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Re-examining "Never Letting the Sun Rise or Set on a Bowel Obstruction" in the Era of Acute Care Surgery

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Abstract

Background—Small bowel obstruction (SBO) no longer mandates urgent surgical evaluation raising the question of the role of operating room (OR) access on SBO outcomes.

Methods—Data from our 2015 survey on emergency general surgery (EGS) practices, including queries on OR availability and surgical staffing, were anonymously linked to adult SBO patient data from 17 Statewide Inpatient Databases (SIDs). Univariate and multivariable associations between OR access and timing of operation, complications, length of stay (LOS), and in-hospital mortality were measured.

Results—Of 32,422 SBO patients, 83% were treated non-operatively. Operative patients were older (median 66 vs 65 years), had more comorbidities (53% vs 46% with ≥ 3), and experienced moresystemic complications (36% vs 23%), higher mortality (2.8% vs 1.4%), and longer LOS (median 10 vs 4 days). Patients had lower odds of operation if treated at hospitals lacking processes to tier urgent cases (aOR 0.90, 95% CI [0.83–0.99]) and defer elective cases (aOR 0.87

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Compliance with Ethical Standards

Conflict of Interest Dr. Santry is a paid consultant by the Johnson & Johnson Company on a fragility fracture advisory board. The submitted work is not related to this topic.

[0.80–0.94]). Patients had higher odds of operation if treated at hospitals with surgeons sometimes (aOR 1.14 [1.04–1.26]) or rarely/never (aOR 1.16 [1.06–1.26]) covering EGS at more than one location compared to always. Odds of systemic complication (OR 2.0 [1.6–2.4]), operative complication (OR 1.5 [1.2–1.8]), and mortality were increased for very late versus early operation (OR 2.6 [1.7–4.0]).

Conclusions—Although few patients with SBO require emergency surgery, we identified EGS structures and processes that are important for providing timely and appropriate intervention for patients whose SBO remains unresolved and requires surgery.

Keywords

Emergency general surgery; workforce; mortality; survey; small bowel obstruction

Background

Each year, an estimated 350,000 patients are admitted with a diagnosis of small bowel obstruction (SBO) in the USA [1]. These patients are typically managed by general surgeons and make up 12 to 16% of surgical admissions [1–3]. Of these admissions, approximately 30% result in an operation [4]. Given the high incidence and substantial costs of managing SBOs, estimated to be 2.3 billion dollars annually [1], timeliness and cost-effectiveness of treating SBO are of interest from both surgical and public health perspective.

Traditionally, surgeons have been taught: "Never let the sun set or rise on a bowel obstruction," and that operating early was best. However, with advances in imaging and a better understanding of the natural history of SBO, urgent operations are becoming less common with more than 70% of patients successfully treated non-operatively [4–6]. More recently, there has been evidence that an early gastrograffin challenge may reduce the need for operation [7].

Just as the management for SBO has evolved, the way that emergency general surgery (EGS) care is provided has also progressed. The acute care surgery (ACS) model of care was in part conceptualized in the mid-2000s to address the growing shortage of general surgeons providing EGS coverage[8–10]. Nationally, ACS implementation has been increasing and presumably enhancing access to round the clock (RTC) EGS care [11, 12]. Given the evolving nature of managing SBO, it is unclear whether patients with SBO will directly benefit from a model that improves RTC operating room (OR) access.

In 2015, during a time of shrinking access to EGS care both at the surgeon and the hospital level [9, 13–17], our group conducted a survey of hospitals across the USA, examining structures and processes in EGS care delivery to better understand differences in structure and process investments in EGS care delivery as well as nationwide variations in policies and procedures implemented to optimize EGS outcomes [18]. In this study, we specifically examined whether structures and processes ensuring timely access to operation (e.g., overnight presence of OR staff, EGS surgery block time, process for tiering emergency cases) have an impact on patients with a diagnosis of SBO. Given that the majority of SBOs resolve without surgery, we hypothesized that enhanced OR access would not affect outcomes for patients admitted with SBO.

Methods

The methods of the survey development and implementation have been previously described [19]. In brief, we surveyed 2811 hospitals across the USA regarding their EGS structures and processes using a hybrid paper or electronic survey option. The survey can be found in Appendix 1. The survey included questions on how access to surgical care is assured through a number of key structure and process features (e.g., overnight presence of OR staff, EGS surgery block time, process for tiering emergency cases). Hereafter, these will be referred to collectively as “OR access” resources. The survey was implemented in two rounds to maximize response rate. In the first round, surgeons responsible for oversight of EGS coverage were asked to respond. For hospitals without a response after the first round, hospitals with two or more general surgeons had the survey sent to the next most senior surgeon involved in EGS care and hospitals with only one surgeon had the survey sent to the hospital’s chief medical officer. After the second round, we had received 1690 responses (60.1% response rate) from all states. The cohort presented in this manuscript received care in 17 of these states due to limitations in data linkage with State Inpatient Databases (SIDs) from which the patient-level data in this manuscript is derived.

