Process mapping as a framework for performance improvement in emergency general surgery

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Background: Emergency general surgery conditions are often thought of as being too acute for the development of standardized approaches to quality improvement. However, process mapping, a concept that has been applied extensively in manufacturing quality improvement, is now being used in health care. The objective of this study was to create process maps for small bowel obstruction in an effort to identify potential areas for quality improvement.

Methods: We used the American College of Surgeons Emergency General Surgery Quality Improvement Program pilot database to identify patients who received nonoperative or operative management of small bowel obstruction between March 2015 and March 2016. This database, patient charts and electronic health records were used to create process maps from the time of presentation to discharge.

Results: Eighty-eight patients with small bowel obstruction (33 operative; 55 nonoperative) were identified. Patients who received surgery had a complication rate of 32%. The processes of care from the time of presentation to the time of follow-up were highly elaborate and variable in terms of duration; however, the sequences of care were found to be consistent. We used data visualization strategies to identify bottlenecks in care, and they showed substantial variability in terms of operating room access.

Conclusion: Variability in the operative care of small bowel obstruction is high and represents an important improvement opportunity in general surgery. Process mapping can identify common themes, even in acute care, and suggest specific performance improvement measures.

Contexte : Les conditions dans lesquelles s'effectuent les interventions chirurgicales d'urgence sont souvent jugées trop pressantes pour que l'on puisse mettre au point des approches normalisées d'amélioration de la qualité. Malgré tout, la schématisation des processus, un concept largement appliqué à l'amélioration de la qualité en milieu manufacturier, est maintenant appliquée en santé. L'objectif de cette étude était de schématiser les processus suivis dans les cas d'obstruction du grêle afin de déterminer les aspects dont la qualité pourrait être améliorée.

Méthodes : À partir de la base de données pilote du programme d'amélioration de la qualité des chirurgies générales d'urgence de l'American College of Surgeons, nous avons recensé les patients ayant reçu un traitement chirurgical ou non chirurgical pour une obstruction du grêle entre mars 2015 et mars 2016. Nous avons aussi utilisé cette base de données, de même que les dossiers des patients et les dossiers médicaux électroniques, pour schématiser les processus suivis de l'arrivée à l'hôpital jusqu'au congé.

Résultats : Nous avons recensé 88 patients atteints d'une obstruction du grêle (33 soumis à une chirurgie, et 55 à un traitement non chirurgical). Les patients opérés ont présenté un taux de complications de 32 %. Les processus thérapeutiques de l'arrivée au suivi se sont avérés très détaillés et variables en durée; par contre, la séquence de soins était uniforme. Nous avons utilisé des stratégies de visualisation des données pour repérer les goulots d'étranglement au chapitre des soins, ce qui a révélé une variabilité substantielle dans l'accès au bloc opératoire.

Conclusion : La variabilité observée dans les soins chirurgicaux pour l'obstruction du grêle est élevée et représente une importante occasion d'amélioration en chirurgie générale. La schématisation des processus permet de dégager des thèmes communs, même dans un contexte d'urgence, et met en lumière des possibilités précises d'amélioration du rendement.

Emergency general surgery conditions are often thought of as being too acute and unpredictable for the development of standardized approaches to quality improvement (QI). However, the surgical literature shows that delays in acute care can cause adverse outcomes and negatively affect the patient and their health care experience.[1–3] Effective strategies to measure the process of acute care surgery may open opportunities to improve performance and optimize surgical outcomes in complex and vulnerable surgical populations.

William Edwards Deming revolutionized the manufacturing world and helped to transform Japanese automobile production when he introduced the concept of process mapping.[4] Process mapping uses a technique that breaks down complex events into individual processes and evaluates how these processes can be made more efficient. The pioneering work of Dr. Deming is epitomized by understanding and learning to manage variation.[5] Variation exists in all processes and people as well as in the outcomes that are produced in any given system. In his seminal work, he stratifies the concept of variation into common and special causes.[6] Common causes of variance are predictable, expected and natural to the system.[5] Identifying common causes is challenging; however, these variables (e.g., speed and runtime of electronic health records) generally do not require change strategies. Alternatively, special causes are new and unanticipated variables that cause variance, and these causes are defects within the system that necessitate improvement (e.g., different physician management strategies for clinical presentations).[5,7]

