The Impact of Teaching on Fundamental General Urologic Procedures: Do Residents Help or Hurt?

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OBJECTIVE To examine the effects of trainee involvement on fundamental urology procedures.

METHODS Current Procedural Terminology codes were used to identify patients within the National Surgical Quality Improvement Program database who underwent a selection of fundamental general urology procedures (2005-2013). Operative time and perioperative complications (30-day) were compared between cases with and without trainee involvement.

RESULTS 29,488 patients had general urology procedures with information regarding trainee involvement, 13,251 (44.9%) with trainee involvement, and 16,237 (55.1%) without. Overall patients who underwent procedures with trainee involvement were younger and had fewer comorbidities (Table 1). Trainee involvement showed significant increase in operative time in all procedures included in the study (Table 2). On multivariate analysis trainee involvement increased the risk of complications (Odds Ratio (OR) 1.61, 95% CI 1.45-1.78, $P < .001$). Other factors that increased the risk of complications were: American Society of Anesthesiologists (ASA) class 3-4 (OR 2.01, 95% CI 1.46-2.77, $P < .001$), partially or totally dependent functional status (OR 2.22, 95% CI 1.68-2.94, $P < .001$), diabetes mellitus (OR 1.21, 95% CI 1.05-1.39, $P = .008$), heart disease (OR 1.19, 95% CI 1.02-1.38, $P = .027$), and respiratory disease (OR 1.33, 95% CI 1.09-1.63, $P = .027$).

CONCLUSION While trainees are valuable members of the urology team at teaching hospitals and training is necessary, their involvement in urologic surgery appears to increase operative time for all procedures and complications in certain procedures. Further research needs to be done on how to mitigate these effects while preserving surgical education quality. UROLOGY 121: 44–50, 2018. © 2018 Elsevier Inc.

Intraoperative experience is essential to surgical training.[1] Trainees are an important component of academic hospitals, however the impact that this has on patient care is unclear. There has been increased focus on supervision and quality of care in resident education. The existing literature suggest that trainee involvement in surgery leads to increased operative time however there is no consensus on how this affects patient outcomes. The impact of trainee involvement in urologic surgery has not been well studied. We wanted to examine the effects of trainee involvement on fundamental urology procedures.

METHODS

Current Procedural Terminology codes were used to identify patients within the National Surgical Quality Improvement Program (NSQIP) database who underwent a selection of fundamental general urology procedures (2005-2013). The American College of Surgeons National Surgical Quality Improvement Program Participant Use File is a validated, multi-institutional clinical database of preoperative through 30-day postoperative surgical data. The data is collected on randomly assigned patients from more than 250 academic and nonacademic institutions. A trained surgical clinical reviewer at each site validates the data prior to submission and data is audited through site visits to ensure interinstitutional reliability.[2]

We defined fundamental urology procedures as procedures that would be done with high volume both at academic and community hospitals by both academic and nonacademic urologists. Procedures included were: open radical prostatectomy, laparoscopic and/or robotic radical prostatectomy, open radical nephrectomy, laparoscopic and/or robotic radical nephrectomy, hydrocele repair, mid-urethral sling, small transurethral resection of a bladder tumor (TURBT), medium TURBT, greenlight laser ablation of the prostate, transurethral resection of the prostate. We did not include partial nephrectomy or large TURBT because of variability in the technical difficulty of these procedures.

Demographic information and comorbidities were collected. The above general urology cases were included if they had

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Table 1. Patient characteristics in trainee and nontrainee cases

