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## Analysis of uroflow patterns in children with dysfunctional voiding

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### KEYWORDS

Dysfunctional voiding;  
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Overactive bladder;  
LUT dysfunction

**Abstract** *Objective:* Although a staccato uroflow pattern is considered representative of dysfunctional voiding (DV), we recently found that only a third of children with staccato flow had an active pelvic floor electromyography (EMG) during voiding. Here, we analyzed the reverse, that is, how often a staccato flow pattern occurs in children with documented DV. In addition, we reviewed what other flow patterns are prevalent in this condition.

*Materials and methods:* We reviewed our LUT dysfunction registry for children with EMG-confirmed DV. Uroflow patterns were categorized as staccato, interrupted, mixed (i.e., staccato and interrupted patterns), or grossly normal.

*Results:* Of 596 children who underwent a uroflow/EMG examination, 121 had an active pelvic floor EMG during voiding, that is a finding consistent with the diagnosis of DV. The flow patterns identified in those diagnosed with DV were staccato in 70 (58%), interrupted in 22 (19%), mixed in 12 (10%), and a bell-shaped or depressed curve in 17 (14%). Staccato pattern became normal in 96% following successful treatment with biofeedback.

*Conclusions:* While a staccato uroflow pattern was the most common pattern seen in children diagnosed with DV by a uroflow/EMG, nearly a third had an interrupted or mixed flow pattern underscoring the importance of performing simultaneous pelvic floor EMG during a uroflow study, especially when trying to rule out DV. Failure of the staccato flow pattern to normalize after therapy strongly suggests either inadequate therapy or an incorrect diagnosis.

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## Introduction

Dysfunctional voiding (DV) in children is defined as “habitual contractions of the urethral sphincter during voiding” [1]. According to the International Children’s Continence Society (ICCS), this diagnosis can be strongly suggested by a simple uroflow examination demonstrating a staccato uroflow pattern, a finding that is thought to be reflective of pelvic floor and external sphincter activity. However, the ICCS did warn that the diagnosis of DV based solely on a staccato uroflow pattern should not be applied unless repeat uroflow measurements show similar staccato flow curves or unless verified by either simultaneously performed electromyography (EMG) or invasive urodynamic investigation [1]. Yet, despite this admonition, the approach for identifying DV based on uroflow pattern alone is employed by the majority of practices throughout the world who evaluate children with lower urinary tract dysfunction [1–4]. We, as well as a distinct minority of centers, believe that by combining the uroflow with a simultaneous pelvic floor EMG using skin patch electrodes, as we routinely do in all our screening examinations of children with suspected lower urinary tract dysfunction (LUTD), very much enhances the accuracy of the study and better reflects external sphincter activity during voiding [5,6]. In fact, we recently found that when uroflow is performed with simultaneous pelvic floor EMG, two-thirds of children with a staccato uroflow pattern did not have an active EMG during voiding or, in other words, did not have DV [6]. These results suggest that a significant number of patients with a staccato uroflow pattern quite possibly may be placed on biofeedback therapy for a condition they do not have. In this study, we wanted to use the reverse approach and focus only on patients with EMG-documented DV and determine how often a staccato uroflow pattern is identified in patients with DV, as well as what other uroflow patterns are typically seen.

## Materials and methods

The work in this research analysis was approved by the institutional review board (IRB) of Columbia University Medical Center prior to starting the study.

We reviewed our IRB-approved pediatric LUTD registry for neurologically/anatomically normal patients diagnosed with DV, as documented by uroflow studies performed with simultaneous pelvic floor EMG demonstrating an active pelvic floor EMG during voiding and corroborated on repeat uroflow/EMGs. Any associated lower urinary tract symptoms (LUTS), bowel habits, and other associated clinical characteristics were also assessed. A single experienced clinician performed all uroflow/EMG studies. No patient was on treatment with any pharmacotherapy for LUTS at the time of evaluation.

### Definitions of uroflow patterns

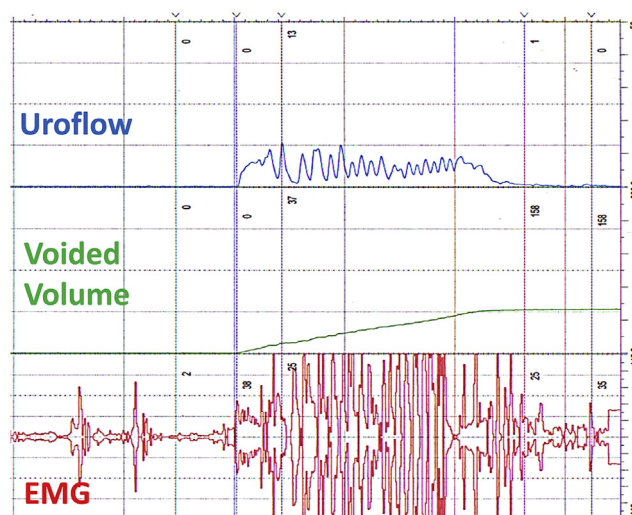
Determination of flow patterns (staccato and interrupted) was based on current ICCS definitions [7,8]. The ICCS defines a staccato uroflow pattern as characterized by multiple peaks and troughs in the uroflow curve, with the

magnitude of these fluctuations larger than the square root of the maximum uroflow rate (see Fig. 1). An *interrupted* pattern is defined as having discrete segments of urine flow, separated by segments with zero flow (see Fig. 2) [1]. The International Continence Society (ICS) refers to these two types as *fluctuating* and *intermittent*, respectively [7]. When a patient’s uroflow pattern exhibited characteristics of both, it was defined as *mixed* (see Fig. 3). The remainder of the uroflows did not meet either criteria and was reported as grossly normal, albeit with flow parameters that tended to be slightly depressed (see Fig. 4).

### Urodynamics and EMG

All urodynamic and uroflow/EMG studies were performed using either a Medtronic (Minneapolis, Minnesota, USA) (Mediwatch) Duet system or a Laborie Aquarias (Toronto, Ontario, Canada) TT urodynamics system in accordance with current ICS guidelines. The EMG modules of both systems have high sampling rates with broad sensitivities that yield high quality graphic images and have a good quality audio monitor for discerning electric artifacts from true pelvic floor motor activity, which has been previously described in detail [6]. In brief, the pelvic floor EMG recording was performed using integrated biosensor patch EMG electrodes placed at the 3 and 9 o’clock positions at the margin of the external anal sphincter. We also used real-time bladder ultrasound on initial assessment before voiding to ensure that the patient was adequately filled, and immediately after voiding to ensure accurate post-void residual (PVR) assessment. Ultrasound also allowed for the assessment of the bladder wall and bladder neck appearance, for lower ureteral dilation and assessment of the rectum with regard to bowel function.

A minority of patients with DV also underwent video urodynamic study (VUDS) because of (1) a history of urinary tract infection (UTI), most often febrile, and LUTS when not infected, (2) unsatisfactory response to previous empirically prescribed therapies, and (3) ultrasound findings of



**Figure 1** Example of a 10-year-old girl with typical staccato flow pattern, as well as an active pelvic floor electromyography (EMG) during the voiding phase, diagnostic of dysfunctional voiding.

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