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Conversion to Radical Nephrectomy From Robotic Partial Nephrectomy Is Most Commonly Due to Anatomic and Oncologic Complexity

Yuzhi Wang, Samantha Wilder, Mohit Butaney, et al; Michigan Urological Surgery Improvement Collaborative.

Correspondence: Brian R. Lane, MD, PhD (brian.lane@corewellhealth.org).

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Study Need and Importance: Partial nephrectomy is standard-of-care treatment for small renal masses. As utilization of partial nephrectomy increases and includes larger and complex tumors, the risk of conversion to radical nephrectomy increases. There needs to be better understanding of the predisposing factors behind conversions. We evaluated incidence and reason for conversion to radical nephrectomy in patients scheduled for partial nephrectomy by surgeons participating in MUSIC (the Michigan Urologic Surgery Improvement Collaborative).

What We Found: Of 650 patients scheduled for robotic partial nephrectomy, conversion to radical nephrectomy occurred in 27 (4.2%). No conversions to open were reported. Preoperative documentation indicated a plan for possible conversion in 18 (67%) patients including partial with possible radical (n = 8), partial vs radical (n = 6), or likely radical nephrectomy (n = 4). Intraoperative documentation indicated that only 5 (19%) conversions were secondary to bleeding, with the remaining conversions due to tumor complexity and/or oncologic concerns (Figure). Patients undergoing conversion had larger (4.7 vs 2.8 cm, $P < .001$) and higher-complexity tumors (64% vs 6%, $P < .001$) with R.E.N.A.L. (for radius, exophytic/endophytic, nearness of tumor to collecting system, anterior/posterior, location relative to polar line) nephrometry score ≥ 10. The converted cases had a higher rate of $\geq$ pT3 (27% vs 8.4%, $P = .008$).

Limitations: As documentation was variable and not explicitly standardized, conclusions that can be made regarding factors associated with conversions and our understanding of pre- and intraoperative decision-making were somewhat subjective. The low number of conversions further limited the generalizability of our results, and we did not have sufficient conversion events to conduct a meaningful multivariable model.

Interpretation for Patient Care: While reported rates of conversion are already low, there is an even lower risk of conversion for bleeding rather than for minimization of oncological risk. Urologists should discuss that a higher risk of conversion and other complication may exist for certain patients rather than having an identical discussion for patients with standard robotic partial nephrectomy.

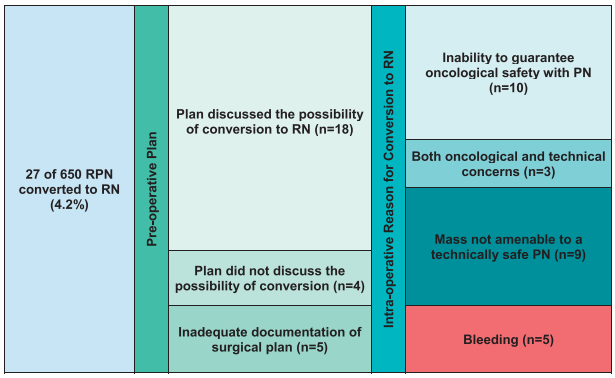

Figure. Preoperative and intraoperative documentation in the 27 robotic partial nephrectomy (RPN) cases converted to robotic radical nephrectomy (RN). PN indicates partial nephrectomy.

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Conversion to Radical Nephrectomy From Robotic Partial Nephrectomy Is Most Commonly Due to Anatomic and Oncologic Complexity

Yuzhi Wang,[1]* Samantha Wilder,[1]* Mohit Butaney,[1] Mahmoud Hijazi,[2] David Gandham,[2] Monica Van Til,[2] Benjamin Goldman,[3] Ji Qi,[2] Mahin Mirza,[2] Anna Johnson,[2] Michael Rudoff,[4] David Wenzler,[4] Craig G. Rogers,[1] and Brian R. Lane[5,6] for the Michigan Urological Surgery Improvement Collaborative

