ORIGINAL ARTICLE

Contemporary Management of Sigmoid Volvulus

Scott C. Dolejs[1] · Michael J. Guzman[1] · Alyssa D. Fajardo[1] · Bryan K. Holcomb[1] · Bruce W. Robb[1] · Joshua A. Waters[1]

Abstract

Background Sigmoid volvulus is an uncommon cause of bowel obstruction that is historically associated with high morbidity and mortality. The objective of this study was to evaluate contemporary management of sigmoid volvulus and the safety of primary anastomosis in patients with sigmoid volvulus.

Methods The National Surgical Quality Improvement Project from 2012 to 2015 was queried for patients with colonic volvulus who underwent left-sided colonic resection. A propensity score-matched analysis was performed to compare patients with sigmoid volvulus undergoing colectomy with primary anastomosis without proximal diversion to colectomy with end colostomy.

Results Two thousand five hundred thirty-eight patients with sigmoid volvulus were included for analysis. Patients had a median age of 68 years (interquartile range, 55–80) and 79% were fully independent preoperatively. Fifty-one percent of operations were performed emergently. One thousand eight hundred thirteen (71%) patients underwent colectomy with anastomosis, 240 (10%) colectomy with anastomosis and proximal diversion, and 485 (19%) colectomy with end colostomy. Overall, 30-day mortality and morbidity were 5 and 40%, respectively. After propensity score matching, mortality, overall morbidity, and serious morbidity were similar between groups.

Conclusions Sigmoid volvulus occurs in elderly and debilitated patients with significant morbidity, mortality, and lifestyle implications. In selected patients, anastomosis without proximal diversion in patients with sigmoid volvulus results in similar outcomes to colectomy with end colostomy.

Keywords Sigmoid volvulus · Intestinal volvulus · Colectomy · Colostomy

Introduction

Colonic volvulus is an uncommon cause of intestinal obstruction wherein a long and redundant colonic segment rotates around an elongated mesentery with a narrow base.[1,2] It is the cause of 2–3% of bowel obstructions in the USA but causes as many as 10–50% of bowel obstructions in other areas of the world (Latin America, Africa, Eastern Europe, Russia, Middle East, and India).[1,3–6] Sigmoid volvulus (SV) is the most common cause of colonic volvulus, accounting for 50–90% of all cases.[1,3,4,7] SV commonly occurs in patients older than 70 with a history of chronic constipation who are institutionalized and debilitated, or have underlying neuropsychiatric disorders.[1,8,9] Bowel gangrene, peritonitis, and death may develop if prompt volvulus reduction is not achieved.[7,10] This deadly pathophysiology combined with concomitant frailty results in a high expected mortality for sigmoid volvulus that varies between 9 and 70% depending on the series and severity of disease.[7,8,10–12]

Endoscopic reduction is the preferred initial management of SV, assuming peritonitis has not developed. Endoscopic reduction has been used for over 70 years, is successful in reducing the volvulus 77–98% of patients, and has been shown to reduce mortality compared with emergent colectomy.[8,10–16] With endoscopic detorsion alone, recurrence rates have been reported to be between 7 and 67%.[3,10,12–14,17] As a result, colectomy is recommended after successful endoscopic detorsion.[3,10,12–14,17] Colectomy can be accompanied

✉ Joshua A. Waters
jwaters1@iuhealth.org

1   Department of Surgery, Indiana University School of Medicine, 1801 N. Senate Blvd., Suite 635, Indianapolis, IN 46202, USA

by a primary anastomosis with or without proximal diversion or a colectomy with end colostomy.[1] There is little, low quality evidence to recommend one operative approach over the other.

The primary purpose of this study is to evaluate nationwide trends in the operative management and presentation of patients with sigmoid volvulus and to determine the safety of primary anastomosis in patients with sigmoid volvulus.

We hypothesize that the actual morbidity and mortality of volvulus will be lower than historically reported rates, and secondarily that primary anastomosis will not be associated with elevated morbidity and mortality in selected patients.

