

Transfusion rates after 800 Aquablation procedures using various haemostasis methods

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Objective

To determine if athermal methods are as effective in preventing blood transfusions as the use of cautery across various prostate volumes following prostate tissue resection for benign prostatic hyperplasia using Aquablation.

Patients and methods

The current commercial AQUABEAM robot that performs Aquablation therapy was first used in 2014. Since then numerous clinical studies have been conducted in various countries; Australia, Canada, Germany, India, Lebanon, Spain, New Zealand, United Kingdom, and the United States. All of the clinical trial data since 2014 were pooled with the early commercial procedures from France, Germany, and Spain to determine the effectiveness of haemostatic techniques in reducing the transfusion rate in patients after Aquablation.

Results

In all, 801 patients were treated with Aquablation therapy from 2014 to early 2019. The mean (SD, range) prostate volume was 67 (33, 20–280) mL and 31 (3.9%) transfusions were reported. The largest contributing factor to transfusion

risk was prostate size and method of traction. There was an increasing risk of transfusions in larger prostates when robust traction using a catheter-tensioning device (CTD) without cautery was used, ranging from 0.8% to 7.8% in prostates ranging from 20 to 280 mL. However, when standard traction (taping the catheter to the leg, gauze knot synched up to the meatus, or no traction at all) was used and where the surgeon performed bladder neck cautery only when necessary, the risk of transfusion was 1.4–2.5% in prostates ranging from 20 to 280 mL.

Conclusions

While the athermal subgroup with robust traction with a CTD had comparable transfusion rates for smaller prostates, the risk increased significantly as prostate volume increased. With standard traction methods and selective bladder neck cautery, the risk of transfusion was reduced to 1.9% across all prostate sizes.

Keywords

benign prostatic hyperplasia, transfusions, lower urinary tract symptoms, robotic, Aquablation therapy

Introduction

Surgical management remains the cornerstone of treating moderate-to-severe LUTS refractory to lifestyle changes and medical management. TURP has long been the comparator to new technologies, such as photoselective vaporisation (PVP) and endoscopic enucleation of the prostate (EEP), although open simple prostatectomy remains a standard surgical option for larger glands and complex pathologies for most

surgeons. While each modality has inherent strengths and weaknesses, all modalities require a keen focus on postoperative bleeding management to avoid significant drops in haemoglobin that require a blood transfusion. TURP is a highly effective treatment, yet presents technical challenges in larger prostate volumes when the procedure time exceeds 90 min resulting in a 7% transfusion rate [1]. A more contemporary analysis was done of 31 813 patients who underwent TURP and concluded longer surgical duration was

associated with increased odds of any complication and, specifically, blood transfusion after controlling for age, race, comorbidities, American Society of Anesthesia (ASA) class, type of anaesthesia administered, and trainee involvement [2]. PVP has been shown to have a low bleeding risk; however, in larger prostates, data show that the number of conversions to TURP in the operating room due to bleeding [3–5] is significantly higher. EEP is the only technique that can remove all of the prostate tissue up to the capsule through an endoscopic approach. It is effective for prostates of any size; however, the learning curve is so challenging [6] that only a small minority of surgeons have adopted this technique. Published data have shown transfusion rates of 4% for holmium enucleation of the prostate (HoLEP) [7,8]. Finally, open prostatectomy is often the go to option for larger prostates for surgeons who are not trained in EEP, but is a highly invasive surgery. Intraoperative haemostasis is achieved with electrocautery, yet studies report transfusion rates as high as 24% [7,9].

Aquablation therapy is a new endoscopic, transurethral procedure for LUTS due to BPH. Aquablation therapy leverages real-time ultrasound imaging to enable the surgeon to personalise the resection path for each patient under direct visualisation. This enables optimal resection while avoiding critical anatomical areas. The robotic technology autonomously ablates the prostate tissue using a heat-free waterjet along the custom resection path. The autonomous robotic technology ensures the procedure is consistent and reproducible, regardless of surgeon skill or experience, allowing for a shallow learning curve. The heat-free waterjet uses room temperature saline to ablate prostate tissue within the confines of the resection path, thereby eliminating heat-induced complications. Seven different clinical trials have been completed showing that Aquablation therapy provides effective and consistent outcomes across all prostate sizes with a minimal learning curve, while maintaining low complication rates and high patient satisfaction. The initial results of Aquablation therapy have been promising [10–14]. Aquablation has been included in the AUA guidelines for the surgical management of BPH/LUTS (for prostate volumes >30/<80 mL) in 2019.