[1]*Vattikuti Urology Institute, Henry Ford Health, Detroit, Michigan*
[2]*Department of Urology, University of Michigan Medical School, Ann Arbor, Michigan*
[3]*Ascension Macomb-Oakland Hospital, Warren, Michigan*
[4]*Comprehensive Urology, Beaumont Hospital, Royal Oak, Michigan*
[5]*Corewell Health Hospital System, Grand Rapids, Michigan*
[6]*Michigan State University College of Human Medicine, Grand Rapids, Michigan*

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Data analysis and interpretation: Wang, Butaney, Wilder, Van Til, Goldman, Qi, Johnson.
Data acquisition: Butaney, Wilder, Gandham, Golman, Mirza, Johnson, Wenzler.
Drafting the manuscript: Wang, Butaney, Wilder, Van Til, Mirza, Rudoff, Wenzler.
Critical revision of the manuscript for scientific and factual content: Wang, Lane, Butaney, Wilder, Gandham, Goldman, Qi, Johnson, Wenzler, Rogers.
Statistical analysis: Wang, Butaney, Wilder, Van Til, Qi.
Supervision: Lane, Butaney, Goldman, Mirza, Rudoff, Wenzler, Rogers.
Other: Gandham, Johnson.

Corresponding Author: Brian R. Lane, MD, PhD, Corewell Health Hospital System, 145 Michigan Ave, Suite 5120, Grand Rapids, MI 49546 (brian.lane@corewellhealth.org).

* Co-first authors.

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Purpose: Partial nephrectomy is standard-of-care treatment for small renal masses. As utilization of partial nephrectomy increases and includes larger and complex tumors, the risk of conversion to radical nephrectomy likely increases. We evaluated incidence and reason for conversion to radical nephrectomy in patients scheduled for partial nephrectomy by surgeons participating in MUSIC (the Michigan Urologic Surgery Improvement Collaborative).

Materials and Methods: All patients in whom robotic partial nephrectomy was planned were stratified by completed procedure (robotic partial nephrectomy vs radical nephrectomy). Preoperative and intraoperative records were reviewed for preoperative assessment of difficulty and reason for conversion. Patient, tumor, pathologic, and practice variables were compared between cohorts.

Results: Of 650 patients scheduled for robotic partial nephrectomy, conversion to radical nephrectomy occurred in 27 (4.2%) patients. No conversions to open were reported. Preoperative documentation indicated a plan for possible conversion in 18 (67%) patients including partial with possible radical (n = 8), partial vs radical (n = 6), or likely radical nephrectomy (n = 4). Intraoperative documentation indicated that only 5 (19%) conversions were secondary to bleeding, with the remaining conversions due to tumor complexity and/or oncologic concerns. Patients undergoing conversion had larger (4.7 vs 2.8 cm, $P < .001$) and higher-complexity tumors (64% vs 6%, $P < .001$) with R.E.N.A.L. (for radius, exophytic/endophytic, nearness of tumor to collecting system, anterior/posterior, location relative to polar line) nephrometry score ≥ 10. The converted cases had a higher rate of $\geq$ pT3 (27% vs 8.4%, $P = .008$).

Conclusions: There was a low rate of conversion from robotic partial to radical nephrectomy in the MUSIC-KIDNEY (Kidney mass: Identifying and Defining Necessary Evaluation and therapY) collaborative, and an even lower risk of conversion due to uncontrolled bleeding. Targeted review of each conversion identified appropriate decision-making based on oncologic risk in most cases.

Key Words: robotic partial nephrectomy, radical nephrectomy, conversion to open

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Partial nephrectomy (PN) has emerged as the standard of care for localized renal masses that are amenable to a nephron-sparing surgery, while radical nephrectomy (RN) is generally performed for larger and more complex tumors.[1,2] PN has been shown to have excellent oncological outcomes and the benefit of preserving renal function compared with RN.[3,4] Robotic PN (RPN) has demonstrated improved outcomes in terms of hospital length of stay, lower blood loss, and postoperative complications when compared to open and laparoscopic approaches.[5-7] Utilization of RPN has expanded to include larger and more complex tumors in many centers.[8-10] For every patient undergoing PN, there are risks, including the potential for conversion to RN.

