Published in final edited form as:

Am J Surg. 2015 August ; 210(2): 201–210.e2. doi:10.1016/j.amjsurg.2014.12.048.

Small Bowel Volvulus in the Adult Populace of the United States: Results From a Population-Based Study

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Abstract

Background—Small bowel volvulus is a rare entity in Western adults. Greater insight into epidemiology and outcomes may be gained from a national database inquiry.

Methods—The Nationwide Inpatient Sample (1998–2010), a 20% stratified sample of United States hospitals, was retrospectively reviewed for small bowel volvulus cases (ICD-9 560.2 excluding gastric/colonic procedures) in patients 18-years old.

Results—There were 2,065,599 hospitalizations for bowel obstruction (ICD-9 560.x). Of those, there were 20,680 (1.00%) small bowel volvulus cases; 169 were attributable to intestinal malrotation. Most cases presented emergently (89.24%) and operative management was employed more frequently than non-operative (65.21% vs. 34.79%, $P < 0.0001$). Predictors of mortality included age > 50 -years, Charlson comorbidity index 1, emergent admission, peritonitis, acute vascular insufficiency, coagulopathy, and non-operative management ($P < 0.0001$).

Conclusions—As the first population-based epidemiological study of small bowel volvulus, our findings provide a robust representation of this rare cause of small bowel obstruction in American adults.

Keywords

Intestinal malrotation; Small Bowel Volvulus; Acute abdomen; National Inpatient Sample; Charlson comorbidity

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Author Contributions: All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* All authors. *Acquisition of data:* All authors. *Analysis and interpretation of data:* All authors. *Drafting of the manuscript:* All authors. *Critical revision of the manuscript for important intellectual content:* All authors. *Statistical analysis:* All authors.

Conflict of Interest Disclosures: None reported.

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Introduction

Small bowel volvulus (SBV) is defined as the twisting of the small bowel around its mesenteric axis. This can lead to bowel obstruction, ischemia, infarction or perforation. Typically, SBV is thought to be a diagnosis in newborns, because one-in-500 live births have intestinal malrotation (IM) and approximately 80% of these IM patients will present with SBV within the first month of life.[1-3] As a result, SBV secondary to IM is most common in children and young adults. However, in rare circumstances, adults can present with SBV secondary to IM.[4, 5] What is less appreciated is that adults can also present with small bowel volvulus (SBV) secondary to adhesions, tumors or Meckel's diverticula.[6] Studies dating back several decades suggest that the annual incidence of SBV is 1.7-5.7 per 100,000 adults in Western countries, and 24-60 per 100,000 adults in Africa, the Middle East and Asia.[7-9] The higher rate in the latter regions has been associated with fiber-rich and serotonin-rich diets, as well as fasting.[8] But, because of its rarity, relatively little is known about the epidemiology, presentation and management of SBV in Western adults; our understanding is solely based upon case reports and single institution case series that are no larger than 129 patients in size.[1, 10, 11] The purpose of this study was to describe the epidemiology and outcomes of both SBV and SBV with IM in U.S. adults. Therefore, we hypothesized that a national database inquiry would provide greater insight into these questions through a population-based analysis.

Methods

Retrospective analysis of the United States Nationwide Inpatient Sample (NIS) was performed spanning the years 1998 through 2010. The NIS, operated by the Agency for Healthcare Research and Quality (AHRQ), is a 20% stratified sample of inpatient discharges from over 1,050 hospitals in 45 states.[12] It covers 95% of the U.S. population and is the largest all-payer inpatient database. National trends can be identified due to weighted sampling. The NIS includes more than 100 clinical and non-clinical data variables from each hospital stay, including primary and secondary diagnoses and procedures, admission and discharge types, patient demographics (i.e., age, sex, Charlson comorbidity index, etc.), insurance type, total charges, length of stay, and hospital characteristics.

We determined the total number of adult patients (i.e., 18 years of age and older) with any bowel obstruction in the database as defined by ICD-9 diagnosis codes 560.0-1, 560.30-31, 560.39, 560.81, 560.89, 560.9 or 560.2.

