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Variation in Laparoscopic Nephrectomy Surgical Costs: Opportunities for High Value Care Delivery

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Abstract

Introduction: Rising health care costs are leading to efforts to minimize costs while maintaining high quality care. Practice variation in the operating room that is not dictated by patient necessity or clinical guidelines presents an opportunity for cost containment. We identified variation in surgical supply costs among urological surgeons performing laparoscopic nephrectomy and evaluated whether this variation was associated with patient outcomes.

Methods: A total of 211 consecutive laparoscopic nephrectomies performed at an academic center between September 1, 2012 and December 31, 2015 were identified and surgical supply costs for each case were determined from the institutional negotiated rate. Patient and surgical factors relevant to case complexity, comorbidity and perioperative outcomes were obtained. Univariate and multivariable analysis of predictors of surgical supply costs and patient outcome as determined by length of stay was conducted.

Results: Median supply cost was $2,537, with individual medians ranging from $1,642 to $4,524, representing a significant variation among surgeons ($p < 0.01$). On multivariable analysis, accounting for patient factors and case complexity, most surgeons remained significant predictors of surgical supply costs. Case supply cost was not a significant predictor of patient outcomes as measured by length of stay on univariate or multivariable analysis controlling for surgeon, patient factors and case complexity.

Conclusions: Significant variation in surgeons' surgical supply costs for laparoscopic nephrectomy exists and is driven by surgeons, and this does not correlate with length of stay. Targeting variation in surgical supply costs in this setting represents an opportunity for cost savings without adversely impacting patient outcomes.

Keywords

costs and cost analysis; practice patterns, physicians'; equipment and supplies; laparoscopy; nephrectomy

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Increasing health care costs are leading to efforts to minimize costs and inefficiencies in care delivery while maintaining high quality care.[1,2] Proponents of high value care emphasize aligning incentives so that patients, physicians, hospitals and health care systems benefit simultaneously. One opportunity for cost savings lies in examining practice variation that is dictated neither by patient necessity nor clinical care guidelines and does not directly impact patient outcomes.[3]

Studies in other surgical specialties, including the evaluation of appendectomy, herniorrhaphy and colectomy, have analyzed operating room supply cost variations, showing that there are significant variations in cost that are not translated to differential patient outcomes.[4–6] Among 14 otolaryngologists performing adenotonsillectomies, for example, surgeons had significant operating room supply cost variation in addition to variation in the cost of other operating related expenses such as those involving the operating room itself, the post-anesthesia care unit, anesthesia and pharmacy.[7] Results such as these show that differences in surgical case costs can be targeted for cost savings without a detrimental impact on patient outcomes.

Laparoscopic nephrectomy was introduced in the 1990s and is now commonly performed by urologists and general surgeons for malignant and benign diseases.[8] A variety of techniques may be used, including transperitoneal vs retroperitoneal approach, incorporation of hand assistance, use of hemostatic agents and mode of specimen extraction. These technical variations lead to differences in surgical supply costs for the same procedure. With increasing interest in health care cost containment, this potentially unnecessary variation in cost offers an opportunity for surgeons to be cost arbiters.[9] We identified variation in surgical supply case costs among urological surgeons performing laparoscopic nephrectomy at an academic medical center to identify variation in case supply costs and the association with patient outcomes.

Methods

Data

We retrospectively identified all laparoscopic nephrectomy operations performed at our institution between September 1, 2012 and December 31, 2015. Only cases that were scheduled as laparoscopic nephrectomies were included and, thus, none of these cases represented conversion from robotic or partial nephrectomy. Surgeons who performed the procedure at least 5 times during this period were thought to have their own standard surgical practice, and were included and de-identified. Trainees were involved in all cases, but it is important to note that the decision as to what equipment to use or supplies to open was driven by the attending surgeon via preference card or intraoperative decision making. Surgeons B and F are primarily endourologists and the other surgeons are primarily urological oncologists.

