

Can Staccato and Interrupted/Fractionated Uroflow Patterns Alone Correctly Identify the Underlying Lower Urinary Tract Condition?

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Abbreviations and Acronyms

DU = detrusor underactivity
DV = dysfunctional voiding
EMG = electromyography
ICCS = International Children's Continence Society
ICS = International Continence Society
IDOD = idiopathic detrusor overactivity disorder
LUTC = lower urinary tract conditions
LUTS = lower urinary tract symptoms
PBNB = primary bladder neck dysfunction
PVR = post-void residual urine
Qave = average uroflow rate
Qmax = maximum uroflow rate
uroflow/EMG = uroflow with pelvic floor electromyography
VUDS = videourodynamics

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See Editorial on page 1960.

Purpose: Worldwide, uroflowmetry without simultaneous electromyography is often the only testing performed during the initial assessment of children with lower urinary tract symptoms. Various alterations in uroflow pattern are thought to indicate particular types of lower urinary tract conditions, specifically staccato uroflow indicating dysfunctional voiding and intermittent/fractionated uroflow indicating detrusor underactivity. We determined how reliable uroflow pattern alone is as a surrogate for simultaneously measured pelvic floor electromyography activity during voiding, and how well staccato and interrupted uroflow actually correlate with the diagnoses they are presumed to represent.

Materials and Methods: We reviewed uroflow/electromyography studies performed during the initial evaluation of 388 consecutive neurologically and anatomically normal patients with persistent lower urinary tract symptoms. We identified those with staccato, interrupted/fractionated and mixed uroflow based on current International Children's Continence Society guidelines.

Results: A total of 69 girls (58.5%) and 49 boys (41.5%) met inclusion criteria. Staccato uroflow was noted in 60 patients, interrupted/fractionated uroflow in 28 and a combination in 30. An active electromyography during voiding confirmed the diagnosis of dysfunctional voiding in 33.3% of patients with staccato, 46.4% with interrupted/fractionated and 50% with mixed uroflow patterns.

Conclusions: Diagnoses based on uroflow pattern appearance without simultaneous electromyography to support them can be misleading, and reliance on uroflow pattern alone can lead to overdiagnoses of dysfunctional voiding and detrusor underactivity. When assessing patients with uroflow, an accompanying simultaneous pelvic floor electromyography is of utmost importance for improving diagnostic accuracy and thereby allowing for the most appropriate therapy.

Key Words: lower urinary tract symptoms, urination, urination disorders, urologic diseases

CHILDREN with significant lower urinary tract symptoms without associated neurological or anatomical abnormalities are considered to have lower urinary tract malfunction. This entity can be divided into specific urodynamically defined conditions.¹⁻⁴ An approach may be to categorize cases into

the 4 conditions of dysfunctional voiding (active pelvic floor electromyography during voiding with or without detrusor overactivity), idiopathic detrusor overactivity disorder (detrusor overactivity with a quiet pelvic floor electromyography during voiding), detrusor underutilization disorder (volitionally deferred

urination, large bladder capacity, quiet pelvic floor electromyography during voiding and, on occasion, detrusor overactivity) and primary bladder neck dysfunction (prolonged opening and electromyography lag times, impaired uroflow as a consequence of inadequate and delayed bladder neck opening and a quiet pelvic floor electromyography during voiding with or without detrusor overactivity).¹⁻⁴ These 4 conditions and their characteristics are summarized in the Appendix. However, the majority of children with lower urinary tract symptoms are not evaluated with urodynamic studies, nor should they be. Instead, reliance on a single noninvasive study (ie uroflowmetry without simultaneous pelvic floor electromyography) to evaluate and diagnose these cases has long been the standard throughout the world, although combined uroflow/electromyography has been acknowledged to improve diagnostic accuracy.^{1,5-9}

The primary reason for the pervasive reliance on uroflow alone to diagnose LUTC has been the belief that certain alterations in uroflow patterns are indicative of particular types of lower urinary tract dysfunction, most notably DV and detrusor hypocontractility.¹⁰ According to the ICS and the ICCS, a staccato or fluctuating urinary flow pattern is presumed to reflect pelvic floor activity during voiding, a finding indicative of DV.^{5,11} However, there is disagreement between these 2 organizations regarding the terminology used to describe a start and stop uroflow pattern and what condition this pattern is thought to represent. The ICCS refers to this pattern as interrupted/fractionated and postulates that the starting and stopping of uroflow is secondary to straining to void as the consequence of an underactive or acontractile bladder. However, the ICS calls this pattern intermittent and considers it representative of DU or DV. Both organizations consider DV not to be present when the uroflow pattern is smooth.

