Research Square

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HoLEP for Large and Mega Glands: Real-World Outcomes and Evidence of Size-Enhanced Efficiency

Yadong Lu
University of Rochester Medical Center
Elisabeth Hayward
University of Rochester
Carl Ceraolo
University of Rochester Medical Center
Soumya Konar
University of Rochester Medical Center
Nitin Sharma
University of Rochester Medical Center
Rajat Jain
University of Rochester Medical Center
Scott Quarrier
scott_quarrier@urmc.rochester.edu

University of Rochester Medical Center

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Abstract

Objective:
The term “mega gland” commonly refers to prostates >200 mL on preoperative imaging. These glands are traditionally perceived as technically challenging for holmium laser enucleation of the prostate (HoLEP) due to increased vascularity, difficult dissection planes, and instrument length limitations. We evaluated perioperative outcomes and procedural efficiency of HoLEP for mega glands compared with large glands (120–200 mL).

Methods:
We performed a single-center retrospective analysis of patients undergoing HoLEP for glands ≥120 mL between January 2021 and June 2025. Patients were categorized into large (120–200 mL) and mega (>200 mL) gland groups. Baseline characteristics, intraoperative parameters, efficiency metrics, and postoperative outcomes were compared using Wilcoxon rank-sum, Pearson’s chi-square, and Fisher’s exact tests.

Results:
Among 602 HoLEPs performed, 243 patients met inclusion criteria, including 208 with large glands and 35 with mega glands. Baseline characteristics were similar, although mega glands had higher PSA values (9.9 vs 5.6 ng/mL, p=0.001). Operative time was longer in mega glands (114 vs 96 min, p=0.003). However, enucleation speed (2.8 vs 1.6 g/min, p<0.001) and energy efficiency (0.8 vs 0.5 g/kJ, p<0.001) were significantly higher despite similar enucleation times. Postoperative outcomes, including catheter duration, failed void trial, emergency department visits, readmissions, and 3-month PROMs, were similar between groups.

Conclusion:
HoLEP for prostates >200 mL demonstrated higher enucleation speed and energy efficiency without worse short-term outcomes. These findings demonstrated HoLEP may be a size-enhanced procedure, not merely size-independent. Further work is needed to define this efficiency threshold more precisely and explore its clinical implications.

Introduction

Holmium laser enucleation of the prostate (HoLEP) is a well-established surgical treatment for benign prostatic hyperplasia (BPH), offering durable symptom relief with low retreatment rates across a wide range of prostate sizes[1, 2]. Unlike resective techniques, HoLEP enables complete adenoma removal along the surgical capsule and has consistently demonstrated favorable perioperative and functional outcomes, leading to its endorsement as a size-independent surgical option for BPH management[3, 4].

Despite this, very large prostates continue to pose perceived challenges for transurethral surgery[5–8]. The term “mega gland,” while not formally defined, is commonly used to describe prostates exceeding 200 mL on preoperative imaging[6, 9]. These glands are traditionally considered technically demanding

for HoLEP due to increased vascularity, difficulty maintaining consistent dissection planes, limitations in instrument reach, and concerns regarding operative efficiency. As a result, open or robotic simple prostatectomy is still frequently considered for patients with extreme gland enlargement, despite the minimally invasive advantages of HoLEP[10, 11].

Existing literature has demonstrated that HoLEP can be performed safely in large and very large prostates, with comparable complication rates and functional outcomes across prostate volumes[6, 7]. However, most prior studies have focused on feasibility, perioperative safety, or postoperative symptom improvement[6]. Quantitative assessments of procedural efficiency—such as enucleation speed and energy utilization—have been less well characterized, particularly in glands exceeding conventional size thresholds[8, 11]. As surgical efficiency has important implications for operative time, resource utilization, and surgeon decision-making, a more nuanced understanding of how prostate size influences HoLEP performance is warranted.

Accordingly, we sought to evaluate perioperative outcomes and procedural efficiency of HoLEP in patients with very large prostates. In a contemporary real-world cohort, we compared intraoperative performance metrics, postoperative outcomes, and short-term functional results between patients with large glands (120–200 mL) and those with mega glands (> 200 mL). We hypothesized that beyond a certain volume threshold, HoLEP efficiency may not only be preserved but enhanced.

