STUDY ON THE RELATION OF THE SHAPE OF THE UROFLOWMETROGRAM AND THE URETHRAL LOSS COEFFICIENT CALCULATED FROM THE UROFLOWMETROGRAM

Ken-ichi NISHIMOTO[1], Koichiro TASHIRO[1], Naomasa YOSHIDA[1], Koji HARIMOTO[1], Keiichiro NISHIKAWA[1], Tomoaki TANAKA[2], Tatsuya NAKATANI[2] and Kosaku YASUDA[3]

[1]*The Department of Urology, Fuchu Hospital,*
[2]*The Department of Urology, Osaka City University, Graduate School of Medicine,*
[3]*The Department of Urology, Dokkyo University, School of Medicine, Koshigaya Hospital*

The shape of the uroflowmetrogram reflects voiding conditions. Using a voiding simulation, we examined whether the urethral loss coefficient (LC) calculated from the approximated uroflowmetrogram correlates with parameters that regulate the shape of the uroflowmetrogram.

A total of 161 normal and abnormal uroflowmetrograms were used. Normal female subjects and patients before and after transurethral resection of the prostate (TURP) were also studied. The ratio of maximum flow rate (Qmax) to flow time (T), a parameter expressing the shape of the uroflowmetrogram, was calculated. The uroflowmetrograms were approximated using a voiding model, and the urethral LC was calculated.

As a result, a strong negative correlation was observed between the Qmax-flow time ratio, Qmax/T, and LC. Qmax/T is the vertical to horizontal ratio of the uroflowmetrogram and indicates the average degree of acceleration of flow rate during voiding. On the other hand, urethral LC, which can be estimated from the shape of the uroflowmetrogram, is considered a kind of urethral resistance. We concluded that when urethral resistance is high, the degree of acceleration of flow rate is low on average. Our study also indicated that Qmax/T was less affected by voided volume (VV) compared to Qmax. As Qmax/T is not as dependent on VV, it is useful for comparing cases with different VV

(Hinyokika Kiyo **52** : 7-10, 2006)

Key words : Loss coefficient, Uroflowmetry, Voiding model, Maximum flow rate, Simulation

INTRODUCTION

The shapes of uroflowmetrograms are thought to reflect voiding conditions. This is because the temporal change in flow rate is dependent on the relation of detrusor pressure and urethral resistance during voiding. We have reported a method to distinguish normal and abnormal uroflowmetrograms using three parameters regulating the shapes of uroflowmetrograms[1,2] Two of these parameters do not have dimensions while one (Qmax/T) does. This dimension is L^3T^{-2} and is the same as the temporal change in flow rate.

On the other hand, the urethral loss coefficient (LC) can be calculated from the relation of kinetic energy and pressure loss obtained by approximating the uroflowmetrograms using a voiding model[3,4] This LC is a kind of urethral resistance and is presumed to have a negative correlation with the degree of acceleration of flow rate. By comparison with the actually measured Qmax/T ratio, we can determine whether urethral LC can be practically used, whether it can be conveniently substituted by Qmax/T and to what extent Qmax/T reflects urethral LC. For this purpose, we examined the relation between urethral LC and the shape of the uroflowmetrogram.

MATERIALS AND METHOD

A total of 161 normal and abnormal uroflowmetrograms were used. In addition, 9 normal female subjects and 16 cases before and after transurethral resection of the prostate (TURP) (8 patients) were studied. The Qmax/T ratio was calculated from maximum flow rate (Qmax) and flow time (T) obtained from these curves (Fig. 1).

Uroflowmetrograms were approximated using our

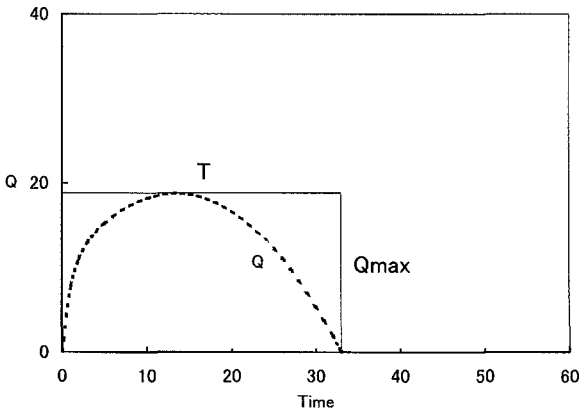

Fig. 1. Qmax/T shows the vertical to horizontal ratio of the uroflowmetrogram.