Variables	No Trainee n = 16237		Trainee n = 13251		*P* Value
Age					<.001
<45	1305	(8.16)	972	(7.38)	
45-54	2364	(14.78)	2248	(17.07)	
55-64	4108	(25.69)	4097	(31.10)	
65+	8215	(51.37)	5856	(44.45)	
Race					<.001
White, non-Hispanic	11368	(91.16)	8941	(87.97)	
Non-white	1103	(8.84)	1223	(12.03)	
ASA					<.001
1	1010	(6.23)	706	(5.33)	
2	8253	(50.93)	7244	(54.73)	
3-5	6943	(42.84)	5287	(39.94)	
Functional status					<.001
Independent	15810	(97.44)	13073	(98.66)	
Partially or totally dependent	416	(2.56)	178	(1.34)	
Approach					<.001
Open	6200	(38.18)	5734	(43.27)	
Lap	6706	(41.30)	2921	(22.04)	
Endo	3331	(20.51)	4596	(34.68)	
Steroid	284	(1.75)	286	(2.16)	.011
Smoker	2495	(15.37)	1742	(13.15)	<.001
Alcohol	470	(2.95)	542	(4.13)	<.001
Diabetes	2588	(15.94)	1767	(13.33)	<.001
HTN	8949	(55.11)	6711	(50.65)	<.001
Heart disease	2169	(13.36)	1348	(10.17)	<.001

ASA, American society of anesthesiologists; HTN, hypertension.

information specifying if a trainee was or was not involved in the case and each case was grouped as "trainee" or "non-trainee." Operative time and perioperative complications (30-day) were examined and compared between cases with and without trainee involvement. Logistic regression analysis and generalized linear models were used to identify significant factors affecting the complications and operative time respectively. All data analysis was done using IBM SPSS software, Version 23 (IBM Corp, Armonk, NY).

RESULTS

Twenty-nine thousand four hundred and eighty-eight patients had general urology procedures with information regarding trainee involvement, 13,251 (44.9%) with trainee involvement, and 16,237 (55.1%) without. Overall there were demographic differences between the two cohorts. A greater portion of patients without trainee involvement were over 65 years of age (51% vs 44%, $p < 0.001$) and white (91% vs 88%, $p < 0.001$). Patients with no trainee involvement had a higher rate of American Society of Anesthesiologists (ASA) class 3-5 (43% vs 40%, $P < .001$), a higher rate of partially or totally dependent functional status (3% vs 1%, $P < .001$), and lower rate of steroid use (1.8% vs 2.2%, $P < .001$). When comparing specific comorbidities, patients in the no trainee cohort had a higher rate of smoking (15% vs 13%, $P < .001$), diabetes (16% vs 13%, $P < .001$), hypertension (HTN) (55% vs 51%, $P < .001$), heart disease (13% vs 10%, $P < .001$), respiratory disease (6% vs 3%, $P < .001$), and neurologic disease (7% vs 5%, $P < .001$). Cases involving trainees had a higher rate of open and endoscopic approach and a lower rate of laparoscopic approach (Table 1).

Trainee involvement showed significant increase in operative time in all procedures included in the study ($P < .001$). The greatest time differences were for open radical nephrectomy (73.2 average increase in minutes, 95% CI 54-92) and laparoscopic and/or robotic radical nephrectomy (42.0 average increase in minutes, 95% CI 33-51; Table 2).

On multivariate analysis trainee involvement increased the risk of complications (OR 1.61, 95% CI 1.45-1.78, $P < .001$). The greatest risk factors for increased complications were other comorbidities (including ascites, rest pain, 10% weight loss in prior 6 months, acute renal failure, dialysis use at time of surgery, preoperative transfusion within 72 hours prior to surgery, esophageal varices, disseminated cancer, bleeding disorder, and open wound infection) (OR 2.32, 95% CI 1.95-2.76, $P < .001$) and partially and/or totally dependent functional status (OR 2.22, 95% CI 1.68-2.94, $P < .001$). Other factors that increased the risk of complications were: older age (55-64 year old [yo] OR 1.34, 95% CI 1.06-1.71, $P < .016$, 65+ yo OR 1.44, 95% CI 1.13-1.84, $P = .003$), ASA class 3-4 (OR 2.01, 95% CI 1.46-2.77, $P < .001$), diabetes mellitus (OR 1.21, 95% CI 1.05-1.39, $P = .008$), heart disease (OR 1.19, 95% CI 1.02-1.38, $P = .027$), and respiratory disease (OR 1.33, 95% CI 1.09-1.63, $P = .027$). Laparoscopic approach showed a decreased risk in complications (OR 0.44, 95% CI 0.39-0.49, $P < .001$; Table 3).