Methods

Study design and patient population

We performed a retrospective cohort study of consecutive patients who underwent holmium laser enucleation of the prostate (HoLEP) at a single tertiary referral center between January 2021 and June 2025. This study was approved by the Institutional Review Board (STUDY00008627), with waiver of informed consent due to the retrospective nature of the analysis. Patients were eligible for inclusion if they had a preoperative prostate volume ≥ 120 mL measured on cross-sectional imaging or transrectal ultrasound and underwent HoLEP for benign prostatic hyperplasia–related lower urinary tract symptoms or urinary retention. Patients with incomplete operative data were excluded from analyses involving intraoperative efficiency metrics. The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Prostate volume stratification

Patients were stratified a priori into two groups based on preoperative prostate volume: Large gland: 120–200 mL; Mega gland: >200 mL. The > 200 mL threshold was selected based on common clinical usage of the term “mega gland” in HoLEP literature and practice, as well as its relevance to operative planning, instrument reach, and perceived technical difficulty[9, 6, 12].

Surgical technique and perioperative management

Three fellowship-trained endourologist performed HoLEP for all individuals in this study. Each case included an assisting resident. Within the endourology team, for all cases, anticoagulation was held pre-operatively according to a modified version of the American Society of Regional Anesthesia neuraxial block protocol[13]. Oral anticoagulants such as apixaban, rivaroxaban, and dabigatran were held for 48 hours, while warfarin was held for 5 days. Antiplatelet agents such as clopidogrel and ticagrelor were held for 5 days and bridged with aspirin 81mg if the patient was not already prescribed it. Cases were all performed with an en-bloc early apical release technique. Enucleation was performed with either the Boston Scientific MOSES 2.0 holmium laser system or the QUANTA 150 holmium laser system (Varese, Italy). Laser settings were 2 Joules and 50 Hertz for both laser systems utilizing their respective pulse modulation setting for enucleation settings and 1.5 Joules and 20 Hertz with long pulse width for hemostasis settings. Normal saline was utilized for irrigation. The Richard Wolf 26fr scope and morcelloscope was used for all cases. Morcellation was performed with a Richard Wolf Piranha morcellator at a frequency between 500 and 1,500 rpms. Hemostasis was addressed with laser fulguration throughout the case. Same day discharge occurred as able. Overnight observation on continuous bladder irrigation and discharge on post-operative day one occurred in situations where the patient had hematuria grade 3 in the first 4 hours after surgery. Postoperatively, patients underwent standardized catheter management and voiding trial protocols according to institutional practice.

Data collection

Baseline demographic and clinical variables included age, Charlson Comorbidity Index, prostate volume, prostate-specific antigen (PSA), baseline urinary status (preoperative incontinence, catheter or clean intermittent catheterization), and patient-reported outcome measures (PROMs), including the International Prostate Symptom Score (IPSS) and Male Incontinence Symptom Index (MISI). Intraoperative variables included operative time, enucleation time, morcellation time, laser activation time, and total laser energy delivered. Enucleated tissue weight was recorded from pathology reports. Postoperative outcomes included length of stay, catheter duration, failed voiding trial, emergency department visits within 30 days, and readmissions within 30 days. PROMs were reassessed at approximately 3 months postoperatively when available.

Definitions of efficiency metrics

To characterize procedural efficiency, the following metrics were calculated: enucleation speed (defined as enucleated tissue weight divided by enucleation time), energy efficiency (defined as enucleated tissue weight divided by total laser energy used), morcellation speed (defined as enucleated tissue weight divided by morcellation time), and enucleation ratio (defined as enucleated tissue weight divided by preoperative prostate volume). These metrics were selected to assess tissue removal efficiency independent of absolute gland size.

Statistical analysis

Continuous variables were summarized as median with interquartile range (Q1–Q3) and compared using the Wilcoxon rank-sum test. Categorical variables were summarized as counts and percentages and compared using Pearson's chi-square test or Fisher's exact test, as appropriate. All statistical analyses were performed using R version 4.4.3. A two-sided p-value < 0.05 was considered statistically significant.

Results

Patient characteristics

A total of 602 HoLEP procedures were performed during the study period, of which 243 patients met inclusion criteria with preoperative prostate volume ≥ 120 mL. Among these, 208 patients had large glands (120–200 mL) and 35 patients had mega glands (> 200 mL). Baseline demographic and clinical characteristics are summarized in Table 1. Median age and Charlson Comorbidity Index were similar between groups. As expected, median prostate volume was significantly higher in the mega gland group. Patients with mega glands had a higher median preoperative PSA compared with those with large glands. Baseline urinary status, including rates of preoperative incontinence and catheter or clean intermittent catheterization, as well as baseline IPSS and MISI scores, were comparable between groups.

