

How I do it: Aquablation of the prostate using the AQUABEAM system

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Benign prostatic hyperplasia (BPH) represents one of the most common conditions encountered in urological practice. For many years, transurethral resection of the prostate (TURP) has been considered the gold standard for surgical management of symptoms in prostates of 30 cc-80 cc. Although TURP provides excellent functional outcomes, there is significant morbidity associated with the procedure, particularly with regards to bleeding, electrolyte imbalance and sexual dysfunction. Emerging

technologies aim to maintain the excellent functional results of TURP whilst decreasing the adverse events experienced by the patient.

Aquablation is a novel therapy using a high-velocity waterjet and real-time ultrasound imaging with robotic assistance for targeted removal of prostate tissue. We present our experiences with this new technique, the equipment required and steps involved.

Key Words: benign prostatic hyperplasia, bladder outlet obstruction, aquablation, ablation techniques, transurethral resection of prostate

Introduction

Benign prostatic hyperplasia (BPH) and its associated lower urinary tract symptoms (LUTS) are a significant disease burden around the world. The estimated prevalence of BPH is 10% for men in their 30s, with this number rising to 80% in men over the age of 70.¹ LUTS due to BPH are associated with significant morbidity and reduced health-related quality of life (HRQL), with the prevalence of moderate-to-severe LUTS increasing with age.²

For most of the last century, surgical management of BPH has been dominated by the transurethral resection of the prostate (TURP), with an extensive body of research on the technique and its propensity to improve LUTS. However, there is also morbidity associated with TURP including bleeding, electrolyte disturbances and the long term sequelae of erectile dysfunction and retrograde ejaculation.³⁻⁵ In an effort

to reduce these complications, novel techniques have been developed to utilize alternate energy sources whilst maintaining good functional outcomes.

Aquablation utilizes a high-velocity saline stream to resect parenchymal tissue, a waterjet technique having first been described in canine liver resection.⁶ Waterjet technology was then adapted for use in human liver resection, with further experience showing that the technique was feasible in neurosurgical, pulmonary and bladder tumor resections.⁷⁻¹⁰ This technology has been further developed for use in prostatic ablation in the AQUABEAM (PROCEPT BioRobotics, Redwood Shores, CA, USA) system which utilizes a minimally invasive, image-guided, high-velocity waterjet for prostate ablation. We describe the steps involved in performing Aquablation using this technique.

Patient selection

Patients are assessed in the outpatient clinic, as is standard at our center prior to surgical intervention. A history is taken and physical exam performed. Routine tests such as urinalysis, uroflowmetry with post void residual, flexible cystoscopy and trans-rectal ultrasound to assess prostate size are performed.

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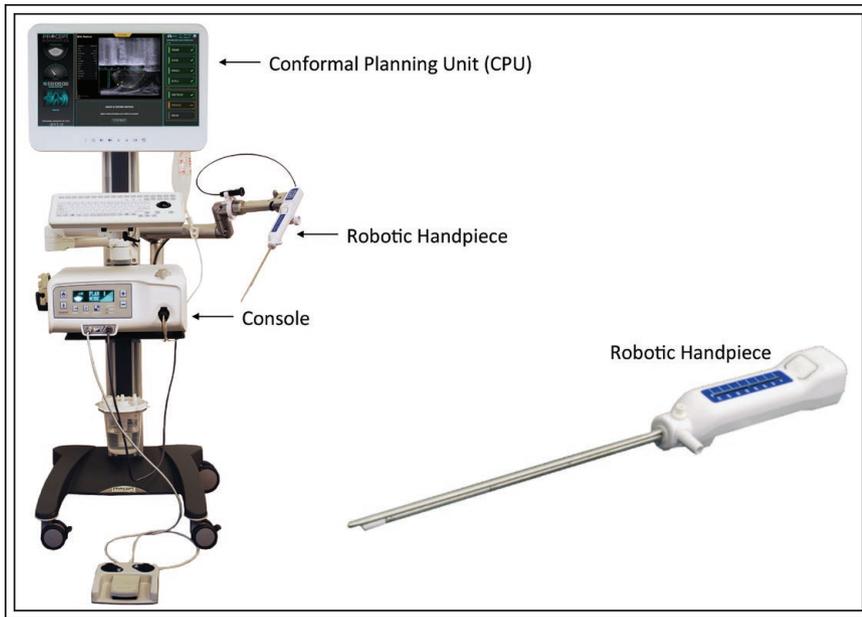


Figure 1. The AQUABEAM system console, pump and articulating arm with handpiece.

Patients who have moderate to severe LUTS are deemed appropriate candidates for this procedure, and they are then counseled and consented accordingly. An anesthetic review is performed for all patients prior to coming forward for surgery. Specialist reviews are obtained to assess co-morbidities if deemed necessary. Patients stop any anticoagulation 5-7 days prior to surgery if appropriate.