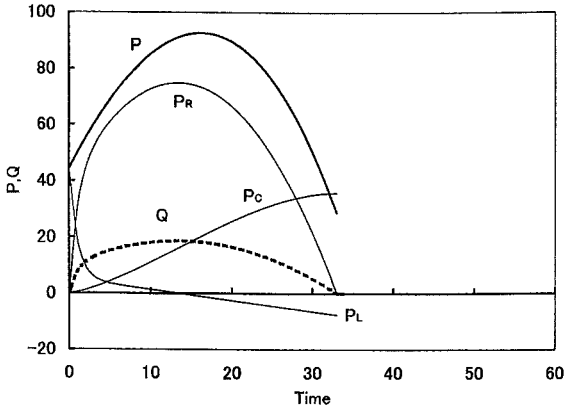

Fig. 2. Pressure components (P_L, P_R, P_C) of the intraurethral pressure prifile (P) corresponds to uroflow (Q).

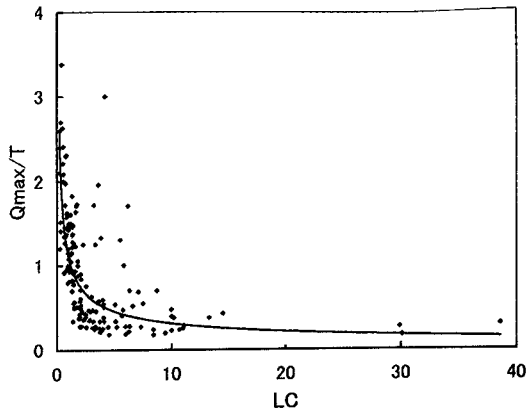

Fig. 3. Correlation between LC and Qmax/T. $Qmax/T = 1.09\ (LC)^{-0.54}$, $R^2 = 0.51$.

previously reported voiding model[3,4], and urethral LC and voided volume (VV) were calculated[5] As the temporal change in pressure loss contributing to urethral inertial resistance, frictional resistance and elastic resistance can be separately calculated by approximating the uroflowmetrograms using our voiding model[4], LC was calculated as follows. When the integral value of pressure loss during voiding time contributing to inertial, frictional and elastic resistance was P_L, P_R and P_C, respectively (Fig. 2), and the total sum of energy used for elastic resistance during voiding was W_L, $LC = (P_R + P_C)/W_L$. VV was calculated by integrating the approximated flow rate. Age was not taken into consideration.

RESULTS

The relation of Qmax/T and LC was expressed by the regression line $Qmax/T = 1.09 \times LC^{-0.54}$ (Fig. 3). The relation of Qmax and LC was similarly expressed by $Qmax = 18.3 \times LC^{-0.26}$ When the contribution of VV on Qmax/T and Qmax was studied, the contribution rate of both LC and VV on Qmax/T calculated by multivariate analysis was $R^2 = 0.55$. The contribution rate of both LC and VV on Qmax was $R^2 = 0.67$.

DISCUSSION

Urethral LC had a negative correlation with Qmax/T, and the contribution rate of LC alone on Qmax/T was 51% and the correlation coefficient was 0.71. The contribution rate of both VV and LC on Qmax/T was 55%. As there was only a 4% increase in the contribution rate when VV was taken into consideration, the effects of VV were thought to be minimal. The contribution rate of LC alone on Qmax was 36% and the correlation coefficient was 0.6. The contribution rate of both LC and VV on Qmax was 67%. This indicated that the degree of contribution of LC alone was smaller on Qmax compared to Qmax/T, while the degree of contribution of both LC and VV was similar on Qmax. These results suggested that Qmax/T better reflected urethral LC compared to Qmax, and that the effects of VV were minimal on Qmax/T. Qmax/T is therefore more suitable compared to Qmax when examining patients with different VV.