A variety of techniques have been employed for haemostasis management, including an integrated 3–5 W coagulating laser, roller-ball or loop electrocautery, and athermal traction utilising either a specially designed catheter-tensioning device

(CTD) or tape or gauze traction. The CTD is an external catheter accessory mounted at the pubis that maintains and holds calibrated tension with a traction force of 600–1500 g on the urinary catheter, with the aim to eliminate the need of cautery. The purpose of the present analysis was to evaluate these different haemostatic techniques on transfusion rates following Aquablation therapy to determine if athermal methods are as effective in preventing postoperative transfusions as the use of selective bladder neck cautery across various prostate volumes. The basis for the present analysis was an observed chronological transfusion rate increase across various data sets (Table 1).

Patients and methods

The AQUABEAM Robotic System (PROCEPT BioRobotics, Redwood City, CA, USA) used to perform Aquablation therapy utilising a maximum waterjet resection depth and treatment angle of 24.3 mm and 225 °, respectively, and a resection length of 70 mm was first used in 2014 [15]. Prior generations of the robot had a shorter maximum resection depth and are excluded from this analysis. Data from seven clinical studies, sponsored by PROCEPT BioRobotics, along with four high-volume early commercial users of the technology were included. The clinical studies were AQUABEAM India Study for the Treatment of Benign Prostatic Hyperplasia (ABS;

ClinicalTrials.gov Identifier: NCT03167294), Acute Hemostasis Following the Use of the AQUABEAM® System for the Treatment of Benign Prostatic Hyperplasia (AHA; NCT03125863), AHA II (NCT03125889), Waterjet Ablation Therapy for Endoscopic Resection of prostate tissue (WATER; NCT02505919), WATER II (NCT03123250), Français-WATER (NCT03191734), and OPEN WATER (NCT02974751). The four commercial centres that contributed consecutive data were Asklepios Klinikum Harburg (author T.B.), American University of Beirut Medical Center (A.E.), Clinique Pasteur (V.M.), and Hospital Quirón Salud Barcelona (E.R.).

The procedural data collected were prostate volume and haemostasis method used (athermal, bladder neck cautery after Aquablation, and method of traction). Traction was defined as robust if set to a tension of >600 g (5.9 N) with a CTD or defined as standard, which was traction using the following methods: taping the catheter to the leg, gauze knot

Table 1 Transfusion rates by data set organised chronologically (left to right).

	Pre-WATER		WATER		WATER II		Commercial	
	Standard	Robust	Standard	Robust	Standard	Robust	Standard	Robust
N	79	0	135	0	0	101	108	378
Prostate size, mL, median (range)	38 (28–133)		52 (25–80)			105 (80–150)	60 (20–160)	60 (20–280)
Transfusion rate, %	1.3		1.5			9.9	2.8	4.0

Table 2 Baseline characteristics.

Characteristic	No transfusion subgroup (n = 770)	Transfusion subgroup (n = 31)	P
Mean (SD, range)			
Prostate volume, mL	66.3 (32.4, 20–280)	88.3 (34.4, 37–160)	0.001
Baseline haemoglobin, g/dL	14.5 (1.4, 7.5–19)	13.6 (1.6, 8.7–16)	0.002
Resection time, min	4.6 (2.7, 1–17)	6.7 (3.7, 2.4–17)	0.015
Bladder neck cauterly, n (%)	141 (18)	8 (26)	0.343
Robust traction, n (%)	454 (59)	25 (81)	0.015
PSA level, ng/mL, mean (SD, range)	4.9 (4.9, 0.1–36)	6.2 (3.7, 0.48–15)	0.082

synched up to the meatus or no traction at all. All patients received continuous bladder irrigation as per hospital standard practice.

Statistical analysis

The data were grouped by prostate volume tertiles to observe transfusion rates across small, medium, and large prostates by haemostasis methods. Logistic regression modelling was used to assess the impact of prostate size and haemostasis method to assess postoperative haemoglobin changes. Exploratory modelling using interaction terms was performed. All statistical analysis was performed using R (R Foundation for Statistical Computing, Vienna, Austria) [7].

