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Elimination of waste: creation of a successful Lean colonoscopy program at an academic medical center

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Abstract
Objective Lean processes involve streamlining methods and maximizing efficiency. Well established in the manufacturing industry, they are increasingly being applied to health care. The objective of this study was to determine feasibility and effectiveness of applying Lean principles to an academic medical center colonoscopy unit.
Methods Lean process improvement involved training endoscopy personnel, observing patients, mapping the value stream, analyzing patient flow, designing and implementing new processes, and finally re-observing the process. Our primary endpoint was total colonoscopy time (minutes from check-in to discharge) with secondary endpoints of individual segment times and unit colonoscopy capacity.
Results A total of 217 patients were included (November 2013–May 2014), with 107 pre-Lean and 110 post-Lean intervention. Pre-Lean total colonoscopy time was 134 min. After implementation of the Lean process, mean colonoscopy time decreased by 10 % to 121 min ($p = 0.01$). The three steps of the process affected by the Lean intervention (time to achieve adequate sedation, time to recovery, and time to discharge) decreased from 3.7 to 2.4 min ($p < 0.01$), 4.0 to 3.4 min ($p = 0.09$), and 41.2 to 35.4 min ($p = 0.05$), respectively. Overall, unit capacity of colonoscopies increased from 39.6 per day to 43.6. Post-Lean patient satisfaction surveys demonstrated an average score of 4.5/5.0 ($n = 73$) regarding waiting time, 4.9/5.0 ($n = 60$) regarding how favorably this experienced compared to prior colonoscopy experiences, and 4.9/5.0 ($n = 74$) regarding professionalism of staff. One hundred percentage of respondents ($n = 69$) stated they would recommend our institution to a friend for colonoscopy.
Discussion With no additional utilization of resources, a single Lean process improvement cycle increased productivity and capacity of our colonoscopy unit. We expect this to result in increased patient access and revenue while maintaining patient satisfaction. We believe these results are widely generalizable to other colonoscopy units as well as other process-based interventions in health care.

Keywords Lean · Process improvement · Colonoscopy · Quality improvement

The use of colonoscopy as a screening tool for colon and rectal cancer has been widely validated and has the potential to prevent approximately 65 % of colon and rectal cancers [1]. This procedure may be carried out in either an endoscopy suite or operating room in both the inpatient and outpatient setting [2]. Use of these facilities incurs significant costs, particularly when non-procedural time is high [3]. In order to remain competitive in an increasingly cost-conscious healthcare system, both hospitals and individual practitioners are expected to provide high-quality care while minimizing costs.

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Initially derived from the Toyota Production System in the 1980s, Lean process improvement focuses on adding value by eliminating waste [4]. Waste is considered the expenditure of any resource (time, money, material, etc.) that does not directly lead to the end product.

Well established in the manufacturing industry, Lean principles are increasingly being applied to health care [5–7]. Rather than being a one-time fix for complicated problems, Lean healthcare delivery depends on continuous process improvement from multidisciplinary teams that ultimately aim to transform the culture of an organization [8].

In the manufacturing industry, multiple steps are taken to turn raw materials into a completed product. These processes are repeated multiple times per hour or day, and small decreases in waste can result in significant increases in efficiency and throughput. Similarly, colonoscopy requires several steps from pre-procedure to recovery. As these steps are repeated several times per day, we hypothesized that when Lean management tools were applied to an academic medical center colonoscopy unit, efficiency and throughput would increase. In addition, we aimed to perform this process improvement with no additional utilization of resources such as staff or equipment.

Methods

Setting

UMass Memorial Medical Center is a 779-bed tertiary care academic medical center located on three campuses in Worcester, MA. Colonoscopies are performed at one of the three endoscopy suites. Our Lean pilot study was conducted at the Memorial Campus consisting of 4 endoscopy rooms, staffed by 14 endoscopists, 12 nurses, 4 technicians, and 1 secretary. Approximately 3200 colonoscopies are performed at this campus per year (30 % screening, 13 % surveillance, 44 % diagnostic, and 13 % other). Pre-Lean colonoscopies were performed by eight endoscopists and post-Lean by six endoscopists.

Aim

The initial push for process improvement stemmed from a recent change in procedural sedation from midazolam to propofol. As propofol has been demonstrated to have a shorter recovery period, it was unclear why total colonoscopy time did not decrease following the switch at our institution [9, 10]. We therefore hypothesized that there were inefficiencies within the colonoscopy process itself.

