants [27–29]. Dysfunctional voiding is also defined earlier [2] as being (cited:) "characterised by an intermittent and/or fluctuating Q due to involuntary intermittent contractions of the peri-urethral striated muscle during voiding in neurologically normal individuals." The WG recommends not using the terms dysfunctional voiding, functional obstruction or overactive urethral function [2,15,30,31] in relation with PFS, as they are lacking urodynamic quantifiers. This WG considers these definitions clinically not unacceptable but not applicable in UDS or PFS-analysis. It is impossible to confirm or refute on the basis of PFS urodynamics that involuntary intermittent contractions of the peri-urethral striated muscle during voiding have caused the Q to be intermittent. For example, a pivotal study mentions that dysfunctional voiding can only be diagnosed when a sustained detrusor contraction is present [32], but regrettably without mentioning how frequently a nonsustained detrusor contraction has been an alternative cause of irregular or intermittent flow. The WG contemplates that dysfunctional voiding is a clinical diagnosis (only) after excluding unsustained detrusor voiding contraction (DVC), detrusor underactivity (DU), BOO, anatomical abnormalities of the bladder outlet or non-representative voiding. This WG has also not further defined overactive bladder outlet function, overactive urethral function during voiding or, dysfunctional voiding as was defined in earlier standards [2] or paraphrased later [15] and is not recommending quantifiers for these, based on standard PFS-analysis. The WG acknowledges, however, that in addition to the (P)URR, the term dynamic urethral resistance relation (DURR) [4,14,22] is used in conjunction with PFS observations to depict and quantify abnormal UR patterns. The WG, however, concluded that commonly agreed parameters to clinically demarcate or grade abnormal from normal bladder outlet behaviour are not yet applicable and also that the term dynamic (in DURR) too easily can lead to confusion with regard to the normality or the abnormality of the bladder outlet function. The WG recommends further scientifically evaluating the PFS clinically and mathematically regarding the normality of UR pattern and, recommends clinical validation or confirmation of earlier proposed quantifiers [1,8,21,22,24,26].

The WG acknowledges that, apart from the physically obstructive effect of the transurethral catheter (mentioned in part 1), also inability to fully relax the PFM and situational inhibition can play a role during PFS and recommends awareness of this as well as serious consideration of the representativeness of the voiding when an abnormal UR pattern is diagnosed (see part 1 of this standard).

The WG recommends using this current standard of PFS-analysis and the existing paradigms of LUT-(patho)physiology as the basis for the diagnosis of UR pattern abnormalities and recommends also specifically to consider the representativeness of the voiding as well as clinical comparison with the noncatheterized flow(s) of the same patient (see also part 1 of this standard).

2.1.2. Conclusions and recommended terms

The WG has introduced the term normal UR pattern for PFS-analysis, based on the distensible-collapsible urod(hydro)dynamic paradigm of voiding, and also explained that an abnormal UR pattern is diagnosed when the pattern deviates from the normal pattern. However, a precise demarcation between these patterns is not available and consequently the WG cannot give a urodynamic quantification of voiding (or UR) *pattern* abnormalities. The WG considers the term abnormal urethral resistance pattern is recommended for PFS diagnosis, rather than the clinical terms e.g., overactive urethral function or dysfunctional voiding. Bladder outflow obstruction is the preferred term to use when an UR above a (clinically relevant) limit is diagnosed.

2.2. DVC and acontractile detrusor

ICS-ST97 and ICS-ST02 [1,2] defined DU and acontractile detrusor as different from normal detrusor activity during voiding, and ICS-GUP16 [4] introduced that DVC and pressure during one voiding may be variable. A later standard introduced a different definition for acontractile detrusor (in Section 3.7) [15] and the WG recommends ignoring this definition for PFS-analysis.

The WG recommends, as ICS-GUP16 [4] did, that only analysis of p_{det} combined with synchronous Q can qualify or quantify the detrusor contraction during voiding [33]. This WG considers here also that the term detrusor contractility should be preferred for the result of any method or test that diagnoses intrinsic detrusor muscle properties (e.g., potential maximum of force or maximum of shortening velocity). We here refer to e.g., stop-flow or interrupted-voiding tests and condom pressure voiding tests, and mathematical or graphical extrapolation methods of PFS curves.

2.2.1. Detrusor voiding contraction

The WG recommends continuing to use the terms underactivity and acontractile detrusor. However, the WG prefers that (**new**) **DVC, Detrusor Underactive Voiding Contraction (DUVC)** or DU when DVC is observed below a limit is used. Especially the terms DUVC or DU should be used to delineate this objective result of PFS-analysis from the term underactive bladder symptom complex or, syndrome, based on symptom clustering with a currently unknown (but presumably low [12]) specificity and sensitivity for the diagnosis of DU or DUVC. The WG **recommends that DUVC** ("**contraction**" see Section 5.1) is used to refer to the fact that only one PFS is analysed. DU would refer to a definitive diagnosis of a detrusor that is unable to generate normal power and/or endurance during voiding. It is uncertain how well one PFS can assess **contractility** (see Section 5.1), or how many standard PFS or which other tests may be necessary to establish the diagnosis of

DU. The WG also discussed whether it is relevant to introduce a term voluntary detrusor contraction as contrasting to involuntary (detrusor overactivity) contraction. However, although involuntary contraction is used it is not the official, however frequently used, term. The contrasting term seems unnecessary and is less descriptive and includes a not measurable description: (in)voluntary.

The terms unsustained or fading contraction [34] (ICS-GUP16 [4] and ICS-ST-2002 [2]) are relevant and supported by this WG in the hope that analysis methods and cut-off values or pattern descriptions will be developed. The terms are at present not precisely defined and the WG recommends studying and better classifying the deviations from a normal sustained DVC [2,6]. This WG recommends however the use of here above-mentioned terms to describe DVC pattern.

The WG recommends (new) **not to diagnose DUVC or DU on the basis of detrusor pressure or flow rate alone**, i.e., without using the product of synchronous pressure and flow (see Section 5). During PFS, DUVC may be observed as a contraction of insufficient maximum power when the maximum product of pressure and Q is relatively low. DUVC may also be seen as a contraction with insufficient duration to completely empty the bladder (fading contraction) or show an unsustained pattern [34]. The two elements of the definition, duration and, contraction power [6], may also be observed alone or in combination with a representative longer duration to start the voiding. The WG suggests further studies of these elements of DUVC to better enable grading of DVC dysfunction.

2.2.2. *Acontractile detrusor and inability to void*

The ICS-ST-2002 specifically defined acontractile detrusor as "one that cannot be demonstrated to contract during urodynamic studies" [2]. This WG recommends using the **new** definition for the term **acontractile detrusor:** A detrusor that does not show any contractile activity (no detrusor pressure increment and no flowrate) during a urodynamic study (including cystometry) in patients for whom a cause of the inability to voluntarily initiate the voiding reflex is clinically foreseeable. To explain: The WG considers that the PFS diagnosis acontractile detrusor should be based on the combination of PFS observation with a history of congenital or later life neurogenic, or myogenic (after large volume urinary retention) abnormalities or of pharmacogenic effects on the LUT. The WG states that representative inability to void (history) with no DVC activity, thus acontractile detrusor, is a secondary LUT dysfunction in the vast majority of cases. The WG cannot however exclude that in some patients no reason can be found for acontractile detrusor during UDS in combination with a history of inability to void this would be labelled idiopathic acontractile detrusor. The WG recommends, in this regard, that a PFS diagnosis cannot be made when a patient is situationally unable to void (**new**).

The WG recommends thus that situational inability to void should not lead to a diagnosis of acontractile detrusor (see part 1 of PFS23). As is included in the definition, plausible and acceptable causes—from clinical history—for acontractile detrusor are neurogenic central or peripheral nerve lesions in the innervation tract of the LUT or detrusor overstretching, causing myogenic mechanical lesion of the detrusor muscle and pharmacogenic effects [35,36]. Clinical history and exams are mandatory for the diagnosis of acontractile detrusor and a patient who is usually able to void (with or without signs of dysfunction) in the daily life situation will have a diagnosis situational inability to void when appropriate. Below, the WG explains voiding with (very) low UR or with little or absent p_{det} increase during voiding.

Whereas inability to void during PFS should not be confused with acontractility of the detrusor the WG prefers the descriptive term "situational inability to void" (see part 1) and does not recommend the terms paruresis, shy bladder syndrome or bashful bladder syndrome, because they are not precisely defined at present and demarcations from somatic or pharmacogenic dysfunctions are insufficiently established [37].

In this context, the WG also does not recommend the term "nonobstructive urinary retention" for patients unable to void during UDS (or "chronic nonobstructive urinary retention" as a syndrome) as is frequently referred to in relation to neuromodulation (e.g. [38], for the simple fact that it is impossible to diagnose (absence of) BOO or low UR, without a PFS voiding, when retention exists. The WG also recommends considering that 'situational inability to void as usual' [2,4] i.e., not representative voiding, will often negatively affect the pressure-flow ratio and quantifications of DVC and UR (or BOO) and may lead to over-diagnosis of outlet and/or DVC function abnormalities.

The WG recommends here also not to use the diagnosis of acontractile detrusor for the situation of detrusor overactivity (in the filling phase) and absence of detrusor contraction after permission to void and suggests the descriptive: inability to voluntarily initiate the voiding and not acontractile detrusor because contractions were observed during the filling phase. Reduced compliance with or without overflow incontinence should however be distinguished from detrusor overactive contraction and inability to void in combination with reduced compliance is more likely representative and, acontractile detrusor will be diagnosed in this situation.

As explained in part 1 of this standard, the observation of abdominal straining at the beginning of the PFS and/or during the voiding may affect PFS analysis and diagnosis. The questioning by the urodynamicist about the representativeness of the voiding if straining was observed on the PFS graph is relevant, and if the result was not representative, this should lead to the diagnosis 'situational inability to void as usual' during PFS and should also lead to considering an immediate repeat of the cystometry. Good evidence to recommends cut-off values for the relevance of abdominal pressure variations during voiding is however lacking. Because abdominal pressure affects Q in women [39] more easily than in men (where the flow controlling zone of the bladder outlet tract (prostate) lies within the influence of abdominal pressure) [40], PFS analysis by standard means is less or not applicable for female PFS when straining occurs. The WG recommends caution to use (disproves) PFS-analysis as is standardized in this document for PFS-graphs or PFS-plots with significant straining (Valsalva or Credé) and considers that the PFS-analysis methods are only validated for voidings that are generated by (predominance of) p_{det} or DVC -shortening velocity.

The WG recommends also to understand, also in this context, that voiding frequently occurs without an increment in p_{det} above the baseline in the situation of low UR. A large percentage of women as well as men after radical prostatectomy have a UR low enough to allow voiding with normal or high Q without p_{det} (or p_{abd}) -rise; the pressure of the abdominal content resting on top of the urinary bladder alone provides enough energy for this. The detrusor is not acontractile in this situation but is contracting rapidly (see Section 2.1.1) to allow urine to leave the bladder with a high Q.

