EUROPEAN UROLOGY 75 (2019) 628–634

available at www.sciencedirect.com
journal homepage: www.europeanurology.com

European Association of Urology

Platinum Priority – Statistics in Urology

Editorial by Phil Pierorazio and Scott Eggener on pp. 635–636 of this issue

Variability in Partial Nephrectomy Outcomes: Does Your Surgeon Matter?

Julien Dagenais [a], ***Riccardo Bertolo*** [a], ***Juan Garisto*** [a], ***Matthew J. Maurice*** [a], ***Pascal Mouracade*** [a], ***Onder Kara*** [a], ***Jaya Chavali*** [a], ***Jianbo Li*** [b], ***Ryan Nelson*** [a], ***Amr Fergany*** [a], ***Robert Abouassaly*** [a], ***Jihad H. Kaouk*** [a,*]

[a] *Glickman Urological and Kidney Institute, Cleveland Clinic, Cleveland, OH, USA;* [b] *Quantitative Health Sciences, Cleveland Clinic, Cleveland, OH, USA*

Article info

Article history:
Accepted October 19, 2018

Associate Editor:
Giacomo Novara

Keywords:
Nephron sparing
Partial nephrectomy
Renal neoplasm
Outcomes
Surgeon
Complications

Abstract

Background: Understanding physician-level discrepancies is increasingly a target of US healthcare reform for the delivery of quality-focused patient care.
Objective: To estimate the relative contributions of patient and surgeon characteristics to the variability in key outcomes after partial nephrectomy (PN).
Design, setting, and participants: Retrospective review of 1461 patients undergoing PN performed by 19 surgeons between 2011 and 2016 at a tertiary care referral center.
Intervention: PN for a renal mass.
Outcomes measurements and statistical analysis: Hierarchical linear and logistic regression models were built to determine the percentage variability contributed by fixed patient and surgeon factors on peri- and postoperative outcomes. Residual between- and within-surgeon variability was calculated while adjusting for fixed factors.
Results and limitations: On null hierarchical models, there was significant between-surgeon variability in operative time, estimated blood loss (EBL), ischemia time, excisional volume loss, length of stay, positive margins, Clavien complications, and 30-d readmission rate (all $p < 0.001$), but not chronic kidney disease upstaging ($p = 0.47$) or percentage preservation of glomerular filtration rate ($p = 0.49$). Patient factors explained 82% of the variability in excisional volume loss and 0–32% of the variability in the remainder of outcomes. Quantifiable surgeon factors explained modest amounts (10–40%) of variability in intraoperative outcomes, and noteworthy amounts of variability (90–100%) in margin rates and patient morbidity outcomes. Immeasurable surgeon factors explained the residual variability in operative time (27%), EBL (6%), and ischemia time (31%).
Conclusions: There is significant between-surgeon variability in outcomes after PN, even after adjusting for patient characteristics. While renal functional outcomes are consistent across surgeons, measured and unmeasured surgeon factors account for 18–100% of variability of the remaining peri- and postoperative variables. With the increasing utilization of value-based medicine, this has important implications for the goal of optimizing patient care.
Patient summary: We reviewed our institutional database on partial nephrectomy performed for renal cancer. We found significant variability between surgeons for key outcomes after the intervention, even after adjusting for patient characteristics.

* Corresponding author. Glickman Urological and Kidney Institute, Cleveland Clinic Foundation, 9500 Euclid Ave, Cleveland, OH 44195, USA. Tel. +1 216 4442976.
E-mail address: kaoukj@ccf.org (J.H. Kaouk).

https://doi.org/10.1016/j.eururo.2018.10.046
0302-2838/

1. Introduction

The aim in partial nephrectomy (PN) is to balance oncologic effectiveness with renal functional optimization and limited perioperative morbidity [1]. This requires careful operative planning, a refined technique, and thoughtful intraoperative decision-making to accomplish all three endpoints. While it has been well documented that a variety of patient [2] and tumor [3] characteristics influence both functional and oncologic goals, the complexities of the procedure mean that PN is prone to between-surgeon differences in outcomes. At present, a variety of approaches remain acceptable according to various national and international guideline panels [4,5].

