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Research Article

Using Flexible Regimentation to Standardize Surgical Technique and the Impact on Supply Cost and Operation Time in Laparoscopic Appendectomy

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Abstract

Introduction: Laparoscopic appendectomy is a common procedure with variable supply costs that do not necessarily correlate with outcomes. The aim of this study was to evaluate the impact of using less expensive supplies on supply costs, operation times, and operation outcomes and describe how such changes can be introduced and disseminated.

Methods: The Model for Improvement was used to drive the improvements described. Process mapping and flexible regimentation were used to determine which appendectomy steps could be standardized. Supply costs, operation times and outcomes were evaluated for all patients who underwent uncomplicated laparoscopic appendectomy by a single surgeon before and after the implementation of a lower supply cost preference card. Our aim was to decrease supply costs for laparoscopic appendectomy by 50% at a free-standing children's hospital within one year.

Results: Sixty-three patients underwent laparoscopic appendectomy for uncomplicated (nonperforated) appendicitis by the selected surgeon over the one-year study period. Supply costs decreased from approximately $2,000 to $1,000 per case and subsequently to approximately $250 per case, with no initial explanation for the stepwise decrease and no change in complications or operative time. Subsequent investigations using statistical process control revealed systemic discrepancies in the supply charge entry process secondary to COVID-19-related delays in system updates.

Conclusions: Using less expensive supplies in laparoscopic appendectomy decreased costs with no negative impact on operation time or outcomes. Careful assessment of the data revealed systemic improvement opportunities.

Keywords: *Appendectomy, Supply Cost, Variation, Standardization, Flexible Regimentation*

Introduction

Laparoscopic appendectomy is one of the most commonly performed procedures in children [1]. As a result, it is an excellent candidate treatment protocol for standardization. Multiple studies have demonstrated the positive impact of standardization on cost, quality, and safety metrics [2,3]. However, resistance to standardization can arise because of its potential or perceived impact on the ability of physicians to make the best clinical decisions for their patients. To address this issue, the concept of "flexible regimentation" has been introduced by ThedaCare; this concept refers to the preservation of physician autonomy while allowing key treatment steps to be standardized [4]. Specifically, the idea of regimentation refers to the implementation of a standard process for "performing a specific service based on the best available evidence," and flexibility refers to the ability for continued optimization.

Finally, engaging providers in recognition of the value of standardization can also be difficult.

We present an approach in which a single surgeon led a quality improvement project aimed at reducing costs and improving the quality and safety of appendectomies. The outcomes of the project will be shared with multiple surgeons. In this study, we evaluated whether changes in the operative technique of a single surgeon resulted in lower costs or affected operation durations and outcomes. Ultimately, standardizing certain aspects of surgical practice helps create a repeatable, reliable system for managing improvements and ensuring safety.

Methods

Study Design and Setting: This quality improvement project was implemented by a single surgeon at an urban children's hospital using the Model for Improvement [5]. This interrupted time series was deemed a quality improvement project by the Institutional Review Board and thus Human Ethics, Consent to Participate and Clinical Trial Number declarations were not applicable. There was no study funding, and the authors declare no conflict of interest. Data on the operation duration and supply costs were obtained from the Cerner electronic health record (Oracle Cerner, North Kansas City, MO) using Qlik Sense software (Qlik, King of Prussia, PA) after the conclusion of the study period.

At our hospital, nine surgeons perform over 700 laparoscopic appendectomies every year. Surgical supply costs per operation range from just over $200 to over $2,000, depending on the surgeon's equipment preferences. The operating room time is even more expensive. However, surgeons with higher costs do not necessarily have fewer complications or decreased operative times (Figure 1).