The SIDs are a product of the Healthcare Cost and Utilization Project (HCUP) with 48 states currently participating. Each SID is an all-payer database that includes inpatient discharge records from community hospitals (non-federal, non-prison, accessible to any community member) in any given state that is translated by HCUP into a uniform format to facilitate multi-state comparisons and analyses [20]. While overall SID encompasses about 97% of all the US community hospital discharges, only 17 states release discharge data with American Hospital Association unique identifiers (AHAID) that allow for direct linkage of hospital-level data (such as that which we derived from our survey) with patient-level data. Therefore, for the present research, respondent answers to queries regarding OR access structure and process measures were anonymously linked to patient-level data from 510 hospitals in these 17 states for the year 2015, the year the survey was conducted.

From SIDs, we identified all emergency/urgent admissions for adults age 18 and older to acute care hospitals with a primary diagnosis of SBO (see Appendix 2). Admissions for volvulus and incarcerated/strangulated hernia were excluded to avoid misclassification. We also excluded patients who were transferred in from another acute care hospital with a diagnosis of SBO since time to operation was an outcome of interest. After applying these inclusion and exclusion criteria, patients in the resulting cohort had received care at 458 of the 510 hospitals with linkable data available. Our first outcome measures of interest were related to operation: timing (none; early [where operation occurred on the calendar date of admission or the following calendar date]; late [where operation occurred on the third, fourth, or fifth calendar date after admission]; and very late [where operation occurred on the sixth calendar date of after admission or later]), approach (laparoscopic vs open), and procedure(s) performed (lysis of adhesions [LOA], small bowel resection (SBR) and/or stoma creation during same operation) (see Appendix 3). Other outcome measures included any major systemic complication (e.g., pneumonia, sepsis), any major surgical complication (e.g., deep organ space infection, wound dehiscence), in-hospital mortality, and length of stay (LOS) (see Appendix 4 for complications). We also measured patient age, sex, race, insurance status, and Elixhauser Index (a validated comorbidity measure) [21] in order to adjust for case-mix based on data available in SIDs. These patient-level administrative data lack clinical granularity on severity of illness at the time of presentation.

Using bivariate and multivariable models, we measured the association between timing of operation, if any, and the treating hospital's OR access resources. Multivariable models were adjusted for patient and hospital characteristics and accounted for clustering of care among individual hospitals. A subset analysis was then performed on patients that required operation as part of their hospitalization to compare secondary outcomes by timing of operation.

This research was reviewed and approved by the Institutional Review Boards at both the University of Massachusetts Medical School and the Ohio State University College of Medicine. Response to survey was considered implied consent. The cover letter (see Appendix 5) included with the survey stated that survey results would be anonymously linked to routinely collected patient data and released in aggregate form only.

Results

Table 1 shows the distribution of operating room access resources across hospitals represented in our study. The median number of operating rooms across hospitals represented in our study is 18 (IQR 9–27). The majority of hospitals (77%) had less than 1 day of operating room block time for EGS. More than half (62%) of the hospitals had a tiered system for booking emergency cases (e.g., emergency, urgent, non-urgent), 66% had a process to defer elective cases, and 97% hospitals had overnight operating room access available. The median number of surgeons covering EGS was 5 (IQR 3–8). The majority of hospitals always have a daytime surgeon covering EGS working post-call (78%) and have a traditional 24 h model for EGS coverage (59%).Most hospitals rarely or never had an in-house surgeon overnight for EGS (55%), always or often had an overnight surgeon also responsible for covering trauma (65%), rarely or never had an overnight surgeon also responsible for covering ICU care (53%), and rarely or never had an overnight surgeon also responsible for covering EGS at more than one hospital (67%). Regarding surgical staffing, a plurality of hospitals had on-call (vs in-house or none) overnight scrub techs (70%), overnight operating room nurses (71%), overnight recovery room nurses (80%), and overnight anesthesia staff (48%).

In 2015, our 458 hospital sample across 17 states had 32,422 patients admitted urgently or emergently with SBO. A total of 5493 (17%) underwent surgery (early = 64%, late = 23%, very late = 11%, unknown = 2.3%). Table 2 describes patient characteristics, interventions, and outcomes by operative versus non-operative intervention. The median age for the non-operative cohort was 65 and 66 in the operative group with the majority of patients being > 64 years old in each group (non-operative 54%, operative 55%), and female (55% and 59% respectively). Having 3 or more comorbidities was associated with operation (53% vs 46%, *P* < 0.0001). In the operative group versus the non-operative group, mortality was significantly higher (2.7% vs 1.4%, *P* < 0.001) and median length of stay was significantly longer (10 vs 4 days). Patients managed non-operatively were more likely to have no major systemic complications (77% vs 64%, *P* < 0.001). Among those undergoing operation, the majority (64%) underwent early operation while only 11% underwent very late operation. Appendix 6 details demographic and clinical differences based on operative timing.

