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CLINICAL ARTICLE

Incidence and Risk Factors for Postoperative Ileus after Posterior Surgery in Adolescent Idiopathic Scoliosis

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Objective: Postoperative ileus (POI) is a relatively common complication after spinal fusion surgery, which can lead to delayed recovery, prolonged length of stay and increased medical costs. However, little is known about the incidence and risk factors of POI after corrective surgery for patients with adolescent idiopathic scoliosis (AIS). This study was performed to report the incidence of POI and identify the independent risk factors for POI after postoperative corrective surgery.

Methods: In this retrospective cohort study, A total of 318 patients with AIS who underwent corrective surgery from April 2015 to February 2021 were enrolled and divided into two groups: those with POI and those without POI. The Student's *t* test, Mann–Whitney U test, and Pearson's chi-square test were used to compare the two groups regarding patient demographics and preoperative characteristics (age, sex and the major curve type), intraoperative and postoperative parameters (lowest instrumented vertebra [LIV], number of screws, and length of stay), radiographic parameters (T5–12 thoracic kyphosis [TK], T10–L2 thoracolumbar kyphosis and height [TLK and T10–L2 height], L1–S1 lumbar lordosis [LL], and L1–5 height). Then, a multivariate logistic regression analysis was used to identify independent risk factors for POI, and a receiver operating characteristic (ROC) curve was performed to assess the predictive values of these risk factors.

Results: Forty-two (13.2%) of 318 patients who developed POI following corrective surgery were identified. The group with POI had a significantly longer length of stay, more lumbar screws, higher proportions of a major lumbar curve and lumbar anterior screw breech, and a lower LIV. Among radiographic parameters, the mean lumbar Cobb angle at baseline, the changes in the lumbar Cobb angle, and T10–L2 and L1–5 height from before to after surgery were significantly larger in the group with POI than in the group without POI. Multivariate logistic regression analysis showed that large changes in T10–L2 (odds ratio [OR] $=2.846$, $P = 0.007$) and L1–5 height (OR $= 31.294$, $p = 0.000$) and lumbar anterior screw breech (OR $= 5.561$, $P = 0.006$) were independent risk factors for POI. The cutoff values for the changes in T10–L2 and L1–5 height were 1.885 cm and 1.195 cm, respectively.

Conclusion: In this study, we identified that large changes in T10–L2 and L1–5 height and lumbar anterior screw breech were independent risk factors for POI after corrective surgery. Improving the accuracy of pedicle screw placement might reduce the incidence of POI, and greater attention should be given to patients who are likely to have large changes in T10–L2 and L1–5 height after corrective surgery.

Key words: Adolescent Idiopathic Scoliosis; Posterior Scoliosis Correction and Spinal Fusion; Postoperative Ileus; Risk Factors

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INTRODUCTION

Posterior corrective surgery has become a commonly used, effective surgical treatment for adolescent idiopathic scoliosis (AIS).[1] Because it often requires extensive exposure, a large number of fused spinal levels and osteotomy, the relatively high rates of surgical and medical complications present a challenge that cannot be ignored in corrective surgery for patients with AIS.[2,3] Many investigators have tried to identify the incidence and independent risk factors for perioperative complications, including neurological deficits, infections, and pulmonary complications.[4–6] Of note, we found that patients with AIS usually complain of abdominal symptoms, such as nausea, vomiting, and bloating after corrective surgery, which have been rarely addressed in previous studies.

Postoperative ileus (POI), which is defined as a temporary nonmechanical blockage of the gastrointestinal tract that occurs after surgery, frequently causes abdominal distension, nausea and vomiting, and intolerance of an oral diet.[7] Although POI is a self-limiting condition, it can lead to patient discomfort, decreased mobility, delayed recovery, and ultimately, prolonged length of stay and increased medical costs.[8,9] Recently, spinal surgeons have become aware that POI is a relatively common complication after spinal fusion surgery, with an incidence ranging from 0.6% to 17.4%, depending on the type of surgery and surgical approach.[8,10–17] Some studies have reported that POI is more common after the anterior or lateral approach due to the higher possibility of bowel manipulation during the procedure. In addition to the surgical approach, we speculated that the change in spinal alignment after corrective surgery could also have a significant impact on the occurrence of POI. In reviewing previous studies, we found the incidence of POI after spinal corrective surgery was the highest: 17.4% after corrective surgery according to Ohba *et al*., which partially confirmed our hypothesis. However, the patients were enrolled in Ohba *et al*.'s study all had adult spinal deformity with an average age of 71 years, and the incidence of POI might increase in elderly patients which means the situation in adolescent patients could be significantly different. To date, little is known about the incidence of POI after corrective surgery for patients with AIS. Therefore, the purposes of this study were to describe the incidence of POI and to identify the independent risk factors for POI in patients with AIS who underwent corrective surgery.

METHODS

Patients and Surgical Procedure

This retrospective study was approved by the Ethics Committee of the local hospital (No. 2019-852). The inclusion criteria were: (i) patients with AIS who underwent posterior corrective surgery between April 2015 and February 2021; and (ii) age between 10 and 20 years. The exclusion criteria were as follows: (i) history of irritable bowel syndrome or abdominal surgery, and (ii) incomplete medical records.

All patients underwent the same surgical procedure by one of two senior surgeons after general anesthesia was administered by a skilled anesthesiologist. The pedicle screw fixation system was used as the fixation implant, and bilateral Smith–Peterson osteotomies in the apical region were performed in all patients. One drain was placed at the wound site during closure and was removed postoperatively when the drainage volume was less than 100 mL over a 24-h period. Oral nutrition solution was started for all patients at 6 h postoperatively, and a normal diet was gradually resumed according to the patient's tolerance. An ultrasound conductometer was used to facilitate bowel movement at 1 day postoperatively. All patients attempted to get out of bed with a thoracolumbar brace at 2 days postoperatively.

