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The Evolution of KTP Laser Vaporization of the Prostate

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The search for a minimally invasive approach to the treatment of Lower Urinary Tract Symptoms (LUTS) suggestive of Benign Prostatic Hyperplasia (BPH) is probably as old as Transurethral Resection of the Prostate (TURP). In an effort to overcome the limitations and morbidities of TURP, and in light of evidence suggesting that medical treatment for BPH has a limited life-span, laser-based treatments have emerged during the last decade. Photoselective Vaporization of the Prostate (PVP) by the "GreenLight" KTP laser is considered one of the most promising options, one that is constantly evolving new technologies in prostate surgery. In this overview of KTP laser usage in BPH treatment, we will briefly discuss the evolution of this modality since it was first introduced and focus on the available evidence regarding safety, efficacy and cost parameters of its application.

Key Words: Lasers, benign prostatic hyperplasia, surgery

INTRODUCTION

The search for the optimal minimally invasive technique for the treatment of LUTS associated with BPH carries quite a history. Over the past 15 years, efforts have been taken to introduce an ideal minimally invasive treatment option for benign prostatic hyperplasia (BPH). Different treatment modalities employing varied delivery systems to create heat to treat the prostate have not shown consistent or durable efficacy compared to the reference standard, transurethral resection of the prostate (TURP). Recent advancements in the field of bipolar plasma-kinetic vaporization of the prostate[1,2] and the emergence of alternative treatment options for BPH[3] have made this goal even more challenging than previously considered.

Some of the laser-based treatment modalities exhibited promising results and were initially welcomed with expectations and enthusiasm by the urological community. Unfortunately, few stood the test of time, and even fewer were able to withstand the comparison to the long-standing reference treatment for BPH, transurethral resection of the prostate (TURP).

Recent advancements in laser technology, together with the increasing demand for a minimally invasive procedure to alleviate lower urinary tract symptoms more safely and efficaciously than TURP, have led to the introduction of photoselective vaporization of the prostate using the "GreenLight" KTP laser. The purpose of this review is to explain the basic principles of KTP lasers in urology and address the current status of the application of this modality in the treatment of BPH.

DISCUSSION

The characteristics of the KTP laser and how they apply to prostate surgery

All lasers are not created equal. Proof of this is the vast difference in the characteristics and the interactions between different laser beams and tissues. By doubling the frequency of pulsed Nd:YAG laser energy with a potassium-titanyl-phosphate-KTP crystal, a 532-nm wavelength laser is created which has substantially different laser-tissue interaction properties compared with its predecessor, the Nd:YAG. One main difference lies in the fact that the 532-nm wavelength beam

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of the KTP laser rests within the visible green region of the electromagnetic spectrum (Greenlight-laser), unlike the 1064 nm Nd:YAG light beam, which is within the infrared portion of the electromagnetic spectrum.[4]

The KTP laser beam can be fully transmitted through aqueous irrigants but is highly absorbed by hemoglobin inside prostatic tissue. This selective absorption of the green KTP laser beam by hemoglobin in tissue is the reason KTP laser vaporization prostatectomy was named photoselective vaporization of the prostate (PVP). Absorption leads to instant removal of prostatic tissue by a rapid photothermal vaporization of heated intracellular water.[5] Because of the short optical penetration of the KTP laser into tissue (0.8 mm), the resulting coagulation zone is limited (1 - 2 mm), which leads to a more focused and efficient vaporization.[6]

The KTP laser is used to effectively vaporize prostatic adenomatous tissue and create an unobstructed TURP-like cavity. For this reason, the KTP laser fiber is delivered via a relatively small-caliber scope (22 - 23F). PVP is performed in a near-contact mode with a 70 degree side firing fiber. A continuously emitted beam allows rapidly progressive and efficient vaporization of glandular tissue down to the prostatic capsule (where vaporization efficiency of the laser is hampered by the relatively hypovascular fibrous capsule). The effectiveness of vaporization is judged by bubble formation. Normal saline is usually used as an irrigant, although water can also be used, without however enhancing visualization.[7]