Table 3 shows the odds of undergoing any operation and early versus all other late operation categories by OR access resources. Patients were less likely to have an operation if treated at hospitals that did not have a tiered system for booking emergency cases (aOR 0.90, 95% CI 0.83–0.99) or did not have a process to defer elective cases were less likely to have an operation (aOR 0.87, 95% CI 0.80–0.94). Patients treated at hospitals without a process to defer elective cases were also less likely to have an early versus later operation (aOR 0.83, 95% CI 0.71–0.98). In addition, while having any operation was not influenced by daytime EGS coverage scheme, patients were more likely to have an operation if treated at hospitals with surgeons sometimes (aOR 1.14 95% CI 1.04–1.26) or rarely working post-call (aOR 1.16, 95% CI 1.06–1.26) compared to always working post-call, with the odds of early operation higher if sometimes working post-call (aOR 1.26 (1.04–1.53)). Patients were more likely to have an operation if treated at hospitals with surgeons sometimes (aOR 1.14, 95% CI 1.02–1.30) and rarely (aOR 1.21, 95% CI 1.10–1.32) covering EGS at more than one location. In contrast, patients were less likely to have an operation if treated at hospitals with surgeons rarely in-house overnight for EGS (aOR 0.91, 95% CI 0.85–0.98), who were not typically also providing trauma coverage (sometimes, aOR 0.79, 95% CI 0.67–0.94 and rarely/never, 0.87 95% CI 0.81–0.93), or who rarely/never provided ICU coverage (aOR 0.88, 95% CI 0.82–0.94). Patients treated at hospitals with surgeons who were rarely/never providing ICU coverage were also less likely to have an early operation (aOR 0.86, 95% CI 0.75–0.99). Patients were also less likely to undergo early operation if treated at hospitals with sporadic daytime shifts rather than longer episodes of daytime coverage lasting 5 or more consecutive days (aOR 0.73, 95% CI 0.58–0.92). Finally, patients were less likely to have an operation if treated at hospitals where overnight OR staff were on-call compared to in-house (scrub techs [aOR 0.82, 95% CI 0.76–0.88]; OR nurses [aOR 0.86, 95% CI 0.79–0.92]; PACU nurses [aOR 0.91, 95% CI 0.84–0.99]; anesthesia staff [aOR 0.87, 95% CI 0.81–0.94]).

Figure 1 shows the odds of major systemic complication, major operative complication, and mortality by timing of operation only for those patients who underwent surgery. Odds of in-hospital mortality for late versus early operation was significantly increased (aOR 1.65, 95%CI 1.1–2.4) as was the odds of in-hospital mortality for very late versus early (aOR 2.6 95% CI 1.7–4.0) (*P* < 0.001). The odds of major systemic complication for late versus early (aOR 1.5, 95% CI 1.3–1.8) and very late versus early operation (aOR 2.0, 95% CI 1.6–2.4) were both significantly increased (*P* < 0.001). Finally, the odds of major operative complication for late versus early (OR 1.3 95% CI 1.1–1.4) and very late versus early (OR 1.5 95% CI 1.2–1.8) were both significantly increased (*P* < 0.001).

Discussion

In this study, we have identified key hospital-level structures and processes related to operating room (OR) access that affect the management and outcomes of patients with small bowel obstruction (SBO) in the modern era. We found that patients were less likely to undergo an operation if their treating hospital lacked processes to book emergency cases or to defer elective cases; had surgeons with competing clinical duties during the day, working post-call, or whose roles only encompassed EGS coverage; and employed perioperative staff taking home call vs in-house call. For patients who had an operation, an early operation was more likely at hospitals with processes to defer elective cases, with surgeons whose EGS coverage duties are notable for typically not working post-call, providing consistent coverage with consecutive days on service, and whose roles also encompass trauma/critical care coverage. These features of surgeon coverage and responsibility are consistent with many acute care surgery models [12, 22–24].

The finding that overnight in-house surgeon presence and perioperative staffing did not affect timing of operation is consistent with an evolving philosophy towards SBO management. As we hypothesized, management of SBO has evolved from the old adage of never letting the sun set or rise on a bowel obstruction to a much more nuanced and patient-specific approach that allows for longer trials of non-operative management that the literature suggests will be successful in 7 out of 10 SBO patients [24]. Thus, rendering structures and processes to ensure OR access at off-hours is less important in the management of SBO as few patients require truly emergency surgery. This raises the question, however, of which dedicated EGS structures and processes are important for providing timely and appropriate intervention for those 3 out of 10 SBO patients who will require surgery. Our findings provide novel insight into the modern management of SBO from a broad perspective across more than 400 hospitals in 17 states to better understand this frequent EGS conundrum.

Our results suggest that the presence of a team of surgeons, or a surgical coverage model similar to those commonly employed by acute care surgery teams, results in potentially prompter operative treatment of SBOs that will not resolve after an initial trial of non-operative management. However, owing to the lack of granular clinical details in our patient-level data, we cannot definitively determine who needed an operation in the present analyses. Nevertheless, these results do point to potential benefits of adopting some features of the acute care surgery model (e.g., trauma coverage or critical care certified surgeons) even if a full model is not feasible or warranted. This finding is important because the majority of the hospitals in our sample, and indeed the majority of hospitals where EGS care is provided in the USA, are community-based, non-academic medical centers [11]. As such, no block time, no in-house surgeon or daytime surgical staff without competing responsibilities, and no tiered posting of operative cases are the reality for most hospitals delivering EGS care. Therefore, while the absence of these resources does not equate to substandard hospitals, our findings provide evidence to explore certain structures and processes as potential ways to standardize care of SBO patients irrespective of where they seek care.

