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Sigmoid volvulus—Can CT features predict outcomes and recurrence?

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Objectives Sigmoid volvulus (SV) is a common cause of bowel obstruction, especially in older patients. SV can be mesenteroaxial (M-SV) or organoaxial (O-SV). The purpose of this study was to assess if CT findings in SV are associated with clinical outcomes. including recurrence, choice of management, and mortality.

Materials and methods This study includes patients with SV and a CT within 24 hours of presentation. CT features, including mesenteraoxial/organoaxial arrangement, direction of rotation, transition points, distension, whirl-sign, ischemia, and perforation were determined. Demographics, treatment, recurrence, and outcome data were recorded.

Results One hundred and seventeen cases were diagnosed in 80 patients (54 male). The mean age was 70 years (± 17.1). M-SV and O-SV were equally prevalent ($n = 39$ *vs.* $n = 41$, respectively). M-SV was significantly more common with anticlockwise rotation in the axial plane ($p = 0.028$) and clockwise rotation in the coronal plane ($p = 0.015$). All patients with imaging features of ischemia underwent surgery ($n = 6$). There was no significant difference in outcome variables (30-day mortality, 30-day readmission, recurrence) between the O-SV and M-SV groups. The degree of bowel distension on initial presentation was a significant predictor of recurrence, with ≥ 9 cm vs < 9 cm associated with an increased odds of any recurrence (OR: 3.23; 95%CI: 1.39–7.92).

Conclusion In SV, sigmoid distension of more than 9 cm at baseline CT was associated with an increased risk of recurrence. Imaging features of ischemia predicted surgical over endoscopic intervention. Organoaxial and mesenteroaxial SV had similar prevalence, but the type of volvulus was not associated with clinical outcomes or choice of management.

Clinical relevance statement There is a risk of recurrent sigmoid volvulus with colonic distension greater than 9 cm. This work, comparing volvulus subtypes, shows that this finding at the initial presentation could expedite consideration for surgical management.

Key Points

- *Reports of outcomes for different subtypes and rotational directions of volvuli have been contradictory.*
- *No difference in measured outcomes was found between subtypes; distension ≥ 9 cm predicted recurrence.*
- *CT features can aide management of sigmoid volvulus and can prompt surgical intervention.*

Keywords Sigmoid volvulus, Volvulus, Colonic distension, Recurrence

Introduction

Sigmoid volvulus (SV) is an acquired cause of large bowel obstruction with an increased prevalence in older persons and hospitalized patients [1]. Sigmoid volvulus is the third leading cause of large bowel obstruction in adults and accounts for as many as 5% of all large bowel obstructions [1–4]. Sigmoid volvulus results from pathologic twisting of the sigmoid colon (Fig. 1). This can result in both bowel obstruction and ischemia [5, 6]. Typically, patients have an elongated and redundant sigmoid colon, often associated with a colonic dysmotility such as long-standing constipation [7, 8] or, less commonly, predisposing conditions such as Hirschsprung's disease [9].

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The typical management of sigmoid volvulus includes flexible endoscopy as the first line to decompress the sigmoid colon, or emergent surgical resection when perforation or ischaemia is suspected or when endoscopic decompression has not been successful. Sigmoid resection should subsequently be offered to those with successful endoscopic decompression to prevent recurrence. [10] Sigmoid volvulus, however, is particularly common in older patients, frail patients, and long-term care (LTC) residents [2, 11, 12]. These patients may pose a higher surgical risk but are also at a higher risk of morbidity and mortality when hospitalized [13, 14]. Prediction of recurrence is of paramount importance in this group, as it may help select patients for definitive surgical management.

