The Impact of Anesthesia-Induced Intraoperative Hypotension on Hemostasis during Holmium Laser Enucleation of the Prostate

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Background and Objective
Benign prostatic hyperplasia (BPH) is a common cause of lower urinary tract symptoms (LUTS) in men. Holmium laser enucleation of the prostate (HoLEP) has emerged as a superior option for patients with hemostatic concerns. Intraoperative hypotension (IOH) during general anesthesia is a phenomenon whereby general anesthetics reduce a patient's blood pressure (BP) and is commonly defined as a >20% reduction from baseline. Existing literature on the relationship between IOH and postoperative blood loss is sparse in urology but has been proposed in plastic surgery literature. This study aims to address this critical knowledge gap by investigating the effect of IOH during HoLEP on post-operative hematuria.

Methods
A retrospective analysis was conducted of all patients who underwent HoLEP by a single surgeon from 1/1/2024 to 12/31/2024. The primary comparison group was the incidence of clinically significant hematuria (CSH), defined as clot retention, reoperation, management change, or persistent hematuria longer than one month after the operation. Groups with and without CSH were matched by preoperative prostate volume as determined by preoperative imaging using coarsened exact matching. Mean baseline systolic BP (SBP) within 1 year before HoLEP, highest SBP during the first half of the procedure (the "enucleation phase"), and highest SBP during the second half (the "hemostasis and morcellation phase") were recorded. IOH was defined in two ways: (1) mean SBP greater than 20% below baseline during a procedural phase, and (2) peak intraoperative SBP greater than 20% below the peak SBP up to one year before the procedure. Perioperative characteristics were compared using the Wilcoxon Rank Sum test for continuous variables and either the Chi-squared or Fisher's exact test for categorical variables.

Results
Of 212 HoLEP patients, 22 developed CSH; 18 were successfully matched to controls. Baseline characteristics were similar. Under the peak definition, IOH during the enucleation phase was significantly associated with CSH (OR 3.31; 95% CI 1.13–9.7; p=0.029). CSH patients also experienced higher rates of emergency department visits (42% vs. 6%) and readmissions (37% vs. 3%), reflecting greater morbidity and healthcare utilization.

Conclusion
IOH during the enucleation phase of HoLEP was associated with an increased risk of CSH. Optimizing blood pressure during this phase may enhance hemostatic durability and reduce postoperative complications. Collaboration between surgical and anesthesia teams is critical to improving safety and outcomes.

Tables / Figures

Descriptive Summary of Non-CSH vs. CSH cohorts (Matched)			
Variable	**No Hematuria (n=18)[1]**	**Hematuria (n=18)[1]**	**p-value[2]**
Baseline Characteristics			
BMI	28.0 (24.4, 31.2)	30.0 (25.5, 31.0)	0.4
Mean Awake SBP (mmHg)	135.3 (126.0, 143.0)	141.0 (132.7, 149.0)	0.061
Peak Awake SBP (mmHg)	154.0 (142.0, 166.0)	172.0 (159.0, 182.0)	**0.003**
Preoperative PSA (ng/mL)	4.1 (2.2, 7.1)	4.2 (3.6, 6.8)	0.7
Preoperative Hematocrit (%)	44.0 (39.0, 47.0)	41.0 (36.0, 45.0)	0.058
Preoperative ACAP Use	31 (37%)	12 (71%)	**0.012**
Hypertension Diagnosis	58 (70%)	13 (72%)	0.8
HTN Medication Use	44 (53%)	14 (78%)	0.054
Charlson Comorbidity Index	3.0 (3.0, 4.0)	4.0 (3.0, 5.0)	0.3
Intraoperative Factors			
Mean SBP During Enucleation (mmHg)	114.5 (104.0, 125.5)	107.5 (100.0, 116.0)	0.2
Mean SBP During Hemostasis (mmHg)	117.0 (108.0, 126.5)	119.5 (104.0, 127.5)	0.7
Highest SBP During Enucleation (mmHg)	137.0 (116.0, 153.0)	124.0 (114.0, 132.0)	0.1
Highest SBP During Hemostasis (mmHg)	138.0 (121.0, 152.0)	141.0 (117.0, 150.0)	0.6
IOH During Enucleation (Mean Definition)	31 (37%)	10 (59%)	0.1
IOH During Hemostasis (Mean Definition)	20 (24%)	6 (35%)	0.4
IOH During Enucleation (Peak Definition)	25 (30%)	10 (59%)	**0.024**
IOH During Hemostasis (Peak Definition)	25 (30%)	7 (41%)	0.4
IV Anesthetics Used	3.0 (2.0, 3.0)	3.0 (2.0, 3.0)	0.5
IV Pressors Used	1.0 (1.0, 1.0)	1.0 (1.0, 1.0)	0.5
Inhalational Agents Used	1.0 (1.0, 3.0)	1.0 (1.0, 1.0)	0.2
Enucleation Time (min)	38.0 (31.0, 46.0)	43.5 (30.0, 52.0)	0.4
Morcellation Time (min)	7.0 (4.0, 11.0)	7.5 (5.0, 12.0)	0.4
Laser Time (min)	28.0 (23.0, 36.0)	30.0 (23.0, 36.0)	>0.9
Postoperative Outcomes			
Estimated Blood Loss (mL)	50.0 (50.0, 100.0)	50.0 (50.0, 100.0)	0.8
Postoperative ED Visits	5 (6.0%)	6 (33%)	**0.004**
Postoperative Admissions	2 (2.4%)	5 (28%)	**0.002**