Process mapping in health care involves following patients through their hospital journey and documenting every interaction they have with the hospital system. The method allows providers to notice the small steps before management and discharge and identify areas of high variation and bottlenecks for future improvement. Insights from process mapping have driven large QI advances in cardiac surgury, otolaryngology and orthopedic surgery.[8–15]

We applied the first 3 steps of the Six Sigma methodology[16] — Define, Measure, Analyze, Improve and Control (DMAIC) — the business world's equivalent to the Plan, Do, Study and Act (PDSA) cycle, by measuring and analyzing variation in the patient experience of care to quantify acute care service delivery. Ultimately, our study aimed to use process mapping to deconstruct the surgical care of patients presenting to emergency general surgery services with acute small bowel obstruction (SBO). To our knowledge, process mapping has not yet been applied in evaluating the delivery of acute care surgery services.

Methods

Ethics approval was granted at our tertiary health care centre. We used the American College of Surgeons (ACS) Emergency General Surgery Quality Improvement Program (EQIP) pilot database to identify patients presenting to a single, large teaching hospital over a 1-year period (Mar. 1, 2015, to Mar. 1, 2016), for the nonoperative or operative management of SBO.

Inclusion and exclusion criteria were defined by the ACS EQIP pilot. Inclusion criteria were diagnosis of SBO by a physician, admission to hospital or observation unit and imaging consistent with SBO. Patients had to be older than 18 years and admitted to the general surgery acute care service. Exclusion criteria were SBO occurring within 4 weeks of pelvic surgery; SBO occurring secondary to a ventral, inguinal or femoral hernia; SBO secondary to Crohn's disease; or SBO occurring more than 48 hours after a patient's hospital admission.

The EQIP database as well as charts and electronic health records were used to create process maps for each patient from the time of onset of symptoms to the time of discharge. The time points for which we collected data included time to emergency department (ED) triage, assessment by an ED physician, computed tomography (CT) scan, general surgery consult request, assessment by a general surgeon, admission to the general surgery service, transport to the ward, operative case booking, arrival in the operating room (OR) and discharge. We also collected time of admission and discharge to the intensive care unit (ICU) where applicable. Data for most time points were gathered from paper charts; however, time to the ED and time of discharge are recorded electronically, so we collected these data from the electronic charts. We evaluated the process maps to identify important process issues and their potential impact on clinical outcomes. We used Microsoft Excel version 15.18 for statistical analysis.

Results

Patients presenting with SBO at our tertiary level 1 trauma centre, Vancouver General Hospital, between Mar. 1, 2015, and Mar. 31, 2016, were stratified into 2 groups based on their treatment and management (Fig. 1). A total of 88 patients were included: 33 (40%) were managed operatively, and 55 (60%) were managed conservatively. The differences in the mean age (66.3 ± 17.6 yr v. 67.5 ± 17.3 yr, $p = 0.75$) and sex (21 [57%] men v. 29 [53%] men, $p = 0.70$) between the operative and conservative management cohorts, respectively, were not statically significant. Similarly, the difference in medical comorbidities between the groups was not significant (Table 1).

Evaluating the mean process intervals and standard deviations of conservatively managed patients showed an unexpectedly high degree of variation in the time interval of care for patients with SBO (Table 2). The greatest amount of variability was in transferring these patients to the ward after admission to the acute care surgery service (259 ± 257 min). There was also a longer time and variability associated with time from emergency physician evaluation and

