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The impact of surgeon choices on costs associated with uncomplicated minimally invasive colectomy: you are not as important as you think

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Abstract

Background: There is increasing public discussion about the escalating cost of healthcare in America. There are no published data regarding the contribution of individual surgeons' choices on the cost of uncomplicated minimally invasive colectomy.
Methods: A review of a hospital cost-accounting database of the direct costs related to the index operation and postoperative care of all patients who underwent elective minimally invasive segmental colectomy over a 1-year period was performed.
Results: A total of 111 cases were enrolled in this study, 18 of which were performed robotically. The average direct cost after minimally invasive colectomy was $5536. The cost of robotic colectomy was 53% greater than laparoscopic ($7806 vs $5096, $p < 0.001$). There was no statistically significant difference in overall costs among laparoscopic cases performed by three surgeons ($5099 vs $5108 vs $5055, $p = 0.987$). Average operating room supply costs among the three surgeons were $1236, $1105 and $1030, respectively ($p = 0.067$), with a standard deviation of $328 (6.4% of overall cost).
Conclusions: No significant difference in overall costs between surgeons was demonstrated despite varied training, experience levels and operative techniques. Total costs are relatively institutionally fixed and minimally influenced by variations in individual surgeon preferences.

Key words: cost; minimally invasive colectomy; laparoscopy; individual surgeon

Introduction

The utilization of minimally invasive techniques for segmental colectomy for both benign and malignant disease has increased in frequency in recent years [1]. Multiple studies have demonstrated both the short- and long-term cost-effectiveness of laparoscopy when compared to the open approach [2–6]. Increasing levels of pressure are being exerted by insurers, politicians,

healthcare policy makers and the public to reduce healthcare costs while maintaining high levels of care. Some of this pressure is directed towards procedurally based specialists. There are relatively few data in the literature to suggest which factors, patient-related or otherwise, are associated with increased costs after uncomplicated minimally invasive segmental colectomy. A paucity of data exists regarding what impact decisions of individual surgeons has on these costs. Additionally, cost

data are frequently presented as either billed charges or insurance reimbursements. Neither of these methods reflects the true cost of care provided, nor do they help us to understand factors that might be controlled to reduce costs. The goal of this study is to determine whether individual surgeons' clinical choices impact on the cost of care by analysing actual hospital-cost data.

Methods

Using a retrospective hospital-based cost-accounting database, all patients who underwent an elective laparoscopic or robotic segmental colon resection with primary anastomosis between October 2013 and October 2014 were identified using ICD-9 and CPT codes. Patients who underwent subtotal colectomy, low anterior resection or segmental colectomy combined with another major urologic or gynecologic procedure were excluded. All elective segmental colectomies were included regardless of functional status or pre-operative comorbidities. Emergent cases were excluded. All operations were performed at a quaternary care center by three experienced colorectal surgeons, typically with the assistance of a surgical resident in their third to fifth clinical year. A minimally invasive thermal-energy device was used in all cases and all patients underwent a stapled anastomosis. Post-operatively, all patients were managed via a standardized post-colectomy enhanced recovery pathway. Each surgeon had disparate fellowship training and different preferences with regard to operative technique and surgical equipment which were not standardized. Patients who had a major post-operative complication (i.e. myocardial infarction, pulmonary embolism, anastomotic leak) were excluded from the study.

For the purpose of this study, cost was defined as actual cost to the hospital providing the direct peri-operative patient care. These costs were obtained through the hospital cost-accounting department and were calculated beginning the day of admission for surgery and ending the day of discharge. Costs associated with outpatient care or readmissions were not included. These cost data are proprietary to our hospital system and, as such, are limited in the actual values disclosed here. Professional fees, such as surgical, anesthesia or pathology, were not included in the calculated cost. Fixed direct costs included basic surgical supplies, prophylactic antibiotics and pre-operative holding-area costs. Variable costs included operating room (OR) time, anesthesia delivery time, surgeon-specific instrument/equipment preferences, post-anesthesia care unit (PACU) care/nursing costs, surgical floor care/nursing costs, medications, imaging, ancillary service charges (i.e. physical therapy, respiratory therapy), laboratory/blood bank studies and pathology/histology studies. Patient variables assessed included patient age, gender, underlying medical conditions as represented by Charlson comorbidity scores, left- versus right-sided colon resection, indication for colectomy, length of hospital stay, operative times, experience level of assisting resident and time spent in the PACU. Chief resident status was defined as a surgical resident in the last year of clinical training. Expected cost for an uncomplicated laparoscopic segmental colon resection at our institution was determined based on the known cost of basic surgical supplies/equipment (estimated to be $1981) as well as estimated nursing, OR and anesthesia charges. Assuming a 3-day post-operative stay with no deviation from the established colectomy pathway, 180 minutes of OR time and the use of basic post-operative labs and medications (specified in the pathway), the estimated cost to the hospital was $5419 per case.