Method and surgical technique

The AQUABEAM system consists of three main components: the console, the robotic handpiece and the conformal planning unit (CPU), Figure 1. On the day of surgery patients are given antibiotic prophylaxis at induction of general anesthesia, and then prepped and positioned in the dorsal lithotomy position. A bi-plane transrectal ultrasound (TRUS) transducer is inserted and positioned with a table-mounted stepper. The bladder is then accessed by transurethral insertion of the 24-Fr AQUABEAM handpiece, which has an integrated flexible scope. The handpiece is positioned so that the tip is inside the bladder, 1-2 centimeters past the bladder neck. The integrated scope is retracted to visualize the bladder neck, confirming the correct positioning of the handpiece, and then positioned proximal to the external sphincter, protecting it from resection. After positioning, the handpiece is stabilized by a magnetic lock on an articulating arm also connected to the bed.

In order to optimize visualization of the prostate and maximize tissue removal, positioning and compression with the TRUS is important. The TRUS is advanced in the sagittal view to center the prostate, whilst providing an image both of the bladder and the handpiece's integrated cystoscope. Simultaneously, the surgeon elevates the tip of the TRUS probe to apply compression on the prostatic fossa, improving visualization and enabling deeper ablation of the prostate. Adjustments can then be made by advancing, retracting, or rotating the TRUS and stepper.

Following successful positioning and placement of the TRUS probe and AQUABEAM handpiece, the surgeon confirms the handpiece is centered and aligned in the transverse view using visual markers provided on

the computer screen. The waterjet is then rotationally aligned to two positioning points in the software at three o'clock and nine o'clock on the computer screen. This registers the handpiece in the system software.

After registration of the handpiece, the surgeon begins the planning process using the AQUABEAM monitor. In the transverse view, the prostate is scanned using the TRUS probe, and by retracting the stepper the surgeon can identify the largest cross-section of the prostate, Figure 2. Once the largest section of the prostate is identified, the surgeon plans the depth and the angle of resection using



Figure 2. The depth and the angle of resection are planned in the transverse view using the integrated transrectal ultrasound (TRUS) image on the AQUABEAM system's conformal planning unit (CPU).

the AQUABEAM system's software. The maximum angle of resection is 225 degrees and the maximum cut depth is 25 mm. If a median lobe is present, the surgeon can advance the TRUS probe to visualize the median lobe and separately plan the resection angle and depth for the median lobe. To finalize the planning, the surgeon inputs the resection contour using the sagittal view of the prostate, Figure 3. At this stage, the surgeon draws a treatment contour that conforms to the shape of the adenoma while sparing the bladder neck and verumontanum.

Once surgical mapping is complete, the surgeon initiates the aquablation treatment using a foot pedal. Upon foot pedal activation, the console pump delivers a high-velocity sterile saline stream orthogonally to the length of the handpiece at various flow rates, based on the required depth of penetration. The AQUABEAM system has a variety of integrated safety mechanisms; for example, tissue resection only occurs in front of the integrated cystoscope, which protects the external sphincter. In addition, the software enables the surgeon to identify the verumontanum and will direct the waterjet to resect tissue on either side of the verumontanum to ensure it is preserved.

As with any surgical removal of prostate tissue, a degree of bleeding can be expected. Either bipolar or monopolar cautery can be used for hemostasis following aquablation, per surgeon preference. Our initial experience with laser cautery found it to be ineffective. We now prefer to achieve hemostasis by positioning the balloon of a 22-Fr 3-way Foley catheter inside the prostatic cavity to tamponade the bleeding, thus eliminating the need for cautery, Figure 4.

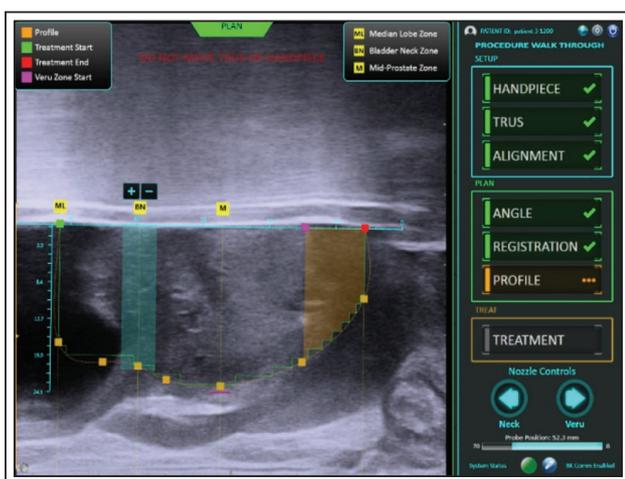


Figure 3. The area of resection is mapped in the longitudinal plane using the AQUABEAM system's keyboard to position the markers.

