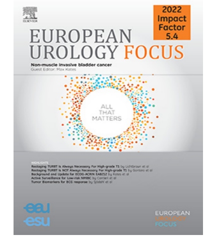
ARTICLE IN PRESS

EUROPEAN UROLOGY FOCUS xxx (xxxx) xxx

available at www.sciencedirect.com
journal homepage: www.europeanurology.com/eufocus



Review – Benign Prostatic Hyperplasia

Will Aquablation Be the New Benchmark for Robotic Minimally Invasive Surgical Treatment for Benign Prostatic Hyperplasia?

Carlotta Nedbal[a,b,*], *Daniele Castellani*[a], *Virgilio De Stefano*[a], *Carlo Giulioni*[a], *Rossella Nicoletti*[c,d], *Giacomo Pirola*[e], *Jeremy Yuen-Chun Teoh*[c], *Dean Elterman*[f], *Bhaskar Kumar Somani*[b], *Vineet Gauhar*[g]

[a] *Urology Unit, Azienda Ospedaliero-Universitaria delle Marche, Università Politecnica delle Marche, Ancona, Italy;* [b] *Department of Urology, University Hospital Southampton NHS Trust, Southampton, UK;* [c] *Department of Surgery, S.H. Ho Urology Centre, The Chinese University of Hong Kong, Hong Kong, China;* [d] *Unit of Urological Robotic Surgery and Renal Transplantation, Careggi Hospital, University of Florence, Florence, Italy;* [e] *Urology Unit, San Giuseppe Hospital, Multimedica Group, Milan, Italy;* [f] *Division of Urology, Department of Surgery, University Health Network, University of Toronto, Toronto, Canada;* [g] *Department of Urology, Ng Teng Fong General Hospital, Singapore*

Article info

Article history:
Accepted December 18, 2023

Associate Editor: Christian Gratzke

Keywords:
Benign prostatic hyperplasia
Aquablation
Robotic water jet
Prostate ablation
Minimally invasive surgical treatment

Abstract

Background and objective: Aquablation is included in the European Association Urology guidelines as an alternative surgical technique for prostate resection. The evidence summary states that it is subjectively and objectively as effective as transurethral resection of the prostate (TURP) and enucleation, but concerns remain regarding postoperative bleeding. Our aim was to provide an evidence-based overview of the trials, triumphs, and technical challenges of Aquablation.

Methods: A literature search in the PubMed, EMBASE, and Scopus databases was performed to identify clinical prospective and retrospective studies and reviews on Aquablation. A total of 54 reports were included. A narrative review of current evidence and an overview of the surgical technique are provided.

Key findings and limitations: Aquablation demonstrates excellent short- and long-term functional outcomes, with a good safety profile comparable to that of TURP. The procedure is efficient and safe, even for very large prostates, with sustained improvements in functional outcomes well maintained up to 5 yr. The unique ability to conduct robotically controlled precise ablation of enlarged tissue while maintaining the sphincter makes Aquablation a very good ejaculation-sparing BPH treatment option. Initial issues with hemostasis have been successfully overcome with the use of gentle bladder-neck cautery after the procedure, allowing for early catheter removal. The above features make Aquablation an attractive minimally invasive technique and show that it is noninferior to holmium laser enucleation.

Conclusions and clinical implications: Aquablation is a valid alternative to standard resection techniques, showing excellent long-term functional outcomes, good preservation of sexual function, a good safety profile, and good compliance for all prostate sizes and patient ages. Aquablation is still performed in high-volume centers, but the results can easily be emulated in other centers worldwide.

* Corresponding author. Urology Unit, Azienda Ospedaliero-Universitaria delle Marche, Università Politecnica delle Marche, Via Conca, 71, 60126 Ancona AN, Italy. Tel. +39 33 4399 7886.
E-mail address: carlottanedbal@gmail.com (C. Nedbal).

https://doi.org/10.1016/j.euf.2023.12.001

Advancing practice: Our review indicates that if Aquablation outcomes are emulated globally, this technique could easily become a new benchmark in robotic treatment for BPH.

Patient summary: Aquablation is a safe and effective surgical technique for treatment for benign enlargement of the prostate, with excellent medium-term outcomes. Although long-term studies are needed, the results are promising and challenge the current surgical and laser techniques used to reduce the size of the prostate gland.

1. Introduction

Aquablation is included in the European Association of Urology (EAU) guidelines as an alternative surgical technique for prostate ablation, and the evidence summary states that it is subjectively and objectively as effective as transurethral resection of the prostate (TURP), but concerns remain about post-treatment hemostasis [1]. Aquablation is only recommended for patients with moderate to severe lower urinary tract symptoms (LUTS) with a prostate volume of 30–80 cm^3. Patients should be aware of the risk of bleeding and the lack of long-term follow-up data.

Following US Food and Drug Administration approval of the AquaBeam robotic system (PROCEPT Biorobotics, Redwood City, CA, USA), which provides precise, robotically controlled resection of prostate tissue with a heat-free water jet for autonomous tissue removal for the treatment of benign prostatic hyperplasia (BPH), the American Association of Urology (AUA) guidelines included a statement that Aquablation therapy may be offered to patients with LUTS attributed to BPH. This recommendation for Aquablation therapy follows the 2018 addition of Aquablation therapy to the Canadian Urological Association guideline on male urinary tract symptoms and paves the way for a personalized treatment plan for each patient [2].

The aim of this scoping review was to provide an evidence-based overview of trials, triumphs, and technical challenges of Aquablation and the current evidence that supports its potential as a new benchmark in BPH management for all prostate sizes.

2. Methods

2.1. Literature search

The aim of this scoping review was to assess the safety and efficacy of Aquablation for clinical BPH. The literature search was performed on July 31, 2023 in the PubMed, EMBASE, and Scopus databases. The following terms and Boolean operators were used: (BPH OR benign prostatic hyperplasia) AND (lower urinary tract symptoms OR LUTS) and (aquablation OR water jet therapy OR aquabeam OR robotic water jet ablation).

2.2. Study selection criteria

The PICOS (Population, Intervention, Comparator, Outcome, Study type) model was used to frame and answer the following clinical question:

– Population: patients with an indication for surgical treatment of clinical BPH.
– Intervention: Aquablation.
– Comparator: no treatment or other BPH surgical procedures.
– Outcome: early (within 30 d) and late complications and functional outcomes.
– Study type: retrospective and prospective studies, and reviews.

2.3. Study screening and selection

Studies were included on the basis of the PICOS eligibility criteria. Only English papers were accepted. Preclinical studies were excluded, as were letters, case reports, and meeting abstracts.

All the studies retrieved were screened by two independent authors using the Covidence tool for systematic review management (Veritas Health Innovation, Melbourne, Australia). Discrepancies were resolved via discussion with a third author. The full text of screened papers identified as pertinent to the purpose of this review was selected for assessment. The review was registered on OSF Registries (https://osf.io/3jt4p).

2.4. Literature screening

The literature search identified 373 papers, of which 122 duplicates were automatically removed, leaving 251 papers for screening by title and abstract. Of these, 123 papers were further excluded because they were irrelevant to this review. The remaining 128 full-text papers were screened for pertinence. One paper was manually retrieved. A total of 75 papers were excluded. Finally, 54 papers were accepted and included in the review. Figure 1 shows a flow diagram of the literature search.

2.5. Study characteristics

Tables 1 and 2 show the characteristics of studies comparing Aquablation versus other BPH surgical procedures and single-arm series, respectively. Table 3 shows results from published reviews on Aquablation.

Seven papers reported results from one prospective randomized study comparing Aquablation versus TURP (the WATER study), eight papers reported results from one prospective study including patients with a prostate volume of 80–150 ml (the WATER II study), and two papers reported results from another prospective study (the OPEN WATER trial).

There were six single-arm prospective studies and five retrospective studies. One prospective study compared Aquablation versus TURP for a cost-analysis perspective [3]. One retrospective study compared Aquablation to holmium laser enucleation of the prostate (HoLEP). Seven papers reported pooled data from the WATER and WATER II studies. One paper reported pooled data on blood transfusion rates from seven studies. Finally, there were 16 reviews.

The full list of studies included in the review is available in the Supplementary material.