Methods

Patient Selection

The American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Colectomy-Targeted Dataset was queried for patients with intestinal volvulus who underwent operative repair from 2012 to 2015. Patients with intestinal volvulus were identified based on an International Classification of Diseases, Ninth Revision (ICD-9) diagnosis of 560.2. This code does not differentiate between cecal and sigmoid volvulus. As such, patients were classified as having a sigmoid volvulus if they underwent a left-sided colectomy. Table 1 provides a breakdown of the Current Procedural Terminology (CPT) codes that defined sigmoid volvulus and details how the differentiation between colectomy with anastomosis vs colectomy without anastomosis (Hartmann's procedure) was made.

A comparative analysis in patients with sigmoid volvulus was performed to study the safety of a primary anastomosis in these patients. This study was deemed exempt by the Indiana University School of Medicine Institutional Review Board.

Study Variables

Multiple preoperative and postoperative variables were collected. Preoperative variables included preoperative patient location, gender, age, race, body mass index, American Society of Anesthesiology physical status classification (ASA score), and patient comorbidities. Operative variables include the emergency status of the procedure, preoperative wound class, method of wound closure, operative time, operative approach (minimally invasive or not), and the utilization of an anastomosis. Thirty-day postoperative outcomes included mortality, overall morbidity, serious morbidity (defined as reoperation within 30-days, prolonged ventilation, organ space surgical site infection (SSI), wound dehiscence, postoperative sepsis, transfusion of greater than or equal to 4 units of packed red blood cells, cardiac arrest, postoperative myocardial infarction, pulmonary embolism, or anastomotic leak), length of stay, discharge destination, and other ACS-NSQIP defined outcomes.

Statistical Approach

Univariate statistics were performed to determine baseline differences between patients with sigmoid volvulus who underwent colectomy with anastomosis without proximal diversion and a Hartmann's procedure with Chi-squared, Fisher's exact, or Wilcoxon rank-sum tests,

Table 1 Breakdown of how current procedural terminology (CPT) codes were used to define left-sided colectomy with or without anastomosis

Colectomy with or without anastomosis	Proximal diversion status	Operative approach	CPT code
With anastomosis	With proximal diversion[1]	Laparoscopic	44208
		Open	44141
			44146
	No proximal diversion	Laparoscopic	44204
			44207
		Open	44140
			44145
			45550
Without anastomosis	With end colostomy	Laparoscopic	44206
		Open	44143
			44144

CPT Current Procedural Technology

[1] Proximal diversion was also classified if a patient had a concurrent or other CPT code indicating proximal diversion was utilized

given lack of normality, as appropriate. A 1:1 propensity score-matched analysis was then performed to explore the relationship between Hartmann's procedure and colectomy with anastomosis without proximal diversion. This analysis was repeated to compare outcomes in cases that were coded as emergent in ACS-NSQIP. Propensity score matching allows for control of differences in baseline covariables to make the group of patients undergoing Hartmann's procedure comparable to the group of patients undergoing colectomy with anastomosis without proximal diversion.

Results

Overview of Sigmoid Volvulus

A total of 2538 patients underwent operative repair of sigmoid volvulus. Patients had a median age of 68 years (interquartile range, 55–80) and 79% were fully independent preoperatively. Fifty-one percent of operations were performed emergently (Table 2). One thousand eight hundred thirteen (71%) patients underwent colectomy with anastomosis, 240 (10%) colectomy with anastomosis and proximal diversion, and 485 (19%) colectomy with end colostomy. Patients with sigmoid volvulus had a mortality of 5.4%, a serious morbidity of 24.9%, and were discharged to a rehabilitation facility postoperatively 32.5% of the time. The anastomotic leak rate of patients with sigmoid volvulus was 4.9%.