To construct the SBV study cohort, we identified hospital stays with the primary or secondary ICD-9 diagnosis code of 560.2, which represents any volvulus in patients 18 years of age and older. This was analogous to Halabi and colleague's coding for colonic volvuli.[13] However, since this diagnosis code is not specific for the volvulus location, we then excluded all patients undergoing gastric or colonic procedures during the same hospitalization in order to identify patients undergoing small bowel procedures during the same hospitalization. By excluding gastric and colonic procedures associated with gastric volvuli and colonic volvuli,[13] we aimed to identify the study cohort with SBV

(Supplemental Table 1). Although this approach may underestimate the true SBV population, which may have undergone gastric or colonic procedures, we preferred this potential type II error as opposed to overestimation with a type I error.

Patients with SBV and IM were also identified within the SBV cohort using the ICD-9 code 751.4, which describes anomalies of intestinal fixation including congenital adhesions, Jackson's membrane, malrotation of colon, rotation of cecum/colon or universal mesentery. SBV and IM patients had both 560.2 and 751.4 diagnosis codes. Emergent versus non-emergent admissions were identified based on the NIS definition of emergency or urgent admission. Findings upon presentation, including acute vascular insufficiency, peritonitis, coagulopathy, and pneumoperitoneum were defined using ICD-9 codes 557.0-1, 567.1-9, 286.0-9, and 568.89, respectively. Management of SBV was defined as operative based upon procedure codes listed in Supplemental Table 2. Non-operative management included procedures such as nasogastric decompression, mechanical ventilation and supportive care.

Patient demographics, Charlson comorbidity index, hospital types (i.e., teaching versus non-teaching), hospital location (i.e., rural versus urban), findings upon presentation, operative procedures and in-hospital mortality were described for the entire SBV cohort. The Charlson comorbidity index is a measure of comorbidities based on the presence or absence of certain diagnoses in the patient. These are then combined together in a weighted formula.[14] Hospital teaching status was defined by the presence of a general surgical residency program. Univariate tests, utilizing chi-square and Student's t-test were performed for comparison of categorical and continuous variables, respectively. Multivariate analysis was performed to assess for differences in in-hospital mortality, controlling for age, sex, race, Charlson comorbidity index, year, emergent admission, presentation (i.e., peritonitis, acute vascular insufficiency, pneumoperitoneum, and coagulopathy), teaching hospital status, hospital location, and utilization of operative management. Statistical analyses were performed using STATA 11.1 software (StataCorp, College Station, TX, USA), with statistical significance set at a *P*-value 0.05.

Results

Hospitalizations for Small Bowel Volvulus

There were 2,065,599 hospitalizations for bowel obstruction (ICD-9 560.x) observed over this 13-year period from 1998 to 2010, representing an estimated 10.33 million hospitalizations across the entire United States. After excluding gastric and colonic procedures, 20,680 hospitalizations (1.00%) were attributable to SBV. Among patients hospitalized for bowel obstruction, the overall mortality was 5.61% and the mortality rates in the operative and non-operative groups were similar (5.58% vs. 5.62% *P*=0.33).

Demographics of Small Bowel Volvulus Cohort

Over the study period, 20,680 patients with SBV were recorded in the NIS, projecting to approximately 103,400 patients nationwide (Table 1). These patients were predominately female (56.60%) and white (75.34%) with a mean age of 66.0 ± 19.4 years (range: 18-103 years). These demographics were generally similar to the entire cohort of patients presenting

with bowel obstruction, despite statistically significant differences observed due to the large sample sizes (Table 1). Most cases presented emergently (89.24%) with 19.1% of patients presenting with signs of an acute abdomen, such as peritonitis, acute vascular insufficiency or pneumoperitoneum. Overall, adhesive disease appeared to be the leading cause of SBV (32.44%). Operative management was employed in 65.21% of admissions and the average time from admission to operation was 1.6 ± 2.9 days. The overall inpatient mortality rate was 7.92% in all patients with SBV. In subset analyses, the mortality rate was 4.78% among patients that had an operation on the day of admission, while it was 6.65% among patients that had an operation after the day of admission ($P < 0.0001$). The mean time from admission to death was 8.11 ± 11.6 days (range: 0-209 days).