Prior reports indicate rates of conversion of RPN to RN between 0.14% and 14%, with all sources but 1 at $< 6\%$.[11-16] These published rates are often from high-volume and/or academic centers. Implicit within this literature is that these conversions are generally performed after a complication has occurred for patient safety, rather than as a decision intentionally made in order to obtain optimal cancer control. However, review of the available literature indicates insufficient insight to understand the reasonings for the conversions. A better understanding of the factors predisposing patients to a higher risk of conversion and the actual reasons behind conversion can help guide patient counseling preoperatively and assist in surgical planning.

The Michigan Urologic Surgery Improvement Collaborative (MUSIC) is a statewide quality improvement (QI) collaborative that seeks to improve the quality of care received by patients with urologic conditions. The MUSIC–Kidney mass: Identifying and Defining Necessary Evaluation and therapY (KIDNEY) program seeks to standardize and improve care for patients with renal masses. The aim of the present study is to report the incidence and reasons associated with conversion from RPN to RN within practices participating in MUSIC-KIDNEY.

METHODS

MUSIC-KIDNEY

MUSIC-KIDNEY's inception, protocols, and methodology have been reported previously.[17] Briefly, trained data abstractors at each clinical site review the primary medical record at least 4 months (120 days) after initial office visit to capture patient demographics, tumor characteristics, initial workup, plan, and treatment decision (intervention vs surveillance) for each patient at 16 community-, academic-, and hospital-based MUSIC practices. All participating sites obtained exemption or approval from local institutional review boards for participation in MUSIC-KIDNEY QI activities.

Study Sample

All patients with a T1 renal mass (T1RM) and an initial plan to undergo RPN were included in this analysis. Patients with simple cyst, Bosniak type 2 cyst, angiomyolipoma, and "other" tumor types were excluded. Patients who underwent laparoscopic and open PNs were excluded due to the small sample size ($n = 3$ and $n = 25$, respectively). MUSIC-KIDNEY began collecting data in July 2016, and registry entries up until January 2021 were complete at the time of statistical analysis. Patient, tumor, and practice data were obtained for all patients undergoing RPN or RN.

All preoperative and operative records associated with conversions to RN were obtained from the treating practices for review. A thorough chart review was performed by 3 reviewers for all 27 converted surgeries. Preoperative documentation was reviewed for the original surgical plan and assessment of RPN difficulty by the surgeon. Surgical plans were categorized into RPN (without mention of conversion), RPN with possible RN, RPN vs RN, and likely RN. Operative note was reviewed to determine reasons for conversion from RPN to RN. Reasons for conversion were grouped according to the following: anatomic complexity, advanced disease, and complications including bleeding. Reasons involving tumor size/location/depth and difficulty/inability to reconstruct the kidney after tumor resection were categorized as anatomic complexity. Reasons involving greater tumor burden/spread than expected and the inability to obtain negative surgical margins were categorized as advanced disease.

Statistical Analysis

Patients were stratified into cohorts based on whether they ultimately received RPN or RN. Patient factors included age, sex, race, BMI, Charlson Comorbidity Index, preoperative renal function (serum creatinine), and insurance type. Tumor factors included clinical size, stage, and R.E.N.A.L. (for radius, exophytic/endophytic, nearness of tumor to collecting system, anterior/posterior, location relative to polar line) nephrometry score. R.E.N.A.L. score was used to evaluate tumor complexity, and scores were categorized into low (4-6), intermediate (7-9), and high (10-12) complexity as initially described by Kutikov and Uzzo.[18] Practice factors included annual PN volume (<20 or ≥ 20 cases) and practice type (academic, hybrid, or community) which were consistently defined in previous MUSIC analyses. Patient, tumor, and practice characteristics were compared between cohorts. To identify independent factors associated with conversion, χ^2 and Fisher exact tests were used for categorical variables, Jonchkeere-Terpstra test for ordinal variables, and Wilcoxon rank sum test for continuous variables. Practice-level variation in the proportion of patients converted to RN were also examined for practices with at least 10 PN cases (per MUSIC protocol). All analyses were performed using SAS 9.4, and statistical significance was set at 2-sided P values $\leq .05$.