When broken down by surgery type, trainee involvement increased the risk of complications in open radical prostatectomy (OR 2.34, 95% CI 1.76-3.12, $P < .001$), open radical nephrectomy (OR 1.98, 95% CI 1.18-3.32, $P = .009$), and mid-urethral sling (OR 1.36, 95% CI 1.09-1.70, $P = .006$). Partially and/or totally dependent functional status continued to be a risk factor for laparoscopic and/or robotic prostatectomy (OR 5.95, 95% CI 1.13-31.31, $P = .035$), hydrocele repair (OR 18.01, 95% CI 2.34-138.86, $P = .006$), small TURBT (OR 2.77, 95% CI 1.07-

Table 2. Impact of trainee involvement on operative time by urologic procedure

Urologic Procedure	B	95% CI	*P* value
Open radical nephrectomy	73.2	54.2-92.1,	<.001
Laparoscopic/robotic radical nephrectomy	42.0	33.0-51.0	<.001
Open radical prostatectomy	37.9	28.6-47.2	<.001
Mid-urethral sling	35.4	31.5-39.2	<.001
Green Light laser vaporization of the prostate	22.4	18.5-26.2	<.001
Laparoscopic/robotic radical prostatectomy	19.6	15.3-23.9	<.001
TURP	19.3	15.8-22.9	<.001
Hydrocele	14.4	9.7-19.1	<.001
Small TURBT	13.2	7.4-19.0	<.001
Medium TURBT	11.9	8.4-15.5	<.001

TURP, transurethral resection of the prostate; TURBT, transurethral resection of a bladder tumor.

7.17, $P = .036$), medium TURBT (OR 4.46, 95% CI 1.98-10.05, $P < .01$), and transurethral resection of the prostate (OR 2.08, 95% CI 1.20-3.60, $P = .009$). Another common risk factor was diabetes: open radical nephrectomy (OR 2.35, 95% CI 1.2-4.61, $P = .013$), laparoscopic and/or robotic radical nephrectomy (OR 1.64, 95% CI 1.08-2.47, $P = .019$), medium TURBT (OR 1.71, 95% CI 1.01-2.89, $P = .044$).

Table 3. Multivariable analysis predicting all complications

Variable	Adjusted OR (95% CI)	*P* value
Age		
<45	REF	
45-54	1.04 (0.81 −1.34)	.753
55-64	1.34 (1.06 −1.71)	.016
65+	1.44 (1.13 −1.84)	.003
Race		
White	REF	
Non-white	1.07 (0.91 −1.26)	.435
ASA Class		
1	REF	
2	1.30 (0.95 −1.76)	.096
3-4	2.01 (1.46 −2.77)	<.001
BMI		
<18.5	REF	
18.5-25	1.42 (0.87 −2.29)	.158
25-30	1.03 (0.90 −1.19)	.646
>30	0.95 (0.82 −1.10)	.496
Functional status		
Independent	REF	
Partially/totally dependent	2.22 (1.68 −2.94)	<.001
Chronic steroid use	1.28 (0.95 −1.72)	.100
Current smoker	1.02 (0.88 −1.19)	.750
Alcohol	0.74 (0.54 −1.01)	.057
Hysterectomy or prolapse repair	0.84 (0.70 −1.00)	.055
Diabetes mellitus	1.21 (1.05 −1.39)	.008
Hypertension	0.99 (0.88 −1.11)	.819
Heart disease	1.19 (1.02 −1.38)	.027
Respiratory disease	1.33 (1.09 −1.63)	.006
Neurologic disease	1.05 (0.86 −1.28)	.621
Other comorbidities	2.32 (1.95 −2.76)	<.001
Resident/fellow involvement	1.61 (1.45 −1.78)	<.001
Laparoscopic approach	0.44 (0.39 −0.49)	<.001

BMI, body mass index.

