Incremental cost of complications in colectomy: a warranty guided approach to surgical quality improvement

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\textbf{KEYWORDS:}

Colectomy; Cost; Complication; Surgical Quality; Warranty

\textbf{Abstract}

\textbf{BACKGROUND:} We assessed the warranty cost for colectomy at a single institution, as defined by the additional cost of treating complications distributed across all patients treated.

\textbf{METHODS:} All segmental colectomies from July 8 to June 12 were reviewed for 0, 1, 2, and 3 complications. Warranty cost is defined as follows: ([mean additional cost of the case with complication(s) – mean base case cost] × number of episodes)/total population.

\textbf{RESULTS:} Thousand four hundred twenty-two colectomies were analyzed. The lowest cost case was a laparoscopic resection with 0 complications ($7,739 ± 4,150). Warranty costs were less for laparoscopic versus open colectomy (0 - $0, 1 - $128, 2 - $66, 3 - $248 vs 0 - $1,036, 1 - $501, 2 - $520, 3 - $1,971). This was true for costs associated with readmission ($303 vs $1,519). Emergency status and elderly status also impacted warranty costs.

\textbf{CONCLUSIONS:} The data demonstrate that warranty costs were highest with open colectomy, emergency cases, and the elderly. These data can be used to measure both quality and cost impact of mitigation strategies.

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Fair implementation of a “bundled care” payment structure for colon resection will require definition of the cost structure of the “perfect outcome,” with subsequent adjustment by the cost impact of complications. However, the cost of process measure implementation is often ignored in this discussion. This basic concept is often lacking in the current reality of “consensus driven” process measures that do not validate both the cost impact and cost savings associated with adoption.\textsuperscript{1} One needs to look no further than the recommended and subsequently rescinded measures of strict glucose control and beta-blocker administration to drug-naïve patients, or the frequently referenced cost of >$40,000 for a central line infection.\textsuperscript{2,3} The ability of an institution or provider to economically survive within a bundled payment program will require precise risk adjustment methodologies, definitions of complications and cost structure, and an assessment of the cost effectiveness of mitigation strategies.\textsuperscript{4,5}

Therefore, if public reporting and implementation of an accurate pay-for-performance program which supports high quality and high value care is desired, then a transparent, transferrable, and accurate measurement tool is required. As previously defined by Fry et al,\textsuperscript{6} this system should allow for the easy, reliable, and consistent reporting of information from the medical records which have been accurately monetized to the cost of a deliverable episode of
care. In this study, we developed a potential strategy for understanding the warranty cost of colectomy based on either the financial impact of complications or the type of admission (elective vs urgent/emergent) in a single healthcare system. The purpose of this study was simply to define the cost and frequency of a given complication in isolation and in common clusters, and then to determine the cost impact across the entire colectomy population we managed, i.e., the warranty cost.

Methods

We reviewed all segmental colectomies performed at a single institution from July 8 to June 12 and the data were obtained from the UB-2004 claim submission form and supplemented by chart review as needed. The study received the Institutional Review Board approval. Data collected included the following: age, gender, type of admit, procedure (defined by the Current Procedural Terminology Codes – 44204, 44207, 44140, and 44160), length of stay (LOS), unplanned readmissions, and complications. Anastomotic leak was recorded. Surgical site infection was defined as superficial, deep, and organ space (in the absence of anastomotic leak). The selection of laparoscopic versus open colectomy was at the discretion of the operating surgeon and a standard enhanced recovery protocol was used for all open colectomy was at the discretion of the operating surgeon. We reviewed all segmental colectomies performed at a single institution from July 8 to June 12 and the data were obtained from the UB-2004 claim submission form and supplemented by chart review as needed. The study received the Institutional Review Board approval. Data collected included the following: age, gender, type of admit, procedure (defined by the Current Procedural Terminology Codes – 44204, 44207, 44140, and 44160), length of stay (LOS), unplanned readmissions, and complications. Anastomotic leak was recorded. Surgical site infection was defined as superficial, deep, and organ space (in the absence of anastomotic leak). The selection of laparoscopic versus open colectomy was at the discretion of the operating surgeon and a standard enhanced recovery protocol was used for all open.

We compared the means and variances of LOS for elective and open colectomies. We also determined the age range for patients undergoing segmental colectomy, and the mean and median age for the patients. We analyzed the data for the impact of complication and admission type (elective vs urgent/emergent) on warranty costs.

Results

One thousand four hundred twenty-two colectomies were analyzed from the defined study period and included 654 Lap and 768 open segmental colectomies. The mean LOS for laparoscopic colectomies was 4.4 ± 6.6 days compared to 9.0 ± 7.1 days for open cases (P < .001). The ASA distribution for laparoscopic and open elective colectomies was similar (P = .320), but open colectomies had slightly higher average age (59.9 ± 15.2 vs 61.2 ± 18.1; P < .001). Laparoscopy was associated with a reduced number of complications per patient compared to open colectomy (26 ± .03 vs 1.15 ± .08; P < .001). The data demonstrated that age correlated statistically with 1 or more complications compared to cases without complications (0 complications: 57.5 years, 1 complication: 67.8 years, 2 complications: 65.2 years, ≥3 complications: 66.1 years; P = .042) and urgent/emergent admissions were associated with increased numbers of complications per patient (P = .010).