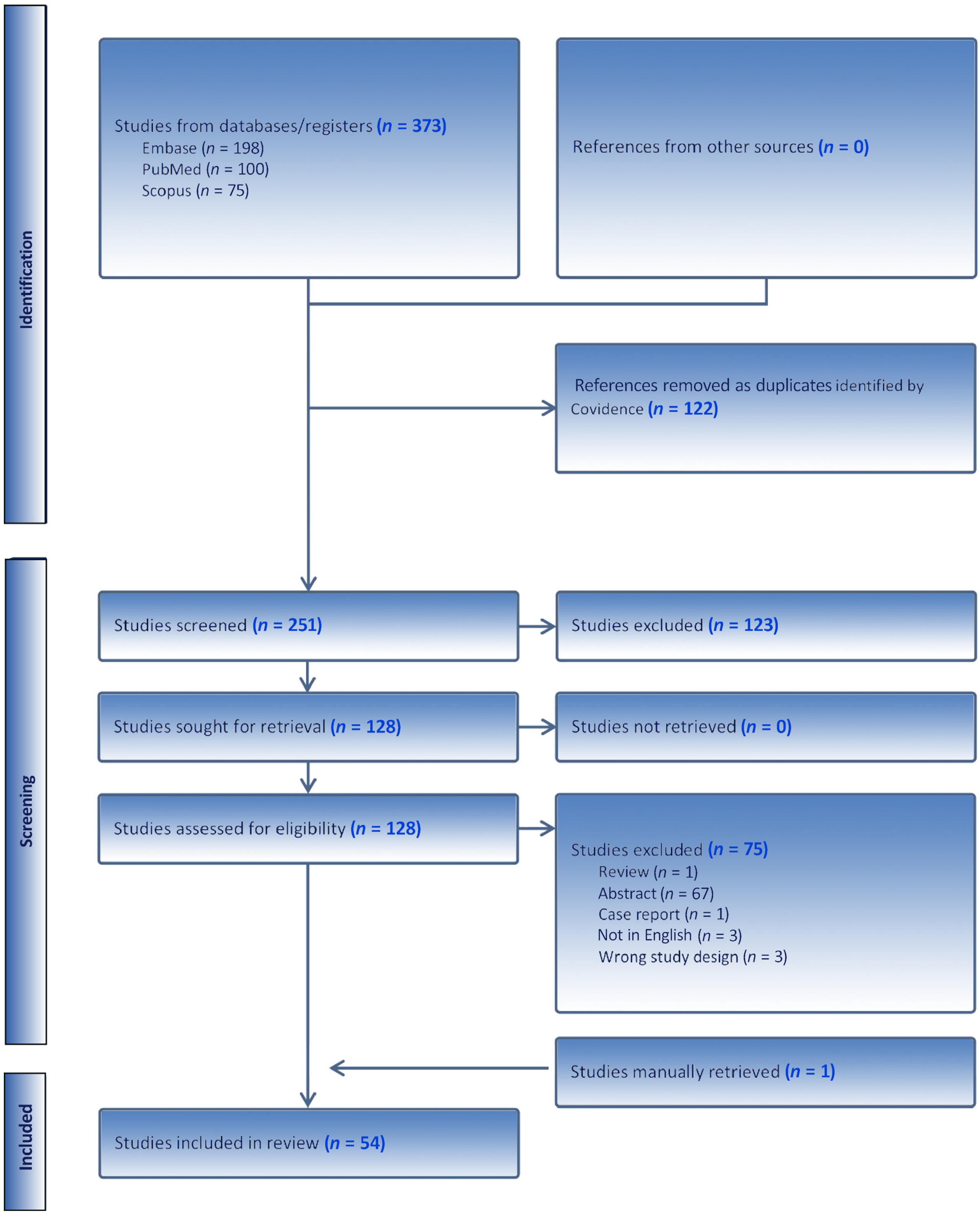


Fig. 1 – Flow diagram of the literature search, screening, and study selection process.

3. Results

3.1. Aquablation device and surgical steps

Aquablation is an ablative therapy in which a high-pressure water jet is applied to prostatic tissue. The technique combines image guidance and robotics with rapid high-volume injection of saline for targeted and heat-free removal of adenoma [4].

The AquaBeam system comprises three parts: (1) a conformal planning unit (CPU), an interface used by the sur-

Table 1 – Characteristics of studies comparing Aquablation to other techniques for BPH surgery

Study [a]	Design	FU (mo)	COMP	Patients (*n*)		Conclusion
				Aquablation	COMP	
Bach 2022 [23] WATER I + WATER II	RCT and PS	36	TURP	SP: 127 MP: 90	65	Despite larger baseline PV, the MP protocol led to better voiding outcomes and IPSS improvements and was superior to SP Aquablation and to TURP at 3-yr FU. A second pass with the water jet may have a long-term durable efficacy benefit.
Gilling 2018 [6] WATER	RCT	6	TURP	117	67	The two techniques showed similar rates of major complications, with a lower risk of anejaculation with Aquablation. For PV of 50–80 ml, the latter was more effective and safer.
Gilling 2019 [13] WATER	RCT	12	TURP	117	67	Aquablation provides similar outcomes to TURP in terms of LUTS resolution, even at 12-mo FU, with a low AE rate for men with medium PV (<80 cm^3). It can be an alternative to TURP in men wishing to preserve ejaculation.
Gilling 2019 [15] WATER	RCT	24	TURP	110	59	2-yr efficacy outcomes after TURP and Aquablation were similar, with a similar low surgical retreatment rate
Gilling 2020 [16] WATER	RCT	36	TURP	97	55	3-yr BPH symptom reduction and urinary flow rate improvement were similar after TURP and Aquablation therapy. No subjects required surgical retreatment beyond 20 mo postoperatively.
Gilling 2022 [17] WATER	RCT	60	TURP	116	85	Outcomes from Aquablation outweigh those offered by TURP; considering efficacy and lower risk of needing a secondary intervention and avoiding retrograde ejaculation. Following Aquablation, symptom reduction, and uroflow improvement are durable and consistent. Larger prostates (>50 ml) have major safety and efficacy benefits for Aquablation.
Plante 2019 [12] WATER	RCT	6	TURP	97	55	In men with larger (>50 g) prostates, Aquablation provided a greater reduction in symptom scores and a lower rate of postoperative complications (especially anejaculation) vs TURP. In men with larger prostates, the rate of Clavien-Dindo ≥2 complications favored Aquablation (19% vs 29%).
Te 2023 [18] WATER I + WATER II	RCT and PS	36	TURP	146	39	Functional outcomes did not differ between Aquablation and TURP at 36-mo FU. Both techniques are effective in patients for whom medical therapy has truly failed, and Aquablation delivered this benefit for a much broader PV range.
Gloger 2021 [b,c]	RS	1	HoLEP	215	167	The risks of perioperative blood loss, postoperative reintervention, and blood transfusion after Aquablation followed by selective transurethral hemostasis are equivalent to those after HoLEP.

BPH = benign prostatic hyperplasia; RCT = randomized controlled trial; PS = prospective study; RS = retrospective study; FU = follow-up; COMP = comparator; TURP = transurethral resection of the prostate; HoLEP = holmium laser enucleation of the prostate; SP = single-pass Aquablation; MP = multiple-pass Aquablation; AE = adverse event; IPSS = International Prostate Symptom Score; LUTS = lower urinary tract symptoms; PV = prostate volume; Qmax = maximum flow rate; UTI = urinary tract infection.

[a] WATER inclusion criteria: men aged 40–80 yr; PV size 30–80 cm^3; moderate to severe LUTS (IPSS >12); Qmax <15 ml/s; WATER exclusion criteria: history of prostate or bladder cancer; neurogenic bladder; bladder calculus or clinically significant bladder diverticulum; active UTI; treatment for chronic prostatitis; diagnosis of urethral stricture, meatal stenosis or bladder neck contracture; damaged external urinary sphincter; stress urinary incontinence; postvoid residual volume >300 ml or urinary retention; use of self-catheterization; and prior prostate surgery. WATER II inclusion criteria: age 45–80 yr; PV 80–150 ml on transrectal ultrasound; IPSS ≥12; Qmax <15 ml/s; serum creatinine <2 mg/dl; history of inadequate or failed response to medical therapy; and mental capacity and willingness to participate in the study. WATER II exclusion criteria: body mass index > 42 kg/m^2; history of prostate or bladder cancer; concomitant bladder calculus/clinically significant bladder diverticulum; active UTI; previous urinary tract surgery; indwelling catheter for ≥90 d; chronic pelvic pain; history of clinically significant urethral stricture, meatal stenosis, or bladder neck contracture; use of anticholinergic agents; and other general conditions that could prevent adequate FU.

[b] Inclusion and exclusion criteria not reported. Reference details are provided in the Supplementary material.

geon to plan the treatment; (2) a console, which receives instructions from the CPU and controls and delivers the treatment; and (3) a robotic hand piece composed of reusable and disposable sterile parts that delivers a stream of saline to the target tissue.

The patient is placed in the lithotomy position under general or spinal anesthesia. The bladder is accessed transurethrally under vision using a custom 22-Fr rigid cystoscope secured in place using a bed-mounted rigid arm. A transrectal ultrasound (TRUS) probe is inserted and fixed to a second bed-mounted arm. Under TRUS guidance, the surgeon maps the exact prostatic gland contours on a computer console (Fig. 2) with the aim of preventing any injury to the bladder neck, ejaculatory ducts, and urinary sphincter (Fig. 3). A foot pedal is used to activate an orthogonally positioned jet of high-velocity sterile saline that moves from backwards starting from bladder to verumontanum. The entire process is monitored via TRUS to ensure smooth visualized control throughout the procedure. Once the treatment is complete, both the transurethral and TRUS probes are removed, and the bladder is thoroughly irrigated to remove any residual floating tissue particles and blood. Specimens can be collected and sent for histological analysis. The procedure is then completed with electrocautery hemostasis and a catheter is usually inserted.

