The Effect of Resident Involvement on Perioperative Outcomes in Transurethral Urologic Surgeries

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OBJECTIVE: To conduct the first study of intra- and postoperative outcomes related to intraoperative resident involvement in transurethral resection procedures for benign prostatic hyperplasia and bladder cancer in a large, multi-institutional database.

DESIGN: Relying on the American College of Surgeons National Surgical Quality Improvement Program Participant User Files (2005-2012), we abstracted all cases of endoscopic prostate surgery (EPS) for benign prostatic hyperplasia and transurethral resection of bladder tumors (TURBTs). Multivariable logistic regression models were constructed to assess the effect of trainee involvement (postgraduate year [PGY] 1-2: junior, PGY 3-4: senior, PGY $\geq$ 5: chief or fellow) vs attending only on operative time and length of hospital stay, as well as 30-day complication, reoperation, and readmission rates.

RESULTS: In all, 5093 EPS and 3059 TURBTs for a total of 8152 transurethral resection procedures were performed during the study period for which data on resident involvement were available. In multivariable analyses, resident involvement in EPS or TURBT was associated with increased odds of prolonged operative times and hospital readmissions in 30 days independent of resident level of training. Resident involvement was not associated with overall complications or reoperation rates.

CONCLUSIONS: Resident involvement in lower urinary tract surgeries is associated with increased readmissions. Strategies to optimize resident teaching of these common urologic procedures in order to minimize possible risks to patients should be explored. (J Surg Ed 72:1018-1025. © 2015 Association of Program Directors in Surgery. Published by Elsevier Inc. All rights reserved.)

KEY WORDS: surgical education, bladder cancer, benign prostatic hyperplasia, complications

COMPETENCIES: Patient Care, Practice-Based Learning and Improvement

INTRODUCTION

Since their introduction during the first half of the 20th century, transurethral resection (TUR) techniques have been among the most commonly performed urologic procedures.[1] In the United States, an estimated 150,000 endoscopic prostate surgeries (EPSs) (including transurethral resection of prostates [TURP] and similar laser procedures) and transurethral bladder tumor resections (TURBTs) are performed annually.[2] Despite a consistent refinement of resection techniques and technological advancements, little is known about surgeon-derived factors driving perioperative outcomes in common urologic procedures like TUR.

Historically, TUR procedures at academic institutions have been considered "resident-level cases," and may be among the earliest procedures in which residents perform a substantial portion of cases with attending guidance. Unlike open or laparoscopic surgeries, TUR can be performed by only a single operator (resident or attending) at a given time,

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making them ideal procedures to evaluate the effect of resident involvement on perioperative outcomes.

In the setting of resident work hour restrictions in the United States and an increased emphasis on quality improvement measures,[3] it follows that intraoperative resident exposures will become progressively limited, which may affect patient outcomes.[4] Although simulation-based training may help reconcile the conflict between the need for resident teaching and the optimization of patient outcomes,[5,6] real-world data from large multi-institutional cohorts are lacking.[7] Hence, we sought to examine the effect of resident involvement in TUR on clinically relevant intra- and perioperative outcomes, including operative time (OT), complications, length of stay, and rates of readmission and reoperation, using data from American College of Surgeons National Surgery Quality Improvement Program (ACS-NSQIP) participating hospitals.

MATERIALS AND METHODS

Data Source

The ACS-NSQIP collects a sample of risk-adjusted surgical patient data from member hospitals to facilitate the assessment of outcome measures after surgery. In 2012, the ACS-NSQIP included data from 374 participant institutions with more than 2.3 million cases having been contributed. A trained Surgical Clinical Reviewer prospectively collects the NSQIP data from clinical records.[8] Validated data from patients' medical records allow quantification of 30-day risk-adjusted surgical outcomes, including postdischarge information.

Study Population

Using Current Procedural Terminology (CPT) codes, we identified patients who underwent TURBT (CPT codes: 52234, 52235, and 52240) or EPS (CPT codes: 52601, 52648, and 52649) from 2005 to 2012. We excluded EPS performed for residual prostate tissue or regrowth after previous EPS (CPT: 52630) and included traditional TURPs as well as potassium titanyl phosphate (KTP) laser vaporizations and holmium laser enucleation (HoLEP) procedures (CPT: 52601, 52648, and 52649).

