A Study of Normal Female Uroflowmetry for Development of Flow Volume Nomogram in an Indian Population

Rana Pratap Singh[1], Arshad Jamal[2]

ABSTRACT

Introduction: Uroflowmetry is a common urological tool to diagnose bladder outlet obstruction in males but it is not appropriate to use the same for females as female uroflowmetry nomograms are not universally acceptable. By conducting this study we aim to create a nomogram for our population and compare our findings with other investigators. Study aimed to establish maximum flowrate and average flowrate in women and develop its Nomogram

Material and Methods: A total of 445 patients meeting inclusion criteria were enrolled and uroflowmetry performed. Peak flow rate (Qmax), average flow rate (Qave),time to peak flow rate (TQmax),voided volume(VV), post void residue(PVR) and total voiding time (TVV) were recorded. Corrected Qmax, Corrected Qave and Body Mass Index (BMI were calculated. statistical analysis was done.

Result: Both peak flow rate and average flow rate correlates positively with voided volume while they correlates negatively with age and BMI. Both corrected Qmax and corrected Qave were not having significant negative correlation with age and BMI. Multivariate regression analysis revealed only voided volume to significantly affect PFR independently. Univariate linear regression analysis revealed that only voided volume affects the Average flow rate.

Conclusion: This study gives a reference value of peak and average flow rates of normal women in the form of confidence limit to help clinicians diagnose poor flow rates taking into account voided volumes (flow–volume nomograms) as well as age (corrected flow–age nomogram).

Keywords: Female Uroflowmetry, Flow Volume Nomogram

INTRODUCTION

Uroflowmetry is one of the most commonly used screening outpatient tool used in urology. This test gives an objective assessment of voiding symptoms. Being non-invasive,easy to perform and relatively inexpensive, it plays an important role in early diagnois of voiding lower urinary tract symptoms(LUTS).[1-3]

Bladder Outlet Obstruction (BOO) and post micturition symptoms in women are still an enigma for physicians[4] mostly because of underreporting,unclear pathophysiology compounded by lack of diagnostic tools and lack of clear cut definitions of obstruction. It is not appropriate to utilize nomograms developed for men to be used in women as voiding physiology are different. Unlike men, no universally accepted nomogram is available for them.

Liverpool nomogram is available for women and is considered standard. Recently investigators have tried to create nomograms for Indian women.[1,2] A range of results are required to define the abnormal flow, after studying the various uroflow parameters in population of healthy persons. By conducting this study we aim to create a nomogram for our population and compare our findings with other investigators.

The objective of this study was at measurement of urine flow parameters by noninvasive uroflowmetry to establish normal reference ranges of maximum and average flow rates in healthy young adult women and to chart these values in the form of a nomogram.

MATERIAL AND METHODS

The Study was conducted in Department of Urology, Rajendra Institute Of Medical Sciences, Ranchi. Approval for the study was taken from Ethical committee of the institute. It was a cross sectional study descriptive in nature, conducted between March 2018 – March 2019. The sample size was calculated on the basis of validation from previously established RIs. Taking those values as reference, the minimum required sample size with error estimate to be within 1 ml/sec and 5% level of significance is around 340 patients. All healthy women volunteers of menstrual age group, including hospital staff, nursing students, visitors and relatives of patients were be our study population Volunteers meeting the inclusion criteria were enrolled after taking Informed consent. All volunteers were evaluated by history, general clinical examination and LUTS evaluation with IPSS scoring. Patients who met the inclusion criteria were enrolled. We analyzed a total of 445 female patients. Enrolled volunteers underwent uroflowmetry test in sitting position in adequate privacy. The uroflowmetry was done using the gravitimetric method. Peak flow rate (Qmax), average flow rate (Qave),time to peak flow rate (TQmax),voided volume(VV), post void residue(PVR) and total voiding time (TVV) were recorded. Definitions

1. Corrected Qmax = Qmax/$\sqrt{VV}$
2. Corrected Qave = Qave/$\sqrt{VV}$

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3. Body Mass Index (BMI) =Weight (kg)/Height (m)^2.

Inclusion Criteria

Healthy women of menstrual age group

Exclusion Criteria

Significant lower urinary tract symptoms, dysuria, hematuria, tuberculosis history, pregnancy, history of catheterization and refusal to participate.