A standard linear regression analysis with calculation of two-tailed unpaired t-tests, one-way ANOVA and p-values was performed.

Results

In total, 111 cases met inclusion criteria, 18 of which were performed robotically. Compared to the robotic group, patients who underwent laparoscopic resection tended to be older (62 vs 53 years) and were more likely to be female (58% vs 44%). Charlson comorbidity scores were lower in the robotic group ($p = 0.07$), though this did not reach statistical significance. While the majority of laparoscopic cases were right-sided colectomies (63%), 94% of the robotic cases involved left-sided resections. The indications for resection were similar between groups, with 53% versus 56% of individuals undergoing resection for benign disease in the laparoscopic and robotic groups, respectively (Table 1).

The average cost of robotic segmental colectomy was $7806 versus $5096 in the laparoscopic group ($p < 0.001$) (Table 2). The actual total cost per case in the laparoscopic arm was similar to our projected cost of $5419. At a median value of $3086, the cost of surgical supplies in robotic cases was nearly triple that of the laparoscopic group ($p < 0.001$); this calculation does not include the amortized cost of owning the robot. Robotic cases were associated with longer overall operative time (248 vs 177 minutes, $p < 0.001$). Variable costs associated with care outside of the OR are outlined in Table 2. The average length of stay was not significantly different between groups. There was a non-statistically significant trend towards longer PACU stay (229 vs 213 minutes, $p = 0.5$) in robotic cases.

There was no statistically significant difference in overall costs among laparoscopic cases performed by individual surgeons ($5099 vs $5108 vs $5055, $p = 0.987$) (Table 3). Surgical supply costs varied among surgeons, with average costs ranging from $1030 to $1236 ($p = 0.067$) with a standard deviation of $328, accounting for 6.4% of overall cost. Average operative time and post-operative length of stay were near equivalent among surgeons. There was no statistically significant difference between surgeons in cost of utilization of post-operative laboratory or imaging studies.

Laparoscopic cases were divided into four cost quartiles in order to determine which factors, if any, were associated with increased costs (Table 4). The low-cost first quartile comprised all cases in which the overall cost was less than $4340. The cost of cases in the highest, fourth quartile were greater than $5913. Average patient age rose across the cost quartiles. Charlson comorbidity scores increased across expense quartiles, with scores of 2.3 versus 5.1 in the low-cost and high-cost groups, respectively. Left-sided resections represented a higher proportion of higher cost quartiles. Nine percent of resections in the lowest cost group were left-sided versus 46% in the highest cost group. Benign disease was associated with lower overall costs, in general. As would be expected, length of stay, operative time and time spent in PACU increased across expense quartiles. There was no clear correlation between cost and patient gender or experience level of the assisting resident.

Compared to right-sided resections, left colectomies were more costly, due to higher overall surgical supply costs ($984 vs $1439, $p < 0.001$) and longer operative times (157 vs 210 minutes, $p < 0.001$) (Table 5). The average length of stay and time spent in the PACU were not significantly different between these groups.