Covariates

For each patient, age, body mass index, race, smoking status, diabetic condition, and American Society of Anesthesiology physical status were extracted. TURBT and EPS procedures were analyzed separately. For TURBT, we additionally adjusted for patient gender and size of bladder tumor (0.5-2 cm, 2-5 cm, or >5 cm according to CPT codes). For the EPS analyses, we additionally adjusted for method of EPS (TURP, KTP vaporization, or HoLEP). Residents were categorized according to their postgraduate year (PGY) status at the time of surgery as junior (PGY1-2), senior (PGY 3-4), or chief (PGY ≥ 5).

Outcomes

Perioperative outcome measures included OT, overall complication rates, blood transfusions, urinary tract infections (UTI), septic shock, length of hospital stay (LOS), readmissions, and reoperations. All outcomes were captured within 30 days after the procedure. Prolonged length of stay (pLOS) and prolonged operative time (pOT) were defined according to the highest quartiles after excluding outlier cases with OT $<$ 20 minutes (considered unreflective of typical procedures). According to the upper quartiles for EPS, pOT $\geq$ 77 minutes and LOS $\geq$ 2 days; for TURBT, pOT $\geq$ 55 minutes and pLOS $\geq$ 1 day.

Statistical Analyses

Frequencies and proportions of categorical variables were assessed using the chi-square test. Multivariable logistic regression models fitted for significant different patient or procedure characteristics tested the association between preoperative covariates and the aforementioned outcomes. Multivariable analyses were performed for all perioperative outcome measures with observed associations on univariable analysis and $p < 0.2$. All statistical tests were performed using Stata, Version 13, with a 2-sided significance level set at $p < 0.05$. An institutional review board waiver was obtained before conducting this study, in accordance with institutional regulation when dealing with deidentified administrative data.

RESULTS

Cohort Characteristics

Baseline characteristics for TURBT and EPS procedures are displayed in Table 1. Overall, 5093 EPS were included, of which 31.99% were performed with intraoperative resident involvement. The majority (78.1%) were TURPs followed by KTP (19.9%) and HoLEP (2.1%). A significantly higher proportion of laser procedures involved residents (27% vs 20%, $p < 0.001$). Resident involvement was associated with younger age and nonwhite patients ($p = 0.049$ and <0.001, respectively). The resident subgroup contained significantly lower proportions of smokers and diabetics ($p = 0.008$ and 0.027, respectively) but there was no significant differences in body mass index or American Society of Anesthesiology score ($p = 0.12$ and 0.4, respectively).

Regarding TURBTs, 3059 cases were identified (Table 1). Of these, 41% involved residents. Resident cases were associated with significantly smaller tumor sizes and patients were less frequently smokers ($p = 0.027$ and 0.021,

TABLE 1. Baseline Characteristics of 8152 Patients ≥18 Years Who Underwent Endoscopic Prostate Surgery or Transurethral Resection of Bladder Tumors Stratified According to Intraoperative Resident Involvement and Surgical Procedure (National Surgical Quality Improvement Program Database Years 2005-2011)