Demographics of Small Bowel Volvulus Cohort with Intestinal Malrotation

Among the hospitalizations for SBV, 0.82% (169 unweighted cases) was attributable to SBV+IM. The average age of presentation was 48.2 ± 21.2 years (range: 18-95 years) with 53.85% female (Table 2). SBV+IM was most common in white patients (77.54%) and most hospitalizations were on an emergent basis (89.73%). Operative management was utilized in 79.29% of hospitalizations and the average time from admission to operation was 1.0 ± 1.9 days. The inpatient mortality was 2.37%.

Characteristics of Small Bowel Volvulus Patients with Emergent or Elective Presentations

We performed unadjusted analyses of patients presenting emergently or electively (Table 3). Patients presenting emergently were older (66.2 vs. 64.0, $P < 0.0001$) and more likely to receive operative management (66.39% vs. 58.38%, $P < 0.0001$). The overall mortality was higher in the emergent group (8.02% vs. 5.44%, $P < 0.0001$).

Characteristics of Small Bowel Volvulus Patients Undergoing Operative or Non-operative Management

We performed unadjusted analyses of patients undergoing operative or non-operative management (Table 4). Patients undergoing operative management were significantly younger (63.8 vs. 70.1, $P < 0.0001$) and more likely to present emergently (90.41% vs. 87.01%, $P < 0.0001$) (Table 4). The most common procedure performed was adhesiolysis (32.44%) with 6.34% of all procedures being performed laparoscopically. Additionally, 23.96% of patients underwent a bowel resection. In this subset of patients ($N=4,949$), the mortality rate was 7.88%. In contrast, the mortality rate was 4.81% in the patients not undergoing resection ($N=8,529$, $P < 0.0001$). However, the overall mortality was higher in the non-operative cohort than the operative cohort (11.65% vs. 5.94%, $P < 0.0001$).

Characteristics of Small Bowel Volvulus Patients with Intestinal Malrotation Undergoing Operative or Non-operative Management

We performed unadjusted analyses of patients undergoing operative or non-operative management in the subset of SBV+IM patients (Table 5). Patients undergoing operative management were significantly younger (46.1 vs. 56.0, $P < 0.05$). The most common procedures performed were adhesiolysis (65.67%), bowel manipulation (37.31%), and

Ladds procedure (23.88%). There was one death in the non-operative cohort (N=35) and three deaths in the operative cohort (N=134; $P=NS$).

Multivariate Analysis of the Small Bowel Volvulus Cohort for Predictors of Mortality

We then performed multivariate analysis of the entire SBV cohort for predictors of mortality (Table 6). Analysis demonstrated that independent risk factors for mortality included male sex, age greater than 50 years, Charlson comorbidity index ≥ 1 , emergent admission, peritonitis, acute vascular insufficiency, coagulopathy and non-operative management ($P<0.0001$). Race, hospital teaching status, hospital location, year of admission, and pneumoperitoneum had no significant impact on mortality.

Discussion

In this study, we report the first population-based analysis of a cohort of 20,680 adults with small bowel volvuli (SBV) in the United States. Of an estimated 10.33 million hospitalizations for bowel obstructions over the 13-year study period, 1.00% was attributable to SBV. Of this fraction, 0.82% (i.e., 0.0082% of all bowel obstructions) were patients presenting with small bowel volvulus (SBV) and intestinal malrotation (IM). SBV with and without IM is a rare cause of bowel obstruction in the U.S. We define the epidemiology, presentation and management of SBV in Western adults. We found that SBV patients tended to be older, white females while SBV+IM patients tended to be younger. Most patients presented emergently, a factor associated with higher in-hospital mortality. Operative management was more commonly utilized and non-operative management was significantly associated with higher mortality rates, although patient age and comorbidities likely confound any causal relationship between management choice and mortality. In line with this fact, additional predictors of mortality included older age, male sex, increased comorbidities, and presentations suggestive of an acute abdomen. Taken together, our findings provide a robust representation of small bowel volvuli in U.S. adults in the 21st century.