Colectomy with Anastomosis Versus Hartmann's Procedure Prior to Matching

Prior to propensity score matching, there were marked differences in patients undergoing colectomy with primary anastomosis without diversion to those undergoing Hartmann's procedure for sigmoid volvulus (Table 3). Patients undergoing Hartmann's procedure tended to be more commonly transferred from a nursing home, older, male, non-white, have higher ASA class, higher rates of emergency surgery, higher rates of comorbidities, higher rates of preoperative partial or total dependence (37.9 vs 11.2%, $P < 0.001$), higher wound classification, and lower rates of minimally invasive surgery. The median operative time for both techniques was identical (93 min for both, $P = 0.42$). Patients undergoing Hartmann's procedure had higher mortality (10.1 vs 3.6%, $P < 0.001$), overall morbidity (48.7 vs 35.7%, $P < 0.001$), and higher serious morbidity (32.7 vs 21.5%, $P < 0.001$). The anastomotic leak rate in patients with a primary anastomosis was 5.3%.

Table 2 Characteristics of patients undergoing surgery for sigmoid volvulus

Characteristic:	Sigmoid volvulus ($n = 2538$)
Preoperative characteristics	
Age, median (IQR)	68 (55–80)
Gender, % male	51.6
Body mass index, median (IQR)	25 (22–28)
Race, % non-white	23.6
ASA class, % 3–4:	65.4
Emergency surgery, %:	50.6
Transferred from nursing home, %:	7.9
Functional status	
% Partially dependent	11.7
% Totally dependent	6.6
Ascites	0.9
Bleeding disorders, %	10.4
Diabetes, %	12.1
Preop dialysis, %	1.0
Preop disseminated cancer, %	0.8
Preop dyspnea, %	5.75
CHF, %	2.0
COPD, %	7.4
Hypertension, %	47.4
Preop sepsis, %	18.6
Steroid, %	3.6
Preop vent, %	2.2
Preop weight loss, %	2.4
MIS, %	19.0
Primary anastomosis, %	80.9
Hartmann's procedure, %	19.1
Ostomy, %	28.6
Outcomes	
Mortality, %	5.4
Overall morbidity, %	39.6
Serious morbidity, %	24.9
Discharged to rehab/acute care/SNF, %	32.5
Anastomotic leak, %	4.9

Colectomy with Anastomosis Versus Hartmann's Procedure after Matching

After propensity score matching, 440 patients undergoing colectomy and anastomosis without proximal diversion were compared to 440 patients undergoing Hartmann's procedure. There were no significant preoperative differences between groups ($P > 0.10$ for all comparisons) (Table 4). The median operative time was 92 min in both groups ($P = 0.38$). Mortality, overall morbidity, and

Table 3 Characteristics of patients with sigmoid volvulus undergoing Hartmann's procedure versus colectomy with primary anastomosis without proximal diversion prior to propensity score matching

Characteristic	Colectomy with primary anastomosis ($n = 1813$)	Hartmann's procedure ($n = 483$)	p value
Preoperative characteristics			
Age, median (IQR)	66 (53–78)	74 (63–84)	< 0.001
Gender, % male	45.4	64.6	< 0.001
Body mass index, median (IQR)	24 (22–28)	25 (22–28)	0.07
Race, % non-white	22.1	28.2	0.001
ASA class, % 3–4:	57.2	87.0	< 0.001
Emergency surgery, %:	47.7	57.4	< 0.001
Transferred from nursing home, %:	4.7	16.2	< 0.001
Functional status			< 0.01
% Partially dependent	7.6	23.0	
% Totally dependent	3.6	14.9	
Ascites, %	0.8	1.2	0.41
Bleeding disorders, %	8.4	16.8	< 0.001
Diabetes, %	10.4	16.1	< 0.001
Preop dialysis, %	0.7	1.9	0.03
Preop disseminated cancer, %	0.4	2.5	< 0.001
Preop dyspnea, %	4.6	9.3	< 0.001
CHF, %	1.3	3.3	0.002
COPD, %	5.9	11.8	< 0.001
Hypertension, %	43.9	56.1	< 0.001
Preop sepsis, %	14.1	30.4	< 0.001
Steroid, %	2.9	5.0	0.03
Preop vent, %	1.2	4.4	< 0.001
Preop weight loss, %	2.0	2.9	0.26
MIS, %	24.1	6.4	< 0.001
Wound class, % 3–4	17.9	35.4	< 0.001
Wound closure, %			0.21
All layers closed	97.7	96.2	
Only deep closed	1.8	2.3	
No layers closed	0.5	1.5	
Operative time, median (IQR)	93 (68–125)	93 (70–130)	0.42
Outcomes			
Mortality, %	3.6	10.1	< 0.001
Overall morbidity, %	35.7	48.7	< 0.001
Serious morbidity, %	21.5	32.7	< 0.001
Discharged to rehab/acute care/SNF, %	24.0	56.6	< 0.001
Anastomotic leak, %	5.3	N/A	

