The "Rule of W" in Urology: Testing Surgical Dictum

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OBJECTIVE To evaluate the timing and frequency of postoperative occurrences as described in the "Rule of W" mnemonic for modern urologic and general surgical cases.

METHODS Using data from the American College of Surgeons National Surgical Quality Improvement Program, patients who underwent a urologic or general surgery procedure and developed a postoperative pneumonia (PNA), urinary tract infection (UTI), surgical site infection, venous thromboembolic event, or myocardial infarction (MI) were included. Frequency and median days to complication were compared.

RESULTS A total of 445,639 general surgery and 57,963 urology patients were included. Median time to occurrence differed between the cohorts for PNA, UTI, superficial infection, organ space infection, and MI. MI occurred earliest on POD3 for both groups ($P = .0438$). PNA occurred second on POD4 and POD5 for general surgery and urology, respectively ($P = .0034$). Venous thromboembolic events occurred third with PE occurring on POD8 for both cohorts ($P = .1225$) and deep venous thrombosis occurring on POD10 and POD11 ($P = .6879$) for general surgery and urology, respectively. Wound-related complications occurred at days 9-12 for general surgery and 11-13 for urology. The final sequence yielded waves, wind, walking, water/wound for general surgery and waves, wind, walking, wound, water for urology.

CONCLUSION A different chronology of postoperative events was found for urology patients than that described in the original mnemonic. UTIs and wound-related complications represent the most frequent morbidities for the urologic and general surgical patient, respectively. As patient demographics and practice patterns evolve, the "Rule of W", and other teaching tools, will need to be continually and critically reviewed. UROLOGY 130: 29−35, 2019. © 2019 Elsevier Inc.

For decades, the doctrine "wind, water, wound, and walking" has been engrained into the minds of medical trainees to commit the causes and patterns of postoperative fevers to memory. This "Rule of W" describes the etiology of postoperative fever to be due to: "wind," or pneumonia (PNA), on postoperative day (POD) 1-3; "water," or urinary tract infection (UTI), on POD 3-5; "wound," or surgical site infection (SSI), on POD 4-7; and "walking," or a venous thromboembolic event (VTE), on POD 7-10.[1] Subsequent iterations of the mnemonic included "wonder drugs" or fevers secondary to medication, as well as "waves" referring to EKG changes or cardiac events as a postoperative complication.[2]

The purpose of this mnemonic is no different than any other in medical education in that it serves to simplify a complex issue such as postoperative fever into a quick, easy-to-recall phrase. This memory aid ultimately serves to create a differential diagnosis and assist with patient care. However, the concern with mnemonics is that their scientific backing is often lacking and their use can be propagated without evidence-based support. Recent studies have questioned both this mnemonic's relevance in present day general surgical cases as well as the timing of events; the results have been conflicting.[2,3]

From our literature review, the relevance of the "Rule of W" as it pertains to postoperative fever or complications in urology has not been addressed. Given the breadth of surgical techniques in present day urologic cases — encompassing endoscopic, laparoscopic, open, and robotic techniques with varying surgical times — it is reasonable to suspect that the timing of urologic postoperative complications may differ from the original description of the mnemonic. Likewise, the landscape of general surgery cases has also evolved since the mnemonic's origin. It remains unclear what differences in postoperative complications, if any, are found between urology and general surgery cases and if the mnemonic can be broadly applied to all postoperative patients regardless of the surgical field.

With the addition of categorical urology interns, it behooves us to critically assess this mnemonic as it pertains to urologic cases to ensure we are appropriately educating future urologists and house staff. For these reasons, we seek to evaluate the timing and frequency of postoperative

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Submitted: October 16, 2018, accepted (with revisions): January 30, 2019

https://doi.org/10.1016/j.urology.2019.01.074
0090-4295

morbidity relative to the "Rule of W," for both urologic and general surgical cases in the modern environment.

We hypothesize that the timing and frequency of postoperative occurrences relative to the "Rule of W" would differ between the 2 specialties. Specifically, we expect no differences in VTE, PNA, and MI and increased UTI risk in urologic patients and increased wound infection risk in general surgery patients.