Our findings corroborate and expand upon seven major case series of SBV in adults that have been reported by American [10, 15-17] and European [1, 11, 18] groups. These include reports from the Massachusetts General Hospital and Mayo Clinic in the United States.[10, 15] These studies ranged in length from 10 to 30 years with an average of 19.6 years. In these series, a total of 354 patients were reported (median 40, range: 4-129) with an average of 0.13 to 5.7 cases per year. In the current series, we observed 20,680 hospitalizations for SBV over 13 years. The prior studies reported mean ages from 45 to 67 years old. Similarly, the mean age in our study was 66.0 ± 19.4 years. Moreover, consistent with our sex distribution of 56.6% females, Welch,[1] Ruiz-Tovar [11] and Roggo [10] reported sex distributions with 52.8%, 53.5%, and 54% females, respectively. In these seven studies, 35.3% (range: 10.0-89.5%) were primary volvuli and 64.7% (range: 10.5-85.7%) were secondary volvuli. Four of the studies reported the mortality associated with non-viable bowel. In this latter subgroup, the mortality ranged from 17% to 61%, while the overall mortality ranged from 9% to 33%. Consistent with these findings, in the current study, we determined that acute vascular insufficiency was an independent predictor of mortality and

we observed an overall mortality rate of 7.92%. Our current findings corroborate and expand upon these earlier reports.

The major strengths of our study include the large sample size, which is 58.4-fold larger than the combined seven major American (N=4 [10, 15-17]) and European (N=3 [1, 11, 18]) studies, as well as its broad applicability; this is the first study to utilize a national database to characterize the nature of SBV. Since the NIS database samples 20% of all hospitals in the United States, we can estimate current trends and management of SBV and SBV+IM at a national level as opposed to previous studies that have been limited to single institution series of less than 129 patients.[10, 15-17] Additionally, we note that year of diagnosis does not affect mortality, despite a number of developments that have come about during our study period which have improved surgical outcomes, including the introduction of clinical pathways and the establishment of quality care initiatives, such as perioperative antibiotic administration.

The major limitation of our study is the lack of specificity of ICD-9 codes for SBV. We addressed this limitation by excluding all patients who had undergone gastric or colonic procedures in order to isolate patients with SBV; however, this approach possibly excludes some patients with SBV, leading to potential underestimation, which we preferred to overestimation by including gastric and colonic procedures. Along this line, large databases, such as the NIS, are also susceptible to coding discrepancies and missing data. These are unlikely to cause significant biases, as they would be random and evenly distributed across all groups. An additional limitation is the lack of coding for all presenting signs and symptoms. We elected to utilize common signs of an acute abdomen upon presentation. Given the infinite number of potential presentations and codes, we were unable to clearly identify all presentations. Finally using NIS, we are unable to clearly differentiate primary from secondary volvuli, a distinction commonly made in institutional case series. Primary volvuli are defined as having no underlying cause. These are most common in children and young adults, while secondary volvuli are due to congenital or acquired lesions.[6] In our case, we can assume that many are secondary and caused by adhesions because 32.44% of patients were managed with adhesiolysis. However, others have reported additional causes including internal hernias, tumors, mesenteric lymphadenopathy and masses, Meckel's diverticula, pregnancy, endometriosis, abscesses, peritoneal mycobacterial disease, aneurysms, and hematomas.[19] Determining each individual secondary cause is beyond the scope of our current report.

Conclusions

In conclusion, while relatively uncommon compared to other causes of bowel obstructions, surgeons should be cognizant of the potential for SBV and SBV+IM in the adult population, especially when imaging findings are concerning for these diagnoses. Waiting for signs of peritonitis, intestinal ischemia, coagulopathy, and/or failure of non-operative management should be avoided in order to improve outcomes. Taken together, we provide strong evidence that timely diagnosis and operative management should be utilized for the treatment of medically fit adult patients presenting with SBV, including those with SBV and IM.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of patients with bowel obstruction and small bowel volvulus.*

