Clinical characteristics and outcomes of acute pancreatitis following spinal surgery: a systematic review

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Abstract
Objective: This study reviewed the current evidence on the clinical characteristics and outcome of acute pancreatitis (AP) following spinal surgery.

Methods: A systematic search was performed to identify English articles published through May 2020 in PubMed, Scopus, EMBASE, Latin American & Caribbean Health Sciences Literature, and Cochrane Library. Data on clinical characteristics, risk factors, and outcomes were analyzed.

Results: Eleven papers (including six case reports) were included, with 306 patients (incidence, 23.0%) developing AP after spinal surgery (mean age, 14.2 years). Of the studies that specified symptoms (55 patients), abdominal pain (43.6%), nausea and vomiting (32.7%), and abdominal distension (7.27%) were most prevalent. The mean duration from surgery to symptom onset was 6.15 days (range, 1–7). The most common complications of AP were glucose intolerance (25%), peritonitis (2%), pseudocyst formation (2%), and fluid collection (2%) were most prevalent. Prolonged fasting time (13.6%), intraoperative blood loss (9.09%), gastroesophageal reflux disease (9.1%), age >14 years (9.1%), and low BMI (9.1%) were most commonly associated with AP. Two deaths (0.6%) were reported.

Conclusion: AP remains an important complication of spinal surgery because of its morbidity and mortality. Avoiding major risk factors can reduce the incidence of AP following spinal surgery.

Keywords
Acute pancreatitis, spinal surgery, scoliosis, systematic review, postoperative complication, abdominal pain, nausea, vomiting, multiorgan failure

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**Introduction**

Acute pancreatitis is a known postoperative complication of many abdominal and extra-abdominal surgeries.\(^1\)–\(^5\) Postoperative pancreatitis is associated with a higher risk of local and systemic complications as well as high morbidity and mortality rates.\(^6\) The severity of pancreatitis ranges from mild to severe, with increasing mortality observed in patients with severe pancreatitis, necrotizing pancreatitis, and multiorgan failure.\(^7\) In patients with postoperative pancreatitis, the mortality rate has been reported to be as high as 50%.\(^1\) Although the incidence of postoperative pancreatitis is low, routinely monitoring with clinical and biochemical parameters can facilitate early diagnosis and treatment, especially among patients undergoing surgeries with a known high risk of pancreatitis.\(^8\)

A diagnosis of acute pancreatitis is considered if a patient satisfies at least two of the following criteria: clinical features including abdominal pain, nausea, and vomiting; biochemical features including serum lipase levels three times above the upper limit of normal; and characteristic findings in imaging including computed tomography (CT) or magnetic resonance imaging (MRI).\(^9\)

The pathogenesis of pancreatitis following spinal surgery is attributed to multiple factors such as splanchnic hypoperfusion caused by intraoperative hemodynamic instability,\(^8,\)\(^10\) mechanical compression caused by spinal correction mainly in individuals with lower body mass index (BMI), pancreatic ischemia caused by lower intraoperative mean arterial pressures,\(^8,\)\(^11\) and depressed trypsin inhibitor activity leading to reduced immunity to autodigestion postoperatively.\(^2\) It has been observed that patients with neurofibromatosis type 1, Marfan syndrome, and cerebral palsy are at higher risk of developing acute pancreatitis following spinal surgery, although the exact mechanism of the higher risk among these patients is poorly understood.\(^8\)

The available literature on acute pancreatitis following spinal surgery is limited. Therefore, we conducted this systematic review to describe the clinical characteristics, risk factors, and outcomes of acute pancreatitis among patients undergoing spinal surgeries.

**Methods**

A systematic review of all studies on pancreatitis following spinal surgeries, including prospective and retrospective cohort analysis and experimental studies, was performed. Because of the limited number of studies, we decided to include case reports in this review. Studies describing patients meeting at least two of the three criteria of acute pancreatitis after any spinal surgery were eligible. As a systematic review, ethics committee approval and patient consent were not required.