STATISTICAL ANALYSIS

For purpose of nomograms (flow–volume and corrected flow–age) multiple transformations of data were asessed and the goodness-of-fit tested to determine whether a linear, quadratic,cubic,or logarithmic function best described the relation between the Qmax/Qave and volume and corrected Qmax /corrected Qave and age. The nomograms were expressed in the form of confidence limits. A p value of <0.05 was considered statistically significant.

The data was entered in MS EXCEL spreadsheet and analysis was done using Statistical Package for Social Sciences (SPSS) version 19.0.

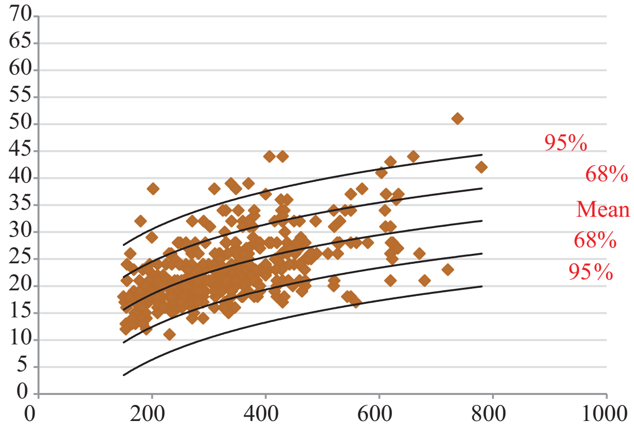
Variables	Mean ± Stdev	Median	Min-Max
Age	31.10 ± 7.90	31	18-45
Wt	52.83 ± 5.97	56	38-72
Height(meter)	1.43 ± 0.05	1.43	1.33-1.55
Bmi	21.45 ± 1.199	22.52	14.57-30.49
Voided volume	339 ± 184.55	320	150-1080
Pfr	22.93 ± 6.08	21	11-51
Afr	9.81 ± 2.62	6.25	4.3-20.2
Time to pfr	8.91 ± 4.73	8.6	5-30
Voiding time	28.2 ± 17.46	25	11-98
Corrected pfr	1.28 ± 0.27	1.24	0.39-1.023
Corrected afr	0.54 ± 0.124	0.54	0.24-1.287

Table-1: Observed variables

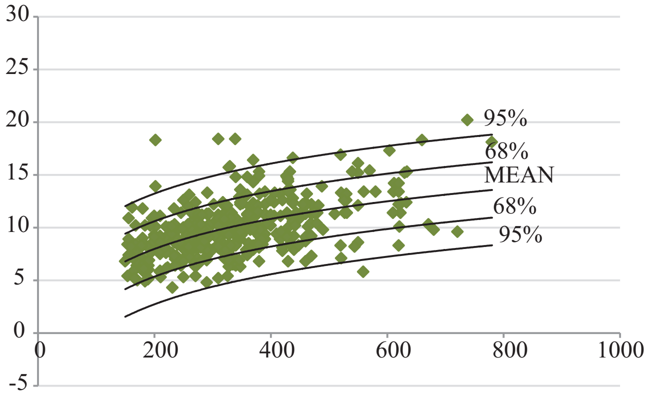
RESULTS

Records of 445 asymptomatic women were collected during the period of study.

Out of 445 women the mean age was 31.10 years with standard deviation (stdev) of 7.90 years. Study population has BMI 21.45 kg/m^2 with stdev of 1.19 kg/m^2. Mean value of



Graph-1- PFR and voided volume nomogram



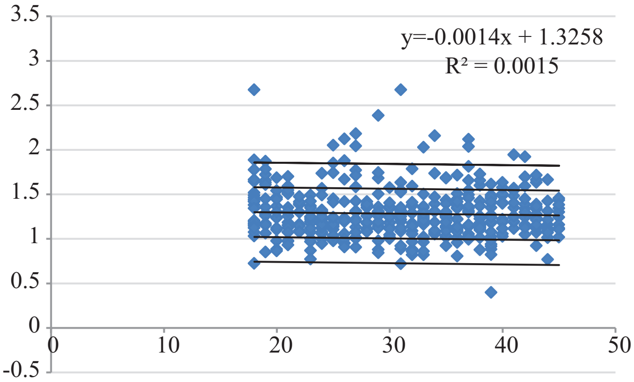
Graph-2: AFR and voided volume nomogram

		PFR	AFR	Corrected pfr	Corrected AFR
Age	Correlation Coefficient	-.039	-0.086	-.067	-.056
	P value	.406	.0717	.16	.287
Bmi	Correlation Coefficient	-0.122	-0.206	-0.235	-0.301
	P value	.027	.116	.130	.071
Voided volume	Correlation Coefficient	0.589	0.544	-0.097	-0.105
	P value	<.0001	<.0001	<.0296	<.006

