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Clinical Importance, Incidence and Risk Factors for the Development of Postoperative Ileus Following Adult Spinal Deformity Surgery

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Abstract

Study Design: Retrospective observational study of a cohort of consecutive patients.

Objectives: Postoperative ileus (POI) is associated with a variety of adverse effects. Although the incidence of and risk factors for POI following spinal surgery have been reported, the frequency and pathology of POI after spinal corrective surgery for adult spinal deformity (ASD) are still largely unknown. The study objectives were to: (1) clarify the prevalence and clinical significance of POI, (2) elucidate the risk factors for POI, (3) determine radiographically which preoperative and/or postoperative spinal parameters predominantly influence the risk of POI after spinal corrective surgery for ASD.

Methods: We included data from 144 consecutive patients who underwent spinal corrective surgery. Perioperative medical complications and clinical information were extracted from patient electronic medical records. Preoperative radiographic parameters and changes in radiographic parameters after surgery were compared between patients with and without POI. Multivariate logistic regression analyses were performed to clarify potential risk factors for POI.

Results: POI developed in 25/144 (17.4%) patients and was the most common complication in the present study. The frequencies of smoking, gastroesophageal reflux disease, and lateral lumbar interbody fusion (LLIF), as well as the duration of surgery were significantly greater in the group with POI versus the group without POI. Among radiographic parameters, only the change in thoracolumbar kyphosis (TLK) from before to after surgery was significantly larger in the group with POI. Multivariate logistic regression analysis showed that male sex, LLIF and large changes in TLK from before to after surgery were significantly associated with the development of POI.

Conclusions: These results suggested that LLIF and large corrections in TLK were independent risk factors for POI after ASD surgery. When patients with ASD have large TLK preoperatively, and it is determined that a large correction is needed, physicians must be aware of the potential for occurrence of POI.

Keywords
adult spinal deformity, postoperative ileus, thoracolumbar kyphosis, surgical spinal correction, perioperative complications, lateral lumbar interbody fusion

Introduction

Despite having a crucial role to improve the health-related quality of life (HRQoL) of patients with adult spinal deformity (ASD), spinal corrective surgery for ASD often requires extensive dissection, with a large number of exposed spinal levels, osteotomy, blood transfusion, and extended hospitalization. Over the last few decades, the ability to treat ASD has advanced, including improvements in minimally invasive

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techniques, such as lateral lumbar interbody fusion (LLIF), and other surgical strategies.[1-4] However, surgical treatment of spinal deformities for elderly patients remains challenging because of the high rates of surgical and medical complications.[5,6] Therefore, many investigators have tried to determine the incidence of and risk factors for perioperative complications associated with the surgical treatment of ASD. In those studies, infections, neurologic deficits, cardiopulmonary complications, cerebrovascular accident and deep venous thrombosis were identified as major complications. We recently noted that many patients with ASD complain of abdominal symptoms after spinal corrective surgery (Supplemental Table).

Postoperative ileus (POI) is defined as the temporary obstipation of the gastrointestinal (GI) tract and overall disruption of normal peristalsis in response to surgical stress, manifested clinically by nausea, vomiting, inability to tolerate an oral diet, abdominal distension, and/or delayed passage of flatus or stool for 3 or more days after surgery.[7] POI is associated with a variety of adverse effects, such as increased postoperative pain, increased pulmonary morbidity and infectious complications, poor wound healing, delayed postoperative mobilization, prolonged hospitalization, decreased patient satisfaction, and increased health care costs.[8] Although POI is a well-known complication after intra-abdominal surgery, it has also been known to develop after orthopedic surgery.[9] To date, the incidence of and risk factors for POI following spinal surgery have been reported.[10,11] However, the frequency and pathology of POI after spinal corrective surgery for ASD are still largely unknown.

The purposes of present study were (1) to clarify the prevalence and clinical significance of POI, (2) to elucidate the risk factors for POI, and (3) to determine radiographically which preoperative and/or postoperative spinal parameters predominantly influence the risk of POI after spinal corrective surgery for ASD.