Table 1. Patient data

	All cases (n = 111)	Laparoscopic cases (n = 93)	Robotic cases (n = 18)
Age (years)			
Mean	60	62	53
Median	62	64	53
Female gender (n, %)	62 (56%)	54 (58%)	8 (44%)
Charlson comorbidity score			
Mean (p = 0.07)	3.5	3.7	2.4
Median	3	3	2.5
Disease (n, %)			
Benign	59 (53%)	49 (53%)	10 (56%)
Malignant	52 (47%)	44 (47%)	8 (44%)
Surgical procedure (n, %)			
Right hemicolectomy	60 (54%)	59 (63%)	1 (6%)
Left/sigmoid colectomy	51 (46%)	34 (37%)	17 (94%)

Table 2. Costs and variables associated with costs

	All cases (n = 111)	Laparoscopic cases (n = 93)	Robotic cases (n = 18)
Total cost			
Mean	$5536	$5096	$7806
Median	$5186	$4917	$7343
Range	$3204–12 285	$3204–8473	$5949–12 285
OR-related costs			
OR related cost			
Mean (p < 0.001)	$5536	$5096	$7806
Median	$5186	$4917	$7343
Range	$3204–12 285	$3204–8473	$5949–12 285
Operative time (minutes)			
Mean (p < 0.001)	188	177	248
Median	181	172	234
OR supply cost ($)			
Mean (SD) (p < 0.001)	$1512 (987)	$1150 (328)	$3382 (1142)
Median	$1076	$1044	$3086
Number of staple loads			
Mean	3.5	3.5	3.2
Median	4	4	3
With chief resident assisting (n, %)	71 (64%)	57 (61%)	14 (78%)
Non-OR-related costs			
Non-OR-related cost			
Mean (p < 0.001)	$5536	$5096	$7806
Median	$5185	$4917	$7343
Range	$3204–12 285	$3204–8473	$5949–12 285
Length of stay (days)			
Mean	3.1	3.2	2.9
Median	3	3	3
Time in PACU (minutes)			
Mean (p = 0.5)	216	213	229
Median	199	193	223
Blood work cost			
Mean	$28	$28	$25
Median	$19	$19	$19
Radiology cost			
Mean	$15	$15	$14
Median	0	0	0

OR, operating room; SD, standard deviation; PACU, post-anesthesia care unit.

Left-sided colectomies were most often performed for benign disease and in patients with lower Charlson comorbidity scores (2.9 vs 4.2, p = 0.03).

Laparoscopic resection of benign disease was several hundred dollars less expensive, on average, when compared to resection of malignancy ($4918 vs $5294, p = 0.088) (Table 6). This is despite the lower OR supply costs required for resection of malignant disease (p = 0.003) reflecting the preponderance of right-sided resections in malignancy. OR times were equivalent. Patients with malignant disease had higher Charlson scores (it

Table 3. Subgroup analysis according to individual surgeons (laparoscopic cases)

	Surgeon A ($n = 40$)	Surgeon B ($n = 39$)	Surgeon C ($n = 14$)
Total cost			
Mean ($p = 0.987$)	$5099	$5108	$5055
Median	$4958	$4849	$5032
Mean OR supply cost (SD) ($p = 0.067$)	$1236 (330)	$1105 (329)	$1030 (272)
OR supply cost SD as percent of total cost	6.5%	6.4%	5.4%
Mean blood work costs	$27	$33	$21
Mean radiologic study costs	$22	$7	$13
Mean number of staple loads	3.9	3.1	3.9
Mean age (years)	60	64	61
Female (n, %)	25 (62%)	20 (51%)	9 (64%)
Mean Charlson score	3.7	4.0	3.1
Right hemicolectomy (n, %)	22 (55%)	28 (72%)	9 (64%)
Left/sigmoid colectomy (n, %)	18 (45%)	11 (28%)	5 (36%)
Resection for benign disease (n, %)	23 (57%)	19 (49%)	7 (50%)
Resection for malignancy (n, %)	17 (37%)	20 (53%)	7 (50%)
Mean length of stay (days)	3.0	3.4	3.2
Mean operative time (minutes)	185	167	181
mean time in PACU (minutes)	197	231	214
With chief resident assisting (n, %)	38 (95%)	11 (28%)	8 (57%)

OR, operating room; SD, standard deviation; PACU, post-anesthesia care unit.