The prevailing literature on management of SBO suggests that most patients improve within 2 to 5 days after initiation of NGT therapy [25, 26]. Failure to regain bowel function after 5 days suggests the need for an operation [27]. Therefore, our findings on the association between features such as continuity of daily rounding on EGS patients, tiering of OR cases, deferring of elective cases, more robust after hours surgeon availability, and in-house surgical staffing and receipt of surgery in our a priori time period of early and late (i.e., by the 5th hospital day) likely reflect relative advantages of such structures and processes in making decisions to operate on a semi-urgent, rather than a truly emergency, basis on patients with SBO. Thus, it is not surprising that our results also showed that odds of complications and mortality were more pronounced when comparing early vs very late operations rather than early vs late operations.

Perceived perioperative risk is also critical when making decisions on necessity and timing of operation for SBO. Consistent with recently published data [6], we found that patients with no or few comorbidities tended to undergo non-operative management more often than those with multiple comorbidities. These findings may be due to use of water-soluble contrast studies for therapeutic benefit in the setting of partial SBO longer than 48 h duration which have been shown to improve time to return of bowel function and decrease length of stay [7, 28, 29]. Surgeons may be using this approach in otherwise very healthy patients who could tolerate a delay in otherwise inevitable operation. However, we also found that among those who did undergo an operation, accounting for comorbidities (along with key demographic factors) did increase odds of complications while not affecting odds of mortality, again supporting the clinical goal of expediting operation for those who will fail non-operative management. While we were able to control for comorbidities in this study, we could not adjust for clinical triggers for early operation (e.g., peritonitis, signs of bowel ischemia on laboratory data, signs of internal hernia on CT scan) or receipt of a water-soluble contrast study due to the nature of our administrative database. Therefore, additional research with richer clinical detail is warranted to explore the role of newer adjuncts in the non-operative management of SBO, patient comorbidities, and other patient-level, including black race which we like others found to be associated with higher rates of operation [30].

Surgeon comfort/experience and availability of equipment (not ascertainable in administrative data) are at least anecdotally known to play a role in the management of SBO. Although previously reserved only for simple SBO, current literature supports the use of laparoscopy in complex SBO with dilated bowel and multiple previous abdominal operations [31, 32]. A meta-analysis of 29 studies reported a conversion rate of 29% and an enterotomy rate of 7% [33]. Yet, successful laparoscopic surgery is associated with an earlier recovery of bowel function and a shorter length of stay [34]. In our cohort, the most common procedure performed for early, late, and very late operative intervention was open lysis of adhesions (Appendix 6); however, laparoscopic lysis of adhesions was more common in the early and late group versus the very late group. Additionally, open small bowel resection was significantly more common in the very late group compared to the early and late group. Furthermore, the longest delays in operative management were associated with increased mortality, morbidity, and longer length of stay, also consistent with previously reported data [6, 30]. Thus, our findings suggest that if non-operative management is indeed failing, earlier operation may spare some patients the need for a more morbid laparotomy incision, bowel resection, and increased risk of complications, longer length of stay, and higher mortality.

Given the escalating cost of healthcare in the USA and rampant over-crowding of hospitals nationwide, these results have important implications for the management of SBO patients who do initially meet criteria for operation. In addition, prolonged NGT decompression when operation is warranted may both increase NGT complications and reduce patient satisfaction, a key criterion in measuring healthcare delivery in the modern area. Protocolized pathways including careful clinical follow-up and algorithms for adjuncts like water-soluble contrast studies as described by Zielinski et al. [7] are one way of ensuring providers monitor and react to appropriate triggers for operation when the initial management plan is NGT decompression. Expediting and formalizing processes to determine the need for semi-urgent surgery will likely improve outcomes.

Our results must be understood in the context of a number of limitations, some of which have been previously noted. Although we have robust primary data representing operating room access resources from 458 hospitals in the USA capable of providing EGS care, our survey, like all such surveys utilizing self-reported data, is subject to social desirability bias, recall bias, and lack of generalizability, in particular outside the 17 states that allowed linkage to our survey data. However, our stepwise method of survey creation and pilot testing, along with our high response rate, assists in mitigating the first two of these risks common to survey research. We must further acknowledge the known limitations of using administrative data including possibility of systematic upcoding and lack of clinical granularity. While we excluded volvulus and incarcerated hernia, we cannot tell which of those patients with primary diagnosis codes for SBO had concerning clinical exam findings such as fever, tachycardia, or peritonitis or concerning CT scan findings such a fecalized small bowel contents, swirl sign, free air, or new as cites to warrant truly emergency operation. Furthermore, by defining an early operation by receiving the operation on the date of admission or the following calendar date, there is a possibility that a small proportion of the patients who had an operation after the 2nd midnight was misclassified as a late operation. In addition, given that our analyses relied on date of admission, we cannot account for extraordinary delays in the emergency department prior to admission when determining timing of operation for our analyses.