Table 1
Baseline demographic and preoperative characteristics

Variables	120–200 mL[a]		> 200 mL[a]		p-value[b]
	N		N		
Age (years)	208	70.3 [66.3, 76.8]	35	73.5 [67.3, 78.4]	0.322
Charlson Comorbidity Index	208	3.0 [2.0, 5.0]	35	3.0 [3.0, 4.0]	0.304
Prostate volume	208	144.5 [131.8, 167.2]	35	237.0 [209.5, 272.0]	**< 0.001**
Most recent pre-op PSA (ng/mL)	188	5.6 [3.6, 8.7]	31	9.9 [6.2, 13.8]	**0.001**
MISI Severity Score (preop)	71	4.0 [1.0, 7.5]	12	4.5 [1.5, 7.2]	0.969
MISI Bother Score (preop)	72	1.0 [0.0, 2.2]	12	2.0 [0.0, 2.2]	0.371
Baseline IPSS Score	108	15.0 [8.0, 22.0]	16	14.5 [11.0, 21.2]	0.834
Pre-op incontinence, n (%)	208	73 (35.1%)	35	15 (42.9%)	0.377
Pre-op catheter or CIC, n (%)	208	89 (42.8%)	35	18 (51.4%)	0.341

[a]Median (Q1,Q3); N(%)

[b]Wilcoxon rank sum, Pearson's chi squared, and Fisher exact tests

Intraoperative performance and efficiency

Intraoperative parameters are detailed in Table 2. Median total operative time was longer in the mega gland group compared with the large gland group. However, median enucleation time did not differ significantly between groups, despite substantially larger prostate volumes in the mega gland cohort. Measures of procedural efficiency differed significantly by gland size. The mega gland group demonstrated a higher enucleation speed and greater energy efficiency compared with the large gland group. The enucleation ratio (enucleated tissue weight divided by prostate volume) did not differ significantly between groups, indicating that observed efficiency gains were not attributable to proportionally greater tissue removal. Morcellation time was longer for mega glands, while morcellation speed was similar between groups. Total laser energy use was higher in the mega gland cohort, although energy efficiency remained superior. When prostate volume was examined across the observed range, enucleation speed increased with increasing gland size, with a noticeable inflection beyond approximately 200 mL. Group-based comparisons further demonstrated higher enucleation speed and energy efficiency in mega glands compared with large glands (Fig. 1a and 1b).

Table 2
Intraoperative parameters and enucleation efficiency

Variables	120–200 mL[a]		> 200 mL[a]		p-value[b]
	N		N		
Operative Time (min)	207	96.0 [71.5, 124.5]	35	114.0 [92.0, 156.0]	**0.003**
Enucleation Time (min)	207	59.0 [43.0, 80.0]	35	59.0 [53.0, 78.5]	0.257
Morcellation Time (min)	207	15.0 [10.0, 21.0]	35	27.0 [20.0, 38.0]	**< 0.001**
Laser Time (min)	204	40.0 [31.4, 51.0]	35	47.0 [40.0, 52.5]	**0.004**
Total Energy (kJ)	205	202.0 [157.0, 253.6]	35	228.6 [203.5, 264.3]	**0.027**
Enucleation Ratio (g/mL)	208	0.7 [0.5, 0.8]	35	0.7 [0.6, 0.9]	0.110
Enucleation Speed (g/min)	207	1.6 [1.3, 2.2]	35	2.8 [2.0, 3.4]	**< 0.001**
Morcellation Speed (g/min)	207	6.5 [5.2, 8.6]	35	6.1 [4.8, 8.6]	0.418
Energy Efficiency (g/kJ)	205	0.5 [0.4, 0.6]	35	0.8 [0.6, 0.9]	**< 0.001**

[a]Median (Q1,Q3); N(%)

[b]Wilcoxon rank sum, Pearson's chi squared, and Fisher exact tests

Postoperative outcomes and patient-reported outcomes

Postoperative outcomes are summarized in Table 3. Median length of stay was slightly longer in the mega gland group, though most patients in both groups were discharged within one postoperative day. Rates of failed voiding trial, postoperative catheter duration, emergency department visits within 30 days, and 30-day readmissions were low and did not differ significantly between groups. Changes in patient-reported outcome measures at approximately 3 months postoperatively are shown in Table 3. Improvements in IPSS and MISI severity scores were observed in both groups, with no significant differences in the magnitude of symptom improvement between large and mega gland cohorts.