serious morbidity were similar between groups (Table 5). More patients undergoing Hartmann's procedure were discharged to a rehabilitation facility, acute care facility, or skilled nursing facility (SNF) (55.2 vs 43.6%, $P < 0.001$). The rate of anastomotic leak in patients undergoing colectomy with primary anastomosis was 6.2%. There were statistically significant increases in the reintubation rate (8.2 vs 4.6%, $P = 0.03$) and organ space SSI (5.9 vs 2.1%, $P = 0.003$) in patients with colectomy and primary anastomosis.

Emergent Colectomy with Anastomosis Versus Emergent Hartmann's Procedure After Matching

After matching, 232 patients undergoing emergent colectomy with anastomosis were compared to 232 patients undergoing emergent Hartmann's procedure (Table 6). The preoperative and operative characteristics of both groups were similar (Supplement 1). There was no difference in mortality, overall morbidity, or serious morbidity between groups. More patients undergoing a Hartmann's procedure were discharged

Table 4 Preoperative and operative characteristics of patients with sigmoid volvulus undergoing Hartmann's procedure versus colectomy with primary anastomosis without proximal diversion after propensity score matching

Characteristic	Colectomy with primary anastomosis ($n = 440$)	Hartmann's procedure ($n = 440$)	p value
Preoperative characteristics			
Age, median (IQR)	73 (61–83)	74 (63–84)	0.47
Gender, % male	61.6	62.3	0.84
Body mass index, median (IQR)	24 (21–28)	25 (22–28)	0.35
Race, % non-white	22.7	27.5	0.31
ASA class, % 3–4:	85.5	87.3	0.56
Emergency surgery, %:	56.4	55.2	0.73
Transferred from nursing home, %:	10.7	15.2	0.19
Functional status			0.72
% Partially dependent	19.3	22.3	
% Totally dependent	12.7	13.0	
Ascites, %	0.7	1.1	0.73
Bleeding disorders, %	15.5	15.5	1.0
Diabetes, %	17.5	15.7	0.77
Preop dialysis, %	1.6	1.8	0.79
Preop disseminated cancer, %	1.6	1.8	0.79
Preop dyspnea, %	7.5	8.6	0.82
CHF, %	2.7	3.2	0.69
COPD, %	8.9	11.6	0.18
Hypertension, %	57.5	55.9	0.63
Preop sepsis, %	27.3	26.4	0.50
Steroid, %	2.7	4.3	0.20
Preop vent, %	3.0	4.1	0.36
Preop weight loss, %	2.7	2.7	1.00
MIS, %	6.8	7.1	0.89
Wound class, % 3–4	31.8	32.7	0.60
Wound closure, %			0.55
All layers closed	95.0	96.7	
Only deep closed	3.8	2.1	
No layers closed	1.3	1.3	
Operative time, median (IQR)	92 (67–122)	92 (70–127)	0.38

to a rehabilitation facility, acute care facility, or SNF (54.0 vs 38.2%, $P = 0.001$). The rate of anastomotic leak in patients undergoing colectomy with primary anastomosis was 4.0%. The rate of wound dehiscence was significantly higher in patients undergoing colectomy with primary anastomosis (5.2 vs 1.7%, $P = 0.04$). The length of stay was 2 days shorter on average in patients undergoing colectomy with primary anastomosis (7 vs 9 days, $P = 0.01$).