MATERIALS AND METHODS

We conducted a retrospective cohort study using the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) Participant Use File for 2016.[4] NSQIP is a data registry developed by the ACS using standardized definitions of perioperative occurrences with trained personnel to collect these data during the initial 30-day postoperative window.[5] This database has been well validated and is felt to be thorough as evidenced by declines in complication rates in participating hospitals.[6] The current study was evaluated and determined to be exempt from review by the Institutional Review Board at Naval Medical Center San Diego. All patients from NSQIP participating sites who underwent a general surgery or urologic procedure in 2016 were included in this study. Patients were excluded if their operation was classified under cardiac surgery, gynecology, interventional radiology, neurosurgery, orthopedics, otolaryngology, plastic surgery, thoracic surgery, and vascular surgery. Table 1 lists the most common Current Procedural Terminology (CPT) codes for included urology and general surgery procedures.

The postoperative outcomes analyzed were determined based on the "Rule of W" dictum and included the following: PNA ("wind"), UTI ("water"), SSI ("wound"), VTE ("walking"), and myocardial infarction (MI, "waves"). SSI was further categorized as superficial infection, deep infection, organ space infection, and wound dehiscence. VTE included both deep venous thrombosis (DVT) and pulmonary embolus (PE). All of these outcomes were defined in accordance with the ACS NSQIP protocol.[4] Unlike the original mnemonic, the presence of fever and atelectasis were not examined as this information was not available in the NSQIP database.

Descriptive statistics were used to characterize the cohort. Preoperative risk factors, as defined by the ACS surgical risk calculator, were compared between the general surgery and urology patients. This was done using the chi-square test for categorical variables and a 2-sample t test for continuous variables. Similarly, frequencies of complications were compared using the chi-square test, and days to complications were compared using the 2-sample t test. Kaplan-Meier failure curves were generated for each of the "Rule of W" outcomes. Differences in these curves were analyzed using the log-rank test. Statistical significance was established at $\alpha \leq 0.05$. Statistical analysis was performed with STATA 12 (StataCorp LP, College Station, TX).

RESULTS

This study included 503,602 patients in total. Of these, 445,639 (88.5%) underwent a general surgery procedure and 57,963 (11.5%) underwent a urology procedure. Patient demographic and clinical characteristics are presented in Supplementary Table 1. Significant differences were found in every category

Table 1. CPT codes for most common general surgery and urology procedures

Procedure	CPT Code	Percent
General surgery		
Hernioplasty, herniorrhaphy, herniotomy procedures	49505, 49585, 49560, 49561, 49587	12.97
Laparoscopic procedures biliary tract	47562, 47563	12.77
Laparoscopic procedures on the Appendix	44970	9.28
Laparoscopic excision procedures on the intestines (except rectum)	44204, 44207, 44205	6.13
Excision procedures on the intestines (except rectum)	44140, 44120, 44160, 44143, 44145	6.04
Mastectomy	19301, 19303	5.57
Laparoscopic bariatric surgery procedures	43775	3.94
Hernia laparoscopic procedures	49650	2.63
Excision procedures on the breast	19125, 19120	2.59
Laparoscopic procedures on the stomach	43644	1.86
Hernia laparoscopic procedures	49652	1.31
Excision procedures on the thyroid gland	60240	1.23
Excision procedures on the parathyroid, thymus, adrenal glands, pancreas, and carotid body	60500	1.00
Other		32.68
Urology		
Vesical neck and prostate procedures	52601, 52648	17.69
Laparoscopic prostate procedures	55866	14.67
Urethra and bladder transurethral surgical procedures	52234, 52235, 52240	13.84
Laparoscopic procedures on the kidney	50543, 50545, 50546	12.2
Repair procedures on the vagina	57288	2.86
Excision procedures on the bladder	51595	2.38
Excision procedures on the tunica vaginalis	55040	2.23
Excision procedures on the kidney	50240	2.13
Other		32.0

Table 2. Time to postoperative occurrences over 30 days

	Median (IQR) Days to Occurrence		
	General Surgery	Urology	P*
PNA	4 (2,9)	5 (2,11)	.0034
UTI	10 (5,18)	14 (8,21)	.0001
Superficial infection	12 (7,18)	13 (8,20)	.0017
Deep infection	11 (6,18)	12 (8,19)	.1994
Organ space	9 (6,16)	13 (8,20)	.0001
Wound dehiscence	11 (7,17)	11 (7,16)	.1973
PE	8 (4,16)	8 (4,18)	.1225
DVT	10 (5,17)	11 (6,17)	.6819
MI	3 (1,7)	3 (1,10)	.0438

* Two sample *t* test.

apart from a history of disseminated cancer, dyspnea, and acute renal failure.