Prior studies have attempted to address aspects underlying surgeon differences by examining surgeon approach [6], the learning curve [7,8], fellowship training [9,10], and surgeon volume [11,12], including within urology [13–16]. However, many of these studies have relied on single-surgeon series or looked at a single surgeon attribute in isolation, but failed to account for case mix or the individual surgeon, which may have a profound influence on the interpretation of any findings. As has been shown for radical prostatectomy, there can be substantial variation in patient outcomes, even among high-volume surgeons [17].

The composite influence of all measured and unmeasured surgeon factors may generate significant variability in how a given surgeon responds to a given patient and a given tumor, and this may in turn lead to differences in outcomes. Understanding such physician-level discrepancies is increasingly a target of US health care reform for the delivery of quality-focused patient care [18]. Hierarchical models can allow isolation of measured and unmeasured surgeon factors that influence the outcome in question, while adjusting for all measurable patient factors of relevance. However, to the best of our knowledge, no such study has been performed to assess the independent influence of the surgeon on key perioperative outcomes after PN. We thus reviewed 6 yr of data for 19 surgeons at our high-volume tertiary care referral center to determine the percentage variability contributed by surgeon factors to key outcomes after PN.

2. Patients and methods

All patients undergoing robotic or open PN for renal cell carcinoma at our institution had clinical and pathological features entered into our computerized database approved by the institutional review board. Records for consecutive patients who underwent surgery between 2011 and 2016 at three hospitals affiliated with our tertiary care center were reviewed. Patients with a solitary kidney and patients who received neoadjuvant therapy were excluded. Nineteen deidentified surgeons with case volumes that exceeded two PNs per year were included [16]. Our robotic [19] and open [20] techniques for PN have previously been described.

During PN, goals include balancing oncologic and functional outcomes while limiting perioperative complications and operative time [1]. Thus, the following outcomes were studied: operative time, estimated blood loss (EBL), ischemia time, excisional volume loss (EVL), length of stay (LOS), glomerular filtration rate (GFR) preservation (GFR at 3–12 mo/preoperative GFR, expressed as %), positive margins, chronic kidney disease (CKD) upstaging, any Clavien grade complications, and 30-d readmission. EVL was calculated using existing pathologic measurements as the difference between specimen and tumor volume, which amounts to the rim of healthy excised parenchyma [21]. On the basis of prestudy hypotheses, we anticipated significant differences in these outcomes between surgeons. A preliminary analysis was performed to graphically assess whether any surgeon-specific differences existed in these outcomes after accounting for patient variables. We began by running a standard multivariate linear or logistic regression for each outcome, collapsed across all surgeons. Predicted values for each outcome were determined, and then surgeon-specific curves were generated for assessment of departures from one another (between-surgeon variance; Vb) and from a surgeon's own expected values (within-surgeon variance; Vw). Given the appearance of clustering of patients within surgeons [22], multilevel hierarchical regression mixed models were used.

Prespecified outcomes were assumed to be influenced by a combination of measurable patient- and surgeon-level characteristics (fixed effects) and immeasurable random effects attributable to subtleties of the individual surgeon. The patient's clinicodemographic characteristics specific to a given regression model were chosen according to the existing literature and a priori hypotheses. The surgeon characteristics chosen for each model were consistent and included: approach (robotic vs open), annual PN volume (tertiles), fellowship training (yes/no), and whether they were past a learning curve ($\geq$25 cases in prior years) [8]. To account for the fact that absolute PN volumes were higher among robotic surgeons, surgeons were split into open and robotic groups and then into tertiles by annual case volume, creating six subdivisions. The high-, intermediate-, and low-volume open and robotic surgeons were then collapsed across approach. Surgeons qualified for fellowship training for robotic PN if they had completed a dedicated laparoscopy-robotics fellowship, and for open PN if they had completed a dedicated Society of Urologic Oncology or kidney transplant fellowship.

We first quantified the variance ascribed to surgeon-level effects using an empty hierarchical regression model. In each case, the log-likelihood of the hierarchical model was compared to its linear or logistic regression counterpart to estimate whether clustering was significant. Outcomes for which clustering was nonsignificant were included for the purposes of discussion. To quantify the extent of clustering, the intraclass correlation coefficient (ICC) was calculated as Vb/(Vb + Vw), expressed as a percentage, with higher numbers indicative of greater between-surgeon differences in the variance for that given outcome [23].