Demographics	Bowel Obstruction (%)	Volvulus (%)	P-value
Total Patients	2,063,457	20,680	
Age, mean (sd), years	64.6 (17.8)	66.0 (19.4)	<0.0001
Sex			0.039
Female	1,153,682 (55.89%)	11,696 (56.60%)	
Male	910,682 (44.11%)	8,970 (43.30%)	
Race			<0.0001
White	1,212,965 (76.35%)	12,167 (75.34%)	
Black	195,071 (12.28%)	2,218 (13.73%)	
Hispanic	110,579 (6.96%)	1,058 (6.55%)	
Asian or Pacific Islander	30,988 (1.95%)	299 (1.85%)	
Indian/Other	38,999 (2.46%)	408 (2.53%)	
Insurance			<0.0001
Medicare	1,168,594 (56.70%)	12,255 (59.38%)	
Medicaid	147,270 (7.15%)	1,238 (6.00%)	
Private	624,037 (30.28%)	5,863 (28.41%)	
Self-pay	644,330 (3.12%)	762 (3.69%)	
No charge	6,515 (0.32%)	65 (0.31%)	
Other	50,376 (2.44%)	456 (2.21%)	
Charlson Comorbidity Index			<0.0001
0	846,468 (40.98%)	10,601 (51.26%)	
1-2	661,957 (32.05%)	6,800 (32.88%)	
3	557,174 (26.97%)	3,279 (15.86%)	
Presentation			<0.0001
Emergent	1,436,630 (78.15%)	16,322 (89.24%)	
Elective	401,560 (21.85%)	1,968 (10.76%)	
Hospital Type			
Urban	1,740,835 (84.28%)	17,061 (82.50%)	<0.0001
Teaching	833,369 (40.48%)	8,267 (40.12%)	0.295
Rural	324,764 (15.72%)	3,619 (17.50%)	<0.0001
Management			
Non-operative	1,683,036 (81.48%)	7,194 (34.79%)	<0.0001
Operative	382,563 (18.42%)	13,486 (65.21%)	<0.0001
Adhesiolysis	261,446 (12.66%)	6,709 (32.44%)	<0.0001
Small bowel resection	101,397 (4.91%)	4,954 (23.96%)	<0.0001
Manipulation	6,542 (0.32%)	2,763 (12.26%)	<0.0001
Dilation	19,849 (0.96%)	2,451 (11.85%)	<0.0001

Demographics	Bowel Obstruction (%)	Volvulus (%)	P-value
Small bowel surgery	75,182 (3.64%)	2,021 (9.77%)	<0.0001
Destruction of peritoneal tissue	34,578 (1.67%)	888 (4.29%)	<0.0001
Laparoscopic	36,777 (1.78%)	855 (4.13%)	<0.0001
Exploratory laparotomy	22,070 (1.07%)	544 (2.63%)	<0.0001
Ladds	1,709 (0.08%)	72 (0.35%)	<0.0001
Small bowel pexy	579 (0.03%)	68 (0.33%)	<0.0001
Presentations of acute abdomen			
Acute vascular insufficiency	50,801 (2.46%)	3,510 (16.97%)	<0.0001
Peritonitis	39,599 (1.92%)	639 (3.09%)	<0.0001
Coagulopathy	24,913 (1.21%)	265 (1.28%)	0.318
Malrotation	1,745 (0.08%)	169 (0.82%)	<0.0001
Pneumoperitoneum	4,911 (0.24%)	85 (0.41%)	<0.0001
Mortality			
In-hospital mortality	115,730 (5.61%)	1,637 (7.92%)	<0.0001
Admission to death time, mean (sd), days	14.1 (17.5)	8.11 (11.6)	<0.0001

* Percentages are based upon the denominator of available data.

Table 2

Characteristics of patients with small bowel volvulus and intestinal malrotation.*

Demographics	Number (%)
Total Patients	169
Age, mean (sd), years	48.2 (21.2)
Sex	
Female	91 (53.85%)
Male	78 (46.15%)
Race	
White	107 (77.54%)
Black	16 (11.59%)
Hispanic	10 (7.25%)
Asian or Pacific Islander	3 (2.17%)
Indian/Other	2 (1.45%)
Insurance	
Medicare	45 (26.63%)
Medicaid	20 (11.83%)
Private	83 (49.11%)
Self-pay	14 (8.28%)
No charge	1 (0.59%)
Other	6 (3.55%)
Charlson Comorbidity Index	
0	120 (71.01%)
1-2	29 (17.16%)
3	20 (11.83%)
Presentation	
Emergent	131 (89.73%)
Elective	15 (10.27%)
Hospital Type	
Urban	152 (89.94%)
Teaching	80 (47.34%)
Rural	17 (10.06%)
Management	
Non-operative	35 (20.71%)
Operative	134 (79.29%)
Adhesiolysis	88 (52.07%)
Manipulation	50 (29.59%)
Ladds	32 (18.93%)
Small bowel resection	26 (15.38%)

