**Is EMG uroflowmetry utilizing a urethral catheter at the pressure flow phase a reliable test in children? A comparative study between EMG uroflowmetry with and without a catheter**

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**Abstract**

Introduction: Electromyography (EMG) uroflowmetry is an essential phase of pressure flow evaluation. The International Children’s Continence Society (ICCS) guidelines affirm that 6Fr or 7Fr catheters do not obstruct the urethra. Given different results at our institution, we evaluated the accuracy of EMG uroflowmetry in children utilizing a urethral catheter.

Methods: A retrospective study of children undergoing a urodynamic evaluation at our institution between 8/2018-7/2022 was employed. Urination curves and pelvic floor muscle activity were compared in an invasive and non-invasive EMG uroflowmetry test. The non-invasive test was selected as the standard benchmark.

Results: 104 children were tested, with 34 children (33%) being able to urinate only in a non-invasive EMG uroflowmetry. The percentage of boys unable to urinate with a catheter was significantly higher than girls (54% vs. 13%, p-value<0.001). In 70 children, a normal bell-shaped urination curve was found in 13 compared to 33 children in the invasive and non-invasive tests, respectively. Invasive EMG uroflowmetry demonstrated a specificity of 39% (95% CI 23-57) and positive predictive value (PPV) of 61% (95% CI 53-67) in finding non-bell-shaped curves. Relaxation of pelvic muscles was found in 21 (30%) as opposed to 39 (55%) of children in invasive and non-invasive EMG uroflowmetry, respectively (p-value=0.5).

Conclusions: The accuracy of invasive EMG uroflowmetry in children, primarily in boys, compared to the non-invasive test, was poor. This may pose potential errors in diagnosis and subsequent treatment. We recommend completing a non-invasive EMG uroflowmetry in cases where the child refused to urinate, or pathology was found, requiring a modification in treatment.

*Keywords:* urodynamic; EMG-flow; voiding curves; validity; lower urinary tract symptoms

1. **Introduction**

Urodynamic studies (UDS) are a valuable tool for assessing lower urinary tract symptoms (LUTS). Both the filling phase and the pressure-flow (PF) phase of the UDS ﻿provides specific, and detailed information for accurate diagnoses to be made 1–3. EMG uroflowmetry is an essential phase of pressure flow evaluation, assisting in determining treatment options, for which its accuracy is critical.

In adults, the effect of a small caliber urethral catheters in the PF phase is well documented and researched. It was established that an 8F catheter or smaller does not cause a significant obstructive effect during voiding, and does not affect the Qmax of uroflowmetry4–7.

The International Children’s Continence Society (ICCS) guidelines affirm that 6Fr or 7Fr catheters do not obstruct the urethra3,8. However, the effect of a catheter in the PF phase of UDS in children is largely unknown and not discussed elsewhere. From tests carried out at our institution, the impression is that despite efforts to adjust the setting of urination to help the child relax and void, some children don’t succeed. Either pain, fear, or voiding in the presence of a foreign object doesn’t allow stimulating normal urination. This raises questions regarding the accuracy of the EMG uroflowmetry in UDS, performed with a catheter placed in the urethra.

Non-invasive EMG uroflowmetry for evaluating lower urinary tract function was shown to ﻿optimize diagnostic accuracy and selection of appropriate treatment for ﻿non-neurogenic voiding disorders9–12.

While non-invasive uroflow-EMG is well established for being a valid diagnostic tool for assessing the voiding phase, the evidence of validation for UDS voiding with a urethral catheter is scarce. This study aimed to assess the accuracy of EMG uroflowmetry with a urethral catheter compared to the noninvasive uroflow-EMG, in children.

1. **Methods**

A cross-sectional design was utilized. We retrospectively reviewed urodynamics studies (UDS) and EMG uroflowmetry of children, in our institute.

* 1. *Patients and data collection*

The study population included all children between 4 and 18 years of age who underwent UDS between August 2018 and July 2022.

Indications for UDS included: lower urinary tract dysfunction~~-~~ resistant to conservative treatment, and recurrent urinary tract infections (UTI). Included were children who underwent an EMG uroflowmetry no longer than one months before or after the UDS.

Excluded were children who performed clean intermittent catheterization (CIC). UDS ﻿was performed in accordance with International Continence Society recommendations 13.

To compare UDS and non-invasive EMG uroflow tests, we screened the voiding curves of each exam. The voiding curve was divided into five main patterns. The normal bell-shaped curve, tower-shaped, staccato, interrupted and low and elongated curves 14. Pelvic-floor muscles activity, voided volume, and residual urine volume were also recorded. Collected were also demographic and clinical characteristics, comorbidities, and medication treatment for each patient.

*2.2. Statistical analysis*

Categorical variables were summarized by number and percentage, and continuous variables by the median and interquartile range (IQR). The Chi square test was used to examine differences in sociodemographic characteristics between children who agreed to urinate on both the invasive and non-invasive EMG uroflowmetry and children being able to urinate only in a non-invasive test. A Chi square test was also used to examine differences in the voiding curve and pelvic floor muscles activity between the invasive and non-invasive EMG uroflowmetry. Sensitivity and specificity were calculated for voiding curves (normal bell-shape/pathological) while the non-invasive test was selected as the standard benchmark. Additional analyses were performed in stratification by children’s age group, sex, and anticholinergic treatment. All analyses were performed using SPSS software version 27.