Table 3
Postoperative outcomes and short-term functional results

Variables	120–200 mL[a]		> 200 mL[a]		p-value[b]
	N		N		
Length of stay (days)	208	1.0 [1.0, 1.0]	35	1.0 [1.0, 2.0]	**0.011**
Failed Void Trial	208	20 (9.6%)	35	1 (2.9%)	0.327
Duration of catheter post-op (days)	208	1.0 [1.0, 2.0]	35	1.0 [1.0, 1.5]	0.537
ED visits within 30d	208	24 (11.5%)	35	3 (8.6%)	0.776
Readmissions within 30d	208	11 (5.3%)	35	1 (2.9%)	1.000
MISI Severity Score change at 3m	42	0.0 [-2.8, 4.8]	8	2.5 [-0.2, 4.2]	0.248
IPSS Score change at 3m	66	-5.5 [-15.0, 1.0]	10	-6.5 [-11.0, -4.5]	0.533

[a]Median (Q1,Q3); N(%)

[b]Wilcoxon rank sum, Pearson's chi squared, and Fisher exact tests

Discussion

In this contemporary real-world cohort of patients undergoing HoLEP for large prostates, we observed that glands exceeding 200 mL demonstrated significantly higher enucleation speed and superior energy efficiency, despite similar enucleation times compared with glands measuring 120–200 mL. Importantly, these gains in efficiency were achieved without compromise in perioperative safety or short-term functional outcomes. To our knowledge, this is among the first studies to demonstrate a potential efficiency advantage in very large prostates. When prostate volume was examined as a continuous variable, procedural efficiency increased with gland size, with an apparent inflection beyond approximately 200 mL. Together, these findings suggest that HoLEP is not merely size-independent, but may become increasingly efficient as prostate volume increases, challenging the traditional perception that very large glands inherently confer technical disadvantage.

Several factors may explain the observed improvement in enucleation efficiency among mega glands. Larger prostates often exhibit a more clearly developed surgical capsule and more distinct adenoma–capsule planes, facilitating rapid and uninterrupted enucleation once the correct dissection layer is established[14, 15]. In addition, the higher adenoma-to-capsule ratio in very large glands may reduce the need for frequent plane re-identification, contributing to sustained enucleation momentum[16]. From an energy utilization standpoint, the increased tissue bulk encountered in mega glands may allow more efficient translation of laser energy into tissue separation rather than repeated coagulation or plane correction. This is supported by the observed increase in grams of tissue removed per kilojoule of laser energy, despite higher absolute energy use. Similar to observations in platform-comparison studies,

efficiency metrics may be more informative than absolute time or energy values alone when evaluating operative performance in HoLEP[17].

These findings have several important clinical implications. First, concerns regarding diminished efficiency or excessive operative burden in prostates exceeding 200 mL may be overstated, particularly in experienced hands. While total operative and morcellation times were longer for mega glands, enucleation—the most technically demanding component of HoLEP—was performed at a higher rate of tissue removal. Second, these data support the role of HoLEP as a preferred surgical option for very large prostates[12], particularly when open or robotic simple prostatectomy is being considered primarily on the basis of gland size[10, 11]. Improved efficiency at higher volumes may offset concerns related to operative duration and resource utilization, especially in high-volume centers. Finally, the observation of a potential efficiency threshold suggests that prostate volume should not be viewed solely as a marker of procedural complexity, but also as a variable that may influence surgical performance in a non-linear manner.

Prior studies have consistently demonstrated that HoLEP outcomes are largely independent of prostate size, with comparable safety and functional results across a broad volume spectrum[18, 14, 8, 19]. However, most prior analyses have focused on feasibility, complication rates, or symptom improvement rather than quantitative efficiency metrics[9, 19, 12]. Our findings extend the existing literature by demonstrating that, beyond a certain volume threshold, HoLEP performance may actually improve with increasing gland size. This aligns with prior observations that experienced HoLEP surgeons can maintain operative consistency across large prostates, while adding the novel insight that efficiency itself may be enhanced in very large glands[12, 20, 6, 21].

This study is limited by its retrospective design and single-center setting. Although procedures were performed by fellowship-trained endourologists using a standardized technique, unmeasured surgeon-level or team-level factors may have influenced operative performance. Additionally, two holmium laser platforms were used during the study period; however, laser settings and surgical technique were standardized, and efficiency trends were consistent across gland sizes. Follow-up PROM data were available for a subset of patients, reflecting real-world clinical practice and limiting conclusions regarding long-term functional outcomes. Finally, while the 200 mL cutoff was selected a priori based on clinical convention, the observed efficiency inflection suggests that future analyses treating prostate volume as a continuous variable may further refine this threshold. Importantly, this analysis was limited to glands ≥ 120 mL, and inclusion of smaller prostates may further refine the volume–efficiency relationship

Future studies should explore volume–efficiency relationships using continuous modeling approaches and multicenter datasets to validate the presence and generalizability of a size-enhanced efficiency threshold. Additional work examining surgeon experience, morcellation dynamics, and workflow factors may further elucidate mechanisms underlying improved efficiency in very large glands.