The median time to presentation for each occurrence was calculated to assess chronological patterns (Table 2). Myocardial infarction occurred earliest at median day of POD 3 for both groups (*P* = .0438). PNA occurred second on POD 4 and POD 5 for general surgery and urology, respectively (*P* = .0034). VTEs presented third in sequence, with PE found on POD 8 for both cohorts (*P* = .1225) and DVT identified on POD 10 and POD 11 (*P* = .6879) for general surgery and urology, respectively. Wound-related infections included superficial, deep, organ space, and wound dehiscence and occurred at median days 12, 11, 9, and 11 for general surgery and 13, 12, 13 and 11 for urology (*P* = .0017, *P* = .1994, *P* = .0001, and *P* = .1973). UTIs occurred as a later complication at median day POD 10 for general surgery and POD 14 for urology (*P* = .0001). For general surgery patients, the final sequence based on median day to occurrence yielded waves – wind – walking – water/wound. The order for urology patients was waves – wind – walking – wound – water.

The frequency of postoperative occurrences within 30 days of surgery is depicted in Table 3. The overall cumulative complication rates (# of occurrences/# of patients) for general surgery and urology procedures were 8.64% and 7.36%, respectively. Significantly increased rates of PNA (1.43% vs 0.72%, *P* <.0001) and wound-related complications were seen in the general surgery group (1.92% vs 0.84%, 0.48% vs 0.19%, 2.23% vs 0.86%, 0.43% vs 0.28%, all with *P* <.001 for superficial infection, deep infection, organ space infection, and wound dehiscence, respectively). The urology group had a significantly increased rate of UTIs (3.15% vs 0.98%, *P* <.001) and PE (0.41% vs 0.29%, *P* <.001) compared to the general surgery cohort. No differences were found for rates of DVT and MI between the groups. Additionally, Kaplan-Meier failure curves were constructed for each of the complication categories – the W's (Supplementary Figures 1-5). There was no difference in MI or VTE between groups (*P* = .5252 and *P* = .1354, respectively). However, differences were noted for PNA, UTI, and SSI (all with *P* <.0001).

The daily incidence for each complication in the urology cohort was estimated for each POD (Fig. 1). Myocardial infarction was the most common complication on POD 1 and decreased sharply thereafter accounting for <10% daily complications after POD 3. The incidence of PNA peaked on POD 1-3. UTI had the highest daily incidence from POD 4-30. Wound-related complications remained relatively stable, and occurred second in incidence after UTI on POD 4-30. The daily risk of VTE remained low, but stable throughout the 30 days postoperatively and was never the most likely event to occur.

DISCUSSION

This was a retrospective study using data from over 500,000 patients enrolled in the NSQIP database to assess the sequence and frequency of postoperative complications described in the "Rule of W" for both urology and general surgery cases in a single year (2016). The time order of postoperative occurrences in this study differed both from the original version of the mnemonic, as well as between the 2 cohorts. MI and PNA were the first to present and occurred within the first week for both cohorts. UTIs, VTEs, and SSIs occurred at similar times within the second week for general surgery patients. Urologic VTEs occurred during the second week at a time similar to the general surgery cohort; however, SSIs and UTIs occurred later in the second postoperative week compared to the general surgery cohort. Compared to the original chronologic description, the most notable difference in this study's "Rule of W" is the much later presentation of UTIs for both cohorts.

UTIs occurred most frequently within the urology cohort whereas wound infections predominated in the general surgery cohort. Operations involving urinary tract manipulation and postoperative catheterization accounted for the majority of urology cases (Table 1). A cumulative risk of bacteriuria with each catheter day, and overall risk

Table 3. Frequency of postoperative occurrences at 30 days

	% Occurrences (Number)		
	General Surgery *n* = 445,639	Urology *n* = 57,963	P*
PNA	1.43% (6,378)	0.72% (416)	<.001
UTI	0.98% (4,370)	3.15% (1,824)	<.001
Superficial infection	1.92% (8,571)	0.84% (486)	<.001
Deep infection	0.48% (2,148)	0.19% (109)	<.001
Organ space	2.23% (9,943)	0.86% (499)	<.001
Wound dehiscence	0.43% (1902)	0.28% (165)	<.001
PE	0.29% (1,310)	0.41% (237)	<.001
DVT	0.56% (2,516)	0.56% (326)	.948
MI	0.32% (1,430)	0.35% (205)	.192

* Chi-square test.