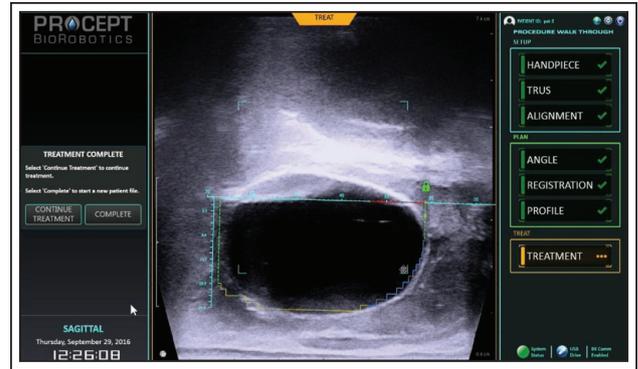


Figure 4. Foley balloon catheter in the prostatic cavity.

The catheter is placed on traction for 2 hours, with continuous bladder irrigation running as needed. The patient remains in hospital overnight, with catheter removal and trial of void routinely performed the morning after surgery and discharge later that day, as is standard at our institution following holmium laser enucleation of the prostate (HoLEP).

Discussion

The first published human study using the AQUABEAM system was a single center non-randomized trial from our institution.¹¹ Fifteen patients underwent aquablation, which was a technical success in all cases. The men enrolled in the trial, running from January 2013 to February 2014, were aged 50-80 years (mean 73 years) and had LUTS that had not responded adequately to standard medical therapy for BPH. Prostate size ranged from 27 cc-85 cc with a mean size of 54 cc.

Functional results were encouraging, with a statistically significant improvement in International Prostate Symptom Scores (IPSS), maximum flow rate (Qmax), quality of life scores (QoL) and post void residual (PVR). IPSS improved from 23.1 at baseline to 8.6 at 6 months of follow up ($p < 0.001$). QoL score improved from 5 to 2.5 ($p < 0.001$), Qmax improved from 8.6 mL/s to 18.6 mL/s ($p < 0.001$) and PVR improved from 91 mLs to 30 mLs ($p < 0.013$).

In this study eight of the fifteen patients had at least one adverse event, but these were all classified as minor, being Clavien-Dindo grade I-II. Five patients required re-catheterization; three had hematuria not requiring any intervention, and three complained of dysuria. No patient experienced incontinence, retrograde ejaculation or erectile dysfunction as measured by the IIEF-15 questionnaire.

A second phase I trial involving nine patients also showed encouraging results.¹² Once again

this trial involved patients with symptomatic BPH and urodynamic confirmation of bladder outlet obstruction. The mean age of these patients was 68 years, with mean prostate volume of 37 cc. IPSS improved from 22.1 at baseline to 2.3 at 1 year (90% improvement). QoL scores improved from 5.7 to 0.7 (88% improvement). Qmax improved from 7.0 mL/s to 14.1 mL/s at 1 year (101% improvement).

The third phase I trial¹³ also involved nine patients aged 62-75 (mean 66.7 years) with a mean prostate size of 61 cc (30 cc-102 cc). At 3 months of follow up the mean IPSS had improved from 23.1 to 5 ($p < 0.001$). QoL improved from 5 to 0.9 ($p < 0.0001$). Qmax improved from 8.3 mL/s to 17.9 mL/s ($p < 0.001$). Finally, PVR improved from 178.8 mLs to 58.1 mLs ($p < 0.05$). All patients were discharged on postoperative day 1, with the majority having removal of catheter prior to discharge. An unspecified number of patients experienced mild dysuria, with no other complication seen at 3 months of follow up. Once again there was no incontinence, retrograde ejaculation or erectile dysfunction reported.

In our experience, adverse events within the first 30 days postoperatively have been minor. Dysuria, hematuria, urinary tract infection, bladder spasm and meatal stenosis have been seen, each affecting a single patient. These early results are comparable to large TURP trials with the incidence of these events being approximately 4%.¹⁴ Retrograde ejaculation is reported at an average of 65% in large RCTs involving long term follow up of TURP. To date there have been no reports of this outcome in patients undergoing aquablation.⁶ Three of our patients undergoing aquablation failed their initial trial of void, requiring reinsertion of a catheter, but all subsequently had their catheters removed. No patient has required blood transfusion and to date there have been no Clavien-Dindo grade III-V adverse events.

One of the theoretical advantages to this technique is that the avoidance of thermal energy results in less tissue destruction and damage. In practice, the hope is that this will result in fewer irritative symptoms experienced by the patient. Concerns about hemostasis when aquablation was first used meant that cautery was performed as routine. We have since moved to using a Foley balloon catheter inside the prostatic cavity to tamponade the bleeding, thus eliminating the need for cautery, with no increase in bleeding complications. The pivotal randomized trial comparing aquablation and TURP is currently completing enrolment and will address comparative issues between techniques. The cost of the technology has yet to be determined but should be comparable with alternative methods of laser ablation.

Conclusion

Aquablation is a new method of prostate ablation showing functional improvement that compares favorably to other BPH technologies. The safety profile of the procedure is also favorable, with no grade III-V adverse events. At this time there have been no reports of retrograde ejaculation or sexual dysfunction, with most men reporting improvement in IIEF scores postoperatively. Longer term data with larger patient numbers are required, but this technique shows promise to improve LUTS with the potential for less morbidity than traditional TURP. □

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