Methods

Patients and Surgical Techniques

This study was approved by the institutional review board (IRB) of the authors' affiliated institution. We carried out a retrospective observational study of a cohort of consecutive patients with a diagnosis of ASD who underwent spinal corrective surgery. Patients were considered candidates for thoracolumbar correction if fusion was indicated because of ASD and a full course of conservative care had been exhausted. The inclusion criteria were a radiographic diagnosis of ASD defined by at least one of the following parameters: a coronal Cobb angle >30°; a C7 sagittal vertical axis (SVA, defined as the distance between the C7 plumb line and the posterosuperior edge of S1) >5 cm; and/or a >30° pelvic tilt (PT), which is the orientation of the pelvis with respect to the femurs and the rest of the body. We only included cases of de novo degenerative spinal deformity to study, separate from secondary degenerative scoliosis superimposed on adolescent idiopathic scoliosis.

Table 1. Patient Characteristics.

	N = 144
Age, years	71 ± 7
Female/male, n	127/17
LLIF, n (%)	97 (67%)
SRS osteotomy classification, n (%)	
Grade 1-2	88 (61%)
Grade 3-5	56 (39%)
Location of UIV, n (%)	
Th9-11	117 (81.3%)
Th8 ∼	27 (18.8%)
Bleeding, ml	996 ± 838
Duration of surgery, min	457 ± 84

Interval and ratio values represent the mean ± standard deviation.
LLIF, lateral lumbar interbody fusion; SRS, Scoliosis Research Society; UIV, upper instrumented vertebra.

Patients were excluded if they had a history of abdominal surgery, a rounded back because of Parkinson's disease and a diagnosis of adolescent idiopathic scoliosis. We included data from 144 consecutive patients who underwent spinal corrective surgery between April 2012 and March 2019, as performed by 3 board-certified spinal surgeons at a single institution.

If it was judged to be valid by pre-operative radiographic flexibility evaluations, as previously reported,[12] the surgeons used an anterior approach to LLIF from L1–L2 or L2–L3 to the level of the L4-5 disc to obtain adequate coronal and sagittal global spine alignment in patients with ASD (Table 1). Subsequently each patient was placed in a prone position to undergo a posterior lumbar interbody fusion (PLIF) at the level of the L5-S1 disc, and the spinal kyphosis was corrected using a cantilever force with bilateral S1 screws and bilateral single or dual iliac screws. All surgeries with LLIF were performed as single-staged lateral-posterior combined surgeries. Where flexibility of spinal motion was lost, we performed a suitable osteotomy, which was classified as grade 1–6 by Scoliosis Research Society–Schwab criteria14 (Table 1).

All patients received intravenous patient-controlled analgesia with droperidol, fentanyl citrate and lidocaine; oral administration of non-steroidal anti-inflammatory drugs (NSAIDs) was added for postoperative pain management at the request of the patient.

Data Extraction

We extracted the following sociodemographic and clinical information from the patient electronic medical records: age, sex, body mass index (BMI), preoperative intake of medicine for constipation, preoperative intake of NSAIDs/opioids, smoking status, and history of gastroesophageal reflux disease (GERD). Evaluation of GERD was conducted within 2 weeks prior to surgery. GERD was diagnosed by a gastroenterologist based on the patient's response to proton pump inhibitor (PPI) medication and/or a Frequency Scale for Symptoms of GERD (FSSG) score >8 points.[13]

Perioperative (within 30 days of surgery) medical complications were also collected (Supplemental Table), and included the following: infection (pneumonia, urinary tract infection, sepsis, and surgical site infection), cerebrovascular accident, cardiopulmonary complications (deep venous thrombosis, pulmonary embolism, myocardial infarction, arrhythmia, congestive heart failure, pneumothorax, atelectasis, adult respiratory distress syndrome, electrolyte imbalance), neurologic deficit, symptomatic spinal epidural hematoma, renal complications (acute renal failure with and without hemodialysis) and POI. Patients were identified as having POI if they exhibited at least 2 of the following: the presence of gastrointestinal symptoms or signs, such as anorexia, nausea, vomiting, failure to pass stool or flatus for 3 days, and abdominal distension or radiographic findings of paralytic ileus within 30 days after spinal surgery.