Discussion

Colonic volvulus is a rare condition that tends to occur in an elderly patient population in the USA.[1,3,14] Despite prior series asserting that 18.3–45.1% of patients with sigmoid volvulus present from a skilled nursing facility, our data indicate that only 7.9% of patients with sigmoid volvulus are transferred

from a nursing home and that 81.7% of patients with sigmoid volvulus are independent preoperatively.[3,14,18,19] Thus, sigmoid volvulus is not a disease exclusive to the infirm and should be considered in the differential diagnosis of adult patients with bowel obstructions.

Colonic volvulus and sigmoid volvulus, in particular, carry a serious morbidity and mortality. The mortality for all patients with sigmoid volvulus undergoing operative repair in our series was 5.4%. In patients requiring emergent colectomy for sigmoid volvulus, the mortality was 6.8%. This rate is near the lowest rate of mortality in the current literature, which ranges from 6 to 70%.[7,8,10–12,20,21] The relatively low rate of mortality in our series compared to the older literature is concordant with a recent large analysis that used the Nationwide Inpatient Sample from 2002 to 2010 and found that SV had a mortality of 9.4%.[1] Thus, it is possible that with improved perioperative management, the mortality from sigmoid

Table 5 Postoperative outcomes of patients undergoing Hartmann's procedure versus colectomy with primary anastomosis without proximal diversion after propensity score matching

Characteristic	Colectomy with primary anastomosis ($n = 440$)	Hartmann's procedure ($n = 440$)	p value
Outcomes			
Mortality, %	9.1	9.1	1.00
Overall morbidity, %	50.7	45.7	0.14
Serious morbidity, %	33.6	29.6	0.19
Discharged to rehab/acute care/SNF, %	43.6	55.2	< 0.001
Anastomotic leak, %	6.2	NA	
Readmission rate, %	13.2	12.5	0.77
Ileus, %	36.6	28.5	0.07
Reoperation rate, %	11.4	7.7	0.07
Pneumonia, %	11.4	9.1	0.27
Prolonged ventilation, %	9.1	8.6	0.81
Reintubation rate, %	8.2	4.6	0.03
Superficial SSI, %	7.5	4.8	0.09
Deep incisional SSI, %	0.9	1.4	0.53
Organ space SSI, %	5.9	2.1	0.003
Wound dehiscence, %	3.4	1.6	0.08
Postoperative sepsis, %	16.4	13.2	0.18
Bleeding requiring ≥ 4 transfusions, %	12.3	10.7	0.46
Deep vein thrombosis, %	1.6	2.3	0.46
Pulmonary embolism, %	0.9	0.7	1.00
Acute kidney injury, %	4.1	3.9	0.86
Urinary tract infection, %	4.6	5.0	0.75
Cardiac arrest, %	1.1	1.4	0.76
Myocardial infarction, %	2.5	2.5	1.00
Stroke, %	0.5	0.5	1.00
Length of stay, median (IQR)	8 (5–13)	8 (5–12)	0.58

volvulus is improving. Our series may demonstrate selection bias, as some patients were likely not offered an operation due to prohibitive comorbidities and declining clinical condition and thus were not captured by the dataset.

Despite a lower mortality than previously quoted, this study highlights very important outcome metrics. One particularly troubling finding was that despite only 7.9% of patients with sigmoid volvulus coming from a nursing home, 32.5% of patients were discharged to a facility. Sigmoid volvulus thus may have profound impacts on patients' lives, even if they survive to discharge.