	EPS				TURBT			
	Total (*n*)	Attending (%)	Resident (%)		Total (*n*)	Attending (%)	Resident (%)	
	5093	68.01	31.99	p Value	3059	58.78	41.22	p Value
Sex								
Female	—	—	—		769	25.31	24.90	0.176
Male	5093	100.00	100.00		2281	74.25	75.02	
Unknown	—	—	—		9	0.44	0.08	
Age								
≤50	1445	27.22	30.82	0.049	937	30.26	31.17	0.73
51-60	1856	36.52	36.28		912	29.25	30.61	
61-70	1493	30.02	27.81		887	28.92	29.10	
≥71	179	3.70	3.13		162	5.62	4.84	
Unknown	120	2.54	1.96		161	5.95	4.28	
Race								
White	4001	85.08	64.70	<0.001	2441	86.60	70.10	<0.001
Nonwhite	1092	15.07	34.99		618	13.40	29.90	
ASA class								
1-2	2259	43.68	45.79	0.12	1131	38.15	35.29	0.106
3-5	2834	56.47	53.90		1928	61.85	64.71	
BMI								
<25	1406	27.54	27.75	0.4	910	30.42	28.79	0.623
25-30	2069	40.44	41.01		1158	37.93	37.75	
>30	1570	31.58	29.22		962	30.98	32.12	
Unknown	48	0.43	2.03		29	0.67	1.35	
Smoker								
No	4540	88.48	90.55	0.008	2445	78.53	81.92	0.021
Yes	553	11.66	9.15		614	21.47	18.08	
Diabetes								
No	4043	78.64	80.97	0.027	2417	79.64	78.11	0.306
Yes	1050	21.51	18.72		642	20.36	21.89	
Anesthetic								
General	3706	73.47	71.27	0.108	2637	85.43	87.31	0.39
Local	1365	26.13	28.24		344	10.68	12.05	
Unknown	2	0.40	0.49		78	3.89	0.63	
Tumor size, cm								
<2	—	—	—		1202	37.43	41.95	0.027
2-5	—	—	—		1089	36.15	34.81	
>5	—	—	—		768	26.42	23.24	
Type of EPS								
Loop resection	3975	80.34	73.17	<0.001	—	—	—	
KTP Laser	1013	18.68	22.47		—	—	—	
HoLEP	105	1.13	4.05		—	—	—	

ASA, American Society of Anesthesiology; BMI, body mass index.

respectively). Contrary to the EPS group, resident involvement was not associated with patient age or diabetic condition compared with the attending group.

Perioperative Outcomes

Among EPS procedures, we observed no differences between attending-only and resident-involved cases in rates of overall complications (5.94% vs 5.54%, respectively), blood transfusions (1.35% vs 1.79%), UTI (4.79% vs 4.13%), or septic shock (0.2% vs 0.06%) (all $p > 0.05$). The resident group had higher rates of pOT (33.0% vs 18.56%, $p < 0.001$) and readmissions (20.6% vs 12.9%, $p < 0.0001$) but lower rates of pLOS ($p < 0.001$) (Table 2). These associations were confirmed in adjusted multivariable analyses (Table 3). The resident group was 50% less likely to have pLOS ($p < 0.001$), but had a 2-fold higher likelihood of pOT ($p < 0.001$) and a 1.6-fold higher likelihood of readmissions ($p < 0.001$). In stratified subanalyses, according to level of resident training, these differences remained significant with no observed seniority-based trends (Fig.).

In the TURBT cohort, we observed no statistically significant associations between resident involvement and

TABLE 2. Univariate Rates of 30-Day Outcomes After Endoscopic Prostate Surgery as a Function of Intraoperative Resident Involvement (National Surgical Quality Improvement Program Database Years 2005-2011)

	EPS				TURBT			
Outcome	**Total (%)**	**Attending (%)**	**Resident (%)**	**p Value**	**Total (%)**	**Attending (%)**	**Resident (%)**	**p Value**
pOT	23.2	18.6	33.0	<0.001	18.0	14.6	22.9	<0.001
pLOS	32.7	37.4	22.7	<0.001	31.2	28.8	34.6	0.001
Complications	6.0	6.2	5.6	0.28	5.2	5.3	4.9	0.792
Transfusion	1.5	1.4	1.8	0.237	2.0	2.0	2.1	0.908
UTI	4.6	4.8	4.1	0.294	4.0	3.8	4.1	0.689
Septic shock	0.2	0.2	0.1	0.239	0.2	0.3	0.2	0.496
Reoperation	2.1	2.2	1.8	0.461	3.7	3.9	3.3	0.415
Readmission	15.4	12.9	20.6	<0.001	24.7	21.5	29.4	<0.001