Radiographic Measurements

Radiographic data consisted of full-length lateral radiographs obtained preoperatively and 4–6 weeks postoperatively, with the patients in a freestanding posture and their fingers placed on their clavicles. On pre- and postoperative coronal radiographs, the Cobb angle (the angle between the superior endplate of the most tilted vertebra cranially and the inferior endplate of the most tilted vertebra caudally) was measured. The following sagittal radiographic parameters were measured pre- and postoperatively using a lateral view: T5−T12 thoracic kyphosis (TK); T10-L2 thoracolumbar kyphosis (TLK); T12−S1 lumbar lordosis (LL) angles; pelvic incidence (PI); PT; sacral slope (SS); SVA; T1 pelvic angle (TPA), which is the angle between the line from the center of the femoral heads to the center of S1 and the line from the femoral head to the center of T1[14]; and global tilt (GT), which is the angle formed by the intersection of 2 lines, the first line drawn from the center of C7 to the center of the sacral endplate and the second line drawn from the center of the femoral heads to the center of the sacral endplate.[15] Radiographic measurements were made by 2 board certified spine surgeons (TO [author 1] and HO [author 3]) to determine interobserver error. We applied the mean values of these measurements to the analyses that followed. The intraclass coefficient was 0.880, indicating that the inter-rater reliability was almost ideal. These authors had >10 years of experience in spinal surgery and were blinded to patient data before the measurements were made.

Statistical Analyses

We report mean ± standard deviation (SD) for continuous variables and number (percentage) for categorical variables. We performed a Student *t* or Fisher exact test when we compared means between 2 groups statistically, assuming normal distributions for continuous variables. We used Prism (version 7.0; GraphPad Software, La Jolla, CA) to calculate summary statistics and perform the *t* tests. Multivariate logistic regression analyses were performed with R software, version 3.2.3, to evaluate the odds ratio (OR) with a 95% confidence interval (95% CI) for potential risk factors for POI. Statistical significance was set at $P < 0.05$.

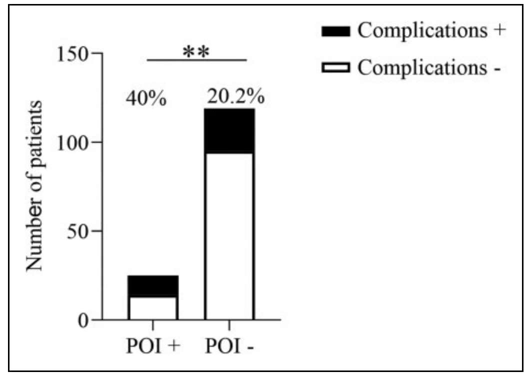

Figure 1. Comparison of the frequency of non-POI complications between the POI (+) and POI (−) groups. POI; postoperative ileus.

Results

Patient Population and Overall Complications

We included 144 eligible patients in this study; 88% were female, and the mean age was 71.1 ± 7.1 years. LLIF was used in 67% of patients, grade 2 osteotomy was used in 61%, and grade 3-5 osteotomy was used in 39%. Mean bleeding was 996 ± 838 ml, and mean duration of surgery was 457 ± 84 min (Table 1). A summary of perioperative complications is shown in supplemental Table 1. POI developed in 25/144 (17.4%) patients and was the most frequent complication in the present study. Additionally, the incidence of non-POI complications was significantly higher in the POI (+) group compared to the POI (−) group (Figure 1).

Comparison of Patients With and Without Postoperative Ileus

As shown in Table 2, there were no significant differences between groups in age, sex, BMI, frequency of preoperative constipation, frequency of NSAID and/or opioid use, preoperative Cobb angle, estimated blood loss, frequency of osteotomy or the period from surgery to the start of ambulation. In contrast, the frequency of smoking, the frequency of GERD, the duration of surgery and the frequency of LLIF were significantly greater in the group with POI than in the group without POI (Table 2).