POI Determination and Data Collection

We identified the occurrence of POI by retrospectively reviewing electronic medical records. POI was defined as two or more of the following events at 72 h postoperatively: (i) the absence of flatus; (ii) intolerance of an oral diet; (iii) ongoing abdominal distention; (iv) ongoing nausea or vomiting; or (v) imaging confirmation.[18]

Patient demographics and preoperative characteristics, including age, sex, weight, height, body mass index, American Society of Anesthesiologists (ASA) grade, and the major curve type, were obtained before surgery. Intraoperative and postoperative parameters were also collected, including operative time; estimated blood loss; lowest instrumented vertebra (LIV); number of screws, osteotomies and levels fused; amount of intraoperative remifentanil and opioid dosage administered in the first 24 h postoperatively; and length of stay (Fig. 1).

To assess radiographic changes, standing whole-spine posteroanterior and lateral radiographs and three-dimensional CT were reviewed pre- and postoperatively. The Cobb angles of the main thoracic and lumbar curves and the correction rate were measured on coronal radiographs. T5–12 thoracic kyphosis (TK), T10–L2 thoracolumbar kyphosis and height (TLK and T10–L2 height), L1-S1 lumbar lordosis (LL), and L1–5 lumbar height were obtained from sagittal radiographs (Fig. 2). To measure the rotation deformity of the apical vertebra and its postoperative correction, the Nash–Moe classification of vertebral rotation was used.[19] Postoperative three-dimensional CT was performed to observe and record whether the lumbar screws penetrated the anterior vertebral wall in each patient. A total of 40 patients were randomly selected to undergo an evaluation to determine the reliability of radiological measurements. One week after the orthopedic surgeon (Z.Z.) measured these parameters for every patient, he repeated the measurements in the 40 randomly selected patients to evaluate intraobserver reliability. The orthopedic surgeon (J.L.) also measured these parameters in the 40 patients to evaluate interobserver reliability. The intraclass coefficients (ICCs) of the intraobserver and interobserver reliability were 0.894 and 0.901, respectively.

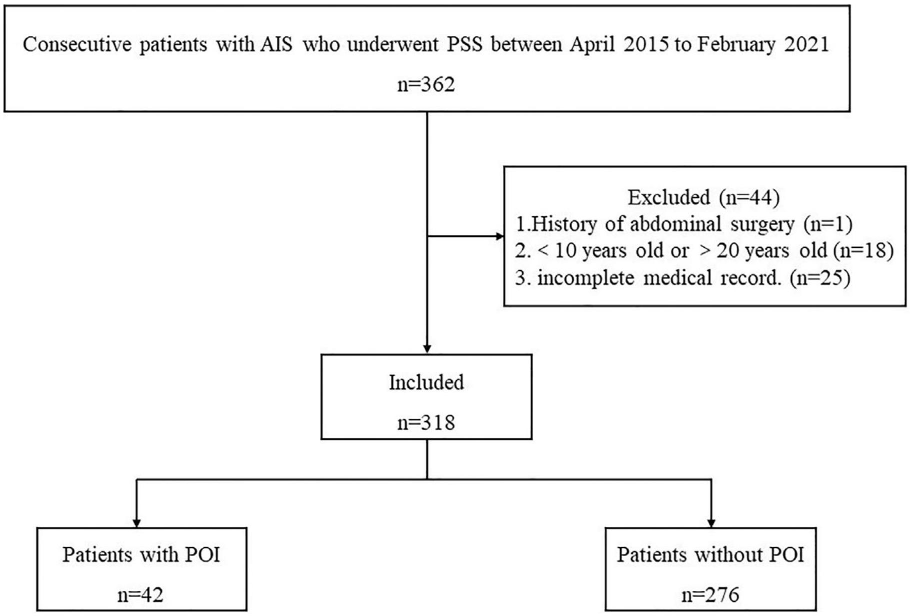

Fig 1 The flow diagram of patients through this study. AIS, adolescent idiopathic scoliosis; POI, Postoperative ileus