RESULTS

Between July 2016 and January 2021, a total of 650 patients were diagnosed with T1RMs and scheduled for RPN by surgeons participating in MUSIC-KIDNEY. The rate of conversion from RPN to RN was 4.2% (27/650). No conversions to open PN or open RN were documented. Figure 1 shows the variation in

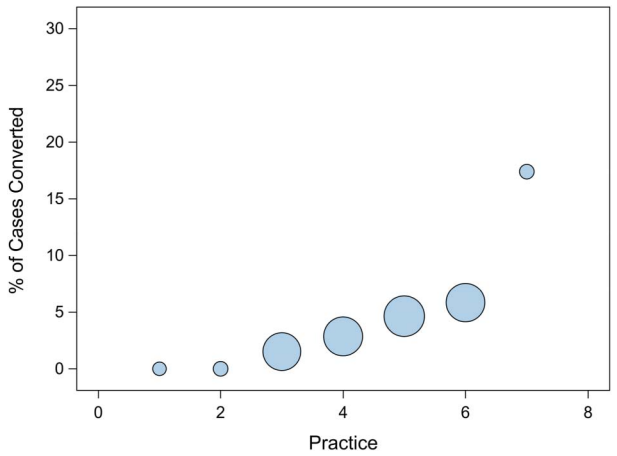

Figure 1. Practice-level rate of conversion from robotic partial nephrectomy to radical nephrectomy. Each circle represents a single Michigan Urologic Surgery Improvement Collaborative practice; the size of each circle correlates with the number of included cases. Only practices with ≥ 10 cases of robotic partial nephrectomy in the registry were included in the Figure.

conversion rate for the 7 out of 12 MUSIC practices included in the study with ≥ 10 RPNs in the registry; conversion rates ranged from 0% to 17%. Table 1 compares the patient, tumor, and practice characteristics of this cohort by conversion status. Patients converted to RN had significantly larger tumors (median size 4.7 vs 2.8 cm, $P < .001$), and more frequently had tumors with high R.E.N.A.L. nephrometry score (26% vs 3.2%, $P < .001$) and T1b clinical stage (67% vs 21%, $P < .001$). Of 345 cases with reported R.E.N.A.L. score, only 6% of unconverted RPN had a high R.E.N.A.L. score, compared to 64% of converted cases ($P < .001$).

Pathological Outcomes

Table 2 highlights the significant differences in tumor pathology between cases converted to RN vs non-converted RPN cases. Among the 27 converted cases, there were significant differences in tumor histology, particularly clear cell, papillary, and chromophobe renal cell carcinoma (65% vs 56%, 16% vs 0%, and 15% vs 6.1%, respectively, $P = .040$). ≥ pT3a tumor was present in 27% of converted cases compared to only 8.4% of nonconverted cases ($P = .008$).

Assessment of PN Difficulty and Reasons for Conversion

Figure 2 highlights the preoperative and postoperative reasoning for converted cases. Review of the 27 individual converted cases found that 22 had preoperative documentation with sufficient detail regarding assessment of PN difficulty and/or likelihood of conversion. Among these, 82% (18/22) indicated surgeon assessment of increased surgical complexity ("plan for RPN with possibility of conversion to RN," "plan for PN vs RN," "complicated or challenging PN," "likely RN, will attempt RPN"). The surgeon assessment included a plan for possible conversion in 18 (67%) of patients (PN possible RN [n = 8], PN vs RN [n = 6], and likely RN [n = 4]). In 4 patients, the preoperative documentation did not mention the possibility of conversion and was felt to be inadequate in an additional 5 patients.

There was postoperative documentation regarding the reason for conversion in all 27 identified cases. Five cases were converted due to complications of bleeding, which included bleeding from accessory renal arteries (n = 2), injury to the main renal artery (n = 1), parasitic vessels (n = 1), and renal vein injury (n = 1). Each of these operative reports indicated difficulty in controlling the bleed due to tissue friability and/or tumor location which ultimately led to the decision to convert to RN.

The remaining 22 cases had controlled conversions due to anatomic complexity (n = 10), locally advanced disease (n = 7), or both (n = 5). All 22 cases were converted to RN with reasons categorized as an inability to guarantee maximal oncological safety with PN (n = 10), the renal mass not being amenable to a safe PN (n = 9), or both (n = 3). Among these, 4 cases had documentation explicitly describing unexpected tumor growth relative to the preoperative imaging and/or potential upstaging due to tumor invasion. Additionally, 2 cases had documentation indicating minimal added benefit to nephron preservation due to the low amount of viable renal tissue left after attempted PN.