Study design

After determination from the institutional review board that the project was quality improvement (not human research), it was exempted from further review. We then initiated a Lean project to improve the efficiency of our colonoscopy process. This involved Lean training for endoscopy personnel, observing patients undergoing colonoscopy, mapping the value stream, analyzing patient flow, redesigning and implementing new processes, and finally re-observing the process. Our primary endpoint was *total colonoscopy time*, measured as total amount of time (minutes) from check-in until discharge, with secondary endpoints of individual segment times and unit colonoscopy capacity.

The project was initiated by creating a charter identifying project leadership and team members from various departments including surgery, anesthesiology, and nursing. Key stakeholders involved in the project were staff colorectal surgeons, gastroenterologists, a surgical resident, the director of perioperative services, staff anesthesiologists, certified registered nurse anesthetists (CRNAs), the nurse manager of endoscopy, unit nurses, endoscopy technicians, and the unit secretary.

The overall problem, purpose of the project, inclusion and exclusion criteria, and time-specific goals were outlined with the aid of a process improvement charter (Fig. 1). The specific problem identified by our group was that total colonoscopy time was excessive leading to decreased capacity of the endoscopy unit, decreased patient access, and low patient satisfaction.

To create our value stream map (VSM), we identified all steps patients partake in from registration to discharge and how long each component took in order to undergo colonoscopy. In addition, we identified each sub-task required to progress from one step to the next, as well as the undesirable elements or problems associated with each step. This was combined with pre-Lean times to complete our VSM (Fig. 2). From the undesirable elements, we selected the four that were felt to be the highest yield in terms of time wasted and feasibility to fix.

Statistical analysis

Once collected on paper forms, data were entered into and managed using Microsoft Excel (c) version 14.3.9 (Microsoft, Redmond WA). A two-tailed t test was used to compare mean segment time and total colonoscopy time between the pre-Lean and post-Lean groups. Significance was set to $p < 0.05$. Statistical analysis was performed using Stata IC (c) version 12.1 (StataCorp, College Station TX). Missing data for individual segment times were excluded; however, as long as check-in and discharge time were recorded, total colonoscopy time was calculated. The