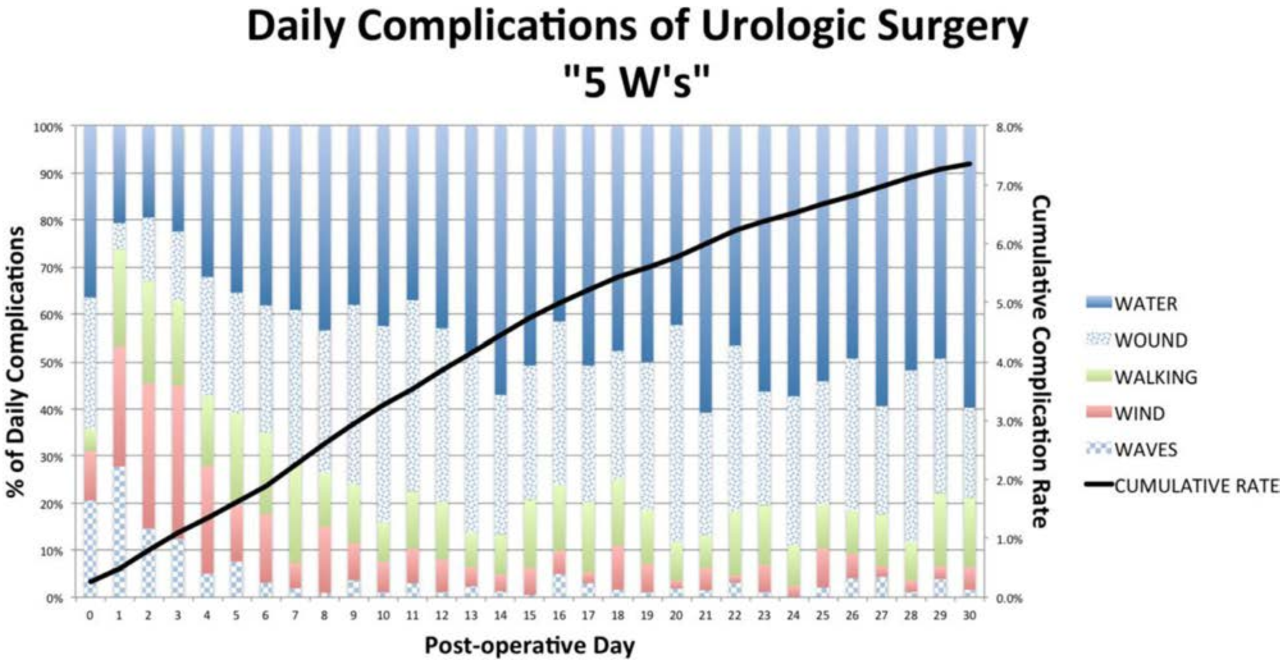

Figure 1. Daily incidence of index postoperative complications over 30 days. (Color version available online.)

of UTI after catheter removal, has been reported up to 25%.[7] Furthermore, 85% of urology cases were class II wounds (Supplementary Table 1) reflecting the inherent risk of UTI in these patients. Similar to data presented here, previous reports of urologic postoperative complications using NSQIP data also show UTIs to be the most frequent complication.[8,9] In a similar way, common surgical procedures and wound classes corresponded to the increased wound infection risk with the general surgery patients. Approximately 20% of their procedures involved bowel manipulation (Table 1), which itself carries an intrinsic risk for gross spillage, and 20% of their wounds were contaminated or dirty (Supplementary Table 1). These results are intuitive knowing the procedures and wound classes most common to each specialty.

PEs occurred infrequently, accounting for <1% of postoperative occurrences for both cohorts; however, a significant increase was found within the urology cohort. No differences in DVT or overall VTE frequency were noted between the groups. An explanation for these findings is not entirely clear. Both the American Urological Association and ACS follow the American College of Chest Physicians guidelines for current perioperative VTE risk prevention; therefore, differences in the approach to VTE prevention does not appear to be a contributing factor to differences reported here.[10] Furthermore, the general surgery patients presented here were more likely to have risk factors for VTE including sepsis, end-stage renal disease (ESRD), immobility, emergent surgery, and steroid use (Supplementary Table 1).[11] Strong clinical conclusions regarding differences in rate of VTE among urology and general surgery patients cannot be made. Further investigation is warranted.