**Ethical aspects**

The study protocol was approved by our Institutional Review Board.

1. **Results**

A total of 104 children were included in our study. There were 50 (48%) males and 54 (52%) females with a median age of 8 (interquartile range [IQR]: 6-11) years. Forty-one (39%) children have vesicoureteral reflux (VUR), 9 (9%) were diagnosed with dysfunctional voiding (DV), 9 (9%) underwent excision of a posterior urethral valve (PUV), and 11 (10%) children underwent ureteral re-implantation surgery.

Fifty-three (51%) children had symptoms of urinary incontinence, and 38 (37%) children had recurrent UTIs (Table 1).

Out of 104 children who underwent UDS and EMG uroflow, 34 (33%) refused or could not void on UDS and voided only on the non-invasive EMG uroflow. There was no significant difference between children who agreed to void on both exams vs. those who voided only on the non-invasive EMG uroflow in the different age groups; however, the latter included a significantly higher percentage of males (54% vs. 13%, Chi Square p-value<0.001) (Table 2).

In comparing the voiding curves of 70 children with both EMG flow and UDS, only 30 (41%) children had concordant results. While a normal “bell shaped” curve was found in 33 (47%) children on the non-invasive EMG uroflow, only 13 (18%) had the same result on UDS (Chi Square p-value= 0.02). Out of 15 (21%) children with “interrupted” voiding curve on non-invasive EMG uroflow, only 5 (7%) had concordant “interrupted” voiding curve on UDS (Chi Square p-value= 0.09). UDS showed more children with staccato (32%) and elongated (21%) voiding curves than found on non-invasive EMG uroflow (Chi Square p-value=0.2 & p<0.001, respectively). In comparing pelvic-floor muscles electrical activity between non-invasive EMG-uroflow and UDS, 36 (51%) children had concordant muscles relaxation or activation. While 39 (55%) children were able to normally relax their pelvic floor muscles during voiding on the non-invasive EMG-uroflow, only 21 (30%) children were able to do so on UDS (Chi Square p-value=0.5) (Table 3).

Based on UDS, 51 (72%) children had abnormal voiding curves, compared to 37 (52%) according to non-invasive EMG uroflow. Among children with abnormal voiding curves based on non-invasive EMG uroflow, 31 were also classified with an abnormal curve on UDS, yielding a sensitivity of 83% (95% CI 68-93). Among 33 children who had a normal “bell shaped” voiding curve based on non-invasive EMG uroflow, 13 were also classified with a normal “bell shaped” voiding curve according to UDS, thus yielding a specificity of 39% (95% CI 23-57). A false positive result was demonstrated for 20 children (60%) classified with an abnormal voiding curve on UDS, thus yielding a positive predicting value (PPV) of 61% (95% CI 53-67). Stratification by sex and age had a limited effect on the sensitivity of abnormal voiding curves on UDS. Slight differences were observed in the specificity (with overlapping confidence intervals), being lower in males vs. females (Table 4).

1. **Discussion**

PF evaluation with a urethral catheter as part of urodynamic studies is a valuable tool in assessing lower urinary tract dysfunction in children and determining appropriate treatment. In fact, no alternative tools are available, and the urethral catheter is necessary to calculate particular measurements such as opening pressure and detrusor contractility.2 However, the catheter has a disruptive effect on children’s normal voiding behavior and their ability to void.

The ICCS guidelines for urodynamic studies note that voiding with a catheter is unnatural and therefore children may experience difficulty voiding with a catheter in place, but additionally note that small-caliber catheters of 6 or 7Fr do not obstruct the urethra and allow normal flow of urine.8

In the current study, the catheter’s disruptive effect was evident in the fact that of 104 children who underwent urodynamic testing, 34 (33%) failed to produce urine or refused to void with the catheter during the PF phase. Thus, before addressing the test’s accuracy, it is imperative to note that a significant percentage of children will not initiate voiding with a catheter, largely due to reasons other than the organic effects associated with diagnosing the dysfunction.

The effect of urinary catheters on PF results in adult males was assessed in several studies, with conflicting results. For example, Reynard et al. noted no significant difference in maximal flow rate in a study of 59 men who underwent PF testing with and without an 8Fr catheter. A larger cohort study by Harding et al. demonstrated no significant effect on Qmax during the PF phase in 200 men with and without a small caliber catheter. On the other hand, in a study of 40 men with BPH, Zhao et al. observed that an 8Fr catheter had a significant effect on maximal flow rate, which correlated with the degree of bladder outlet obstruction. Klingeler et al. reported similar results in an earlier study of 64 men with BPH.4-6,15

In women who undergo urodynamic evaluation for urinary incontinence or LUTS, several studies concluded that urinary catheters had obstructive effect.16-18 Scaldazza et al. observed that even 6 and 7Fr transurethral catheters may obstruct micturition, in a study of 60 women undergoing PF studies for LUTS evaluation. A larger study by Constantini et al. of 239 women with LUTS demonstrated reduced Qmax in PF studies with every diameter of transurethral catheter.