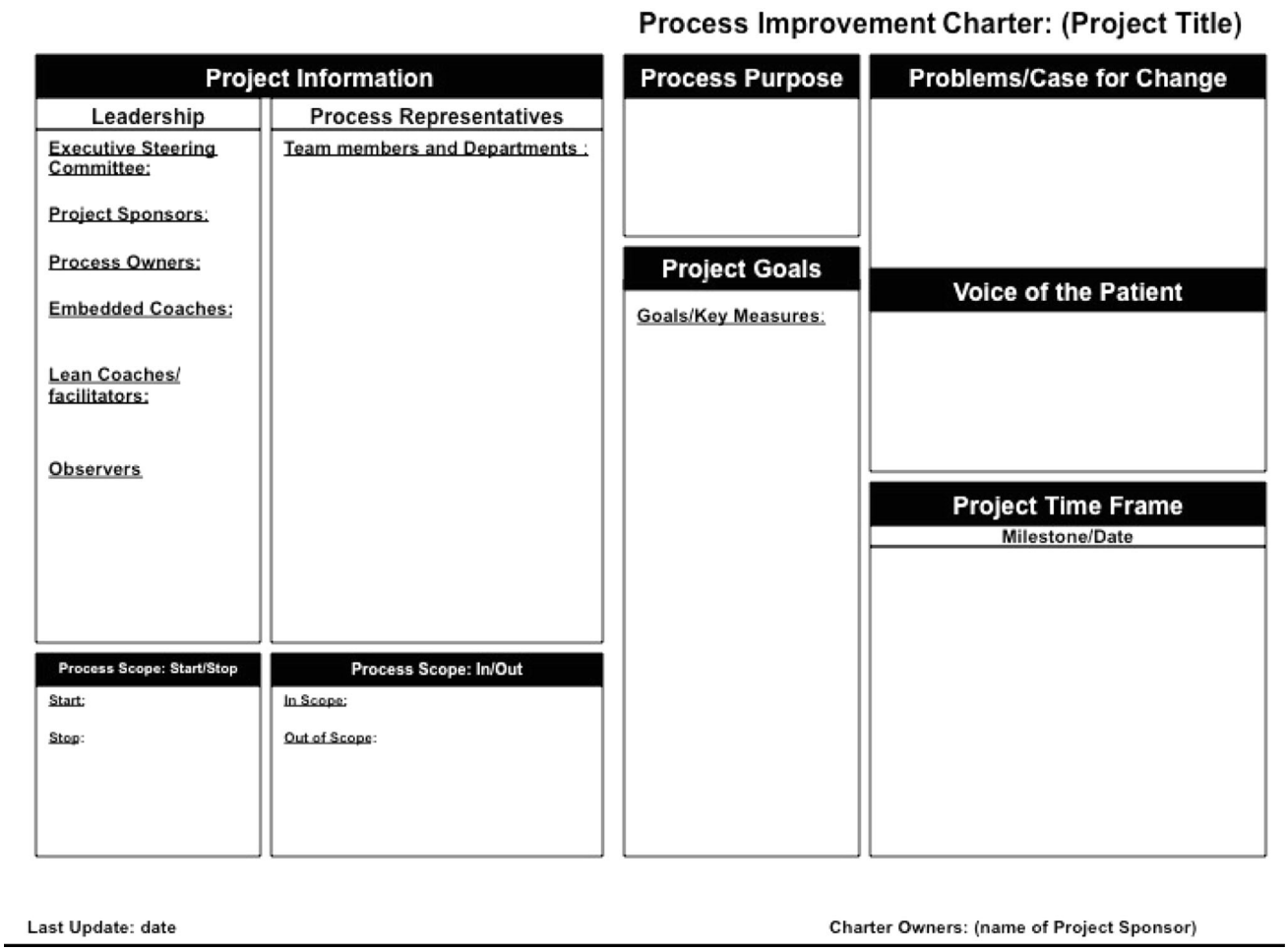

Fig. 1 Example of process improvement charter

study was powered to detect a 10 % difference between groups.

Results

Significant findings and interventions

We identified several problems through this process. An early finding was that no single individual had a detailed understanding of all steps of the process from registration to discharge, underscoring the importance of the multidisciplinary nature of the team. Identified problems were analyzed on a scale of 1–3 regarding their negative impact as well as 1–3 regarding their feasibility for improvement. The top four choices were selected for volunteer work groups to create solutions and are listed below.

1. *Inconsistent sedation delivery* Initially, it was unknown to our group that different anesthesia providers delivered propofol in different ways (bolus versus drip infusion). These different methods of administration have different pharmacokinetics affecting the time required to reach adequate sedation. By bringing this to light in our initial quality improvement meeting, we were able to establish a uniform delivery protocol and reduce the time it took for patients to reach an adequate level of sedation for colonoscopy.
2. *Inadequate communication* Prior to our intervention, a lack of communication between the endoscopist and anesthesiologist led to either inadequate sedation during the procedure resulting in increased colonoscopy time and patient discomfort, or over sedation at the end of the procedure leading to a prolonged recovery time. We therefore created a standardized communication time (i.e., when the cecum was reached) for endoscopists and anesthesia personnel. This provided an opportunity for everyone in the room to clarify whether the procedure was nearing its end, or whether further interventions, such as polypectomy, would be performed. Provider communication was