Demographics	Number (%)
Small bowel surgery	18 (10.65%)
Laparoscopic	13 (7.69%)
Destruction of peritoneal tissue	3 (1.78%)
Exploratory laparotomy	3 (1.78%)
Dilation	1 (0.59%)
Small bowel pexy	1 (0.59%)
Presentations of acute abdomen	
Acute vascular insufficiency	22 (13.02%)
Peritonitis	5 (2.96%)
Mortality	
In-hospital mortality	4 (2.37%)
Admission to death time, mean (sd), days	1 (0.82) days

* Percentages are based upon the denominator of available data.

Table 3

Characteristics of patients with small bowel volvulus presenting emergently or electively.*

	Emergent	Elective	P-value
Total Patients	16,322 (78.90%)	1,968 (9.50%)	
Age, mean (sd), years	66.2 (19.5)	64.0 (18.5)	<0.0001
Sex			0.178
Female	9,233 (56.57%)	1,144 (58.16%)	
Male	7,089 (43.43%)	823 (41.84%)	
Race			<0.0001
White	9,482 (76.30%)	1,135 (80.96%)	
Black	1,890 (15.21%)	143 (10.20%)	
Hispanic	625 (5.03%)	60 (4.28%)	
Asian or Pacific Islander	125 (1.01%)	21 (1.50%)	
Indian/Other	305 (2.45%)	43 (3.06%)	
Insurance			<0.0001
Medicare	9,803 (60.18%)	1,079 (55.05%)	
Medicaid	920 (5.65%)	111 (5.66%)	
Private	4,528 (27.80%)	672 (34.29%)	
Self-pay	636 (3.90%)	49 (2.50%)	
No charge	61 (0.37%)	4 (0.20%)	
Other	341 (2.09%)	45 (2.30%)	
Charlson Comorbidity Index			0.542
0	8,380 (51.34%)	1,021 (51.88%)	
1-2	5,420 (33.21%)	617 (31.35%)	
3	2,522 (15.45%)	330 (16.77%)	
Hospital Type			
Teaching	6,751 (41.53%)	740 (37.74%)	0.001
Rural	2,937 (18.07%)	460 (23.37%)	<0.0001
Urban	13,319 (81.93%)	1,508 (76.63%)	<0.0001
Management			
Non-operative	5,486 (33.61%)	819 (12.99%)	<0.0001
Operative	10,836 (66.39%)	1,149 (58.38%)	<0.0001
Adhesiolysis	5,338 (32.70%)	632 (32.11%)	0.598
Small bowel resection	4,048 (24.80%)	344 (17.48%)	<0.0001
Manipulation	2,256 (13.82%)	246 (12.50%)	0.107
Dilation	2,046 (12.54%)	140 (7.11%)	<0.0001
Small bowel surgery	1,607 (9.85%)	193 (9.81%)	0.957
Destruction of peritoneal tissue	638 (3.91%)	137 (6.96%)	<0.0001
Laparoscopic	646 (3.96%)	115 (5.84%)	<0.0001

	Emergent	Elective	P-value
Exploratory laparotomy	444 (2.72%)	46 (2.34%)	0.320
Ladd's	56 (0.34%)	11 (0.56%)	0.134
Small bowel pexy	46 (0.28%)	14 (0.71%)	0.002
Presentations of acute abdomen			
Acute vascular insufficiency	2,856 (17.50%)	219 (11.13%)	<0.0001
Peritonitis	479 (2.93%)	74 (3.76%)	0.043
Coagulopathy	200 (1.23%)	24 (1.22%)	0.982
Malrotation	131 (0.80%)	15 (0.76%)	0.849
Pneumoperitoneum	61 (0.37%)	15 (0.76%)	0.011
Mortality			
In-hospital mortality	1,308 (8.02%)	107 (5.44%)	<0.0001
Admission to death time, mean (sd), days	7.8 (11.4)	10.2 (13.7)	0.0436

* Percentages are based upon the denominator of available data.