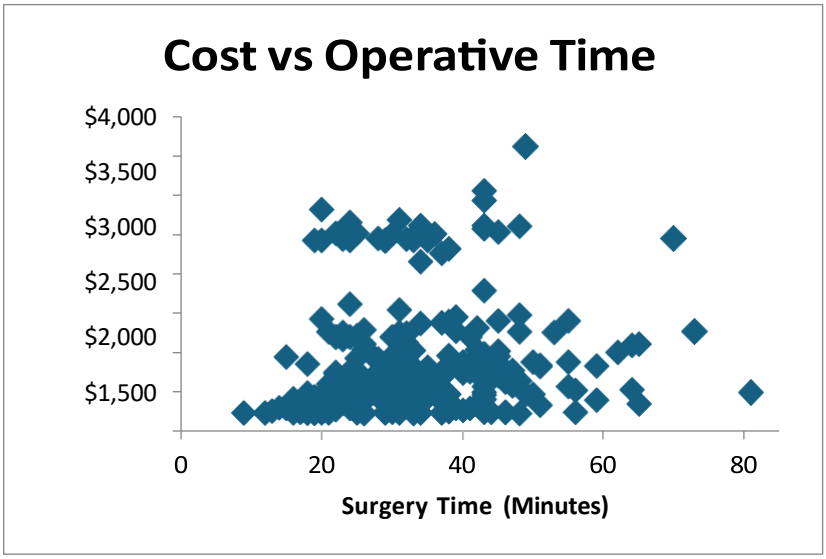


Figure 1. *Cost vs. Operative Time.*

Higher costs did not correlate with decreased operative time (Figure 1) or fewer complications (data not shown).

A retrospective review of all past appendectomies over a 12-month period was performed. The preferences of the surgeon with the lowest supply costs were examined and then emulated. A Pareto analysis of supply expenditures demonstrated that the greatest opportunity for cost savings was to avoid the use of expensive endomechanical devices such as ultrasonic tissue sealers and staplers (Figure 2).