Fig. 1 Scout View demonstrating a markedly dilated loop of the colon in sigmoid volvulus

While diagnosis of sigmoid volvulus was previously informed by abdominal plain films, with signs including large, dilated loop of colon (coffee bean sign) with absence of rectal gas, CT is now frequently being used to aid diagnosis in these patients and may have an important role to play in their risk stratification. Two distinct forms of sigmoid volvulus have been previously described, based on the anatomical orientation [15, 16]. In mesenteroaxial sigmoid volvulus (M-SV), the loop of the sigmoid colon twists about its mesentery resulting in two transition points (short axis, Fig. 2A). Alternatively, in organoaxial sigmoid volvulus (O-SV), the sigmoid instead twists along its long axis with only a single transition point, Fig. 2B. However, only a small number of patients with sigmoid volvulus have been described in relation to M-SV vs O-SV, and the association between the type of SV and outcomes is unknown. To date, small studies have provided contradictory results. For instance, Jausset et al reported a lower recurrence rate with O-SV, and Schofield et al reported higher recurrence rates with O-SV [17, 18]. In addition, in routine clinical practice, we identify that the direction of the twist may either be clockwise or counterclockwise, and the association between the direction of twist and outcomes has not been previously described.

In this study we aim to observe the prevalence of the two forms of sigmoid volvulus and the direction of twist of the various forms of sigmoid volvulus during first presentation on CT. In addition, we assess if CT findings in SV are associated with clinical outcomes including recurrence, choice of management, and mortality.

Materials and methods

Study design and participants

This was an Institutional Review Board-approved multicenter retrospective study involving consecutive patients with sigmoid volvulus in 2 institutions (3 emergency

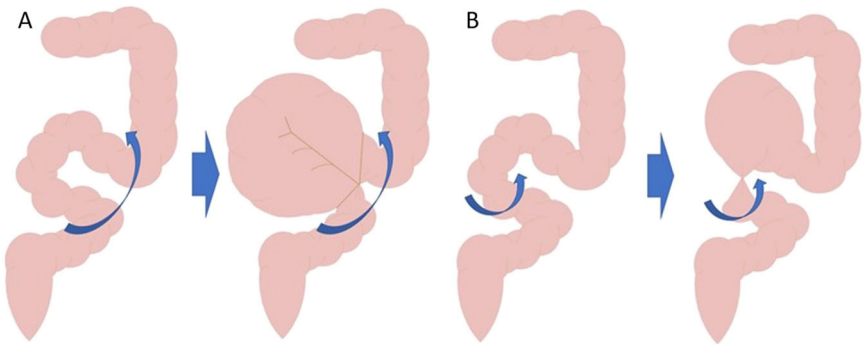

Fig. 2 **A** Mesenteroaxial sigmoid volvulus, with a torsion of a loop of sigmoid colon, with two involved transition points. **B** Organoaxial sigmoid volvulus, with torsion of a single limb of the colon, with one involved transition point

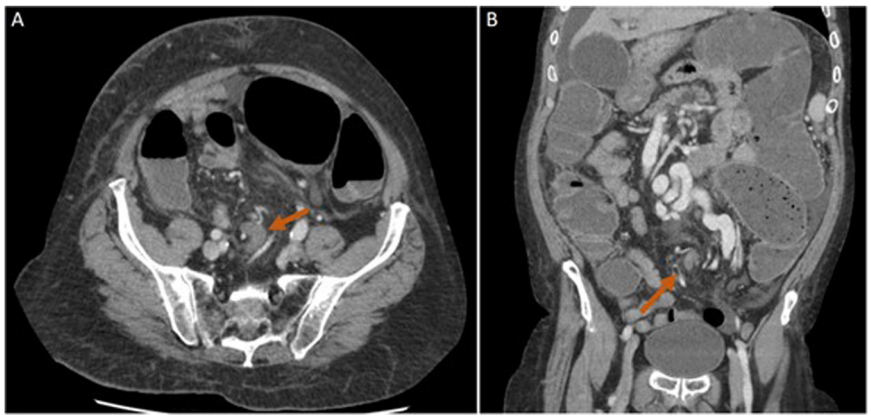

Fig. 3 The whirl sign, frequently also termed the whirlpool sign, results from the mesentery and mesenteric vessels undergoing a twist, demonstrated on axial (**A**) and coronal (**B**) images

departments and five hospitals) in Toronto, Ontario. The inclusion criteria were as follows: clinically confirmed sigmoid volvulus; CT of the abdomen and pelvis performed within 24 hours of presentation; and presentation between January 2007 and December 2021. CT images were reviewed to determine radiological findings, and a chart review of the electronic patient records was performed to determine demographic, clinicopathological characteristics and outcomes of interest.