We subsequently generated linear predictors of the outcome in question using patient-level covariates followed by surgeon-level covariates. The relative increase or decrease in variance attributed to surgeon-level random effects (Vb) was then calculated to determine the influence of each parameter on the variation observed [24,25]. When Vb increased with the addition of patient-level covariates, Vb was set to the value for the null model to avoid negative percentages. This modeling technique allowed us to simultaneously determine the explanatory power of measurable patient and surgeon factors for the outcome, while assessing variance not explained by fixed factors that are the result of residual between-surgeon differences. The latter allows us to investigate whether patients presenting to a given surgeon have differing results, even after adjusting for covariates. Among the models that remained significant, best linear unbiased predictions (BLUPs) were calculated to estimate the surgeon-specific random effects in the final model and determine the surgeon-specific departures from the overall mean that remained.

The maximum likelihood estimator was used for hierarchical models. For each regression, the normality and homogeneity of variances were

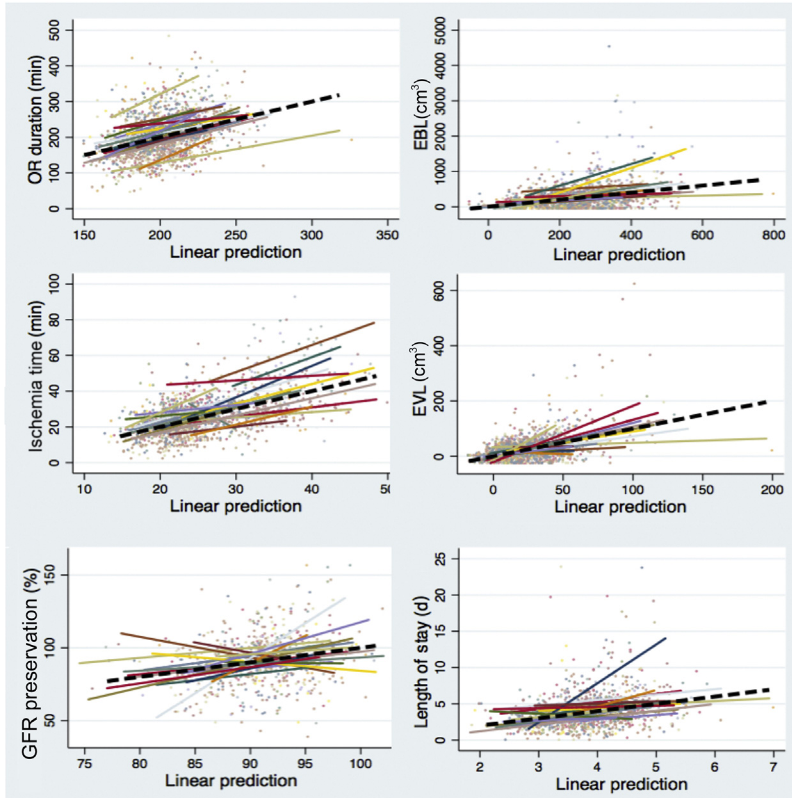

Fig. 1 – Observed versus predicted values for a given outcome of interest with a fitted line for each surgeon (colored lines) and the average regression for the group (black dashed line). Predicted values were determined using multivariate regressions that accounted for case mix, and covariates included: preoperative glomerular filtration rate (GFR), age, sex, race, body mass index, Charlson comorbidity index, maximum tumor diameter on imaging, and RENAL score. For the outcome of ischemia time, an additional binary covariate for warm versus cold ischemia was added. Differences in the slope and intercept between the surgeon-specific lines and the group line suggest between-surgeon variation. Differences between the surgeon-specific dots and fitted line suggest within-surgeon variation. OR = operating room; EBL = estimated blood loss; EVL = excisional volume loss.

examined using residual plots. Collinearity was also tested. All statistical testing was two-sided except where indicated, and $p < 0.05$ was considered statistically significant. Stata version 13 software (StataCorp, College Station, TX, USA) was used for all statistical analyses.