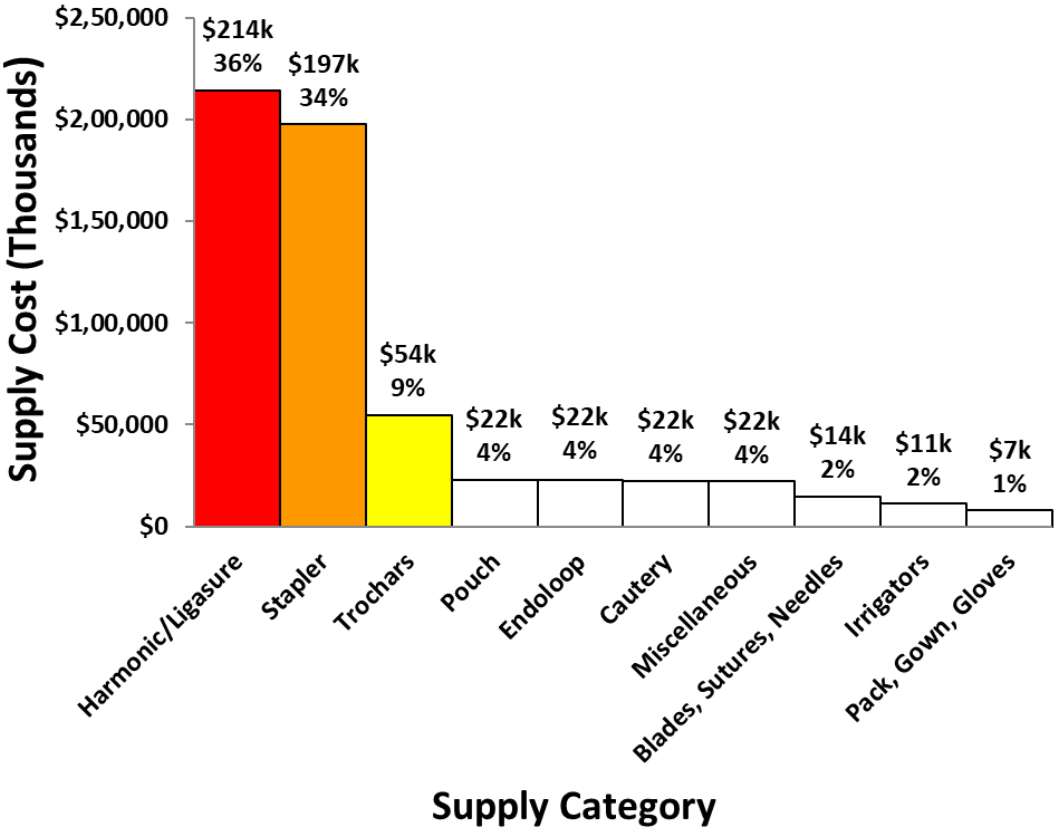


Figure 2. *Pareto distribution of supply costs.*

Iterative Improvements and Related Analyses: A single surgeon participated in the study. To protect proprietary supply contract information, specific manufacturer identification is not reported in this study. All 63 patients who underwent laparoscopic appendectomy by a single surgeon were included in the 12-month study period; 18 had ruptured (complicated) appendicitis, and 45 had simple (non-ruptured or noncomplicated) appendicitis. The 45 simple appendectomies were evaluated. The primary outcome measure was the actual supply cost, whereas the balancing measures were the operative time in minutes and complication and readmission rates (Figure 3).

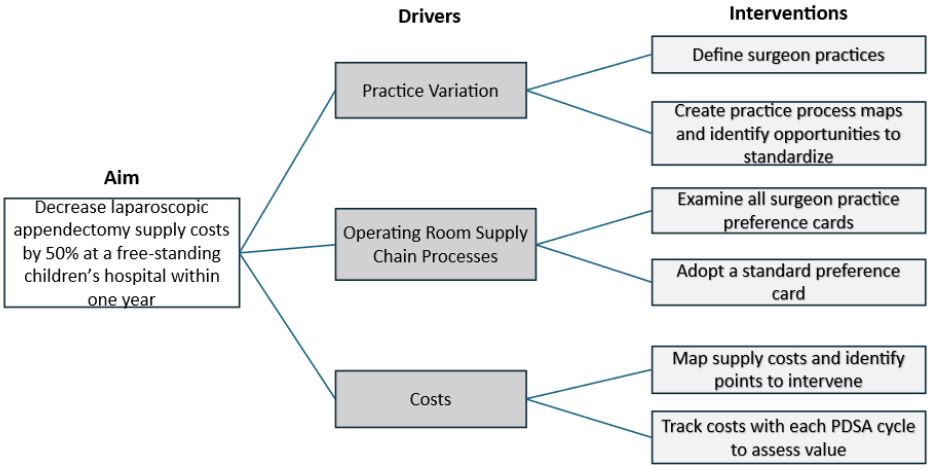
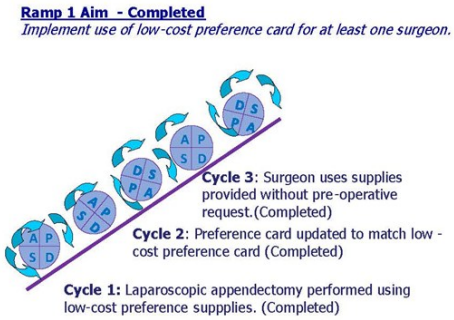


Figure 3. *Key Driver Diagram.*

In the first plan–do–study–act (PDSA) cycle (cases 13–20), the operating surgeon verbally requested lower-cost supplies, including electrocautery, in place of an endomechanical tissue sealer, and ligatures rather than a stapler to close the appendiceal stump; however, the preference card indicating the surgeon's preferred supplies was left unchanged. During the second PDSA cycle (cases 21–29), the surgeon requested an update to the preference card to reflect their preferences for the lower-cost supplies. In the third cycle (cases 30–46), no specific supply requests were made at the start of the case; instead, the surgeon relied on the use of the revised preference card (Figure 4).

Figure 4: PDSA Cycles



All the statistical process control charts were created using QI Charts and QI Macros software (Denver, CO). Charts were phased using the standard criteria described by Provost and Murray [6].