The primary objective was to describe the clinical characteristics, risk factors, and outcomes of acute pancreatitis following spinal surgeries. We also aimed to describe attempted treatment modalities and their outcomes when relevant. The methodology of this review followed the PRISMA recommendations.\(^12\)

**Search strategy**

All articles published before May 2020 were searched electronically using PubMed/Medline, Scopus, EMBASE, Cochrane Central Register of Controlled Trials (CENTRAL), and Latin American & Caribbean Health Sciences Literature (LILACS) without any restrictions regarding language or the publication status. Keywords related to acute pancreatitis and its complications and various types of spinal surgeries were searched in the title and abstract fields. The detailed search
strategy is presented in the supplementary file (Annexure 1). Furthermore, the list of references of eligible articles was manually searched, and relevant articles were added to the review.

The initial eligibility screening was performed by two investigators using the titles, abstracts, and keywords of the citations. Thereafter, the full text of all relevant records was assessed according to the inclusion criteria. In cases of disagreement, a consensus was reached after input from the senior authors. All data pertaining to the clinical presentation, risk factors, investigations, treatment and outcomes were extracted, categorized, and tabulated. Finally, qualitative analysis was performed using the available data. A meta-analysis could not be performed because of the heterogeneity in the study methodology, treatment options, and description of outcomes. The risk of bias assessment of eligible studies was performed using the Downs and Black checklist, which is a valid and a reliable tool for assessing both randomized and non-randomized control studies (external validity, KR20 = 0.54; internal consistency, KR20 = 0.89),13 and the findings are presented in Table S1.8,10,13–30

Results

Overall summary and patient characteristics

The search of PubMed/Medline, Scopus, EMBASE, CENTRAL, and LILACS resulted in 687 citations. After excluding duplicates, 620 were evaluated for eligibility. Of these, 598 papers were excluded after reviewing the titles and abstracts. The full texts of the 22 remaining papers were assessed for eligibility. Of these papers, 11 were excluded because the full text did not meet the inclusion criteria. Finally, 11 manuscripts, including six case reports and five cohort studies, were included in this systematic review. No relevant unpublished studies were obtained. The included studies described a total of 1326 patients, of whom 306 patients (23%; mean age, 22.2 years; 68.3% female [n = 209]). Three studies included children with cerebral palsy, and eight studies included patients undergoing surgery for scoliosis (Supplementary File S1).

Clinical symptoms and signs

Of the studies that specified symptoms (n = 55), abdominal pain (43.6%, n = 24), nausea and vomiting (32.7%, n = 18), and abdominal distention (7.3%, n = 4) were most prevalent. The other described features included reduced bowel sounds (5.4%, n = 3), food intolerance (3.6%, n = 2), and prolonged ileus (3.6%, n = 2). These clinical features appeared after a mean of 6.1 days after surgery (Table 1).

Biochemical findings

Only studies reporting serum amylase elevation of more than three times the upper limit of normal were included; therefore, all studies and case reports reported an elevation of serum amylase levels. Serum lipase elevation was observed in 65% of patients (n = 199; Table 2).

Imaging findings

Only studies that included definitive imaging evidence of acute pancreatitis were included. Although, all studies and case reports included imaging findings, only 24.5% (n = 75) of patients had detailed imaging data. Of these patients, 81.3% (n = 61) underwent abdominal ultrasound, and the remaining 18.6% (n = 14) underwent CT (Table 2).

Treatments used

All but one patient was treated non-operatively nil by mouth with nasogastric
Table 1. Clinical characteristics of acute pancreatitis following spinal surgeries.