In addition to looking at the 5 W's chronology and 30-day frequency, and perhaps more importantly, we compared the daily relative frequency of events for urology cases. UTIs occurred most frequently on almost all days in the urology cohort during the 30-day postoperative period, likely for reasons as previously discussed (Fig. 1). PNA and MI were more likely to occur in the immediate PODs and steadily decreased thereafter. This contrasted with the incidence of wound and VTE complications, which remained fairly stable throughout the entire postoperative course. The sustained risk of postoperative VTE found here has been previously demonstrated in the CANBESURE trial which, along with several meta-analyses, supports the extended use of VTE chemoprophylaxis for abdominal and pelvic cancer surgery.[12-15]

The validity of this mnemonic has been previously challenged. Sonnenberg et al evaluated the sequence of occurrences by median day to presentation before and after hospital discharge in a cohort of general surgery patients. Distinct from the original iteration of the W's, their results showed VTEs preceding wound-related complications for their inpatient cohort with no discernable pattern for the complications found upon discharge. However, even when differences were found, a wide interquartile range for the events was seen indicating overlap in timing of the occurrences. They suggested the mnemonic be revised to "wind, water, walk, and wound" and only be applied to patients prior to discharge.[3]

A later study also challenged the "Rule of W" in general surgery and vascular surgery patients by assessing the relative frequency of events in the initial 30 days postoperatively.[2] MI was the most common complication on POD 0, PNA most common on POD1-2, UTI and PNA equally most common on POD 3, and wound-related complications most common thereafter. Their final sequence based on frequency corroborated the original dictum with the addition of cardiac changes — waves, wind, water, wound, and walking. Like our urology cohort, the overall incidence of postoperative VTE was low, never accounted for the most common complication, but had a sustained risk in the weeks following surgery. In contrast, however, UTI was never the single most common complication for their general surgery cohort. Instead, like our general surgery cohort, wound infections predominated.

Conclusions can be drawn from the studies above taken with the data presented here. First, unique sequences for the W's were found within each general surgery cohort, which further contrasted with a urology cohort, therefore highlighting the limitations of the "Rule of W" and its generalizability. Second, general surgery patients suffered more from wound-related infections whereas urology patients were at greatest risk for UTI, further elucidating the different postoperative risk profile of these patients. Lastly, both Hyder's study and the current study demonstrate a sustained risk of DVT, which should serve to caution providers to remain vigilant for signs and symptoms of VTE throughout the entire 30-day postoperative course.

There are some limitations of the data in this study. First, the retrospective analysis inherent in NSQIP studies must be considered. NSQIP event reporting is done by personnel outside the treating team and is therefore vulnerable to diagnosis bias. It is also retrospective, and is thus subject to a number of other potential well-described biases. However, the use of standardized definitions for postoperative occurrences helps to mitigate these vulnerabilities. In addition, the urologic patients accounted for only 11% of the patients in this study which could make drawing significant clinical differences in postoperative complications difficult. This discrepancy in urology patients reflects the national urologic participation in the NSQIP database. The NSQIP database was originally intended to track general surgery and vascular surgery postoperative complications; however some, but not all, participating sites have started to sample surgical subspecialty cases. Furthermore, not all urologic procedures are sampled in NSQIP creating another potential limitation. For example, ureteroscopy with stone manipulation, one of the most common urologic procedures performed, is not included in NSQIP.

Several clinical and demographic differences were noted between the general surgery and urology groups. These differences could, and do, clearly contribute to the differences in postoperative events that were identified. However, this also highlights the fact that patient comorbidities vary among the surgical subspecialties, so it is reasonable and expected that these patients have varying postoperative courses. Indeed, that is why we undertook this study. Simply put, urology patients are not general surgery patients and urology procedures are not general surgical procedures. It is likely that patterns and frequencies of postoperative complications will vary based on surgical specialties, each having inherently different patient populations and procedures performed. Our expectations for the frequency and chronology of the postoperative morbidities analyzed in this study must therefore be different for different specialties. Clinicians and medical trainees must also understand that the pattern of postoperative events given in the mnemonic does not reflect the most likely diagnosis on any given POD, but rather the generalized sequence based on median days to occurrence. Additionally, the studied complications do not represent an exhaustive list of postoperative morbidity, and it must be understood that a simple mnemonic cannot ever fully summarize the complexities of surgical management.