rates of overall complications (5.23% attendings vs 4.76% residents), blood transfusions (2.0% vs 2.06%), UTI (3.84% vs 4.12%), or septic shock (0.28% vs 0.16%) (all $p > 0.05$). In univariate analyses, resident involvement was associated with pOT (14.6% vs 22.9%, $p < 0.001$), pLOS (28.8% vs 34.6%, $p = 0.001$), and readmissions (21.5% vs 29.4%, $p < 0.001$) (Table 2). Multivariable analyses corroborated a 1.4-fold higher likelihood of pLOS, 1.5-fold higher odds for readmissions, and a 100% increase in pOT (all $p < 0.001$) (Table 3). These findings were independent of resident level of training (Fig.).

DISCUSSION

We observed no significant effect of resident involvement on overall or specific complication rates following EPS and TURBT, but a significant effect on operative times and readmission rates. These findings highlight the potential effect that residency education can have on surgical outcomes. The need to optimize surgical training while minimizing patient harms will become more imperative in the coming years. Surgical education is in the midst of important changes with unknown long-term implications.[9] As the emphases on patient safety and outcome transparency increase in conjunction with resident work hour limitations, intraoperative exposure for surgical residents is becoming increasingly limited.[10] Surgical volume-outcome relationships have been established for advanced surgical procedures, leading to centralization processes, which may further limit resident exposure.[11] Although TURBT and EPS are regarded as simple endoscopic procedures to be mastered by trainees, scarce data exist regarding the real-world consequences of resident involvement in these common procedures. Moreover, previous studies suggest an underappreciated learning curve for TURP that persists well beyond residency training.[12,13]

Though rare overall, complications from EPS and TURBT often involve bleeding, which may necessitate reoperation to achieve hemostasis. Delayed bleeding may result from sloughing of tissue and result in readmission for continuous bladder irrigation or reoperation. We found that neither transfusion rates nor reoperations were significantly different between the resident and attending groups. Further, multivariable analyses excluded a potential seniority effect expected for higher complication rates in less experienced hands. Interestingly, the only previous study to examine resident effect on postoperative complication rates following TURBT found a positive association between higher levels of resident training and complications, suggesting increased autonomy of senior residents or involvement in more complex cases.[7] In spite of no observed association

TABLE 3. Multivariable Logistic Regression Analyses of Effect of Residency Involvement on Perioperative Outcomes of Endoscopic Urologic Surgery of the Lower Urinary Tract (National Surgical Quality Improvement Program database years 2005-2011)

Procedure	**Outcome**	**Attending-Only, Adjusted OR**	**Resident-Nvolved, Adjusted OR**	**p Value**
EPS*	pLOS	1	0.501	<0.001
	pOT	1	2.03	<0.001
	Readmission	1	1.61	<0.001
TURBT†	pLOS	1	1.437	<0.001
	pOT	1	2.022	<0.001
	Readmission	1	1.5	<0.001

OR, odds ratio.

*Covariates in logistic regression models for EPS analyses included age (<50 [reference], 51-60, 61-70, and >70), BMI (<25 [reference], 25-30, and >30), smoking status, diagnosis of diabetes, ASA score (1-2 vs 3-5), and method of EPS (TURP [reference], KTP, and HoLEP).

†Covariates in TURBT models included age (<50 [reference], 51-60, 61-70, and >70), gender, BMI (<25 [reference], 25-30, and >30), smoking status, diagnosis of diabetes, ASA score (1-2 vs 3-5), and size of bladder tumor (<2 cm [reference], 2-5 cm, and >5 cm).