The lack of significant absorption of the irrigation fluid during PVP has already been proven by using expired breath ethanol measurements; therefore, there is no safety issue in using sterile water as an irrigant for this procedure.[8]

Haemostasis is achieved by the inherent superficial coagulative effect of the KTP laser beam, allowing for an almost bloodless procedure. A coagulation zone thickness of only 1 to 2 mm avoids the problems associated with earlier Nd:YAG laser treatments in which much deeper tissue coagulation necrosis (7 mm) led to severe post-operative dysuria and delayed sloughing, resulting in prolonged obstruction.[9]

The evolution of KTP lasers for the treatment of BPH

Most of the early data available addresses the Nd : YAG laser coagulation. Visual laser ablation of the prostate (VLAP), first introduced by Costello using a 1064 nm Nd : YAG laser, was used to apply the effects of coagulation to prostate tissue.[10] The limitation of applying the technique to small prostates, together with a prolonged operative time, dysuric symptoms, and considerable post-operative catheterization time due to massive sloughing of necrotic tissue, did not add to its reputation or durability.[11]

Early experience: the "hybrid" techniques

KTP lasers were actually introduced in the treatment of BPH in combination with already existing laser modalities. These so-called 'hybrid' techniques were developed with the intention to combine the coagulation and haemostatic effects of the 1064 nm Nd:YAG laser with the excellent excision and vaporization efficacy of the 532 nm wavelength KTP laser. The use of the KTP laser in conjunction with the Nd:YAG laser allows for vaporization of more tissue, thus decreasing the amount of tissue undergoing coagulation necrosis. The KTP laser energy was used to perform a bladder neck incision and, in some cases, to vaporize any median lobe.

The rationale behind these 'hybrid' techniques was that the additional incisions using the KTP laser would decrease some of the aforementioned problems faced when Nd : YAG techniques alone were used; specifically, prolonged catheter drainage and troublesome dysuria. The use of the KTP laser added only 15 minutes to the procedure. In the KTP laser prostatectomy series originally reported, a laser calibrated to 38 W was used, but, in reality, it rarely delivered more than 20 W of power. The vaporization procedure was lengthy, tedious and often erratically performed.[4]

The first description of KTP laser prostatectomy came from Watson in 1995,[12] who utilized the 30 W KTP laser followed by Nd : YAG laser coagulation. In a series of cases with short-term follow-up, the technique was characterized as safe; however, the rate of post-operative retention and the delayed onset of therapeutic effects continued to be an issue.[13] Comparison of low (20 W) to high power (40 W) KTP laser added to a standard 60 W Nd : YAG ablation favored the 40 W KTP mainly because of a more rapid improvement in symptoms.[14] Kollmorgen et al.,[15] in their 2.5 years follow-up of two groups of men undergoing VLAP (40 W Nd : YAG) compared to VLAP with subsequent KTP laser prostatotomies (34 W KTP laser), reported that the 'hybrid' group faired much better in terms of recatheterization rates (33% versus 70.5%). The advantages of the 'hybrid' technique over VLAP seen in early (18 h) catheter removal in the 'hybrid' arm (80% versus 57%) were emphasized in a prospective double-blind randomized trial.[16]

Hybrid techniques eventually had to be compared to the "gold standard," TURP, and this first took place in a randomized, control trial by Carter et al. The hybrid technique in question involved the initial delivery of 30 W of KTP laser energy. The KTP laser was used to create bladder neck incisions at the 5 or 7 o'clock positions, and any median lobe or obstructive bladder neck tissue was vaporized. Additional prostatotomies were performed on any large prolapsing lateral lobes. The prostate was subsequently treated with Nd : YAG laser coagulation.

