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Age, gender, and voided volume dependency of peak urinary flow rate and uroflowmetry nomogram in a tertiary care centre

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ABSTRACT

Uroflowmetry is a simple, diagnostic screening procedure used to calculate the flow rate of urine over time. The measurement of urine flow by uroflowmetry is non-invasive and is the easiest urodynamic test useful as preliminary or follow-up investigation of the lower urinary tract symptoms. **Introduction:** Uroflowmetry is a non-invasive test used to assess bladder and sphincter function. Even though uroflowmetry is not specific in identifying outlet obstruction, the flow rate remains an extremely sensitive indicator of lower urinary tract symptoms..Here the amount of urine, rate of flow in seconds, and length of time is calculated until completion of the void and this information is converted into a graph and interpreted by a urologist. The information helps to evaluate function of the lower urinary tract or help determine obstruction of normal urine outflow. **Materials and Methods:** The present study was conducted on 5 groups of people attending the emergency surgical ward and OPD at a tertiary care centre from Jan 2011 to Oct 2012 who were analyzed separately and intergroup differences were statistically studied.l Nomograms were presented in centile form and prepared for each group. The difference was assessed for significance using a student's t- test. Nomograms were constructed depicting the normal Gaussian distribution of maximum and average urinary flow rate at volumes ranging from 50 to 1000 cc.. Evaluated parameters were voided volume, maximum flow rate, average flow rate, flow time, and time to Qmax **Results:** Maximum flow rate (Qmax) is more significantly correlated with age and voided volume than average flow rate (Qavg); hence, Qmax is the single most useful parameter of uroflowmetry.Qmax increases with age in the paediatric population and decreases with age in the adult and elderly population.Qmax in girls was significantly higher than in boys.Nomogramsin centile form can be constructed to provide normal reference ranges for urinary flow rates covering a wide range of voided volumes

Key words: Uroflowmetry, voided volume,nomograms

INTRODUCTION

The test is non-invasive (the skin is not pierced) and may be used to assess bladder and sphincter function. The measured urinary flow is the product of detrusor contractility and urethral resistance, in some cases modified by abdominal straining. Even though uroflowmetry is not specific in identifying outlet obstruction, the flow rate remains an extremely sensitive indicator of lower urinary tract symptoms. It is performed by having a person urinate into a special funnel that is connected to a measuring instrument. The measuring instrument calculates the amount of urine, rate of flow in seconds, and length of time until completion of the void. This information is converted into a graph and interpreted by a urologist. The information helps to evaluate function of the lower urinary tract or helps determine obstruction of normal urine outflow.

Indications of uroflowmetry

Benign prostatic hypertrophy (BPH),Carcinoma prostate, carcinoma urinary bladder , urinary incontinence –(involuntary release of urine from the bladder), urinary blockage ,neurogenic bladder dysfunction ,frequent urinary tract infections .

The normal flow pattern is a continuous, bell-shaped, and smooth curve with a rapidly increasing flow rate. Because small voided volumes affect the curve shape and Qmax is volume dependent, only voided volumes of at least 150 ml should be interpreted. The maximum flow rate should always be documented together with the total voided volume and postvoid residual volume with the following standard format: Maximum flow rate/volume voided/postvoid residual volume. Most consider Qmax >15–20 ml/s as normal and <10 ml/s abnormal. These numbers decline with age by 1–2 ml/s per 5 years. There is a decline in peak flow with age resulting in a maximum flow of 5.5 ml/s at 80 years. In the normal woman, Qmax can be >30 ml/s, the flow curve is bell-shaped as in men, and the flow time is shorter. Maximum flow in women does not seem to be dependent on age.

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Aims and Objectives

- The objective of this study is the measurement of urine flow parameters by a non-invasive urodynamic test
- To establish normal reference ranges of maximum and average flow rates
- To see the influence of age, gender, and voided volume on flow rates, and to chart these values in the form of a nomogram.

MATERIALS AND METHODS

The present study was conducted on the people attending the emergency surgical ward and the outpatient department at a tertiary care centre from January 2011 to October 2012.

Different Age Groups of the Healthy Population Were

- Group I (16–50-year-old males) - 20 patients
- Group II (>50-year-old males) - 20 patients
- Group III (children 5–15 years old) - 20 patients
- Group IV (premenopausal females) - 20 patients
- Group V (postmenopausal females) - 20 patients.

These five groups were analyzed separately and intergroup differences were statistically analyzed. Statistical analysis was performed using SPSS Software (SPSS, Inc.). Several transformations of data and the relationship between the maximum or average flow rates and the voided volume were assessed. The quantile regression method was used to establish the percentile levels (5, 10, 25, 50, 75, 90, and 95). Nomograms were presented in centile form and prepared for each group. The difference was assessed for significance using a Student's *t*-test. Data were analyzed for "goodness of fit" using the Kolmogorov–Smirnov test (K–S test). Healthy relatives of admitted patients were recruited after taking valid consent. The five groups were analyzed separately, and intergroup differences were statistically analyzed. We used the gravimetric method for uroflowmetry, using Santron 2pl; PC-based uroflometer. Calibration was initially performed using the internal self-calibration program on the apparatus and repeated at intervals to ensure consistency. The checking of voided volume, flow time, and average flow rate was performed using known fluid volumes and time (stopwatch). We descriptively analyzed flow chart parameters and used statistical calculation for drawing uroflow nomograms. Nomograms were constructed depicting the normal Gaussian distribution of maximum and average urinary flow rate at volumes ranging from 50 to 1000 cc. These healthy populations were evaluated by history, examination, and investigations. Evaluated parameters were voided volume, maximum flow rate, average flow rate, flow time, and time to Qmax. Exclusion criteria were patients with urological complaints or a history of neurological disorders.