Table 4. Subgroup analysis according to cost quartiles (Laparoscopic cases)

	First quartile ($n = 23$)	Second quartile ($n = 23$)	Third quartile ($n = 23$)	Fourth quartile ($n = 24$)
Total cost range	<$4340	$4340–4947	$4948–5913	>$5913
Mean OR supply cost (SD) ($p = 0.059$)	$1010 (311)	$1158 (278)	$1159 (263)	$1268 (403)
Mean number of staple loads	3.4	3.7	3.4	3.6
Mean age (years)	57	60	64	66
Female (n, %)	18 (78%)	10 (43%)	12 (52%)	14 (58%)
Mean Charlson score (n, %)	2.3	3.2	4.1	5.1
Right hemicolectomy (n, %)	21 (91%)	14 (61%)	11 (48%)	13 (54%)
Left/sigmoid colectomy (n, %)	2 (9%)	9 (39%)	12 (52%)	11 (46%)
Resection for benign disease (n, %)	15 (65%)	12 (52%)	11 (48%)	11 (46%)
Resection for malignancy (n, %)	8 (35%)	11 (48%)	12 (52%)	13 (54%)
Mean length of stay (days)	2.3	2.5	3.2	4.6
Mean operative time (minutes)	136	178	193	199
Mean time in PACU (minutes)	187	209	232	224
With chief resident assisting (n, %)	11 (48%)	16 (70%)	17 (74%)	13 (54%)

OR, operating room; SD, standard deviation; PACU, post-anesthesia care unit.

Table 5. Right vs left/sigmoid colectomy (Laparoscopic cases)

	Right colectomy ($n = 59$)	Left/sigmoid colectomy ($n = 34$)
Mean total cost ($p = 0.013$)	$4892	$5451
Mean OR supply cost (SD) ($p < 0.001$)	$984 (202)	$1439 (305)
Mean age (years)	64	58
Mean Charlson score ($p = 0.03$)	4.2	2.9
Resection for benign disease (n, %)	25 (42%)	24 (71%)
Resection for malignancy (n, %)	34 (58%)	10 (29%)
Mean length of stay (days)	3.3	3.0
Mean operative time (minutes) ($p < 0.001$)	157	210
Mean Time in PACU (minutes)	222	198

OR, operating room; SD, standard deviation; PACU, post-anesthesia care unit.

Table 6. Benign vs malignant disease (laparoscopic cases)

	Benign disease (n = 49)	Malignancy (n = 44)
Mean total cost (p = 0.088)	$4918	$5294
Mean OR supply cost (SD) (p = 0.003)	$1246 (385)	$1044 (207)
Mean age (years)	57	67
Mean Charlson score	2.0	5.7
Mean length of stay (days)	2.9	3.5
Mean operative time (minutes)	179	174
Mean time in PACU (minutes)	212	215

OR, operating room; SD, standard deviation; PACU, post-anesthesia care unit.

should be noted that malignancy contributes to the Charlson score) and had a longer length of stay. Nearly all patients with malignant disease were charged for additional immunocyto-chemistry studies such as KRAS and microsatellite instability as part of their pathology evaluation at a cost of several hundred dollars per study.

There were no significant differences in measured outcomes between patients who underwent laparoscopic resection with the assistance of chief residents versus junior residents. Overall costs were nearly identical: $5039 versus $5132 in the junior and chief resident groups, respectively.

Discussion

Limited data are currently available with regard to real, direct hospital costs associated with minimally invasive colectomy. Laparoscopic colon resection has been reported to be associated with reduced overall healthcare costs, as well as decreased long-term healthcare utilization after the post-operative period, when compared to open colectomy [2–6]. This has not been confirmed in other series [7,8]. Other authors note that laparoscopic cases are associated with greater overall OR costs [9,10]. Open colectomy cases are associated with more morbidity and therefore greater utilization of healthcare dollars after the index case. The cost of laparoscopic colectomy tends to vary between hospitals and regions, and is not necessarily associated with increased patient complexity or clinical outcomes [11,12]. Cost variations between individual hospitals are likely related to a number of factors, including the use of standardized post-operative 'pathways' and differences in surgical device preferences. In the Medicare population, payments to hospitals after colectomy may vary by up to $2500 even after adjusting for geographical reimbursement differences and patient illness severity. This would suggest that many hospitals could work to improve the cost-effectiveness of delivered care [13].