Contrary to adult studies which do not demonstrate a significant difference between men and women in transurethral catheter effect on PF19, the current study observed that in children, the percentage of boys who failed to void with the catheter was nearly four times as high as in girls (13% vs 54%). It appears that stimulation of the longer urethra in young boys results in a greater degree of pain and discomfort, which interferes with micturition. The high percentage of children who failed to void with the transurethral catheter raises concerns regarding the test’s reliability and its ability to correctly evaluate PF and inform treatment plans in children who voided successfully.

There is a dearth of studies in children that validate the PF phase in invasive urodynamic studies. To validate this, PF parameters can be compared in patients studied with and without catheters. The EMG uroflowmetry is nearly identical to the PF phase in urodynamic testing, but is performed without a catheter. EMG uroflowmetry was subjected to validation studies which proved it to be a valid tool for evaluating and devising treatment plans for LUTS.12

At our institution, many children routinely undergo non-invasive EMG uroflowmetry during clinical visits due to the test’s ready availability. Thus, many patients with indications for urodynamic studies have also undergone noninvasive EMG uroflowmetry for comparison. By comparing results from both tests, in the current study we examined the accuracy of invasive EMG uroflowmetry during the PF phase of urodynamic studies.

We found very poor correlation between invasive and noninvasive EMG uroflow results. In fact, only 30 children (41%) had identical micturition curves in both tests, which were performed less than a month apart. In children with identical micturition curves in both tests, results most commonly showed a normal bell curve. Thus, children with normal micturition curves in the noninvasive test succeeded in voiding better in the invasive test and achieved an identical bell curve. Children whose micturition curve was abnormal in the noninvasive test had abnormal curves in the invasive exam as well, which showed different patterns than the curves recorded during the noninvasive test.

Pathological micturition curves were observed more frequently and more distinctly in invasive urodynamic studies. While nearly 50% of children demonstrated normal bell-shaped micturition curves, the percentage of children with normal curves dropped significantly with the invasive test, with only 30% of children demonstrating normal curves with a catheter.

Pathological micturition curves such as elongated curves were observed more frequently in the catheter test. These curves suggest an obstructive pattern and correspond to the adult studies which demonstrated that the catheter had an obstructive effect in PF studies.20

Interrupted and staccato micturition curves were observed with higher frequency in invasive catheter studies. These results suggest difficulty achieving relaxation of sphincter and pelvic floor muscles. We believe that the urethral stimulation, pain and anxiety caused by the urethral catheter interferes with children’s ability to relax sphincter and pelvic floor muscles as is necessary for normal micturition. This is evident in our results as well, as 55% of children sufficiently relaxed pelvic floor muscles during noninvasive EMG uroflowmetry, while in the invasive test 70% of children demonstrated increased pelvic floor muscle tension on EMG. Although not statistically significant, the tendency toward failure to relax pelvic floor muscles with the catheter is clear.

Finally, by comparing results of invasive and noninvasive EMG uroflow studies, we succeeded in assessing the accuracy of invasive catheter studies. We found the invasive study’s sensitivity to be fairly good at 83%. Thus, if the noninvasive study is normal, the invasive PF study will most likely show similar results. In contrast, the invasive study’s sensitivity was very low, at 39%. With a high number of false positives of 60% and a low PPV of 61%, it appears that the invasive catheter study demonstrates pathological micturition characteristics which apparently do not reflect the child’s true micturition patterns. The sensitivity and specificity were calculated based on comparison of micturition curves, however we can conclude that the test has poor specificity for detecting excessive pelvic floor muscle activity during micturition.

Our study’s strengths include a large study population consisting of children of varying ages, which represent a large treatment center that treats varied urinary pathologies in children. An additional strength is the fact that the comparison between invasive and noninvasive urodynamic studies were performed using a paired method on the same child, within a narrow time frame between tests and without any changes to treatment between the two tests.

One of the limitations of our study was the use of uroflowmetry with low micturition volumes, but few tests had low volume and none of these was lower than 100cc, which is defined by ICCS as a reliable test.2 Another limitation of the current study is the fact that interpretation of the EMG uroflowmetry is not identical between different testers. However, two pediatric urologists highly experienced with interpreting such studies reviewed results and concurred on their interpretation.

In summary, the level of accuracy of EMG uroflowmetry with the use of a catheter in children, in comparison to the non-invasive test was poor. The effect of the urethral catheter in boys is even more drastic. We demonstrated very low specificity and PPV of the EMG uroflowmetry in finding pathological urination patterns. This may pose potential errors in the diagnosis and subsequent treatment. We recommend considering the completion of non-invasive EMG uroflowmetry in cases where the child refused to urinate or in cases where pathology was found, requiring a modification in treatment.

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