Results

In all, 801 patients were treated with Aquablation therapy from 2014 to early 2019 from the data sources described in the Methods section (Table 2). The mean (SD, range) prostate volume was 67 (33, 20–280) mL. The small prostate tertile had a mean (SD, range) prostate volume of 35 (7, 20–48) mL. The medium prostate tertile had a mean (SD, range) prostate volume of 62 (8, 48–77) mL. The large prostate tertile had a mean (SD, range) prostate volume of 104 (26, 77–280) mL.

Transfusions were reported in 31 (3.9%) patients. Most transfusions occurred before hospital discharge and none of the transfusions occurred beyond 30 days. Figure 1 compares the transfusion rate comparing robust traction vs standard traction across prostate volume tertiles. While the transfusion rate is similar in small prostates, the transfusion rate increased 2–5-fold with robust traction over medium and large volumes. In all, 35% of the standard traction method procedures utilised focal bladder neck cauterly. Figure 2 shows a similar rate of transfusion across all prostate sizes.

Haemoglobin changes followed a similar pattern, with statistically significantly larger predicted perioperative drops in patients with larger prostates, and a lesser change when cauterly was used (all $P < 0.001$). Predicted haemoglobin changes were lowest when standard traction was used along with bladder neck cauterly (Fig. 3).

Fig. 1 Transfusion rate comparing robust traction (grey) and standard traction (black) across prostate volume (mL) tertiles.

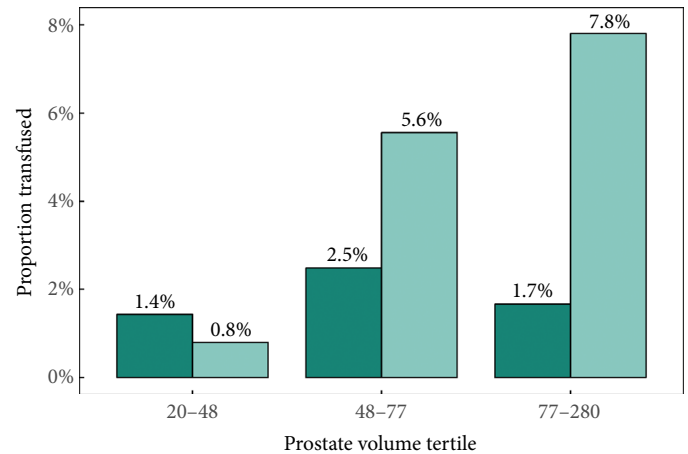
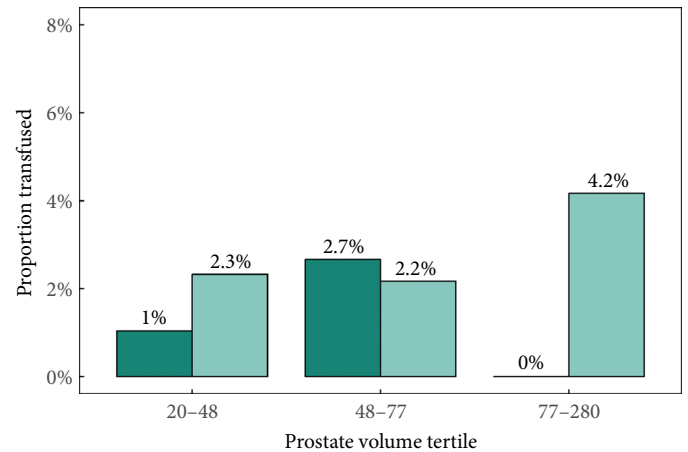


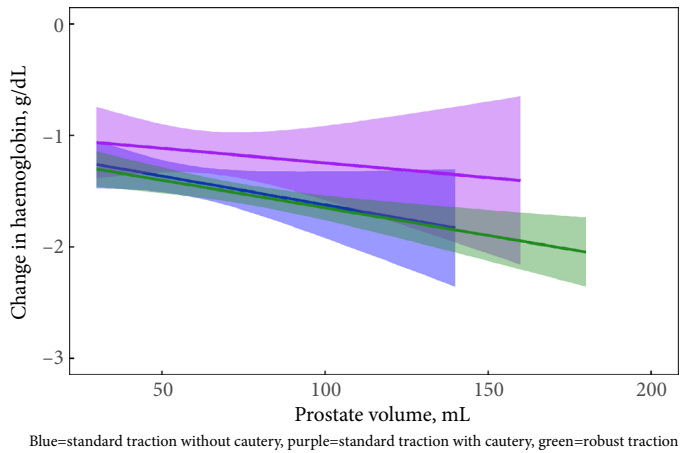
Fig. 2 Transfusion rate comparing standard traction without any cauterly (black) and standard traction with focal bladder neck cauterly (grey) across prostate volume (mL) tertiles.