2.2.3. *Quantification of voiding completeness*

As stated here above, voiding should end with an empty bladder. Postvoid residual urine (PVR) and voided percentage (Void%) are defined in ICS-GUP16 and the WG defines **(new) incomplete voiding** for any voiding with a Void% less than 100%. Although the terms 'complete emptying' and 'incomplete emptying' are often used in the literature and in many definitions of ICS terms, the WG prefers consistency and recommends using the word voiding, as is also used in the parameter Void% [2,4]. The WG also advises to use **PFS-PVR** or **PFS-Void%** to discriminate from uncatheterized voiding [4]. The WG does not recommend clinical limits for (PFS-) Void% to diagnose incomplete voiding. The WG recommends the use of the clinical term urinary retention only in the case of a total inability to void (Void% = 0 with or without DVC) and not as an alternative term for incomplete voiding (Void% > 0) and also not as the alternative for acontractile detrusor. (The WG does not recommend using the terms incomplete or complete urinary retention as are defined in the standard for neurogenic LUTD [41] for PFS diagnosis of patients with normal neurological function.) The term urinary retention should, within the context of this standard, continue [2] to be used for inability to void with a (over)filled bladder, with or without sensation of filling (or relevant pain) with matching history and clinical signs.

2.3. Conclusions and recommended terms

The WG has recommended that only analysis that is based on a combination of pressure with flow is valid for quantification of DVC. Analysis of a voiding during PFS will result in quantification of detrusor voiding contraction. The WG recommends that this clinical analysis of a voiding contraction should be distinguished from techniques or methods that would assess contractility [42]. The WG has defined DUVC and also acontractile detrusor. Especially acontractile detrusor has a more limited definition as is commonly used up to to-date, and especially also the conclusion ("diagnosis") situational inability to void after PFS is considered relevant in this context. The WG has reconfirmed that acontractile detrusor is a secondary diagnosis, only applicable in combination with a pharmacogenic cause or a myogenic or neurogenic condition. Situational inability to void should not lead to a diagnosis about voiding. The WG has recommended caution for the analysis of PFS when large abdominal pressure variations are observed during PFS. Analysis of DVC should be completed with assessment of voiding completeness quantified with (PVR) and PFS-Void%. Void% = 0 represents the term urinary retention; the term incomplete voiding for any voiding with (any) PVR (void% < 100).

3. Pressure-flow analysis, general principles, and practice

3.1. PFS graph

The **PFS-graph**, showing pressure and Q together with a horizontal time axis after the permission to void, allows assessment of the permission to void indicator, the time to Q and the flowrate pattern and interruptions of Q. PFS-graph observations are relevant to study the time course of voiding. Flow rate as well as p_{ves}, p_{abd} and p_{det} -graph traces are used to observe and classify patterns. Flow rate-abnormalities, sustained or unsustained detrusor voiding pressure, DVC [4], and abdominal pressure increments are relevant for PFS diagnosis.

The WG uses, as in ICS-GUP16 [4], the words voiding and contraction in the terms DVC and DUVC (see Section 2.2.1), to distinguish from detrusor overactive contraction and also to depict that a single voiding is analysed. This WG does not include recommendations for analysis of detrusor contractility, requiring specific tests or more than one voiding, other than defining the term (see explained in Section 2.2.1).

Detrusor sphincter dyssynergia was defined earlier [2] to: (cited) "typically occur in patients with a supra-sacral spinal cord lesion." Detrusor sphincter dyssynergia is a feature of the lack of neurological coordination between the DVC and the bladder outlet. The antagonistic function is disturbed, and the outlet closes involuntarily together with continuation of the DVC. Detrusor sphincter dyssynergia has the typical PFS pattern of a diminishing (or stopping) of Q synchronous with an increase of p_{det} (as in a "stop test") [43,44], and should be differentiated from unsustained DVC (see Section 2.2.1) with synchronous flow variations and abnormal UR pattern with (pressure and) flow variations, in patients without relevant neurological abnormalities. Although it is sometimes very obvious that DVC or Q during a PFS are not continuous, the WG does not further discuss the diagnosis detrusor sphincter dyssynergia, being (neurogenic dysfunction) outside the scope of the ICS-PFS23 but recommends that the term detrusor sphincter dyssynergia is not used for patients without relevant neurological abnormalities [2,15] and that abnormal UR pattern (Section 2.1.1) e.g., with or without sustained DVC [6,8] is reported as PFS diagnosis when occurring.

The WG considers that evidence is lacking [45] that PFM-EMG during PFS is sufficiently reliable, or reproducible (investigator independent) to quantify peri-urethral striated muscle activity and considers that reliable assessment of whether PFM activity during voiding is voluntary or not is impossible. Because pressures and Q during PFS are intrinsically more reliable than PFM-EMG, the WG recommends descriptive terms such as Q variations associated with abdominal pressure variations, or Q variations associated with p_{det} variations or as defined here above, abnormal UR pattern (when the ratio of p_{det} and Q is included). The WG is not recommending PFM surface EMG (also not ICS standard for UDS [4]) as an addition to PFS study or analysis.

3.1.1. Post-PFS quality checks

Urodynamic traces and results should be quality checked by the responsible person before making a urodynamic diagnosis. Quality checks and [1,2,4,44,46,47] Cystometry—initial resting pressures should be checked posttest and be in the physiologic range. Furthermore, also pressure (ves-abd) balance, liveliness and cough responses during the cystometry should be in the expected ranges before PFS. Observation of cough checks before and after voiding should be used to recognize an expelled or kinked catheter. Peak flow rate artefacts and peak pressure artefacts during voiding (PFS) need to be recognized and corrected before further analysis of UR and DVC. Further details regarding quality analysis are available [4,45,46,48]. Pressure-flow plotting is helpful to recognize PFS artefacts; prolonged dribbling after voiding is usually not representing the true p_{det}-Q relation and can be ignored (although included in voiding time, see appendix part S1). With the help of PFS-plot observation the true end of the voiding (see Section 3.2 and Fig. 6) can usually be easily recognized. Furthermore, voided volume should have been measured in a calibrated bowl and PVR should be included, to account for the addition of diuresis volume to the machine calibrated cystometry-pump volume and to (re-)calculate the (true fill volume sensations and the) PFS-Void%.

3.2. PFS plot

This WG again recommends the PFS-plot as introduced by the ICS-ST97 [1], to be used in addition to the (filling cystometry and) PFS-graph. The ICS-PFS-plot (as the successor of the plot from ICS-ST97) shows the detrusor pressure and flow curves from the PFS-graph, but in an X–Y-plot of flow and synchronous pressure and thus shows the relationship between p_{det} and Q throughout the voiding (see Fig. 1). This presents as a loop; the URR and the lower pressure border of the URR is depicted as the passive urethral resistance relation (PURR) [1]. The ratio of p_{det} to Q during a PFS (= URR), observable in the PFS-plot, allows observation and quantification of UR and BOO (see below) as well as qualitive judgement of normality of the UR pattern during voiding. A PFS-plot furthermore allows simple visualisation of $p_{det.max}$ and instantaneously shows the combination of UR with DVC specifically when the $p_{detQmax}$ point is observed. This will be explained further below.

The WG proposes however in this standard that ICS-PFS-plots with the nomograms used for grading of dysfunction (see below) are preferably presented (**new**) **with the detrusor pressure along the X-axis (horizontal) and the flow rate plotted along the Y-axis (vertical)**. This is different from the ICS-ST97 where Q was on the horizontal axis (see Fig. 1).

The argument for this is first, the intention to be in line with international convention for naming of X–Y plots where the independent variable is on the horizontal axis and leading the name of the plot. As the WG argued above the detrusor (the independent) generates the flow rate (dependent). For a given individual load (= UR) the Q depends on the energy that the detrusor transfers to the bladder content. It is true that during one voiding, especially in the distension phase, the Q (UR) dictates the pressure, but at maximum the Q is limited by the pressure and flow without pressure is impossible. A PFS-plot with the pressure(X) -flow(Y) orientation is recently also introduced and adopted as "new" in an ICS glossary [15]. Also, the ICS-ST97 plot with flow-pressure orientation, is not often included in a publication. Furthermore, standard contemporary urodynamic equipment allows plots in both orientations; pressure-flow as well as flow-pressure (ICS-ST97 orientation). The WG considers these the arguments to propose

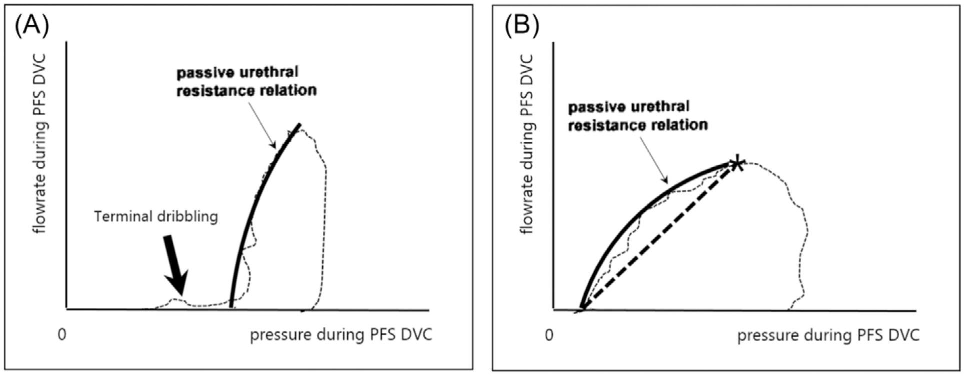

Fig. 6. (A) Shows how terminal dribbling is usually visible in the PFS-plot. And how the PURR should exclude this part because the dribbling is asynchronous with the DVC - pressure. (B) Shows the URR in the PFS = plot and the PURR adjusted to its lower pressure border (compare Fig. 1). The dotted line connects $p_{det.min.void}$ and $p_{detQmax}$ (see Section 4.2) with the WG-suggested aim to further (sub) type UR—two points analysis—, especially when BOO is present. BOO, bladder outflow obstruction; PFS, pressure-flow study; URR, urethral resistance relation; WG, working group.

correction of PFS-plot axes orientation in this standard as the preferred, while suggesting a transitional phase. To clarify the changes and assist urodynamicists who are used to the previous format, both orientations are included in this standard (see paragraph 8). The WG expresses the hope that the here proposed correction will soon be put in every practice.

Digital storage of data in the contemporary urodynamic equipment allows direct posttest displaying of cystometry and PFS-graphs and a also the (preferred) PFS-plot after closing the UDS measurement. The WG recommends **(new)** to **adjust equipment so that the (preferred standard) ICS-PFS-plot is shown in the report form of every urodynamic study that included a voiding**.