In series dating back to 1946, colonic resection and primary anastomosis have been described in the setting of colonic volvulus and a review in 1982 indicated that resection with primary anastomosis was the most commonly performed technique at that time.[4,7,16,22] Despite over seven decades of experience, there are few studies directly comparing Hartmann's procedure to colectomy with primary anastomosis without diversion for sigmoid volvulus. Our study directly compares primary anastomosis without proximal diversion to Hartmann's procedure for sigmoid volvulus after appropriate

statistical adjustment. This demonstrates that a primary anastomosis without proximal diversion is associated with similar outcomes to end colostomy following colectomy for sigmoid volvulus. However, surgeons must be aware of the rate of anastomotic leak of 6.2% and make decisions about the need for proximal diversion based on this higher than expected rate of anastomotic leak.

Despite the safety demonstrated in our study and the long experience in the literature with primary anastomosis in the treatment of SV, there was still a high utilization of Hartmann's procedure in both elective (15%) and emergent cases (24%) in this series, which appear relatively unchanged over the last 50 years in the management of this condition.[7,10,21,23,24] Proponents of Hartmann's procedure in emergent cases cite two primary reasons for its use: the risk of anastomotic leak if the colon is gangrenous or if there is a large amount of mismatch in bowel diameter and the ability to decrease operative time in a potentially infirm and septic patient.[25] Interestingly, in both elective and emergent cases, the operative time was identical in patients with sigmoid volvulus undergoing primary anastomosis or Hartmann's

Table 6 Postoperative outcomes of patients undergoing emergent Hartmann's procedure versus emergent colectomy with primary anastomosis without proximal diversion after propensity score matching

Characteristic	Colectomy with primary anastomosis ($n = 232$)	Hartmann's procedure ($n = 232$)	p value
Outcomes			
Mortality, %	10.8	12.1	0.66
Overall morbidity, %	53.0	53.9	0.85
Serious morbidity, %	36.6	40.1	0.45
Discharged to rehab/acute care/SNF, %	38.2	54.0	0.001
Anastomotic leak, %	4.0	NA	
Readmission rate, %	16.0	11.6	0.18
Ileus, %	29.1	31.1	0.74
Reoperation rate, %	13.8	9.5	0.15
Pneumonia, %	12.1	12.9	0.78
Prolonged ventilation, %	10.3	14.7	0.16
Reintubation rate, %	9.5	6.9	0.31
Superficial SSI, %	6.5	6.0	0.17
Deep incisional SSI, %	0.4	2.2	0.22
Organ space SSI, %	6.5	3.5	0.13
Wound dehiscence, %	5.2	1.7	0.04
Postoperative sepsis, %	16.8	20.7	0.28
Bleeding requiring ≥ 4 transfusions, %	12.5	11.6	0.78
Deep vein thrombosis, %	1.7	0.9	0.69
Pulmonary embolism, %	0.9	0.9	1.00
Acute kidney injury, %	5.6	6.9	0.57
Urinary tract infection, %	3.0	5.2	0.24
Cardiac arrest, %	2.2	2.2	1.00
Myocardial infarction, %	1.7	3.0	0.36
Stroke, %	0.4	0.4	1.00
Length of stay, median (IQR)	7 (5–13)	9 (6–15)	0.01

procedure. Therefore, operative time should not be used as the prime justification for avoidance of a primary anastomosis. While the risk of anastomotic leak is high, this can be tempered with a proximal diversion in high-risk patients, such as patients with malnutrition, on steroids, with tobacco and alcohol use, severe cardiovascular disease, operative time over 2 h, poor blood supply, perioperative transfusion requirement, high tension, or intraoperative sepsis.[26]