DISCUSSION

Based on our analysis of a statewide QI registry focused on T1RM, we found a low rate of conversion to RN (4.2%) in patients with masses which were intended to undergo RPN. Given the technical complexity of PN, it may be assumed by some that conversions are most likely due to intraoperative complications, such as uncontrolled bleeding. However, MUSIC-KIDNEY data suggest that most conversions to RN are controlled conversions performed to ensure oncologic safety, and that many of these were likely anticipated preoperatively. Tumor-specific factors associated with conversion from RPN to RN included larger tumor size, higher R.E.N.A.L. score, and higher stage. These results provide further evidence for the safety and appropriateness of surgical decision-making for T1RM, even for larger or higher complexity masses.

The 4.2% rate of conversion to RN reported in our study is comparable to other rates reported in literature, which have ranged from 0.14% to 14%.[11-16] Identifying patients who are at a high risk of conversion to RN may help inform preoperative counseling. Our study identified that patients with larger and high-complexity tumors were more likely to

Table 1. *Patient, Tumor, and Practice Characteristics for Robotic Partial Nephrectomy Cases and Cases Converted to Radical Nephrectomy From July 2016 to January 2021*

	RPN N = 623 (95.8%)		Converted to RN N = 27 (4.2%)		*P* value
Age, median (IQR), y	60	(49-67)	62	(52-69)	.4
Sex, No. (%)					.9
Male	402	(65)	17	(63)	
Female	221	(35)	10	(37)	
Race, No. (%)					.9
White	499	(80)	22	(81)	
African American	63	(10)	3	(11)	
Other	61	(9.8)	2	(7.4)	
BMI, median (IQR), kg/m^2	30.8	(27.1-35.2)	29.4	(27.5-33.2)	.4
CCI, No. (%)					.5
0	389	(62)	19	(70)	
1	114	(18)	3	(11)	
≥2	120	(19)	5	(19)	
Preoperative creatinine, median (IQR), mg/dL	0.91	(0.78-1.09)	0.95	(0.80-1.20)	.5
Preoperative tumor size, median (IQR), cm	2.8	(2.0-3.8)	4.7	(3.5-5.2)	**< .001**
Tumor stage, No. (%)					**< .001**
cT1a	493	(79)	9	(33)	
cT1b	130	(21)	18	(67)	
R.E.N.A.L. nephrometry score, No. (%)					**< .001**
Low	162	(26)	0		
Intermediate	152	(25)	4	(15)	
High	20	(3.2)	7	(26)	
Unknown[a]	288	(46)	16	(59)	
Annual PN practice volume, No. (%)					.15
<20 cases	80	(13)	6	(22)	
≥20 cases	542	(87)	21	(78)	
Practice type, No. (%)					.5
Academic	143	(23)	4	(15)	
Hybrid	452	(73)	21	(78)	
Community	28	(4.5)	2	(7.4)	
Insurance, No. (%)					.7
Private	417	(67)	17	(63)	
Public	194	(31)	9	(33)	
None	11	(2)	1	(3.7)	

Abbreviations: CCI, Charlson Comorbidity Index; PN, partial nephrectomy; R.E.N.A.L., radius, exophytic/endophytic, nearness of tumor to collecting system, anterior/posterior, location relative to polar line; RN, radical nephrectomy; RPN, robotic partial nephrectomy.
Bolded *P* values indicate statistically significant difference.
Data were unavailable for BMI in 4 patients and insurance type in 1.
Categorical variables were assessed using χ^2 and Fisher exact tests. Ordinal variables (CCI and R.E.N.A.L. nephrometry score) were assessed using Jonckheere-Terpstra tests. Continuous variables were assessed using Wilcoxon rank sum tests.
[a] Unknown category in R.E.N.A.L. nephrometry score was not included in the Jonckheere-Terpstra test to determine *P* value. However, the No. (%) is still reported in the Table.

