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Review

Clinical value of intravesical prostatic protrusion in the evaluation and management of prostatic and other lower urinary tract diseases

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Abstract Intravesical prostatic protrusion (IPP) has emerged as a new prostatic morphometric parameter of significance to aid the clinicians in various aspects of managing the patients with some diseases of the lower urinary tract and the prostate. These include but may not be limited to its role in such conditions as: bladder outlet obstruction, trial without catheter, medical treatment effect, progression of lower urinary tract symptoms related to benign prostatic hypertrophy (LUTS/BPH), risk factor for bladder stone in BPH, overactive bladder, prostate carcinoma, and early urinary continence recovery after laparoscopic radical prostatectomy. In this review, I will try to summarize the different researchers' efforts on the potential practical application of this clinical tool. Technology is ever evolving to help us in the diagnosis and management of our patients. However, we as clinicians should contemplate their cost and possible suffering for the patient by wise and judicious utilization based on our clinical experience and tools. IPP seems to be one such promising clinical tool.

1. Introduction

Jean Casimir Félix Guyon [1], one of the founders of Société Internationale d'Urologie (SIU), gave a lecture on the intravesical prostatic protrusion (IPP) in late 19th Century in Paris. Ohnishi et al. [2] nearly a century later published the first article on the subject in Japanese language. These authors discussed the development and clinical significance of protrusion of hypertrophic prostate into the bladder as estimated by transrectal ultrasonotomography. The authors

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presumed from their observations that the development of protrusion depended upon the growth rate and elasticity of the surgical capsule of the prostate. Watanabe [3] later summarized his achievements in a review article for the diagnosis of benign prostatic hyperplasia (BPH) investigating several indexes, among them was the presumed circle area ratio (PCAR) and concluded that the pathological state of BPH depends not on the size but on the shape of the prostate. However, since the start of the 21st century main studies of IPP originated from the Singapore General Hospital by Prof. Foo and his colleagues [4]. Watanabe and his group [3] relied on transrectal ultrasound sonography (TRS) for their investigations, which appears to be somewhat invasive and unpleasant to the patient. The Singapore group instead used the bedside transabdominal sonography (TAS) technique that is less time consuming, and more comfortable to the patient [4]. These investigators hypothesized that IPP among other subjective and objective measures could potentially be a useful marker for the assessment and management of BPH and tried to develop a reliable and consistent methodology to that effect. Since the bladder volume affects IPP measurement, they tried to determine a suitable volume of the bladder at the time of the TAS. Empty bladder or very full bladder (>400 mL) is not an appropriate condition for the test and they advise a volume between 100 and 200 mL. In addition, their study reveals a good correlation between the transabdominal and transrectal ultrasound measurements of prostatic volume and they have since used the TAS for their IPP measurements [4].

2. IPP in the diagnosis of bladder outlet obstruction

The Singapore group's [5] first attempt to use IPP was to calculate its correlation to the diagnosis of bladder outlet obstruction (BOO). To this effect, they decided to quantitate the degree of prostate intrusion into the bladder in millimeters. They prospectively studied 200 ambulant men aged 50 or more years presenting with lower urinary tract symptoms (LUTS), between July 1997 and December 1999 with a minimum follow-up of 12 months. They excluded patients with a known history of LUTS, prostate or bladder carcinoma, bladder calculi, or neurological deficit from the study. Using TAS at the bladder capacity of 150–250 mL, they moved the sagittal scan of the ultrasound probe both horizontally and longitudinally, and assessed the bladder neck for protrusion of the prostate into the bladder by measuring the vertical distance from the tip of the protrusion to the circumference of the bladder at the base of the prostate gland. Less than 5 mm was graded I, between 5 and 10 mm was graded II, and grade III was more than 10 mm [4,5]. These studies revealed that maximum flow rate (Q_{max}), postvoid residual urine measurement (PVR), prostatic volume (PV) and IPP grade were good predictors of BOO. However, the first three had lower negative (61%–75% *vs.* 79%) and positive (74%–93% *vs.* 94%) predictive values than IPP grade, especially grade III IPP. One hundred and twenty-five patients were diagnosed as having significant BOO (index >40); 95 had grade III and 30 grade I–II IPP. Seventy-five patients had no significant BOO (index <40); of these, only six had grade III and 69 grade I–II IPP. Adding IPP grade to the combination of Q_{max} and PVR increased the predictive power further up. In patients with a low Q_{max} (<10 mL/s) and any PVR or with a high Q_{max} with a high PVR (>100 mL), the presence of IPP grade III would aid in evaluating obstruction compared with IPP grade I–II. For example in case of low Q_{max} and high PVR, IPP grade III missed only one case out of 61 diagnosed as obstructed by pressure-flow study (PFS) (98% sensitivity). Indeed, IPP grade III was associated with higher BOO index (67.15, 101 men) than IPP grade I–II (43.13, 99 men; $p < 0.001$). The logistic regression analysis showed that IPP grade was a significant independent variable when other covariates of PV, PVR, Q_{max}, International Prostate Symptoms Score (IPSS), quality of life (QoL) and age, were considered. In this study and a recent review, almost all patients with IPP grade III had significant obstruction [5,6].