Early results demonstrated that expected post-operative complications, such as irritating symptoms and dysuria, were of similar frequency between the 'hybrid' technique and TURP. Moreover, the median post-operative duration of catheterization was similar in both groups at 2 days.[17]

Results at 1 year revealed a higher rate of urethral stricture in the TURP arm (9.9% versus 2.1%). This was mainly attributed to the larger scope diameter employed in the TURP procedure (24 or 26 Ch versus 21 Ch). However, post-operative urosepsis was more common in the laser group, and this probably relates to the volume of necrotic tissue left in situ at the end of the procedure.

IPSS, Qmax, post-void residuals and improvements in LUTS were similar in each arm both at 1 year and at 1.5 years. Importantly, only one patient in each group required re-operation.[18] Shingleton et al.[19] reported on their three-year results of 100 patients who had undergone either hybrid KTP/Nd : YAG laser prostatectomy or TURP. Both treatments produced equivalent improvements in symptoms and flow rates, although the flow rate improvement in the TURP group was lower than expected from known published series. This might be due to a rather limited resection with a change in mean prostatic volume of only 3.3 cm^3 from baseline to 36 months. The re-treatment rates were also low with no re-operations in the TURP arm compared with 6% for the laser cohort.

Later advancements in KTP lasers

The 'hybrid technique' enjoyed a brief period of popularity that was eventually hampered by prolonged operative times and limited tissue ablation due to low power KTP energy available in the mid 90s. Pure KTP laser vaporization techniques soon took over, demonstrating a gradual increase in their laser power and vaporization ability over time.

Successful experimental animal studies for the evaluation of pure KTP laser vaporization using a 38 W system and a 60 W system on the canine prostate model[9,20] preceded the first pilot clinical study of the 60 W KTP laser vaporization in 10 patients at the Mayo Clinic.[21] The procedure was performed using a 22 Ch continuous flow cystoscope and sterile water as irrigation fluid. Prostate glands of up to 60 mL of volume were treated. Bleeding was successfully controlled by defocusing the laser beam (3 - 4 mm) without needing to switch to Nd:YAG laser for coagulation. No irrigation was required post-operatively and catheters were removed in less than 24 hours. At 24 hours, an impressive improvement in maximum flow rate to 142% was noted and none of the patients required re-catheterization. Results of a three-month follow-up of three patients from this group showed a mean AUA symptom score reduction of 77%, mean peak flow rate increase of 166% and mean post-void residual volume decrease of 82%.[21]

Longer follow-up results from the same institution on the outcome of patients treated with 60 W KTP vaporization of the prostate were published in 2000.[22] Patients with BPH having a mean prostate volume of 43 mL were treated, while patients on retention were excluded. No patient required blood transfusion or re-catheterization. Only two patients (4%) were troubled by post-operative delayed gross hematuria (6 - 8 weeks) following strenuous physical activity. Another 7% described mild dysuria, which settled without treatment. In the longer term study, mean improvement in Qmax was 278% and there was a mean fall of 82% in the AUA symptom score at a two-year follow-up of 14 patients. Retrograde ejaculation was limited to just 9% of patients at two years, possibly implying a very limited resection of the bladder neck.

Going one step further, Carter et al., in their series of 22 patients treated with 60 W KTP laser, left six of the patients without a catheter post-operatively, and they all managed to void freely.[23]

Current experiences with the KTP laser

Despite the good results and its technical simplicity, the 60 W KTP laser had a size limitation on the prostate glands treated (not exceeding 60 mL of weight) due to the less than ideal speed of vaporization at 60 W. In order to improve the speed of vaporization, a quasi-continuous-wave KTP/532 laser was developed that emits an average power of 80 W.