Since the launch of the first-generation machine, there has been much focus on improving hemostasis. In the first feasibility study conducted on a canine model in 2015 (Idea, Development, Exploration, Assessment and Long-term follow-up [IDEAL] stage 0), Faber and colleagues [5] performed surface coagulation of the prostatic fossa using a 2-W GreenLight laser, following the same axial and longitudinal directions as the ablation. In the same year, in the first case series reported by Gilling et al. [4] (IDEAL stage 1), cau-

Table 2 – Characteristics of single-arm Aquablation studies

Study[a]	Design	FU (mo)	Pts	Age (yr)[b]	PV (ml)[b]	OT (min)[b]	AT (min)[b]	Catheter removal (h or d)[b]	LOS (d)[b]	RCZ	Complications		Conclusion
											30 d	>30 d	
Assad 2022 WATER I (WI) + WATER II (WII)	RCT	36	217	WI: 65.9 ± 7.3 WII: 57.4 ± 6.6	WI: 54.1 ± 163 WII: 107.4 ± 20.2	WI: 39.7 ± 15.2 WII: 54.5 ± 19.2	NA	WI: 2 ± 2.3 WII: 3.9 ± 3.6	WI: 1.4 WII: 1.6	NA	NA	NA	Aquablation seems to be safe and effective for BPH independent of PV, with good FO improvements, short OT and LOS, and a very short LC; sustained FOs and low ReTx rates for all PVs at 3-yr FU
Bach 2019 [23]	PS	3	118	69 (8; 88–52)	64.3 (32; 20–154)	20 (7.91; 9–53)	3.2 (1.22; 1.48–7.31)	2.2 (0.46; 2–4)	NA	NA	Overall: 13 (8.5%) CD2: 9 CD3: 4	NA	Aquablation is safe and efficient for a wide PV range, with high AJ rates. PV reduction superior to TURP and comparable to endoscopic enucleation, suggesting Tx durability.
Bach 2020 OPEN WATER	PS	12	178	67.7 ± 8.5	59.3 ± 26.9	24 ± 11.3	18.9 ± 8.5	1.9	2.2 ± 1.7	NA	CD1: 20% CD2: 9% CD3a: 4% CD3b: 9%	3 (urethral stenosis)	Real-world evidence shows that Aquablation is safe and effective for Tx of symptomatic BPH
Bhojani 2019 [44] WATER II	PS	3	101	<100 cm^3: 68 ± 7.1 >100 cm^3: 67 ± 6.2	120.9 ± 15.1	<100 cm^3: 31.2 ± 8 >100 cm^3: 41.7 ± 14.9	<100 cm^3: 6.4 ± 2.8 >100 cm^3: 9.1 ± 2.9	2	<100 cm^3: 1.5 ± 0.7 >100 cm^3: 1.7 ± 1.1	NA	NA	NA	Aquablation normalized outcomes for PVs <100 cm^3 and >100 cm^3. It is safe and effective in patients with PV >100 cm^3, with a smoother LC.
Bhojani 2023 [37] WATER II	PS	60	62	67.5 ± 6.6	107.4 ± 20.2	55 (25–111)	8 (3–17)	NA	NA	NA	NA	Surgical ReTx 3%	At 5-yr FU, Aquablation was safe with durable efficacy and low ReTx rates for large PVs (80–150 ml)
Chughtai 2018 [45] Pooled data for Americans from WATER and WATER II	PS	3	107	67.3 ± 6.5	99.4 ± 24.1	35.6 ± 14.9	7 ± 3.3	NA	1.6 ± 1	NA	EJD: 7 UI: 3 EJD +UI: 2 CD2: 29% CD3: 19% CD4: 1%	NA	Aquablation was safe and effective in patients with PV of 60–150 cm^3. There were improvements in IPSS, Qmax, and PVR at 3 mo in patients with LUTS due to BPH.
D'Agostino 2021 [11]	RS	3	53	62 (57–66)	55 (43–65)	60 (40–80)	NA	2 (1–3)	2 (1–3)	NA	NA	2 (3.8%) Types NR	AquaBeam + Ho laser energy for HST is safe, reproducible for moderate LUTS due to BPH and preserves EJF in younger and sexually active individuals
Desai 2018	PS	3	47	66 ± 6	48 ± 24	35 ± 19	4 ± 2.4	1.9 ± 1.6	3.1 ± 1.6	NA	NA	**CD1**: AUR 3, HUT 1, INF 1 **CD2**: UR 3, UST 2	The 2nd-generation AquaBeam system guarantees safety and short-term efficacy in patients with LUTS due to BPH
Desai 2019 [24] WATER II	PS	6	101	67.5 ±6.6	107.4 ± 22.1	37 ± 13	8 ± 3	94 ± 86 h	1.6 ± 1	1%	CD1: 22% CD2: 14% CD3: 3% CD4: 5%	NA	Aquablation is a reasonable surgical alternative in patients with larger PV, with high efficacy, low OT and LOS, EJF maintenance, and acceptable complication and BT rates
Desai 2019 [8] WATER II	PS	1	101	67.5 ± 6.6	107 ± 20	55 ± 19	37 ± 37	94 ± 86 h	1.6 ± 1	2%	CD2: 29.7% CD3: 6% CD4b: 1%	NA	Aquablation is a reasonable surgical alternative in patients with larger PV with relatively low OT and LOS, acceptable complication and BT rates, and a relatively short LC
Desai 2020 WATER II	PS	60	101	67.5 ± 6.6	107.4 ± 22.1	37	8	NA	NA	2	BL 20, DSU 10 MS 3, MOF 1, scrotal edema 3, UST 1, UR 2, UF 2, UI 5, UTI 5	BL 3, DSU 2 MS 4, UST 1, UR 2, UF 1, UTI: 3 at 3 mo, 9 at 12 mo	Aquablation is safe and effective for Tx of LUTS due to BPH for PV of 80–150 cm^3. with durable Tx efficacy, an acceptable safety profile and a low ReTx rate
El Hajj 2022	RS	12	175	65 (59–70)	70 (50–91)	39 (30–52)	NA	NA	NA	18 (10.3%)	CD1: 8 HU, 1 TEH, 5 LUTS CD2: 1 PNP, 9	NA	Basic urological skills in echographic interpretation allowed for a shorter LC; with a trifecta of outcomes achievable after 5 cases and a pentafecta of outcomes

(continued on next page)

Table 2 (*continued*)

Study[a]	Design	FU (mo)	Pts	Age (yr)[b]	PV (ml)[b]	OT (min)[b]	AT (min)[b]	Catheter removal (h or d)[b]	LOS (d)[b]	RCZ	Complications		Conclusion
											30 d	>30 d	
											UTI, 1 DVT, 1 CPF CD4a: 1 sepsis		after 38 cases
Elterman 2020 [9] ABS, AHA I and II, Water I and II, Francais-WATER, OPEN WATER	PA	NA	801	NR	67 (33; 20–280)	NA	NA	NA	NA	NA	31 (3.9%) BT	NA	With standard traction methods and selective bladder-neck cautery, the risk of transfusion is reduced to 1.9% across all prostate sizes.
Ghiraldi 2022 [39]	RS	1	32	66	65 (30–200)	NA	NA	3.3 ± 4.1	1.8 ± 1.4	2	CD1: 6.3% (AUR) CD2: 28.1% (BL, TBE) CD3b: 3.1%	NA	A combination of traction and focal bladder neck electrocautery should be strongly considered to minimize bleeding complications.
Gilling 2016 [6]	PS	6	15	73 ± 7	54 ± 18	48.3 ± 15.5	11.9 ± 6.8	1.4 ± 1.5	1.8 ± 1.6	5	3 HU not requiring intervention 3 DSU	NA	Early data indicate urodynamic and symptom improvements consistent with other endoscopic strategies for BPH, with a shorter resection time
Gilling 2017 [13]	PS	12	21	70 ± 5	57.2 (30–102)	38	5	NA	1	3	6 patients [c]	NA	Aquablation improved symptom scores and other measures of obstruction at 12 mo in men with LUTS due to BPH
Helfand 2021	RS	7	34	69 ± 8	209 ± 56	64 ± 24	NA	NA	NA	No BT	NA	NA	Aquablation for PV >150 ml showed similar FOs to those for smaller PVs.
Kasivisvanathan 2018 [14] WATER (only US patients analyzed)	RCT	12	61	64.5 ± 7.4	54.2 ± 16.3	27.6	3.9	NA	1.4	NA	CD1: 6.7% CD2: 13.3%	1 ReTx for BPH	Aquablation is a reasonable alternative with good 1-yr outcomes for men with PV of 30–80 cm^3, and a particularly good option for men who wish to maintain their EJF.
Kasraeian 2020 [41]	RS	3	55	67 ± 8.2	100 ± 44	59	NA	NA	1.8	0	5 HU, 1 BSP, 1 DHY, 1 IC, 1 DCE		In community private urology practice, Aquablation can be considered safe and effective for BPH Tx, regardless of prostate shape or size.
Labban 2021	PS	3	59	68.3 (7.9)	71.4 (31.3)	48.5 (2.5)	NA	2.1 (0.3)	2.2 (0.1)	4	5 CD1 (AUR, UTI) 5 CD2 (BL) 2 CD3a, 1 CD3b 1 CD4a (USP)	NA	Effective Tx for BPO with limited AEs
Misrai 2019 [25] Francais WATER	PS	12	30	68 (61–72)	60 (45–69)	30.5 (24–35)	NA	43 h (23–49)	2 (2–4)	NA	NA	NA	Aquablation is reproducible by surgeons early in the LC.
Müllhaupt 2022 [3]	PS	6	24	68.1 ± 6.9	61.9 ± 22.6	99.6 ± 22.1	61.8 ± 20.5	2.8 ± 0.9	3.8 ± 1.0	NA	NA	NA	Similar efficacy for Aquablation and TURP, although the former has a lower cost/benefit ratio
Nguyen 2020 [42] WATER I (WI) + WATER II (WII)	RCT and PS	12	217	NA	NA	NA	NA	NA	<80 cm^3: 1.4 >80 cm^3: 1.6	NA	WI vs WII: CD1: 40.5% vs. 32.7% CD2: 17.2% vs 21.8% CD3: 5.2% vs 12.9% CD3: 0.9% vs 5%	NA	Aquablation effectiveness is independent of PV, with clinical normalization of outcomes for PV of 30–80 cm^3 and 80–150 cm^3 in men treated for LUTS due to BPH, with an expected increase in the risk of complications for larger PV.
Nguyen 2021 [27]	RCT	24	117	65.9 ± 7.3	54.1 ± 16.3	32.8 ± 16.5	NA	2 ± 2.3	1.4	NA	NA	NA	Aquablation has similar efficacy for all PVs, even at 2-