Clinical experience and institutional data clearly support the modern paradigm of not performing emergency surgery for SBO before the next sunset or sunrise. Therefore, even lacking data on clinical acuity at presentation, use of gastrograffin challenges, and factors that drove the decision to operate in our cohort, our findings inform clinicians and policymakers as they develop criteria for the assessment, triage, and treatment of EGS patients including what structures and processes might be harnessed to provide high-quality care for SBO patients. From our results, it appears that the modern management of SBO should at a minimum ensure that processes are in place so that those who will require operation are identified within 2 to 5 days of admission to facilitate timely operation and ameliorate adverse outcomes. While such processes must include clinical data to support decision-making and may include gastrograffin trials as adjuncts, facilitating factors to support early surgery when warranted such as surgeons not required to provide patient care post-call, EGS block time to facilitate daytime OR access for semi-urgent cases, and providing consecutive days of care to observe resolution or progression of non-operative management from a single surgeon's clinical lens, as might be implemented in a dedicated acute care surgery service, might also be easily implemented across hospitals providing EGS care to ensure optimal management of the 350,000 SBO patients treated annually across the USA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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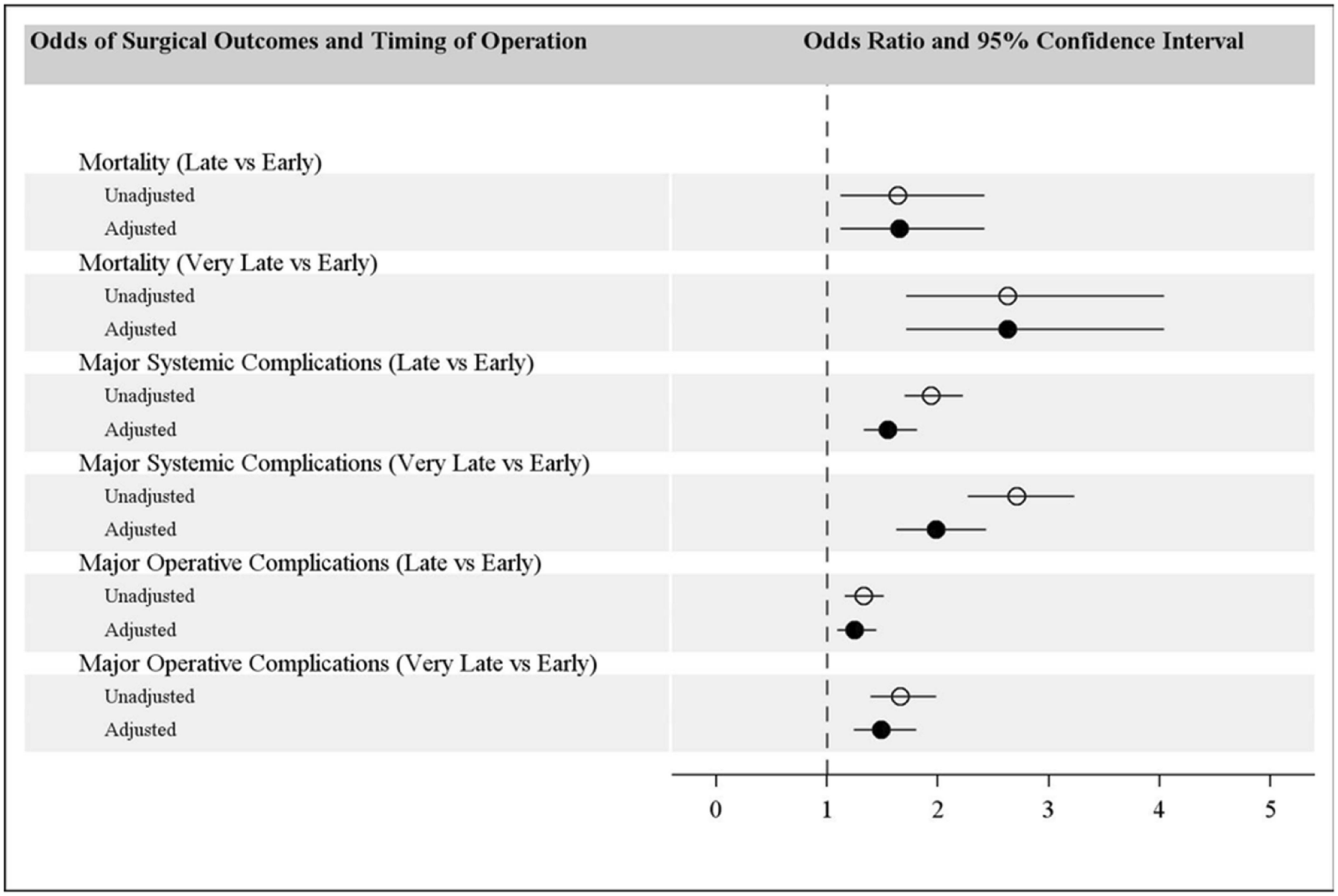

Figure. 1.

