Urine flow rate curve shapes and their descriptors

Abstract

Aims: To review the descriptors and definitions of urine flow rate curve shape with a view to promoting greater clarity and to propose standard terms

Methods: A search was made in the PubMed and ICS standardization documents on urine flow rate curve shape.

Results: The flow shape descriptors and their definitions are summarised and presented. ‘Normal’ was widely used for describing a bell-shaped flow curve, and ‘plateau’ was mostly used where the ICS describe ‘constrictive’ flow shape. The use of shape descriptors ‘fluctuating’, ‘compressive’, ‘tower-shaped’ and ‘intermittent’ varied in the literature.

Conclusion: This survey provides an overview of flow shape descriptors and their definitions. We suggest it is clearer to use only descriptors that describe shape alone, i.e. normal, fluctuating, intermittent and plateau, with comments on symmetry and Q_{max}.

Introduction

Uroflowmetry serves as a preliminary urodynamic test for physicians to indicate the possible cause of lower urinary tract symptoms (LUTS). Alongside the most researched parameter maximum flow rate (Q_{max}), the shape of urine flow rate curve is also reported to associate with one or more voiding abnormalities.[1]

The International Continence Society (ICS) defines a normal flow shape as ‘arc-shaped with high maximum flowrate’.[2] However, the definition did not quantitatively specify the parameter range for normal shape. More quantitative definitions have therefore been proposed. For example, Nishimoto et al.[3] use three parameters, the ratio of maximum flow rate (Q_{max}) and the voiding time (T_v), the ratio of time to peak flow (TQ_{max}) and T_v, and the ratio of the average flow rate (Q_{ave}) and Q_{max}, to differentiate normal and abnormal shape, but this has not become standard.

As suggested by Gammie et al.[4] from the ICI-RS 2017 meeting, the present study investigates the shape of urine flow curve described in the literature and highlights the problems with these descriptors. Proposals for standardised use are suggested.

Methods

A literature search was made in PubMed and ICS standardisation documents, for titles and abstracts of papers including ‘shape’ or ‘pattern’, and additionally including ‘urodynamic’ or ‘uroflow’ or ‘urine flow’ or ‘uroflowmetry’ or ‘urinary flow’ dated to 5 January 2018. The search resulted in a total of 680 articles. After the selection procedure (Figure 1), 22 articles were included in this survey.[2,3,5-24]

Results

The flow shape descriptors in the literature were summarised first under the shape name that the ICS has defined,[5,6] namely ‘normal’, ‘constrictive’, ‘compressive’, ‘fluctuating’ and ‘intermittent’. Further definitions, such as ‘tower’ used by the International Children's Continence Society (ICCS), were included and where possible listed under the relevant ICS definition. A detailed summary of shape definitions is presented as in table 1.

1. Normal

The definitions of normal flow curve are similar in most articles, which are bell-shaped or arc-shaped, approximately symmetrical, uninterrupted and with no rapid amplitude changes.[3-18,20-23] ICCS specifies in children the bell-shaped curve should be regardless of volume voided.[5] Nishimoto et al. suggest quantitative definition using values for the parameters noted above[3] ($Q_{max}/T_v \geq 0.78$, $0.32 \leq TQ_{max}/T_v \leq 0.54$, $Q_{ave}/Q_{max} < 1.59$). Four other articles specifically define normal flow shape: Wyndaele suggests $Q_{max} > 15$ml/s,[8] Abrams indicates Q_{max} appears in first 30% of curve and within 5 seconds from start,[9] Mostafavi et al. use flow within 5% to 90% range of the Iranian nomogram and $Q_{max}^2 >$ volume voided for normal shape,[13] and Ghobish uses time ratio ($T_r = TQ_{max}$/flow time) of 25%-60% and flow ratio ($Q_r = Q_{ave}/Q_{max}$) of 25%-75% to define normal shape.[18]