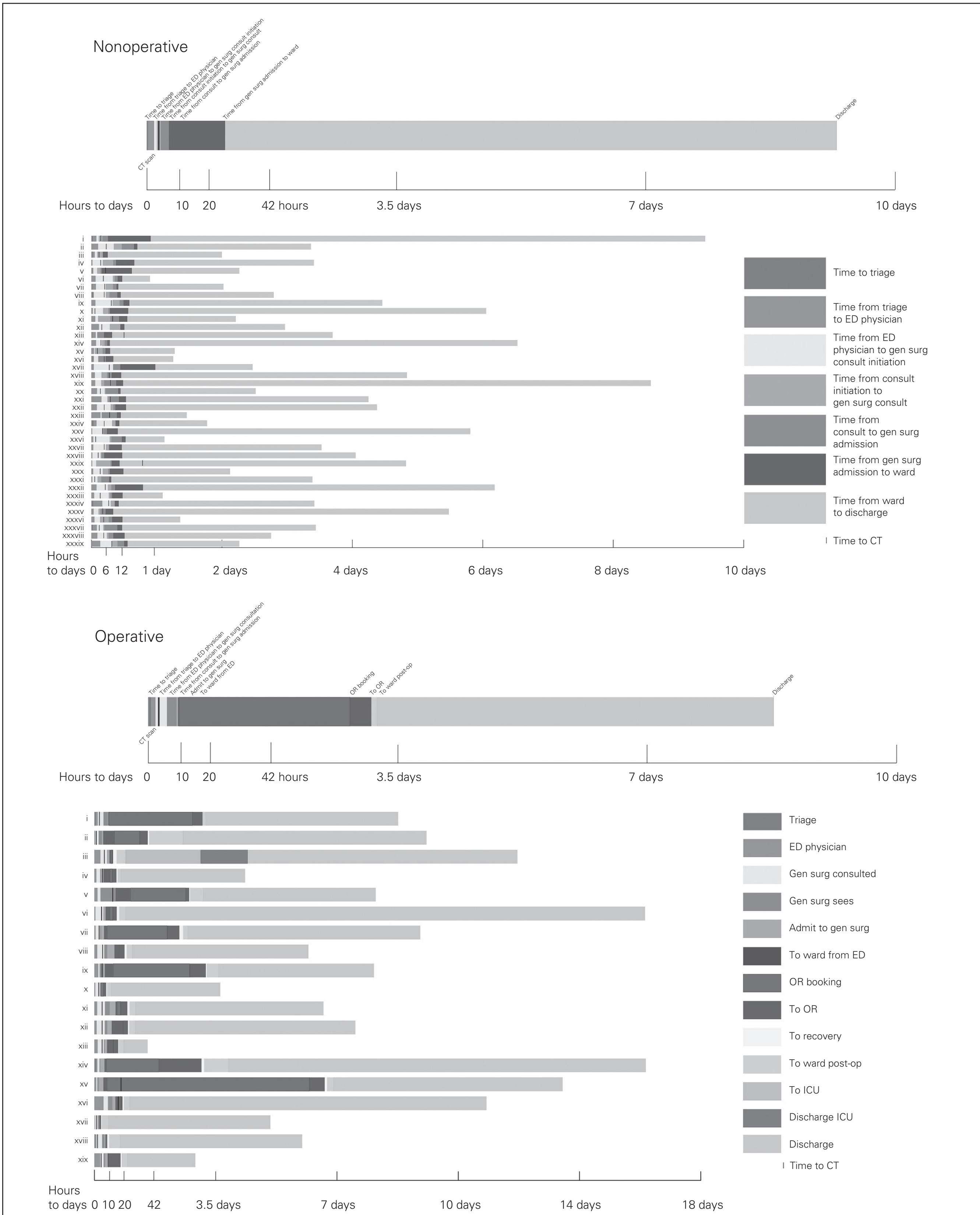

Fig. 1. Mapping the process and flow of a patient with small bowel obstruction from presentation to the emergency department (ED) to discharge from the acute care surgery service. Nonoperatively managed patients are represented in the top map, and operatively managed patients are represented in the bottom map. CT = computed tomography; ICU = intensive care unit; OR = operating room.

CT scan request (112 ± 171 min), which remains the mainstay and gold standard of diagnosis of SBO. The interval between being seen by an ED physician and receiving a consult with the acute care surgery team was also longer and unpredictable.

The process intervals of the operatively managed patients show similar trends of variability (Table 3). The period of time between evaluation by the ED physician and request of CT scan (121 ± 153 min) and between triage and being seen by an ED physician (74 ± 76 min) had greater degrees of variation. In addition, the time required to complete the consult (114 ± 167 min), to admit the patient to the acute care surgery service after the consult (165 ± 220 min) and to arrive in the OR after booking (442 ± 400 min) were also identified as areas in the patient's stay that faced increased variability.