Odds of any major systemic complication, any major operative complication, and mortality by timing of operation for patients treated for small bowel obstruction

Table 1.

Hospital-level resources, policies, and procedures aimed at assuring access to surgical care at 458 hospitals in 17 states in 2015 where patients were treated for small bowel obstruction

Resource, policy, or procedure aimed at ensuring access to operation Operating room access	Proportion of hospitals (*N* = 458) providing these resources	Proportion of patients (*N* = 32,422) exposed to these resources
Total operating rooms, median (IQR)	18 (9.27)	NA
Block time for EGS *N* (%)		
< 1 day (none, < 1)	354 (77.3)	20,871 (64.4)
1–4 days (1, 2, 3, 4)	19 (4.1)	1772 (5.5)
≥ 5 days (5, > 5)	68 (14.8)	8915 (27.5)
Unknown	17 (3.7)	864 (2.7)
Tiered system for booking emergency surgical cases *N* (%)		
Yes	282 (61.6)	22,614 (68.7)
No	113 (24.7)	6026 (18.6)
Unsure	47 (10.3)	2934 (9.0)
Unknown	16 (3.5)	848 (2.6)
Process to defer elective cases *N* (%)		
Yes	304 (66.4)	22,290 (68.7)
No	113 (24.7)	6540 (20.2)
Unsure	47 (10.3)	2616 (8.1)
Unknown	16 (3.5)	976 (3.0)
Overnight OR access available *N* (%)		
Yes	444 (96.9)	32,195 (99.3)
No	11 (2.4)	73 (0.2)
Unknown	3 (0.7)	154 (0.5)
Surgeon coverage		
Total number of surgeons covering EGS, median (IQR)	5 (3.8)	NA
Daytime surgeons covering EGS free of other clinical duties *N* (%)		
Yes	60 (13.1)	7273 (22.4)
No	376 (82.1)	23,286 (71.8)
Missing	22 (4.8)	1863 (5.7)
Daytime surgeon on call for EGS working post-call *N* (%)		
Always/often	359 (78.4)	21,386 (66.0)
Sometimes	43 (9.4)	4361 (13.5)
Rarely/never	32 (7.0)	5112 (15.8)
Missing	24 (5.2)	1563 (4.8)
Daytime EGS coverage scheme *N* (%)		
On service weeks (5 or more consecutive days)	64 (14.0)	4678 (14.4)
Ad hoc daytime shift coverage	38 (8.3)	4475 (13.8)
Traditional 24 h coverage	272 (59.4)	19,565 (60.3)

Resource, policy, or procedure aimed at ensuring access to operation Operating room access	**Proportion of hospitals (*N* = 458) providing these resources**	**Proportion of patients (*N* = 32,422) exposed to these resources**
Other	63 (13.8)	659 (2.0)
Missing	21 (4.6)	3045 (9.4)
In-house surgeon overnight for EGS *N* (%)		
Always/often	154 (33.6)	14,644 (45.2)
Sometimes	27 (5.9)	2517 (7.8)
Rarely/never	253 (55.2)	13,701 (42.3)
Missing	24 (5.2)	1560 (4.8)
Overnight surgeon also responsible for covering trauma *N* (%)		
Always/often	297 (64.8)	20,101 (62.0)
Sometimes	21 (4.6)	1589 (4.9)
Rarely/never	117 (25.5)	9237 (28.5)
Missing	23 (5.0)	1495 (4.6)
Overnight surgeon also responsible for covering ICU care *N* (%)		
Always/often	152 (33.2)	11,278 (34.8)
Sometimes	42 (9.2)	3404 (10.5)
Rarely/never	241 (52.6)	16,274 (50.2)
Missing	23 (5.0)	1466 (4.5)
Overnight surgeon also responsible for covering EGS at more than one hospital *N* (%)		
Always/often	78 (17.0)	4505 (13.9)
Sometimes	50 (10.9)	3982 (12.3)
Rarely/never	306 (66.8)	22,225 (68.5)
Missing	24 (5.2)	1710 (5.3)
Surgical staffing *N* (%)		
Overnight scrub techs		
None	1 (0.2)	11 (0.03)
On-call	320 (69.9)	15,786 (48.7)
In-house	120 (26.2)	16,255 (50.1)
Missing	17 (3.7)	370 (1.1)
Overnight OR nurses		
None	0 (0.0)	0 (0.0)
On-call	325 (71.0)	15,577 (48.0)
In-house	116 (25.3)	16,475 (50.8)
Missing	17 (3.7)	370 (1.1)
Overnight recovery room nurses		
None	11 (2.4)	439 (1.4)
On-call	364 (79.5)	22,737 (70.1)
In-house	63 (13.8)	8774 (27.1)
Missing	20 (4.4)	472 (1.5)
Overnight anesthesia staff (MD, DO, CRNA)		