The base cost for 0 complications was significantly lower for laparoscopic resection (Lap: $7,738 ± 4,150; open: $10,934 ± 12,498; P < .001). The distribution and warranty impact by complication group for Lap was significantly less compared to open (0 - $0, 1 - $128, 2 - $66, ≥3 - $248 vs 0 - $1,036, 1 - $501, 2 - $520, ≥3 - $1,971; Table 1). The warranty cost was always higher for open colectomy patients using either strategy (complications: $4,029 vs $443; admission type: $4,007 vs $438; Table 1). The major difference in cost structure was attributable to both LOS and accumulated complications, both of which were higher with open technique. Readmissions added warranty cost to both Lap and open cases and medically managed issues were significantly less costly than readmits requiring surgical intervention ($57/$246 vs $581/$938; P < .001; Table 2). Assessment of specific complications was performed to determine what issues might have impacted the cost structure and the major clinical issues appeared to be postoperative ileus, postoperative anemia, organ space infection (including anastomotic leak), and unplanned return to the operating room (Table 2). Superficial surgical site infections were associated with multiple complications and in isolation did not significantly impact warranty costs in our dataset (Table 2).

Comments

The data presented in this analysis represent a novel attempt to provide an evidence-informed case rate for colectomy similar to previous work in cancer care, chronic care, interventional cardiology, and orthopedic care.9 We modified the proposed strategy from de Brantes et al10 to define the cost of care for a defined operation (focusing on resection type rather than pathology specific).

Quite simply, we initially determined our cost for managing a given complication or common set of complications and then defined the incremental cost when spread out across the entire population treated. As an example, if a given complication cost $1,000 to manage and occurred in 10/100 patients it would have added $10,000 to institutional cost structure. A preventative strategy that would have to be applied to all 100 patients and was 100% effective would have to cost less than $100 to be cost neutral. Weaknesses of this approach were that we did not assess true resource acquisition cost by tying the analysis to the charge master, nor did we include physician fees in this assessment. Our reliance on the internal administrative data collected in our
information system used to populate the UB-2004 form for bill submission does provide a readily available low cost model to guide cost analysis and outcomes that drive margin and quality. Fry et al.\textsuperscript{11} demonstrated that this type of administrative dataset can be relatively easily modified by the addition of present admission codes and readily available laboratory data to support accurate risk-stratified measurements of clinical outcomes in colectomy patients.

### Table 1

<table>
<thead>
<tr>
<th>Number of complications</th>
<th>Lap</th>
<th></th>
<th>Open</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>569</td>
<td>$7,739 ± 4,150</td>
<td>461</td>
<td>$10,935 ± 12,498</td>
</tr>
<tr>
<td>1</td>
<td>44</td>
<td>$11,878 ± 7,266</td>
<td>114</td>
<td>$13,989 ± 9,570</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>$12,465 ± 4,153</td>
<td>70</td>
<td>$18,300 ± 11,218</td>
</tr>
<tr>
<td>≥ 3</td>
<td>21</td>
<td>$24,549 ± 11,816</td>
<td>123</td>
<td>$30,529 ± 21,704</td>
</tr>
<tr>
<td>Total</td>
<td>654</td>
<td>$8,701 ± 5,765</td>
<td>768</td>
<td>$15,197 ± 15,593</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Readmits</th>
<th>Lap</th>
<th></th>
<th>Open</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgical</td>
<td>45</td>
<td>$15,496 ± 11,247</td>
<td>80</td>
<td>$24,404 ± 20,514</td>
</tr>
<tr>
<td>Medical</td>
<td>20</td>
<td>$11,796 ± 5,663</td>
<td>51</td>
<td>$23,931 ± 19,434</td>
</tr>
<tr>
<td>Total</td>
<td>65</td>
<td>$14,358 ± 9,972</td>
<td>131</td>
<td>$24,220 ± 24,835</td>
</tr>
</tbody>
</table>

### Warranty costs

\[ \text{Warranty cost} = (\text{episode cost} \times \text{number of episodes})/\text{total patient population of 1,422}. \]

\( \text{ANOVA} = \text{analysis of variance}; \text{Lap} = \text{laparoscopic}; \text{n} = \text{number of patients in the group}; \text{SD} = \text{standard deviation}. \)

