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THE CHARACTERISTICS AND IMPROVEMENT OF URINE FLOW RATE NOMOGRAMS

Hypothesis / aims of study

An enquiry to our centre resulted in a search for equations characterising the curves used on three urine flow rate nomograms, as they were needed to test compliance with accepted norms. It was surprising that formulae exist in published form for two nomograms but not for the third. This study aimed therefore to present the equations for frequently used adult nomograms, including the previously unpublished equation, and note the differences between them. The study used these observations to propose new, patient specific nomograms that include post void residual (PVR) urine volume and patient age.

Study design, materials and methods

References are generally made to the Siroky, Liverpool and Bristol nomograms, e.g. in (1). The equations for these three were obtained from, respectively, a later mathematical paper (2), the original study and the unpublished MD Thesis. To compare the nomograms, urine flow data from 15 obstructed and 15 unobstructed patients (both urodynamically proven) were plotted on one graph using the original papers' recommended lower limits of normal values. The specificity was compared both before and after including values for PVR volume and age.

Results

The characteristics of the nomograms are described in Table 1. The Siroky and Liverpool versions can be supplied with most urodynamics machines, whilst the Bristol is only supplied with a few. The equations are presented separately in Table 2.

Nomogram	**Asymptomatic population used**	**Characteristics**
Siroky 1979	80 male, age unknown	Uses bladder volume, not voided volume Average flow nomogram included Quartic equation, developed later (2)
Kadow 1985 (Bristol)	123 male (50 – 80y)	Uses voided volume, is age specific for older men Logarithmic equation
Haylen 1989 (Liverpool)	331 male (16 – 64y) 249 female (16 – 63y)	Equations with age factor, uses voided volume Average flow nomograms included Square root (male), logarithmic (female) equations

Table 1 Characteristics of urine flow rate nomograms

Nomogram	**Equation**
Siroky 1979 from (2)	$Q\max = 7.327 + 0.1126 \times Vblad - 2.243.10^{-4} \times Vblad^2 + 2.604.10^{-7} \times Vblad^3 - 1.615.10^{-10} \times Vblad^4$
Kadow 1985	$Ln(Q\max) = -0.6087 + 0.5852 \times Ln(Vvoid)$
Haylen 1989 (Liverpool)	Male: $\sqrt{Q\max} = 2.37 + 0.18 \times \sqrt{Vvoid} - 0.014 \times age$ Female: $Ln(Q\max) = 0.511 + 0.505 \times Ln(Vvoid)$

Table 2 Equations of flow rate nomogram curves for mean normal values

The recommended curves for lower limits of normal values, and hence for further investigation, are plotted in Figure 1 for comparison, alongside data from obstructed and unobstructed males aged > 50 years.