undergo conversion to RN. These findings are consistent with previous reports in the literature. Single-center retrospective reviews have found higher rates of conversion in patients with poor preoperative renal function, larger tumors, tumors with higher R.E.N.A.L. score, hilar tumors/renal sinus invasion, laparoscopic PN, intraoperative bleeding, positive surgical margins, and advanced

Table 2. *Pathological Outcomes Between Robotic Partial Nephrectomy Cases and Cases Converted to Radical Nephrectomy*

	Not converted N = 623 (95.8%)		Converted to RN N = 27 (4.2%)		*P* value
Pathologic tumor size, median (IQR), cm	2.9 (2.0-3.9)		4.5 (3.8-5.5)		**< .0001**
Histology, No. (%)					**.040**
Clear cell RCC	347	(56)	17	(65)	
Papillary RCC	100	(16)	0		
Chromophobe RCC	38	(6.1)	4	(15)	
Unclassified/other cancer	42	(6.8)	2	(7.7)	
Benign	95	(15)	3	(12)	
≥pT3 stage, No. (%)	52	(8.4)	7	(27)	**.008**
Fat invasion (pT3a)	37	(5.9)	6	(23)	**.006**
Vascular invasion (pT3b)	27	(4.3)	5	(19)	**.008**

Abbreviations: RCC, renal cell carcinoma; RN, radical nephrectomy.
Bolded *P* values indicate statistically significant difference.
Data were unavailable for tumor size in 9 patients, histology in 2, pT3/T4 stage in 29, fat invasion in 29, and vascular invasion in 31.

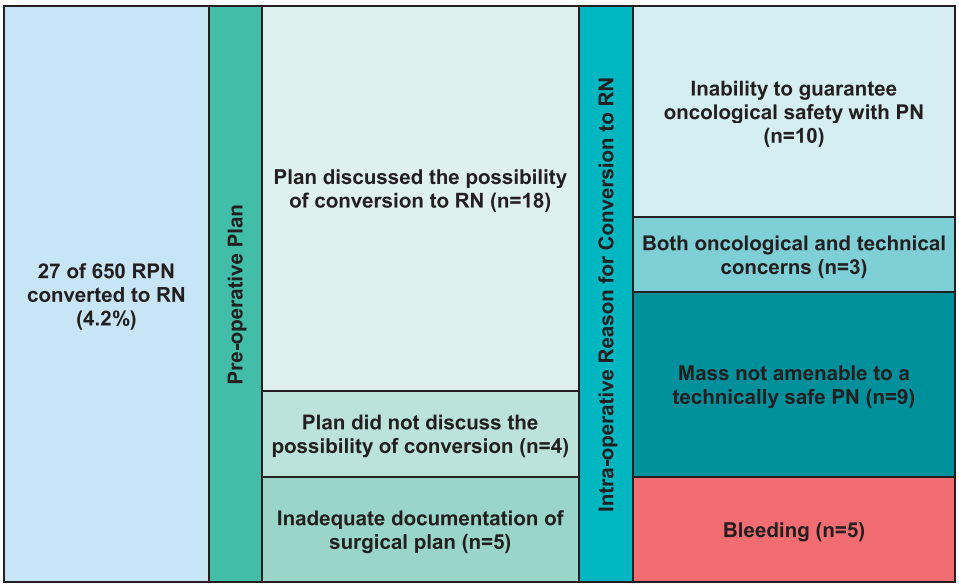

Figure 2. Preoperative and intraoperative documentation in the 27 robotic partial nephrectomy (RPN) cases converted to robotic radical nephrectomy (RN). PN indicates partial nephrectomy.

pathological tumor stage.[11,12,14,15] Assessment of tumor complexity is a necessary component to identify tumors at high risk for conversion and other complications.[19,20] Dahlkamp et al demonstrated the value of R.E.N.A.L. nephrometry score in predicting conversion from PN to RN; their analysis consisted of a higher number of high-complexity tumors, resulting in a higher conversion rate of 13.5% (31/229).[21] In contrast, a prospective multi-institutional study by Arora et al found that tumor factors such as clinical stage, location, multifocality, or R.E.N.A.L. score were not associated with an increased risk of conversion.[13] Although there is no definite consensus in the literature, reporting R.E.N.A.L. score is still valuable for risk assessment and to help guide counseling. Forty-seven percent (304/650) of our patients did not have a R.E.N.A.L. score in preoperative assessment, indicating an area for future improvement.