Results

Supply costs

The operative costs of the different appendectomies performed by a single surgeon decreased over the three PDSA cycles (Figure 5). Importantly, these stepwise declines did not directly correspond to the PDSA cycles as expected. While case #13 represented the first laparoscopic appendectomy performed using the new protocol, changing from using both the harmonic scalpel and the stapler to using neither, costs did not begin to decline until case #20, with a further decline observed starting from case #26.

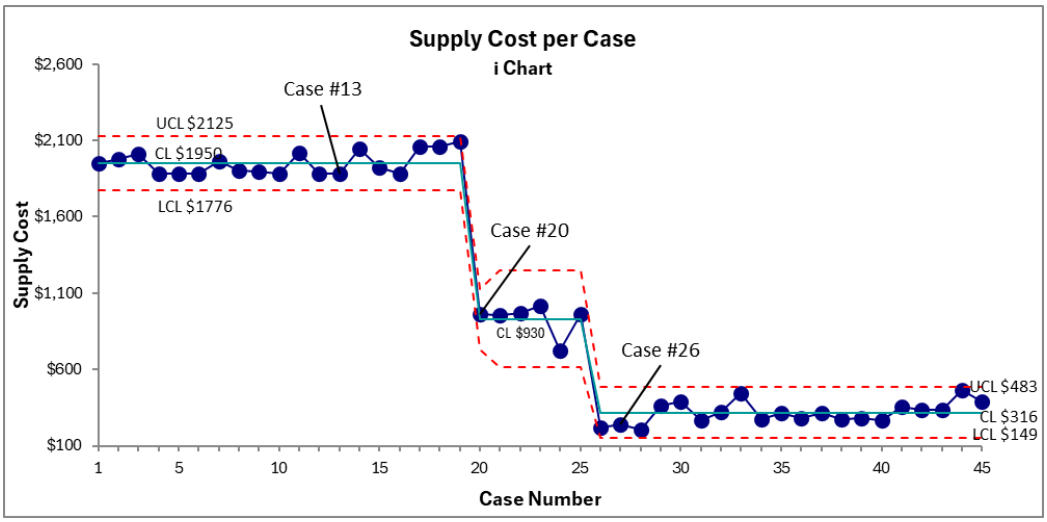


Figure 5. *Surgical supply cost for each appendectomy. Case 13: Use of low-cost supplies. Case 20: Supply switch to lower cost reprocessed endomechanical devices. Case 26: Low-cost preference card finally entered into system.*

The reasons why our predicted decline in costs did not occur when expected led to further analysis of the reason for this. The surgeon confirmed in each case that higher-cost items were not opened and not used, eliminating this as a reason for the higher-than-expected supply costs. To better understand the discrepancy, further analyses of the cost account system revealed that the standard billing practice of the surgical team was to enter supply charges based on the preference card rather than entering individual supplies as they were opened.

While the preference card change was requested beginning with case #13, it was not actually changed in the system until case #26, when the second decrease in cost was observed.

The initial drop in cost with case #20 coincided with an unrelated change in the preference card to allow the use of less costly reprocessed staplers and a harmonic scalpel due to supply shortages. The final drop in case #26 occurred when the preference card was finally updated to reflect the fact that neither the stapler nor the harmonic scalpel had been used.

During the period of cost discrepancy, the OR staff opened the less expensive equipment at the surgeon's request rather than following the outdated preference card, but the charges reported corresponded to the outdated preference card.

Significant staff turnover related to the COVID-19 pandemic resulted in cost entry workarounds with substantial unforeseen consequences. An extensive overhaul of the entire supply cost recording process was then undertaken across all cases in the operating room to ensure that charges more closely reflected actual utilization.

Surgical duration and patient outcomes

Operative time was unchanged throughout the duration of the study (Figure 6). No reported complications or readmissions occurred during the study period.