3. Results

Surgeon characteristics varied appreciably in terms of annual PN volumes (range 3.5–70.4) and years in practice (range 0–22; Supplementary Table 1). The majority were fellowship-trained (12/19) and past their learning curve (11/19). Eight of the 19 surgeons used robotics, while the other 11 used an open technique. Review of surgeon-specific outcomes revealed considerable between-surgeon and within-surgeon variation (Fig. 1), prompting mixed model analysis.

On null hierarchical models, there was significant between-surgeon variability in operative time, EBL, ischemia time, EVL, LOS, positive margins, Clavien complications, and 30-d readmission (all $p < 0.001$). Surgical site infections were the complications most likely to vary between surgeons (Pearson $\chi^2 = 108.7$; $p < 0.001$). There were no between-surgeon differences in GFR preservation or CKD upstaging (Table 1). Patient-level covariates were added to the subsequent model. Patient factors explained a small to moderate proportion of between-surgeon variability in EBL (17%), ischemia time (32%), LOS (10%), and 30-d readmission (10%), and a large proportion of between-surgeon variability in EVL (82%). Patient factors did not explain any of the between-surgeon variability for operative time, positive margins, or complications (Fig. 2). Between-surgeon variability for the models remained significant (Table 1).

Surgeon-level covariates were added to the subsequent model. They explained a small to moderate proportion of variance in operative time (20%), EBL (40%), ischemia time (10%), and EVL (18%), and a substantial proportion of the variance in LOS (90%), positive margins (100%), complications (100%), and 30-d readmission (90%; Fig. 2). Only operative time (27%), EBL (6%), and ischemia time (31%) had significant residual between-surgeon variance (Fig. 2 and Table 1). The residual variability by surgeon was plotted and is shown in Figure 3.

4. Discussion

An appreciation of the variability in outcomes after cancer surgery has become well established over the past few decades. In theory, variability may be explained by patient factors, surgeon factors, or some combination of the two.

Table 1 – Surgeon variability for intraoperative and postoperative outcomes

Model	Outcome			p value[d]
	V_b	V_w	ICC (%)	
Null model[a]				
Operative time (min)	1040	2810	27.1	<0.001*
Estimated blood loss (ml)	33 500	94 800	26.1	<0.001*
Ischemia time (min)	118	82.5	58.8	<0.001*
Excisional volume loss (cm^3)	47.3	1,700	2.70	0.004*
Length of stay (d)	0.890	4.67	16.0	<0.001*
GFR preservation (%)	0.063	287	0.00	0.49
Positive margins	0.326	3.29	9.01	0.001*
CKD upstaging	0.002	3.29	0.05	0.47
Clavien grade ≥1 complication	0.357	3.29	9.80	<0.001*
30-d readmission	0.752	3.29	14.7	<0.001*
Patient model[b]				
Operative time (min)	1450	2320	38.4	<0.001*
Estimated blood loss (ml)	27 900	86 700	24.4	<0.001*
Ischemia time (min)	80.2	61.3	56.7	<0.001*
Excisional volume loss (cm^3)	8.76	1300	0.70	0.08*
Length of stay (d)	0.797	4.32	15.6	<0.001*
GFR preservation (%)	0.024	270	0.00	0.46
Positive margins	0.369	3.29	10.1	<0.001*
CKD upstaging	0.003	3.29	0.10	0.46
Clavien grade ≥1 complications	0.364	3.29	9.96	0.001*
30-d readmission	0.713	3.29	13.4	<0.001*
Full model[c]				
Operative time (min)	1160	2320	33.4	<0.001*
Estimated blood loss (ml)	14 600	86 700	14.4	<0.001*
Ischemia time (min)	68.5	61.3	52.7	<0.001*
Excisional volume loss (cm^3)	0.00	1,300	0.00	1.00
Length of stay (d)	0.00	4.37	0.00	1.00
GFR preservation (%)	0.00	270	0.00	1.00
Positive margins	0.00	3.29	0.00	1.00
CKD upstaging	0.00	3.29	0.00	1.00
Clavien grade ≥1 complications	0.00	3.29	0.00	1.00
30-d readmission	0.00	3.29	0.00	1.00

CKD = chronic kidney disease; GFR = glomerular filtration rate; ICC = intraclass correlation coefficient ($V_b/[V_b + V_w]$) expressed as a percentage, with higher numbers indicating greater between-surgeon differences in the variance for a given outcome, and lower numbers indicating much greater within-surgeon variance; V_b = between-surgeon variance; V_w = within-surgeon variance ($\pi^2/3 = 3.29$ for logistic hierarchical models).