IPP was the subject of another research from Japan and Singapore in the diagnosis of BOO, compared with another non-invasive sonographic method called Doppler ultrasound urodynamics (Doppler UDS) [7]. The purpose was to test each one's accuracy and if their combination would improve this potential. For this study IPP grade I was considered non-obstructive, grade II equivocal and grade III obstructive. An ultrasound image-directed color Doppler system was used by a remote control robotic manipulator to achieve gentle contact with the perineal skin close to the anus. Uroflowmetry (UFM) obtained in sitting position. The flow velocity curves from two sites, the distal prostatic urethra just above the external sphincter (S1), and the sphincteric urethra (S2) were recorded. The maximal flow velocities at both sites were recorded at the same instant. From these data, the velocity ratio (VR = V1/V2, where V1 is the velocity at S1 and V2 is that at S2), and the functional cross-sectional area at S1 (A1) were computed from the following formula: A1 = peak urinary flow rate/V1. Patients with a VR exceeding 1.6 were classified as obstructed, and those with a VR less than 1.1 were classified as unobstructed. Out of 168 initial outpatients, only 30 patients could complete the PFS study. The sensitivity and specificity of the combined methods was 100% and 91%, respectively [7].

In a prospective study, the Singapore group compared IPP, PV, and prostatic specific antigen (PSA) in the prediction of BOO [8]. They enrolled 114 male patients older than 50 years from November 2001 for 1 year. They evaluated the patients with digital rectal examination (DRE), IPSS, PSA, UFM, PVR, IPP, and PV using transabdominal ultrasound scan, which was done by a single operator. Serum PSA levels were divided into three groups: ≤1.5 ng/mL, >1.5–4 ng/mL and >4 ng/mL. PV measurements were also divided into three groups: ≤20 mL, >20–40 mL and >40 mL. Statistical analysis included scatter plot with Spearman's correlation coefficients and nominal logistic regression. This study demonstrates that PSA, PV, and IPP correlate well with one another. With IPP grade III the rate of no obstruction (BOO index ≤ 20) was only 10%. As a non-invasive clinical parameter, IPP predicts BOO better than PSA or PV.

In a more recent study, with 408 males, evaluating PV and IPP effect on benign prostatic obstruction (BPO) [9], investigators found a fair positive correlation between the

PV and IPP (Spearman, $r_s = 0.62$, $p < 0.001$) with important clinical exceptions. There was negative correlation between the PV and Q_{max} ($r_s = -0.20$, $p = 0.022$), IPP and Q_{max} ($r_s = -0.30$, $p < 0.001$). They concluded that IPP is a better predictor of BPO than PV [9]. IPP can be used to direct the appropriate patients to more aggressive treatment strategies, such as surgery [8].

3. IPP as a predictor of trial without catheter (TWOC)

There are five published articles studying IPP as a predictor of TWOC success [10–14] (Table 1). Although the study design and the outcome measures are different, all demonstrate the value of this tool in predicting that high grade IPP causes an unsuccessful TWOC close to 90% in some. The period of indwelling catheterization before TWOC attempts has differed from 24 h to 14 days.