Please cite this article as: C. Nedbal, D. Castellani, V. De Stefano et al., Will Aquablation Be the New Benchmark for Robotic Minimally Invasive Surgical Treatment for Benign Prostatic Hyperplasia?, Eur Urol Focus (2023), https://doi.org/10.1016/j.euf.2023.12.001

Table 2 (*continued*)

Study[a]	Design	FU (mo)	Pts	Age (yr)[b]	PV (ml)[b]	OT (min)[b]	AT (min)[b]	Catheter removal (h or d)[b]	LOS (d)[b]	RCZ	Complications 30 d	Complications >30 d	Conclusion
WATER I + WATER II	and PS												yr FU
Raizenne 2022 [43] WATER I + WATER II	RCT and PS	36	<65 (YM): 83 (38%) ≥65 (EM): 134 (62%)	NA	NA	EM: 46.9± 16.8 YM: 45.4 ± 21.0	EM: 6.1 ± 3.0 YM: 5.4 ± 3.3	EM: 2.95 ± 2.6 YM: 2.84 ± 3.8	EM: 1.6 ± 0.9 YM: 1.4 ± 0.8	NA	YM vs EM: CD2: 4.5% vs 22.4% CD3: 10.8% vs 8.2% CD4: 2.4% vs 3.0%	YM vs EM: CD2: 4.5% vs 22.4% CD3: 10.8% vs 8.2% CD4: 2.4% vs 3.0%	In the EM population, Aquablation offers similar functional and sexual outcomes compared to those for YM.
Whiting 2021 OPEN WATER	PS	12	55	64.1 ± 7.9	58.2 ± 23.9	26.9 ± 9.2	NA	2.3 ± 2.6	1.8 ± 0.9	5 (9.1%)		2 (3.6%) HUT; 3 (5.5%) UTI; 2 CD4: 1 gross HU requiring HST, 1 RPC	Aquablation seems to be safe and well tolerated, with LUTS improvements comparable to standard procedures and greater preservation of sexual function
Yafi 2018 WATER II	PS	3	82	68 ± 6.46	107.8 ± 21.1	38.2 ± 14.4	7.7 ± 3.3	4.3 ± 3.8.	1.6 ± 1.04	11%		BT 10.9% FBC 4.9%	Aquablation seems to be a good surgical option for men with LUTS/BPH with larger PV, with good FOs, relatively short OT and LOS, and acceptable complication and BT rates
Zorn 2019 [30] WATER II	PS	3	19	66 ± 6.9	105.6 ± 16.6	33.7 ± 7.8	9.0 ± 2.4	2.1 ± 1.5	1.3 ± 0.8	NA		EJD 32% CD2 31.6%	Aquablation seems to be a good surgical option for men with LUTS/BPH with larger PV, with impressive FOs, relatively short OT and LOS, and acceptable complication and low BT rates
Zorn 2022 [26] WATER II	PS	36	101	67.5 ± 6.6	107.4 ± 22.1	55	8	NA	NA	1%	BT 9.9% FBC 3% Cardiac event 3% Stroke 1% EJD 14.9%	MS 3% UST 1% UI 6.9% UTI 5.9%	Sustained symptom reduction at 3-yr FU and a low rate of irreversible complications after Aquablation in men with LUTS due to BPH and PV of 80–150 cm^3

BPH = benign prostatic hyperplasia; LUTS = lower urinary tract symptoms; RCT = randomized controlled trial; PS = prospective study; RS = retrospective study; PA = pooled analysis; FU = follow-up; RCZ = recatheterization; LOS = length of hospital stay; NA = not available; AE = adverse event; AJ = antegrade ejaculation; AT = ablation time; BL = bleeding; CD*x* = Clavien Dindo grade *x* complications; EM = elderly men (≥65 yr); YM = young men (<65 yr); BSP = bladder spasms; BT = blood transfusion; CE = cardiac event; CPF = capsular perforation; DCE = death from cardiovascular event; DHY = dehydration; DSU = dysuria; DVT = deep vein thrombosis; EJD = ejaculatory dysfunction; EJF = ejaculator function; FBC = fulguration for bleeding control; FO = functional outcome; HST = hemostasis; HU = hematuria; HUT = HU requiring transfusion; IC = intolerance to catheter; INF = infection; LC = learning curve; LOS = length of hospital stay; MOF = multisystem organ failure; MS = meatal stenosis; OT = operative time; PNP = pyelonephritis; Pts = patients; PV = prostate volume; ReTx = retreatment; RPC = rectal perforation requiring colostomy; TBE = thromboembolism; TEH = thrombosed external hemorrhoids; Tx = treatment; UF = urinary frequency; UI = urinary incontinence; UR = urinary retention; USP = urosepsis needing intensive care unit admission; UST = urethral stricture; UTI = urinary tract infection

[a] For studies without a reference number, details are available in the Supplementary material.

[b] Results are presented as the mean ± standard deviation or mean (median; interquartile range).

[c] Six patients had at least one grade 1 (self-resolving dysuria and hematuria, catheter reinsertion for retention) and/or grade 2 (medically treated UTI) complications.