2. Constrictive

Schafer et al. in the ICS Good Urodynamic Practices document define constrictive shape as a smooth, flat and plateau-like curve with lower flow rate.[2] It is named as plateau in 10 articles,[5,7,12-17,20,21] and in other articles as ‘long flow + low max flow’,[8] long and low Q_{max},[11] box-shaped,[18] and prolonged.[19] It is agreed in most articles that constrictive flow shape has a relatively longer flow time, flattened shape with a constant Q_{max} almost the same as Q_{ave}. In addition, five articles have given a more specific definition: variations less than 1ml/s,[12,14] variation<1ml/s for at least 4 seconds,[20] Q_{max}/flow time<0.5,[13] Q_r>80% and T_r<10%.[18]

3. Compressive

ICS defines the compressive flow shape as a flattened asymmetric low curve with a slowly declining end part.[2] Additionally Ghobish defines it by 30%-60% Q_r and 10-25% T_r[18], and van der Vis-Melsen et al. name it ‘low flat’ with definition of flat flow with low average and maximum index of urine transport (IUT, the ratio of flow rate and square root of bladder volume).[23] Other researchers have mostly the same definition as ICS, but use different terms: slow start,[8] flattened,[16] low flow,[17] long-tail,[18] approximately normal,[19] and prostatic.[21]

4. Fluctuating

Fluctuating flow shape is described by the ICS as a continuous urine flow having multiple peaks.[5]. The ICCS[7], and also Mostafavi et al.[13] call it staccato, and define it as an irregular fluctuating curve without flow reaching zero, where fluctuations are greater than root of Q_{max}. The shape is named as fluctuating in five other articles with the same definition as in ICS.[8,13,16,17,21] Two articles name this flow pattern as intermittent, defined as a wavy curve not reaching the baseline with a duration of at least 15 seconds,[20] and variations in flow rate of at least 5ml/s.[22] Fantl calls it multiple peak, and specifies that the 2nd peak amplitude should be higher or equal to 20% of Q_{max}[10]. Pauwels names this flow shape undulating, and defines it as asymmetric curve with steep slope, with a long and flattened foothill.[10] van der Vis-Melsen et al. call this shape sawtooth and define with low average IUT and normal maximum IUT.[23]

5. Intermittent

The intermittent flow shape is defined as flow stopping and starting during a single void in an ICS standardisation document.[6] Other defined names are: interrupted,[7,10,13,18] fractioned,[21] void 2x,[8] fractionated[11,17,20,22] and sawtooth.[15] Even though the name of this shape varies, the definition is generally the same as the ICS standardisation. Three articles give additional definitions for this shape. Fantl considers intermittent as flow less than 2ml/s instead of completely stopping,[10] Ghobish further subdivided intermittency into two patterns by interruption duration threshold of ≤ 2 second, named type A, and repeated interruptions due to abdominal straining as type B,[18] and Jensen et al. define intermittent flow as lasting for at least 15 seconds of flow time with one or more interruptions.[20]

6. Tower-shaped

This shape has not been defined in any ICS document, but ICCS defines it as sudden, high-amplitude flow with short duration.[6] Abrams calls it supranormal and gives the more specific definition of a sharply increase flow to a very high Q_{max} in the first 1-3 seconds, and followed by a sudden reduction.[9] Chou et al.[16] and Jorgensen et al.[17] call this shape ‘tall and peaked’ and ‘high flow’ respectively, but the definition is similar to ICCS. Using $Q_{max}>95\%$ on the Iranian nomogram, Mostafavi et al. also call this pattern ‘tower’.[13]

7. Other shape definitions

Ghobish defines two extra shapes: ’high start’ as 20%-60% Q_r and 0-10% T_r to describe a sudden rise to Q_{max} then steep steady fall shape, and ‘inverted long-tail’ as 30%-60% Q_r with $T_r>60\%$ to describe a steady rise then sudden fall down shape.[18]