We sought to determine how reliable staccato and interrupted/fractionated type uroflow patterns alone are in diagnosing the disorder each is presumed to represent. We hypothesized that performing uroflow alone without simultaneous pelvic floor EMG may lead to misdiagnosis due to the inability to distinguish accurately between the aforementioned LUTC.

MATERIALS AND METHODS

With institutional review board approval, we reviewed the initial diagnostic uroflow/EMG studies in 388 patients. Those uroflow studies demonstrating a staccato and/or interrupted/fractionated pattern based on current ICCS guidelines were included in this study. We analyzed voided volume, Qmax, Qave, post-void residual and the presence or absence of EMG activity during the voiding phase as well as EMG lag time (interval between the onset of pelvic floor relaxation with permission to void and the

start of urine flow).¹⁰ Of the patients 8% underwent VUDS as well because of 1) a history of urinary tract infection and LUTS when not infected, 2) prior unsatisfactory response to empirically prescribed therapies (pharmacotherapy or biofeedback), 3) ultrasound findings of significant bladder wall thickening, hydronephrosis or lower ureteral dilatation and 4) diminished uroflow despite quiet pelvic floor activity on screening uroflow/EMG.

All uroflow/EMG and urodynamic studies were performed by a single experienced clinician. Patients were excluded if they had any known neurological or anatomical abnormalities, or if they were subsequently diagnosed with either. No patient was on any pharmacotherapy for LUTS at the time of the evaluation.

Definitions of Uroflow Patterns

A staccato uroflow pattern as defined by the ICCS is characterized by multiple peaks and troughs in which the magnitude of the fluctuations in the uroflow curve is larger than the square root of the maximum uroflow rate. An interrupted/fractionated uroflow pattern is defined as having discrete peaks in urine flow, separated by segments with zero flow.⁷ The ICS refers to these 2 types of uroflow patterns as fluctuating and intermittent.⁵ Examples of staccato and interrupted/fractionated uroflow and their associated EMG patterns are shown in the figure.

To avoid the overinterpretation of anomalous uroflow patterns, abnormalities of flow that only occurred during the first or last 10% of the total volume voided were disregarded, as were abnormalities noted to be the result of flowmeter artifacts. As is our practice, most patients underwent 2 or more uroflow/EMG studies to monitor for consistency. Any study where artifact was suspected was repeated. If the flow/EMG was well performed and conformed with the rest of the clinical picture, the study might not have been repeated. If a patient was bothered by the perianal electrodes to an extent where the uroflow pattern seemed to be affected by artifact, a repeat uroflow without EMG was performed.

Urodynamics, EMG and Abdominal Ultrasound

All urodynamic and uroflow/EMG studies were performed using either a Medtronic Duet® system or a Laborie Aquarius™ TT urodynamics system. The EMG modules of both systems have high sampling rates with broad sensitivity that yields high quality graphic images that are recorded as raw EMG. Each unit also has a high quality audio monitor that allows for differentiation between motor recruitment activity and activity caused by electrical artifact, such as wire movement or wetting of the electrodes. Pelvic floor EMG recording was performed using integrated biosensor patch EMG electrodes with isolated circuits. EMG patches were placed at the 3 and 9 o'clock positions at the margin of the external anal sphincter. On initial evaluation and uroflow/EMG real-time bladder ultrasound was used before voiding to ensure that the patient was adequately filled and immediately after voiding to ensure accurate PVR assessment. In addition, bladder ultrasound was used to assess the appearance of the bladder wall and bladder neck, and to check for lower ureteral dilatation as well as the presence of a large stool mass in the rectum. While many children in the study cohort also

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