[a] The null model is the empty hierarchical regression model (no covariates).

[b] The patient model contains demographic (age, sex, race), clinical (body mass index, preoperative GFR, Charlson comorbidity index), and tumor characteristics (tumor size, RENAL score). The ischemia time model also include ischemia type (warm vs cold) and the positive margin model also includes tumor grade and stage.

[c] The full model contains all the aforementioned patient variables, as well as measured surgeon variables (approach, annual partial nephrectomy volume, learning curve, fellowship training).

[d] A p value ≤0.1 * (1 degree of freedom) indicates that the mixed effects model outperforms its linear or logistic regression comparator via testing of log-likelihoods.

Much of the research on this matter has focused on patient and tumor characteristics; however, a growing body of literature suggests that surgeon and hospital factors also play a major role in outcomes after oncologic surgery [11,12]. These types of analyses are of increasing importance in an era in which quality metrics and value-based health care delivery are being closely scrutinized.

PN is a sufficiently complex procedure that differences between surgeons may be anticipated. Unsurprisingly, we found significant variability in the vast majority of intraoperative and postoperative outcomes after PN. In fact, the only outcomes for which there were no baseline differences between surgeons were the functional outcomes of percentage GFR preservation and CKD upstaging. For these outcomes, variability was overwhelmingly within-surgeon rather than between-surgeons. Therefore, even though an average 20% reduction in kidney function in the operated kidney may be anticipated after PN [26], there is significant spread in that outcome within a given a surgeon, and this variability may be further subject to the inherent fluctuations in GFR measurements and the challenges in building models to reliably predict GFR changes after PN. Therefore, functional outcomes and some of their surrogates such as ischemia time and volume loss may not be valuable as endpoints for quality initiatives.

More profoundly, however, even after equilibrating the case mix across different surgeons by adjusting for patient and tumor characteristics, significant between-surgeon variability remained for a number of key outcomes, including operative time, EBL, ischemia time, EVL, LOS, positive margins, Clavien complications, and 30-d readmission. Furthermore, the introduction of patient factors did not reduce the between-surgeon variability in operative time, positive margin rates, and complications. Rather, for all the above outcomes, a very large proportion of between-surgeon differences could be explained by measurable surgeon factors. This demonstrates the significant composite role played by quantifiable measures of experience and technique that define a surgeon, including annual PN volume, fellowship, modular training, use of simulators, being on or past a learning curve, and open versus robotic approach.

The influence of certain of these factors on variability in outcomes after urologic surgery has previously been shown in isolation in a few key studies in the literature. Abouassaly et al. [16] used the Canadian Institute of Health Information database to investigate the role of surgeon volume in rates of PN use and associated complications, and showed that higher-volume surgeons performed PN more often and with lower complications. A systematic review of outcomes after radical prostatectomy also showed a strong volume-outcome relationship [27], which appears to be applicable across multiple surgeries within uro-oncology [15]. Prior studies on fellowship training [9] or surgical approach [6] in isolation showed that these factors also play a role in urologic outcomes.

However, a given surgeon is a product of not only these quantifiable factors but also attributes such as skill, technique, decision-making, fortitude, and any number of other factors that are harder to define [28]. Eastham et al. [17] published one of the rare studies investigating this phenomenon. They explored rates of positive margins after radical prostatectomy at two tertiary care referral centers and showed that not only surgeon volume but also the surgeon themselves was independently associated with the outcome in question.

For the outcomes of operative time, EBL, and ischemia time, we found an additional independent influence of unmeasured and more nuanced surgeon-specific factors.