Singaporean researchers in this regard took the first attempt [10]. They prospectively used IPP in 100 patients to predict the failure rate of TWOC in males older than 50 years presenting with an initial episode of acute urinary retention (AUR). IPP was measured using their previously published technique [5]. UFM and PVR were recorded after catheter removal. Failure was defined as unsuccessful voiding after catheter removal, PVR $>$ 100 mL, or $Q_{max} < 10$ mL/s. The failure rate of the voiding trial based on IPP grades I to III were 36% (13 of 36 cases), 58% (11 of 19), and 67% (30 of 45). This rate was significant (chi-square test for trend 0.007). According to these findings, approximately two thirds of IPP grade I patients benefit from the TWOC attempt, while two thirds of IPP grade III patients fail this attempt [10].

Researchers from Edinburgh, UK tried to identify white patients that would not benefit from TWOC according to Asian studies and avoid trying TWOC on them [11]. They studied the effects of PV and IPP in these patients to find out if α-blockers before a TWOC are of any benefit to them. They prospectively recruited 121 men aged 50 years or more presenting with AUR based on a strict selection criteria. At presentation, factors thought to precipitate AUR were treated, α-blocker therapy started, and the patients brought back for a trial without catheter after 2 weeks. PV and IPP were measured by TRS. Fifty-seven patients fulfilled the study selection criteria. Twenty-five men (43.9%) had a successful TWOC. Mean IPP was significantly smaller in those who had a successful TWOC (7.2 *vs.* 16.5 mm, 95%CI 4.5–14, $p < 0.001$). With IPP correlating well with PV ($r = 0.588$), mean PV was also smaller in men with a successful TWOC, albeit with a smaller effect size. Men with an IPP of 10 mm or less, compared to those with a larger IPP, were 6 times more likely to have a successful TWOC.

Researchers from National University Hospital of Singapore compared the efficacy of Alfuzosin XL 10 mg once daily for 2 days in the acute management of AUR with placebo in 67 patients with BPH and determined its impact as a predictor in a double blind placebo controlled clinical trial [12]. Patients with IPP grade III had a significantly lower chance of successful TWOC ($p = 0.04$) compared with lower grades. IPP remained a significant independent predictor for failed TWOC after AUR ($p = 0.034$) on multivariate analysis.

Nepalese investigators conducted a study to identify the factors predicting the success or failure of TWOC in 64 patients with first episode of AUR [13]. They prescribed Tamsulosin 0.4 mg daily for 3 days to 64 patients and TWOC was successful in 28 patients. Using receiver operating characteristic curves (ROC) a cut-off value of 8 mm for IPP detected failures with a specificity of 89% and success with a sensitivity of 92% with area under ROC (AUROC) of 0.98. They concluded that IPP is the most accurate parameter in predicting the success of TWOC.

Malaysian researchers studied 32 patients with first episode AUR by TAS. Patients with IPP grade III had a significant failed TWOC compared with grade I ($p = 0.022$) and grade II ($p = 0.041$) [14]. This subject is reiterated in a recent review [6].

4. IPP as a predictor of medical treatment effect

The role of IPP has been studied in various fields of therapy such as efficacy (response to) of α-blocker treatment,

Table 1 Brief presentation of five published articles studying intravesical prostatic protrusion (IPP) as a predictor of trial without catheter (TWOC) success.

Reference	*n*	Catheterization periods (days)	Age (years)	Failed TWOC
Tan and Foo (2003) [10]	100	$\leq$2	71	G1: 36% G2: 57% G3: 67%
Mariappan et al. (2007) [11]	57	14	70	G1 and G2: 22% G3: 87%
Tiong et al. (2009) [12]	67	2	NA	G3 $>$ G1-2 ($p = 0.04$)
Bhomi and Bhattachan (2011) [13]	64	3	NA	IPP cut-off value 8 mm AUROC = 0.98
Syazarina et al. (2013) [14]	32	10	70.5	G1: 13% G2: 14% G3: 82%

AUROC, area under receiver operating characteristic curves.

photoselective vaporization of prostate (PVP), and dutasteride prescription as a predictor of the outcome of the treatment.