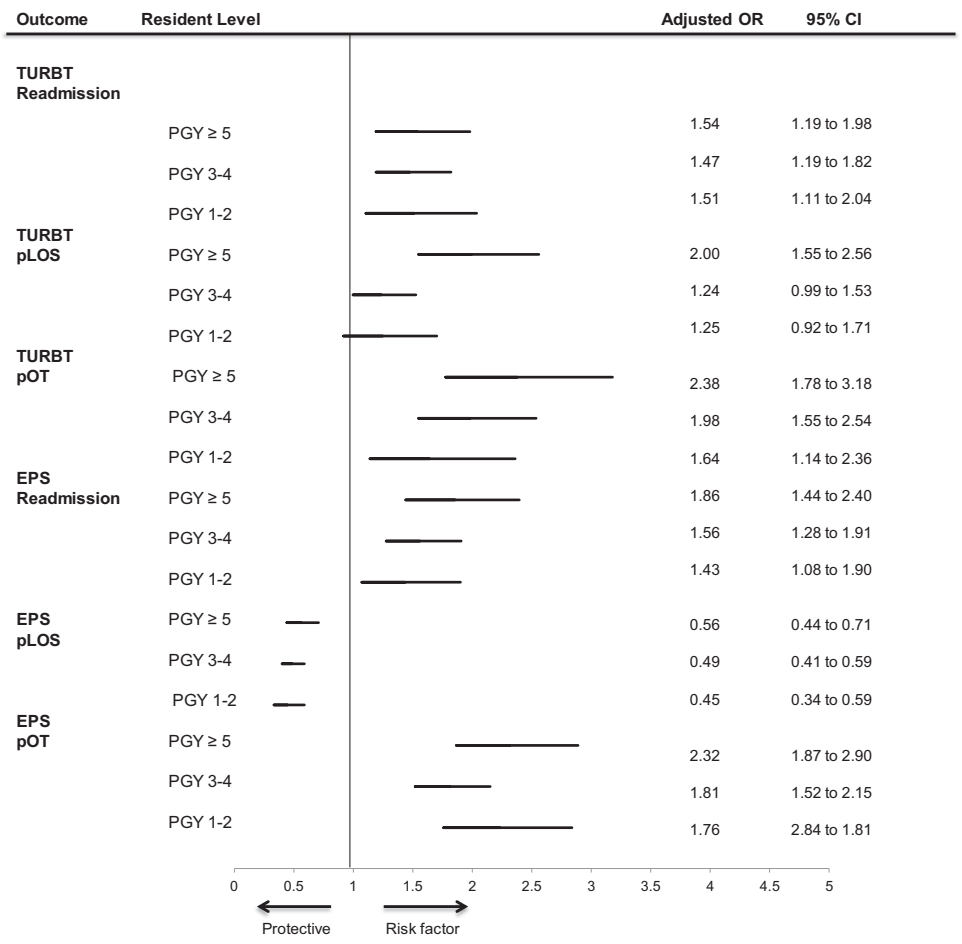

FIGURE. Multivariable logistic regression analyses of effect of level of residency training* on perioperative outcomes of endoscopic urologic surgery of the lower urinary tract (National Surgical Quality Improvement Program database years 2005-2011); Covariates in logistic regression models for EPS analyses included age (<50 [reference], 51-60, 61-70, >70), BMI (<25 [reference], 25-30, >30), smoking status, diagnosis of diabetes, ASA score (1-2 vs 3-5), and method of EPS (TURP [reference], KTP, and HoLEP). Covariates in TURBT models included age (<50 [reference], 51-60, 61-70, >70), gender, BMI (<25 [reference], 25-30, >30), smoking status, diagnosis of diabetes, ASA score (1-2 vs 3-5), and size of bladder tumor (<2 cm [reference], 2-5 cm, >5 cm). *Reference: attending-only surgery. ASA, American Society of Anesthesiology; BMI, body mass index; OR, odds ratio.

with immediate complications, resident involvement was independently associated with 30-day readmissions following both EPS and TURBT procedures. Although the indications for readmission are unknown, this finding suggests a negative effect of resident training with significant financial and clinical implications.

Although it may be inferred that resident integration for TURBT is safe in terms of immediate complications, we were not able to evaluate the predictive value of resident involvement on oncologic outcomes. Indeed, Jancke et al.[14] showed that resident involvement increased recurrence rates in Ta/T1 bladder cancers, possibly resulting from inadequate tumor resections.[15,16] Regarding the effect of residents on EPS procedure outcomes, only single-institution series have previously evaluated this relationship. Fechner et al.[17] reported overall safety among residents and attendings and noted long-term functional outcomes to be similar between groups. Owing to the design of NSQIP, we were not able to evaluate the effect of resident involvement on volume of resected or vaporized prostate tissue or on clinical outcomes such as symptom improvement.