3.3. Flow delay

A PFS-graph and a PFS-plot display the relation of p_{det} with Q, however, they are not obtained exactly synchronously. Because the flow hits the collecting device bottom somewhat later than the vesical pressure that generates it, flow delay should be considered not only in the PFS-graph but also in the ICS-PFS-plot [1]. This delay is reported in the ICS-ST97 [1] and the later ICS good urodynamic practices document [49] to be between 0.5 and 1 or 2 s in the typical system set-up although a specific reference for this was not provided. One study is, however, available and recommends that a lag time of 0.4 s should be used for sitting voiding and 1.1 s for standing [50]. The WG supports the earlier recommendation to minimize the meatus to flowmeter distance [2,4,50]. A simple graph [51] suggests that a distance of 20–30 cm would result in a delay of 0.25 s of the external stream or shorter if a starting velocity from the meatus is assumed. Especially in men there will be, on the other hand, some additional delay from the bladder-neck to the meatus. The WG suggests bearing this in mind when setting the flow delay specific to the lab [2,4], especially because various sources of variation exist [50].

3.4. Dribbling, intermittent flow, and after-contraction

Terminal dribbling can be observed on a PFS-graph and the WG considers that especially in men, because of the longer urethra, the delay between p_{det} and the dribbling is likely much longer than during the voiding. Dribbling will show a tail of Q at the low pressure side of the PFS-plot pressure-flow loop. Usually, it is easily visible at which point the physiological pressure-flow pattern changes into a uroflow-dribble-tail (see Fig. 6). The WG recommends recognizing this point to help determining minimum voiding pressure (see appendix in PFS23 part S1), $p_{det.min.void}$ and identification of the lower pressure border of the PFS-plot.

A PFS voiding may be intermittent, as observable on the PFS-graph. On the PFS-plot this will project as two or more loops; and the WG recommends using the “best” $p_{det.Qmax}$ -Q_{max} point for analysis. This “best point” should indicate or represent the lowest UR.

The feature after-contraction is defined in ICS-GUP16 including a comment on the relevance of postvoiding cough checks [4]. The relevance of after-contraction has not been clearly established [52,53]. The WG does not recommend about relevance of after contractions in PFS analysis e.g., for diagnosis of voiding dysfunction or the quantification of DVC or UR. After- contractions will not be visible on a PFS-plot because Q is zero during this contraction.

3.5. Pressure-flow analysis

Direct inspection of the raw pressure and flow data on the PFS-graph before during and, at the end of voiding is essential because it allows artefacts and untrustworthy data to be recognized and eliminated (Section 3.1.1) [1,2,4,46,49]. The flow pattern in a PFS should be compared with—good quality—free-flow studies in the same patient. Although clinical representativeness and comparison with free flow are both relevant, it is acceptable to use the results nonetheless because PFS results consider a ratio of pressure and flow. Nevertheless, the WG recommends caution regarding clinical diagnosis if the PFS and free-flow differ very much (e.g., also in volume voided and or PVR or PFS-void%).

The distensibility and flow controlling zone diameter of adult women are usually much larger than those of men and the effect of the (6–8F ICS-standard) catheter by itself, on Q or UR, is likely to be minimal. The reduction of Q caused by the catheter is a known issue, but diagnostic cut-offs have been formed with the catheter in place, so comparison can be validly made. The data in one publication demonstrates that the difference between 4F or 10F catheters in men selected for prostatectomy has been less than one class of the linearized passive urethral resistance relation (LinPURR) nomogram [26] representing test retest variation in men [54] ≈10–15 cmH_2O, as a measure of UR [55]. The WG suggests considering that when PFS are done in male patients with a suprapubic catheter, adjustment of the pressure for grading of UR and comparing to clinical limits may be relevant, without the WG being able to precisely guide in this.

3.6. Discussion

The WG here acknowledges that ICS-standard PFS analysis with p_{det} may not always resemble the true dynamics of voiding. Especially in women (or men after radical prostatectomy) a proportion of the energy that drives Q is the gravitational force of the abdominal content on the bladder, and therefore not only the detrusor muscle (see also

Section 2.1.1). The WG suggests studying ICS-PFS-plots as well as PFS-graphs that also combine p_{ves} as well as p_{abd} with Q, in experimental cohorts to further evaluate the relevance of these.

3.7. Conclusions

The PFS-graph allows diagnosis of patterns over time, related to the progress of voiding. The diagnosis of detrusor sphincter dyssynergia requires the clinical presence of LUT relevant neurological abnormalities. The diagnoses "dysfunctional voiding" or "functional obstruction" are not descriptive enough for PFS diagnoses and the WG recommended using descriptive terms regarding DVC, flow rate and UR and hopes that clustering of these descriptions will lead to more specific diagnoses and management of adult non-neurogenic abnormal urethral resistance patterns - bladder outlet dysfunctions.

The ICS-PFS-plot added to the (time-based) PFS-graph is reintroduced and especially useful to help diagnosing and grading UR, BOO and DVC-strength. The WG will further detail on the ICS-PFS-plot and grading of UR and DVC here below.

3.8. Recommendations

The WG recommends the diagnosis of dyssynergia only for patients with relevant neurological abnormalities. The WG recommends using descriptive terms or pattern descriptions for abnormal bladder outlet or DVC-function on the basis of pressure and flow rate patterns on the PFS-graph and acknowledges that precise quantification or cut-offs for deviations from normal UR dynamics are not yet available.

The WG recommends the ICS-PFS-plot, preferably displayed with pressure along the horizontal axis and flow rate along the vertical, for the graphical display of UR (BOO) and DVC as adjunct to the PFS-graph for every patient.

4. Classifying and grading of urethral resistance

BOO was defined in the earliest ICS standards [1,20] as elevated pressure in combination with reduced Q. UR can be assessed throughout the entire voiding, but is clinically used to grade BOO, from the second phase of voiding after Q_{max}, where the pressure and flow continue in the most "balanced" manner (see Section 2.1). This second phase is visible as the lower pressure border in the PFS-plot [1].

The "group specific" UR parameter URA [34,56] ("urethral resistance A" was defined group specific because this was, when published, only validated for men with prostatic enlargement) and the PURR have been presented as quantifiers for UR and BOO in the ICS-ST97. Linearized PURR nomogram (linPURR) [26] and A-G number (later renamed bladder outlet obstruction index [BOOI]) were then introduced as "simplifications" of these URR bases concepts [1]. All methods to grade UR are based on the ratio of pressure and flow during the voiding [43]. The BOOI was presented in an individual publication after an International Consultation (LUTD) meeting [57] as a "simple index" derived from both Schäfer's and Griffiths' publications. The PFS pressure-flow ratio principles from these publications were simplified, from a pressure-flow ratio to a subtraction containing pressure minus flow. Together with other indices (see below) the outlet index was launched as part of the gold standard to urodynamically analyse voiding in another individual manuscript [58]. BOOI using a subtraction ($p_{detQmax}$–$2Q_{max}$) to replace the ratio is frequently used and generally accepted to grade UR [15]. The BOOI has been shown to adequately approximate URA or PURR analysis [59,60] (see also Fig. 4).

This WG proposes (**new**) **ICS-BOOI** as the **ICS-standard parameter to quantify UR**. The WG, however, considers that ICS-BOOI potentially overestimates the grade of BOO in the higher pressure regions (above ≈60–70 cmH_2O), because the relative weight of p_{det} in the ratio decreases when UR is higher, as a sign of nonlinear reduction of distensibility [26] (see also D'Ancona et al. [15], referring to Schäfer [26]). The WG considered that LinPURR corrects (with adapting gradients or class lines) for the nonlinear distensibility [26] of UR in patients with (higher grade of UR) as a result of BPE, although the differences between this quantification and others will have only little effect on diagnosis if all types of analysis are, as recommended in this standard, interpreted as being continuous scales. The WG recommends including BOOI as well as URA and (lin)PURR analysis for reporting cohorts in research [1,43,61]. Other parameters used to depict or classify UR were theoretically explained and compared [62] and were listed in the ICS-ST97 [1] but have found little implementation. The WG recommends these for specific research application and validation but at present not for routine clinical practice. The WG has updated the table from ICS-ST97 [1] (see Table 1).

4.1. Urethral resistance and grading of BOO

The WG recommends that UR is defined as the lower pressure border of the PFS-plot loop when artefacts and dribbling are omitted (Fig. 6A).

The WG recommends (**new**) clinical **grading of UR by using the point showing the Q_{max} with the $p_{detQmax}$** in the ICS-PFS-plot or just to calculate indices (see Sections 6.1 and 7.1). Many UDS machines may give the PURR projected in the ICS-PFS-plot however the WG does not recommend this for routine clinical analysis. The WG supports **(new) to put the point $p_{det.min.void}$ and the point $p_{detQmax}$ with Q_{max} in an ICS-PFS-plot and connect these** [26] as is also explained in an ICS glossary [15]. This WG suggests this to obtain more information about the type of UR (if BOO exists) as is discussed in Section 2.1.1 (e.g., compressive or constrictive) without recommending its clinical relevance at present (Fig. 6B).

The ICS-PFS-plot allows observation of whether the voiding of an individual takes place at high or low pressure; if the low pressure part of the loop projects at the right hand—high pressure—side of the graph, BOO is the case. The further the loop projects from the origin to the right, the higher the grade of BOO (Fig. 5). A line, as described here above between $p_{det.min.void}$ and the point $p_{detQmax}$ with Q_{max} will show the grade and gradient of BOO [6,23,26] (Fig. 6B).

4.2. Conclusions

The WG has again presented the p_{det}-Q plot (ICS-PFS-plot) and the earlier recommended quantifiers of UR. The ICS-PFS-plot allows recognition of peak artefacts (adding on to the PFS-graph analysis) and observation of the low pressure border of the pressure-flow relationship. The WG recommends ICS-BOOI as the single point quantifier of UR and suggests also 2PFS-points analysis for clinical diagnosis. Furthermore, WG recommends considering URA and linPURR, especially for scientific reporting.

4.3. Recommendations

The lower pressure border of the PFS-plot-loop (URR) from the detrusor pressure and flow rate curves represents UR and grade of UR is quantified by fitting to this. The WG recommends the simplified analysis of the PFS-plot that uses the $p_{detQmax}$ point with the $Q_{max.}$ This point can be observed in the PFS-graph, and even more easily in the ICS-PFS-plot and is used in the ICS indices as described here below. The WG suggests that another simple manner to clinically grade UR, that uses a line between $p_{det.min.void}$ and $p_{detQmax}$ with Q_{max}, may be used to grade BOO while taking gradient (elasticity) into account although the WG recommends further research regarding its relevance.

5. Classifying and grading DVC

5.1. Detrusor contractility and detrusor contraction

A PFS allows calculation of the DVC-work, during that particular voiding by the product of Q and p_{det} (see below). Derivatives such as

Table 1
All currently available parameters to depict or classify UR.