Table 3 – Results from previous Aquablation reviews

Review[a]	Design	Studies included	Patients included	FU (mo)	Primary outcome	Secondary outcomes	Conclusions
Chen 2023	SRV + MA	7	551	12	Effects of Aquablation on improving urinary outcomes (IPSS, QoL)	Sexual outcomes (IIEF-5, MSHQ scores), morbidity, perioperative outcomes	Aquablation seems to improve LUTS in men with BPH while providing relatively preserved sexual function. Morbidity and perioperative outcomes seem to be acceptable.
Elterman 2021	MA with IPD	4	425	12	Improvements in storage and voiding symptoms and uroflowmetry, and impact on UI	None	Aquablation improves symptoms and uroflowmetry measures in men with a small or large prostate and men with an obstructive median lobe. UI severity improved in men with severe baseline UI
Fiori 2020	SRV	6	Aquablation: 117 TURP: 67	6	To summarize current evidence on Aquablation and its results in comparison to outcomes reported for TURP	None	Aquablation has high clinical efficacy with an excellent safety profile. For PV of 30–80 cm^3, comparative studies demonstrated that the procedure offers clinical results at least comparable to those of conventional TURP. Latest evidence showed that Aquablation may be used effectively for PVs up to 150 cm^3. Major strengths are its high-speed resection time, low complication rate, and potential for sexual function preservation.
Hwang 2019	NRV	1	181	12	To assess Aquablation for LUTS Tx in men with BPH (urologic symptom scores, QoL, major AEs)	Repeat Tx, erectile function, ejaculatory function, minor AEs, AUR, IDC, LOS	According to short-term (up to 12 mo) FU, the effect of Aquablation on urological symptoms is probably similar to that of TURP
Mann 2019	NRV	1	Aquablation: 116 TURP: 65	6	to detail and discuss the results of the WATER study	None	Aquablation provides non-inferior symptom relief when compared with TURP and demonstrates a significantly superior safety profile and lower risk of sexual dysfunction
Pimentel 2016	NRV		NR		To evaluate the mechanism of action, safety and efficacy of Aquablation	None	Aquablation has potential for improving LUTS due to BPH. Its appeal lies in its precise and selective ablation capabilities, with minimal complications
Pimentel 2018	NRV		NR	n	To describe the AquaBeam system and assess its safety and efficacy for LUTS due to BPH	None	Aquablation demonstrates efficacy akin to that of TURP, with a lower rate of perioperative complications.
Probst 2022 [36]	NRV	4	NR	3	None	None	None
Reale 2019	SRV + MA	9	664	6	To evaluate functional outcomes after Aquablation (improvement in IPSS, QoL, Qmax, PVR)	Sexual outcomes, adverse events	Aquablation provides functional outcomes comparable to TURP. It proved to be a safe technique, with a rate of adverse events similar to TURP with a low rate of retrograde ejaculation.
Saadat 2019	NRV	6	418	3 + 12	To review the evolution of the Aquablation system and its safety and functional outcomes	None	Aquablation seems to be a promising option for management of LUTS due to BPH for varying PVs. The robotic system provides reproducible ablation, independent of PV, without a need for extensive training.
Sadri 2021	NRV	5	543	NR	To discuss the literature on Aquablation, its limitations, and opportunities for its use in BPE Tx	None	Aquablation is a safe and effective alternative for BPH Tx for small to large prostates.
Stein 2021 [38]	NRV		NR	NA	To compare Aquablation with TURP, transurethral laser enucleation, and simple prostatectomy	To highlight further developments and modifications, particularly for hemostasis	Initial concerns regarding a higher risk of bleeding and transfusion for larger prostates were resolved by modification of the hemostasis technique.
Suarez-Ibarrola 2020	SRV	16	446 in Aquablation (prospective studies)		To summarize the literature on Aquablation and evaluate its safety and efficacy for Tx of symptomatic BPE	None	Aquablation is comparable to TURP in effectively improving symptom scores and functional parameters related to BPH and BOO. Evidence for procedure-related AEs supports the safety of Aquablation.
Taktak 2018	NRV	12	NR	12–24	To summarize the literature on Aquablation and evaluate its safety and efficacy	None	Aquablation is a novel and minimally invasive surgical technology; early studies showed high clinical efficacy and a strong safety profile.
Tokarski 2021	NRV	13	NR	12–24	To evaluate the most recent evidence from the literature	None	Aquablation offers OTs similar to TURP and shorter than HoLEP, with similar levels of efficacy and safety.
Yassaie 2017	NRV	2	36	12	To evaluate improvements in functional outcomes 1 yr after Aquablation	Sexual function, complications	Aquablation is a safe alternative to conventional surgical therapies for BOO secondary to BPH.

SRV = systematic review; MA = meta-analysis; NRV = narrative review; IPD = individual patient data; LUTS = lower urinary tract symptoms; BOO = bladder outlet obstruction; BPE = benign prostatic enlargement; BPH = benign prostatic hyperplasia; TURP = transurethral resection of the prostate; NA = not available; NR = not reported; AE = adverse event; AUR = acute urinary retention; IDC = indwelling catheter; IIEF = International Index of Erectile Function; IPSS = International Prostate Symptom Score; MSHQ = Male Sexual Health Questionnaire; PV = prostate volume; PVR = postvoid residual volume; Qmax = the maximum flow rate; QoL = quality of life; OT = operative time; Tx = treatment; UI = urinary incontinence.
[a] Reference details for all the reviews included in this table are provided in the Supplementary material.

Please cite this article as: C. Nedbal, D. Castellani, V. De Stefano et al., Will Aquablation Be the New Benchmark for Robotic Minimally Invasive Surgical Treatment for Benign Prostatic Hyperplasia?, Eur Urol Focus (2023), https://doi.org/10.1016/j.euf.2023.12.001

tery was performed using either a roller-ball or a loop for hemostasis. The low-powered lasers (3–5W) used in early cases was then abandoned in favor of diathermy because of lack of effectiveness.

The first double-blind study comparing Aquablation with TURP was the WATER trial [6] (IDEAL stage 3), in which hemostasis was achieved using focal, nonresection electrocautery or low-pressure inflation of a Foley balloon catheter in the prostatic fossa. The hemostasis technique involves placing a three-way inflated Foley balloon in the prostatic fossa for up to 5 h to provide tamponade and ensure simultaneous slow irrigation [7].

In 2017, a catheter tensioning device (CTD, PROCEPT Biorobotics, Redwood Shores, CA, USA) was first introduced in the WATER II trial [8] (IDEAL stage 2b), a multicenter prospective study exploring the feasibility of Aquablation in large-volume prostates (80–150 ml). A CTD is a single-use device able that can maintain and hold a calibrated tension (between 600 and 1500 g) on the catheter via the pubic area as a support. However, the CTD was abandoned in 2020 as it showed no extra benefit over standard traction [9]. In a large pooled analysis involving >800 patients, comparison of different hemostatic techniques revealed that the CTD resulted in more bleeding events because of higher levels of bladder spasm and pain.

In 2021, Elterman et al. [10] described focal bladder-neck cautery, a two-step procedure involving removal of "fluffy" tissue (a cloud-like layer of tissue at a depth of 8–15 mm left after treatment in the prostate cavity) and then identification and coagulation of hidden bleeding vessels. CTD is no longer used, and combined focal bladder-neck cautery and standard traction currently represents standard clinical practice. Finally, a case series [11] reported that holmium laser coagulation after Aquablation using a 550-µm end-firing holmium laser fiber (coagulation settings 60 W/2 J × 30 Hz, with a long pulse wave), was feasible and safe, with good outcomes.

3.2. *Outcomes of Aquablation versus TURP*

Aquablation has been extensively compared to TURP to determine whether it represents a valid alternative to the current gold standard for BPH treatment.

Early postoperative outcomes were reported by Plante and colleagues [12] from a double-blind prospective study based on the WATER trial. The authors analyzed 6-mo outcomes in 116 patients treated with Aquablation and 65 patients who underwent TURP. Aquablation resulted in a significant difference in International Prostate Symptom Score (IPSS) improvement for PV $\geq$50 cm^3, with a more meaningful decrease in IPSS of 4 points (p = 0.0197), and a better improvement in maximum flow rate (Qmax) in patients with a median prostatic lobe (4.4 points greater for Aquablation vs TURP; p = 0.0482). With an excellent safety profile, Aquablation also resulted in lower complication rates (20% vs 46% in the TURP group; p = 0.011).

Gilling et al. [13] subsequently reported 1-yr outcomes from the WATER trial. The functional outcomes were similar, with a Qmax improvement of 10.3 ml/s with Aquablation versus 10.6 ml/s with TURP (p = 0.86) and an IPSS reduction of 15.1 points for both procedures (p = 0.99); the rate of complications was low.

Kasivisvanathan and Hussain [14] also analyzed 12-mo outcomes for a double-blind prospective study based on the WATER trial, matching 90 randomized patients from the Aquablation and TURP groups. The analysis confirmed similar functional outcomes for the two procedures, while Aquablation had a significantly lower rate of Clavien-Dindo grade 1–2 complications (20% vs 47%; p = 0.0132) and a lower rate of postoperative anejaculation (9% vs 45%; p = 0.006) versus TURP.

Gilling and colleagues [15] further evaluated 24-mo outcomes from the WATER trial in an understandably smaller but still representative cohort of 24 patients treated with Aquablation and 67 patients who underwent TURP. With similar functional outcomes, TURP showed a lower rate of surgical retreatment at 12 mo (1.7% in the Aquablation vs 0% in the TURP group). Over a 2-yr period, the overall surgical BPH retreatment rate was 4.3% for Aquablation and 1.5% for TURP (p = 0.4219). Sexual function, assessed using the Male Sexual Health Questionnaire (MSHQ), was stable after Aquablation but decreased in the TURP group.

Gilling et al. [16] reported 3-yr safety and efficacy results for 65 men who underwent TURP and 116 men treated with Aquablation in a prospective, double-blind trial. There was a significant difference in sexual function, with a change in ejaculatory function close to 0 with Aquablation (measured using the MSHQ ejaculatory dysfunction domain) versus a reduction of 2.8 points in the TURP group (p = 0.0008). The Aquablation group also had a lower rate of postoperative anejaculation (11% in Aquablation vs 29% in TURP group, p = 0.0039). Aquablation led to better results for PV $\geq$50 cm^3 at 3 yr after treatment, with a reduction in IPSS that was 3.5 points greater than in the TURP group (p = 0.0125).

Final 5-yr outcomes for the WATER population reported by Gilling and colleagues [17] revealed a consistent safety and efficacy profile and better outcomes for PV >50 cm^3. Te et al. [18] analyzed 3-yr outcomes for 146 patients who underwent Aquablation and 39 patients treated with TURP (data from the WATER and WATER II trials) and compared the efficacy of the surgical approaches in groups on medical therapy (α-blockers or 5α-reductase inhibitors) or no preoperative medications. In the TURP cohort, a significantly worse ejaculation dysfunction rate was observed for patients with preoperative medical therapy. Urinary outcomes were similar in the two groups for both procedures. There was no significant difference in Clavien Dindo grade $\geq$2 complications.