Conclusions

In this contemporary cohort, HoLEP performed for prostates exceeding 200 mL was associated with higher enucleation speed and improved energy efficiency, without adverse impact on perioperative safety or early functional outcomes. These findings suggest that HoLEP may be a size-enhanced procedure, rather than simply size-independent, reinforcing its role as an optimal surgical option for patients with very large prostates.

Declarations

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Authors' Contributions: Conceptualization: YL, CC and SQ. Data curation and investigation: YL, EH, CC and SK. Formal analysis: YL. Methodology: YL, CC and SQ. Visualization: YL, EH, CC and SQ. Writing—original draft: YL. Writing—review and editing: YL, CC, and SQ. Supervision: SQ

Data Availability: The data that support the findings of this study are not publicly available due to patient privacy and institutional restrictions but are available from the corresponding author upon reasonable request.

Disclosure:

-Conflicts of interest: SQ is a HoLEP lecturer and proctor for Cook and Wolf. He is on the BPH advisory board for Coloplast. RJ is a HoLEP lecturer for Cook. The rest of authors have no conflict of interest to declare.

-Approval of research protocol by an Institutional Reviewer Board: The protocol for the research project was approved by the ethics committee of the institution where this work was undertaken (the Institutional Review Board ID# STUDY00008627)

-Informed Consent: waived

-Registry and the Registration No. of the study/trial: N/A

-Animal Studies: N/A

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Figures

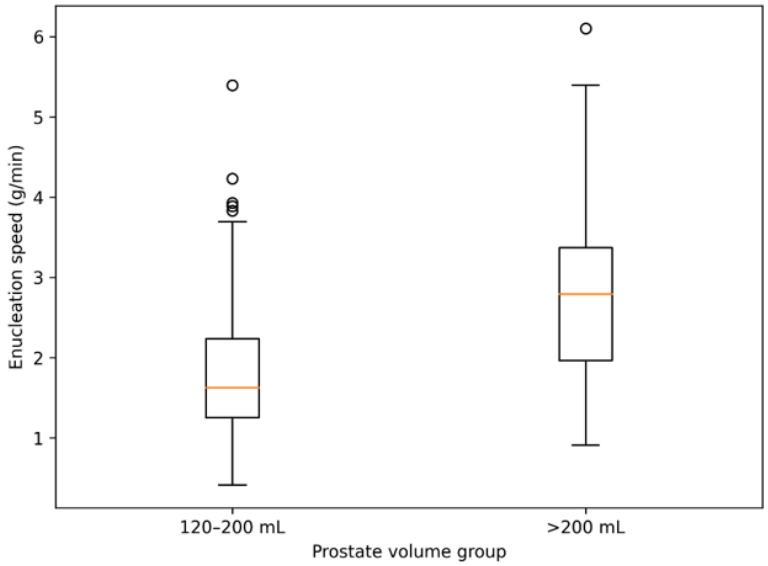


Figure 1A.

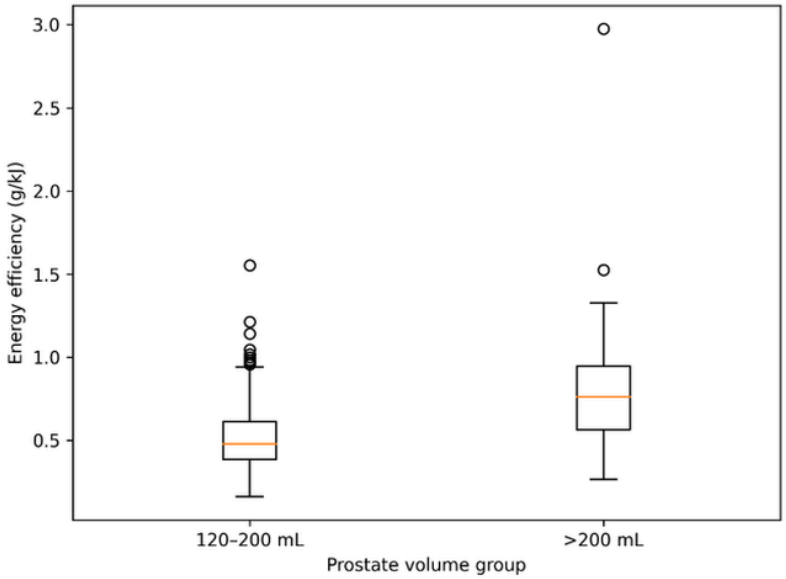


Figure 1B.

Figure 1

A. Enucleation speed by prostate volume group

B. Energy efficiency by prostate volume group