The 80 W KTP laser system (GreenLight® PV, American Medical Systems, Minnetonka, MN, USA) described above uses a 70° side firing laser fiber emitting laser at a 532 nm wavelength, which is delivered through a small (21 - 23 F) continuous-flow cystoscope. Total energy delivery may amount to 200,000 Joules for a prostate of 70 - 80 mL, and the procedure is usually over in an hour or so. PVP can be a catheter-free procedure. However, even in cases where a catheter is left, the duration of post-operative catheterization time is minimal. Most patients can be treated on an outpatient basis and may return home the same evening. Post-operative irrigation is rarely necessary and may be applied to the occasional patient with bleeding disorders or a very large prostate.

Pre-operative evaluation

The routine pre-operative evaluation of BPH patients suffices for laser treatment with the KTP laser. Particular attention should be paid to accurate prostate volume measurement by TRUS, particularly in large glands in order to estimate parameters such as vaporization energy and operative time.[24]

Because there is no tissue specimen provided by PVP, prostate cancer cannot be diagnosed based on histological examination, thus continued post-operative surveillance by digital rectal examination and PSA are required. In cases of a pre-operative elevated PSA or a suspicious DRE, a TRUS biopsy should be done. Even so, some cases of prostate cancer will still go undiagnosed because of normal pre-operative PSA and DRE. However, there is evidence deriving from a series of prostate cancers incidentally diagnosed by TURP that these cancers will eventually be missed by KTP vaporization were usually managed with active surveillance due to their low stage and moderate Gleason score.[25] However, the clinical significance of these cancers in the long-term is uncertain at the present time.

Anesthesia options

A wide range of different options for delivering anesthesia and analgesia to patients undergoing PVP has been described. In a hospital setting, light general anesthesia is usually preferred, since regional anesthesia precludes a catheter-free procedure. In most series, either regional or general anesthesia was used depending on the patient's ASA score.[26,27]

In an outpatient setting, a two-step anesthesia process combining a cocktail of oral analgesics, sedatives and non-steroidal anti-inflammatory agents with bladder instillation of lidocaine has been utilized. Local anesthesia in the form of a periprostatic or pudendal nerve blocks using lidocaine, bupivacaine or ropivacaine solutions[28] have also been described, but their efficacy and safety have been questioned by others.[24]

Outcomes of 80 W KTP laser prostatectomy

Initial results for the 80 W KTP laser came from a small pilot series of 10 patients with a one-year follow up.[29] The authors reported a reduction in prostate volume of 27%, which is somewhat less than the 40 - 50% reduction seen with TURP. Results from uncontrolled clinical trials with a maximum follow-up of one year followed.

In these trials, a total of 759 men (aged 45 - 90 years) with prostate volumes ranging from 15 - 250 mL (mean volume ~ 49.6) were treated. Mean operative time was 53.7 minutes, and the procedures were performed under general or regional anesthesia. Some studies excluded men with urinary retention,[26] very large prostates or elevated PSA > 10 ng/dL.[30] In one study, patients with prostate cancer were also enrolled.[31]

Reduction in prostate volume ranged from 37%[30] to 53%[27,32] and was comparable to that after TURP. Mean catheterization time ranged from 6 to 69 hours, while in one study 44 patients (32%) were left without a catheter at the end of the procedure.[30] No significant bleeding was encountered, and no blood transfusion was required whatsoever. The efficacy of the procedure was mirrored in the excellent Qmax and IPSS improvements. Mean improvement in Qmax was 13.6 mL/sec from baseline, while there was a 14 point fall in mean IPSS.

In addition, results from a multicenter study with a three-year follow-up of 139 men treated with an 80 W KTP laser confirmed the overall efficacy of the procedure. The significant differences seen in the level of improvement for patients with a baseline total PSA > 6 ng/dL were explained by the vast difference in mean prostate volume between the two subgroups (group 1, 48.3 mL; group 2, 83.1 mL). Still, these results may raise scepticism about the efficacy of PVP in very large prostates.[33]

Regarding the safety of the procedure, the main complications encountered in these series consisted of urinary retention ranging from 1%[34] to 15.4%,[31] dysuria ranging from 6.2% to 30% and minor haematuria (up to 18%). The occurrence of retrograde ejaculation ranged between 36% and 55% in previously potent men.