Surgical supply use was tabulated from operating room billing records and the institution negotiated rate paid for each item used to calculate supply costs. Item costs were then averaged over that urologist’s cases during this period. Patient factors relevant to case complexity and comorbidity were abstracted from the medical record, including age, sex, BMI, ASA, preoperative creatinine, kidney weight (as determined by pathological specimen weight) and surgical indication (benign vs malignant). Case duration (in minutes) was obtained from operating room logs and was used as a proxy for case complexity. Length of stay (in days) was used as a marker of short-term perioperative outcomes. Length of stay at our institution is driven by individual surgeons, who customize their own postoperative care pathways. All patients are rounded on and cared for by a team comprised of rotating trainees directed by individual attending surgeons, with inpatient care performed by permanent nurse practitioners based on the inpatient floor. Estimated blood loss was low across all patients and was not included in the study.

Statistical Methods

Baseline differences in patient cohorts among surgeons were compared using chi-squared tests for categorical factors and analysis of variance for continuous factors. Univariate associations between patient factors and both supply cost and length of stay were performed using least squares regression. Separate multivariable linear regression models were created using all predictors for the 2 separate outcomes of supply cost and length of stay (days). Regression diagnostics confirmed there were no multicollinear factors or highly influential outliers. We did identify a significant interaction between BMI and case length and this interaction term was included in the final multivariable models. All analyses were performed using R software, with p <0.05 considered significant.[10] This study was approved by the institutional review board.

Results

A total of 211 laparoscopic nephrectomies were performed by 6 attending urologists (range 5 to 82 cases per surgeon) between September 1, 2012 and December 31, 2015. Univariate analysis was performed to identify differences in case mix among surgeons, with significant differences identified in patient age and sex, kidney weight, indication (benign vs malignant) and case duration (table 1).

We identified significant variation in supply costs among surgeons. Median case supply cost was $2,537 (IQR $1,827–$3,629), with individual medians ranging from $1,642 to $4,524 (p <0.01, fig. 1). Supply cost was also significantly associated with patient age, surgery indication (benign or malignant) and case duration (all p <0.01, table 2). On multivariable analysis, adjusting for patient factors, case complexity and an interaction between BMI and case duration, nearly all surgeons were significant predictors of supply costs. Surgeons B (median supply cost $4,524; p <0.01), D (median supply cost $2,348; p = 0.02) and F (median supply cost $3,124; p <0.01) were associated with higher supply costs while surgeon C (median supply cost $1,877; p = 0.03) was associated with lower supply costs.

To determine whether supply cost was associated with patient outcome, we evaluated predictors of length of stay as a marker of patient outcome (see supplementary table, http://urologypracticejournsal.com/). On univariate analysis higher ASA status, higher preoperative creatinine and longer case duration were predictors of longer length of stay. On multivariable analysis adjusted for surgeons, patient factors, case complexity, and an interaction between BMI and case duration, supply cost was not a significant predictor of length of stay (p = 0.85).

Top drivers of supply cost by category were then evaluated using median per-case itemized supply costs by surgeon (fig. 2). Surgeons' variation in spending by category reflects a compounded measure of the cost of the individual items and the number of the items used over time.

Discussion

Our study of laparoscopic nephrectomy at a university medical center revealed significant supply cost variation among surgeons which does not correlate with differences in short-term perioperative patient outcome measured by hospital length of stay. These results provide empirical support that surgical case cost differences represent an opportunity to drive health care value.

Disposable costs of operating room supplies in some cases can exceed hospital reimbursements, which means that hospitals are forced to cover that excess cost.[11] In our experience surgeons do not know the cost of these items, so that when they are selecting which device to use, cost does not have a role in this decision. However, these cost variances make it clear that surgeons should be informed about the cost of supplies stocked in their operating room so that they can make cost-effective decisions about which supplies to use.[12] Research has shown that merely educating surgeons about supply costs can reduce costs without compromising outcomes,[5,13–15] in some cases yielding up to 10% to 20% reductions in supply costs.[5,15] Such education could lead surgeons to shift to lower cost items of equal efficacy and to reevaluate their use of expensive items.