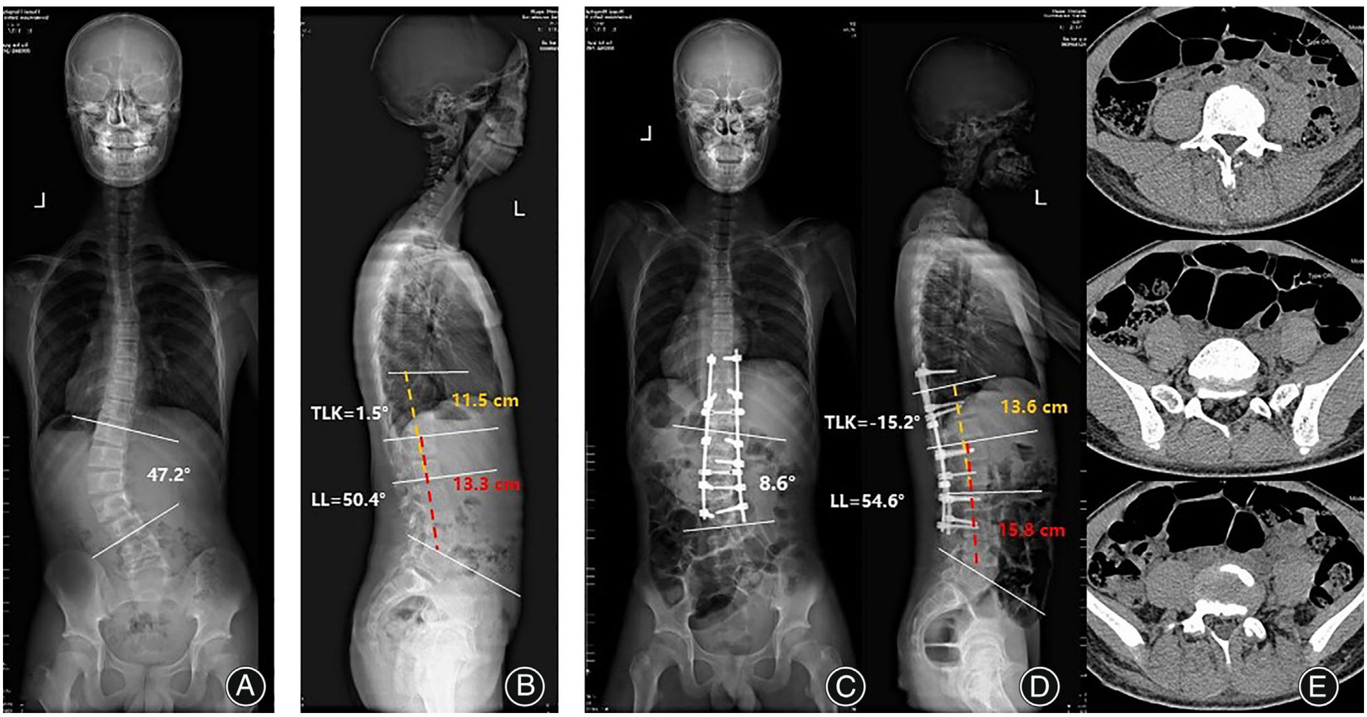

Fig 2 A 15-year-old male patient diagnosed with Lenke type 5 CN AIS and sacral lumbarization who underwent corrective surgery. (A, B) Preoperative standing whole-spine radiographs showed that the Cobb angles of the lumbar curve, TLK, and LL were 47.2°, 1.5°, and 50.4°, respectively, and the heights of T10–L2 and L1–5 were 11.5 cm and 13.3 cm, respectively. (C, D) Whole-spine radiographs at 3 days postoperatively indicated a significant increase in the height of both T10–L2 and L1–5 (2.1 cm and 2.5 cm, respectively), and demonstrated a large amount of bowel gas. (E) CT scans at 3 days postoperatively also showed diffuse distention of the large bowel. TLK, thoracolumbar kyphosis; LL, lumbar lordosis; T10–L2 height, the distance from the midpoint of the upper endplate of T10 to the lower endplate of L2; L1–5 height, the distance from the midpoint of the upper endplate of L1 to the lower endplate of L5

Statistical Analysis

A preliminary comparison analysis was performed to determine the presence of differences between the patients with and without POI. The normal distribution of continuous variables was verified by the Shapiro–Wilk test. Student's *t* test was used for variables that followed a normal distribution (height, body mass index [BMI], major Cobb angle, operative time, etc.). The Mann–Whitney U test was used for those not following a normal distribution (estimated blood loss, intraoperative remifentanil, TK, TLK, etc.)

Pearson's chi-square test or Fisher's exact test was used for categorical variables. A multivariate logistic regression analysis was used to calculate the odds ratio (OR) and 95% confidence intervals (CI) of the potential risk factors for POI. A receiver operating characteristic (ROC) curve was generated to assess the predictive values of risk factors for POI. All data were analyzed using SPSS 23.0 software (SPSS, Inc., Chicago, IL, USA). A *P* value less than 0.05 indicated a significant difference.

RESULTS

Study Subjects and the Incidence of POI

A total of 362 patients diagnosed with AIS who underwent corrective surgery were identified. Among them, patients with a history of abdominal surgery (n = 1), those younger than 10 years old or older than 20 years old ($n = 18$), and those with incomplete medical records (n = 25) were excluded, leaving 318 patients in total (Fig. 1). There were 71 males and 247 females, with an average age of 15.1 (range 10–20) years. In the present study, the incidence of POI following corrective surgery was 13.2% (42/318) (Fig. 3).

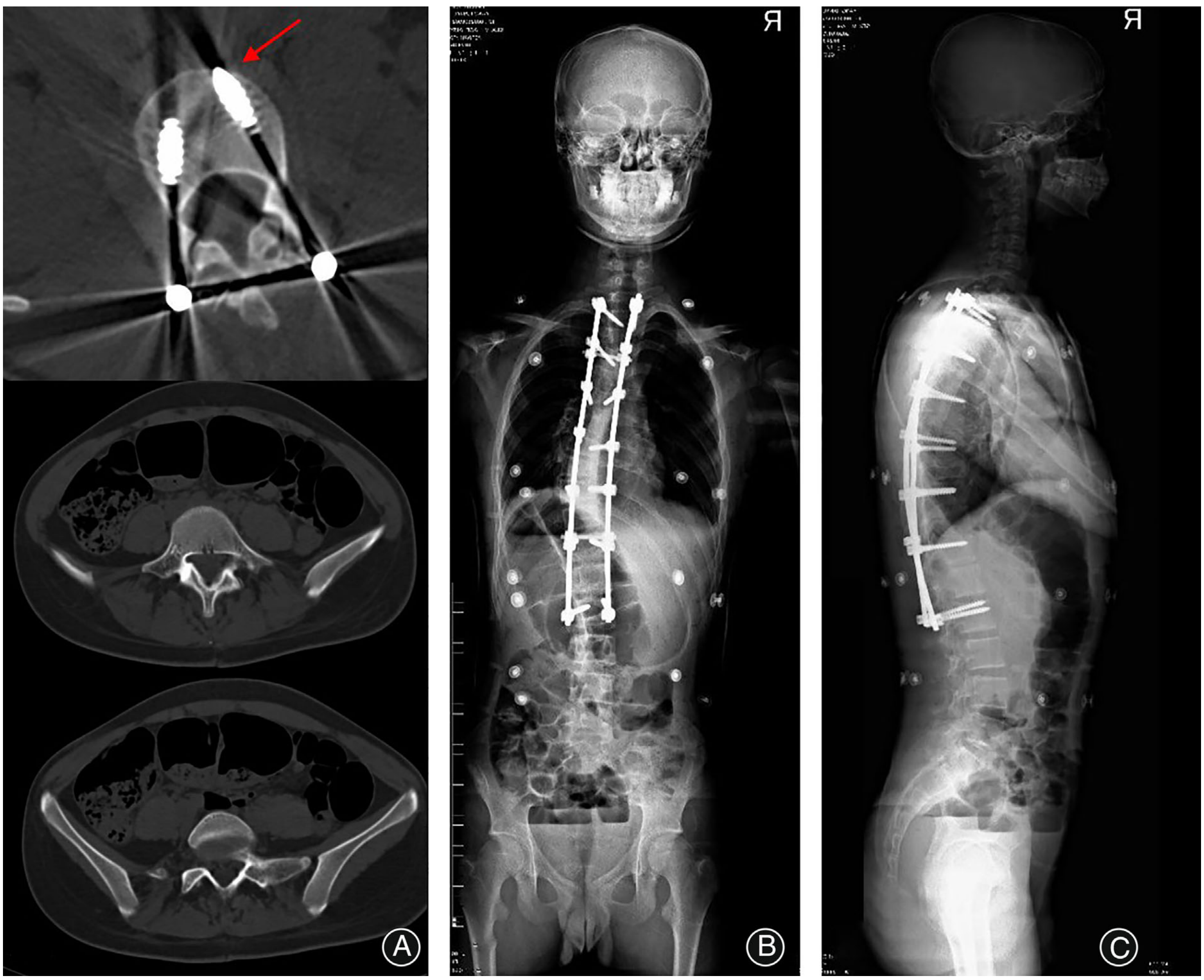

Fig 3 A 17-year-old male patient diagnosed with Lenke type 2 AN who developed POI after corrective surgery. (A) CT scans at 3 days postoperatively showed that the left screw of L2 had penetrated the anterior vertebral wall accompany with a large amount of bowel gas. (B, C) Standing whole-spine radiographs at 3 days postoperatively also showed massive amount of bowel gas and diffuse distention of the intestinal cavity