The longest follow-up (five years) results published by Malek et al.[35] raised some criticism[36,37] because of the high attrition (at five years, only 14 out of the original 94 patients were evaluated) and the fact that only 15 of the patients studied were actually treated with the "new" 80 W KTP laser. Complications described were transient dysuria (6%), hematuria (3%), bladder neck contracture (2%), and retention (1%). Whatever the significance of these shortcomings, at five years, 79% of treated patients had maintained a 100% improvement of their Qmax from baseline, while all patients maintained an improvement of at least 50% in their symptoms (IPSS) from baseline.[35]

A large series reporting complication rates after PVP comes from Switzerland.[38] A total of 406 patients including men in retention, on anticoagulation therapy and of an advanced age were treated and followed-up for three years. No serious bleeding or TURP-syndrome was observed. Bladder irrigation was required for 9.6% of patients, most of whom were on anticoagulants. Post-operative retention and re-catheterization rate was 9.6% and strongly correlated with age but not with prostate volume at baseline. Also, in 2.2% of the procedures, a transient conversion to TURP for electrocoagulation of troublesome capsular bleeding was necessary. Late complications included a 6.3% urethral stricture rate, while 21 patients (5.2%) experienced recurrence of LUTS due to insufficient initial vaporization.

a) High-risk patients & patients on anticoagulants

Theoretically, one major advantage of PVP is that a virtually bloodless tissue ablation technique can be applied to high-risk patients relatively safely. Evidence of this comes from a two-center study evaluating a total of 66 men with an ASA score of 3 or greater.[39]

Safety results were encouraging as there were no blood transfusion requirements and no fluid absorption. There was an 11% need for re- catheterization, while the results on voiding parameters revealed an impressive 222% improvement in Qmax from baseline in one year and a mean reduction in IPSS of about 14 points at one year follow-up.

Similar efficacy results were presented in another study.[40] Interestingly, the mean operative time was only 25.6 minutes, which is largely disproportionate to the mean prostate volume at baseline (72.5 mL). However, there are no data on mean prostate volume reduction or re-operation rates.[40]

A major cohort of patients considered to be at high-risk for bleeding and transfusion are those on anticoagulation therapy. Currently, urologists are faced with an increasing number of patients requiring prostatectomy while on oral anticoagulation therapy. Unfortunately, conventional TURP has failed to provide acceptable safety for these patients, for the transfusion rate has been exceeding 30%.[41] The most commonly-used perioperative management in anticoagulated patients is discontinuation of oral anticoagulant therapy several days before TURP and conversion to conventional or low molecular weight heparin (LMWH) as bridging therapy perioperatively. However, perioperative use of LMWH has led to a significant increase in catheterization time and hospital stay while maintaining an unacceptable transfusion rate of 20%.[42]

The safety of PVP in men with serious co-morbidities necessitating continuous anticoagulation was assessed in a series of 116 men on coumadin, aspirin or clopidogrel. This group of men on oral anticoagulation was compared to a control group of men undergoing PVP without taking anticoagulants.[43]

Results showed similar efficacy in terms of voiding parameters between the two groups. In the group of patients on anticoagulants, no thromboembolic or bleeding complications were observed and no blood transfusions were required. The only difference was a higher rate of transient 24 hour post-operative irrigation (17% vs 5.4% in the control group) resulting in a longer catheterization time. Post-operative retention rates were slightly higher than previously reported (~12% in both groups), while a 40% decline in PSA values at two years was observed in both groups, indicating that an equal amount of tissue was removed.

b) Patients with large prostates

The issue whether very large prostates could be adequately treated with KTP laser within a reasonable time with acceptable reoperation rates was addressed by Sandhu et al.,[44] who evaluated the safety and efficacy of the 80 W KTP laser in 64 patients with prostate volumes in excess of 60 mL. Twenty-eight percent of patients were in retention pre-operatively, and some of them probably would have been otherwise denied a TURP because of their high ASA score.