Radiological findings/sigmoid volvulus specific variables

All CT scans were performed on 64 or 320 multidetector scanners (Aquilion 64 or Aquilion One, Canon (formerly Toshiba) Medical Systems Corporation, Otawara, Japan). CT Images were acquired using 120 kVp, gantry rotation speed of 0.5–0.75 s, and automatic mAs setting with an accepted noise level standard deviation of 13–15 Hounsfield units. Each cross-sectional study was required to include volumetric acquisitions from the lung bases to the ischial tuberosities, which was reconstructed at a 5-mm slice thickness every 2.5 mm in the axial plane and a 3-mm thickness every 3 mm in the coronal and sagittal planes. The manufacturer's standard soft tissue filter (FC04) was used for the reconstruction. The abdomen was imaged in the portal venous phase, 70 s after initiation of contrast bolus injection, which consisted of 100 cc of iopromide (Ultravist 370; Bayer Healthcare, Berlin, Germany) injected at 3 cc/s. The scan acquisition and scan parameters were stable throughout the study period. CT images were reviewed by two fellowship-trained abdominal radiologists (B.M.M., S.K.) with 7 and 15 years of experience in abdominal imaging, respectively. The degree of colonic luminal distension was defined as the greatest luminal diameter on axial or coronal imaging, measured perpendicular to the bowel wall in centimetres to the first decimal point, and was further categorized as either < 9 cm, or ≥ 9 cm, based on previous research [19, 20]. Sigmoid volvulus type (M-SV or O-SV) was determined by the number of transition points, with one transition point indicating O-SV, and two representing M-SV. The direction of rotation (clockwise vs counterclockwise) was systematically determined in the coronal and axial planes [anterior to posterior on coronal imaging and superior to inferior on axial imaging]). The presence of a whirl sign, where the bowel rotates around its mesentery leading to whirls of the mesenteric vessels (Fig. 3), was assessed. Signs of ischemia (bowel thickening, non-enhancement, or pneumatosis) and perforation were also ascertained.

Demographics and clinicopathological characteristics

The demographic characteristics collected included gender, age at presentation, residence in a Long-Term Care (LTC) facility, length of hospital stay and presentation type (emergency, inpatient, or outpatient). The clinical indication for CT was also collected. Management was classified as either endoscopic treatment alone, surgical treatment within 1-week of presentation (sigmoid resection, total and subtotal colectomy), or conservative.

Outcomes of interest

Outcomes of interest included 30-day mortality, 30-day readmission and any recurrence, after first presentation. For assessment of recurrence, those who had definitive surgery at first presentation or died within 30 days were excluded, in addition to those with persistent asymptomatic CT distention. All cases were followed for a minimum of 6-months and volvulus recurrence recorded. Management of the first repeat presentation was also recorded in the same format as for the initial presentation.

Statistical analysis

Statistical analysis was performed using R Statistical Software (R Core Team, NY, USA). Continuous variables were summarized via mean and standard deviation or median and range, as appropriate, while categorical variables were summarized via counts and proportions. Interrater reliability for sigmoid volvulus type and direction of rotation were tested via Cohen's kappa coefficient, with 0.01–0.20 representing no to slight agreement, 0.21–0.40 representing fair agreement, 0.41–0.60 representing moderate agreement, 0.61–0.80 representing substantial agreement, and 0.81–1.00 representing almost perfect agreement. [21] Associations between CT findings were first explored graphically. Differences between variable distributions, in relation to both CT findings and outcomes, were tested via Kruskal-Wallis Rank Sum test or the Pearson's Chi-squared Test, as appropriate. When considering outcomes of interest, where significant differences were found, odds ratios were subsequently calculated, using univariate and multivariable logistic regression, the latter adjusting for age and gender. For all tests, a 2-tailed p value < 0.05 indicated statistical significance.