TABLE 1 Comparison of baseline demographic and preoperative characteristics between patients with and without POI

Demographics	POI (*n* = 42)	Without POI (*n* = 276)	t/X^2	*P*
Age (years)	15.2 ± 2.0	15.1 ± 2.1	0.310	0.757
Sex (M/F)	10:32	61:215	0.061	0.804
Height (m)	1.6 ± 0.1	1.6 ± 0.1	1.214	0.225
Weight (kg)	48.5 ± 8.1	47.1 ± 7.1	1.180	0.239
BMI (kg/m^2)	18.5 ± 2.2	18.4 ± 2.2	0.373	0.710
Type of major curve (n)			5.200	0.023*
Thoracic curve	23	199		
Lumbar curve	19	77		
Lenke classification (n)			7.851	0.144
I	9	86		
II	8	85		
III	4	19		
IV	2	11		
V	11	47		
VI	8	28		
Postoperative opioid (mg/kg)	1.2 ± 0.3	1.3 ± 0.5	0.897	0.417
Correct rate (%)	81.8 ± 9.8	82.4 ± 8.1	−0.467	0.641
Length of stay (day)	8.5 ± 1.7	6.2 ± 1.1	11.904	0.000*

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; M/F, Male/Female; POI, postoperative ileus.; * Statistical significance between two groups (*P*< 0.05).

Comparison of Patients with and without POI

There was no significant difference in age, sex, BMI, ASA grade, or correction rate between the two groups. However, the proportion of patients with a major lumbar curve was significantly higher and the mean length of stay was significantly longer in the group with POI than in the group without POI (19/42 *vs* 77/276, $P = 0.023$; 8.5 ± 1.7 *vs* 6.2 ± 1.1, $P = 0.000$) (Table 1).

In terms of intraoperative factors, the group with POI had a significantly higher number of lumbar screws (4.4 ± 2.2 *vs* 3.3 ± 2.2, $P = 0.003$) and a higher proportion of lumbar screws that penetrated the anterior vertebral wall (11/42 *vs* 17/276, $P = 0.000$) than the group without POI. All of the tips of the misplaced screws were less than 2 mm away from the vertebral wall at a safe distance from the aorta abdominalis, and none of those patients required revision surgery. The proportion of patients with LIV at L2 and lower was also higher in the group with POI than in the group without POI (32/42 *vs* 162/276, $P = 0.030$). Other factors showed no significant differences between the two groups (Table 2).

Regarding radiographic factors, the mean Cobb angle of the lumbar curve in the group with POI was significantly larger than that in the group without POI (48.2 ± 15.6° *vs* 39.1 ± 14.3°, $P = 0.000$), but there was no significant difference in other factors at baseline. The preoperative and postoperative apical vertebral rotation grades were not significantly different between the two groups. The changes in the lumbar Cobb angle and T10–L2 and L1–5 height from before to after surgery were significantly greater in the group with POI than in the group without POI (Table 3).

Risk Factors for POI and Values for Predicting POI

The multivariate logistic regression analysis showed that the following factors were significantly associated with the occurrence of POI: lumbar anterior screw breech (OR = 5.561, $P = 0.006$), ΔT10–L2 height (OR = 2.846, $P = 0.007$), and ΔL1–5 height (OR = 31.294, $P = 0.000$) (Table 4). ROC curve analysis was performed to determine the predictive values of risk factors for predicting POI, and the results are summarized in Fig. 4 and Table 5. The ΔL1–5 height had the highest predictive accuracy for POI (AUC = 0.857, $P = 0.000$), with a sensitivity of 0.786 and specificity of 0.873. The cutoff values of ΔT10–L2 height and ΔL1–5 height for predicting POI were 1.885 cm and 1.195 cm, respectively.

DISCUSSION

POI usually occurs after intra-abdominal surgery, but it is also known to be a relatively common complication after

TABLE 2 Comparison of intraoperative characteristics between patients with and without POI

Intraoperative characteristics	POI (n = 42)	Without POI (n = 276)	t/X^2	*P*
Operative time (min)	235.6 ± 36.7	231.8 ± 31.2	0.710	0.478
Estimated blood loss (ml)	790.5 ± 237.7	802.5 ± 269.5	−0.274	0.784
Thoracoplasty (thoracoplasty/none)	2/40	19/257	0.266	0.606
Intraoperative remifentanil (μg/kg)	32.6 ± 9.3	31.4 ± 19.3	0.169	0.690
LIV (n)			4.690	0.030*
L2 above	10	114		
L2 and below	32	162		
Number of screws (n)	14.1 ± 2.9	13.7 ± 2.5	0.987	0.325
Number of lumbar screws (n)	4.4 ± 2.2	3.3 ± 2.2	3.030	0.003*
Lumbar screw deviation (yes/none)	11/42	17/276	13.492	0.000*
Number of osteotomies (n)	6.9 ± 1.4	6.7 ± 1.3	1.226	0.221
Number of levels fused (n)	11.3 ± 2.3	11.1 ± 2.1	0.486	0.627

Abbreviations: POI, postoperative ileus; LIV, lowest instrumented vertebra.; * Statistical significance between two groups (*P*< 0.05).