| Author, year | Study design     | Participants                                      | Total number of patients | Patients with AP of AP | Incidence of AP (%) | Mean age, years | Sex (F) | Spinal deformity | Type of surgery | Clinical symptoms                                                                                       | Mean duration of symptoms (postoperative days) | Serum amylase > 3 times upper limit of AP | Definitive imaging evidence of AP |
|--------------|------------------|--------------------------------------------------|--------------------------|------------------------|--------------------|-----------------|---------|-----------------|----------------|--------------------------------------------------------------------------------|--------------------------------------------|-------------------------------------|-----------------|
| Core studies | Abousamra 2016 (1) | Case control study                              | Cerebral palsy children with scoliosis | 300                    | 165                | 55%             | 14.5   | 135             | CP, scoliosis          | Posterior spinal fusion ± anterior release, unit rod fixation, pedicle screw fixation, mixed implants | 6                           | Yes                   | Yes              |
| Borkhuu 2009 (2) | Retrospective cohort study | Cerebral palsy patients, who received spine fusion with rod instrumentation | 355                      | 109                    | 30.1%             | 14.07 | 60              | CP, scoliosis          | Posterior spinal instrumentation and fusion/spine fusion with rod instrumentation | NA                          | Yes                   | Yes              |
| Elbouyousfi 2016 (3) | Retrospective cohort study | Adolescents after spine fusion surgery for scoliosis | 571                      | 14                     | 2.4%              | 16.025 | NA              | CP, scoliosis          | Scoliosis surgery | Diffused abdominal pain, pain in the right upper quadrant and epigastric pain | 9.5                        | Yes                   | Yes              |
| He 2004 (4) | Prospective cohort study | Patients with neuromuscular scoliosis who underwent posterior spinal fusion and central line placement | 17                       | 5                      | 29.4%             | 15    | 2               | Neuromuscular scoliosis | Posterior spinal fusion | Upper abdominal pain, epigastric or left upper quadrant tenderness, abdominal distension, nausea and vomiting, and persistent ileus | 2                           | yes                   | Yes              |
| Laplaza 2002 (5) | Retrospective cohort study | Patients undergoing surgery for adolescent idiopathic scoliosis | 80                       | 7                      | 9%                | 16    | 6               | Adolescent idiopathic scoliosis | Isolated posterior spinal arthrodesis; Isola instrumentation, Cotrel–Dubousset instrumentation, and Texas Scottish Rite Hospital system | NA                          | Yes                   | Yes              |
| Author, year | Study design | Participants | Total number of patients | Patients with AP | Incidence of AP | Mean age, years | Sex (F) | Spinal deformity | Type of surgery | Clinical symptoms | Mean duration of symptoms (postoperative days) | Serum amylase | Definitive imaging evidence of AP |
|--------------|--------------|--------------|--------------------------|------------------|----------------|----------------|---------|----------------|----------------|----------------|---------------------|-------------|------------------|
| Ghisi 2018 (6) | Case report | Severe idiopathic scoliosis | 1 | 1 | NA | 15 | I | Scoliosis | Two-stage posterior arthrodesis including first-stage instrumentation with growing magnetic rod and second-stage posterior fixation | Nausea and mild abdominal pain during pressure and vomiting; abdominal distension and hypoactive bowel sounds | 1 | Yes | Yes |
| Hewawitharane 2020 (7) | Case report | Severe proximal thoracic scoliosis with deformity (Cobb's angle of 84°) | 1 | 1 | NA | 13 | I | Scoliosis | Single-stage posterior correction of scoliosis | Abdominal pain, mild distension, nausea, vomiting, low grade fever and diminished bowel sounds | 3 | Yes | Yes |
| Juricic 2017 (8) | Case report | Scoliosis | 1 | 1 | NA | 14 | I | Scoliosis | Posterior instrumentation, correction and, fusion from T2 to S1 using hybrid implants | Mild abdominal pain, vomiting, and abdominal distension | 7 | Yes | Yes |
| Korovessis 1996 (9) | Case report | Thoracolumbar kyphosis | 1 | 1 | NA | 28 | I | Kyphosis | Short apical anterior (Zielke operation) and a posterior rods-sublaminar wires plus Texas Scottish Rite Hospital procedure | Severe abdominal pain associated with severe back pain and repeated vomiting, epigastric tenderness on examination with abdominal distention and absent bowel sounds | 1 | Yes | Yes |