Researchers from Hanyang University College of Medicine, Seoul, Korea analyzed the effectiveness of tamsulosin 0.2 mg once daily in BPH for 3 months according to the degree of IPP [15]. A series of 134 BPH patients age 40 or more years received tamsulosin 0.2 mg between January 2007 and 2009. They classified the patients into three groups based on the degree of IPP: below 5 mm (group A), between 5 and 10 mm (group B), and over 10 mm (group C). They measured the variables: PV, PSA, prostatic urethral length (PUL), and prostatic adenoma urethral length (PAUL), IPSS/QoL, Q_{max}, and PVR volume before treatment, and compared improvement in the groups at 3 months. PV, PUL, PAUL, PSA, Q_{max}, and PVR showed significant correlations with IPP ($p < 0.05$), but not with IPSS/QoL score ($p > 0.05$). They concluded that tamsulosin might be more effective in improving symptom scores and Q_{max} in patients with mild IPP than in those with moderate or severe IPP.

Researchers from Romania assessed the effect of the IPP on the response to medical treatment with tamsulosin for a 3-month period. They performed the study between the years 2009 and 2011 in the outpatient clinic of an academic hospital. They divided a cohort of 183 patients with LUTS/BPH prospectively in two groups (90 and 93 patients, respectively) according to IPP: group A $\leq$ 10 mm; group B $>$ 10 mm [16]. They enforced a strict inclusion and exclusion criteria, and a single experienced physician did the IPP measurements twice and the mean used for analysis. To avoid biases related to prostatic measurement in patients with very low IPP, they chose a cutoff value of 10 mm for IPP as has been reported to have a good sensitivity in defining BOO [5,8,17]. Also, they did not incorporate PFS by limiting inclusion to $Q_{max} < 10$ mL/s. Patients were treated with tamsulosin (0.4 mg, once daily) for 3 months. The IPSS (-35% and -3 points) and Q_{max} assessed by UFM ($+1.6$ mL/s and $+25\%$) response criteria were defined. They compared the patients' responses from the two groups. They observed statistically significant differences between responders and nonresponders in group A, whereas the difference in the group B was not statistically significant for the four categories of response. The authors conclude that men with an IPP higher than 10 mm seem to be more frequently poor responders to medical treatment with tamsulosin among patients with LUTS/BPH, a PV of $<$40 mL, and a PSA of $<$1.5 ng/mL [6,16].

Again in this context a cohort of 49 patients were put on tamsulosin by another group of European investigators and it was shown that increased IPP values are associated with lower response to α-receptor specific management [18].

A Korean group reviewed 177 of their patients who underwent transurethral resection of prostate (TURP) and followed them for at least 6 months [19]. They considered significant IPP (group B) as 5 mm or more. This occurred in 103 patients. They also subdivided IPSS into voiding (IPSS-v) and storage (IPSS-s) symptoms. Other variables included QoL, Q_{max}, PV, PVR, and transition zone volume (TZV). Multivariate logistic regression analysis was performed to identify whether IPP could predict surgical outcomes of TURP. PV and TZV differed between significant IPP group (group B) and no significant IPP group (group A) preoperatively. Changes in Q_{max} and PVR were not significantly different between the two groups. Postoperative changes in IPSS, IPSS-v, IPSS-s, and QoL score were higher in group B than in the group A. The odds ratios (95% CI) of decreased IPSS and IPSS-s in the group B were 3.43 (1.03–11.44) and 3.51 (1.43–8.63), respectively. They concluded that significant IPP is an independent factor for predicting better postoperative outcomes of IPSS and IPSS-s.