TABLE 3 Comparison of radiographic parameters between patients with and without POI

Parameters	POI (n = 42)	Without POI (n = 276)	t/X^2	*P*
Preoperative parameters				
Major Cobb angle (°)	61.0 ± 10.8	58.2 ± 9.8	1.707	0.089
MT Cobb angle (°)	50.6 ± 17.0	52.0 ± 15.2	−0.540	0.590
Lumbar Cobb angle (°)	48.2 ± 15.6	39.1 ± 14.3	3.771	0.000*
TK (°)	20.7 ± 10.4	20.3 ± 11.6	0.236	0.814
TLK (°)	−0.4 ± 11.3	−0.6 ± 8.3	0.099	0.419
T10-L2 Height (cm)	11.0 ± 0.9	11.3 ± 0.9	−1.736	0.083
LL (°)	49.9 ± 10.7	51.4 ± 10.6	−0.868	0.386
L1-5 Height (cm)	14.4 ± 1.0	14.7 ± 1.1	−1.680	0.094
Nash-Moe scale values	2.3 ± 0.5	2.3 ± 0.6	0.850	0.355
Postoperative parameters				
Major Cobb angle (°)	11.3 ± 6.8	10.3 ± 5.1	1.116	0.265
MT Cobb angle (°)	11.5 ± 6.1	10.4 ± 5.6	1.128	0.260
Lumbar Cobb angle (°)	9.4 ± 6.3	8.5 ± 4.9	1.044	0.297
TK (°)	19.5 ± 5.6	18.4 ± 5.1	1.315	0.189
TLK (°)	1.6 ± 8.9	0.8 ± 6.5	0.720	0.454
T10-L2 Height (cm)	13.0 ± 0.7	12.6 ± 0.8	2.979	0.003*
LL (°)	50.7 ± 9.2	51.4 ± 8.3	−0.477	0.634
L1-5 Height (cm)	15.9 ± 0.9	15.6 ± 1.0	2.239	0.026*
Nash-Moe scale values	1.1 ± 0.4	1.2 ± 0.5	1.115	0.271
ΔParameters				
Major Cobb angle (°)	49.7 ± 9.1	47.9 ± 8.6	1.254	0.211
MT Cobb angle (°)	39.1 ± 15.5	41.6 ± 14.2	−1.204	0.306
Lumbar Cobb angle (°)	38.8 ± 14.6	30.6 ± 13.5	3.621	0.000*
TK (°)	1.2 ± 8.2	1.9 ± 10.2	−0.556	0.900
TLK (°)	2.0 ± 13.2	1.3 ± 6.9	0.512	0.117
T10-L2 Height (cm)	1.9 ± 0.8	1.3 ± 0.5	7.159	0.000*
LL (°)	0.8 ± 9.3	0.0 ± 8.0	1.320	0.190
L1-5 Height (cm)	1.5 ± 0.5	0.8 ± 0.4	10.065	0.000*
Nash–Moe scale values	1.2 ± 0.3	1.1 ± 0.4	1.247	0.115

Abbreviations: POI, postoperative ileus; TK, thoracic kyphosis; TLK, thoracolumbar kyphosis.; * Statistical significance between two groups ($P < 0.05$).

spinal fusion surgery and has a significant impact on patient satisfaction and recovery, length of hospital stay, and financial burden.[8,18,20] In this retrospective review of 318 patients, POI occurred in 13.2% (n = 42) of patients with AIS who underwent corrective surgery and resulted in a prolonged hospital stay. Using multivariate logistic regression, we found that the occurrence of POI was significantly associated with large changes in T10–L2 and L1–5 height and the presence of lumbar anterior screw breech.

The Incidence and Risk Factors of POI after Corrective Surgery

The incidence of POI varies greatly in patients undergoing different types of spinal surgery, ranging from 0.6% to 17.4%.[8,10–17] Fineberg *et al.*[10] conducted a review of 220,522 patients and found that the incidence of POI after anterior lumbar interbody fusion (7.5%) was significantly higher than that after posterior lumbar interbody fusion (2.6%). Other studies have shown that the incidence of POI is closely related to the surgical approach, and POI is more likely to occur when the anterior or lateral approach is used due to the higher possibility of bowel manipulation during the procedure than when the posterior approach is used.[11,13,16] However, in reviewing previous studies, we found that the incidence of POI after spinal corrective surgery was relatively high: 17.4% after adult spinal deformity surgery according to Ohba *et al.* and 13.6% after scoliosis surgery according to Bureta *et al.*.[13,17] Similar to those studies, the incidence of POI after corrective surgery was 13.2% in our study, which was also relatively high. This may indicate that the change in spinal alignment after corrective surgery could have a greater

TABLE 4 Multivariate logistic regression analysis of risk factors for POI following corrective surgery

Factors	OR	95% CI	*P*
Sex	0.569	0.194–1.671	0.305
Lumbar Cobb angle	1.008	0.934–1.088	0.841
Postoperative opioid	0.442	0.157–1.243	0.122
Intraoperative remifentanil	1.011	0.996–1.027	0.158
Number of lumbar screws	0.783	0.580–1.056	0.109
Lumbar anterior screw breech	5.561	1.635–18.917	0.006*
ΔLumbar Cobb angle	0.977	0.893–1.070	0.621
ΔT10-L2 Height	2.846	1.330–6.093	0.007*
ΔL1-5 Height	31.294	9.627–101.725	0.000*

Abbreviations: POI, postoperative ileus; TLK, thoracolumbar kyphosis.
* Statistical significance ($p < 0.05$).