Results

Patient demographics

A total of 117 cases of sigmoid volvulus were recorded in 80 patients (Fig. 4). The mean (Standard Deviation [SD]) age at first diagnosis was 69.9 (± 17.4) years, and 67.5% ($n = 54$) were male. A total of 38.8% ($n = 31$) were long-term residents. For the first presentation, emergency admissions accounted for 82.5% ($n = 66$), 12.5% ($n = 10$) were inpatients, and the remaining 5% ($n = 4$) were identified incidentally, on outpatient imaging. Indications on CT request at the first presentation were varied and included query obstruction (66.3%; $n = 53$), dilated loops on radiograph (15%, $n = 12$), query malignancy (3.8%; $n = 3$). Other acute pathology was suspected in 13.8% ($n = 11$), while no clinical information was provided in 1 case. The median length of stay was 5 days, with an interquartile range of 2–11 days.

Features on CT

Of the imaging features, whirl sign [22] was evident in 93.8% ($n = 75$). M-SV accounted for 48.8% ($n = 39$), while O-SV accounted for 51.3% ($n = 41$). The direction of rotation in the coronal plane was clockwise in 43.8% ($n = 35$) and anticlockwise in 52.5% ($n = 42$), while the direction of rotation in the axial plane was clockwise in 53.8% ($n = 43$), anticlockwise in 42.5% ($n = 34$), with the rotation direction being equivocal in the remainder of patients. There was almost perfect agreement between radiologists in relation to sigmoid volvulus type (Cohen's kappa = 0.82) and rotation in both the coronal (Cohen's kappa = 0.92) and axial plane (Cohen's kappa = 0.89). The average luminal distension of the sigmoid was 8.63 cm (SD = 2.02 cm). A total of 41.3% ($n = 33$) had a luminal dimension ≥ 9 cm. CT signs of ischemia (7.5%; $n = 6$), and perforation (1.3%; $n = 1$) were uncommon.

In relation to associations between CT findings, rotation in one direction in the coronal plane was significantly related to the opposite rotation in the axial plane ($p < 0.005$; Fig. 5). Compared to O-SV, M-SV was significantly more common with anticlockwise rotation in the axial plane ($p = 0.028$; Fig. 5) and clockwise rotation in the coronal plane ($p = 0.015$; Fig. 5) (Supplementary video 1 and 2). There was no statistically significant association between sigmoid volvulus type (M-SV/O-SV) and degree of distention on CT ($p = 0.21$; Fig. 5).

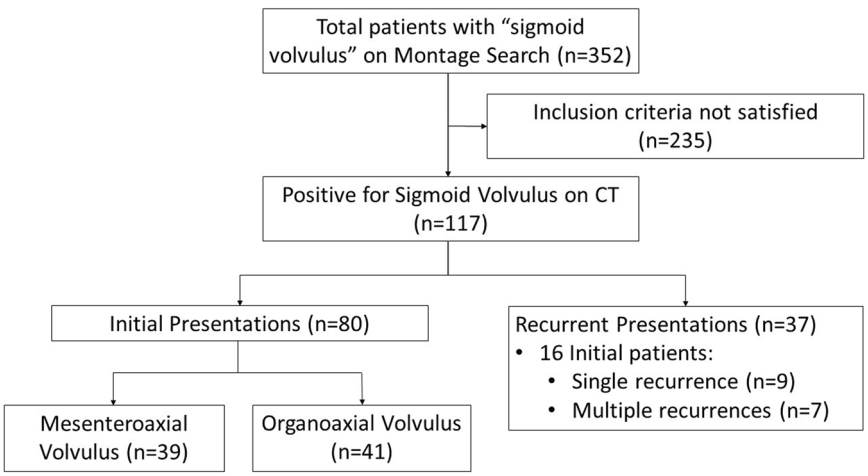

Fig. 4 Patient flow chart; of the 117 patients identified with Sigmoid Volvulus on CT