Another Korean group looked into the effect of PVP on LUTS/BPH with or without IPP [20]. They prospectively followed 134 of their patients treated with PVP (120 W) between January 2010 and July 2011. Presence or absence of IPP was evaluated by retroflexed view from flexible cystoscopy. They defined IPP as an intravesical protrusion of the prostate median lobe of more than 5 mm in diameter. The 14 Fr flexible cystoscope had a 4.7-mm diameter endoscope; therefore, they compared protruding masses by using the endoscope. Patients were subsequently assigned to either the IPP group or the no IPP group for comparison of surgical outcomes. After the operation, there were statistically significant differences compared with preoperative values in IPSS, Q_{max}, PVR, and QoL in both groups at the 1-, 3-, and 6-month follow-ups. The Q_{max} was significantly improved at postoperative month 6 in the IPP group ($+7.8$ mL/s) compared with the no IPP group ($+6.0$ mL/s). The IPP group showed significant improvements in total IPSS and voiding subscores at postoperative months 1 and 3. However, improvement in the QoL score and storage subscore was not significantly different between the IPP and no IPP groups. Improvement of the IPSS obstructive subscore was much higher in the IPP group than in the no IPP group during early ($<$3 months) postoperative follow-up. However, the superiority of the improvement in the IPP group was not sustained at a relatively late period (postoperative month 6). The authors surmise that the elimination of a protruding mass in the bladder neck may have a greater effect on early improvement of voiding symptoms than the release of luminal compression of the prostatic urethra. Therefore, patients with IPP experience early improvement because of the elimination of IPP. According to a long-term study, significant improvement of obstructive symptoms after PVP was shown at months 1 and 6 [21]. Patients with IPP had relatively more symptoms of discomfort than those without IPP. The authors give credit to the flexible cystoscopy in the diagnosis of IPP as compared to TAS, as it is more objective and not operator dependent [6,20].

Japanese researchers looked into the effect of IPP on the non-dynamic portion of benign prostatic enlargement (BPE) medical management by reduction of prostate stromal component through prescription of dutasteride. They enrolled 218 patients for 6 months or more on a combination medical therapy. During follow up 21% needed surgical intervention and IPP (odds ratio 1.133, $p < 0.001$) was the strongest independent factor predicting conversion to surgical intervention [22].

5. IPP as a predictor of progression of LUTS/BPH

Singaporean and Chinese researchers assessed IPP as a novel predictor of clinical progression in patients with BPE

[23]. Files of all patients attending the outpatient clinic at their institutions, treated for LUTS/BPH between January 1997 and December 2003, were reviewed. IPSS, UFM, PVR, IPP, and PSA were extracted. Mean follow-up was 32 months and 259 patients were eligible for analysis. Treatments included watchful waiting (WW) in 63% and medical therapy (MT) in 27%. However, they did not use combined α-blockers and 5-α reductase inhibitors (5ARI). Disease progression was defined as PVR $>$ 100 mL, AUR or a deterioration of at least 4 points in IPSS. Using the Grade I IPP group (107 patients) as a reference, the odds ratio for clinical progression of Grade II (89 patients) and Grade III (63 patients) IPP were calculated by using multivariate analysis. Initial treatment options stratified by IPP grade are as follows. Grade I: WW = 66%, α blockers = 33%, 5ARI = 1%; Grade II: WW = 58%, α blockers = 37%, 5ARI = 5%; Grade III: WW = 65%, α blockers = 24%; 5ARI = 11%. Considering the eligible cohort of 259 patients, progression occurred in 52 patients (20%): 6% in Grade I, 20% in Grade II, and 44% in Grade III IPP groups. However, of patients initially put on WW (58%), the figures are 7%, 19%, and 49% respectively. The proportion of progression markers are: IPSS = 71%, PVR = 25% and AUR = 4%. The authors conclude that IPP is a novel, non-invasive predictor of clinical progression in LUTS/BPH for patients receiving non-surgical treatment. It is easily measured and reproducible by TAS. The incorporation of IPP into current stratification strategies for LUTS/BPH would enhance the clinical assessment by the urologist and refine treatment efficacy of this common urological disease in a more holistic and cost-effective manner [6,23].