In addition to educating surgeons about cost, standardization of operating room supplies is a "passive" method that can decrease costs. Reducing variation by selecting certain standard supplies can increase purchasing power for the institution, further improving cost efficiency. Several groups have looked at developing a standardized preference card for laparoscopic appendectomy and have shown that this method can result in 20% to 30% cost reductions per case, without impacting operating times or outcomes such as length of stay, readmission, postoperative infections or intraoperative infections.[16–18] The main obstacle to streamlining supplies is that surgeons' preferences are to continue using the supplies that they are accustomed to using and to have choice when it comes to supplies when possible. Although at our institution there are strict rules limiting financial relationships between physicians and device manufacturers, it may also be that some surgeons are driven by these relationships with industry.[19]

One opportunity for cost savings is to target supplies such as energy devices and hemostatic agents that are relatively expensive but may be fairly easily replaced with less expensive alternatives. Energy devices tend to be relatively expensive, with prices in the $400 to $1,200 range, yet with fairly minimal differences in the function of the instruments themselves, making them interchangeable in most cases except for surgeon preference. At our institution the Harmonic® scalpel and the LigaSure™ device are nearly equal in price, whereas the Sonicision™ cordless dissection device costs 2.75 times more. Because the Harmonic scalpel can be reprocessed and reused once, the average per use cost of this instrument is 75% of the cost of a new instrument.

Another notable driver of supply cost variation among surgeons is the use of hemostatic agents, which have prices in the $150 to $500 range. These are biological agents that can have vastly different costs that may not reflect a true difference in utility. Although some agents may have certain advantages and specific use cases, there is significant overlap in indications. For example, at our institution 10 ml TISSEEL® fibrin sealant is about twice as expensive as the same quantity of FLOSEAL® Hemostatic Matrix. Interestingly, 5 ml TISSEEL is less than half the price of the 10 ml volume, whereas 5 ml FLOSEAL is only 1.5 times less than the 10 ml volume. While evaluation of the effect of hemostatic agents and outcome was outside the scope of this report, some studies suggest that there is no difference in the comparative efficacy of various hemostatic agents, signifying that cost savings could be achieved by using lower cost agents without a change in outcome.[20,21]

It is important to note that while high cost items they may provide larger opportunities for cost savings, relatively inexpensive items may also represent the potential for large cost savings over time, particularly those supplies that are used in a high volume. Furthermore, the sum of the savings benefits of standardization may be driven by factors beyond the direct cost of supplies themselves. Standardizing preference cards and procedures across surgeons may lead to improved efficiency and more accurate setup in the operating room. Gurnea et al outlined cost saving opportunities in orthopedic trauma, focusing on a significant potential cost savings opportunity even with just standardizing draping technique.[12] They noted that not only can standardization decrease costs by allowing the purchase of less expensive supplies or bundled drape packs of lower cost, but it also helps to improve efficiency by avoiding the problem of surgical technicians having to remember multiple ways of draping.

While standardization has an opportunity for institutional level cost savings, surgeons are often not invested in such processes due to the lack of incentives. One way to operationalize surgeon participation is to offer a shared savings program. A study evaluating a hospital's costs after instituting a surgical shared savings program with the cost savings shared equally between the hospital and the surgical divisions and related departments showed that by aligning surgeon and hospital incentives, they were able to generate significant cost savings of nearly $900,000 annually in a relatively short period.[22]

There are several limitations to this study. The cost data reflect only the cost of surgical supplies in the operating room and do not reflect costs associated with operating time or with the hospital stay, which can dwarf surgical supply costs. However, we believe the focus on supply costs is relevant as these offer opportunities for cost savings on which surgeons themselves can also have a meaningful impact. In addition, despite the fact that these costs are institutionally negotiated and, therefore, are not necessarily generalizable to other institutions, those items that are the highest cost (such as energy devices and hemostatic agents) are likely the highest cost across institutions, even if there is variability in the exact pricing across institutions. Thus, it becomes important for institutions to evaluate their own instruments for cost differences to determine which instruments at their institution have the highest variability and highest costs.