3.3. *Aquablation learning curve*

Technological advances over the years have been aimed at simplifying and standardizing the surgical technique. This could help in making it easier to learn the steps in the Aquablation procedure and could shorten the learning curve.

It has been shown that endoscopic laser procedures reduce the occurrence of associated health issues, making them a feasible choice regardless of prostate size [19]. Nevertheless, factors such as prior surgical experience affect the learning curve, which for HoLEP is typically 20–30 cases [20]. However, some experts have proposed that a minimum of 50 cases, coupled with fellowship training, is necessary, especially when considering operative time, ejaculatory function, and continence function [21]. Even GreenLight laser photovaporization of the prostate has a substantial learning curve and extended operative time, often requiring 20–40 cases for adequate training [22].

By contrast, Aquablation technology uses a water jet that generates no heat for removal of prostate tissue via a specific resection path. This process ensures consistency and reproducibility, irrespective of the surgeon's skill or experience level. Across multiple studies, the Aquablation learning curve appears to be notably short.

Bach and colleagues [23] reported a short learning curve, with a significant decrease in mean operative time from 24.2 to 17 min after 50 cases in their study. Similar to the case for the enucleation technique, this was surpassed by Desai et al. [24] in a multicenter prospective study, in which the average case count was only four per surgeon, highlighting an exceptionally rapid learning curve even in the face of limited previous experience. This low number of procedures was not related to any increase in complications, with only 1% of patients requiring recatheterization and 8% experiencing major complications. Thus, Aquablation seems to be well suited for surgeons of all levels of experience.

These findings were reinforced by Misrai et al. [25], who detailed initial use of Aquablation by three surgeons. The rate of preservation of antegrade ejaculation was remarkable at 73.3%, and there was a minor reintervention rate of 3.3% for bleeding. Importantly, the improvements in functional outcomes persisted at 12 mo after surgery, highlighting optimal results from the outset.

Zorn et al. [26] reported that as well as a short learning curve, as evidenced by surgeons receiving hands-on training before their initial procedures, Aquablation has shorter operative times and hospital stays, and represents an imaging-guided, precision-controlled surgery with the potential to reduce procedure-related complications.

Finally, it is noteworthy that the learning curve seems consistent for both small to moderately sized and large prostates, as demonstrated by Nguyen et al. [27]. The authors compared clinical outcomes from the WATER and WATER II trials, which had prostate size limits of 30–80 cm^3 and 80–150 cm^3, respectively. At 24-mo follow-up, variance analysis revealed no significant differences between the studies across various parameters, including IPSS, IPSS Quality of Life, Qmax, and voided volume.

3.4. Aquablation costs

Medical management of BPH has helped in reducing surgical interventions. However, postponing inevitable surgical management adds to the economic burden and can cause unnecessary delays for patients for whom surgery might be beneficial if performed at an earlier stage [28]. There are other economic ramifications as well [29]. The Aquablation technology has potential for cost savings, including shorter operative times and lower likelihood of retreatment and adverse events, resulting in shorter hospital stays. A therapeutic approach that uses ultrasound guidance and robotic execution within well-defined and replicable parameters and results in shorter operative times warrants recognition as an established standard of care [30].

The Canadian Agency for Drugs and Technologies in Health has highlighted that while Aquablation has potential advantages, concrete real-world data to validate these benefits and thorough, long-term assessments of cost effectiveness are essential [31].

According to the UK National Institute for Health and Care Excellence, the per-patient cost for Aquablation therapy is £2872.42, which includes consumable costs of £1925 per patient [32] and hemostasis achieved via a standard resectoscope. This cost is similar to those for TURP (£3091.97), HoLEP (£3056.66), and GreenLight laser therapy (£2782.14).

Müllhaupt et al. [3] analyzed in-hospital costs for Aquablation (including both resection and diathermy to ensure hemostasis) and TURP. On average, total costs per patient were lower for TURP than for Aquablation (€7445 vs €10 994), with a significant mean difference of €3549 (95% CI €2144–4953; $p < 0.001$). However, the average procedural cost increased by approximately €41 for every additional minute of operative time. Hence, increasing proficiency among surgeons and nursing staff, coupled with a larger patient volume, might mitigate operative time and thus costs.

In conclusion, preliminary expert opinions suggest that the cost of Aquablation could be comparable to those for established laser ablation techniques, but the evidence in the literature is insufficient to draw definitive conclusions. Consequently, the use of Aquablation is currently confined to specific environments.

4. Discussion

4.1. Does Aquablation qualify as MIST?

In recent years, many new minimally invasive surgical treatments (MISTs) have been validated for the management of BPH as alternatives to standard endoscopic techniques such as TURP and laser enucleation of the prostate [33]. The major advantage of MISTs that makes them appealing is the ability to perform the procedures mainly under local anesthesia in an outpatient setting.

Owing to its efficacy and effectiveness, Aquablation can be considered a MIST for BPH according to a recent review [34]. Moreover, results reported for Aquablation show a clear IPSS improvement that makes it comparable to endoscopic techniques and superior to other MISTs, with a significantly lower rate of anejaculation in comparison to TURP (2% vs 41% at 6 mo; $p = 0.0001$) [35].

Despite being classified as a MIST by some authors, Aquablation cannot be performed under local anesthesia with same-day discharge, needing an admission of at least 24 h. For this reason, Aquablation can be considered a "bridge" technique between endoscopic (resection, enucleation, or ablation) and MIST procedures. Further trials comparing Aquablation with other MISTs will shed more light on the differential role of these treatments.

4.2. Challenges, limitations, and future directions

The greatest challenge for Aquablation had been in achieving proper hemostasis. As it lacks the coagulative properties of other BPH treatment techniques (eg, laser or bipolar electrocautery), the water jet has poor control over postoperative bleeding. This was reflected in relatively high transfusion rates during the first trials. A nonresection cautery technique was used in only 40% of patients in the WATER I trial, and no cautery was used in WATER II. How-

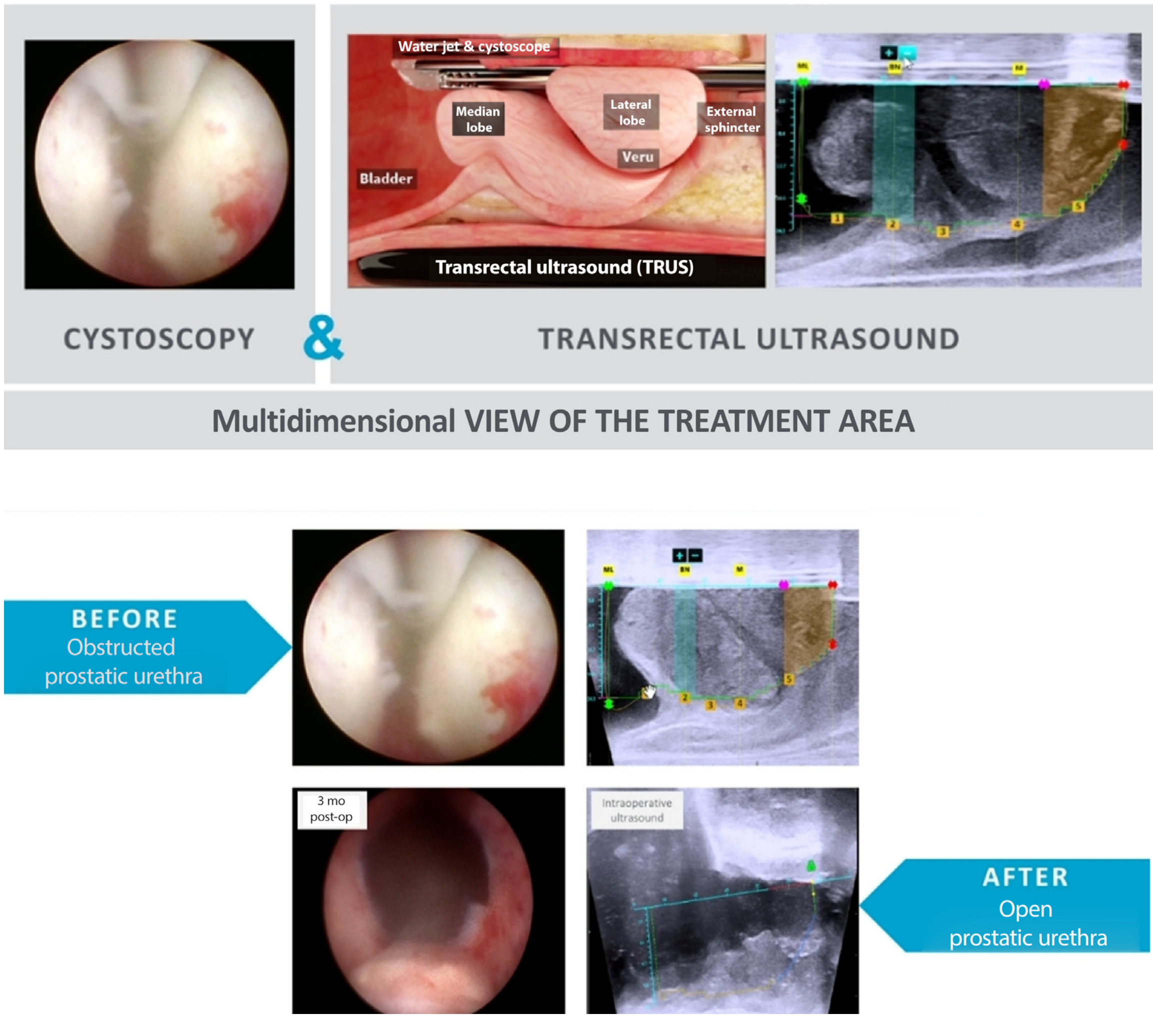


Fig. 2 – Intraoperative images of the Aquablation technique. The upper figure shows the cystoscopic view and initial ultrasound-guided contouring of the glans. The lower figure shows the same cystoscopic and ultrasound images demonstrating the results of water jet resection. Veru = verumontanum.