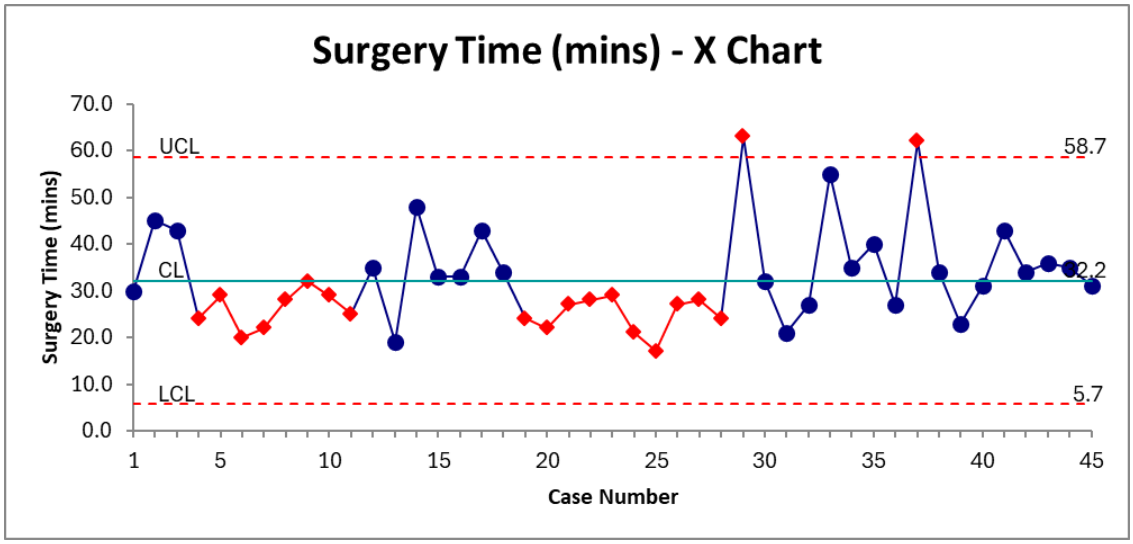


Figure 6. *Operative duration per case.*

Discussion

Creating a culture of innovation and improvement takes considerable effort. The literature offers many examples of such improvements implemented by organizations with established cultures of value-driven improvement and innovation. We describe a methodology for establishing value-based changes in the clinical implementation of a common surgical intervention. Having successfully developed a model for delivering higher-value care, we now aim to extend this approach across the remaining pediatric surgeons to enhance patient outcomes.

The variability in operating room supply costs among surgeons performing laparoscopic appendectomy, including at our hospital, is well described. Likewise, efforts to standardize equipment selection have been shown to reduce costs in laparoscopic appendectomy in both adults and children [7-9]. Through the application of flexible regimentation, the key steps to improve outcomes while reducing costs were identified. Standardization has also been shown to improve patient safety through decreased variation. Supporting these ideas, this study revealed that using cheaper alternatives to technologies such as harmonic scalpels or endoscopic staplers decreased costs with no undesired effects on operating room time, complications, or readmissions.

Surgeon satisfaction with instrument selection was more subjective and thus not quantified in this study.

The more impactful insights of this study were gained from thoroughly investigating discrepancies between the predicted and actual supply costs. Accurate cost accounting and reporting is often a challenge for hospital systems. Like many other health care institutions, our hospital experienced significant personnel turnover during the pandemic, with staff having to perform both clinical and nonclinical tasks. By necessity, new and temporary staff were trained in patient care first, leaving supply documentation to be a lower priority. By analyzing the apparent discrepancy between reported and actual supply utilization, an issue with supply charge capture and reporting was discovered and corrected quickly. Without the use of statistical process control charts, this issue might have gone unnoticed for multiple procedures. The next steps in this quality improvement effort involve standardizing the preference card for other surgeons performing the same procedure at our hospital.

Conclusions

The use of less expensive surgical supplies in pediatric laparoscopic appendectomy resulted in lower costs with no negative impact on operative time, complications, or readmissions. A thorough evaluation of initially unexplained discrepancies in reported and expected costs resulted in the identification of systemic process issues, which were subsequently corrected.

Conflict of Interest

The authors declare no conflict of interest.

Acknowledgement

None.

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