Method	Aim	Number of p/Q points used	Comprised shape of UR lower pressure border	Resulting number of parameters	Resulting number of classes or continuous
ICS nomogram	Classification	1	n.a.	n.a.	3 BOO
Spångberg Nomogram	Classification	1	n.a.	n.a.	2× 4 BOO
LinPURR nomogram	Classification	1 or 2	Linear (linearized)	2	7 grades BOO 4–6 grades DVC
Chess Nomogram	Classification	Continuous; lower pressure border of PFS-plot	Curved	2	16 BOO
URA	Grading UR	1	Curved	1	Continuous
PURR	Grading UR	Continuous; lower pressure border of PFS-plot	Curved	2	Continuous
OBI	Grading UR	Many (or parts of) lower pressure border of PFS-plot	Linear (slope)	1	Continuous
DAMPF	Grading UR	2	Linear	1	Continuous
BOOI	Grading UR	1	n.a.	1	Continuous

Note: The WG recommends these parameters for specific research and further validation, but at present not for routine clinical practice (except BOOI). The WG has updated the table from ICS-ST97 (Griffiths et al. [1]).
Abbreviations: BOOI, bladder outflow obstruction index; DVC, detrusor voiding contraction; ICS, International Continence Society; UR, urethral resistance; WG, working group.

maximum of DVC, duration of DVC and maximum velocity or power of DVC may be reported (see below). The pressure and flow loop in an ICS-PFS-plot will have its point of $p_{detQmax}$ and Q_{max} further away from the origin of the plot when the detrusor is stronger and areas in the graph showing the combinations of pressure and flow can be used to cluster grades of contraction strength.

The WG considers that voiding during a PFS may not represent what the detrusor might potentially achieve under optimal conditions or when challenged. Therefore, the WG recommends using (**new**) **detrusor contractility** exclusively for an analysis or test that reliably produces, calculates, or measures the combined (product or addition of) maximum of shortening velocity or of contraction strength [6,34]. The WG has not further discussed clinical assessment of detrusor contractility but mentions here that an example of this is a stop-flow test during PFS. The isovolumetric p_{det} attained when flow is interrupted provides in theory a good estimate of the maximum contraction strength [63] although in clinical practice voluntary interruption frequently reduces or stops autonomic DVC stimulation, limiting its applicability. External mechanical interruption may also inhibit continuation of voiding especially when it provokes unpleasant sensations. Short time interruptions do cause less discomfort, but do not certainly allow the detrusor contraction to reach its maximum [64].

The "strength" of a DVC is quantified by the product of pressure and flow (similar to "power" which is force × distance/time which equals pressure × detrusor shortening/time where detrusor shortening[2]/time is represented by flowrate.

The force during DVC can be calculated and shown as a curve throughout the entire voiding with the bladder working function (BWF) [8] or, with the bladder watts factor (WF) curve [33] which includes bladder surface area (size-reduction) during voiding in the formula. The WG will not further discuss BWF or WF in detail. The projected isovolumetric pressure (PIP), evaluated in clinical practice from the point of Q_{max}, in the PFS-plot is given by the following formula: $PIP = p_{detQmax} + 5Q_{max}$. Values of PIP greater than 150 cmH_2O are reported to represent a strong maximum of contraction; values from 100 to 150 cmH_2O, a normal contraction (N); values from 50 to 99 cmH_2O a weak-, (W); and values below 50 cmH_2O, a very weak contraction (VW). PIP is later named the bladder contractility index (BCI) and developed, based on the analyses with BWF and WF. BCI introduced as a single point parameter to grade detrusor DVC [57,58]. The BCI as a sum of pressure and (5*)flowrate, instead of a product, has shown to be a reasonable approximation of the maximum of WF in men [65] (see also Fig. 4).

[2] Detrusor shortening/time represents detrusor contraction speed-velocity; diminishing of circumferential size of the bladder.

BCI is not mentioned in the earlier PFS standard (ICS-ST97) but very frequently reported. The WG recommends adopting BCI as the standard with the words (**new**) **Detrusor Contraction Index (ICS-DCI)** with the identical formula. For reasons mentioned here above (reporting a single spontaneous voiding with the p_{det} driving the Q) the WG recommends thus using the word contraction in the index to replace contractility, as well as the word detrusor, to replace bladder. This WG recommends using the ICS-DCI as a continuous scale grading of DVC for clinical reporting. The WG also strongly recommends ICS-DCI for scientific analysis and reporting of cohorts.

The WG presents the ICS-PFS-plot, that allows reporting of DVC strength as a product of $p_{detQmax}$ and Q_{max}, dividing it in two classes (normal DVC and DU—see below), but also as a value on a ratio-scale. The separating line of the classes is a BOR curves simplified to straight lines (a DCI-line) with a fixed slope of 5 (mL/s)/cmH_2O.

5.2. Conclusions

The WG introduced the terms DVC and DUVC and also discussed contraction and contractility with the recommendation to use contraction for the grading of a single PFS. Diagnosis of normal DVC or of DUVC is only possible when the product of p_{det} and Q is considered and not on the basis of p_{det} or p_{ves}, or $Q_{(max)}$, (or (PFS-)void%) alone. The WG has also introduced the principles and the parameter for quantification of DVC on the basis of a standard PFS.

5.3. Discussion

DVC can be normal, (or strong), or weak and the bladder outlet may cause too much UR, prolong voiding time, or cause incomplete voiding. BOO results in high p_{det} during voiding with low Q_{max} and, weak contraction; DU (or DUVC) is recognised as low p_{det} with low Q_{max}. Grading of abnormality is applicable for all elements of PFS. The WG recommends considering that **all three PFS elements** (DVC, UR, and PFS-Void%) **are quantified on a continuous scale** for the individual patient but also in study cohorts.

The WG recommends that grades of dysfunction as well as cut-off values are based on clinical principles and relevance. The WG recommends using the three elements for PFS analysis and urodynamic diagnosis for every test (or series of tests in cohort reports). The WG also acknowledges that precise cut-offs for *clinical* diagnosis will differ between gender, age groups, anatomy of the bladder outlet, and/or of the consequences and risks of e.g., prolonged, high DVC pressure, or incomplete voiding. Below, the WG will suggest provisional cut-off values for BOO, DVC and PFS-Void%.

5.4. Recommendations

The WG recommends using the ICS-PFS-plot as adjunct to the time based PFS-graph for the PFS diagnosis in every patient The WG acknowledges the term UR and recommends the terms BOO, DVC, DUVC as well as incomplete voiding (low PFS-Void%) and complete voiding, when diagnoses are reported on the basis of UDS-PFS (according to this standard).

The WG recommends the term acontractile detrusor for patients with a known cause or reason for this dysfunction and recommends the diagnoses situational inability to void or situational inability to void as usual, in other cases.

The WG (for patients without relevant neurological abnormalities) suggests the term "abnormal urethral resistance pattern" (with some accessory descriptions possible) for any pressure or Q pattern during a representative PFS that is relevantly deviating from a physiologically predicted and normal UR pattern during voiding.

6. ICS-clinical standard for PFS analysis in men

The WG recommends the ICS-PFS-plot to display the individual UR and grades of BOO and DVC, as well as the UR pattern (see Section 2.1).

6.1. Reporting urethral resistance in men

The BOOI (BOOI = $p_{detQmax} - 2Q_{max}$) > 40 is at present a commonly accepted cut-off to diagnose BOO in men if datasets are dichotomized and is a frequently reported parameter in reports about LUTD but was not earlier included in an ICS-practice standard. This WG now recommends using the **ICS-BOOI as a continuous-scale quantifier of BOO** for clinical reporting UDS-PFS result in men. The WG recommends adapting "outlet" into bladder outflow obstruction index BOOI, to be in accordance with ICS-GUP16 terms [4]. The WG also strongly recommends (**changed term**) **ICS-bladder outflow obstruction index (ICS-BOOI)** as a required parameter for scientific reporting of cohorts (men).

The Q_{max} and $p_{detQmax}$ point on the PFS-plot allows observation and grading of the PFS result. The earlier publications [1,57,58] also present 3 areas of UR in the ICS-PFS-plot. The cut-offs of these areas reflect BOO, no BOO and intermediate grade of BOO. The WG recommends **(new) intermediate grade BOO** as the ICS standard alternative, where at present commonly the word equivocal is used. The WG considers intermediate more in agreement with UR as a graded, continuous scale between no BOO and BOO [26].

The WG recommends making ICS-PFS-plot templates with the ICS-PFS23 recommended orientation of the axes and the three areas (Fig. 7). The WG speculates that interpretation of UR as a continuum, using a more detailed, nondichotomous grading will help clinical practice. The WG suggests also introducing (ICS provisional) **moderate BOO** and **severe BOO** as subdivisions of the BOO class. The WG suggests evaluating the clinical value of using (**new ICS**) **classes no BOO, intermediate BOO, moderate BOO, and severe BOO** for example with the classes BOOI < 20; BOOI 20–40; and the arbitrary and provisional BOO classes: BOOI > 40–80; and BOOI > 80, respectively. The WG adds a provisional ICS nomogram for quantification of PFS results with the recommendation to further study and validate this. The WG, however, recommends bearing in mind that UR (BOO) is a continuous scale feature, even when using classes. The WG also recommends evaluating whether the gradients (see Section 4) of the moderate and severe BOOI-lines need adaptation to better reflect physiology or to enhance clinical relevance.

The WG suggests using URA and or linPURR analysis together with ICS-BOOI, for precise analysis and/or further subtyping of UR-BOO grade or UR-dynamics especially in scientific cohorts and recommends explaining the specific differences of ICS-BOOI with these parameters in the manuscript.

6.2. Reporting DVC in men

The WG recommends using clinical classes **normal DVC** and **weak DVC**, and also suggests **strong detrusor voiding contraction** and **very weak DVC** for the reporting of sub-cohorts (male patients) however provides a nomogram with only a "recommended" cut-off between normal DVC and weak DVC (DCI = 100) (see Fig. 7). The WG suggests further studies regarding the validity and relevance of the provisional cut-off's DCI = 50 and DCI = 150. The WG suggests, however, also on the basis of expert opinion, to be very vigilant for artefacts on the PFS-graph, and check vesical and abdominal pressures as well as representativeness, if a male patient ends up in the very weak class (DCI < 50) in PFS-plot analysis.

Maximum WF is a parameter that includes the product of pressure and flow per bladder surface area to quantify detrusor work. Bladder surface area is, in this parameter, based on intravesical volume and used to calculate detrusor shortening velocity [6,33]. WF can be calculated throughout the voiding and its maximum (WF_{max}) is usually observed before Q_{max}, especially in males with higher UR [54]. The WG suggests using WF analysis also (together with ICS-DCI) for precise analysis and to study further subtyping of DVC grade and e.g., DVC-pattern variations especially in scientific cohorts.

6.3. PFS quantifying voiding completeness in men

Voided volume is recorded in the flowmeter, PVR after PFS should be measured. Simple subtraction of voided volume from filled volume after PFS is unreliable because of diuresis during the time of the urodynamic test [3,66]. PFS voiding completeness should be reported in PFS-Void% based on voided volume divided by diuresis plus pump volume.