To our knowledge, this is the first study to specifically evaluate the "Rule of W" mnemonic as it pertains to a surgical subspecialty (in this case, urology). We also systematically studied both the frequency and time-ordered occurrence of common postoperative complications of urology patients. These data provide an understanding of the overall frequency and daily relative risk of postoperative complications within 30 days of surgery, and may be more useful to the clinician than the actual sequence of the W complications used in the mnemonic.

While memory aids and teaching tools are useful, these data confirm that they should also be evidence based. Our results run counter to the traditional teaching and add more granularity on the generalizations of the mnemonic. Caution must always be used with these mnemonics and a one-size-fits-all approach to study aids is not always appropriate or clinically supported. The differences in the postoperative course reflect the uniqueness of each individual subspecialty's patient population. The information provided can help to augment surgical education for residents and medical students alike, and it also provides more specific insight into the postoperative course for urology patients. With the changing face of the urology residency around the corner, we feel analysis of surgical mnemonics as they pertain to urologic surgery is pertinent and timely.

CONCLUSION

In conclusion, this is the first study to evaluate the "Rule of W" as it pertains to the modern surgical environment within urology. Our findings depict a different chronology of postoperative events than described in the original mnemonic. More importantly, however, this study provides an understanding of the overall frequency and daily relative risk of postoperative complications within 30 days of surgery. It should be recognized that UTIs represent the most frequent and predictable daily complication outside of the initial few days after urologic surgery. As patient demographics and practice patterns evolve, the "Rule of W", and other teaching tools, will need to be continually and critically reviewed.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2019.01.074.

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EDITORIAL COMMENT

The National Surgery Quality Improvement Program (NSQIP), which began in the Veterans Affairs' hospital in 1991, was "the first national, validated, outcome-based, risk-adjusted, and peer-controlled" database for use in measuring and enhancing surgical quality.[1] The NSQIP was subsequently adopted by the private sector given the potential for the availability of widespread outcomes data to be used for quality improvement.[2] In this thoughtful manuscript, Dr. Rocco et al use the NSQIP database to examine "The Rule of "W" in Urology," a rule-concerning temporal association of postoperative complications. The authors are to be commended for challenging surgical dictum and dogma through proper study rigor by comparing 30-day morbidity in 60,000 urology patients with 450,000 general surgery patients. A thoughtful description of the complications, not only from a rate perspective, but also from a time perspective is given. The data provide insight on proper differential diagnosis in evaluation of postoperative patient issues during and beyond the hospital encounter. Additionally, the data also show "a one-size-fits-all" approach to postsurgical patients is inappropriate as the timing and frequency of complications differed between the 2 groups. This manuscript is meaningful for, not only attending academic physicians and private practitioners, but also for residents or other providers seeing these patients in the postoperative setting.

Furthermore, complications are profoundly expensive with estimates of $6,000,000 annually for academic institutions.[3] Moreover, complications in Partial Nephrectomy, a NSQIP-included procedure, were found to increase cost by $3700 per case with certain morbidities increasing cost by over $30,000.[4] Complications decrease value from both the cost and outcomes perspectives. As we continue to move toward value-based reimbursement, the effect of complications on value will only become more apparent. Proper and timely identification of complications have the potential to mitigate associated decrease in value, and likely represents an appropriate quality improvement focus.

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https://doi.org/10.1016/j.urology.2019.01.075
UROLOGY 130: 34, 2019.

AUTHOR REPLY

The authors wholeheartedly agree with the comments from Dr. Harris. Several national scale outcomes-based programs, NSQIP being one among them, are in place to allow us to perform more robust analysis into the risk factors for morbidity in our patients. Use of these statistically validated, multi-institutional models will help to advance urology and improve the overall quality of the care we provide.

Additionally, the Accreditation Council for Graduate Medical Education has identified health care quality as one of its focus areas within the clinical learning environment (CLE).[1] Within this focus area (and one of the overarching goals of our urology residency programs) is the aim of advancing residents from the learning stage of awareness, to knowledge, to demonstrated competency in the area of quality improvement. Data systems such as NSQIP can be leveraged to teach residents how to utilize data directly from their patients to improve the quality of the health care they provide. In this study, our group was also able to use this information to challenge traditional surgical educational paradigms and, hopefully, improve the quality of our resident and medical student education as well.

Matthew Christman, Department of Urology, Naval Medical Center San Diego, San Diego, CA

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https://doi.org/10.1016/j.urology.2019.01.076
UROLOGY 130: 34−35, 2019.