(continued)
| Author, year | Study design | Participants | Total number of patients | Patients with AP of AP | Incidence of AP | Mean age, years | Sex (F) | Spinal deformity | Type of surgery | Clinical symptoms | Mean duration of symptoms (postoperative days) | Serum amylase >3 times upper limit of AP | Definitive imaging evidence of AP |
|--------------|-------------|--------------|--------------------------|------------------------|----------------|----------------|--------|----------------|---------------|-----------------|-------------------------------------------|-------------------------------|-----------------------------|
| Rajaraman 2000 (10) | Case report | Grade I spondylolisthesis with mild lumbar spinal stenosis and degenerative disc disease | 1 | I | NA | 60 | I | Spondylolisthesis | Anterior lumbar interbody fusion | Nausea, vomiting, and abdominal distension | 3 | Yes | Yes |
| Tauchi 2013 (11) | Case report | Grade I spondylolisthesis, severe lumbar spinal canal stenosis | 1 | I | NA | 53 | I | Spondylolisthesis | Posterior lumbar interbody fusion | Persisting mild abdominal pain, nausea and vomiting starting several hours after surgery | 1 | Yes | Yes |

AP, acute pancreatitis; NA, not available.
suction, intravenous fluids, somatostatin, and intravenous antibiotic prophylaxis until clinical improvement was observed. Four patients received total parenteral nutrition, and one patient needed total parenteral nutrition. One patient underwent surgery for corporeal fracture of the pancreas postoperatively after correction of the spinal deformity (Table 3).

**Risk factors**

Three studies identified a prolonged fasting time (13.6%), intraoperative blood loss (9.1%), gastroesophageal reflux disease (9.1%), age >14 years (9.1%), low BMI (9.1%), and an anterior or combined approach (9.1%) as the most common risk factors of acute pancreatitis. Risk factors such as the duration of surgery, total parenteral nutrition, feeding difficulty, reactive airway disease, increased TNF-alpha levels, urine trypsin-associated peptide levels, male sex, gastrointestinal tube placement, reactive airway disease, anemia, and the duration of surgery were also associated with acute pancreatitis, albeit at lower frequencies (4.5%, n = 1).

**Complications**

The common complications of acute pancreatitis were glucose intolerance (25%, n = 4), peritonitis (12.5%, n = 2), pseudocyst formation (12.5%, n = 2), and fluid collection (12.5%, n = 2). Other complications including pancreatic pseudocyst formation, pancreatic ascites, and fluid collection were found in 7.1% of patients (n = 2). A minority (6.2%, n = 1) of patients had complications including septicemia, severe pancreatitis, multiorgan failure, phrenic abscess, ascites, and pancreatic duct rupture. The mean hospital stay and intensive care unit stay were 22.1 and 5.4 days, respectively. Two deaths (0.6%) were reported. Of these deaths, one patient died of severe pancreatitis 48 hours after surgery, and the other died 1 month after surgery from multiorgan failure.

**Table 2. Investigation findings of acute pancreatitis following spinal surgeries.**

| Author, year | Biochemical investigations | Imaging | |
|--------------|---------------------------|---------|---|
|              | Hyperamylasemia, n (%)    | Hyperlipasemia, n (%) | Positive ultrasonography, n (%) | Positive CT, n (%) |
| Core studies |                           |         |   |
| Abousamra 2016 (1) | 3 (2%)                  | 147 (89%) | 10 (3.33%) | Not performed |
| Borkhuu 2009 (2)   | 6 (5.5%)                 | 34 (31.2%) | 37 (10.42%) | Not performed |
| Elbouyousfi 2016 (3) | NA                      | NA       | 2 (0.35%) | 9 (1.57%) |
| He 2004 (4)       | NA                       | NA       | 4 (23.52%) | Not performed |
| Laplaza 2002 (5)  | 12 (15%)                 | 12 (15%) | NA   | NA |
| Case studies      |                           |         |   |
| Ghisi 2018 (6)    | I                        | I        | Negative | I |
| Hewavitharane 2020 (7) | I                   | NA       | I   | I |
| Juricic 2017 (8)  | NA                       | I        | Not performed | I |
| Rajaraman 2000 (10) | I                      | I        | Not performed | I |
| Tauchi 2013 (11)  | I                        | NA       | Not performed | I |
| Korovessis 1996 (9) | I                      | NA       | I   | Not performed |