Mean prostate volume was 101 mL and mean operative time was 123 minutes. However, two patients required staged procedures because of their lengthy prostatic urethra. Ninety-five percent of patients had their catheters removed within 23 hours. Three patients needed re-catheterization in the early post-operative period, while the one year re-operation rate was 5%. Regarding efficacy, Qmax improved from 7.9 mL/sec to 18.9 mL/sec in one year, while IPSS declined from 18.4 at baseline to 6.7 post-operatively.

A modified vaporization-incision technique (VIT) in large-volume prostatectomy was evaluated in 20 patients with high-volume prostates, and results were compared with those in 64 prior patients with similar volume prostates who had been treated with standard laser prostatectomy. However, IPSS and flow rates at post-operative months 1 and 3 showed no significant differences between the two techniques .[45]

c) Patients in retention

Another major issue is the outcome of patients with indwelling catheters due to urinary retention. Historically, this subgroup of patients is plagued with a higher complication rate and, sometimes, a poorer outcome in terms of voiding parameters. A study comparing the outcome of 70 patients with refractory retention and 113 men with BPH but no retention was conducted. Functional outcomes and incidence of perioperative complications were similar in the two groups. In particular, the post-operative retention rate observed was comparable between patients with and without retention (12.9% vs 10.6%, respectively). Moreover, there were no statistically significant differences between the two groups with regards to Qmax, IPSS, or PVR.[46]

A direct comparison between PVP and TURP in the treatment of men presenting with acute urinary retention revealed similar efficacy results at one year follow-up, although IPSS scores were better for the TURP arm in the short term (three months).[47]

PVP compared to TURP

Photoselective vaporization of the prostate represents the latest development in technology for the treatment of BPH, and it emerges as an alternative to TURP. However, since the end of 2005, there was only one non-randomized controlled study published[48] to prospectively compare PVP with conventional TURP as the reference treatment for BPH. In this study, PVP was superior to TURP in terms of catheter drainage time and hospital stay, while PVP was somewhat lengthier than TURP. Intraoperative bleeding was a problem in 10.8% of TURP cases but not in PVP. Early (six-month) results revealed similar improvements in voiding parameters. However, prostate volume reduction was significantly greater in the TURP arm, thus questioning the durability of longer-term PVP results. Nevertheless, the mean follow-up of six months a priori precludes any conclusions on durability.

The first randomized, although incomplete, study of 76 patients treated by either TURP or PVP and then followed-up for at least six weeks showed similar results in terms of voiding parameters (Qmax-IPSS) for the two arms.[49] Although data were preliminary and results biased in many ways (men with prostate volumes > 85 mL, on retention or on anticoagulants were excluded and the surgeons were inexperienced in PVP), it was clear that PVP was superior to TURP in terms of earlier catheter removal, hospital stay and early complication rate. Data on re-operation rates and long-term efficacy of the procedures were, unfortunately, not available.

Interim results from the same trial were recently published.[50] Improvements in Qmax and symptom scores were equivalent for both treatments, and although the number of patients available for evaluation at one year (n = 59) was still far from optimal for drawing substantiated conclusions, early re-operation rate was in favor of TURP. However, in total, early complications were fewer and less severe in the PVP arm.

A recent prospective non-randomized study comparing PVP (249 patients) with TURP (129 patients) revealed a significant difference in mean operative time between the two procedures (73′ for PVP vs 53′ for TURP), which was partly due to the larger prostates assigned to the PVP group. Still, there is evidence that the estimated speed of tissue vaporization with the KTP laser is lower than the tissue resection rate with the standard TURP.

