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Use of non-invasive uroflowmetry with simultaneous electromyography to monitor patient response to treatment for lower urinary tract conditions

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Abstract *Objective:* Non-invasive uroflowmetry with simultaneous electromyography (uroflow/EMG) has previously been reported as effective in triaging patients into four specific non-neurogenic lower urinary tract (LUT) conditions for targeted treatment. In this study we sought to determine if the same parameters would be useful for measuring response to treatment.
Material and methods: We reviewed our database of normal children with LUT dysfunction, screened with uroflow/EMG, and diagnosed with a LUT condition: (1) dysfunctional voiding (DV); (2) idiopathic detrusor overactivity disorder (IDOD); (3) detrusor underutilization disorder (DUD); (4) primary bladder neck dysfunction (PBND). Pre- and on-treatment (minimum 3 months) uroflow/EMG parameters and subjective improvements were compared.
Results: Of 159 children (71 boys, 88 girls; median age 7.0 years, range 3.5—18.0 years), median follow up was 13.1 months (range 3—43 months). On targeted treatment, DV patients showed relaxation of pelvic floor during voiding and significant decrease in PVR on biofeedback; IDOD patients had normalization of short lag time and increased capacity on antimuscarinics; DUD patients had a decrease in capacity on timed voiding; PBND patients on alpha-blocker therapy showed improved uroflow rates and a decrease in mean EMG lag time (all $p < 0.05$).
Conclusion: Non-invasive uroflow/EMG is useful not only for diagnosing specific LUT conditions, but also in objectively monitoring treatment efficacy. Subjective improvement on targeted therapy correlates well with objective improvements in uroflow/EMG parameters lending validation to this simplified approach to diagnosis.

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Introduction

In otherwise normal children and adolescents with lower urinary tract (LUT) dysfunction, lower urinary tract symptoms (LUTS) are almost always secondary to one of four previously urodynamically-defined conditions: dysfunctional voiding (DV), idiopathic detrusor overactivity (DO) disorder (IDOD), detrusor underutilization disorder (DUD) or primary bladder neck dysfunction (PBND) [1]. We have previously shown that these four LUT conditions can be accurately diagnosed using non-invasive uroflowmetry with simultaneous electromyography (uroflow/EMG), with special attention to pelvic floor activity during voiding and EMG lag time, thus avoiding the need for invasive video urodynamic study (VUDS) in most cases [2]. These conditions can be divided into their uroflow/EMG equivalents as follows:

- DV—associated LUTS and characterized by an active pelvic floor (i.e., active EMG recording) during voiding, often with a staccato and/or interrupted uroflow pattern;
- IDOD-A—symptom of urgency with a quiet pelvic floor during voiding and a shortened EMG lag time (<2 s);
- IDOD-B—same as IDOD-A, but with a normal EMG lag time (2—6 s);
- DUD—characterized by voided volumes consistently in excess of estimated bladder capacity (EBC) as the result of chronic or episodic willful deferred voiding, but otherwise normal, coordinated voiding with a quiet pelvic floor and normal flow pattern;
- PBND—LUTS, particularly hesitancy, characterized by prolonged EMG lag time

(>6 s) and a depressed, often right-shifted, uroflow curve with quiet pelvic floor during voiding.

While uroflow studies alone provide details on flow rates and uroflow patterns, without simultaneous pelvic floor EMG they can be misleading regarding the underlying LUT condition. For instance, a staccato uroflow pattern is often thought to represent DV. However, as we previously reported in the evaluation of a large group of patients with staccato uroflow patterns, when studied with simultaneous EMG, only a third actually had documented DV [3]. Uroflow/EMG studies not only allow observation of the pelvic floor muscle activity (a surrogate for the external urethral sphincter) during voiding, they can also be used to calculate the time between the start of pelvic floor relaxation on volitional voiding effort and the start of urine flow, that is, the EMG lag time.

In normal children with an adequately filled bladder and urge to void, EMG lag time is normally between 2 and 6 s. We have defined a prolonged EMG lag time as one that is >6 s and a shortened EMG lag time as one that is <2 s. We have previously reported on the usefulness of a prolonged EMG lag time in making the diagnosis of PBND [2,4—6]. In addition, a shortened EMG lag time was found to correlate with the presence of DO on urodynamics and therefore useful in the diagnosis of IDOD [2,7,8]. While previously we have reported on the usefulness of non-invasive uroflow/EMG in the diagnosis of one of four LUT conditions [2], in this study we expand the role of uroflow/EMG in the monitoring of these patients on targeted therapy. Specifically, we assessed the role repeat uroflow/EMG studies had on monitoring objective treatment efficacy in terms of improvement in uroflow/EMG parameters and subjective improvement in symptomatology.

Materials and methods

With Columbia University Medical Center's institutional review board (IRB) approval (IRB-AAAC1100), we retrospectively reviewed 200 consecutive neurologically and anatomically normal children from our prospectively maintained database from January 2008 to December 2010. All patients had presented with significant LUTS, underwent uroflow/EMG testing as part of their initial work-up, and were diagnosed with one of four LUT conditions. Patients were excluded if they only had one uroflow/EMG session, fewer than 3 months of follow-up, or were none compliant with medication as determined by parent/patient interview. All patients had renal/bladder ultrasound studies and were determined to be anatomically normal based on these studies. In addition, all families filled out a diary regarding voiding and bowel habits. Bowel dysfunction was noted as functional constipation based on Rome III criteria, encopresis, or neither. The term encopresis used in this article refers to the isolated finding of fecal incontinence without constipation, and is identical to the term "non-retentive fecal incontinence", as defined by gastroenterologists [9]. The specific diagnosis each received was based on clinical history (including LUTS, voiding/wetting/elimination diary), physical examination, and the uroflow/EMG results. VUDS were obtained in only 11 patients, primarily because of a history of febrile urinary tract infections (UTIs) and suspected vesicoureteral reflux.

Uroflow/EMG studies were performed and analyzed by a single experienced clinician using either a Medtronic Duet system (Mediwatch USA) or an Aquarius TT system (Laborie) in our urodynamic study center. The EMG modules in both units have a high sampling rate and broad sensitivity that yields high-quality graphic images reported as raw EMG, and both have a high-quality audio monitor that allows for differentiation between motor recruitment activity from that activity resulting from electrical artifacts, such as movement or wetting of the electrodes or wires. Real-time bladder ultrasound was also obtained with each uroflow/EMG study to establish adequate volume prior to voiding and to measure post-void residual (PVR). For all uroflow/EMG studies, five parameters were recorded: EMG lag time, maximum urinary flow rate (Qmax), mean urinary flow rate (Qave), voided volume, and PVR. EBC for age was calculated using Koff's formula: (age + 2) × 30 cc [10]. %EBC was calculated using the formula %EBC = [voided volume + PVR]/[EBC]. The shape or pattern of the uroflow curve was also noted as per International Children's Continence Society (ICCS) standards, as was any EMG activity during voiding. In patients with an active pelvic floor during voiding (DV), no EMG lag time was calculated. After initial uroflow/EMG study, the vast majority of patients underwent repeat uroflow with or without EMG at the same visit. Additional uroflow studies were performed to confirm abnormal findings or if initial study was inadequate.