In addition, while we attempted to control for variation in case mix and complexity, we cannot account for all of the cost variation that one might expect from cases of different levels of difficulty, and we acknowledge that the proxies we used, such as operative time and kidney weight, are not perfect surrogates. For example, a straightforward laparoscopic nephrectomy for a renal mass may require different supplies than one for a chronically infected kidney or one for a very large renal mass with a renal vein thrombus. Ideally we might have used case mix index as a marker for case complexity. However, case mix index was not available for this procedure given that most patients are discharged home within 24 hours, so we instead used surgery duration as a marker for case complexity. While this is not a perfect substitute, this variable was predictive of supply cost and length of stay as we would expect for a marker of case complexity. In addition, while we know there are differences among surgeons in terms of years of experience since training and case volume, these variables are by definition linked to the individual surgeons, and due to the small number of surgeons represented, were highly collinear and were not included as separate variables in our multivariable analysis. Furthermore, we did not have data on nursing staff available for analysis, but this could represent an important driver of supply costs. Even though supply use is driven by surgeon preference card and intraoperative choices, we know from experience that nurses or technicians may open unnecessary or more expensive equipment or supplies that could result in higher case costs, and this represents an opportunity for further research.

Finally, we used length of hospital stay as an outcome measure because this was the most reasonable proxy available. Other potential outcome measures such as the read-mission rate, mortality rate or blood transfusions are rare occurrences in this patient cohort and would not accurately reflect outcomes. We did find that variables such as creatinine, BMI and surgery duration, which we would expect to correlate with outcome, were predictive of length of stay. In addition, there was overall little variability in length of hospital stay, which we would expect for this type of procedure.

Conclusion

In this study of real-world variations in supply use and associated costs we identified actionable data that can be fed directly back to surgeons to safely drive cost-effective choices in the operating room without affecting length of hospital stay. These data can facilitate an open discussion about specific supply choices to move toward standardization and cost efficiency. Future studies must identify potential areas for standardization and potential for cost savings while maintaining excellent patient outcomes.

Abbreviations and Acronyms

ASA	American Society of Anesthesiologists® Physical Status classification system
BMI	body mass index