ever, hemostatic techniques have changed since then, with the use of strategies such as prostatic fossa tamponade, hemostatic agents, and traction at the level of the bladder neck [10]. Intraoperative cautery has been used after Aquablation since 2020, but with controversial results. The best way to achieve satisfactory hemostasis is to use a resectoscope to first remove the remnant layer of ablated prostate tissue (so-called “fluffy” tissue) and then coagulate deeper bleeding vessels at the level of the prostatic capsule exposed by water jet resection. Addition of cautery after ablation does not increase the surgical time much, but does improve hemostasis, reducing postoperative bleeding and achieving a transfusion rate similar to that for HoLEP [36].

The WATER II trial demonstrated that even PV >150 cm^3 is not a limitation for Aquablation, with optimal outcomes and durable efficacy in improving flow rates and LUTS at 5-yr follow-up reported [37]. Results confirmed that addition of cautery after ablation also reduces the complication rate for large-volume prostates. A large median lobe with severe intravesical protrusion could be considered challenging for Aquablation [38]. However, thanks to biplanar reconstruction using transverse and sagittal planes and careful identification of the prostate contour, the median lobe can still be completely resected without damaging the posterior bladder wall [39].

Aquablation has been extensively compared to TURP. Nevertheless, studies assessing the noninferiority of Aquablation in comparison to HoLEP and MIST techniques such as Urolift and Rezūm could help in further defining the potential of Aquablation.

Finally, the need for an overnight hospital stay is still considered the main limitation of Aquablation for it to truly become a MIST.

4.3. *Take-home messages for Aquablation*

1. Aquablation is proving to be an innovative and successful approach in BPH treatment.
2. Aquablation allows better targeting of the gland, preservation of ejaculation and sexual functions, and a faster healing process, and has virtually no contraindications and a high acceptance rate among patients [14,40,41].
3. This size-independent procedure [27,42] is safe even in elderly men [43] and for large prostates [37,44] and is associated with a sustained improvement in functional outcomes at 3-yr and 5-yr follow-up [26,27,45].

Please cite this article as: C. Nedbal, D. Castellani, V. De Stefano et al., Will Aquablation Be the New Benchmark for Robotic Minimally Invasive Surgical Treatment for Benign Prostatic Hyperplasia?, Eur Urol Focus (2023), https://doi.org/10.1016/j.euf.2023.12.001

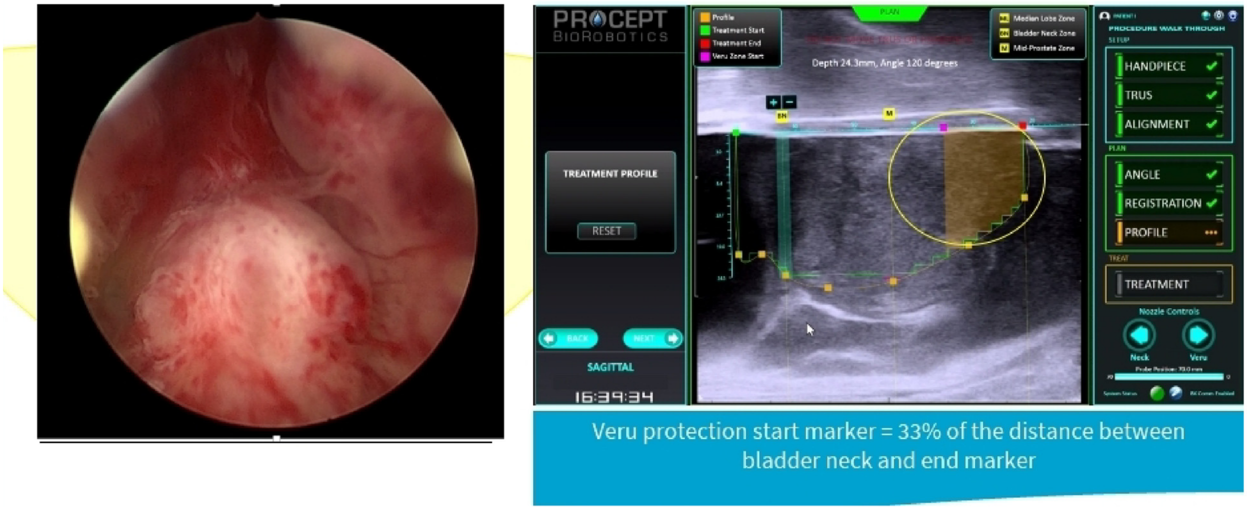


Fig. 3 – The combination of a cystoscopic view and precise ultrasound definition of the prostatic contour allows precise identification and protection of the verumontanum and hence the sphincter. Veru = verumontanum.

5. Conclusions

Our scoping review shows that Aquablation is a viable technique with promising results for BPH treatment and is ready to be included as a standard of care. Widespread diffusion has not been achieved yet and the procedure is still only performed in selected centers. Aquablation has good functional outcomes, including optimal preservation of ejaculatory function and a 5-yr sustainable reduction in LUTS, with a good safety profile and compliance for all prostate sizes and patient ages. If these results can be emulated in a global setting, Aquablation as a cost-effective procedure could challenge the current gold-standard techniques for BPH management.

Author contributions: Carlotta Nedbal had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Nedbal, Gauhar, Castellani, Somani.
Acquisition of data: Nedbal, Castellani, De Stefano, Giulioni, Nicoletti, Pirola, Teoh, Elterman, Somani, Gauhar.
Analysis and interpretation of data: Nedbal, Gauhar, Castellani, De Stefano, Giulioni, Nicoletti, Pirola.
Drafting of the manuscript: Nedbal, Gauhar, Castellani, De Stefano, Giulioni, Nicoletti, Pirola.
Critical revision of the manuscript for important intellectual content: Teoh, Elterman, Somani.
Statistical analysis: None.
Obtaining funding: None.
Administrative, technical, or material support: Teoh, Elterman, Somani.
Supervision: Teoh, Elterman, Somani, Castellani, Gauhar.
Other: None.

Financial disclosures: Carlotta Nedbal certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: None.

Funding/Support and role of the sponsor: None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.euf.2023.12.001.

References

[1] Cornu J, Gacci M, Hashim H, et al. EAU guidelines on non-neurogenic male lower urinary tract symptoms (LUTS) incl. benign prostatic obstruction (BPO). Arnhem, The Netherlands: European Association of Urology; 2023. p. 42–3. https://d56bochluxqnz.cloudfront.net/documents/full-guideline/EAU-Guidelines-on-Non-Neurogenic-Male-LUTS-2023.pdf.
[2] Lerner LB, McVary KT, Barry MJ, et al. Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline part ii—surgical evaluation and treatment. J Urol 2021;206:818–26.
[3] Müllhaupt G, Lyatoshinsky P, Neuenschwander A, Güsewell S, Schmid HP, Abt D. In-hospital cost analysis of Aquablation compared with transurethral resection of the prostate in the treatment of benign prostatic enlargement. Swiss Med Wkly 2022;152:w30136.
[4] Gilling P, Reuther R, Kahokehr A, Fraundorfer M. Aquablation – image-guided robot-assisted waterjet ablation of the prostate: initial clinical experience. BJU Int 2016;117:923–9.
[5] Faber K, Castro de Abreu AL, Ramos P, et al. Image-guided robot-assisted prostate ablation using water jet-hydrodissection: initial study of a novel technology for benign prostatic hyperplasia. J Endourol 2015;29:63–9.
[6] Gilling P, Barber N, Bidair M, et al. WATER: a double-blind, randomized, controlled trial of Aquablation® vs transurethral resection of the prostate in benign prostatic hyperplasia. J Urol 2018;199:1252–61.
[7] Aljuri N, Gilling P, Roehrborn C. How I do it: balloon tamponade of prostatic fossa following Aquablation. Can J Urol 2017;24:8937–40.
[8] Desai M, Bidair M, Bhojani N, et al. WATER II (80–150 mL) procedural outcomes. BJU Int 2019;123:106–12.
[9] Elterman D, Bach T, Rijo E, et al. Transfusion rates after 800 Aquablation procedures using various haemostasis methods. BJU Int 2020;125:568–72.