This data should not supplant surgeon judgment as to whether perform an anastomosis given its limitations, which are inherent in the retrospective, database driven nature of this study. There is only one ICD-9 diagnosis code for colonic volvulus, and procedure codes were thus used to identify the site of volvulus, which could bias our results. Despite using a robust propensity score-matched analysis, there is still the possibility that unmeasured confounders exist and bias our results. Multiple potential preoperative and intraoperative confounders were not available in this analysis. Examples include the presence or absence of bowel gangrene, the need for vasoactive agents, the preoperative continence status of patients, the presence of bedsores, the preoperative utilization

of endoscopic detorsion, or the size mismatch of a possible anastomosis. All of these factors may serve as a rational to perform Hartmann's procedure rather than a primary anastomosis and could thus serve as important potential confounders. Thus, the findings of this study should not supplant intraoperative surgical judgment, but rather provide evidence that primary anastomosis may be considered in patients with sigmoid volvulus, even in emergent situations.

Conclusion

In this contemporary, large, and population-based study of patients who underwent operative repair for sigmoid volvulus, we demonstrate that patients with sigmoid volvulus tend to be younger with fewer morbidities than prior reports indicate. This suggests a need for a high suspicion of sigmoid volvulus in patients who present with bowel obstruction outside of the stereotypical patient populations. Operative repair is associated with lower mortality, even in emergent surgeries, than prior reports. However, the morbidity and lifestyle impact of

sigmoid volvulus is still very large. Colectomy and primary anastomosis may be considered in selected patients and are commonly performed in the treatment of sigmoid volvulus, even in the emergent setting.

Author Contribution Drs. Dolejs, Guzman, Fajardo, Holcomb, Robb, and Waters made substantial contributions to the conception of the work, revision of the work for important intellectual content, final approval of the version to be published, and agreement to be accountable for all aspects of the work. Drs. Dolejs and Waters made substantial contributions to the acquisition, analysis, and interpretation of data, and drafted the work.

Compliance with Ethical Standards

Conflicts of Interest The authors declare that they have no conflicts of interest.