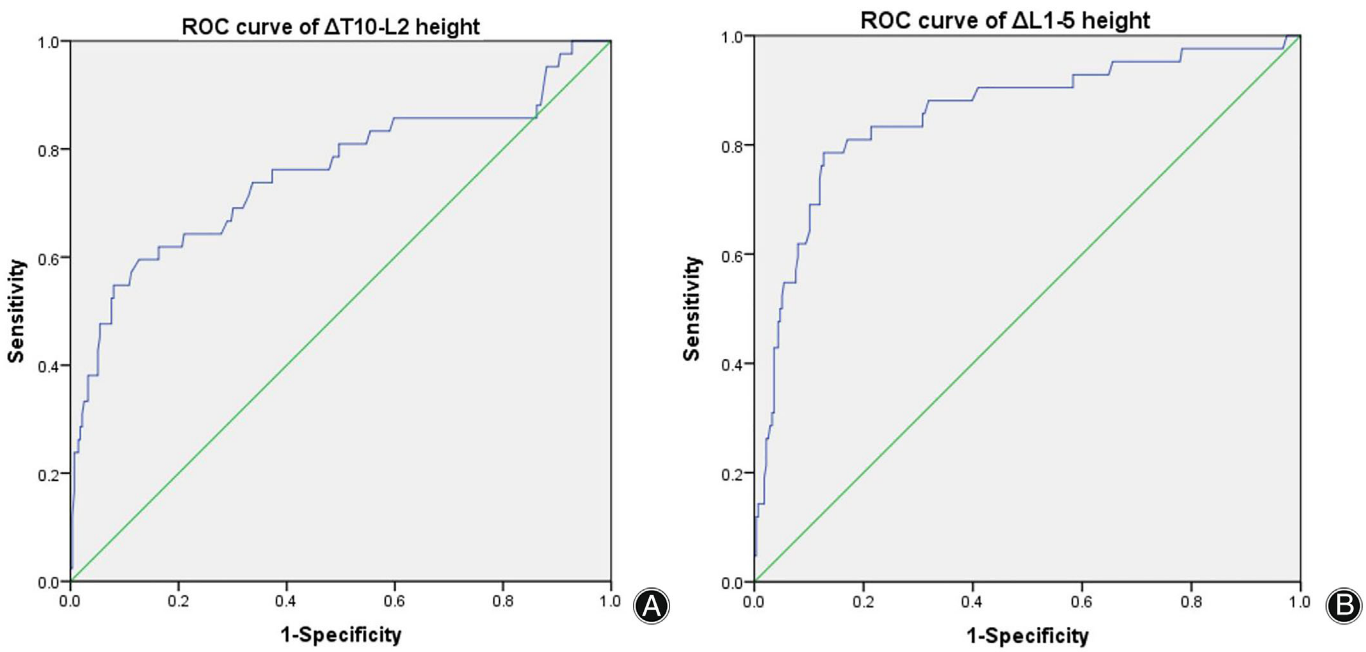

Fig 4 The receiver operating characteristic (ROC) curves of risk factors for predicting POI in patients with AIS who underwent corrective surgery. (A), ROC curve of ΔT10-L2 height; (B), ROC curve of ΔL1-5 height

impact on the occurrence of POI than the surgical approach. Due to this high incidence, we should pay greater attention to the prevention and treatment of POI following corrective surgery.

The pathogenesis of POI is multifactorial and includes inflammatory, neurological and pharmacological factors.[21,22] In this study, our multivariate analysis showed that the significant independent risk factors for POI were large changes in T10–L2 and L1–5 height and the presence of lumbar anterior screw breech. To our knowledge, this is the first study to show that sagittal height correction and lumbar anterior screw breeching could be independent risk factors for POI.

The Association between Sagittal Height Correction and POI

The mechanism of POI after a large change in sagittal height might be neurological and result from the stretching of the nerve plexus in front of the lumbar vertebra and the innervation of the bowels.[11] Anatomically, the celiac plexus is located at T12–L1 and conducts parasympathetic innervation for intestinal motility. Thus, the increased T10–L2 height after corrective surgery may affect the celiac plexus and intestinal motility, resulting in POI. Ohba *et al.*,[13] in a retrospective study with 144 patients, found that a large change in the TLK angle was a risk factor for POI after adult spinal deformity surgery. In contrast, in our study, the change in angle was not an independent risk factor; only the change in height was. Considering the neurological mechanism, we suppose that a change in the TLK angle might ultimately have an effect through the influence of the T10–L2 height, and exploring the latter might better reflect the essence of this impact. However, further studies are needed to clarify the relationship between the change in the TLK angle and T10–L2 height.

In addition, mechanical compression after height correction may result in POI. The superior mesenteric artery (SMA) originates at the L1–2 level from the second branch of the abdominal aorta and forms an acute angle with the aorta; the duodenum crosses through this angle at the midline anterior to the spine (at approximately the L3 level) and the aorta but posterior to the SMA.[23] The increase in L1–5 height after corrective surgery might result in upward tension on the SMA root, decreasing the angle and compressing the duodenum, ultimately affecting intestinal motility and causing POI. This may be the reason that a large change in L1–5 height was another independent risk factor for POI. By comparing the patients' preoperative characteristics, we found that the POI group had a significantly higher proportion of patients with a major lumbar curve and a significantly larger mean Cobb angle of the lumbar curve than the patients without POI. This might be because at the same rate of correction, a more severe lumbar curve at baseline could be associated with larger changes in the T10–L2 and L1–5

TABLE 5 The cut off values, sensitivity and specificity of risk factors for POI

Risk factors	Cutt-off value	Sensitivity	Specificity	AUC
ΔT10-L2 Height (cm)	1.885	0.595	0.873	0.755
ΔL1-5 Height (cm)	1.195	0.786	0.873	0.857

Abbreviations: POI, postoperative ileus; TLK, thoracolumbar kyphosis.

height after surgery and greater difficulty of freehand screw placement, which is more likely to cause lumbar anterior screw breech. However, these two factors were not independent risk factors in the multivariate logistic regression analysis and still need to be further investigated.

The Association between Lumbar Anterior Screw Breeching and POI

In a previous study, it was reported that POI was significantly associated with posterior instrumentation, but the specific aspect of instrumentation was not identified.[11] In the present study, we first reported that lumbar anterior screw breeching could be an independent risk factor for POI. The reason for this result might involve an inflammatory mechanism. First, when lumbar screws penetrate the anterior vertebral wall, they may cause the release of cytokines and other inflammatory mediators and affect the various nerve plexuses lying against the anterior vertebra, resulting in decreased intestinal motility.[24,25] Second, extravasation of the penetrated anterior vertebral wall may cause retroperitoneal bleeding and hematoma, which could compress and affect the local never plexus, thus leading to abnormal intestinal motility.[26] In addition, we also found that patients with POI had a higher proportion of LIV at L2 and below and a larger number of lumbar screws than patients without POI. However, in the multivariate logistic regression, neither of those factors was an independent risk factor for POI, which means that further studies are needed to explore the relationship between these two factors and POI.