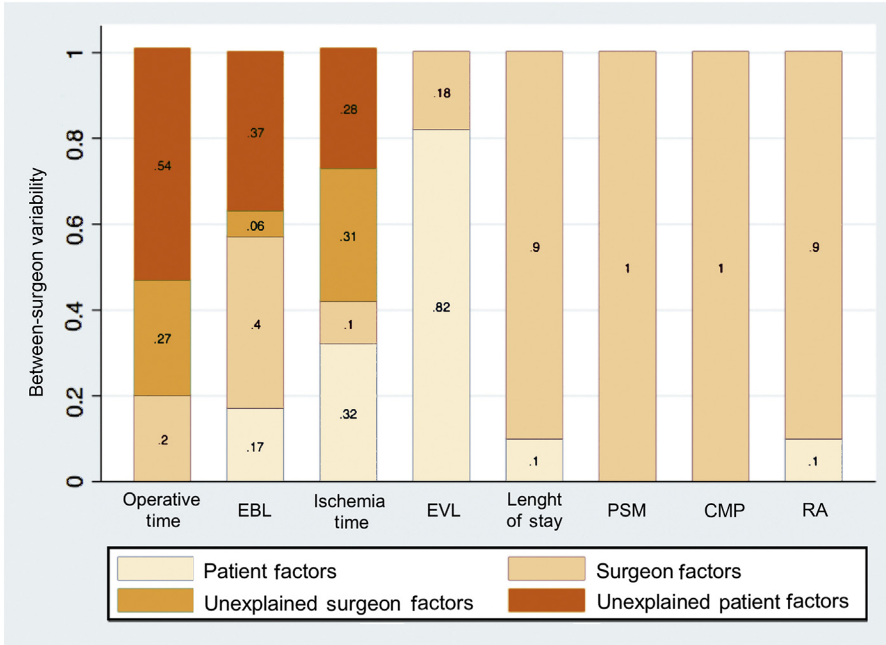

Fig. 2 – Variance partitioning for between-surgeon variability in partial nephrectomy outcomes. Patient and tumor characteristics, followed by surgeon characteristics, were compiled in aggregate using hierarchical linear and logistic regressions. The remaining variation is explained by other surgeon- or patient-level factors. CMP = complications; EBL = estimated blood loss; EVL = excisional volume loss; PSM = positive surgical margin; RA = readmission.

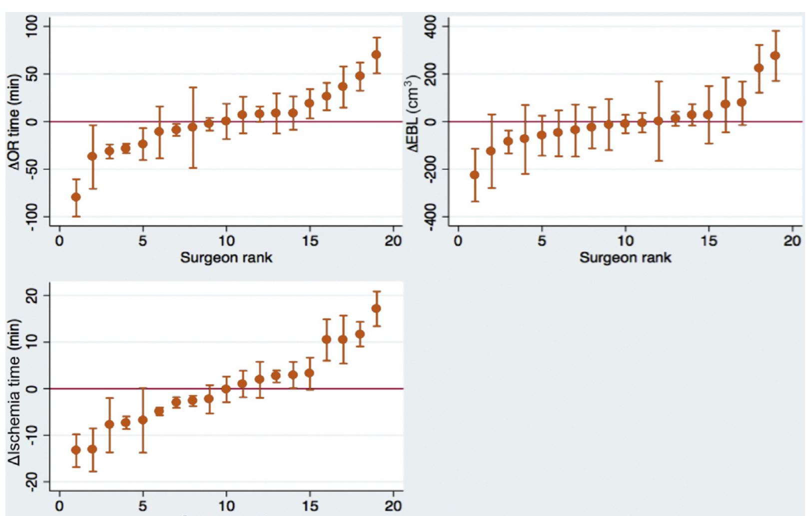

Fig. 3 – Best linear unbiased predictions: residual between-surgeon variation in outcomes. Residuals represent surgeon departures from the overall mean (set to 0) in the final model that controls for all measurable patient and surgeon factors. A surgeon whose confidence interval does not overlap the line at zero is said to differ significantly from the average at the 5% level. The deidentified surgeon ranking is from 1 to 19. The *p* value for all three outcomes is $<$0.001. EBL = estimated blood loss; OR = operating room.

These may reflect not just attributes of the surgeon; given that this is a teaching institution, differences in the levels of trainee involvement are also likely to play a role. Ruhotina et al. [29], for example, showed that resident involvement increased operative time but did not adversely affect other perioperative outcomes in minimally invasive urologic surgeries. Kern et al. [30], by contrast, showed that resident and fellow involvement increased both complications and bleeding in minimally invasive and open PN.