Qmax is often actually used in comparing the degree of changes in lower urinary tract obstruction, but as the degree of contribution of LC and VV on Qmax is about the same, Qmax is affected not by VV alone but also by LC to the same extent. When this relation is illustrated using a VV-Qmax nomogram, the relation of VV-Qmax is thought to change with urethral LC as a parameter[5] (Fig. 4). That is, when VV is the same, Qmax increases as LC decreases and Qmax decreases as LC increases. This agrees with actual clinical phenomena.

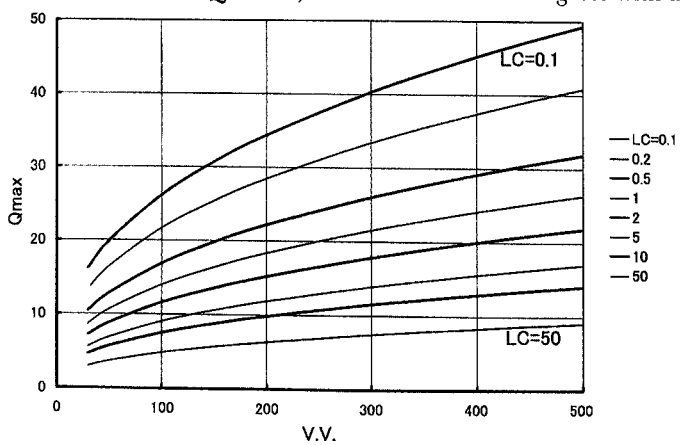

Fig. 4. Qmax-V.V. relation with LC as a parameter.

Table 1. Mean value of the groups

	Female	Male	Post TURP	Pre TURP
Qmax/T	2.10±0.78	1.41±0.43	1.41±0.68	0.276±0.070
Qmax	25.2±9.1	18.7±4.0	18.8±6.0	9.19±2.50
LC	0.36±0.15	1.36±0.92	1.43±1.75	9.4 ±12.1

Mean±S.D.

When Qmax is used to compare urethral resistance, it is necessary to adjust VV to about the same levels. In the result, urethral LC can be calculated non-invasively from the uroflowmetrogram. It correlated with the horizontal to vertical ratio of the uroflowmetrograms, Qmax/T, and the contribution rate was 51%. As Qmax reflected LC and VV to the same extent, Qmax/T better reflected LC compared to Qmax without being affected as much by VV.

Many factors affect Qmax and Qmax/T. However, it is clinically extremely useful to be able to evaluate the conditions of the urinary tract non-invasively with accuracy. Our results suggested that urethral LC can be evaluated by Qmax/T to some extent.

Qmax/T, Qmax and LC were studied in 9 normal female subjects, 60 normal male subjects without urinary disturbance (included in the 161 cases studied) and 16 cases before and after TURP (8 patients) (Table 1). They were not studied according to VV. For example, there was no significant difference in Qmax between male and female groups ($p = 0.064$), but there was a significant difference in Qmax/T between male and female groups ($p=0.032$) (Fig. 5). The ability of Qmax/T to separate a difference among the groups is higher than that of Qmax. We previously reported that the normal value of Qmax/T was 0.78 or more[1], and LC equivalent to this value calculated from the regression line was 1.9 (Fig. 3). When the values of LC for both normal female and male subjects are considered, LC of 2 or less is normal, and from the LC value of 1.35±0.92 obtained from normal male subjects ($n=60$), LC of 4 or more can be regarded as abnormal. LC of 2 to 4 can be considered within the gray zone.