DISCUSSION

We found that for general urology procedures, despite a healthier and younger patient population, trainee involvement was correlated with increased operative time for all procedures and increased rate of complications for open radical prostatectomy, open radical nephrectomy, and mid-urethral sling.

We found a difference in patient demographics and comorbidities between the two groups. Overall the patients without trainee involvement were older, had a higher rate of ASA class 3-5, increased rate of many comorbidities and a greater percentage were white. Increased age is associated with increased comorbidities so the increased age in the nontrainee group may be the explanation for that difference. One explanation for the increased age could be which institutions take Medicaid vs Medicare. The American Urological Association census reports that 69.6% of urologists accept Medicaid[3] however it does not specify which types of Medicaid. Medicare has superior reimbursements so it is possible private centers are skewed toward Medicare over Medicaid raising the patient age. The trainee involvement cohort may have unmeasured characteristics impacting the complication rate. Other studies have shown that lower socioeconomic status leads to worse outcomes postoperatively for colorectal cancer[4] and liver transplantation.[5] It would be interesting to compare information on socioeconomic status and education level between the two patient groups. Teaching centers may be serving patients who otherwise would not be able to have access to this advanced level of care, and these underlying characteristics have an impact on the outcome.

We found that trainee involvement increased operative time for all of the procedures studied. This finding is supported by the literature in general surgery,[6] breast surgery,[7] and urology.[8-11] Multiple hypotheses have been proposed for this, including inherent inefficiencies in large academic centers,[9] the idea that residents may be involved in more complicated cases,[1] or that teaching residents simply adds time to the operation.[9]

Past studies have investigated the connection between an increase in operative time and an increase in complications. The literature supports that increased operative time leads to an increase in infectious risk.[12] Procter et al looked at the NSQIP database for all general surgery procedures from 2005-2007 and found that an increase in operative time from <1 hour to 2-2.5 hours almost doubled the risk of infectious complications.[13] Kim et al examined the NSQIP database from 2006-2011 for single level spinal fusion. They found longer operative times caused a step wise increase in risk for overall complications, medical complications, surgical complications, superficial site infection, and postoperative transfusions.[14] Daley et al

examined the Tennessee Surgical Quality Collaborative data on general and vascular cases and found that procedures running longer than the 95% CI for expected operative time had an increased risk of urinary tract infections, organ space surgical site infections, sepsis and/or septic shock, prolonged intubation, pneumonia, deep vein thrombosis, deep surgical site infection, and wound disruption.[15] These studies emphasize that efficiency in the operating room can improve patient outcomes.

Not only did trainee involvement increased surgery time, we found that trainee involvement also independently increased the risk of complications in open radical prostatectomy, open radical nephrectomy, and mid-urethral sling. While studies have been done in multiple surgical fields, there is no clear consensus on how resident involvement affects surgical outcomes. This question has been explored in a range of fields including general surgery, plastic surgery, orthopedic surgery, neurosurgery, and breast surgery. Some studies have shown trainee involvement associated with increased complications[7,16-20] while others have shown comparable rate of complications to procedures done without trainee involvement.[6,8,21-25]

A few previous studies have explored this topic within urology. Matulewicz et al used the NSQIP database to look at all procedures where urology was listed as the primary surgical service from 2005-2011. They found trainee involvement led to decreased odds of overall complications when adjusting for operative time, however, trainee involvement was associated with longer operative times, so the impact of trainees is unclear. This study did not break down by individual procedure and included the more complex operations usually done at tertiary care academic centers such as cystectomy with ileal conduit.[8]