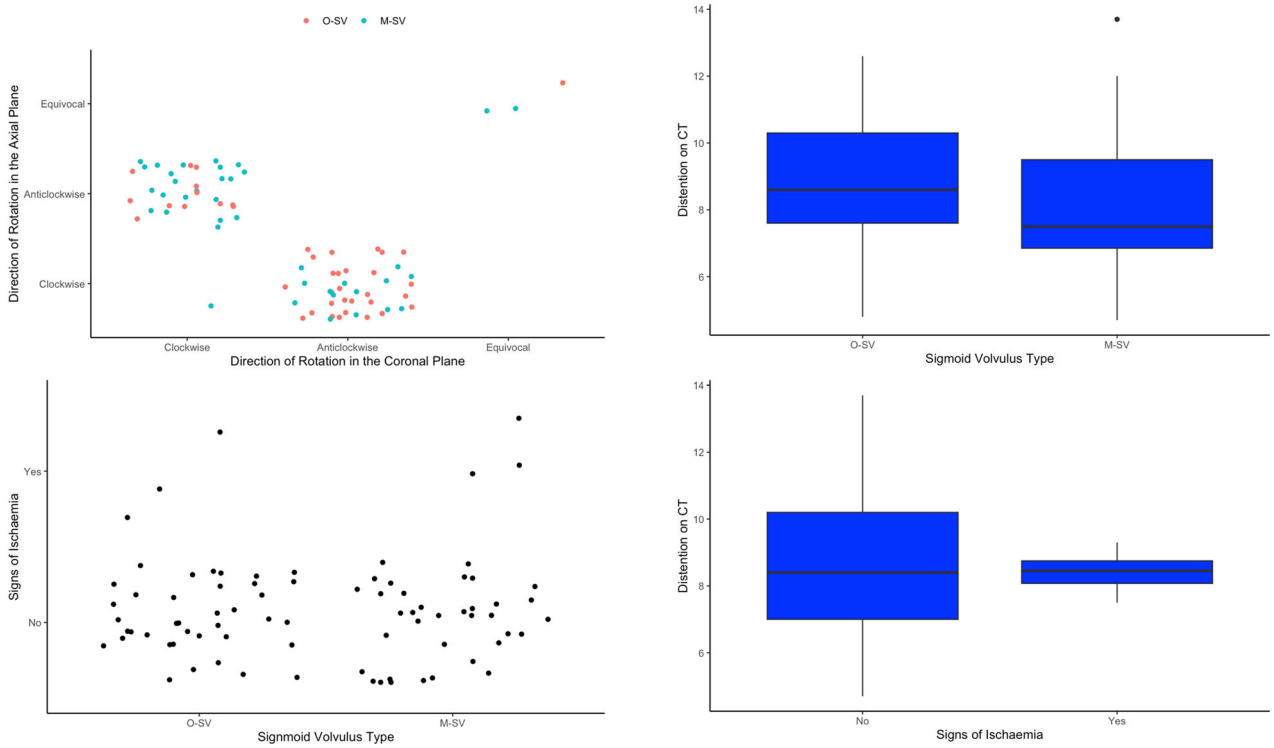

Fig. 5 Relationships between different CT findings

There was also no clear relationship between either distention on CT or sigmoid volvulus type and evidence of ischemia ($p = 0.81$ and $p = 0.98$ respectively; Fig. 5).

Management at initial presentation

The initial management included endoscopy in 85% ($n = 68$), surgery in 6.3% ($n = 5$) and conservative in 8.8% ($n = 7$). There was no significant difference in initial management type when considering gender, age and LTC status ($p = 0.31$, $p = 0.21$, $p = 0.53$). Length of stay was higher in patients with surgery than with endoscopic management (median 9 vs 4.5) ($p = 0.03$). There was no significant difference in management type when considering distension on CT ($p = 0.3$) or sigmoid volvulus type ($p = 0.77$). There was a higher proportion of surgical management in those with anticlockwise rotation in the axial plane (when reviewed superior to inferior) and clockwise rotation in the coronal plane (when reviewed anterior to posterior) (60% vs. 40%), and a higher proportion of endoscopic management in those with clockwise rotation in the axial plane, and anticlockwise rotation in the coronal plane (57% vs. 41%). However, no difference was identified between the direction of rotation and surgery vs. conservative or endoscopic management ($p = 0.30$). Several patients with signs of ischemia (5/6) had an initial sigmoidoscope at presentation, however, all patients with features of ischemia subsequently underwent surgical treatment (100%, 6/6) (Supplementary Appendix).