6.4. Recommendations for PFS in men

PFS analysis of male voiding (individuals and also scientific cohorts) should be reported with continuous grading of UR, DVC, and PFS-Void%. ICS-BOOI, detrusor contraction index (ICS-DCI) and voided percentage (PFS-Void%) should be included. The continuous scales can be divided in four clinically relevant parts to urodynamically class-grade BOO and in normal or underactive DVC. The WG has suggested cut-offs for PFS grading in men. Urodynamic cut-offs and grades of dysfunction should be embedded in all other diagnostic evaluation in an individual patient as per good clinical practice.

7. ICS-clinical standard PFS analysis in women

Due to anatomical differences between males and females, bladder outlet dynamics during voiding vary by sex. Women void with lower detrusor pressures and with higher detrusor muscle shortening velocity (higher Q from faster detrusor contraction ≈(bladder) circumference reduction) than those observed in men because of their lifelong lower grade of UR [67]. Women very frequently void with low UR without needing to increment the intravesical pressure [68] (see also Section 2.1.1). Male DVC is fairly adequately depicted with the Hill muscle force velocity ratio, but female voiding at high muscle shortening velocity is inherently more difficult to quantify. It is accepted that the Hill equation performs sub-optimally to predict high muscle shortening velocity [69]. Furthermore, the weight of the abdominal content on the bladder (even without straining) can probably not be fully ignored in women as a flow driving force [70]. The proportion of detrusor energy transmitted to Q will probably be not well represented (is overestimated) but is unknown. This is, on the other hand, at present not certainly of much clinical relevance because resting abdominal pressure has relatively low inter-individual variability (see the narrow ranges of initial resting pressures [71] in adult women, with approximately average height. PFS without excess abdominal muscle activity will

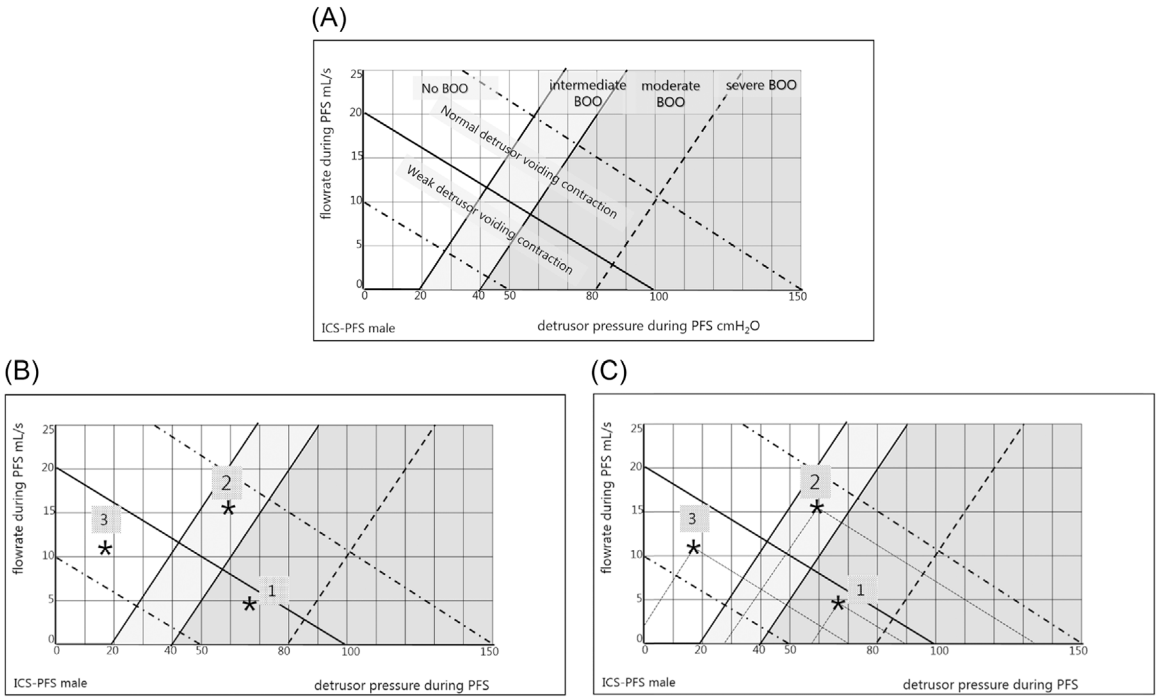

Fig. 7. (A) ICS-PFS plot nomogram for male patients. The nomogram shows 3 vertical area's noBOO (no shade); intermediate BOO (light grey) and moderate plus severe BOO (darker grey). The top right area above the diagonal (representing DCI 100) is normal detrusor voiding contraction and the lower left triangle area is DU. The dotted lines indicate the provisional cut offs, see 6.1 and 6.2. (B) Example diagnoses for 3 $p_{detQmax}$ points. The nomogram with 3 asterisks representing $P_{detQmax}$-Q_{max} points. Patient 1 gets a PFS diagnosis of (moderate) BOO with DU; patient 2 has intermediate BOO and normal DVC and patient 3 has noBOO and DU. (Note that void% should be added to the PFs diagnosis.) Note that two points analysis, URR and PURR (Fig. 6) can be used to add diagnostic information. (C) Example clinical grading of BOO and DVC. Dotted lines are now added in the graph with the asterisks (see B). Patient 1 has a $p_{detQmax}$ point p_{det} 67 cmH_2O and Q_{max} 4.5 mL/s. Therefore, BOOI is (calculated) 58 and DCI 89.5; both thin dotted lines from the asterisk project to the horizontal pressure axis, parallel to the cut-off lines and the corresponding pressures (BOOI 58 and DCI 89.5) can be read. Identical for patient 2; P_{det} 59 cmH_2O and Q_{max} 15.1 mL/s; BOOI 28.8 and DCI 134.5 and patient 3 p_{det} 17 cmH_2O and Q_{max} 10.6 mL/s: BOOI −4.2, projects outside the nomogram, and DCI 70. BOOI, bladder outflow obstruction index; DCI, detrusor contraction index; DU, detrusor underactivity; ICS, International Continence Society; PFS, pressure-flow study.

cause almost identical addition of abdominal content weight so that this abdominal pressure as a driving force of voiding can be ignored, not in physiological sense but as being similar between patients.

When straining occurs during the voiding however, this is considered relevant [72] as it will likely affect Q [73] although its effect on ICS-DCI is little studied. The WG accepts that abdominal pressure may contribute to the driving force for voiding, especially and more often in women. The WG recommends, however, (**new**) **not** to **use standard PFS analysis methods for women with urodynamically significant or relevant abdominal straining**. Regrettably, WG is unable to recommend limits of relevant (Q affecting) abdominal straining on the basis of the current evidence.

While the principles of PFS (and distensible collapsible tube dynamics) have not been demonstrated to be strictly sex-dependent [7,14,18], the observed result regarding outflow function is that women are highly likely to have other cut-offs than men to determine whether UR is high, because of their inherently and life-long lower grade of UR.

7.1. Reporting urethral resistance in women

A female BOOI (BOOIf) is recently presented, calculated as $p_{detQmax}$—$2.2Q_{max}$, and BOO was diagnosed "with high probability" when the result was >18 [74]. A BOOIf = 18 line is added to the provisional ICS-PFS nomogram for women (see Fig. 8). The WG recommends considering also female UR as a continuum but suggests to provisionally adapt BOOIf > 18 (with BOOI > 20 as the comparator for published research with BOOI) as the cut-off to dichotomize female voiding. The WG recommends further studies on whether the BOOIf can be regarded a continuous parameter (and not a "probability" [75] to grade UR in female patients. Further studies are also needed to confirm whether dichotomous grading is sufficient for female BOO. The WG considers that BOO in women is insensitive to medical therapy (whereas alpha(1) receptors are absent in the female bladder outlet) making detailed scaling of BOO less relevant.

The WG considers that criteria for PFS continuous grading of BOO and of DVC (or contractility) used in men, are at present not well enough validated for women to be standardized. Two studies presented at different meetings demonstrated large ranges of overlap when frequently used cut-off values from nomograms for female BOO are projected in the ICS-ST97 PFS-plot [76,77]. Not all "female-specific" UR nomograms published are, however, properly based on the paradigm of distensible collapsing tube hydrodynamics or allow continuous quantification. The WG furthermore considers that too much unsubstantiated relevance is assumed for imaging. (e.g., in Pang et al. [78]) The WG does not recommend earlier published nomograms for female voiding or PFS-analysis methods not based on synchronous pressure and flow [79]. The WG recommends **(new) using the ICS-PFS-plot for displaying PFS results for female patients** in addition to the PFS-graphs and recommends adapting the Q axis in the plot to a maximum of 50 mL/s. The WG has added a BOOIf = 18 line to the ICS-PFS-plot.

7.2. Reporting DVC in women

Although the BCI (now ICS-DCI) was suggested as the standard for female voiding as well [58], there is currently little specific validation, especially not for the diagnosis of DUVC in individual women. An ICS-DCI > 100 represents likely a good DVC, especially when voiding is complete but, an ICS-DCI < 100 is of currently unknown relevance. In one study, where isovolumetric contraction pressures were measured, it was shown that D(B)CI largely overestimates isovolumetric ('stop-test') detrusor pressures in women and that projected isovolumetric pressure 1 (PIP1 = $p_{detQmax} + Q_{max}$) gave a more reliable estimate [80].

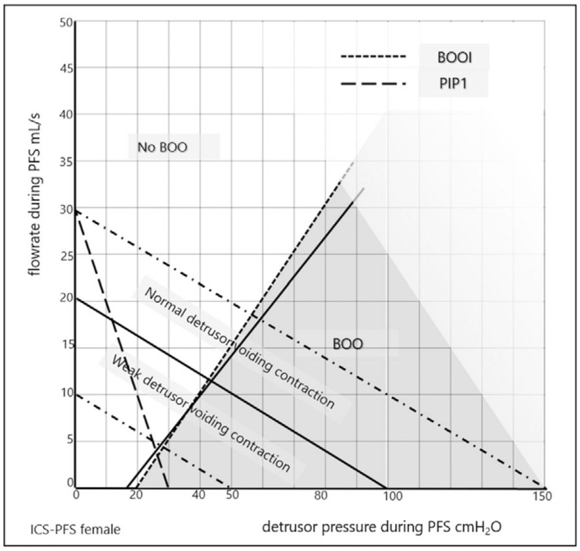

Fig. 8. A ICS-PFS plot nomogram for female patients. The nomogram for female patients with diagnosis of BOO when $p_{detQmax}$ projects in the grey area. The dotted line represents BOOI 20, and the full line represents BOOIf 18, left hand side in the graph is PFS—result without BOO (with a small difference in cut-off between BOOI and BOOIf). DCI 100 is indicated with the diagonal line; lower right hand side triangle (weak detrusor voiding contraction) represents DU. The alternative cut-off for DU is seen the triangle below Q_{max} 30 mL/s and below p_{det} 30 cmH_2O; this is the PIP1 cut-off of 30 (see Section 7.2) (see Fig. 7B and C for clinical diagnosis and grading principles). BOOI, bladder outflow obstruction index; DCI, detrusor contraction index; DU, detrusor underactivity; ICS, International Continence Society; PFS, pressure-flow study.