RESULTS

Group I

In Group I, the median age was 31 years. The mean voided volume was 440 ± 210 ml. The mean maximum flow rate and average flow rate were 23 ± 9 ml/s and 13 ± 6 ml/s, respectively. The correlation between Qmax and Qavg with voided volume was significant (Pearson's correlation coefficient). The higher the voided volume, the higher the flow rates. Qmax values showed a significant correlation with age. Qavg was not significantly correlated with age. There was a decline in Qmax by 1 ml/s/decade. Equation for the flow rates based on voided volume and age in Group I.

$\sqrt{}$ Maximum flow rate (Qmax) = 3.58+0.482$\sqrt{}$ (VV)−0.145×(age)

Nomogram charts for maximum flow rate and voided volume were prepared and plotted based on regression analysis.

Group II

The median age in Group II was 66 years old. Voided volumes were 300 ± 140 ml. The mean maximum flow rate and average flow rate were 17 ± 7 ml/s and 9 ± 4 ml/s. Qmax and Qavg were well correlated with voided volume. Qmax and Qavg in this group were negatively correlated with age.

$\sqrt{}$ Maximum flow rate = 3.2+0.544 $\sqrt{}$ (VV)−0.154 (age), a comparison between Groups I and II and the statistical differences are discussed in Table 1.

Group III

Group III consisted of 5–15-year-old children; the median age was 9 years old. The mean voided volume was 220±140 ml. The mean maximum flow rate and average flow rate were 18±6.2 ml/s and 11±3.5 ml/s, respectively. Qmax and Qavg were positively correlated with age. Qmax values and voided volume were highly correlated.

$\sqrt{}$ Maximum flow rate: 1.996+0.397 $\sqrt{}$ (vv)+0.485 (age)

On analyzing girls and boys separately, for girls, the mean age was 10.05 years old and voided volume was 240±92 ml. Qmax and Qavg values were 19±6.3 ml/s and 12±2.5 ml/s. For boys, the mean age was 9.4 years old and the mean voided volumes were 220±112 ml/s. Mean Qmax and Qavg values were 16±5.7 ml/s and 10±3.8 ml/s, respectively. The maximum flow rate nomogram for boys and girls is shown, and a comparison of the boys and girls in Group III is discussed in Table 2.

Group IV and V

Of 40 females, 20 were premenopausal (Group IV) and 20 were postmenopausal (Group V). The two groups were analyzed separately to assess the effect of hormonal withdrawal with menopause on the physiology of the urethra and pelvic floor and the effect on uroflow parameters. The median age in the premenopausal group was 33. The mean voided volume was 400 ± 190 ml. The mean maximum flow rate and average flow rate were 22 ± 8 ml/s and 12 ± 5 ml/s, respectively. Qmax values were negatively correlated with age.

Group IV

$\sqrt{}$ Maximum flow rate = 4.207+0.470 $\sqrt{}$ (VV)−0.174 (age)

In the group of postmenopausal females, the median age was 61 years old. The mean voided volume was 362 ± 141 ml. The mean maximum flow rate and average flow rate were 17 ± 5 ml/s and 10 ± 3.5 ml/s, respectively. Qmax values were negatively correlated with age, but they were statistically non-significant. Equations for the flow rates based on voided volume and age in Group V.

$\sqrt{}$ Maximum flow rate = 1.36+0.575 $\sqrt{}$ (VV)−0.086 (age)

Table 1: Comparison of various flow parameters in between Group I (16–50 years old) and Group II (>50 years old) male

Parameters evaluated	Group I (16–50 years) males (*n*=20)	Group II (>50 years) males (*n*=20)	*P* (Student's *t*-test)
Maximum flow rate (ml/s) (mean±SD)	23±9	17±7	0.001
Average flow rate (ml/s) (mean±SD)	13±6	9±4	0.001
Voiding time (s) (mean±SD)	37±19	38±20	0.619
Time to Qmax	8±4	11±9	0.001

SD: Standard deviation

Table 2: Comparison of various flow parameters in among Group III (males and females)

Parameters evaluated	Boys (5–15 years) (*n*=20)	Girls (5–15 years) (*n*=20)	*P* (Student's *t*-test)
Maximum flow rate (ml/s) (mean±SD)	16±5.7	19±6.3	0.005
Average flow rate (ml/s) (mean±SD)	10.5±9.8	11±2.8	0.001
Voiding time (s) (mean±SD)	20±9	13±2.5	<0.001
Time to Qmax	8±5	8±4	0.2931