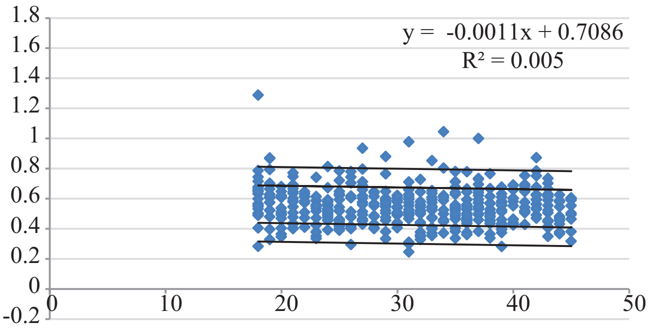
Table-2 showing spearman correlation coefficients between variables and flow rates

		PFR		AFR		CPFR		CAFR	
		CC	P	CC	P	CC	P	CC	P
Age									
	UNI	-0.047	NS	-0.046	NS	-0.079	NS	-0.058	NS
	Multi	-0.047	NS	-0.435	NS				
BMI									
	UNI	-0.198	NS	-0.085	NS	-0.126	0.056	-0.092	NS
	Multi	-0.9	NS	-0.7	NS				
VV									
	UNI	0.406	<.0001	0.311	<.0001	NA	NA	NA	NA
	Multi	0.012	<.0001	0.107	<.0001				

Table-3: Univariate and multi variate analysis summarised



Graph-3: Corrected PFR and age nomogram



Graph-4: Corrected AFR and age nomogram

Qmax and Qave± stedv were 22.93 ±6.08 and 9.81 ± 2.62ml/sec respectively. The mean voided volume with Stdev was 339 ± 184.55. Corrected Qmax and Corrected Qave were 1.28 ± 0.27 and 0.54 ± 0.12 respectively. Time to PFR was 8.91sec ± 4.73 sec, voiding time was 28.2 ±17.46sec. The average voiding time were 28.2 ± 17.46 sec (table-1).

Correlation among various parameters of uroflowmetry

Spearman rank correlation coefficient was used for analysis, Both voided volume and BMI was found to be significantly affecting the PFR. Of this PFR was highly significantly correlated with voided volume($p<.0001$). Voided volume affects PFR positively WHILE BMI ($p=.027$) AND Age negatively (P=NS). AFR similarly negatively correlated with age($p=.07$) and BMI($p=.01$), Voided volume was positively correlated with Qave ($p<.0001$).Both corrected Qmax and corrected Qave were not having significant negative correlation with age and BMI (table-2).

Univariate and multivariate regression analysis

After testing for spearman correlation, linear regression analysis was performed. Univariate linear regression analysis was done to see the factors which affect Qmax. AGE and BMI have no significance while voided volume significantly affects PFR. After adjusting the confounding factors, multivariate regression analysis was performed to see if PFR is affected independently by different variables. We found ONLY voided volume to significantly affect PFR independently. Univariate linear regression was used to find out significant factors affecting AFR. Only voided volume was found to affect the AFR (graph-1,2,3,4).

PFR had significant positive correlation with voided volume ($P < 0.0001$). A quadratic function best describe this relation as per the following equation:

$PFR=12.504+(0.033*VV)-\{(4.1E-6)*VV^2\}$

AFR also had positive correlation with voided volume ($P < 0.0001$) and a quadratic function best described this relation as per following equation:

$AFR=5.15+(0.015*VV)-\{(4.6E-06)*VV^2\}$

Corrected PFR and corrected AFR independently were not affected by any of the variables examined. No multivariate analysis was performed as age and BMI was not found to be affecting AFR significantly.

The final equation for the nomogram graphs were

$\ln PFR=9.975\ln x-34.34$, $R^2=0.323$

$\ln AFR =4.11\ln x-13.80$, $R^2=0.294$

CORRECTED QMAX $=0.001x+0.708$, $R^2=0.005$

CORRETED QAVE $=0.001x+1.325$, $R^2=0.001$

Univariate and multivariate influences of AGE, VV, and BMI, on Qmax, Qave, corrected Qmax, and corrected Qave are shown in Table-3.