Table 4

Characteristics of patients with small bowel volvulus undergoing operative or nonoperative management.*

	Operative management	Non-operative management	P-value
Total Patients	13,486 (65.21%)	7,194 (34.79%)	
Age, mean (sd), years	63.8 (19.4)	70.1 (18.6)	<0.0001
Sex			0.704
Female	7,638 (56.69%)	4,058 (56.42%)	
Male	5,835 (43.31%)	3,135 (43.58%)	
Race			0.001
White	7,925 (76.01%)	4,242 (74.11%)	
Black	1,370 (13.14%)	848 (14.81%)	
Hispanic	678 (6.50%)	380 (6.64%)	
Asian or Pacific Islander	211 (2.02%)	88 (1.54%)	
Indian/Other	242 (2.32%)	166 (2.9%)	
Insurance			<0.0001
Medicare	7,374 (54.81%)	4,881 (67.93%)	
Medicaid	779 (5.79%)	459 (6.39%)	
Private	4,367 (32.46%)	1,496 (20.82%)	
Self-pay	569 (4.23%)	193 (2.69%)	
No charge	49 (0.36%)	16 (0.22%)	
Other	316 (2.35%)	140 (1.95%)	
Charlson Comorbidity Index			<0.0001
0	7,502 (55.63%)	3,099 (43.08%)	
1-2	4,147 (30.75%)	2,653 (36.88%)	
3	1,837 (13.62%)	1,442 (20.04%)	
Presentation			<0.0001
Elective	1,149 (58.38%)	819 (41.62%)	
Emergent	10,836 (90.41%)	5,486 (87.01%)	
Hospital Type			
Teaching	5,509 (40.09%)	2,758 (38.48%)	<0.0001
Rural	2,223 (16.48%)	1,396 (19.41%)	<0.0001
Urban	11,263 (83.52%)	5,798 (80.59%)	<0.0001
Management			
Laparoscopic	855 (6.34%)		
Adhesiolysis	6,709 (32.44%)		
Small bowel resection	4,954 (23.96%)		
Manipulation	2,763 (12.26%)		
Dilation	2,451 (11.85%)		
Small bowel surgery	2,021 (9.77%)		

	Operative management	Non-operative management	P-value
Destruction of peritoneal tissue	888 (4.29%)		
Exploratory laparotomy	544 (2.63%)		
Ladds	72 (0.53%)		
Small bowel pexy	68 (0.33%)		
Presentations of acute abdomen			
Acute vascular insufficiency	3,210 (23.80%)	300 (4.17%)	<0.0001
Peritonitis	543 (4.03%)	96 (1.33%)	<0.0001
Coagulopathy	177 (1.31%)	88 (1.22%)	0.587
Malrotation	134 (0.99%)	35 (0.49%)	<0.0001
Pneumoperitoneum	74 (0.55%)	11 (0.15%)	<0.0001
Mortality			
In-hospital mortality	800 (5.94%)	837 (11.65%)	<0.0001
Admission to death time, mean (sd), days	10.2 (12.8)	6.1 (10.0)	<0.0001

* Percentages are based upon the denominator of available data.

Table 5

Characteristics of patients with small bowel volvulus and intestinal malrotation undergoing operative or non-operative management.*

	Operative management	Non-operative management	P-value
Total Patients	134 (79.29%)	35 (20.71%)	
Age, mean (sd), years	46.1 (19.9)	56.0 (24.3)	0.0136
Sex			0.114
Female	68 (50.75%)	12 (34.29%)	
Male	66 (49.25%)	23 (65.71%)	
Race			0.651
White	82 (75.23%)	25 (86.21%)	
Black	13 (11.93%)	3 (10.34%)	
Hispanic	9 (8.26%)	1 (3.45%)	
Asian or Pacific Islander	3 (2.75%)	0	
Indian/Other	2 (1.83%)	0	
Insurance			0.359
Medicare	31 (23.13%)	14 (40.00%)	
Medicaid	15 (11.19%)	5 (14.29%)	
Private insurance	71 (52.99%)	12 (34.29%)	
Self-pay	11 (8.21%)	3 (8.57%)	
No charge	1 (0.75%)	0	
Other	5 (3.73%)	1 (2.86%)	
Charlson Comorbidity Index			0.479
0	98 (73.13%)	22 (62.86%)	
1-2	21 (15.67%)	8 (22.86%)	
3	15 (11.19%)	5 (14.29%)	
Presentation			0.587
Emergent	104 (90.43%)	27 (87.10%)	
Elective	11 (9.57%)	4 (12.90%)	
Hospital Type			
Teaching	66 (49.25%)	14 (40.00%)	0.329
Rural	11 (8.21%)	6 (17.14%)	0.118
Urban	123 (91.79%)	29 (82.86%)	0.118
Management			
Adhesiolysis	88 (65.67%)		
Manipulation	50 (37.31%)		
Ladd's	32 (23.88%)		
Small bowel resection	26 (19.40%)		
Small bowel surgery	18 (13.43%)		
Laparoscopic	13 (9.70%)		