In some previous studies, researchers have suggested that the cumulative dose of opioids could be a significant risk factor for POI.[27–29] However, we analyzed postoperative opioid intake in this study and found that it did not support this conclusion, a finding that is similar to those of some other studies.[30,31] Although anesthetic drugs may have an inhibitory effect on intestinal motility,[14,24,32] the intraoperative remifentanil dose was not identified as an independent risk factor for POI in our study. Therefore, further studies with a large sample size are needed to clarify the association between pharmacological factors and POI.

Needs to Explore an Effective Protocol for Prevent POI

According to previous studies, preventive measures for POI include the early introduction of oral nutrition, early mobilization, use of coffee and chewing gum,[33–38] and treatments including appropriate fasting and intravenous fluid resuscitation, prokinetic agents, pantothenic acid, μ-receptor antagonist, and nasogastric decompression.[22,39–41] However, the efficacy of these procedures remains controversial, and there is still a lack of a standardized protocol. In this study, we adopted a postoperative protocol of early oral nutrition (at 6 h postoperatively) and early mobilization (at 2 days postoperatively), but the incidence of POI remained relatively high. Currently, the enhanced recovery after surgery (ERAS) pathway has been widely used in corrective surgery for AIS.[42,43] However, those ERAS methodologies mainly focused on decreasing surgical duration, perioperative blood loss, postoperative pain scores and length of stay, while a standardized ERAS pathway for improving POI in AIS patients is still lacking. Therefore, further studies should be conducted to investigate the effect of ERAS on POI and to propose an effective standardized protocol.

Strengths and Limitations

The present study first reported the incidence of POI after posterior corrective surgery for patients with AIS through a relatively large sample size. And three independent risk factors were identified by multivariate logistic regression analysis, which could provide some references for others spine surgeons to prevent POI. However, there were several limitations in this study. First, it was a retrospective study based on a single-center database, which may bias the results. Second, the identification of POI was dependent on electronic medical records, and it is possible that some patients with POI might have been missed. Third, since the relatively lower density selective screw placement, postoperative brace was performed in all patients which might increase the POI incidence in this study.

Conclusion

There was a relatively high incidence of POI (13.2%) after corrective surgery, and we identified three independent risk factors: large changes in T10–L2 and L1–5 height and the presence of lumbar anterior screw breech. Improving the accuracy of pedicle screw placement might reduce the incidence of POI, and greater attention should be given to patients whose changes in T10–L2 and L1–5 height are likely to be larger than 1.885 cm and 1.195 cm after corrective surgery.

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Author Contributions

All authors had full access to 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: Z.Z. and X.Y. Acquisition of data: Z.Z., B.H., J.L. and H.Y. Analysis and interpretation of the data: Z.Z. and B.H. Drafting of the manuscript: Z.Z., B.H., and J.L. Critical revision of the manuscript for important intellectual content: L.L., Y.S., D.M. and X.Y. Statistical analysis: Z.Z. and H.Y. Obtained funding: H.Y, and Y.S. Study supervision: Y.S., and X.Y.