In addition to reviewing the journey of surgical patients through the hospital, we also further stratified the time from OR booking to arrival at the OR to assess the efficiency of the acute care service in meeting expected intervals based on the patient's priority level (Table 4). Patients booked as an E1 owing to hypovolemic shock or peritonitis in the context of an SBO are our highest priority, meaning they should arrive in the OR within 1 hour of booking; these patients never arrived at the OR within the expected time limits. Most patients were booked as an E2 (arriving in the OR within 8–12 h of booking); although 69% of these patients arrived within the expected interval, there was a higher rate of variability and the mean was outside the expected 720 min (746 ± 893 min). Finally, the ACS service has protected OR time, and of the cases completed during these times, 80% were within their booked priority level's time expectations.

Discussion

Variation in the clinical setting is unavoidable, and although some variation is expected owing to the complexity of cases and individual patient characteristics, there are differences in productivity, utilization of services and flow.[7] Adding capacity and ORs addresses only part of this variation, and a deeper assessment of how patients flow through the system can further assist in identifying obstacles and bottlenecks that can be improved. Length of stay and waiting times have become benchmarks of quantifying clinical outcomes; however, our study further stratifies the overall hospital experience into granular periods of time that represent the steps in the clinical management of patients with SBO.

In our study and hospital environment, a source of variation in the operative and conservative management strategies of patients with SBO was during the time in the ED. Delays in requesting clinical imaging led to increases in mean time and variability in initiating an acute care surgery team consult. Additionally, these delays also led to downstream effects for the acute care surgery team and their ability to assess the patient and make relevant clinical decisions about management and treatment.

Another area of clinical variation was in getting our operatively managed patients to the OR. Although this is a well-established barrier affecting surgeons globally,[17] we found that most of the high-priority cases were not getting to the OR in the expected intervals largely because of capacity issues. However, the acute care surgery service at our institution has protected OR time that can be used for urgent cases, and our findings show that this time was being used effectively. The protected time led to patients receiving their surgeries within the expected interval who may not have if it was not for the dedicated time set aside for the acute care surgery teams. Our sample size for this finding is small and reflects a need for further data collection and analysis.

Table 1. Demographic and clinical characteristics of the operative and conservative management cohorts of patients with small bowel obstruction

	Group; mean ± SD or no. (%)		
Characteristic	Operative, *n* = 33	Conservative, *n* = 55	*p* value
Age, yr	66.3 ± 17.6	67.5 ± 17.3	0.75
Male sex	21 (56.8%)	29 (52.7%)	0.70
Comorbidities			
Diabetes mellitus	4 (10.8%)	4 (7.3%)	0.56
Hypertension	16 (43.2%)	21 (38.2%)	0.63
Acute renal failure	0 (0%)	1 (1.8%)	0.42
Congestive heart failure	0 (0%)	0 (0%)	> 0.99
Ascites	0 (0%)	1 (1.8%)	0.42
COPD	0 (0%)	1 (1.8%)	0.42
Smoker	5 (13.5%)	6 (10.9%)	0.71
Disseminated cancer	1 (2.7%)	6 (10.9%)	0.15
Steroid use/ immunosuppression	3 (8.1%)	3 (5.5%)	0.62

COPD = chronic obstructive pulmonary disease; SD = standard deviation.

Table 2. Mean process interval outcomes for conservative (nonoperative) management of small bowel obstruction

Process interval measured	No.*	Time, min; mean ± SD
Time from arrival in ED to triage	55	11 ± 10
Time from triage to emergency physician consult	55	74 ± 59
Time from emergency physician to general surgery consult initiation	55	198 ± 115
Time from emergency physician consult to CT request	48	112 ± 171
Time from CT request to acquisition	49	122 ± 99
Time from general surgery consult initiation to completion	49	92 ± 79
Time from consult to admission to general surgery service	49	114 ± 101
Time from admission to general surgery service to ward	52	259 ± 257
Overall length of stay†	55	83 ± 51

CT = computed tomography; ED = emergency department; SD = standard deviation.
*Denominator varies slightly owing to missing data.
†Reported in hours rather than minutes.