Comparison of Spinopelvic Parameters With and Without Postoperative Ileus

There were no significant differences between the groups for any of the preoperative spine radiographic parameters (Table 3). In contrast, only the change in TLK (ΔTLK) from before to after surgery was significantly larger in the group with POI.

Table 2. Comparison of Patients With and Without Postoperative Ileus.

Variables	Non-POI (n = 119)	POI (n = 25)	*P* value
Age, years	71.3 ± 7.3	72.3 ± 7.1	NS
Female/male, n	107/12	19/6	NS
BMI, kg/m^2	24.0 ± 17.7	21.7 ± 2.6	NS
Preoperative constipation, n (%)	52 (44)	14 (56)	NS
Preoperative NSAID/opioid use, n (%)	65 (55)	12 (48)	NS
Smoking (NSO/CS or FS), n	112/7	19/6	<0.05*
History of GERD, +/−, n	54/65	17/8	<0.05*
Cobb angle ~30°/30°~, n	77/33	14/11	NS
Duration of surgery, min	466 ± 87.4	512 ± 81.2	<0.05*
Estimated blood loss, ml	957.3 ± 818	1004 ± 631	NS
Use of LLIF, n (%)	75 (63)	22 (88)	<0.0001*
Use of osteotomy, G1-2/G3-5, n	73/46	16/9	NS
Period from surgery to the start of ambulation, days	5.2 ± 1.2	5.7 ± 2.1	NS

Interval and ratio values are presented as the mean ± standard deviation.
*vs POI group.
POI, postoperative ileus; BMI, body mass index; NSAID, non-steroidal anti-inflammatory drug; NSO, never smoker; CS, current smoker; FS, former smoker; GERD, gastroesophageal reflux disease; LLIF, lateral lumbar interbody fusion; G, Grade; NS, not significant.

Table 3. Comparison of Preoperative Spinopelvic Parameters in Patients With and Without Postoperative Ileus.

Variable	Non-POI (n = 119)	POI (n = 25)	*P* value
Spinopelvic parameters			
TLK, °	20.3 ± 18.9	27.5 ± 18.1	NS
TK, °	25.9 ± 17.3	24.8 ± 17.8	NS
PT, °	38.7 ± 10.5	35.3 ± 12.9	NS
SS, °	15.1 ± 13.7	13.4 ± 13.3	NS
LL, °	9.4 ± 22.2	5.1 ± 24.7	NS
SVA, mm	125 ± 71.8	130 ± 65.7	NS
GT, °	54.2 ± 17.2	54.3 ± 21.1	NS
TPA, °	42.7 ± 15.3	41.6 ± 14.5	NS
ΔSpinopelvic parameters			
TLK, °	-19.4 ± 18.7	-9.4 ± 21.4	<**0.05***
TK, °	-14.7 ± 13.1	-14.5 ± 14.3	NS
PT, °	-17.4 ± 13.8	20.1 ± 12.6	NS
SS, °	-14.5 ± 13.1	-17.3 ± 13.9	NS
LL, °	41.4 ± 22.9	45.5 ± 24.7	NS
SVA, mm	-94.9 ± 72.4	-108.5 ± 56.9	NS
GT, °	-32.3 ± 18.7	35.7 ± 16.5	NS
TPA, °	25.5 ± 16.0	29.2 ± 12.9	NS

Interval and ratio values are presented as the mean ± standard deviation.
*vs POI group.
TLK, thoracolumbar kyphosis; TK, thoracic kyphosis; PI, pelvic incidence; POI, postoperative ileus; PT, pelvic tilt; SS, sacral slope; LL, lumbar lordosis; SVA, sagittal vertical axis; GT, global tilt; TPA, T1 pelvic angle; NS, not significant. Δ, postoperative values – preoperative values.