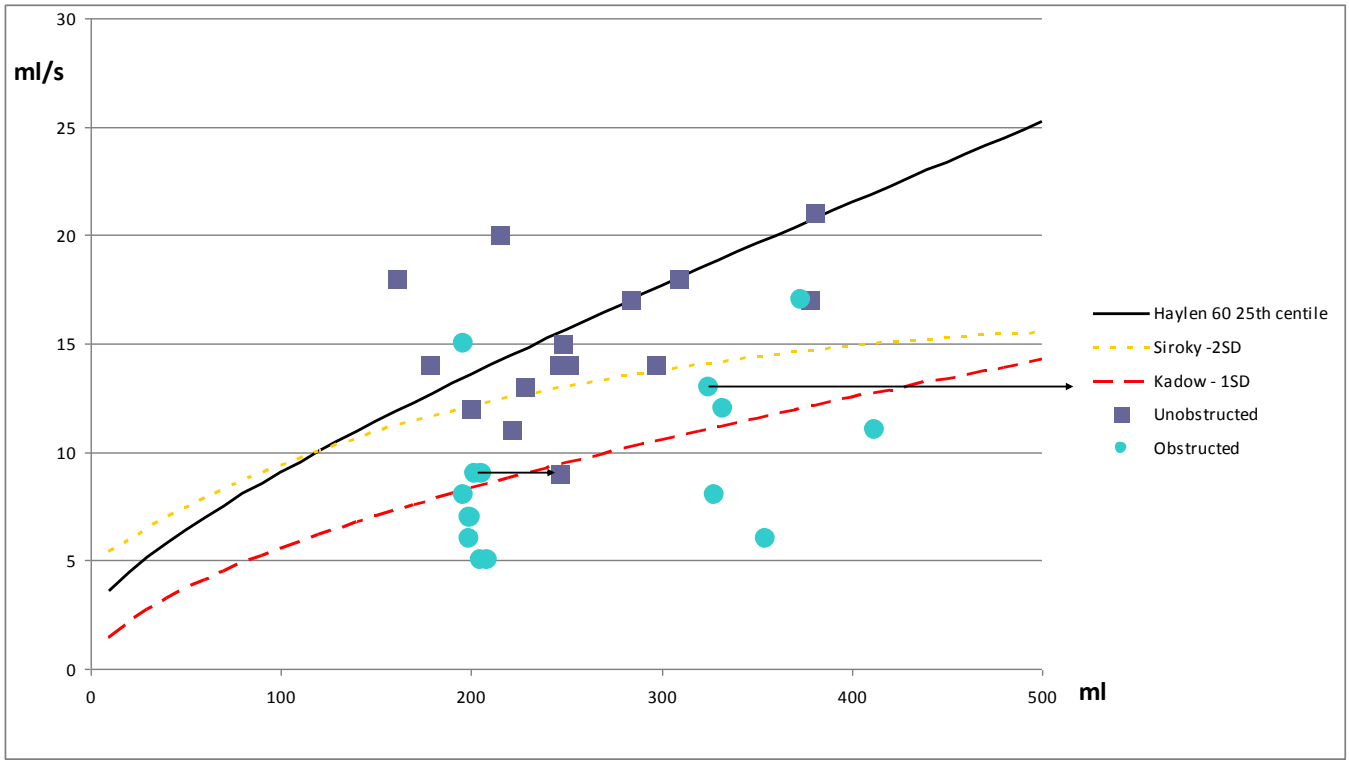

Figure 1 Comparative plot of male flow nomograms, superimposed with data from 15 obstructed and 15 unobstructed males >50 yrs and with >150 ml void

With the sample data above, it is interesting to note that when PVR is included in the volume (equivalent to a right shift of all points by the amount of residual volume), the specificity of the Bristol (Kadow) nomogram alone increases while sensitivity remains constant. The movements of the two points of data effecting this change are marked by arrows on Figure 1.

Interpretation of results

It is significant to note that the Liverpool contains (for men) an age correction that is not generally used, and the Siroky, though developed from men, has been used for women too. Both original papers offer average volume nomograms, though these are rarely cited elsewhere and the value of the measurement is yet to be understood. Also, the Siroky uses bladder volume, whereas the other two use voided volume, a fact we suspect is not often recognised.

The Siroky nomogram uses bladder volume on the graph because the efficiency of the detrusor is best assessed by bladder volume (voided plus residual volumes) rather than the volume voided alone. Thus, any test that uses voided volume as an indicator should consider adding the PVR volume, as this has been shown to increase the specificity of a flow rate test (3). The Liverpool nomogram's age correction can easily be incorporated into computer software, a factor that will again improve the test's specificity, since Kadow showed that an age-specific nomogram is an improvement and the cut off points of these two are widely separated.

We thus propose a four dimensional nomogram incorporating maximum flow rate, voided volume, PVR and patient age. For a given patient and PVR, a two dimensional nomogram with greater specificity than before can then be displayed for clinical assessment.

Concluding message

Currently available nomograms are occasionally misused and differ significantly, particularly for older patients. The development and proper use of these nomograms deserves to be better understood. We propose a nomogram that combines the traditional indices (maximum flow and voided volume) with post void residual volume and patient age.

References

1. "Textbook of Genitourinary Surgery"; Whitfield ed; Blackwell, Oxford. 1998, p.485
2. Comp Meth Prog Biomed 1993: 39:285-288
3. J Urol 2006;175:437

Disclosures

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