Outcomes of interest

Of the 80 first presentation patients, A total of 7 patients (8.8%) died within 30 days of initial presentation and 12 patients (15%) were readmitted within 30 days. The direction of rotation was not associated with death or readmission in 30 days ($p = 0.26$, $p = 0.76$). There were no significant differences in demographic or CT factors, when considering those who died or were readmitted within 30-days (Supplementary Appendix). Similarly, there was no difference in management when considering those who had died or were readmitted. The incidence of mortality after endoscopic detorsion was 5.9% (4/68). After excluding those who had died within 30 days of first presentation, those who had been treated surgically, and those who had persistent asymptomatic dilation on CT, the outcome of any recurrence was assessed in 66 patients. 29 of these patients (43.9%) had at least one recurrence, and 6 patients had more than one recurrence. The demographics of patients with and without recurrence are detailed in Table 1.

When compared to the non-recurrent group, the mean luminal distention at initial presentation was significantly

Table 1 Demographic comparisons

Demographic comparisons				
		No recurrence (*N* = 37)	**Recurrence (*N* = 29)**	***p* value**
Gender	Male	23 (62.2%)	23 (79.3%)	0.22
	Female	14 (37.8%)	6 (20.7%)	
Age	Mean (SD)	66.9 (17.1)	72.7 (17.2)	0.18
LTC Status	No	25 (67.6%)	16 (55.2%)	0.44
	Yes	12 (32.4%)	13 (44.8%)	
Patient Status	ED	28 (75.7%)	26 (89.7%)	0.16
	Inpatient	5 (13.5%)	3 (10.3%)	
	Outpatient	4 (10.8%)	0 (0%)	
Length of Stay	Median [Range]	4.00 [0, 330]	3.00 [0, 61]	0.65
Indication for Initial CT	Query Obstruction	24 (64.9%)	20 (69.0%)	0.33
	Dilated Loops on Radiograph	3 (8.1%)	6 (20.7%)	
	Other Acute Pathology Suspected	7 (18.9%)	2 (6.9%)	
	Query Malignancy	2 (5.4%)	1 (3.4%)	
	No Clinical Information Provided	1 (2.7%)	0 (0%)	