Discussion

Intraoperative haemostasis management is a critical part of any prostate resective surgery to minimise bleeding events. TURP, PVP, EEP, and open simple prostatectomy all rely on intraoperative cauterly by a monopolar device or laser

Fig. 3 Predicted decrease in serum haemoglobin from pre- to postoperatively by prostate volume, traction type, and cautery use. Regressions assume mean baseline haemoglobin levels of 14.5 g/dL.



technology for haemostasis management, which have had varying degrees of success in minimising postoperative transfusions based on prostate size.

The analysis evaluated three different methods of haemostasis management with Aquablation therapy, and the results suggest that there is a relationship between prostate volume, the use of athermal robust traction, and the rate of bleeding events. There were fewer bleeding events without robust traction and when focal cautery at the bladder neck was used immediately after Aquablation, even in the largest tertile of prostate sizes. In the WATER study [10], where one of the inclusion criteria was a prostate volume of <80 mL, the mean haemoglobin decrease was 1.8 g/dL with a blood transfusion reported in one (0.86%) of 116 patients. In the first single-centre report of consecutive patients with prostate volumes reaching 154 mL, the mean haemoglobin reduction was 1.78 g/dL, with a transfusion rate of 2.5% [16]. These rates are acceptable and aligned with what is seen in the literature.

In the WATER II study [17], where prostate volume ranged between 80 and 150 mL, and haemostasis was done using an athermal method with robust traction, an analysis of glands of 80–100 mL had a haemoglobin drop of 2.5 g/dL and a blood transfusion rate of 4.8% (two of 42) before discharge and 4.8% (two of 42) after discharge. Whereas, in the subgroup consisting of glands between 100 and 150 mL, the blood transfusion rates reached 6.7% (four of 59 patients) before discharge and 3.4% (two of 59) after discharge. These data appear to suggest that there is a relationship between prostate volume, the use of athermal robust traction, and the rate of bleeding events. The WATER II protocol required that surgeons rely exclusively on robust traction with the CTD without the use of electrocautery. It is hypothesised, therefore, that the CTD itself resulted in more bleeding events due to increased bladder spasms and pain. The hypothesis is that

increased pain and spasm led to increased blood pressure, which subsequently translated into more bleeding by preventing clot formation. The clinical trials of WATER and WATER II are best suited to support this hypothesis because postoperative medications were diligently collected. There was a 157% increase in pain medication and 575% increase in antispasmodics in WATER II compared to the WATER study.

The accumulated data from the four international commercial centres show that the use of focal cautery at bleeding sites along the bladder neck in larger glands (>100 mL) has shown low rates of bleeding events. Thus, we postulate, in specific cases where active bleeding is observed just after Aquablation, the use of cautery may be an effective haemostasis management technique. This analysis represents a significant step in the evolution of the AQUABEAM technology. We anticipate further refinements in clinical practice and studies to shed further light on optimal haemostatic techniques to complement the impressive volume-independent, waterjet ablation of Aquablation.

Our present study is subject to limitations, including its retrospective nature and unbalanced patient numbers in each group. Further, during the various clinical trials there were limitations on the type of haemostatic methods utilised. Despite this, we had a very large cohort for the present study and our findings include real-world usage. Finally, all procedures in the present study were performed by expert surgeons who were well beyond the learning curve, which could limit the generalisability of our findings to less-experienced surgeons. Notwithstanding, this is to our knowledge the first study to date examining various haemostatic methods and postoperative transfusions.

Conclusions

While the athermal subgroup that received robust traction with a CTD had comparable transfusion rates for smaller prostates, the risk increased significantly as prostate volume increased. With standard traction methods and selective bladder neck cautery, the risk of transfusion is reduced to 1.9% across all prostate sizes.

Conflict of interest

All authors are investigators for PROCEPT.

Source of funding

PROCEPT BioRobotics funded all the clinical trials.

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Abbreviations: CTD, catheter-tensioning device; EEP, endoscopic enucleation of the prostate; HoLEP, holmium enucleation of the prostate; PVP, photoselective vaporisation; WATER, Waterjet Ablation Therapy for Endoscopic Resection of prostate tissue.