The WG acknowledges the clinical use of and scientific reporting of D(B)CI and the associated classes (mentioned here above) in earlier scientific reports regarding female voiding and recommends continuing this with ICS-DCI. However, the WG also considers that specific validation of ICS-DCI for women and comparison with e.g., PIP1 or $WF_{(max)}$ is at present insufficient, and that clinically relevant cut offs are not yet established. The WG considered, however, that the principles of ICS-DCI and PIP1 are applicable and relevant for female voiding.

Prediction of the ability to void after interventions affecting bladder outlet anatomy is a relevant aim of the quantification of DVC. To diagnose and evaluate management of DUVC e.g., of female patients with clinical signs and an underactive bladder syndrome, quantification of DVC is also relevant [81]. The WG speculates that it is not impossible that these two aims require different parameters for DVC in women (and men after radical prostatectomy). Furthermore, the WG contemplates on theoretical grounds [16–18] that $WF_{(max)}$ and PIP1 may (further) demonstrate clinical relevance in women but, potentially better for management of DUVC than for predication of the ability to void after surgery [78,82] but considers that at present evidence is insufficient to include WF in the standard, for women.

7.3. PFS quantifying voiding completeness in women

PFS voiding completeness should be reported in voided percentage (PFS-Void%). Voided volume is recorded in the flowmeter, PVR after PFS should be measured. Simple subtraction of voided volume from filled volume after PFS is unreliable because of diuresis during the time of the urodynamic test.

7.4. Recommendations for PFS in women

PFS analysis of female voiding should be reported with continuous grading of UR, with a quantifier of DVC and voiding completeness.

BOOIf and PFS-Void% are provisional ICS standard parameters for female voiding and BOOI is applicable, also as historical comparator. At present the cut-off BOOIf > 18 or the cut-off BOOI > 20 are supported by this WG, although also here UR is a continuum and further validation of any cut-off is necessary. Based on cut-offs to be determined, the continuous scale can also be divided into more parts to urodynamically define and grade BOO in more detail. The WG adopts the cut-off for urodynamic grading of female BOO with BOOIf > 18 if dichotomizing is necessary.

PIP1 and detrusor contraction index (ICS-DCI) are acceptable for the analysis of female voiding, however, at this time it is not possible to standardize grading of DVC or to define a limit for DU for women although ICS-DCI > 100 may be regarded as a sign of good DVC. The cut-off 30 for PIP1 is probably also not unreasonable as the lower limit for normal DVC but should be further studied.

The WG recommends that, although appropriate validation of especially cut-off's is currently still insufficient, BOOIf and ICS-BOOI as well as PIP1 and ICS-DCI are preferred over other parameters (and published nomograms). The WG's argument is their better association with the paradigmatic knowledge of women's micturition function and the possibility to take advantage of the fact that these are continuous variables.

8. Alternative PFS plot-axes orientation

The WG has proposed and recommended plots for PFS analysis for male (Fig. 7) and female (Fig. 8) patients in the now preferred orientation. Fig. 9 shows the plots in the alternative flow-pressure orientation.

9. Recommendations for further research to clinically validate PFS-analysis

For further research the WG suggests evaluating the clinical value of UR dichotomous BOOIf grading for women in cohort studies with e.g., ICS-BOOI classes (or URA) as the comparator. The WG also suggests (large groups-) clinical epidemiology of female voiding dysfunction based on ICS-PFS-plot analysis and distensible collapsible tube hydrodynamics both for UR (BOOIf, BOOI, and URA) and for DVC, as well as WF (and W_{max}) in relation with voiding time, PFS-Void%.

Given the plethora of currently available treatment types for male (BPE) BOO the WG recommends evaluating whether selection of optimal treatment should or can be based on e.g., the new provisional ICS-BOOI classes and also their combination with e.g. ICS-DCI classes and or PFS-Void%.

The WG considers that also evaluation of DVC patterns (e.g., unsustained, intermittent, or fading) and their effect on signs and symptoms and management and outcomes would be rewarding.

The WG suggests that an International Consultation on Voiding Dysfunction (similar to the Consultations on Incontinence/storage dysfunctions) could boost knowledge about and implementation of PFS-diagnosis and would provide a unique chance to improve healthcare for patients with LUT-dysfunctions.

10. Scientific reporting of PFS results

The WG found that many studies reporting voiding dysfunction have insufficiently included relevant data. The WG recommends that these studies should always include as a minimum; voided volume, PVR, PFS-Void%, $p_{detQmax}$ and Q_{max}. ICS-BOOI or BOOIf as well as ICS-DCI or PIP1 or both should be calculated and presented as continuous variables. A statement about representativeness of the voiding (e.g., % representative voiding according to the patient) and for male persons, position during voiding (% in preferred position). Number of patients per BOOI or BOOIf class should also be reported as well as number of patients per ICS-DCI or PIP1 class.

The WG recommends ICS-BOOI and ICS-DCI (including two or more classes) or PIP1 together with PVR and PFS-Void% in all manuscripts

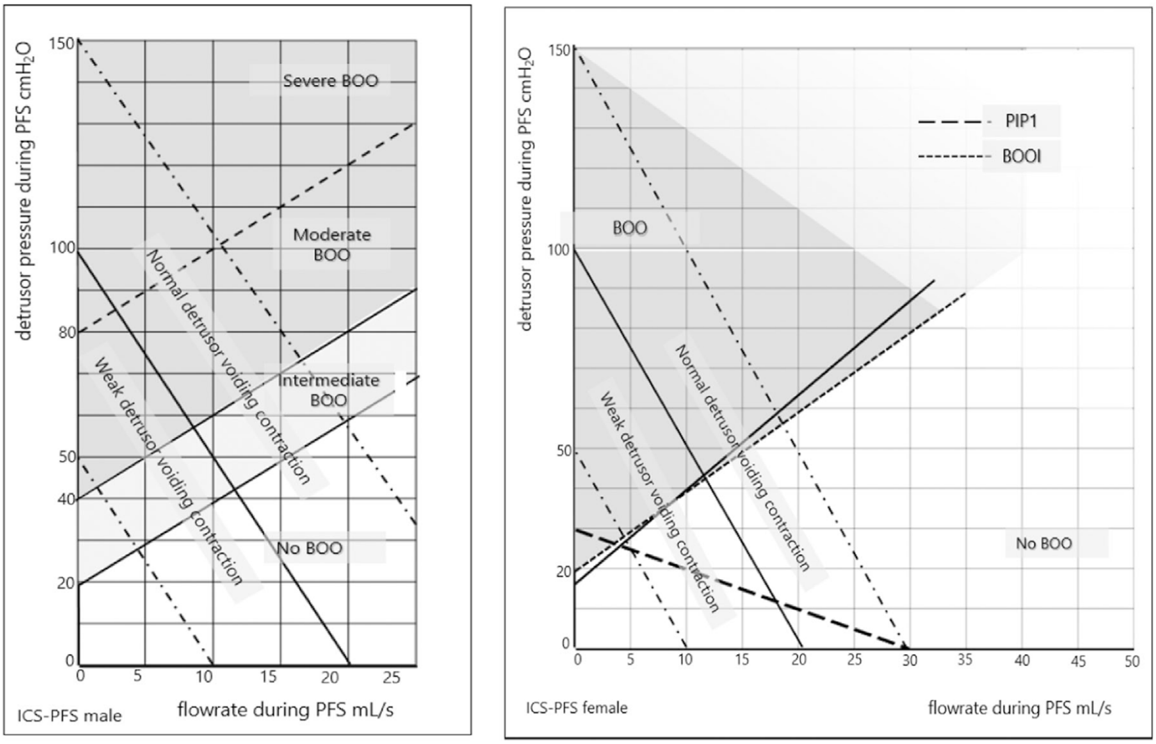

Fig. 9. The two nomograms in the ICS ST97 orientation. ICS-PFS-plot male (Fig. 7A) and ICS-PFS-plot female (Fig. 8A) are adapted in this figure with the axes orientation as was proposed in the ST97. ICS, International Continence Society; PFS, pressure-flow study.

that discuss epidemiology or outcome analysis of voiding dysfunction, with (also) BOOIf as UR cut-off for cohorts of female patients.

The WG recommends that a scatter-graph that displays all included patients' (and or relevant subgroups') $p_{detQmax}$ points with Q_{max} points is mandatory, preferably with the dots in the graph marked according to e.g., a specified PFS-Void% or PVR in scientific manuscripts.

The parameters LinPURR, URA, PIP1, WF_{max}, and quantifiers of obstruction type (e.g., urethral cross sectional area [9,26,83], constrictive or compressive type [8,21–25]) as well as DVC pattern are relevant for analysing PFS-plots [1,44] in scientific cohorts and or outcome studies. The WG considers that, although the here listed parameters and terms were introduced in manuscripts and summarized in earlier ICS standards [1,6], their relevance and meaning is still not sufficiently studied. The WG has—again—included the table, adapted from the ICS-ST97 [1], the parameters that deserve continued attention and further clinical validation for analysis of PFS for men but especially also for women [75] or also, in association with aging [63,67].

11. Conclusions

Pressure-flow voiding cannot be analysed when the voiding has not been representative according to the patient and the urodynamicist. Inability to void and acontractile detrusor (with new definition) cannot lead to a urodynamic diagnosis of urethral resistance or DVC.

The WG has standardized evaluation of voiding of patients without relevant neurological abnormality by urodynamic PFS. The WG recommends to always use a parameter that is based on the combination of synchronous pressure and flow rate in both sex to quantify UR, BOO or DVC. ICS bladder outflow obstruction index (ICS-BOOI) and ICS detrusor contraction index (ICS-DCI), as continuous parameters, are recommended to diagnose in men. BOOIf and PIP1 but also ICS-BOOI and ICS-DCI are recommended for urodynamic diagnosis above other published nomograms for female voiding but should be more precisely validated in clinical studies for women. The WG has recommended the preferred ICS-PFS-plot orientation but accepts the earlier proposed orientation to be used. The WG suggests different clinical cut-offs for ICS-BOOI for adult men and women but recommends further validation of BOOI and BOOIf for female voiding. The WG has recommended DVC classes for men but not for women but recommends PIP1 adjunct to ICS-DCI.

The urodynamic PFS diagnoses of the grade of BOO, the grade of DVC as well as of voiding completeness (PFS-Void%) should, after technical UDS-quality checks, analysis and reporting the diagnosis of the complete urodynamic test, be embedded in all other diagnostic evaluations, and related to risks, symptoms and bother in an individual patient, as per good clinical practice, to propose or initiate management.

The Members of the ICS working group PFS23

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data sharing not applicable to this article as no datasets were generated or analysed to prepare this standard (based on published evidence only).

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.cont.2023.100709.

References

[1] D. Griffiths, K. Höfner, R. van Mastrigt, H.J. Rollema, A. Spångberg, D. Gleason, Standardization of terminology of lower urinary tract function: pressure-flow studies of voiding, urethral resistance, and urethral obstruction, Neurourol. Urodyn. 16 (1) (1997) 1–18.