In this study, KTP vaporization confirmed its superiority with respect to intraoperative safety and earlier discharge from the hospital, yet although both treatments resulted in similar improvements in IPSSs, the Qmax was higher for TURP in the two-year follow-up and there was also a trend for higher re-operation rates for PVP in the long-run.[51] Therefore, there is an issue regarding the long-term durability of the pronounced short-term improvements in micturition parameters achieved with PVP.

The major advantages and drawbacks of PVP compared to TURP are listed in Table 1.

Learning curve

The learning curve for a procedure plays a crucial role in its overall applicability and cost-effectiveness. Evidence to this is the significantly shorter learning curve for the KTP laser as opposed to HoLEP, and this is the main reason for the popularity and wider applicability of the former.[52] However, there are intrinsic difficulties

Table 1. Major Advantages and Disadvantages of PVP Compared to TURP

PVP	TURP
Safer for larger prostates (> 100 mL) with no risk of dilutional hyponatremia	Risk of fluid absorption-TURP syndrome when resection time > 90 min
Lengthier procedure-slower vaporization speed (~0.5 gr/min)	Shorter operation time-higher resection speed (up to 1 gr/min)
Minimal to no catheterization time & reduced hospital stay (day-case procedure)	Catheterization time of at least 2-3 days, resulting to prolonged hospital stay
Reduced risk of retrograde ejaculation (35 - 55%)	Significant risk of retrograde ejaculation (53 - 75%)
Absence of histological evaluation of removed prostatic tissue	Ability to detect (incidental) prostate cancer
Higher reoperation rates	More durable results over time

PVP, photoselective vaporization of the prostate; TURP, transurethral resection of the prostate.

in accurately quantifying the concept of a learning curve. It relies on subjective estimations of the surgeon and is biased by the level of his or her experience and the quality of training and education that each surgeon has received by their own mentors.

Nevertheless, KTP laser vaporization is considered easier to learn and perform than TURP. Most urologists would feel comfortable performing TURPs after about 50 procedures.[50] Rajbabu et al.[24] consider a series of 10 - 20 procedures sufficient for gaining competence using the 80 W KTP laser on small prostates, while others[50] believe that five cases are enough in order for one to safely tackle small glands (< 40 mL) with reasonable median lobes. Larger prostates can be confidently managed after about 20 cases. Meanwhile, a short mentorship training period is essential in order to be able to adequately perform PVP.

Cost implementation of PVP treatment

The issue of cost and effectiveness of various treatment options for BPH has been widely, however insufficiently, addressed as a whole. This is a difficult task to accomplish since the general concept of "costs" related to a certain treatment or intervention is quite heterogeneous. One has to take into consideration both the direct (office visits, hospital costs, imaging studies, etc.) and the indirect costs (absence from work, lost earnings) and also incorporate the costs of treatment failures and re-treatments. Other related issues are the prospective nature of such a study with long-term follow-up in order to reach meaningful results, the actual differences that exist in health systems and patients' perspectives and backgrounds throughout the globe.

There is no doubt that the cost per year for BPH treatment is certainly less for medical treatments than for invasive surgical procedures. The cost of TURP was estimated to be between 3,874 and 8,608 US dollars, while the direct cost of medical therapy ranges from 73 to 974 US dollars per patient per year.[53]

In the long run, however, surgical treatments like TURP, especially for patients younger than 70 years of age,[54] seem preferable as they appear to be more cost-effective due to the increased annual maintenance costs of oral medication. Additionally, the high discontinuation rate (47 - 58%) observed for alpha-blockers in the first three years[55] further contributes to the diminished long term cost-effectiveness of medications for BPH. The treatment pathway, starting with medications and ultimately leading to a TURP or an open procedure, actually carries the highest lifetime treatment cost.[56] Furthermore, this pathway results in fewer patients being operated on for BPH with advanced age, major co-morbidities and larger prostates at the time of surgery.[57] The evolution of PVP will most likely change the landscape in both the surgical and medical treatment of BPH, but this remains to be seen.