\( \ast P < .001 \text{ ANOVA}. \)
We paralleled the work of the PROMETHEUS model which allows the provider to assess the total cost of care and the impact of both implementing preventative strategies and covering the cost of PAC’s that occur with a predictable frequency.\(^\text{10}\) Interestingly, our work also parallels an analysis performed by Fry et al\(^\text{11}\) using a large administrative database and institutional cost-to-charge ratios for an analysis of colectomy. They identified a required hospital care cost of $4,723, and risk adjustment increased cost by an average of $1,219 per case. They then addressed the impact of adverse outcome which was defined as an inpatient death or a risk-adjusted postoperative LOS outlier. This analysis added $4,235 for risk adjustment, and $2,339 for death for an average price of a warranty to cover all these costs of $1,446. An additional $282 per case was allocated to the stop-loss pool to cover extraordinary costs of catastrophic adverse outcomes. The total cost of $9,843 in the work presented by Fry et al was very similar to our base cost of $7,738 for laparoscopic colectomy and $10,934 for open. Therefore, efficient evidence guided outcomes driven care can indeed be cost effective. The gap in the Fry analysis is how to define either actionable reasons for outlier care or alternatively sites consistently unable to deliver high-value colectomy care.

The PROMETHEUS group found only a weak correlation between the severity index of a provider’s patients and provider’s profit margins.\(^\text{10}\) Conversely, our data for a surgical population confirmed that elderly patients and urgent or emergent colectomy were both associated with significant increases in warranty cost primarily because of the increased number of complications occurring per patient. Our analysis also confirmed that the most costly outcomes are usually multifactorial and unlikely to be mitigated by a globally implemented set of process measures. Therefore, it would be reasonable for the provider to expect a premium for the management of older, more complex colectomy populations for selective referral to specific units.

We believe that the proposed economic analysis provides a better framework for both identification of high quality and accurate payment based on clinical outcomes. The payer would be able to better assess the breadth of outcomes, including the fact that certain clinical outcomes will always occur at a predictable frequency. The provider would be rewarded for superior performance because reimbursement would include both the base cost of care and warranty costs. The superior performer would be rewarded with a higher contribution margin, whereas the challenged performer would have an economic incentive to offset effective quality improvement.

**Conclusions**

The data suggest that within this single structured system of colorectal surgical care, the total warranty cost for Lap is significantly less per patient compared to open ($443 vs $4,029) to cover both the index and any readmission risk. This type of analysis can allow an institution to independently analyze both the patient referral base and practice patterns to better determine appropriate contracting. Although further refinement is necessary, these types of data would provide a better approach to value-based purchasing for patients and a better strategy to institution-specific quality improvement based on cost abatement/mitigation.

**References**


**Discussion**

Conor P. Delaney (Cleveland, OH): How well matched were the open and laparoscopic cases? Were they the same or different surgeons? and where did you fit conversions into that, matching first? Were these actual or modeled costs?

Senagore: We really didn’t try to match. The reason was, we took a construct of, let’s just take our best possible performance and then try to figure out the things that drove the cost structure from there. It was the same group of surgeons that did both the Lap and open, and generally the indications to do Lap and open were very similar amongst the surgeons. You know, generally how squishy cost accounting is at the hospital level. This was really, I think reasonably
tight data tied to the general ledger. So it’s probably about as close as we could get to acquisition costs.

Delaney: You excluded the rare complications and the rare outliers. Often those are most expensive or worst cases, because you’re trying to look at process, more of a process control model, or was there other reason for that?

Senagore: I think when we tried to look at that, you know, when we took a patient where all the wheels came off, it was, first of all, harder to decide what came first, what was the complication that did that, and how many complications were due to another complication? And so at a point in time we realized, thankfully, that it only happened to a small percentage of patients, that it was better just to focus on the normal and just say down here, we really couldn’t come up with a good care plan. Clearly, if I knew who was going to have an anastomotic leak, I would send them all to you, but, you know, I think the predictability of some of these things we can mitigate. Some things I think we really don’t have an option. And they are going to occur with a predictable, low level frequency.

Delaney: Finally, then, the implications both for the surgeon and for the hospital. So for the surgeon, hospitals are going to start using these kinds of numbers to compare outcomes between us, and then again for the hospitals as tertiary referral centers, they are going to use these numbers as ways to pick cases to do and cases to transfer, things like that.

Senagore: I think if you actually had this data, it would actually make a cleaner argument with the payer and you, you can have my base cost if that’s what you are going to send me. If you are sending me this, that’s the Ferrari. That’s $225,000, if you want me to do that. Or send it to someone else that either out compete me or avoid the complication. I think the current payment structure really doesn’t adequately reward taking care of the more difficult, complex things, and it tends to overcompensate doing a better job on the more simple things.

William C. Cirocco (Columbus, OH): Tony, I had a quick clarification. Your data, was it elective open versus elective Lap? Because in the abstract you mentioned open emergent, which obviously is the largest warranty group. But that wasn’t embedded in the –

Senagore: We took 2 strategies. One was elective versus elective Lap? Because in the abstract you mentioned open emergent, which obviously is the largest warranty group. But that wasn’t embedded in the –