DISCUSSION

Uroflowmetry is the measurement of urine volume passed per unit time, thus describing the product of detrusor contractility, urethral resistance and, often, abdominal straining. In females the only flow modulating component is the urethra, with an anatomical length of 2-5 cm.[7]

The nomograms were created keeping in mind the differences observed in Indian population[1,2,3] in comparison to western population with regards to various voiding parameters as observed by various investigators. Nomograms in the form of standard deviations were developed. Like other investigators we used statistical transformations in their construction to overcame the problems created by inaccuracies when untransformed standard deviations were used.

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*.[4], Haylen, *et al*.[5], Vikash Kumar et al[2], Barapatre et al.[1]

The use of nomogram help overcome the assumptions based only on single flow rates without considering the voided volumes as they are highly correlated. No deterioration in flow rates were observed at high flow rates as observed by Kumar et al.[2], they concluded that after a VV of 700 ml there is a plateau followed by a decline in PFR but the same was not observed by other investigators.[1,5]

These charts offer a normal flow range in women at a wide range of voided volumes for the PFR and AFR. Corrected Qmax was first defined as Corrected Qmax = Qmax/√VV by Von Garretts considering a curvilinear flow–volume relation. It is another way to evaluate Qmax over a wide-range of VV.

The inclusion of nomograms representing volume corrected PFR and AFR were done to exclude the effects of voided volume on flow rates.

Mean value of Qmax and AFR ± stedv in our study were 22.93 ±6.08 and 9.81 ± 2.62ml/sec respectively similar to most of the studies in Asia probably attributable to lower BMI[1] and sitting position[3] (than squatting) in Indian women these values are lower than most of western data more so making the nomograms and described PFR[5,6,13] for that populations not applicable to our populations.

Our results are consistent with most authors that flow rates in women are independent of age unlike men.

Our finding is similar to Haylen, *et al*.[6] who reported no dependence of flow rate with age but different from Kumar et al[2] and Yogesh Barapatre[1] who observed a negative correlation with age and PFR and AFR.The population in our study is a healthy population with no co morbidities of very young average age (31 Years).Further sub-categorisation of population according to age after inclusion of appropriate number of elderly women will make this issue more clear.

The effect of voiding position[3] may be affecting the flow rates in our study population, squatting position is common in our country but during this study they were asked to sit to void.

Fantl et al. are credited with creation of qmax and volume depicting graphs based on 60 participants and repeated voids.[8]

Haylen et al.[6] described a centile based nomogram, aka 'Liverpool

nomogram' based on results of 249 women.Liverpool nomogram is validated[10] and is considered standard for women.

Elisabetta Costantini[11] et al found that Uroflowmetry results in women can be analysed by using Liverpool nomogram and Uroflowmetry has a good specificity, a high negative predictive value, and a good diagnostic capacity such as to make it useful as the first diagnostic approach in urogynaecologic patients.

Blaivas and Groutz[12] analysed urodynamic database of 600 women of mean age 64.8 ± 10.7 years of age group in and reported PFR 25.6 ± 11.2 ml/sec and mean VV 250 ± 113 ml but they did not study healthy women.

Barapatre. Y et al[1] studied 308 women with mean 33 years, voided volume 289.79 ± 166.52 ml, maximum flow-rate (Qmax) 23.06 ± 9.40 ml/sec, average flow-rate (Qave) 13.08 ± 6.00 ml/sec. Confidence limit flow–volume nomograms were described and validated using data of asymptomatic (n =25) as well as symptomatic women (n = 22). Corrected Qmax and corrected Qave to age nomograms were also introduced.The findings of our study and nomograms created by us are very similar to those obtained by these investigators.

Kumar et al[2] studied 299 females, 202 were pre-menopausal (Group IV) and 97 were post-menopausal, Among female groups, the Qmax values were 22.98 ml/sec in the pre-menopausal group and 19.04 ml/sec in the post-menopausal group.The mean voided volume was 399 ± 189 ml. The mean maximum flow rate and average flow rate were 21.8 ± 8.22 ml/sec and 12 ± 4.6 ml/sec, respectively.

The clinical utility of nomograms in the management and diagnosis of voiding dysfunction cannot be overemphasized.[9] Since flow rates are volume dependent, nomograms essential for correct interpretation of raw uroflowmetry data. Currently available nomograms provide easy interpretation of flow rates with corresponding voided volume relative to normal.

CONCLUSION

This study gives a reference value of peak and average flow rates of normal women in the form of confidence limit to help clinicians diagnose poor flow rates taking into account voided volumes (flow–volume nomograms) as well as age (corrected flow–age nomogram).

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