	Operative management	Non-operative management	P-value
Destruction of peritoneal tissue	3 (2.24%)		
Exploratory laparotomy	3 (2.24%)		
Dilation	1 (0.75%)		
Small bowel pexy	1 (0.75%)		
Presentations of acute abdomen			
Acute vascular insufficiency	21 (15.67%)	1 (2.86%)	0.045
Peritonitis	5 (3.73%)	0	0.246
Mortality			
Inpatient deaths	3 (2.24%)	1 (2.86%)	0.830
Admission to death time, mean (sd), days	0.67 (0.58)	2	

* Percentages are based upon the denominator of available data.

Table 6

Multivariate analysis of all patients with small bowel volvulus.

	Odds Ratio	95% CI		P-value
		Lower	Higher	
Sex				
Female	(Reference)			
Male	1.17	1.02	1.36	0.029
Race				
White	(Reference)			
Black	1.14	0.93	1.39	0.197
Hispanic	1.12	0.79	1.57	0.526
Asian or Pacific Islander	0.87	0.39	1.91	0.722
Indian	0.90	0.34	2.40	0.837
Other	1.09	0.71	1.68	0.694
Age				
18 – <40	(Reference)			
40 – <45	1.61	0.70	3.68	0.263
45 – <50	1.50	0.69	3.27	0.310
50 – <55	2.58	1.36	4.87	0.004
55 – <60	3.38	1.83	6.23	<0.001
60 – <65	4.75	2.60	8.68	<0.001
65 – <70	5.79	3.36	9.99	<0.001
70 – <75	5.60	3.26	9.64	<0.001
75 – <80	7.94	4.75	13.26	<0.001
80 – <85	12.75	7.76	20.97	<0.001
85 – <90	14.62	8.81	24.26	<0.001
90	18.23	10.86	30.59	<0.001
Charlson Comorbidity Index				
0	(Reference)			
1-2	1.59	1.36	1.87	<0.001
3	2.34	1.95	2.81	<0.001
Presentation				
Elective Admission	(Reference)			
Emergent Admission	1.38	1.08	1.76	0.009
Hospital Type				
Non-teaching	(Reference)			
Teaching	1.09	0.94	1.26	0.254
Rural	(Reference)			
Urban	0.96	0.79	1.17	0.698
Management				

	Odds Ratio	95% CI		P-value
		Lower	Higher	
Non-operative	(Reference)			
Operative	0.46	0.39	0.53	<0.001
Year				
1998	(Reference)			
1999	1.35	0.96	1.90	0.081
2000	0.96	0.67	1.38	0.841
2001	1.12	0.78	1.61	0.532
2002	0.87	0.59	1.29	0.495
2003	0.98	0.68	1.40	0.902
2004	1.08	0.77	1.52	0.646
2005	1.04	0.73	1.47	0.841
2006	0.88	0.62	1.25	0.48
2007	0.88	0.61	1.25	0.470
2008	0.88	0.63	1.22	0.440
2009	0.87	0.62	1.22	0.426
2010	0.92	0.65	1.31	0.654
Presentations of acute abdomen				
Peritonitis				
No	(Reference)			
Yes	2.41	1.74	3.33	<0.001
Acute vascular insufficiency				
No	(Reference)			
Yes	3.09	2.60	3.67	<0.001
Coagulopathy				
No	(Reference)			
Yes	6.31	4.29	9.28	<0.001
Pneumoperitoneum				
No	(Reference)			
Yes	2.32	0.76	7.06	0.139