Resource, policy, or procedure aimed at ensuring access to operation Operating room access	**Proportion of hospitals (*N* = 458) providing these resources**	**Proportion of patients (*N* = 32,422) exposed to these resources**
None	89 (19.4)	985 (3.0)
On-call	220 (48.0)	14,772 (45.6)
In-house	127 (27.7)	16,212 (50.0)
Missing	22 (4.8)	453 (1.4)

Table 2

Characteristics, interventions, and outcomes for patients admitted in 2015 to 458 hospitals in 17 states with diagnosis of small bowel obstruction treated operatively versus non-operatively

	Non-operative (*N* = 26,929)	Operative (*N* = 5493)	*P* value*
Demographics			
Age median (q1, q3)	65 (54, 78)	66 (54, 78)	0.43
Age *N* (%)			0.02
18–34 years old	1411 (5.2)	337 (6.1)	
35–49 years old	3360 (12.5)	667 (12.1)	
50–64 years old	7634 (28.3)	1493 (27.2)	
> 64 years old	14,524 (53.9)	2996 (54.5)	
Female *N* (%)	14,922 (55.4)	3238 (58.9)	< 0.001
Race *N* (%)			< 0.001
Non-Hispanic White	18,912 (70.2)	3755 (68.4)	
Black	2615(9.7)	693 (12.6)	
Hispanic	1823 (6.8)	289 (5.3)	
Other	876 (3.3)	178 (3.2)	
Unknown	2703 (10.0)	578 (10.5)	
Insurance *N* (%)			< 0.001
Medicare	15,322 (56.9)	3021 (55.0)	
Medicaid	2504 (9.3)	517 (9.4)	
Private	7834 (29.0)	1718 (31.3)	
Self-pay	628 (2.3)	111 (2.0)	
Other	630 (2.3)	123 (2.2)	
Comorbidities			
Elixhauser index *N* (%)			< 0.0001
No comorbidities	3359 (12.5)	661 (12.0)	
1 comorbidity	5440 (20.2)	912 (16.6)	
2 comorbidities	5679 (21.1)	1025 (18.7)	
3 or more comorbidities	12,451 (46.2)	2895 (52.7)	
Operative timing			
Time of operation** *N* (%)			
Early	–	3529 (64.2)	
Late	–	1250 (22.8)	
Very late	–	589 (10.7)	
Unknown	–	125 (2.3)	
Outcomes			
Mortality *N* (%)	346 (1.4)	151 (2.7)	< 0.0001
Total hospital length of stay*** median (IQR)	4 (2, 5)	10 (5, 12)	< 0.0001

	Non-operative (*N* = 26,929)	**Operative (*N* = 5493)**	***P* value***
Major systemic complications *N* (%)			< 0.0001
None	20,830 (77.4)	3540 (64.4)	
1	5344 (19.8)	1408(25.6)	
2	696 (2.6)	475 (8.6)	
3 or more	59 (0.2)	70 (1.3)	
Major operative complications *N* (%)			< 0.001
None	–	3181 (58.0)	
1	–	1751 (31.9)	
2	–	475 (8.6)	
3 or more	–	86 (1.6)	

*Significant at unadjusted model ($P < 0.05$)

**operative timing (early = the calendar date of admission or the following date; late = on the third, fourth, or fifth calendar date after admission; and very late = on the sixth calendar date of after admission or later). Missing = 125(2.3%).

***For those discharged alive ($N = 26{,}566$ non-operative; $N = 5337$ operative)

Table 3.

Adjusted and unadjusted odds ratios for patients admitted with small bowel obstruction at 458 Hospitals in 17 States across the USA based on resources, policies, and procedures for optimizing operating room access