In summary, we discovered a profound influence of a given surgeon on key outcomes following PN. While prior studies investigating surgeon-level differences in oncologic outcomes largely relied on national databases [12,24,25], there can be significant shortcomings with this approach. We have the advantage of a much more granular data set with a broader range of quantifiable variables to account for case and surgeon mix and allow for a more controlled study of the additional influence of surgeon variability on patient outcomes. Furthermore, while ours is a high-volume tertiary care referral center with a full complement of very experienced urologists, surgeons in our institution with a lower volume or less experience are likely to reflect the practice patterns of those who perform PN less frequently in the community and elsewhere. Thus, we believe that the implications of our findings are likely to be transferrable to the nationwide level. The importance of subspecialization and both external and internal referral to surgeons with more experience and higher levels of training needs to be considered. However, even the less experienced surgeons at our institution probably have an advantage with regard to surgical expertise given that the majority had fellowship training. In addition, the more experienced surgeons could push the curve in the opposite direction, almost "forcing" variability when compared to less experienced surgeons, who could have an average skill set. Lastly, variability in surgeon outcomes exists, but everyone has to start somewhere. Undoubtedly, once out in practice, less experienced surgeons will improve; however, optimization of quantifiable attributes such as fellowship training, surgeon approach, and case volume is likely to minimize that variability.

From a different perspective, we acknowledge the constant surgical refinement of PN. Undoubtedly, an overwhelming within-surgeon rather than between-surgeon evolution exists for such a challenging procedure.

5. Conclusions

Variability in PN outcomes are profoundly and independently influenced by the surgeon, even at a high-volume tertiary care referral center. Quantifiable measures of surgeon experience, training, and approach explained a very large proportion of the variability in key peri- and postoperative outcomes, with the exception of renal functional changes. Nuanced differences attributable to the surgeon continued to explain differences in operative time, estimated blood loss, and ischemia time. Taken together, these results highlight major opportunities for improvement in PN outcomes.

Author contributions: Jihad H. Kaouk had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study concept and design: Kaouk, Dagenais.
Acquisition of data: Dagenais, Maurice, Mouracade, Kara, Chavali, Nelson, Garisto, Bertolo.
Analysis and interpretation of data: Dagenais.
Drafting of the manuscript: Dagenais.
Critical revision of the manuscript for important intellectual content: Kaouk, Fergany, Abouassaly, Bertolo.
Statistical analysis: Dagenais, Li.
Obtaining funding: None.
Administrative, technical, or material support: None.
Supervision: Kaouk.
Other: None.

Financial disclosures: Jihad H. Kaouk certifies that all conflicts of interest, including specific financial interests and relationships and affiliations relevant to the subject matter or materials discussed in the manuscript (eg, employment/affiliation, grants or funding, consultancies, honoraria, stock ownership or options, expert testimony, royalties, or patents filed, received, or pending), are the following: Jihad H. Kaouk is a consultant for Intuitive and Endocare. The remaining authors have nothing to disclose.

Funding/Support and role of the sponsor: None.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.eururo.2018.10.046.