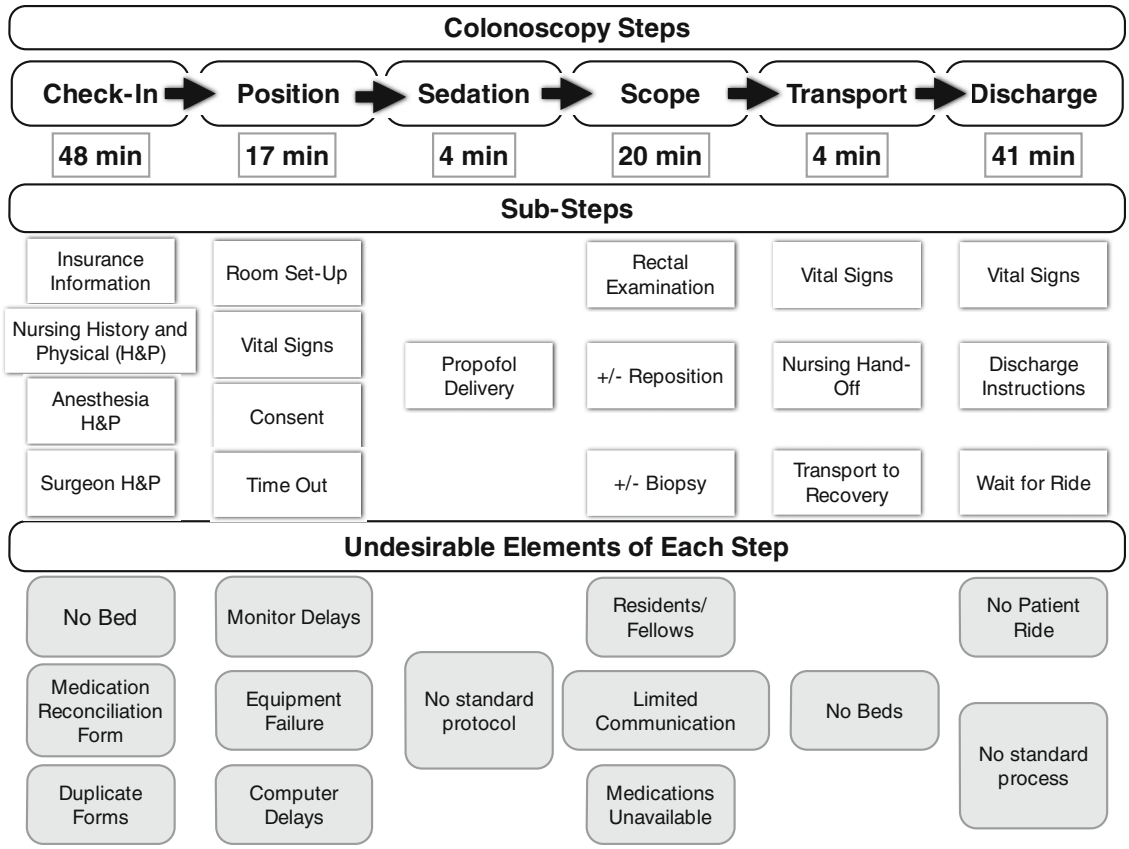

Fig. 2 Pre-Lean intervention value stream map and average times

recorded as part of the standard nursing checklist during the procedure.

3. *Inability to accommodate faster recovery* As our center made a recent change from midazolam to the shorter acting propofol for sedation, post-procedure nurses were often not ready to discharge patients by the time they recovered. When individual nurses were asked how they discharged patients, multiple answers were given. The nursing working group created a standardized discharge protocol that accommodated the faster recovery. In addition, requirements for documentation and vital signs were checked with the compliance office, and it was discovered that after our change in sedation, many of their tasks were no longer required, further expediting the discharge process.
4. *Redundancy of paperwork* Endoscopists, anesthesia providers, and nursing were all required to complete individual history and physical forms in addition to the endoscopy and anesthesia consent forms. There was significant overlap between the three forms, and filling them out leads to significant delays in the check-in process. A series of meetings were held with the compliance office; however, we were not granted permission to change the history and physical forms. Therefore, no intervention was made.

Data analysis

A total of 217 patients were included (November 2013–May 2014), with 107 pre-Lean and 110 post-Lean intervention. Pre-Lean total colonoscopy time was 134 min. After implementation of the Lean process, mean colonoscopy time decreased by 10 % to 121 min ($p = 0.01$). The three steps of the process affected by the Lean intervention (time to achieve adequate sedation, time to recovery, and time to discharge) decreased from 3.7 to 2.4 min ($p < 0.01$), 4.0 to 3.4 min ($p = 0.09$), and 41.2 to 35.4 min ($p = 0.05$), respectively. Of the segments that did not undergo Lean intervention, none had a statistically significant change in time (Table 1). Overall, unit capacity of colonoscopies increased from 39.6 to 43.6 per day. In addition, although patient satisfaction scores were not study endpoints, post-procedure surveys demonstrated an average satisfaction rating of 4.5/5.0 ($n = 73$) in regard to waiting time. When patients subjectively rated their satisfaction on this overall colonoscopy experience compared to

Table 1 Pre- and post-Lean colonoscopy times

	Pre-Lean time (min) $n = 107$	Pre-Lean standard deviation (min)	Post-Lean time (min) $n = 110$	Post-Lean standard deviation (min)	p value
Check-in	48.4	24.2	44.1	27.4	0.23
Positioning	16.8	15.3	15.4	12.1	0.45
Sedation[a]	3.7	4.2	2.4	1.6	<0.01
Scope	20.5	11.0	21.5	11.9	0.50
Recovery[a]	4.0	3.2	3.4	2.0	0.09
Discharge[a]	41.2	23.1	35.4	18.3	0.05
Total	134.1	40.1	120.7	39.9	0.01

[a] Lean intervention

previous, the average score was 4.9/5/0 ($n = 60$). Overall courtesy and professionalism of staff were rated as 4.9/5.0 ($n = 74$), and 100 % of respondents ($n = 69$) stated they would recommend our institution to a friend for colonoscopy.