OR access resource, policy, or procedure	**Odds of operation vs no operation (*N* = 32,422)**		**Odds of early operation vs all later operations (*N* = 5493)**	
Operating room access				
	OR (95%CI)	aOR (95%CI)	OR (95%CI)	aOR (95%CI)
Block time for EGS				
≥5 days (5, > 5) (ref)	–	–	–	–
1–4 days (2, 3, 4)	1.06 (0.93, 1.20)	1.08 (0.93, 1.25)	0.98 (0.76, 1.27)	1.05 (0.79, 1.40)
< 1 day (none, < 1,)	0.93 (0.87, 1.01)	0.97 (0.90, 1.05)	0.87 (0.77, 0.9) *	0.90 (0.77, 1.04)
Tiered system for booking emergency surgical cases				
Yes (ref)	–	–	–	–
No	0.87 (0.81, 0.95) *	0.90 (0.83, 0.99) **	0.92 (0.79, 1.06)	0.94 (0.79, 1.12)
Unsure	1.02 (0.93, 1.13)	1.03 (0.92, 1.14)	1.00 (.82, 1.22)	
Process to defer elective cases				
Yes (ref)	–	–	–	–
No	0.88 (0.82, 0.95) *	0.87 (0.80, 0.94) **	0.84 (0.73, 0.97) *	0.83 (0.71, 0.98) **
Unsure	0.97 (0.87, 1.08)	0.95 (0.84, 1.08)	1.16 (0.93, 1.44)	1.18 (0.92, 1.52)
Surgeon coverage				
Daytime surgeons on call for EGS free of other clinical duties				
Yes (ref)	–	–	–	–
No	0.91 (0.85, 0.98) *	0.95 (0.88, 1.02)	1.02 (0.89, 1.17)	1.04 (0.90, 1.21)
Daytime surgeon on call for EGS working post-call				
Always/often (ref)	–	–	–	–
Sometimes	1.17 (1.07, 1.27) *	1.14 (1.04, 1.26) **	1.36 (1.15, 1.62) *	1.26 (1.04, 1.53) **
Rarely/never	1.23 (1.13, 1.33) *	1.16 (1.06, 1.26) **	0.97 (0.85, 1.13)	0.93 (0.79, 1.09)
Daytime EGS coverage scheme (%)				
On service for 5 or more days (5, 7, longer) (ref)	–	–	–	–
Daytime shifts 8 or more hours	1.03 (0.93, 1.15)	1.05 (0.93, 1.18)	0.69 (0.56, 0.85) *	0.73 (0.58, 0.92) **
24 h of coverage	0.93 (0.86, 1.02)	1.01 (0.92, 1.11)	0.77 (0.65, 0.91) *	0.86 (0.71, 1.04)
Other	0.75 (0.60, 0.96) *	0.80 (0.62, 1.02)	0.83 (0.52, 1.32)	1.05 (0.63, 1.77)
In-house surgeon overnight for EGS				
Always/often	–	–	–	–
Sometimes	0.93 (0.83, 1.04)	0.92 (0.82, 1.04)	1.16 (0.92, 1.45)	1.12 (0.89, 1.42)
Rarely/never	0.90 (0.85, 0.96) *	0.91 (0.85, 0.98) **	1.05 (0.35, 1.19)	1.04 (0.91, 1.19)
Overnight surgeon also responsible for covering trauma				
Always/often (ref)	–	–	–	–

OR access resource, policy, or procedure	Odds of operation vs no operation (*N* = 32,422)		Odds of early operation vs all later operations (*N* = 5493)	
Sometimes	0.86 (0.74, 0.99) *	0.79 (0.67, 0.94) **	1.26 (0.94, 1.69)	1.23 (0.89, 1.70)
Rarely/never	0.88 (0.83, 0.94) *	0.87 (0.81, 0.93) **	0.79 (0.70, 0.90) *	0.89 (0.78, 1.02)
Overnight surgeon also responsible for covering ICU care				
Always/often (ref)	–	–	–	–
Sometimes	1.07 (0.97, 1.18)	1.07 (0.96, 1.19)	1.00 (0.82, 1.21)	1.16 (0.82, 1.63)
Rarely/never	0.85 (0.80, 0.91) *	0.88 (0.82, 0.94) **	0.90 (0.80, 1.02)	0.86 (0.75, 0.99) **
Overnight surgeon also responsible for covering EGS at more than one hospital				
Always/often (ref)	–	–	–	–
Sometimes	1.14 (1.02, 1.3) *	1.14 (1.01, 1.29) **	1.28 (1.02, 1.61) *	1.23 (0.97, 1.57)
Rarely/never	1.21 (1.10, 1.32) *	1.19 (1.08, 1.30) **	1.22 (1.02, 1.44) *	1.69 (0.96, 1.40)
Surgical staffing				
Overnight scrub techs				
In-house (ref)	–	–	–	–
On-call	0.82 (0.77, 0.87) *	0.82 (0.76, 0.88) **	0.92 (0.82, 1.03)	0.93 (0.80, 1.07)
None	0.45 (0.06,3.55)	0.50 (0.07,3.88)		
Overnight OR nurses				
In-house (ref)	–	–	–	–
On-call	0.84 (0.79, 0.89) *	0.86 (0.79, 0.92) **	0.97 (0.87, 1.09)	0.98 (0.85, 1.13)
Overnight recovery room nurses				
In-house (ref)	–	–	–	–
On-call	0.89 (0.84, 0.96) *	0.91 (0.84, 0.99) **	1.09 (0.96, 1.24)	1.12 (0.97, 1.30)
None	1.07 (0.83, 1.38)	0.24 (0.12, 47)	3.14 (1.68, 5.86) *	1.96 (0.37, 10.28)
Overnight anesthesia staff (MD, DO, CRNA)				
In-house (ref)	–	–	–	–
On-call	0.87 (0.82, 0.92) *	0.87 (0.81, 0.94) **	0.88 (0.78, 0.99) *	0.94 (0.82, 1.07)
None	0.78 (0.65, 0.94) *	0.91 (0.73, 1.14)	1.82 (1.2, 2.74) *	2.21 (1.31, 3.72) **

*Significant at unadjusted model ($P < 0.05$)

**significant after being adjusted for age, race, sex, insurance status, Elixhauser index, and total ORs/surgeons ($P < 0.05$)

2.3% (149) of the operations have no information about the timing of the operation and are excluded from results