[2] P. Abrams, L. Cardozo, M. Fall, et al., The standardisation of terminology in lower urinary tract function: report from the standardisation sub-committee of the International Continence Society, Urology 61 (1) (2003) 37–49, https://doi.org/10.1016/s0090-4295(02)02243-4.

[3] P.F.W.M. Rosier, Critical steps in developing professional standards for the International Continence Society, Neurourol. Urodyn. 37 (S6) (2018) S69–S74, https://doi.org/10.1002/nau.23779.

[4] P.F.W.M. Rosier, W. Schaefer, G. Lose, et al., International Continence Society Good Urodynamic Practices and Terms 2016: urodynamics, uroflowmetry, cystometry, and pressure-flow study, Neurourol. Urodyn. 36 (5) (2017) 1243–1260, https://doi.org/10.1002/nau.23124.

[5] A.V. Hill, The heat of shortening and the dynamic constants of muscle, Proc. R. Soc. Lond. [Biol] 126 (1938) 136–193.

[6] D.J. Griffiths, Assessment of detrusor contraction strength or contractility, Neurourol. Urodyn. 10 (1991) 1–18.

[7] D. Griffiths, Basics of pressure-flow studies, World J. Urol. 13 (1995) 30–33.

[8] W. Schäfer, Detrusor as the energy source of micturition, in: F. Hinman, S. Boyarsky (Eds.), Benign Prostatic Hypertrophy, Springer, 1983, https://doi.org/10.1007/978-1-4612-5476-8_43.

[9] P.F.W.M. Rosier, M.J.A.M. de Wildt, J.J.M.C.H. de la Rosette, F.M.J. Debruyne, H. Wijkstra, Analysis of maximum detrusor contraction power in relation to bladder emptying in patients with lower urinary tract symptoms and benign prostatic enlargement, J. Urol. 154 (6) (1995) 2137–2142.

[10] H.S. Lecamwasam, S.V. Yalla, E.G. Cravalho, M.P. Sullivan, The maximum watts factor as a measure of detrusor contractility independent of outlet resistance, Neurourol. Urodyn. 17 (6) (1998) 621–635, https://doi.org/10.1002/(sici)1520-6777(1998)17:6<621::aid-nau6>3.0.co;2-4.

[11] R. Bosch, P. Abrams, M.A. Averbeck, et al., Do functional changes occur in the bladder due to bladder outlet obstruction? - ICI-RS 2018, Neurourol. Urodyn. 38 (suppl 5) (2019) S56–S65, https://doi.org/10.1002/nau.24076.

[12] C.R. Chapple, N.I. Osman, L. Birder, et al., Terminology report from the International Continence Society (ICS) working group on underactive bladder (UAB), Neurourol. Urodyn. 37 (8) (2018) 2928–2931, https://doi.org/10.1002/nau.23701.

[13] R. Abouassaly, J.R. Steinberg, M. Lemieux, et al., Complications of tension-free vaginal tape surgery: a multi-institutional review, BJU Int. 94 (1) (2004) 110–113, https://doi.org/10.1111/j.1464-410X.2004.04910.x.

[14] W. Schäfer, Urethral resistance? Urodynamic concepts of physiological and pathological bladder outlet function during voiding, Neurourol. Urodyn. 4 (1985) 161–201, https://doi.org/10.1002/nau.1930040304.

[15] C. D'Ancona, B. Haylen, M. Oelke, et al., Standardisation Steering Committee ICS and the ICS Working Group on Terminology for Male Lower Urinary Tract & Pelvic Floor Symptoms and Dysfunction The International Continence Society (ICS) report on the terminology for adult male lower urinary tract and pelvic floor symptoms and dysfunction, Neurourol. Urodyn. 38 (2) (2019) 433–477, https://doi.org/10.1002/nau.23897.

[16] S. Martin, D.J. Griffiths, Model of the female urethra: part 1-Static measurements of pressure and distensibility, Med. Biol. Eng. 14 (5) (1976) 512–518, https://doi.org/10.1007/BF02478048.

[17] S. Martin, D.J. Griffiths, Model of the female urethra: part 2-Flow properties, Med. Biol. Eng. 14 (5) (1976) 519–523, https://doi.org/10.1007/BF02478049.

[18] D.J. Griffiths, Urethral elasticity and micturition hydrodynamics in females, Med. Biol. Eng. 7 (2) (1969) 201–215, https://doi.org/10.1007/BF02474176.

[19] D.J. Griffiths, Hydrodynamics of male micturition. I. Theory of steady flow through elastic-walled tubes, Med. Biol. Eng. 9 (6) (1971) 581–588, https://doi.org/10.1007/BF02474637.

[20] P. Abrams, J.G. Blaivas, S.L. Stanton, J.T. Andersen, The standardisation of terminology of lower urinary tract function, World J. Urol. 6 (1989) 233–245, https://doi.org/10.1007/BF00328107.

[21] K. Höfner, A.E.J.L. Kramer, H.K. Tan, H. Krah, U. Jonas, CHESS classification of bladder-outflow obstruction. A consequence in the discussion of current concepts, World J. Urol. 13 (1) (1995) 59–64, https://doi.org/10.1007/BF00182667.

[22] W. Schäfer, The contribution of the bladder outlet to the relation between pressure and flow rate during micturition, in: F. Hinman (Ed.), Benign Prostatic Hypertrophy, Springer Verlag, 1983, pp. 450–469.

[23] D.J. Griffiths, Hydrodynamics of male micturition—II measurements of stream parameters and urethral elasticity, Med. Biol. Eng. 9 (1971) 589–596, https://doi.org/10.1007/BF02474638.

[24] A. Spångberg, Estimation of urethral resistance by curve fitting in the pressure-flow plot. Theory and experience in normal men and men with benign prostatic hypertrophy, World J. Urol. 13 (1) (1995) 65–69, https://doi.org/10.1007/BF00182668.

[25] W. Schäfer, Principles and clinical application of advanced urodynamic analysis of voiding function, Urol. Clin. North. Am. 17 (3) (1990) 553–566.

[26] W. Schäfer, Analysis of bladder-outlet function with the linearized passive urethral resistance relation, linPURR, and a disease-specific approach for grading obstruction: from complex to simple, World J. Urol. 13 (1) (1995) 47–58, https://doi.org/10.1007/BF00182666.

[27] https://www.ics.org/glossary?q=dysfunctional.

[28] W. Nitti Victor, Urodynamic and video- urodynamic evaluation of the lower urinary tract, in: A. Wein, et al. (Eds.), Campbell-Walsh Urology, tenth ed., ISBN: 978-1-4160-6911-9, p. 1862, Ch 63.

[29] J.A. Cohn, E.T. Brown, W.S. Reynolds, M.R. Kaufman, R.R. Dmochowski, Pharmacologic management of non-neurogenic functional obstruction in women, Expert. Opin. Drug. Metab. Toxicol. 12 (6) (2016) 657–667, https://doi.org/10.1080/17425255.2016.1178239.

[30] W. Nitti Victor, Urodynamic and video- urodynamic evaluation of the lower urinary tract, in: A. Wein, et al. (Eds.), Campbell-Walsh Urology, tenth ed., ISBN: 978-1-4160-6911-9, p. 1862, Ch 63.

[31] J.A. Cohn, E.T. Brown, W.S. Reynolds, M.R. Kaufman, R.R. Dmochowski, Pharmacologic management of non-neurogenic functional obstruction in women, Expert. Opin. Drug. Metab. Toxicol. 12 (6) (2016) 657–667, https://doi.org/10.1080/17425255.2016.1178239.

[32] K.V. Carlson, S. Rome, V.W. Nitti, Dysfunctional voiding in women, J. Urol. 165 (1) (2001) 143–148, https://doi.org/10.1097/00005392-200101000-00035.

[33] D. Griffiths, Detrusor contractility, Scand. J. Urol. Nephrol. 38 (215) (2004) 93–100, https://doi.org/10.1080/03008880410015426.

[34] R.V. Mastrigt, H.J. Rollema, The prognostic value of bladder contractility in transurethral resection of the prostate, J. Urol. 148 (6) (1992) 1856–1860, https://doi.org/10.1016/s0022-5347(17)37049-0.

[35] N.M. Resnick, S.V. Yalla, Management of urinary incontinence in the elderly, N. Engl. J. Med. 313 (13) (1985) 800–805, https://doi.org/10.1056/NEJM198509263131307.

[36] I. Hoeritzauer, J. Stone, C. Fowler, S. Elneil-Coker, A. Carson, J. Panicker, Fowler's syndrome of urinary retention: a retrospective study of co-morbidity: Fowler's Syndrome Comorbidity, Neurourol. Urodyn. 35 (5) (2016) 601–603, https://doi.org/10.1002/nau.22758.

[37] K.L.J. Kuoch, D. Meyer, D.W. Austin, S.R. Knowles, A systematic review of paruresis: clinical implications and future directions, J. Psychosom. Res. 98 (2017) 122–129, https://doi.org/10.1016/j.jpsychores.2017.05.015.

[38] J. Drossaerts, K.L.J. Rademakers, S.M. Rahnama'i, T. Marcelissen, P. Van Kerrebroeck, G. van Koeveringe, The value of ambulatory urodynamics in the evaluation of treatment effect of sacral neuromodulation, Urol. Int. 102 (3) (2019) 299–305, https://doi.org/10.1159/000493988.

[39] J.N. Panicker, R. Anding, S. Arlandis, et al., Do we understand voiding dysfunction in women? Current understanding and future perspectives: ICI-RS 2017, Neurourol. Urodyn. 37 (S4) (2018) S75–S85, https://doi.org/10.1002/nau.23709.

[40] N. Hasegawa, Y. Kitagawa, N. Takasaki, S. Miyazaki, The effect of abdominal pressure on urinary flow rate, J. Urol. 130 (1) (1983) 107–110, https://doi.org/10.1016/s0022-5347(17)50982-9.

[41] J.B. Gajewski, B. Schurch, R. Hamid, et al., An International Continence Society (ICS) report on the terminology for adult neurogenic lower urinary tract dysfunction (ANLUTD), Neurourol. Urodyn. 37 (3) (2018) 1152–1161, https://doi.org/10.1002/nau.23397.

[42] C.H. Fry, A. Gammie, M.J. Drake, P. Abrams, D.G. Kitney, B. Vahabi, Estimation of bladder contractility from intravesical pressure-volume measurements, Neurourol. Urodyn. 36 (4) (2017) 1009–1014, https://doi.org/10.1002/nau.23047.

[43] N. Sekido, Bladder contractility and urethral resistance relation: what does a pressure flow study tell us? Int. J. Urol. 19 (3) (2012) 216–228, https://doi.org/10.1111/j.1442-2042.2011.02947.x.

[44] P. Abrams, W. Schäfer, Urodynamic aspects of detrusor mechanics and contractility, World J. Urol. 2 (1984) 174–180, https://doi.org/10.1007/BF00326997.