Cost data in most studies are given in terms of either insurance or patient charges or reimbursement (if any definition is given at all), both of which will vary significantly between individual hospitals, geographic locations and insurers. The cost data in this series are based on the actual cost to the hospital, not on billing charges or realized reimbursement. However, these data are proprietary to our hospital system and are therefore limited. In this series, left-sided laparoscopic and all robotic colectomies were associated with higher overall costs compared to right-sided resections. This difference is likely largely due to fixed costs, including increased surgical equipment costs and increased operative times required for these procedures, rather than differences in patient characteristics or post-operative care. As expected, additional factors that were consistently

noted in individuals who underwent laparoscopic resection that appeared to impact hospital costs were the extent of underlying medical comorbidities, length of the procedure, length of hospital stay, duration of time spent in the PACU and surgical supply cost. Length of stay is affected by numerous factors; even which day of the week the patient is operated on has been shown to play a role [14]. In our series, multiple patients experienced delays in discharge due to challenging transitions of care. Delays in setting up home nursing services and delays in transfers to skilled nursing facilities or rehabilitation facilities all extended lengths of stay and increased costs. Resections for malignant disease were associated with increased costs, some which may be attributed to the added expense of immunocyto-chemistries, oncotyping for pT3N0 tumors and, in several cases, completion of pre-operative staging. In our data, patient age was only loosely associated with increased hospital costs. Keller *et al.* reported similar findings, with no difference in cost noted when comparing elderly patients to individuals who were younger than 70 who underwent laparoscopic colon resections [15]. Other factors that increased total case cost included the use of home medications not on formulary, transfusion of blood products and the use of ancillary support services such as physical therapy and nutrition services. In general, post-operative laboratory and imaging studies contributed very little to the overall cost of most encounters (0.6% and 0.3% of average total costs, respectively).

Our series demonstrated no significant difference in the overall cost of laparoscopic segmental colectomy between individual surgeons. Surgeon equipment preferences and post-operative management variation had no statistical impact on the hospital cost per case. This finding was despite differences in the limited number of factors that are surgeon-controlled such as OR supply/equipment and technical preferences. Non-surgeon-controlled factors such as the indication for the procedure, the segment of colon removed and the patient did not have a significant effect on cost differences between surgeons. Depending on the surgeon, the standard deviation of the average OR supply cost was equivalent to 5.4–6.5% of the total overall cost. These findings suggest that, in the setting of standardized pre- and post-operative care, individual surgeon preferences regarding surgical instruments and operative techniques likely account for only a small proportion of the overall potential variation in cost of minimally invasive segmental colectomy.

As noted above, based on the known cost of our typical institutional post-operative pathway, the expected cost of an elective, uncomplicated laparoscopic segmental colon resection is $5419, with a predicted surgical equipment cost of $1981. This estimate is actually higher than our actual average cost for laparoscopic resection ($5096). This estimate was made without considering surgeon preferences and was still relatively accurate, providing further support that, under the clinical circumstances of this study, the total costs were likely institutionally fixed and minimally influenced by variations in individual surgeon preferences.

To some degree, cost is likely affected by surgeon experience and comfort with laparoscopic colon surgery, although the experience level of assisting residents was not found to correlate with cost. This study represents the experience of three dedicated, board-certified colorectal surgeons, all with greater than 5 years' experience practicing exclusively laparoscopic surgery whenever possible. Since, to date, there is still not universal acceptance or application of laparoscopic colectomy in elective cases throughout the country in larger and smaller

centers, we postulate that, if a similar study was performed across a wider group of surgeons, we might find that, if cost variations were found, it might correlate with surgeon experience with minimally invasive colectomy. Certainly, longer operative times will increase costs. One group noted that laparoscopic colon resections preformed during the surgeon's initial 40 cases were associated with longer operative times, but no increased risk of complications, conversions to open procedure or increase in direct costs (aside from OR time) were demonstrated [16].

Aside from measures aimed at mitigating the risk of post-operative complications, potential ways to reducing costs in patients undergoing minimally invasive colon resection include the implementation of standardized post-colectomy enhanced recovery pathways, the use of generic medications when possible, judicious use of ancillary service evaluations, establishing discharge plans early in the post-operative course or even prior to admission and careful use of expensive surgical equipment, with utilization of reusable instruments when possible. While surgeons should continue to be encouraged to make cost-conscious decisions, our evidence indicates that variations in surgeon choices and surgeon practice preferences play a relatively minor role in the overall cost of care during routine minimally invasive colectomy.

Conflict of interest statement: none declared.

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