Reviewing the very little available literature so far regarding the cost-effectiveness of PVP treatment for BPH, one has to commend the study by Stovsky et al. comparing the costs and clinical outcomes of five interventions for BPH, namely PVP, ILC, TURP, TUNA and TUMT.[58]

Using the decision-analytic Markov model, the authors came to the conclusion that PVP is, overall, less costly than other procedures. The cost savings stemmed from the lower rates of adverse events and re-treatment of PVP, but these conclusions are somewhat premature and certainly hampered by the limited number of prospective long-term studies of PVP.

Similar conclusions were reached in two studies coming from the same group in Australia. In these studies, the direct cost of PVP as a day procedure was estimated to be 3368 AU dollars, while the cost of TURP was 4291 AU dollars.[49] Overall, PVP was considered 22% less costly compared to TURP, mainly because of the shorter hospital stay and complication rate. However, cost analysis was done by taking a random sample of five cases from each group, and the short follow-up period and available patients (59 patients at 12 months) were inadequate for substantial conclusions.[50]

It is certainly early to draw conclusions about the cost-effectiveness of PVP in the treatment of BPH since long-term prospective trials assessing various parameters of "cost" and "effect" are lacking. The heavy financial cost of initial capital investment for the laser base and the disposables (fibers) should be balanced against the savings stemming from reduced hospital stay and fewer complications. Keeping all of this in mind, Alivizatos et al. concluded that although preliminary results of cost-analysis studies of PVP are in favor of PVP versus TURP, further evidence is certainly needed to support this.[59]

High Performance System (HPS)

The 80 W KTP laser system has proven to possess sustained efficacy and safety in the treatment of moderate to large prostates. However, the vaporization procedure for very large glands remained tedious and time-consuming due to the limited rate of power delivered per unit of time. In order to overcome these limitations, the new and improved GreenLight High Performance System (HPS) was recently introduced.

This advanced diode-pumped solid state laser system delivers the same 532 nm wavelength within a power setting of 20 - 120W instead of the 30 - 80 W average power level of its predecessor. This 50% increase in power results in potentially increased vaporization efficacy.

One of the differences between this system and the 80 W KTP laser is that maximum focus with negligible divergence of power is now maintained even within a distance of 3 - 5 mm from the fiber, allowing for vaporization to be consistently efficient despite variable changes in distance between fiber and tissue.[60]

The fiber is covered with a highly reflective coating in order to limit the back-scatter effect and the resulting inadvertent ablation of tissue.

The HPS system also incorporates a dual-power mode function using two pedals; one for vaporizing tissue (60 - 120 W) and another for coagulating at lower power settings (20 - 40 W), while power is now delivered in 10 W instead of 5 W increments.

Initial experience with the HPS 120 W is described as "exciting",[24] but further results from large trials are necessary in order to evaluate the advantages and potential shortcomings of this system.

CONCLUSIONS

Recent improvements in laser technology and a better understanding of the interactions of different laser wavelengths and power settings with tissue have led to the development of promising new treatment modalities. The evolution of laser prostatectomy seems to put into doubt the "gold standard" surgical treatment, TURP, for BPH.

The new generation of high-powered KTP lasers is currently gaining popularity at a fast speed because of its ability to create a prostate cavity almost bloodlessly along with the added benefit of a small learning curve and the prospect of a day-case, catheter-free procedure.

On the other hand, the procedure can be lengthy at times, while the laser and installation costs can be difficult to justify since KTP lasers have limited urological applications thus far. Moreover, issues regarding the sustained long-term results and re-operation rates have to be further addressed in future trials. Furthermore, there is lack of evidence regarding direct comparison of the KTP laser vaporization with other laser-based treatments for BPH, such as holmium /thulium resection-enucleation.

Whether or not KTP laser vaporization will stand to compete with TURP and other emerging minimally invasive treatment options for BPH in the long run is a question whose answer depends on the quality of scientific evidence that will be presented in the near future.

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