Risk Factors for Developing POI

A multivariate logistic regression analysis was conducted with parameters including age, sex, history of GERD, preoperative constipation, smoking status, duration of surgery, LLIF and ΔTLK. Finally, the present study showed that male sex, LLIF and large changes in TLK value from before to after surgery were significantly associated with the development of POI (Table 4).

Table 4. Multivariate Logistic Regression Analysis of Risk Factors for Developing Postoperative Ileus.

Parameter	OR	95% CI	*P* value
Age	1.029	0.955–1.114	NS
Female	0.234	0.053–1.028	< **0.05**
History of GERD	1.366	0.450–4.115	NS
Preoperative constipation	1.996	0.689–5.961	NS
Smoking	4.10	0.736–22.47	NS
Duration of surgery	1.005	0.736–22.47	NS
LLIF	9.46	2.08–74.7	< **0.05**
ΔTLK	0.961	0.97-0.993	< **0.05**

CI, confidence interval; OR, odds ratio; GERD, gastroesophageal reflux disease; LLIF, lateral lumbar interbody fusion; TLK, thoracolumbar kyphosis; NS, not significant.

Discussion

Among perioperative complications, POI was the most frequent complication after ASD surgery in the present study, and 2 patients required laparotomy because of intussusception and severe ileus (Supplemental Table). Additionally, we found that the development of POI might increase the incidence of secondary adverse events, such as deep vein thrombosis, pulmonary embolism, infectious complications and poor wound healing (Figure 1), as in previous reports.[8,16] These results indicate that it has clinical significance to clarify the pathology of POI after spinal surgery for ASD. Actually, POI has been known as a relatively common complication after surgery that affects 3.5%~12% of patients undergoing all spinal procedures.[10,17,18] In particular, ASD surgery has many risk factors that have been reported for POI development, such as use of an anterior approach, surgery in the prone position, scoliosis surgery and intraoperative opioid exposure.[10,11,19-21] A recent study reported a high incidence (18.4%) of POI, and length of stay remains significantly longer in patients who develop POI after adult spinal surgery.[22] However, there was insufficient evidence regarding the risk of development of POI after ASD surgery and the changes in spinal alignment caused by spinal corrective surgery.

Our multivariate analysis clarified that critical risk factors for POI after ASD surgery were LLIF and large changes in the thoracolumbar curve. A previous study not including ASD surgery indicated a relatively high incidence of POI after LLIF, and independent risk factors for POI were a history of GERD, posterior instrumentation, and LLIF at L1-L2.[11] The results of the present study indicated that a lateral and posterior combined approach had significantly higher risk of POI compared with a posterior-only approach. Further study is needed to compare anterior-only, lateral-only, and posterior-only approaches for the risk of developing POI to determine the influence of surgical approach on developing POI. To our knowledge, this is the first study to show that alignment correction in the thoracolumbar curve during surgery was a risk factor for POI after ASD surgery. Recently, we reported that patients with ASD had a high frequency of GERD symptoms, and that TLK is a key spinal parameter involved in the pathology of GERD in patients with ASD.[13,23] Considering these results, the thoracolumbar curve has significant effects on gastrointestinal function in patients with ASD. A limitation of the present study was that there was no consideration of the influence of postoperative narcotic medication on POI, because it was difficult to standardize the dose and frequency of postoperative narcotic medication. Involvement of POI pathogenesis caused by narcotic medication is well known, and recent studies have indicated that a decreasing incidence of POI after orthopedic surgery may be attributed to a reduction in postoperative narcotic use.[24,25]

Conventional treatments for POI include nasogastric suction, prokinetic agents, early mobilization, early enteral feeding, and the use of less invasive surgical procedures.[26] Unfortunately, insufficient evidence of the efficacy of individual conventional treatments has been reported.[8] Further study is needed on how to prevent and/or treat POI. However, this study has a clinically significant result indicating that when patients with ASD have large TLK preoperatively, and it is determined that a large correction is needed, more attention might be paid to the occurrence of POI.

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Declaration of Conflicting Interests

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Supplemental Material

Supplemental material for this article is available online.

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