Continuous variables reported as mean only; categorical variables as n (%).
[1] Mean; n (%)
[2] Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test

Table 4: Matched descriptive summary of non-CSH vs. CSH cohorts

Univariate Predictors of CSH (Matched)			
Variable	**OR**	**95% CI**	**p-value**
BMI	1.03	(0.94–1.14)	0.516
Mean Awake SBP	1.04	(0.99–1.08)	0.096
Peak Awake SBP	1.04	(1.01–1.07)	**0.006**
Preoperative PSA	0.99	(0.93–1.06)	0.795
Preoperative Hematocrit	0.89	(0.81–0.98)	**0.019**
Preoperative ACAP Use	4.03	(1.3–12.51)	**0.016**
HTN Diagnosis	1.12	(0.36–3.48)	0.844
HTN Medication Use	3.1	(0.94–10.22)	0.063
Charlson Comorbidity Index	1.2	(0.84–1.71)	0.319
Mean SBP During Enucleation	0.97	(0.94–1.01)	0.160
Mean SBP During Hemostasis	0.99	(0.96–1.03)	0.619
Peak SBP During Enucleation	0.98	(0.95–1)	0.090
Peak SBP During Hemostasis	0.99	(0.97–1.01)	0.406
IOH During Enucleation (Mean)	2.4	(0.83–6.94)	0.107
IOH During Hemostasis (Mean)	1.72	(0.56–5.24)	0.341
IOH During Enucleation (Peak)	3.31	(1.13–9.7)	**0.029**
IOH During Hemostasis (Peak)	1.62	(0.55–4.75)	0.376
IV Anesthetics Used	1.01	(0.5–2.04)	0.983
IV Pressors Used	0.72	(0.26–1.99)	0.524
Inhalational Agents Used	0.64	(0.33–1.25)	0.192
Enucleation Time	1.01	(0.98–1.04)	0.500
Morcellation Time	1.02	(0.97–1.06)	0.528
Laser Time	1.01	(0.96–1.06)	0.711
Estimated Blood Loss	1	(0.99–1)	0.621
Postop ED Visits	7.8	(2.06–29.59)	**0.003**
Postop Admissions	15.6	(2.73–88.86)	**0.002**

Table 5: Matched univariate regression of IOH and CSH

Multivariate Analysis of IOH During Enucleation (Matched, Mean Definition)			
Variable	**OR**	**95% CI**	**p-value**
IOH During Enucleation (Mean)	2.52	0.78, 8.73	0.13
Preoperative ACAP Use	4.26	1.21, 17.7	**0.031**
Charlson Comorbidity Index	1.08	0.68, 1.65	0.7
Multivariate Analysis of IOH During Hemostasis (Matched, Mean Definition)			
IOH During Hemostasis (Mean)	1.76	0.50, 5.89	0.4
Preoperative ACAP Use	4.69	1.33, 19.6	**0.021**
Charlson Comorbidity Index	1.04	0.66, 1.58	0.9
Multivariate Analysis of IOH During Enucleation (Matched, Peak IOH Definition)			
IOH During Enucleation (Peak)	3	0.93, 10.4	0.071
Preoperative ACAP Use	3.67	0.98, 15.9	0.061
Charlson Comorbidity Index	1.07	0.67, 1.64	0.8
Multivariate Analysis of IOH During Hemostasis (Matched, Peak IOH Definition)			
IOH During Hemostasis (Peak)	1.47	0.44, 4.77	0.5
Preoperative ACAP Use	4.71	1.33, 19.8	**0.022**
Charlson Comorbidity Index	1.03	0.65, 1.56	0.9
Abbreviations: CI = Confidence Interval, OR = Odds Ratio			

Table 6: Matched multivariate regression of IOH and CSH, controlling for ACAP use and CCI