[45] J. Krhut, R. Zachoval, P.F.W.M. Rosier, B. Shelly, P. Zvara, ICS educational module: electromyography in the assessment and therapy of lower urinary tract dysfunction in adults, Neurourol. Urodyn. 37 (1) (2018) 27–32, https://doi.org/10.1002/nau.23278.

[46] A. Gammie, C. D'Ancona, H.C. Kuo, P.F.W. Rosier, ICS teaching module: artefacts in urodynamic pressure traces (basic module): artefacts in Urodynamics-Basic (ICS), Neurourol. Urodyn. 36 (1) (2017) 35–36, https://doi.org/10.1002/nau.22881.

[47] M. Aiello, J. Jelski, A. Lewis, et al., Quality control of uroflowmetry and urodynamic data from two large multicenter studies of male lower urinary tract symptoms, Neurourol. Urodyn. 39 (4) (2020) 1170–1177, https://doi.org/10.1002/nau.24337.

[48] A. Gammie, H. Hashim, P. Abrams, Bristol UTraQ: a proposed system for scoring the technical quality of urodynamic traces, Neurourol. Urodyn. 41 (2) (2022) 672–678, https://doi.org/10.1002/nau.24872.

[49] W. Schäfer, P. Abrams, L. Liao, et al., Good urodynamic practices: uroflowmetry, filling cystometry, and pressure-flow studies**: good urodynamic practices guidelines, Neurourol. Urodyn. 21 (3) (2002) 261–274, https://doi.org/10.1002/nau.10066.

[50] R. Kranse, R. van Mastrigt, R. Bosch, Estimation of the lag time between detrusor pressure- and flow rate-signals, Neurourol. Urodyn. 14 (3) (1995) 217–229, https://doi.org/10.1002/nau.1930140303.

[51] https://en.wikipedia.org/wiki/Free_fall#/media/File:Drop_time.jpg.

[52] P. Rodrigues, F. Hering, J.C. Campagnari, Urodynamic after-contraction waves: a large observational study in an adult female population and correlation with bladder and ureter emptying functions in women, Urol. Int. 93 (4) (2014) 431–436, https://doi.org/10.1159/000360139.

[53] F.A. Valentini, B.G. Marti, G. Robain, P.P. Nelson, Detrusor after-contraction: a new insight, Int. Braz. J. Urol. 41 (3) (2015) 527–534, https://doi.org/10.1590/S1677-5538.IBJU.2014.0152.

[54] P.F.W.M. Rosier, J.J.M.C.H. de la Rosette, E.L. Koldewijn, F.M.J. Debruyne, H. Wijkstra, Variability of pressure-flow analysis parameters in repeated cystometry in patients with benign prostatic hyperplasia, J. Urol. 153 (5) (1995) 1520–1525.

[55] D.E. Neal, C.V.S. Rao, R.A. Styles, T. Ng, P.D. Ramsden, Effects of catheter size on urodynamic measurements in men undergoing elective prostatectomy, Br. J. Urol. 60 (1) (1987) 64–68, https://doi.org/10.1111/j.1464-410x.1987.tb09136.x.

[56] D. Griffiths, R. van Mastrigt, R. Bosch, Quantification of urethral resistance and bladder function during voiding, with special reference to the effects of prostate size reduction on urethral obstruction due to benign prostatic hyperplasia, Neurourol. Urodyn. 8 (1989) 17–27.

[57] P. Abrams, Bladder outlet obstruction index, bladder contractility index and bladder voiding efficiency: three simple indices to define bladder voiding function, BJU Int. 84 (1999) 14–15.

[58] V.W. Nitti, Pressure flow urodynamic studies: the gold standard for diagnosing bladder outlet obstruction, Rev. Urol. 7 (suppl 6) (2005) 14–21.

[59] M.D. Eckhardt, G.E.P.M. van Venrooij, T.A. Boon, Urethral resistance factor (URA) versus Schäfer's obstruction grade and Abrams-Griffiths (AG) number in the diagnosis of obstructive benign prostatic hyperplasia, Neurourol. Urodyn. 20 (2) (2001) 175–185, https://doi.org/10.1002/1520-6777(2001)20:2<175::aid-nau20>3.0.co;2-t.

[60] Y.Y. Ding, P.K. Lieu, Comparison of three methods of quantifying urethral resistance in men, Urology 52 (5) (1998) 858–862, https://doi.org/10.1016/s0090-4295(98)00298-2.

[61] P.F.W.M. Rosier, J.J.M.C.H. de la Rosette, M.J.A.M. de Wildt, F.M.J. Debruyne, H. Wijkstra, Comparison of passive urethral resistance relation and urethral resistance factor in analysis of bladder outlet obstruction in patients with benign prostatic enlargement, Neurourol. Urodyn. 15 (1) (1996) 1–15, https://doi.org/10.1002/(SICI)1520-6777(1996)15:1<1::AID-NAU1>3.0.CO;2-J.

[62] R. Kranse, R. van Mastrigt, A critical comparison of methods proposed for quantification of bladder outlet obstruction, Neurourol. Urodyn. 12 (3) (1993) 267–272, https://doi.org/10.1002/nau.1930120310.

[63] T.L. Tan, M.A. Bergmann, D. Griffiths, N.M. Resnick, Stop test or pressure-flow study? Measuring detrusor contractility in older females, Neurourol. Urodyn. 23 (2004) 184–189.

[64] S.L. McIntosh, C.J. Griffiths, M.J. Drinnan, W.A. Robson, P.D. Ramsden, R.S. Pickard, Noninvasive measurement of bladder pressure. Does mechanical interruption of the urinary stream inhibit detrusor contraction? J. Urol. 169 (3) (2003) 1003–1006, https://doi.org/10.1097/01.ju.0000049031.40088.45.

[65] S.C. Donkelaar, P. Rosier, L. de Kort, Comparison of three methods to analyze detrusor contraction during micturition in men over 50 years of age, Neurourol. Urodyn. 36 (8) (2017) 2153–2159, https://doi.org/10.1002/nau.23260.

[66] J.P.F.A. Heesakkers, V. Vandoninck, M.R. van Balken, B.L.H. Bemelmans, Bladder filling by autologous urine production during cystometry: a urodynamic pitfall!, Neurourol. Urodyn. 22 (3) (2003) 243–245, https://doi.org/10.1002/nau.10108.

[67] P.F.W.M. Rosier, C.S. Ten Donkelaar, L.M.O. de Kort, Clinical epidemiology: detrusor voiding contraction maximum power, related to ageing, Urology 124 (2019) 72–77, https://doi.org/10.1016/j.urology.2018.10.038.

[68] D.J. Griffiths, C.E. Constantinou, R. van Mastrigt, Urinary bladder function and its control in healthy females, Am. J. Physiol. 251 (2 Pt 2) (1986) R225–R230, https://doi.org/10.1152/ajpregu.1986.251.2.R225.

[69] C.Y. Seow, Hill's equation of muscle performance and its hidden insight on molecular mechanisms, J. Gen. Physiol. 142 (6) (2013) 561–573, https://doi.org/10.1085/jgp.201311107.

[70] W. Schäfer, Analysis of active detrusor function during voiding with the bladder working function, Neurourol. Urodyn. 10 (1) (1991) 19–35.

[71] J.G. Sullivan, L. Swithinbank, P. Abrams, Defining achievable standards in urodynamics—a prospective study of initial resting pressures, Neurourol. Urodyn. 31 (4) (2012) 535–540, https://doi.org/10.1002/nau.21229.

[72] J.P. Valdevenito, A. Mercado-Campero, M. Naser, D. Castro, M. Ledesma, L. Arribillaga, Voiding dynamics in women with urinary incontinence but without voiding symptoms, Neurourol. Urodyn. 39 (8) (2020) 2223–2229, https://doi.org/10.1002/nau.24475.

[73] A.M. Devreese, G. Nuyens, F. Staes, R.L. Vereecken, W. De Weerdt, K. Stappaerts, Do posture and straining influence urinary-flow parameters in normal women? Neurourol. Urodyn. 19 (1) (2000) 3–8, https://doi.org/10.1002/(sici)1520-6777(2000)19:1<3::aid-nau2>3.0.co;2-6.

[74] J. Lindsay, E. Solomon, M. Nadeem, et al., Treatment validation of the Solomon-Greenwell nomogram for female bladder outlet obstruction, Neurourol. Urodyn. 39 (5) (2020) 1371–1377, https://doi.org/10.1002/nau.24347.

[75] E. Solomon, H. Yasmin, M. Duffy, T. Rashid, E. Akinluyi, T.J. Greenwell, Developing and validating a new nomogram for diagnosing bladder outlet obstruction in women, Neurourol. Urodyn. 37 (1) (2018) 368–378, https://doi.org/10.1002/nau.23307.

[76] N. Fleischmann, V. Hartanto, N. Rosenblum, C. Kelly, V.W. Nitti, 1703: comparison of diagnostic criteria for female bladder outlet obstruction, J. Urol. 171 (suppl) (2004) 450.

[77] W. Schaefer, Y. Chen, S. Tadic, D. Griffiths, N. Resnick, Urodynamic grading of bladder outflow conditions in females. Abstract 228 presented ICS annual meeting, https://www.ics.org/Abstracts/Publish/47/000228.pdf.

[78] K.H. Pang, R. Campi, S. Arlandis, et al., Diagnostic tests for female bladder outlet obstruction: A systematic review from the European Association of Urology Non-neurogenic Female LUTS guidelines panel, Eur. Urol. Focus. 8 (4) (2022) 1015–1030, https://doi.org/10.1016/j.euf.2021.09.003.

[79] J.G. Blaivas, A. Groutz, Bladder outlet obstruction nomogram for women with lower urinary tract symptomatology, Neurourol. Urodyn. 19 (5) (2000) 553–564, https://doi.org/10.1002/1520-6777(2000)19:5<553::aid-nau2>3.0.co;2-b.

[80] F.A. Valentini, B.G. Marti, G. Robain, P.E. Zimern, P.P. Nelson, Comparison of indices allowing an evaluation of detrusor contractility in women, Progr. Urol. 30 (7) (2020) 396–401, https://doi.org/10.1016/j.purol.2019.11.004.

[81] P.P. Smith, F. Valentini, K.V. Mytilekas, et al., Can we improve our diagnosis of impaired detrusor contractility in women? An ICI-RS 2019 proposal, Neurourol. Urodyn. 39 (suppl 3) (2020) S43–S49, https://doi.org/10.1002/nau.24260.

[82] J. Groen, J.L.H.R. Bosch, Bladder contraction strength parameters poorly predict the necessity of long-term catheterization after a pubovaginal rectus fascial sling procedure, J. Urol. 172 (3) (2004) 1006–1009, https://doi.org/10.1097/01.ju.0000135339.90689.e8.

[83] J.S. Walter, J.S. Wheeler Jr., P. Zaszczurynski, M. Plishka, Urodynamic measure of urethral cross-sectional area: application for obstructive uropathy, Neurourol. Urodyn. 13 (5) (1994) 571–582, https://doi.org/10.1002/nau.1930130511.