References

1. Halabi WJ, Jafari MD, Kang CY, Nguyen VQ, Carmichael JC, Mills S et al. Colonic volvulus in the United States: trends, outcomes, and predictors of mortality. Ann Surg 2014;259(2):293–301. https://doi.org/10.1097/SLA.0b013e31828c88ac.
2. Akinkuotu A, Samuel JC, Msiska N, Mvula C, Charles AG. The role of the anatomy of the sigmoid colon in developing sigmoid volvulus: a case-control study. Clin Anat 2011;24(5):634–7. https://doi.org/10.1002/ca.21131.
3. Swenson BR, Kwaan MR, Burkart NE, Wang Y, Madoff RD, Rothenberger DA et al. Colonic volvulus: presentation and management in metropolitan Minnesota, United States. Dis Colon Rectum 2012;55(4):444–9. https://doi.org/10.1097/DCR.0b013e3182404b3d.
4. Raveenthiran V, Madiba TE, Atamanalp SS, De U. Volvulus of the sigmoid colon. Color Dis. 2010;12(7 Online):e1–17. https://doi.org/10.1111/j.1463-1318.2010.02262.x.
5. Heis HA, Bani-Hani KE, Rabadi DK, Elheis MA, Bani-Hani BK, Mazahreh TS et al. Sigmoid volvulus in the Middle East. World J Surg 2008;32(3):459–64. https://doi.org/10.1007/s00268-007-9353-3.
6. Muyembe VM, Suleman N. Intestinal obstruction at a provincial hospital in Kenya. East Afr Med J 2000;77(8):440–3.
7. Ballantyne GH, Brandner MD, Beart RW Jr, Ilstrup DM. Volvulus of the colon. Incidence and mortality. Ann Surg 1985;202(1):83–92.
8. Mangiante EC, Croce MA, Fabian TC, Moore OF 3rd, Britt LG. Sigmoid volvulus. A four-decade experience. Am Surg 1989;55(1):41–4.
9. Baker DM, Wardrop PJ, Burrell H, Hardcastle JD. The management of acute sigmoid volvulus in Nottingham. J R Coll Surg Edinb 1994;39(5):304–6.
10. Oren D, Atamanalp SS, Aydinli B, Yildirgan MI, Basoglu M, Polat KY et al. An algorithm for the management of sigmoid colon volvulus and the safety of primary resection: experience with 827 cases. Dis Colon Rectum 2007;50(4):489–97. https://doi.org/10.1007/s10350-006-0821-x.
11. Anderson JR, Lee D. The management of acute sigmoid volvulus. Br J Surg 1981;68(2):117–20.
12. Atamanalp SS. Treatment of sigmoid volvulus: a single-center experience of 952 patients over 46.5 years. Tech Coloproctol 2013;17(5):561–9. https://doi.org/10.1007/s10151-013-1019-6.
13. Safioleas M, Chatziconstantinou C, Felekouras E, Stamatakos M, Papaconstantinou I, Smirnis A et al. Clinical considerations and therapeutic strategy for sigmoid volvulus in the elderly: a study of 33 cases. World J Gastroenterol 2007;13(6):921–4.
14. Bruzzi M, Lefevre JH, Desaint B, Nion-Larmurier I, Bennis M, Chafai N et al. Management of acute sigmoid volvulus: short- and long-term results. Color Dis 2015;17(10):922–8. https://doi.org/10.1111/codi.12959.
15. Ali MK. Treatment of sigmoid volvulus: experience in Gondar, north-west Ethiopia. Ethiop Med J 1998;36(1):47–52.
16. Simon HE, Senturia HR, Keller TB. Volvulus of the sigmoid colon. Am J Surg 1946;71:550–2.
17. Yassaie O, Thompson-Fawcett M, Rossaak J. Management of sigmoid volvulus: is early surgery justifiable? ANZ J Surg 2013;83(1–2):74–8. https://doi.org/10.1111/j.1445-2197.2012.06182.x.
18. Tan KK, Chong CS, Sim R. Management of acute sigmoid volvulus: an institution's experience over 9 years. World J Surg 2010;34(8):1943–8. https://doi.org/10.1007/s00268-010-0563-8.
19. Ballantyne GH. Review of sigmoid volvulus. Clinical patterns and pathogenesis. Dis Colon Rectum. 1982;25(8):823–30.
20. Grossmann EM, Longo WE, Stratton MD, Virgo KS, Johnson FE. Sigmoid volvulus in Department of Veterans Affairs Medical Centers. Dis Colon Rectum 2000;43(3):414–8.
21. Kuzu MA, Aslar AK, Soran A, Polat A, Topcu O, Hengirmen S. Emergent resection for acute sigmoid volvulus: results of 106 consecutive cases. Dis Colon Rectum 2002;45(8):1085–90.
22. Ballantyne GH. Review of sigmoid volvulus: history and results of treatment. Dis Colon Rectum 1982;25(5):494–501.
23. Valsdottir E, Marks JH. Volvulus: small bowel and colon. Clin Colon Rectal Surg 2008;21(2):91–3. https://doi.org/10.1055/s-2008-1075856.
24. Akcan A, Akyildiz H, Artis T, Yilmaz N, Sozuer E. Feasibility of single-stage resection and primary anastomosis in patients with acute noncomplicated sigmoid volvulus. Am J Surg 2007;193(4):421–6.
25. Oberkofler CE, Rickenbacher A, Raptis DA, Lehmann K, Villiger P, Buchli C et al. A multicenter randomized clinical trial of primary anastomosis or Hartmann's procedure for perforated left colonic diverticulitis with purulent or fecal peritonitis. Ann Surg 2012;256(5):819–26; discussion 26–7. https://doi.org/10.1097/SLA.0b013e31827324ba.
26. Kingham TP, Pachter HL. Colonic anastomotic leak: risk factors, diagnosis, and treatment. J Am Coll Surg 2009;208(2):269–78. https://doi.org/10.1016/j.jamcollsurg.2008.10.015.