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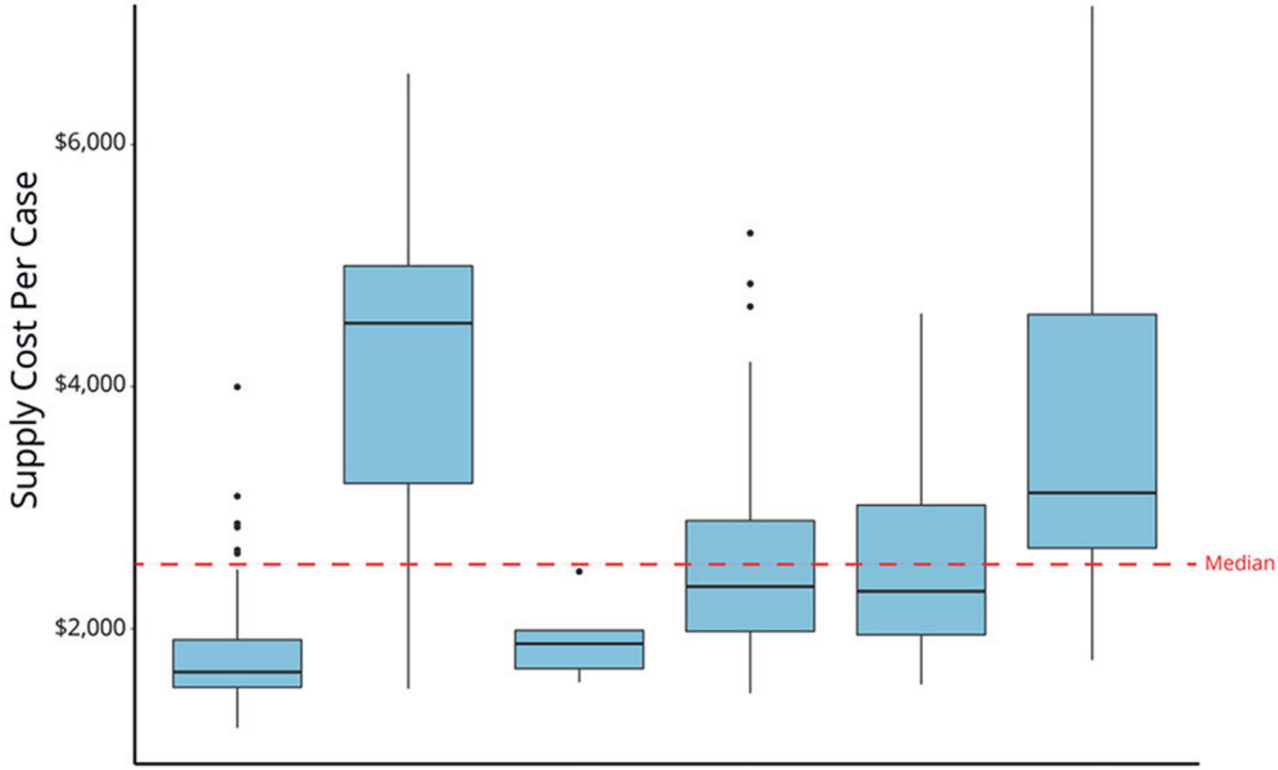

Surgeon	A	B	C	D	E	F
Cases (n)	66	22	5	27	9	82
Median ($) (IQR)	1,642 (1,517 - 1,909)	4,524 (3,202 - 4,998)	1,877 (1,670 - 1,987)	2,348 (1,978 - 2,893)	2,310 (1,950 - 3,020)	3,124 (2,667 - 4,597)

Figure 1.
Variation in laparoscopic nephrectomy supply cost among surgeons. Box plots for individual surgeons represent median and IQR for supply cost per case, with dots representing outliers. Broken red line represents overall median supply cost for all surgeons combined.

Category	Surgeon (median case cost)					
	A ($1,642)	C ($1,877)	E ($2,310)	D ($2,348)	F ($3,124)	B ($4,524)
energy device	431.04	497.75	601.88	556.65	1038.38	1970.41
endo GIA stapler and load	602.36	478.01	751.19	704.81	1153.07	841.40
hemostatic agent	77.93	221.42	382.13	393.93	276.49	209.52
setup	166.54	132.60	209.50	166.55	352.47	318.46
trocars	260.10	293.74	252.79	331.99	291.39	269.77
hemostatic control	150.52	173.01	163.87	236.42	199.23	168.20
suture	15.58	15.98	31.24	49.27	142.35	174.90
specimen retrieval	39.89	33.23	77.36	122.75	48.39	62.91
miscellaneous	48.74	47.74	56.53	68.18	86.18	50.21
dressing supplies	11.60	19.35	19.24	8.93	38.38	40.41
drain	0.85	0	2.61	2.81	0.75	1.39

Figure 2.

Heat map of surgeons' per-case median supply cost by supply category. In each supply category lighter shading represents lower per-case median supply cost and darker shading represents higher per-case median supply cost.

Table 1.