The importance of investigating flow and process intervals in patient care is an emerging field in the era of increasing health expenditure and increasing operative and nonoperative complexity of patients.[17,18] The EQIP pilot program to collect both operative and nonoperative patient outcomes allowed for robust data collection. To our knowledge, this is the first time such robust data collection strategies have been applied to nonoperative patients who are managed by surgical teams. Although there were initial errors that required correction through detailed chart reviews, the program extended the realm of patients who could be studied to improve quality and safety. From our experience, we discovered that these data were not difficult to collect and eventually led to insights that could build efficiencies in the system. Ultimately, collection of process mapping and understanding existing variation in the health system provides services with the ability to create effective data-driven solutions and the capacity to evaluate the impact of incremental changes on workflow processes.

Table 3. Mean process interval outcomes for operative management of small bowel obstruction

Process interval measured	No.*	Time, min; mean ± SD
Time from arrival in ED to triage	33	10 ± 14
Time from triage to emergency physician consult	33	74 ± 76
Time from emergency physician consult to general surgery consult initiation	31	203 ± 102
Time from emergency physician consult to CT request	30	121 ± 153
Time to CT request to acquisition	30	142 ± 58
Time from general surgery consult initiation to completion	30	114 ± 167
Time from consult to admission to general surgery service	30	165 ± 220
Time from admission to general surgery service to ward	24	232 ± 170
Time from OR booking to arrival to the OR	33	442 ± 400
Time from OR to ward postoperatively	30	445 ± 266
Overall length of stay†	33	455 ± 884

CT = computed tomography; ED = emergency department; OR = operating room; SD = standard deviation.
*Denominator varies slightly owing to missing data.
†Reported in hours rather than minutes.

Table 4. Arrival in OR based on priority levels in operative management of small bowel obstruction

Priority level	No.	Time from booking to arrival at OR, min; mean ± SD	No. (%) of patients arriving within expected interval
E1 (< 60 min from booking)	5	80 ± 17	0 (0)
E2 (< 480–720 min from booking)	32	746 ± 893	22 (69)
E3 (< 4320 min from booking)	4	2409 ± 1277	4 (100)
Protected OR time	5	1582 ± 2892	4 (80)

OR = operating room; SD = standard deviation.

Limitations

A limitation of this study is the retrospective nature of data collection, which led to some missing data when reviewing paper medical records. Additionally, even time stamps recorded on the electronic health record for certain points of care were subject to reporting bias. Potential delays around time to CT may be a result of receiving laboratory results, such as renal function, at a later time, leading to a delay in ordering a contrast CT; however, because of the way this is reported, these data cannot be collected, and the impact of timeliness of laboratory results on time to imaging is unknown.

Additionally, our results are specific to our site and should not be generalized to other institutions; however, the methodology could be applied easily to any other system. The population we investigated was specific to a single condition and part of a pilot EQIP project at our hospital, resulting in a small sample size, particularly in our operative group. Future work will be directed at larger groups of surgical patients with the hope of minimizing missing data and generating areas of QI and monitoring. We hope our work inspires other centres to follow similar methodologies to discover areas of improvement for surgical patients.

Future work

In the future, an electronic platform could be adapted to track patient care and document points of care in the patient's journey through the hospital system. With this platform, the general surgery service could have access to real-time data to monitor metrics and evaluate how new QI interventions are working within our system, while simultaneously flagging new areas for intervention. Additionally, investigating the impact of meeting expected intervals based on the patient's priority level and its impact on patient outcomes could help to further justify the need for protected emergency general surgery OR time.

A strategy to improve flow in the ED would be to add preprinted orders (PPOs) that summarize the evidence-based steps of the initial workup of a suspected case of an SBO. Using the PPO, the emergency physician would be able to start several treatment options and order imaging and laboratory tests critical to management of patients with SBO before general surgery consultation. This could potentially streamline and standardize the initial workup, thus improving flow through the department, while providing timely and pertinent clinical information to facillitate the acute care surgery team's decision-making.[17] For instance, the initial PPO laboratory investigations will include relevant kidney function tests that may address the delay in ordering CT imaging with contrast.

Conclusion

Quality improvement is the new science of health care, and our patients expect a "culture of safety" from their health care providers. This represents an exciting time for surgeons to be leaders in safer patient care. Process mapping is a simple way to evaluate a cohort of patients' journeys through the hospital to identify areas for future interventions as well as track the impact of QI projects. Our cohort of patients with SBO are the first group, to our knowledge, to be analyzed using this method, and we hope to expand to more emergency general surgery patients in the future.

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