References

1. Weinstein SL, Dolan LA, Cheng JC, Danielsson A, Morcuende JA. Adolescent idiopathic scoliosis. Lancet. 2008;371(9623):1527–37.
2. Sugawara R, Takeshita K, Takahashi J, Arai Y, Watanabe K, Yamato Y, et al. The complication trends of pediatric spinal deformity surgery in Japan - the Japanese scoliosis society morbidity and mortality survey from 2012 to 2017. J Orthop Sci. 2020;26:744–9.
3. Kwan MK, Loh KW, Chung WH, Chiu CK, Hasan MS, Chan CYW. Perioperative outcome and complications following single-staged posterior spinal fusion (PSF) using pedicle screw instrumentation in adolescent idiopathic scoliosis (AIS): a review of 1057 cases from a single Centre. BMC Musculoskelet Disord. 2021; 22(1):413.
4. Wang Y, Hai Y, Liu Y, Guan L, Liu T. Risk factors for postoperative pulmonary complications in the treatment of non-degenerative scoliosis by posterior instrumentation and fusion. Eur Spine J. 2019;28(6):1356–62.
5. Auerbach JD, Kean K, Milby AH, Paonessa KJ, Dormans JP, Newton PO, et al. Delayed postoperative neurologic deficits in spinal deformity surgery. Spine. 2016;41(3):E131–8.
6. Subramanyam R, Schaffzin J, Cudilo EM, Rao MB, Varughese AM. Systematic review of risk factors for surgical site infection in pediatric scoliosis surgery. Spine J. 2015;15(6):1422–31.
7. Baig MK, Wexner SD. Postoperative ileus: a review. Dis Colon Rectum. 2004; 47(4):516–26.
8. Kiely PD, Mount LE, Du JY, Nguyen JT, Weitzman G, Memstoudis S, et al. The incidence and risk factors for post-operative ileus after spinal fusion surgery: a multivariate analysis. Int Orthop. 2016;40(6):1067–74.
9. Kehlet H, Holte K. Review of postoperative ileus. Am J Surg. 2001;182(5A Suppl):3 S–10 S.
10. Fineberg SJ, Nandyala SV, Kurd MF, Marquez-Lara A, Noureldin M, Sankaranarayanan S, et al. Incidence and risk factors for postoperative ileus following anterior, posterior, and circumferential lumbar fusion. Spine J. 2014; 14(8):1680–5.
11. Al Maaieh MA, Du JY, Aichmair A, Huang RC, Hughes AP, Cammisa FP, et al. Multivariate analysis on risk factors for postoperative ileus after lateral lumbar interbody fusion. Spine. 2014;39(8):688–94.
12. Brau SA. Mini-open approach to the spine for anterior lumbar interbody fusion: description of the procedure, results and complications. Spine J. 2002; 2(3):216–23.
13. Ohba T, Koyama K, Oba H, Oda K, Tanaka N, Haro H. Clinical importance, incidence and risk factors for the development of postoperative ileus following adult spinal deformity surgery. Global Spine J. 2020;12:1140.
14. Park SC, Chang SY, Mok S, Kim H, Chang BS, Lee CK. Risk factors for postoperative ileus after oblique lateral interbody fusion: a multivariate analysis. Spine J. 2021;21(3):438–45.
15. Ravinsky RA, Ouellet JA, Brodt ED, Dettori JR. Vertebral osteotomies in ankylosing spondylitis-comparison of outcomes following closing wedge osteotomy versus opening wedge osteotomy: a systematic review. Evid Based Spine Care J. 2013;4(1):18–29.
16. Asha MJ, Choksey MS, Shad A, Roberts P, Imray C. The role of the vascular surgeon in anterior lumbar spine surgery. Br J Neurosurg. 2012;26(4):499–503.
17. Bureta C, Tominaga H, Yamamoto T, Kawamura I, Abematsu M, Yone K, et al. Risk factors for postoperative ileus after scoliosis surgery. Spine Surg Relat Res. 2018;2(3):226–9.
18. Vather R, Trivedi S, Bissett I. Defining postoperative ileus: results of a systematic review and global survey. J Gastrointest Surg. 2013;17(5):962–72.
19. Nash CL Jr, Moe JH. A study of vertebral rotation. J Bone Jt Surg. 1969; 51(2):223–9.
20. Lee MJ, Vaughan-Shaw P, Vimalachandran D, Group AGR. A systematic review and meta-analysis of baseline risk factors for the development of postoperative ileus in patients undergoing gastrointestinal surgery. Ann R Coll Surg Engl. 2020;102(3):194–203.
21. Vather R, O'Grady G, Bissett IP, Dinning PG. Postoperative ileus: mechanisms and future directions for research. Clin Exp Pharmacol Physiol. 2014;41(5):358–70.
22. Daniels AH, Ritterman SA, Rubin LE. Paralytic ileus in the orthopaedic patient. J Am Acad Orthop Surg. 2015;23(6):365–72.
23. Shapiro G, Green DW, Fatica NS, Boachie-Adjei O. Medical complications in scoliosis surgery. Curr Opin Pediatr. 2001;13(1):36–41.
24. Mattei P, Rombeau JL. Review of the pathophysiology and management of postoperative ileus. World J Surg. 2006;30(8):1382–91.
25. Bragg D, El-Sharkawy AM, Psaltis E, Maxwell-Armstrong CA, Lobo DN. Postoperative ileus: recent developments in pathophysiology and management. Clin Nutr. 2015;34(3):367–76.
26. Venara A, Neunlist M, Slim K, Barbieux J, Colas PA, Hamy A, et al. Postoperative ileus: pathophysiology, incidence, and prevention. J Visc Surg. 2016;153(6):439–46.
27. Gifford C, Minnema AJ, Baum J, Humeidan ML, Vazquez DE, Farhadi HF. Development of a postoperative ileus risk assessment scale: identification of intraoperative opioid exposure as a significant predictor after spinal surgery. J Neurosurg. 2019;31(5):748–55.
28. Barletta JF. Clinical and economic burden of opioid use for postsurgical pain: focus on ventilatory impairment and ileus. Pharmacotherapy. 2012;32(9):12s–8s.
29. de Boer HD, Detriche O, Forget P. Opioid-related side effects: postoperative ileus, urinary retention, nausea and vomiting, and shivering. A review of the literature. Best Pract Res Clin Anaesthesiol. 2017;31(4):499–504.
30. Trescot AM, Glaser SE, Hansen H, Benyamin R, Patel S, Manchikanti L. Effectiveness of opioids in the treatment of chronic non-cancer pain. Pain Physician. 2008;11(2 Suppl):S181–200.
31. Marderstein EL, Delaney CP. Management of postoperative ileus: focus on alvimopan. Ther Clin Risk Manage. 2008;4(5):965–73.
32. Mythen MG. Postoperative gastrointestinal tract dysfunction. Anesth Analg. 2005;100(1):196–204.
33. Sun DL, Li WM, Li SM, Cen YY, Xu QW, Li YJ, et al. Comparison of multi-modal early oral nutrition for the tolerance of oral nutrition with conventional care after major abdominal surgery: a prospective, randomized, single-blind trial. Nutr J. 2017;16(1):11.
34. Waldhausen JH, Schirmer BD. The effect of ambulation on recovery from postoperative ileus. Ann Surg. 1990;212(6):671–7.
35. Jennings JK, Doyle JS, Gilbert SR, Conklin MJ, Khoury JG. The use of chewing gum postoperatively in pediatric scoliosis patients facilitates an earlier return to normal bowel function. Spine Deform. 2015;3(3):263–6.
36. Kane TD, Tubog TD, Schmidt JR. The use of coffee to decrease the incidence of postoperative ileus: a systematic review and meta-analysis. J Perianesth Nurs. 2020;35(2):171–177 e171.
37. Chan CYW, Chiu CK, Lee CK, Gani SMA, Mohamad SM, Hasan MS, et al. Usage of chewing gum in posterior spinal fusion surgery for adolescent idiopathic scoliosis: a randomized controlled trial. Spine. 2017;42(19):1427–33.
38. Meng Y, Lin T, Shao W, Jiang H, Li T, Gao R, et al. A prospective single-blind randomized controlled trial of chewing gum on bowel function recovery after posterior spinal fusion surgery for adolescent idiopathic scoliosis. Clin Spine Surg. 2018;31(3):132–7.
39. Traut U, Brugger L, Kunz R, Pauli-Magnus C, Haug K, Bucher HC, et al. Systemic prokinetic pharmacologic treatment for postoperative adynamic ileus following abdominal surgery in adults. Cochrane Database Syst Rev. 2008;23(1): CD004930.
40. Weinstock LB, Chang AC. Methylnaltrexone for treatment of acute colonic pseudo-obstruction. J Clin Gastroenterol. 2011;45(10):883–4.
41. Chamie K, Golla V, Lenis AT, Lec PM, Rahman S, Viscusi ER. Peripherally acting mu-opioid receptor antagonists in the Management of Postoperative Ileus: a clinical review. J Gastrointest Surg. 2021;25(1):293–302.
42. Julien-Marsollier F, Michelet D, Assaker R, Doval A, Louisy S, Madre C, et al. Enhanced recovery after surgical correction of adolescent idiopathic scoliosis. Paediatr Anaesth. 2020;30(10):1068–76.
43. Yang YJ, Huang X, Gao XN, Xia B, Gao JB, Wang C, et al. An optimized enhanced recovery after surgery (ERAS) pathway improved patient care in adolescent idiopathic scoliosis surgery: a retrospective cohort study. World Neurosurg. 2021;145:e224–32.