Shih investigates flow shape by using a geometric approach and divides flow patterns into three groups by quantitative classification rules. An almost normal to mildly obstructive shape is defined as $Q_{max}\geq15$ml/s when volume voided ≥200ml or $Q_{max}\geq10$ml/s when volume voided <200ml, and time to Q_{max} is in the range of 5 seconds to 5/12 flow time, and $Q_{max}/Q_{ave}>4/3$. A moderately to severely obstructive pattern is defined as $Q_{ave}\leq4$ml/s or flow time ≥90 seconds when volume voided is less than 400ml. The remaining patterns are recognised as mildly to moderately obstructive.[24]

Discussion

The urine flow curve shape contains relevant and interpretable information on a patient's urinary conditions, and it is suggested it could serve as a guide to identify LUT dysfunction.[2,5,7] However, the definitions found in the literature are not consistent and it is not possible to uncover pathophysiology when terms are not consistently used. In ICS Good Urodynamic Practices, the shape definitions of constrictive and compressive are describing the presumed cause of the shape, not the shape itself.[2,4] Since the musical definition of staccato follows the Italian meaning 'detached', the use of this phrase for fluctuating yet continuous flow is misleading.

The start and end point for a flow curve is not properly defined. For instance, an early or end dribble is normally included in the flow curve, as it is a part of voiding, but the shape could therefore be classified as intermittent even the rest of flow is bell-shaped. Jensen et al. exclude 'bubbles', i.e. small separate flows, less than 2ml/s at the start and end of micturition for pre-processing of the flow data.[20] A recent study proposed that 0.5ml/s could be used as the threshold point for the starting and ending point of micturition,[25] which may help avoid erroneous classification of urine flow shape, but this has not become standard.

The present survey summarises the descriptors used for flow shape and their definitions, compared with current ICS/ICCS standardization. We found that the descriptor and definition for normal flow shape was consistently used, while plateau was mostly used for describing ICS's 'constrictive' shape. The descriptors of compressive, fluctuating, intermittent and tower-shaped varied in the literature, with some researchers giving more quantitative definitions for these shapes.

There is no strong correlation between any shape to specified symptoms or diagnosis reported in these articles. Furthermore, Pauwels et al. demonstrates that a bell-shaped curve could not be an exclusion criterion of voiding dysfunction in women,[11] and Chou et al. noted that the flow pattern could not be used as a screening test for urinary dysfunctions.[16]

We therefore propose that only shape descriptors that refer to actual shape, easily defined, are the ones considered for standard use. We suggest using normal, fluctuating, intermittent as defined by the ICS, and plateau instead of the ICS's 'constrictive', for describing flow shape, with additional comment on symmetry and Q_{max}. This removes from use descriptors that are misleading, e.g. 'staccato' and 'biphasic'. A complex flow shape could be described as a combination of descriptors or with specified Q_{max} detail. For example, 'compressive' could be expressed as an asymmetric shape with low Q_{max} in the first half, and 'tower' described as a normal shape with a very high Q_{max}.

Any definitions that refer to possible cause are not recommended, such as prostatic, constrictive and compressive, as it may be taken by inexpert observers to imply diagnosis. Other definitions requiring detailed mathematical analysis are not readily usable, and could therefore only be recommended if diagnostic specificity could be proven. As yet, no shape definition fulfils these criteria.

Conclusion

The varying descriptors of urine flow curve shape cause confusion and may result in inaccurate clinical screening. Consistency and clarity in description are required, and development of standardisation of shape descriptors is recommended. We suggest that only ‘normal’, ‘fluctuating’, ‘intermittent’ and ‘plateau’ descriptions, with additional comment on symmetry and Q_{max}, be used to describe urine flow rate curve shape, and the definitions for these descriptors should follow the terms in the ICS standardization documents

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Table and Figure Legends

Table 1 Urine flow shape descriptors and their definitions.

Q_{max}=maximum flow rate; Q_{ave}=average flow rate; Q_r= Q_{ave}/Q_{max}; T_r= TQmax/flow time.

Figure 1 PRISMA flow diagram.