Laparoscopic nephrectomy case mix by surgeon

	Surgeon A		Surgeon B		Surgeon C		Surgeon D		Surgeon E		Surgeon F		p Value
No. cases	66		22		5		27		9		82		
Surgeon annual vol	20		7		2		8		3		25		<0.01
Median pt age (IQR)	64.6	(54.7–71.7)	53.2	(46.3–62.5)	67.3	(53.9–80.5)	62.9	(52.7–70.1)	70.1	(64–72.4)	56	(45.6–61.6)	<0.01
Sex (% male)	69.7		54.5		40		74.1		77.8		34.1		<0.01
Median kg/m^2 BMI (IQR)	29.2	(26.3–32.5)	29.9	(24.5–31.5)	25.2	(24.1–26.9)	29.1	(26.2–32.4)	28.5	(25.3–31.4)	28	(23.9–30.9)	0.88
No. ASA 1–2 (%)	40	(60.6)	13	(59.1)	4	(80.0)	14	(51.9)	4	(44.4)	51	(62.2)	0.76
No. ASA 3–4 (%)	26	(39.4)	9	(40.9)	1	(20.0)	13	(48.1)	5	(55.6)	31	(37.8)	
Median creatinine (IQR)	0.98	(0.84–1.22)	1.07	(0.87–1.25)	0.75	(0.7–0.99)	0.97	(0.76–1.19)	0.9	(0.76–0.93)	0.89	(0.74–1.3)	0.90
Median gm kidney wt (IQR)	677	(416–936)	380	(126–694)	624	(491–683)	754	(452–962)	785	(607–1,019)	340	(170–555)	<0.01
No. indication (% malignant)	63	(95.5)	11	(50.0)	5	(100.0)	26	(96.3)	9	(100.0)	31	(37.8)	<0.01
Median mins case duration (IQR)	152	(140–204)	276	(235–323)	341	(338–450)	206	(188–269)	262	(236–369)	248	(209–301)	<0.01
Mean ± SD days length of stay	1.8 ± 1.1		2.2 ± 1.4		2.8 ± 1.9		2.4 ± 1.6		2.1 ± 0.8		2.0 ± 1.1		0.20

Table 2.

Univariate and multivariable analysis of predictors of supply cost

	Univariate Analysis			Multivariable Analysis		
	Estimate	(95% CI)	p Value	Estimate	(95% CI)	p Value
Surgeons:			<0.01			
Surgeon A	1,805.14	(1,552.84; 2,057.44)		Ref		
Surgeon B	2,302.43	(1,797.84; 2,807.03)		1,834.81	(1,282.59; 2,387.04)	<0.01
Surgeon C	107.69	(−843.04; 1,058.41)		−1,079.36	(−2,046.97; −111.75)	0.03
Surgeon D	837.14	(368.90; 1,305.38)		507.96	(70.24, 945.67)	0.02
Surgeon E	743.21	(14.90; 1,471.53)		181.42	(−514.59, 877.42)	0.61
Surgeon F	1,836.05	(1,497.10; 2,175.00)		1,552.50	(1,130.01; 1,974.99)	<0.01
Pt factors:						
Age	−17.98	(−30.60, −5.36)	<0.01	−3.76	(−14.20, 6.68)	0.48
Sex (male)	−293.60	(−661.61, 74.40)	0.12	179.41	(−109.38, 468.20)	0.22
BMI	−8.44	(−34.63, 17.74)	0.53	48.16	(−4.52, 100.85)	0.07
ASA status (3–4)	154.23	(−221.02, 529.48)	0.39	33.03	(−270.56, 336.62)	0.83
Creatinine	67.83	(−26.05, 161.71)	0.16	−1.34	(−72.36, 69.68)	0.97
Kidney wt	−0.13	(−0.52, 0.26)	0.50	0.27	(−0.09, 0.62)	0.15
Indication (malignant)	−999.59	(−1,373.08; −626.09)	<0.01	192.83	(−188.50, 574.17)	0.32
Case complexity:						
Case duration	8.23	(6.41, 10.06)	<0.01	13.05	(7.09, 19.00)	<0.01
Interactions:						
BMI*case duration				−0.26	(−0.45, −0.08)	<0.01