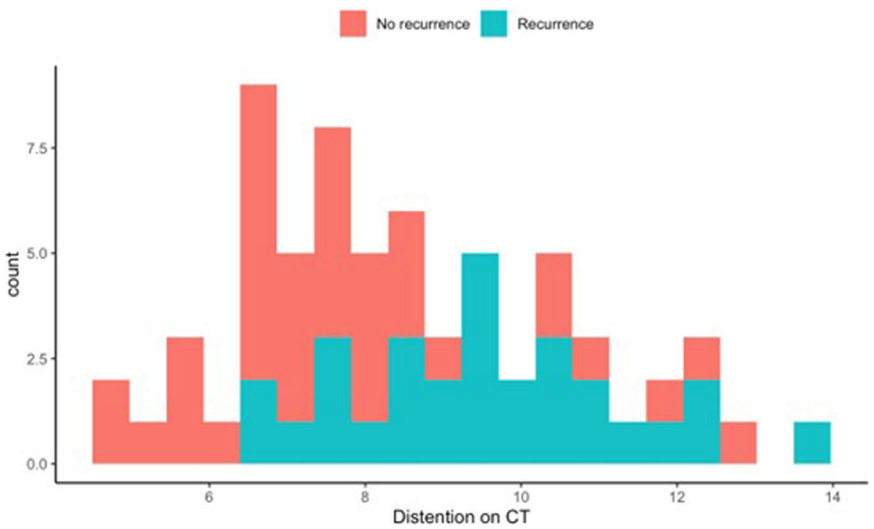

Fig. 6 Distention on CT in those with and without recurrence

higher in the recurrent group ($p < 0.001$, Fig. 6, Table 2) and this was also true when initial distention was categorized as < 9 cm /≥ 9 cm ($p < 0.001$). There were significantly increased odds of recurrence per centimeter increase in distention on CT (OR: 1.35; 95%CI: 1.08–1.73), with significantly increased odds of recurrence for those with ≥ 9 cm of distention vs. < 9 cm (OR: 3.23; 95%CI: 1.39–7.92). These findings remained significant after adjusting for age and gender (OR: 1.33; 95%CI: 1.06–1.72 and OR: 3.3; 95%CI: 1.36–8.52, respectively). There was no difference in direction of rotation for those with/without recurrence ($p = 0.44$).

Discussion

Sigmoid volvulus is a common cause of emergency admissions, particularly in older patients and long-term care (LTC) residents [10]. It is unclear if patients with sigmoid volvulus can be subdivided into different types based on CT findings, and if CT findings can predict outcomes in patients with sigmoid volvulus, with a particular focus on management, mortality, readmission and recurrence [23–25].

Our study confirms two distinct variations of sigmoid volvulus, organoaxial (O-SV) and mesenteroaxial (M-SV). While it has been previously reported that M-SV may be

Table 2 Comparison of imaging findings at initial presentation

Comparison of imaging findings at initial presentation				
		No recurrence ($n = 37$)	**Recurrence ($n = 29$)**	***p* value**
CT Distension	Mean (SD)	7.69 (1.96)	9.53 (1.76)	< 0.001
	< 9 cm	30 (81.1%)	10 (34.5%)	< 0.001
	≥ 9 cm	7 (18.9%)	19 (65.5%)	
Volvulus type	O-SV	16 (43.2%)	20 (69.0%)	0.07
	M-SV	21 (56.8%)	9 (31.0%)	
Direction of rotation (Coronal)	Clockwise	16 (43.2%)	13 (44.8%)	0.44
	Anticlockwise	19 (51.4%)	16 (55.2%)	
	Equivocal	2 (5.4%)	0 (0%)	

more prevalent than O-SV [10], the prevalence of the two distinct forms of sigmoid volvulus was evenly distributed in our study. In addition to O-SV and M-SV, we also identified two distinct forms of sigmoid volvulus based on the direction of rotation on axial (superior to inferior) and coronal planes (anterior to posterior). In either plane, the direction of rotation could either be clockwise or anticlockwise, and the prevalence was similar. There was a strong association between the direction of rotation in one plane and the opposite direction of rotation in the opposite plane. For example, a clockwise rotation in the axial plane was strongly associated with an anticlockwise rotation in the coronal plane and vice versa. In addition, we also identified a strong relationship between this direction of rotation and the type of volvulus. M-SV was associated with anticlockwise rotation in the axial plane and clockwise rotation in the coronal plane. O-SV was associated with clockwise rotation in the axial plane and anti-clockwise rotation in the coronal plane. While identification of O-SV and M-SV may be done by identification of the number of transition points [26], identifying direction of rotation may be reliable, and potentially easier to distinguish between the two types of volvulus. The almost perfect agreement between radiologists in determining sigmoid volvulus type and rotation direction enhances the reliability of our findings.

More than one-third of our patients were from long-term care facilities, which is similar to prior studies [27], potentially highlighting the need for lower thresholds of suspicion in these patients. The majority of our patients had endoscopic management, which is in line with WSES guidelines for sigmoid volvulus management [10]. While there is a growing push for all patients to undergo surgery [27], in our study, endoscopic management was sufficient in some patients. Endoscopic management also had lower median time of hospitalization (4.5 vs 9 days). While some studies have reported higher mortality rates up to 37% after conservative treatment [28] our study had an approximately 6% 30 day mortality rate after endoscopy, which is comparable with other reports [2, 29, 30]. However, identification of CT signs of ischemia predicts surgery, as all patients with imaging findings of ischemia underwent early surgery. Imaging is crucial to triage these patients to surgery as it not only impacts the decision for emergent surgery, but also may impact operative details (resection of infarcted bowel is usually performed without detorsion and with minimal manipulation to prevent release of endotoxin, potassium and bacteria into the general circulation and to avoid perforation of the colon) [10]. There was no mortality following surgery in this subset of patients.