6. IPP as a risk factor for bladder stone in BPH

Korean investigators reviewed the data of 271 consecutive patients with BPH who underwent TURP between January 2008 and December 2012 [24]. Group 1 with bladder stone comprised 9.9% of patients. The BMI, IPSS, and urodynamic parameters, age, TPV, TZV, IPP and UFM were compared between the two groups. The first three variables did not differ significantly, but the other remaining five variables were all significant in the group 1. IPP (HR = 1.145; $p < 0.001$) was at the top of effective variables. Older age, bigger prostate, lower Q_{max} and longer IPP increase the possibility of stone in bladders of patients with LUTS/BPH.

7. IPP as a predictor of overactive bladder

Researchers from Taiwan, China investigated IPP and detrusor instability (DI) in 40 patients with BPH by urodynamic study and transrectal ultrasound. They found DI in 17 patients. PV, PCAR, and prostatic calcifications did not differ significantly between the groups with and without DI. However, the incidence of IPP is significantly higher in patients with DI than in patients with stable bladder (53% *vs.* 13%, $p < 0.01$). They postulated that IPP might increase afferent impulses from the prostate and alter the stability status of the urinary bladder [25].

Korean investigators studied 95 patients between August 2006 and July 2007 and correlated IPP with storage symptoms, but used TRS to measure the IPP. Other variables included PV, IPSS, UFM, and response to medication. The IPP was compared with the total IPSS, IPSS-v, IPSS-s, UFM, and the flow patterns (normal, obstructive, detrusor impairment, Valsalva). They found a significant correlation between IPP and IPSS-s only [26]. It is apparent that IPP as a morphometric tool is unable to measure detrusor impairment or contractility.

Other Korean researchers investigated the interrelation between male overactive bladder (OAB) symptoms and IPP for estimating anatomical changes to the prostate [27]. They assessed 179 consecutive men aged $>$40 years who presented with LUTS, by IPSS, QoL, TRUS, UFM, and PVR and determined their degrees of IPP. They divided patients into three groups according to their degree of IPP. Group A, grade I = 114, Group B, grade II = 38, and Group C, grade III = 27 patients. Urgency occurred in 64% of cohort (45%, 74% and 70% in grades I, II and III respectively). The results of this study suggest that male OAB is correlated with IPP.

8. IPP as a predictor of prostate carcinoma

Chinese investigators planned to define the correlation between IPP and PSA and develop a new model to predict prostate cancer [28]. IPP, PSA (total and free), TPV and TZV were measured in 339 men $>$45 years old before transrectal guided biopsy. Given that IPP has an impact on the tPSA levels, they tried a model to remove this impact. They devised a new mathematical model, named IPP removed prostate cancer predicting score (IRPPS). IRPPS was calculated by the formula: [tPSA $-$ IPP(1/3)]/TZV. Using ROC curves, the AUROC for IRPPS, prostatic specific antigen density and %PSA and tPSA were 0.786, 0.768, 0.664, and 0.585, respectively. IRPPS has a higher accuracy than the other three indicators.

9. IPP as a predictor of early urinary continence recovery after laparoscopic radical prostatectomy

Korean researchers studied the impact of IPP on recovery of urinary continence in 242 patients after laparoscopic radical prostatectomy [29]. Continence at 1, 3, 6 and 12 months postoperatively was assessed by dividing the patients into two groups based on the degree of IPP. The urinary continence rates at postoperative month 1, 3, 6, and 12 were 19%, 50%, 79.8% and 92.1%, respectively. Markedly improved urinary continence was observed in the non-significant IPP group (IPP$<$5 mm) at all periods ($p < 0.05$). In an editorial comment, other than possible effect of IPP on storage capabilities of the bladder, the significance of IPP in causing more surgical damage at the smooth muscular internal sphincter during bladder neck dissections put forward as a possible contributor. The suggestion is that surgeons can use IPP status to select the procedure and operative methods in terms of urinary continence [30].