Our findings are in contrast with a recent study using ACS-NSQIP, which demonstrated a lack of association between resident involvement and perioperative outcomes from laparoscopic and robotic urologic oncology procedures.[18] It is plausible that EPS and TURBT are uniquely prone to effects of resident involvement owing to the limitation of an individual using a resectoscope at any given time. Insufficient or overly aggressive resections might be inadvertently performed by residents during TUR, which cannot be completely corrected by a supervising attending physician. In light of the observed association between resident involvement and increased readmission rates, longer-term associations may exist which were not captured within the 30-day window available in this database. Furthermore, the deidentified nature of the ACS-NSQIP

data prohibits assessment of effects of individual attending surgeon or hospital volume on perioperative outcomes.

Although intraoperative resident presence or absence is reliably captured, the degree to which residents participated in cases is unknown. Although we adjusted for all available clinically relevant covariates, it is possible that the increased rates of readmissions relate to unmeasured confounding factors. For example, residents may preferentially select more advanced cases that are more prone to readmissions for a variety of reasons. Although we could not identify some features of difficult cases, such as sessile tumors, it is not the case that residents preferentially selected large tumors; in fact, as shown in Table 1, the opposite is true (41.95% vs 37.43%, <2 cm tumors for resident and attending-only cases respectively; $p = 0.027$). Importantly, it cannot be inferred from our analysis that perioperative outcomes necessarily differ between academic and community centers as this relationship was not assessed.

We noted a surprising contrast in the effect of residents on LOS among TURBT and EPS procedures. Residents were associated with pLOS for TURBT patients, and they were conversely associated with decreased LOS for EPS procedures. Although residents were involved in significantly more laser procedures that have been associated with decreased LOS,[19] our findings are independent of the EPS method (TURP, KTP, and HoLEP) in multivariable analysis. Preferential resident case selection of less challenging EPS procedures performed on smaller glands, similar to the preference for smaller bladder tumors described earlier, may account for the apparent paradox.

Finally, we observed an association between resident involvement and pOTs for both procedures, which is not surprising. Previous studies confirm this observation among multiple surgical procedures.[20-22] In laparoscopic urologic procedures, an increased OT was noted for partial and radical nephrectomy as well as radical prostatectomies.[18] A recent study of resident involvement in urethroplasties found pOT for chief resident cases but no effect of junior residents, suggesting minimal involvement of junior residents in these more highly specialized operations.[23] pOT has consistently been shown to constitute a considerable financial effect on the health care system but is likely a necessary consequence of resident teaching. [24-26]

Simulation-based training is a proposed solution to the observed clinical and financial effects of surgical resident training. Indeed, simulation-based trainers can improve surgical technique and dexterity in transurethral procedures.[27-30] However, the degree to which these educational tools are used in residency programs is unknown, and implementation faces hurdles such as upfront costs and time restraints.[28] As a consequence of such challenges, standardizations of resident training processes to optimize the residency experience while minimizing negative effects on outcomes have been initiated and warrant ongoing evaluation.[31,32]

CONCLUSIONS

Our findings demonstrate, for the first time in a large comprehensive database, that trainee involvement in urologic TUR procedures is associated with increased readmission rates and operative time but not immediate postoperative complications. Increased operative times and readmissions inevitably result in significant financial effects and may result in long-term clinical sequelae. These observations should not prompt further restrictions on surgical exposures, which would only exacerbate the problem. Rather, evaluation of novel methods of surgical training, as well as adoption of existing modules, should be strongly encouraged for teaching hospitals.

AUTHOR CONTRIBUTION

C.B. Allard—project development, data collection, analysis, and writing

C.P. Meyer—project development, data collection, analysis, and writing

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M.A. Preston—data collection and analysis

Q.D. Trinh—project development, data collection, analysis, and writing

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