Recurrence after endoscopy was identified in 44%, which is consistent with previous literature, which shows high rates of recurrence in this patient population [28, 31, 32]. While some studies and guidelines routinely recommend elective surgery at the first admission in all patients to prevent recurrence, surgical outcomes in frail older individuals with this disease may be less than ideal [10]. Therefore, it is desirable to identify features at initial presentation that may be associated with subsequent recurrence, to potentially triage for surgery. Small-scale studies have previously shown an association between the type of the volvulus and outcomes [26, 33], but the reports from these small studies were contradictory, as to which type was associated with worse outcomes. In our study with a larger number of patients, neither the type of volvulus (O-SV vs M-SV) nor the direction of rotation was associated with recurrence. Larger multicenter studies may be helpful to validate our findings.

Our study underscores the importance of luminal distention at initial presentation as a predictor of recurrence. The odds of recurrence increases with increasing distension, and a luminal distention of ≥ 9 cm was significantly associated with an increased risk of recurrence, aligning with recent research trends indicating higher degrees of distention as a risk factor. The significant association between luminal distention and recurrence, even after adjusting for age and gender, underscores the robustness of this relationship. This observation supports the notion that the degree of distention may serve as valuable indicator in risk stratification, aiding clinicians in deciding the most appropriate management strategy, which may be potentially helpful to triage patients requiring elective sigmoidectomy [24].

Our study is not without limitations. Firstly, the retrospective nature and reliance on electronic patient records may introduce selection bias. Secondly, data on follow up and number of recurrences was limited to the

institutions and potential recurrences treated at a different institution could not be excluded. This was mitigated to an extent by a multicenter study design, and by involving the three major emergency departments and five hospitals with a large catchment area in the city. Additionally, the relatively small sample size is a further limitation, and the findings may not apply to other centers with different patient demographics emphasising the need for larger multicenter studies to replicate our results. Long-term follow-up and exploration of additional factors, such as colonic dysmotility or predisposing conditions, may further refine our understanding of recurrence in sigmoid volvulus.

Conclusion

In conclusion, our study contributes valuable insights into the relationships between CT findings and outcomes in sigmoid volvulus. Imaging identification of ischemia is uncommon in sigmoid volvulus, but when present is a strong predictor of early surgery. Luminal distention is as a crucial predictor of recurrence, with potential to guide the selection of patients for definitive surgical management. The even distribution of organo-axial and mesenteroaxial types and the association between rotation direction and initial management decisions add complexity to the clinical landscape, warranting further exploration. However, the type of volvulus was not associated with mortality, readmission, or recurrence risk. As our understanding evolves, these findings may influence risk stratification, management decisions, and ultimately improve outcomes for patients with sigmoid volvulus.

Abbreviations

CT	Computed tomography
LTC	Long-Term Care
M-SV	Mesenteroaxial sigmoid volvulus
O-SV	Organoaxial sigmoid volvulus
SV	Sigmoid volvulus
SD	Standard deviation

Supplementary information

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Compliance with ethical standards

Guarantor

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Conflict of interest

The authors of this manuscript declare no relationships with any companies, whose products or services may be related to the subject matter of the article.

Statistics and biometry

One of the authors [Dr Christine Mc Carthy] has statistical expertise in clinical epidemiology.

Informed consent

Written informed consent was waived by the Institutional Review Board.

Ethical approval

Institutional Review Board approval was obtained.

Cohort overlap

No study subjects nor cohorts have been previously reported.

Methodology

- Retrospective
- Observational
- Multicenter study

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