Welk et al used administrative data from the province of Ontario to compare urology procedures performed at teaching and nonteaching hospitals from 2002-2013. The procedures included in the study were circumcision, hydrocelectomy, open radical prostatectomy, transurethral prostatectomy, and mid-urethral sling. This study had the most similar approach to ours as they selected general urology procedures. They found a longer operative time in teaching hospitals however, they did not compare outcomes. Interestingly while our cohort was divided fairly evenly between the two groups, in Canada a much smaller portion of the cases were done in teaching hospitals. Open radical prostatectomy was the procedure done most commonly at a teaching hospital (28.6%) and hydrocelectomy was the procedure done least commonly at a teaching hospital (13.3%).[9] Other studies have examined the impact of trainee involvement on specific urologic procedures. Loppenberg et al examined the NSQIP database to examine the impact on outcomes of hydrocelectomy from 2005-2013. They found that trainee involvement led to a significant increase in operative time and no increase in complication rate in hydrocele repair.[11] Our study was consistent with these findings. Kern et al examined outcomes of partial nephrectomy in the NSQIP database from 2005-2010 and found an increased risk of overall, serious, and nonserious morbidity, superficial and overall surgical site infections, bleeding, and sepsis and/or septic shock in the trainee involvement group.[26] MacDonald et al examined the NSQIP database from 2006-2013 to evaluate single stage anterior urethroplasty. They found that there was not a significant difference in any complication between the trainee and no trainee involvement groups.[10] Our study excluded partial nephrectomy and anterior urethroplasty from our cohort because we felt there was more room for interprocedure variability in terms of difficulty. Additionally, these were procedures we believed were more likely to be referred to a specialist and done at an academic center. This literature supports our hypothesis as 68% of partial nephrectomies included trainee involvement[26] and 74% of the anterior urethroplasties had trainee involvement.[10] Our study was unique in that it looked at a range of urologic procedures that are commonly done by general urologists and trainees as a whole and was broken down by procedure type.

There are other benefits to having trainees involved in patient care. U.S News and World Reports explains that academic hospitals are on the forefront of medical research and can provide specialized care for rare or less common diseases and procedures.[27] A study using a survey to assess patient perceptions of general surgery residents found that the patients felt they received more attention due to the resident involvement.[28] Additionally, residency training is necessary if we want doctors for the future and hands on experience is a key part of surgical residency.

This study, and others on the topic are essential to highlight areas for improvement in patient care. While it has always been clear that trainees are essential to the future of medicine, relatively recently there has been a shift to focus on patient outcomes as well. The Accreditation Council for Graduate Medical Education (ACGME) has highlighted the focus on patient outcomes. In 2012, the ACGME implemented the Clinical Learning Environment Review Program which includes a focus on patient safety, health care quality, and supervision.[29]

Additionally, the ACGME implemented a new accreditation system for Urology in 2013. Our data captures the patient experience leading up to these changes (2005-2013) and it will be interesting to assess the impact of these interventions. As simulators and virtual reality become more developed, it will be interesting to assess the impact that this has on surgical training and patient outcomes as well. The individual procedures that showed increased complication rate with resident involvement were all open. That is interesting, as laparoscopy and robotic skills are something that can be practiced significantly in the simulation labs and on the laparoscopic trainer or robotic console.

Limitations of our study include that it is from a database that only includes 30-day perioperative information. Additionally, it would be beneficial if we had more information about the patient's socioeconomic status and other potential confounding variables. To address the

concern that cases done at academic hospitals may be more complicated we excluded cases that had greater potential for a range of complexity such as partial nephrectomy and TURBT. However, there could still be differences in complexity within the cases we selected. Strengths of our study include the range of fundamental general urology procedures included, the large number of cases from a diverse group of institutions, and the relatively long duration of data from 9 years.

CONCLUSION

While trainees are valuable members of the urology team at teaching hospitals and training is necessary, their involvement in urologic surgery appears to increase operative time in all procedures and complications in select operations. Further research needs to be done on how to mitigate these effects while preserving surgical education quality.

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EDITORIAL COMMENT

This is a survey of almost 30,000 general urology procedures, half with and half without trainee involvement. Of note, the trainee groups were not stratified by level of training, and included both residents and fellows. Despite patients in the trainee group being "healthier", this group had longer operative times and a higher risk of complications. The reasons for these findings are not clear, but obviously important.