[10] Elterman DS, Foller S, Ubrig B, et al. Focal bladder neck cautery associated with low rate of post-Aquablation bleeding. Can J Urol 2021;28:10610–3.

[11] D'Agostino D, Colicchia M, Corsi P, et al. The combination of waterjet ablation (Aquabeam®) and holmium laser power for treatment of symptomatic benign prostatic hyperplasia: early functional results. Cent Eur J Urol 2021;74:222–8.

[12] Plante M, Gilling P, Barber N, et al. Symptom relief and anejaculation after aquablation or transurethral resection of the prostate: subgroup analysis from a blinded randomized trial. BJU Int 2019;123:651–60.

[13] Gilling PJ, Barber N, Bidair M, et al. Randomized controlled trial of Aquablation versus transurethral resection of the prostate in benign prostatic hyperplasia: one-year outcomes. Urology 2019;125:169–73.

[14] Kasivisvanathan V, Hussain M. Aquablation versus transurethral resection of the prostate: 1 year United States – cohort outcomes. Can J Urol 2018;25:9317–22.

[15] Gilling P, Barber N, Bidair M, et al. Two-year outcomes after Aquablation compared to TURP: efficacy and ejaculatory improvements sustained. Adv Ther 2019;36:1326–36.

[16] Gilling P, Barber N, Bidair M, et al. Three-year outcomes after Aquablation therapy compared to TURP: results from a blinded randomized trial. Can J Urol 2020;27:10072–9.

[17] Gilling PJ, Barber N, Bidair M, et al. Five-year outcomes for Aquablation therapy compared to TURP: results from a double-blind, randomized trial in men with LUTS due to BPH. Can J Urol 2022;29:10960–8.

[18] Te AE, Sze C, Kaplan SA, Chughtai B. Surgical treatment for BPH refractory to medication: robotic water jet ablation vs. TURP functional outcomes from two FDA clinical trials. Can J Urol 2023;30:11408–13.

[19] Cornu JN, Ahyai S, Bachmann A, et al. A Systematic review and meta-analysis of functional outcomes and complications following transurethral procedures for lower urinary tract symptoms resulting from benign prostatic obstruction: an update. Eur Urol 2015;67:1066–96.

[20] Elshal AM, Nabeeh H, Eldemerdash Y, et al. Prospective assessment of learning curve of holmium laser enucleation of the prostate for treatment of benign prostatic hyperplasia using a multidimensional approach. J Urol 2017;197:1099–107.

[21] Robert G, Cornu JN, Fourmarier M, et al. Multicentre prospective evaluation of the learning curve of holmium laser enucleation of the prostate (HoLEP). BJU Int 2016;117:495–9.

[22] Valdivieso R, Hueber PA, Meskawi M, et al. Multicentre international experience of 532-nm laser photoselective vaporization with GreenLight XPS in men with very large prostates. BJU Int 2018;122:873–8.

[23] Bach T, Giannakis I, Bachmann A, et al. Aquablation of the prostate: single-center results of a non-selected, consecutive patient cohort. World J Urol 2019;37:1369–75.

[24] Desai M, Bidair M, Zorn KC, et al. Aquablation for benign prostatic hyperplasia in large prostates (80–150 mL): 6-month results from the WATER II trial. BJU Int 2019;124:321–8.

[25] Misrai V, Rijo E, Zorn KC, Barry-Delongchamps N, Descazeaud A. Waterjet ablation therapy for treating benign prostatic obstruction in patients with small- to medium-size glands: 12-month results of the first French Aquablation clinical registry. Eur Urol 2019;76:667–75.

[26] Zorn KC, Bidair M, Trainer A, et al. Aquablation therapy in large prostates (80–150 cc) for lower urinary tract symptoms due to benign prostatic hyperplasia: WATER II 3-year trial results. BJUI Compass 2022;3:130–8.

[27] Nguyen DD, Barber N, Bidair M, et al. WATER versus WATER II 2-year update: comparing Aquablation therapy for benign prostatic hyperplasia in 30–80-cm^3 and 80–150-cm^3 prostates. Eur Urol Open Sci 2021;25:21–8.

[28] Presicce F, De Nunzio C, Gacci M, et al. The influence of the medical treatment of LUTS on benign prostatic hyperplasia surgery: do we operate too late? Minerva Urol Nefrol 2017;69:242–52.

[29] Taub DA, Wei JT. The economics of benign prostatic hyperplasia and lower urinary tract symptoms in the United States. Curr Urol Rep 2006;7:272–81.

[30] Zorn KC, Goldenberg SL, Paterson R, So A, Elterman D, Bhojani N. Aquablation among novice users in Canada: a WATER II subpopulation analysis. Can Urol Assoc J 2018;13:E113–8.

[31] Topfer L, Ryce A, Loshak H. Minimally invasive treatments for lower urinary tract symptoms due to benign prostatic hyperplasia. CADTH Issues Emerging Health Technol 2020;182:1–20. https://www.cadth.ca/sites/default/files/hs-eh/eh0078-therapies-for-bph.pdf.

[32] National Institute for Health and Care Excellence. Medtech innovation briefing. NICE Guidelines. Aquablation robotic therapy for lower urinary tract symptoms caused by benign prostatic hyperplasia. National Institute for Health and Care Excellence website. September 13, 2023. https://www.nice.org.uk/advice/mib315.

[33] Franco JV, Jung JH, Imamura M, et al. Minimally invasive treatments for lower urinary tract symptoms in men with benign prostatic hyperplasia: a network meta-analysis. Cochrane Database Syst Rev 2021;2021:CD013656.

[34] Cheng BKC, Castellani D, et al. Defining minimal invasive surgical therapy for benign prostatic obstruction surgery: perspectives from a global knowledge, attitudes, and practices survey. Asian J Urol 2022:2214–3882. https://doi.org/10.1016/j.ajur.2022.02.011.

[35] van Kollenburg RAA, van Riel LAM, de Bruin DM, de Reijke TM, Oddens JR. Novel minimally invasive treatments for lower urinary tract symptoms: a systematic review and network meta-analysis. Int Braz J Urol 2023;49:411–27.

[36] Probst P, Desai M. Expectations facing reality: complication management after Aquablation treatment for lower urinary tract symptoms. Eur Urol Focus 2022;8:1733–5.

[37] Bhojani N, Bidair M, Kramolowsky E, et al. Aquablation therapy in large prostates (80–150 mL) for lower urinary tract symptoms due to benign prostatic hyperplasia: final WATER II 5-year clinical trial results. J Urol 2023;210:143–53.

[38] Stein J, Cox A, Hauser S, Ritter M, Bach T. Evolution of AquablationVR—from innovation to establishment. Turk J Urol 2021;47:351–7.

[39] Ghiraldi EM, Ambinder D, Son Y, Sterious S. Aquablation for the treatment of benign prostatic hyperplasia in a large volume prostate with an intravesical median lobe. J Endourol Case Rep 2020;6:110–3.

[40] Kaplan S. Aquablation is proving to be an innovative and successful approach in BPH procedures. New York, NY: Mount Sinai Hospital; 2022. https://reports.mountsinai.org/article/uro2022-05-aquablation-is-proving-to-be-innovative-and-successful.

[41] Kasraeian A, Alcantara M, Alcantara KM, Altamirando JA, Kasraeian A. Aquablation for BPH. Can J Urol 2020;27:10378–81.

[42] Nguyen D, Barber N, Bidair M, et al. Waterjet Ablation Therapy for Endoscopic Resection of prostate tissue trial (WATER) vs WATER II: comparing Aquablation therapy for benign prostatic hyperplasia in 30–80 and 80–150 mL prostates. BJU Int 2020;125:112–22.

[43] Raizenne BL, Bouhadana D, Zorn KC, et al. Functional and surgical outcomes of Aquablation in elderly men. World J Urol 2022;40:2515–20.

[44] Bhojani N, Nguyen DD, Kaufman RP, Elterman D, Zorn KC. Comparison of <100 cc prostates and >100 cc prostates undergoing Aquablation for benign prostatic hyperplasia. World J Urol 2019;37:1361–8.

[45] Chughtai B, Thomas D. Pooled Aquablation results for American men with lower urinary tract symptoms due to benign prostatic hyperplasia in large prostates (60–150 cc). Adv Ther 2018;35:832–8.

Please cite this article as: C. Nedbal, D. Castellani, V. De Stefano et al., Will Aquablation Be the New Benchmark for Robotic Minimally Invasive Surgical Treatment for Benign Prostatic Hyperplasia?, Eur Urol Focus (2023), https://doi.org/10.1016/j.euf.2023.12.001