SD: Standard deviation

Table 3: Comparison of various flow parameters in between Group IV (premenopausal female) and Group V (postmenopausal female)

Parameters evaluated	Group I (16–50 years) males (*n*=20)	Group II (>50 years) males (*n*=20)	*P* (Student's *t*-test)
Maximum flow rate (ml/s) (mean±SD)	22±8.2	17±5.55	0.001
Average flow rate (ml/s) (mean±SD)	12±5	10±3.5	0.009
Voiding time (s) (mean±SD)	36±16.5	41±19.5	0.0153
Time to Qmax	8±3.8	10±6.1	0.09

SD: Standard deviation

Table 4: Mean maximum and average flow rate parameters in different age groups

Male population	Maximum flow rate (ml/s)	Average flow rate (ml/s)
16–50 years old	23±9	17±5.55
>50 years old	17±7	10±3.5
Premenopausal	22	12
Postmenopausal	17.5	10
Girls	19	11
Boys	17	10

Nomograms for premenopausal and postmenopausal females are shown, and a comparison of premenopausal and postmenopausal females is discussed in Table 3.

DISCUSSION

Mean maximum and average flow rate parameters in different age groups are shown in Table 4. Nomograms were constructed to provide normal reference ranges for both genders for urinary flow rates covering a wide range of voided volumes and in centile form. The use of statistical transformations in their construction overcame the problems created by inaccuracies when untransformed standard deviations were used, i.e., the Siroky nomogram.

Qmax values in the 16–50-year-old group were 23 ± 9 ml/s - significantly higher than in the >50-year-old and 5–15-year-old groups, which were 17 ± 7 ml/s and 17 ± 6 ml/s, respectively. Similar statistical differences were found by Suebnukanwattana *et al*.[1] in his study comparing two groups. Group I comprised 50 males, aged 18–30 years old and Group II comprised 20 males pre-elderly, aged 50–60 years old. Qmax values in our population of adult males were 23 ml/s, which are lower than 28.4 ml/s and 31.2 ml/s in the Austrian male adolescent and Thai population, respectively.[2] Qmax values in the elderly population were 17.04 ml/s significantly lower than the study in the Thai population (27.5 ml/s). Among female groups, the Qmax values were 22 ml/s in the premenopausal group and 17.5 ml/s in the postmenopausal group. There was a negative correlation with age and Qmax and Qavg. A significant positive correlation with age was seen in the 5–15-year-old age group and a negative correlation of Qmax values with age was seen in the 15–50-year-old group and in the more than 50-year-old group. Similar negative correlations with age were shown by the Liverpool nomogram and the study in the Thai population. We found a strong relationship between Qmax and Qavg values with voided volume in all the three groups. A similar strong correlation was found by Siroky *et al*.[3] Uroflowmetry nomograms were drawn based on these positive correlations between voided volume and flow rates. On comparing the flow rates of the male and female groups, Qmax values were 23 ± 9 ml/s and 20.5 constant maximum flow rates were higher in females. Similarly, Drach *et al*.[4] reported in their study that normal female subjects have a higher Qmax value for a given voided volume than do normal males of the same age. Normally, females have a short urethra usually with minimal outlet resistance. Voiding time was prolonged in postmenopausal females, which is significantly higher than the premenopausal and 5–15-year-old groups. Among the pediatric population, flow rates for girls and boys were 19 ± 7 ml/s and 17 ± 5 ml/s, respectively ($P < 0.001$). Similar results have been seen by Segura[5] and Kajbafzadeh *et al*.[6] Guitierrez Segura's report confirmed that the Qmax value increased with volume and age. Mean values were higher in girls than in boys. In our study, we also found a positive correlation of age with maximum flow rates. On comparing flow time and time to Qmax, there is no statistically significant difference in both groups for time to Qmax, but there was statistically significant difference between the two groups in voiding time ($P < 0.001$). Jensen *et al*.[7] showed that flow time is shorter in girls. Qmax was found to be positively correlated with voided volume that is seen up to 700 ml voided volume; after 700 ml, there is a plateau followed by a decline. A similar report was conducted by Dicuio *et al*.,[8] who found a positive correlation until voided volumes of 350 ml in the adolescent population, but constant until 500 ml and a decrease in Qmax values after 500 ml, voided volume changes significantly with age in the 5–15-year-old group. To eliminate the factor of rising voided volume on rising flow rate with age, an analysis of flow rate at a constant voided volume was done. At a constant voided volume of 200–250 ml, the maximum flow rate is significantly correlated with age.[9]

CONCLUSIONS

Following were the conclusion which was drawn from our study.

Maximum flow rate (Qmax) is more significantly correlated with age and voided volume than average flow rate (Qavg); hence, Qmax is the single most useful parameter of uroflowmetry.

- Qmax increases with age in the pediatric population and decreases with age in the adult and elderly population
- Qmax in girls was significantly higher than in boys
- No artificial restriction of voided volume, for example, minimum 150 ml, is appropriate. Patients with voided volume up to 50 ml can also be evaluated with the help of a nomogram
- Nomograms in centile form can be constructed to provide normal reference ranges for urinary flow rates covering a wide range of voided volumes.

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