Given the ongoing financial pressures on physicians for "more with less", these findings make me curious about how many of these cases were performed with overlapping surgeries. Most fellowships are funded by the individual hospital or department, putting pressure on attending staff physicians to generate revenues to support this. The practice of "running two rooms" generally occurs in teaching hospitals, where the attending surgeon delegates trainees to perform parts of one surgery, while (s)he works on a second patient in another operating room. Medicare permits this practice as long as the surgeon is present during the "critical portion" of each operation, but does this practice in part explain the findings of this study? A recent JAMA article looking at overlapping surgery in patients undergoing hip operations found that this practice was associated with an increased risk of surgical complications, and the duration of surgical overlap was associated with an increased risk for complications.[1] Other studies have not identified this risk for overlapping surgeries.[2]

If trainee involvement truly is negatively impacting patient outcomes, it would behoove us to identify barriers to trainees seeking attending physician guidance. There has been a renewed interest in this as physician burnout has become a more prominent interest. A survey of general surgery trainees found that 47% reported having been bullied to some degree and 68% reported having witnessed bullying of surgical colleagues in the last 12 months. Surgeons themselves were the most common source of bullying, but only 18% of trainees made a formal complaint.[3] Similarly, in a an analysis of surgeons responses to colleague harassment in the operating room, 30% of respondents reported that they would not voice their concerns out of fear.[4] Surgical specialties are by nature hierarchical, but we need to cultivate a culture in the operating room where intervention and the raising of concerns is both allowed and respected.

It is important that we train our future urologists, but not at the expense of patient outcomes. The next, critically important step is to identify why this discrepancy was found, so that we can focus our efforts on optimizing the balance between urology trainee learning and patient outcomes.

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EDITORIAL COMMENT

The authors compared the operative time and 30-day complication rate of over 30,000 general urologic procedures performed at academic and community hospitals using the NSQIP database with and without trainee involvement. They found that for general urology procedures, resident involvement was correlated with longer operative time as expected, but also surprisingly an increased rate of 30-day complications which was not explained by a sicker patient population; in fact, the patients with no trainee involvement had a higher rate of medical comorbidities. Notable factors that could not be analyzed were year of resident training and socioeconomic status of the patients as social determinants of health outcomes are powerful factors that influence access, healthcare delivery and outcome.

The topic is of interest and importance to academic urology, residency training programs, hospital administrators and patients. Although the ideal study design to isolate the effect of trainees involved in surgical care would be to compare the same surgeon at the same institution performing a procedure both with and without a trainee, the feasibly of this is limited and the authors do an admirable analysis of a large volume database of bread and butter general urologic procedures.

As educators we recognize the necessity of the experiential training gained during residency as the hallmark of our professional development to independent practice. Indeed, we have arrived at our own status as experts by going thru the same process we use to train the future generation of urologists. Inherent in this residency process is the tension of involving novice, competent, and subsequently proficient trainees in patient care and providing them with enough opportunity for graduated responsibility. The central mission of the ACGME is to improve health care and population health by assessing and advancing the quality of resident physicians' education thru accreditation.[1] The ACGME's current philosophy is to seek to improve health and healthcare as an outcome of the training process itself. In this context, the findings of these researchers are more startling.

However, the delivery of urologic care at academic centers and especially at safety net hospitals depends trainee involvement. These results should lead us to double down on thoughtfully engaging residents in quality improvement and patient safety and ensure systems-based practice is emphasized under the milestone competencies. Shifting learning curves by utilizing simulation can better prepare trainees but there is simply no substitute for mastering clinical medicine than patient care and shoulder to shoulder operative teaching at the OR table by an expert surgeon. To this end as surgeons and educators we have to recognize that surgery is a *team sport* and while the surgeon might make significant clinical decisions and execute the

[1] *Accreditation Council for Graduate Medical Education*. *http://www.acgme.org/About-US/Overview*; *Accessed 2 July 2018*.

technical procedure, the entire perioperative team and institution all influence the patient's outcome. Education and training of the next generation of urologists in maximizing quality improvement through interprofessional teamwork at the institutional level is just as important as operative teaching and might be key to a surgical success.

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