10. IPP in Iran

Researchers at Urmia Medical Sciences University performed the first IPP study in Iran on 2009, which is in Farsi

(non-published article, the corresponding author's email is mohammadifallah44@gmail.com). They were aware of international studies showing good correlation between IPP and BOO or AUR but were inspired by a Greek publication to conduct their study [31]. They noticed that there has been no comparison between IPP in patients with BPH and non-BPH individuals. This encouraged them to compare these factors between the two groups and determine their relationship to the degree of BOO and the symptom severity of patients with BPH and the predictive power of these factors in a need for a surgical intervention. They compared 72 patients with LUTS/BPH referred to their hospital clinic with 50 symptom free men as control group aged 60 or more years. Variables included IPSS, IPP height, IPP volume, PVR, PSA, total PV, and Q_{max}. There was a significant difference between all variables in two groups of BPH/CONTROLS (mean), some are as follows: IPP height = 10.19/2.96 mm ($p = 0.001$), Q_{max} = 10.38/16.16 mL/s ($p = 0.001$), and PSA = 2.90/1.72 ng/mL ($p = 0.001$). IPP height showed the highest Spearman correlation coefficient (−8.80, $p = 0.001$) with the degree of BOO (based on UFM). IPP height (mm) in BPH group was 2.57, 7.39, and 23.24 for IPSS grades mild, moderate, and severe respectively. In addition, comparison of variables between 52 patients in BPH group treated by surgery and 20 on medical therapy revealed that only IPP height and volume were statistically significant in these subgroups ($p = 0.001$, $p = 0.002$). The 12 patients with AUR, had their IPP volume statistically significant as in comparison to other variables of BPH group ($p = 0.001$). The authors conclude that patients "with greater IPP have more chance to receive surgical treatment and higher likelihood of AUR".

Research on IPP has started as resident thesis at Dr. Shariati Hospital, Tehran University of Medical Sciences.

11. The future trends

The Japanese urologists in collaboration with their Medical System Engineering colleagues investigated the hydrodynamic aspects of IPP in patients with voiding dysfunction. Three models for flat, slightly and severely deformed bladder outlet by protruded prostate were prepared. They used CAD software (SolidWorks, SolidWorks Japan Inc., Tokyo, Japan) to depict the three-dimensional (3D) models of the bladder and prostatic urethra, tracing the MR image of the patients with BPH. They used the software to test the hydrodynamic simulation on the models. The hydraulic energy was calculated using the following formula: Ep/wg(Q/A)2/2 g (E: hydraulic energy, p: pressure, w: density of water, g: gravity, Q: flow rate, A: cross area of flow). The protrusion of the prostate in the bladder outlet clearly disrupted the urine flow. The hydraulic energy of the urine flow was reduced through passing the bladder outlet in the slightly protruded model, but it was deteriorated before reaching the bladder outlet in the severely protruded model. This study indicates the importance of the shape of the bladder outlet for voiding dysfunction [32].

I recently came across a very interesting study from China [33]. The authors argue that many studies have indicated that IPP is relevant to prognosis of LUTS, however, the confounding effects of PV, urethra anterior curvature angle and other factors make it hard to evaluate the role of IPP in clinical observation. They proposed a fluid structural interaction analysis approach. They constructed 3D models based on MR images, and prostatic urethra diameters were calibrated with urodynamic data. Comparisons of urine flow dynamics were made between models with various degrees of IPP, while the intravesical pressure, anterior urethra curvature angle, and diameter of prostatic urethra were the same among all models to rule out their confounding effects. Simulation result showed that the decrement of diameter and increment of variation in cross-sectional area for prostatic urethra were related to the degree of IPP. Such deformation would lead to deterioration of flow efficiency and could compromise the effect of BOO alleviation treatment. They concluded that these results provided further evidence for IPP being an independent risk factor for BOO severity and demonstrated that IPP would be a promising marker in clinical decision making.

Continuing efforts certainly bring about the need for more multi-national cooperative studies with longer follow-up periods and continual efforts at revival and application of clinically objective, non-invasive, less-expensive tools in decision-making for management of LUTS/BPH.

12. Conclusion

Technology is ever evolving to help us in the diagnosis and management of our patients. However, we as clinicians should contemplate their cost and possible suffering for the patient by wise and judicious utilization based on our clinical experience and tools. IPP seems to be one such promising clinical tool. However, there is a need for more multi-national cooperative studies and longer follow-ups in this context.

Conflicts of interest

The author declares no conflict of interest.

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