We uniquely had the ability to access records to assess decision-making and intraoperative events, which may be challenging or impossible to conduct in other multi-institutional and retrospective studies. Our registry provides us with granular data which may not be available in some large national or multi-institutional databases. While much of the nuance of preoperative and intraoperative decision-making is not captured in the medical record in its entirety, our database captures information about each patient beginning from the initial diagnosis, allowing greater assessment of surgeon intent and decision-making.

Most studies in the literature come from high-volume and/or major academic centers, with limited available data regarding conversion from PN to RN among community and hybrid practices. MUSIC is a community that partners to improve patients' lives by inspiring high-quality care through data-driven best practices, education, and innovation. MUSIC-KIDNEY provides an opportunity to evaluate practice patterns and variation across the spectrum of urologic practices within the state of Michigan. While the number of conversions in our database is relatively small and the number of conversions secondary to intraoperative complications and bleeding is even smaller, we have identified opportunities for QI within our collaborative, and outside of it. To this end, we have conducted both live and virtual skills workshops, including a recent nationwide seminar on bleeding management during RPN, and a collaborative-wide RPN video review with the goal of providing objective and specific feedback to participating surgeons regarding technical skill. Although our registry and those at other centers do not provide granular data regarding the nuances of preoperative and intraoperative decision-making, our collaborative structure allowed for deep dives into individual charts to capture information about each patient from the initial diagnosis, allowing greater assessment of surgeon intent and decision-making. In these reviews, we have identified clear differences in documentation, a golden opportunity to learn from best practices and improve the quality of care each patient receives.

The increased use of PN for more complex and larger tumors has raised concerns regarding safety and appropriateness. Our results indicate that although most conversions were driven by tumor features, a small proportion (19%) of conversions were due to bleeding complications and thus potentially

avoidable with upfront RN. Preoperative patient counseling should additionally include discussion of the possibility of conversion, especially for cases anticipated to be more challenging than a standard PN. In our review, we found that preoperative documentation was highly variable regarding explicit discussion of PN difficulty or potential for conversion, and as such we have encouraged surgeons within our collaborative to explicitly document their assessment of PN difficulty and tumor complexity.

Our analysis is subject to several limitations. While the MUSIC-KIDNEY database is prospective in design, this study relied on retrospective review of individual medical records to evaluate the reasons for conversion. As such, this analysis is subject to inherent limitations associated with retrospective analyses. With limited and nonstandardized documentation not explicitly created for this research question, the conclusions that can be made regarding factors associated with conversions and our understanding of pre- and intraoperative decision-making were somewhat subjective. However, the fact that our registry does capture physician intent to perform RPN prospectively does provide additional insight that is not possible with some retrospective analyses. While intraoperative documentation generally was sufficient to explain much of the decision-making process, there was variability in the quality of documentation. To facilitate standardized documentation and aid surgeons in reporting their assessment of PN feasibility, we have distributed templates for both preoperative and intraoperative notes within our collaborative (Supplementary Appendix, https://www.jurology.com). Additionally, only 53% of patients had documented R.E.N.A.L. nephrometry scores; although we included all patients in the analysis by creating an "unknown" category, the relationship between tumor complexity and conversion from PN to RN may be better defined with more widespread documentation of R.E.N.A.L. score. The limited number of conversions in our dataset further limits the generalizability of our results, and better understanding of the association of these factors requires further study with higher-powered datasets; we did not have sufficient conversion events to conduct a meaningful multivariable model. Additionally, the small number of conversions limited our ability to evaluate the role of surgeon experience or position on the robotic learning curve.

CONCLUSIONS

While reported rates of conversion are already low, there is an even lower risk of conversion for bleeding rather than for minimization of oncological risk. This further provides additional data to justify the safety of PN, even in cases of larger or more complex tumors. We have identified QI opportunities to standardize preoperative documentation regarding PN difficulty, and multiple initiatives within MUSIC-KIDNEY exist to improve this and other aspects of surgical care for patients with renal masses.

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