Discussion

Lean process improvement has led to increased efficiency in the manufacturing and healthcare industries. Our study demonstrates that even when carried out on a small scale, Lean process improvement can lead to a significant increase in efficiency. In addition, as other studies confirm, this increased efficiency does not necessarily come at the expense of patient satisfaction and has actually been shown to increase it [11].

Although this study did not quantify the financial impact of increased efficiency, others have demonstrated a significant effect [7]. Collar et al. [12] performed a Lean operating room (OR) turnover study that projected an annual 4500 min of added capacity, by reducing time by 20.2 min per case. Based on their estimated revenue per minute of OR time, this is translated into an additional annual potential revenue of approximately $330,000. Our study increased the capacity of colonoscopies by approximately 10 %. The 2009 American Society of Gastrointestinal Endoscopy operations survey data estimated the mean revenue per procedure to be $583 [13]. Based on these estimates, we calculate the potential annual increased revenue from our Lean intervention to be over $185,000 per year.

Lessons learned

In addition to the potential financial impact, we learned several key lessons from this project. The first lesson was how willing the staff were to improve their system when given the chance. This was purely a volunteer effort, and no employee was mandated to participate in the Lean initiative. However, it is intuitive that when provided an avenue to decrease the daily frustrations of their job, employees would take this opportunity. This held true for employees at all levels. Because of the staff's willingness to participate, we were able to evaluate problems from a broad perspective. This frontline employee involvement and empowerment to inspect and improve their own work is a key principle of Lean [14]. Many problems discussed would not have been known if this project was run entirely by physicians or administrators. We believe we were able to obtain this buy-in from our staff due to the involvement, rather than just oversight of key leaders in the endoscopy department.

The second lesson was how many easily correctable problems there were in the system. In the previous year, the colonoscopy process had undergone an attempted process improvement by management and the assumption was that most problems we encountered would be complex. After the VSM process, we were surprised to see how many easily fixable problems quickly arose. For example, the issue regarding delivery of sedation was fixed within a few minutes and only existed due to a lack of standardization and communication. Simply by getting the appropriate people in the room at the same time, we were able to provide solutions. We hypothesize that this is a widely generalizable finding in health care.

Our third key lesson came from learning what we could and could not easily fix. The goal of Lean is to maximize value-added work while eliminating waste. However, in addition to value-added work, the remainder of tasks can be divided between non-value add required activities (NVAR) (e.g., documentation required by regulatory bodies) and pure waste [15]. We encountered difficulty when trying to reduce NVAR which is very common in the medical field. While practitioners may

consider much of the NVAR work to be pure waste as it often adds little clinical value, it is critical to maintaining regulatory certification and, often, financial reimbursement. A great source of frustration to providers in our study was the duplication of forms (e.g., history and physical, consent) that take place prior procedure. However, because of their importance for regulatory reasons, they could not be changed without a major undertaking from our compliance office. Considering our initial VSM identified many other problems that were identified as pure waste and much easier to fix, this issue was temporarily abandoned. The lesson learned was that healthcare processes have a considerable amount of NVAR, and at least in the initial process improvement cycles, problems of pure waste may be easier to fix. However, we plan to readdress the issue of documentation in future process improvement cycles.

Limitations

This study does have limitations. As it was an observational, non-randomized study, there is a risk of cofounders influencing the results. In particular, as the staff were not blinded to the fact that they were participating in a process improvement study, their behavior may have influenced results. However, only the steps of the process that underwent Lean intervention had a significant decrease in time. In addition, our potential increased revenue assumes all excess capacity could be filled. Finally, patient satisfaction scores were not formal study endpoints and tested prior to the Lean intervention.

Conclusion

This study demonstrated that Lean process improvement can have a significant impact on efficiency with no additional utilization of staff or purchasing of resources. The improvement process was easily and enthusiastically embraced by frontline, medical, and administrative staff. The realized improvements can be leveraged to increase unit capacity and enhance revenue while maintaining patient satisfaction. We believe Lean process improvement to be widely generalizable across health care, but in particular for procedure-driven practices such as endoscopy.

Compliance with ethical standards

Disclosures Dr. Damle, Mr. Andrew, Drs. Kaur, Orquiola, Alavi, Steele, and Maykel have no conflict of interest or financial ties to disclose.

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