References

[1] Uzzo RG, Novick AC. Nephron sparing surgery for renal tumors: indications, techniques and outcomes. J Urol 2001;166:6–18.
[2] Lane BR, Babineau DC, Poggio ED, et al. Factors predicting renal functional outcome after partial nephrectomy. J Urol 2008;180:2363–8.
[3] Crispen PL, Boorjian SA, Lohse CM, et al. Outcomes following partial nephrectomy by tumor size. J Urol 2008;180:1912–7.
[4] Campbell S, Uzzo RG, Allaf ME, et al. Renal mass and localized renal cancer: AUA guideline. J Urol 2017;198:520–9.
[5] Ljungberg B, Bensalah K, Canfield S, et al. EAU guidelines on renal cell carcinoma: 2014 update. Eur Urol 2015;67:913–24.
[6] Wu Z, Li M, Liu B, et al. Robotic versus open partial nephrectomy: a systematic review and meta-analysis. PLoS One 2014;9:e94878.
[7] Link RE, Bhayani SB, Allaf ME, et al. Exploring the learning curve, pathological outcomes and perioperative morbidity of laparoscopic partial nephrectomy performed for renal mass. J Urol 2005;173:1690–4.
[8] Haseebuddin M, Benway BM, Cabello JM, et al. Robot-assisted partial nephrectomy: evaluation of learning curve for an experienced renal surgeon. J Endourol 2010;24:57–61.
[9] Rosser CJ, Kamat AM, Pendleton J, et al. Impact of fellowship training on pathologic outcomes and complication rates of radical prostatectomy. Cancer 2006;107:54–9.
[10] Leroy TJ, Thiel DD, Duchene DA, et al. Safety and peri-operative outcomes during learning curve of robot-assisted laparoscopic prostatectomy: a multi-institutional study of fellowship-trained robotic surgeons versus experienced open radical prostatectomy surgeons incorporating robot-assisted laparoscopic prostatectomy. J Endourol 2010;24:1665–9.
[11] Taub DA, Miller DC, Cowan JA, et al. Impact of surgical volume on mortality and length of stay after nephrectomy. Urology 2004;63:862–7.
[12] Birkmeyer JD, Stukel TA, Siewers AE, et al. Surgeon volume and operative mortality in the United States. N Engl J Med 2003;349:2117–27.
[13] Joudi FN, Konety BR. The impact of provider volume on outcomes from urological cancer therapy. J Urol 2005;174:432–8.
[14] Begg CB, Riedel ER, Bach PB, et al. Variations in morbidity after radical prostatectomy. N Engl J Med 2002;346:1138–44.
[15] Grande P, Campi R, Roupret M. Relationship of surgeon/hospital volume with outcomes in uro-oncology surgery. Curr Opin Urol 2018;28:251–9.
[16] Abouassaly R, Finelli A, Tomlinson GA, et al. Volume-outcome relationships in the treatment of renal tumors. J Urol 2012;187:1984–8.
[17] Eastham JA, Kattan MW, Riedel E, et al. Variations among individual surgeons in the rate of positive surgical margins in radical prostatectomy specimens. J Urol 2003;170:2292–5.
[18] Orszag PR. US health care reform: cost containment and improvement in quality. JAMA 2016;316:493–5.

[19] Kaouk JH, Khalifeh A, Hillyer S, et al. Robot-assisted laparoscopic partial nephrectomy: step-by-step contemporary technique and surgical outcomes at a single high-volume institution. Eur Urol 2012;62:553–61.

[20] Fergany AF, Hafez KS, Novick AC. Long-term results of nephron sparing surgery for localized renal cell carcinoma: 10-year follow-up. J Urol 2000;163:442–5.

[21] Bertolo RG, Zargar H, Autorino R, et al. Estimated glomerular filtration rate, renal scan and volumetric assessment of the kidney before and after partial nephrectomy: a review of the current literature. Minerva Urol Nefrol 2017;69:539–47. http://dx.doi.org/10.23736/S0393-2249.17.02865-X.

[22] West BT, Galecki AT, Welch KB. Linear mixed models. Boca Raton, FL: CRC Press; 2014.

[23] Goldstein H, Browne W, Rasbash J. Partitioning variation in multilevel models. Understand Stat 2002;1:223–31.

[24] Sheetz KH, Dimick JB, Ghaferi AA. The association between hospital care intensity and surgical outcomes in Medicare patients. JAMA Surg 2014;149:1254–9.

[25] Sheetz KH, Dimick JB, Ghaferi AA. Impact of hospital characteristics on failure to rescue following major surgery. Ann Surg 2016;263:692–7.

[26] Mir MC, Ercole C, Takagi T, et al. Decline in renal function after partial nephrectomy: etiology and prevention. J Urol 2015;193:1889–98.

[27] Leow JJ, Leong EK, Serrell EC, et al. Systematic review of the volume-outcome relationship for radical prostatectomy. Eur Urol Focus 2018;4:775–89.

[28] Simpson L. What makes a good surgeon? J Natl Med Assoc 2008;100:261–4.

[29] Ruhotina N, Dagenais J, Gandaglia G, et al. The impact of resident involvement in minimally-invasive urologic oncology procedures. Can Urol Assoc J 2014;8:334–40.

[30] Kern SQ, Lustik MB, McMann LP, et al. Comparison of outcomes after minimally invasive versus open partial nephrectomy with respect to trainee involvement utilizing the American College of Surgeons National Surgical Quality Improvement Program. J Endourol 2014;28:40–7.