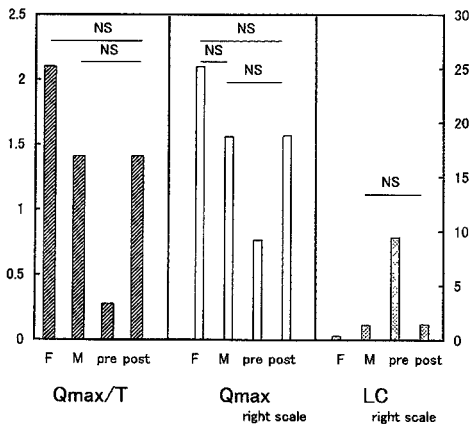

Fig. 5. Significant difference among the groups in Qmax/T, Qmax and LC ($p<0.05$). Simplified characters show as follows. F: normal female group, M: normal male group, pre: preTURP group, post: postTURP group, NS: no significance.

Urethral LC is smaller in normal female subjects compared to normal male subjects, reflecting the anatomical structure of the urinary tract. It is increased in BPH patients before TURP, but urethral resistance decreases and LC improves to about the same as those in normal male subjects after surgery. Qmax/T also improves to normal levels after TURP. Qmax is also higher in female normal subjects compared to normal male subjects and improves after TURP (Fig. 5).

Urethral LC can be calculated non-invasively from the uroflowmetry curve, and if it is used clinically, it can quantitatively express the conditions of the urinary tract. Moreover, our results indicated that as Qmax/T reflects urethral LC, LC can be conveniently estimated from Qmax/T to some extent.

REFERENCES

1) Nishimoto K, Iimori H, Ikemoto S, et al.: Criteria for differentiation of normal and abnormal uroflowmetrograms in adult men. Br J Urol **73**: 494–497, 1994
2) Shimizu K, Takahashi Y, Nakai K, et al.: A new method of analysing uroflowmetric studies in low voided volume males with obstructive diseases of the lower urinary tract. Jpn J Urol **75**: 1964–1969, 1984
3) Nishimoto K, Nishio S and Hayahara N: Approximation of uroflowmetrograms using micturition model. Hinyokika Kiyo **41**: 27–32, 1995
4) Nishimoto K, Yasuda K, Nishikawa K, et al.: Non-invasive estimation of intra-urethral pressure profile from uroflowmetric curve. Int J Urol **11**: 885–889, 2004
5) Nishimoto K, Yoneda Y, Kiyota A, et al.: Relation of maximum flow rate and voided volume estimated from uroflowmetry curve. Proceedings of ICS 32nd Annual Meeting: 82–83, 2002

(Received on January 6, 2005
Accepted on August 2, 2005)

和文抄録

尿流曲線の形と尿流曲線から計算された尿道の損失係数との関係についての考察

西本　憲一[1]，田代孝一郎[1]，吉田　直正[1]，張本　幸司[1]
西川慶一郎[1]，田中　智章[2]，仲谷　達也[2]，安田　耕作[3]
[1]生長会府中病院泌尿器科，[2]大阪市立大学大学院泌尿器病態学講座
[3]獨協医科大学越谷病院泌尿器科

尿流曲線の形は排尿状態を反映している．排尿のシミュレーションを使い尿流曲線の近似から計算された尿道の損失係数が尿流曲線の形を規定するパラメーターと相関するのか検討した．

合計161例の正常異常尿流曲線を使用した．さらに正常女性，経尿道的前立腺切除術前後の症例についても検討した．尿流曲線の形を表現するパラメーターの1つである最大尿流率（Qmax）と排尿時間（flow time, T）の比を計算した．一方，尿流曲線を排尿モデルで近似し，尿道の損失係数（LC）を計算した．

結果として，Qmax と flow time の比 Qmax/T は LC と強い相関を認めた．

Qmax/T は尿流曲線の縦横比であるが，排尿中の平均的な流量の加速の度合いを示している．一方尿道の損失係数 LC は尿道の抵抗の一種と考えてよい．抵抗が大きい尿道では，尿流量の加速の程度が平均値として小さいと結論された．尿流曲線の形から尿道の損失係数を推定できる．Qmax/T は Qmax に比較して排尿量の影響が少なかった．Qmax/T は排尿量に依存する程度が小さく排尿量の異なる症例を比較するのに適当である．

（泌尿紀要 **52**：7-10，2006）