CT, computed tomography; NA, not available.
Table 3. Management, complications, and outcomes of acute pancreatitis following spinal surgeries.

| Author, Year | Management | Spinal surgery-related | Complications | Acute pancreatitis-related | Outcome |
|--------------|------------|------------------------|---------------|----------------------------|---------|
|              |            |                        | Local         | Acute systemic             | Mean postoperative ICU stay, days | Mean postoperative hospital stay, days | Mortality |
| **Core studies** |            |                        |               |                            |         |                      |           |
| Abousamra 2016 (1) | NA       |                        | None          | Postoperative septicemia    | 3       | 20                   | None      |
| Borkhuu 2009 (2) | NA       | Ascending paralysis    | Severe pancreatitis with pseudocyst formation | Hepatitis, hypotension, and coagulopathy attributable to severe hemorrhagic pancreatitis | NA     | 23.1     | Seven-year-old girl with severe quadriplegic pattern CP had an uneventful spine fusion but developed hemorrhagic pancreatitis 48 hours postoperatively and died |
| Elbouyousfi 2016 (3) | NA       | Pneumonia and surgical site infection | Peritonitis and phrenic abscess, abscess in the pouch of Douglas, multi-organ failure | Peritonitis, glucose intolerance needing insulin, peritonitis following peripancreatic effusion, shock with respiratory and neurological failure | 28.25   | 51       | None     |

(continued)
| Author, Year | Management | Spinal surgery-related | Complications | Outcome |
|--------------|------------|------------------------|---------------|---------|
| He 2004 (4)  | NA         | NA                     | Not mentioned | Sepsis  |
| Laplaza 2002 (5) | Non-operative management; symptomatic patients were treated with bowel rest, intravenous fluids, and fasting until clinical improvement was observed; two patients required total parenteral nutrition | NA | Abdominal pain, nausea, or vomiting | Mean postoperative ICU stay, days: NA, 28 | Mean postoperative hospital stay, days: NA, 9 | Mortality: None |
| Case studies | | | | |
| Hewawitharane 2020 (7) | Non-operative management | Intraoperative blood loss | None | 6 | 10 | None |
| Ghisi 2018 (6) | Non-operative management | Intraoperative blood loss | Asites | NA | 19 | None |
| Rajaraman 2000 (10) | Non-operative management | Intraoperative ileus | None | NA | 10 days | 21 | None |
| Tauchi 2013 (11) | Non-operative management | Intraoperative blood loss | Acute fluid collection | NA | 30 | None |
| Juricic 2017 (8) | Abdominal exploration confirmed pancreatic fracture; a jejunal lesion was resected with direct anastomosis; drains were placed around the pancreatic area | Pancreatic fracture with pancreatic ductal disruption | Pancreatic duct rupture, acute fluid collection, and ascites | NA | NA | One death after 6 months |
| Korovessis 1996 (9) | Non-operative management | Intraoperative blood loss | None | NA | NA | None |

ICU, intensive care unit; UTI, urinary tract infection; NA, not available; CP, chronic pancreatitis
attributable to complications of pancreatitis, including pancreatic duct rupture and leakage with pseudocyst formation and acute digestive peritonitis (Table 3).

**Discussion**

Acute pancreatitis occurring following spinal surgery can severely disrupt the postoperative course, leading to unexpected morbidity and mortality. It is associated with a relatively high mortality rate of 10% to 45% because of its potential to evolve into life-threatening systemic disease. Postoperative pancreatitis occurs following several surgeries, including both abdominal and extra-abdominal surgeries, although it occurs mostly following gastric and hepatobiliary surgery. However, few studies have described its occurrence following spinal surgery. To our knowledge, this is the first systematic review of the clinical characteristics and outcomes of acute pancreatitis following spinal surgery.

Overall, the evidence suggests that acute pancreatitis is an uncommon yet important postoperative complication following spinal surgery. The studies included in our review described 306 patients who developed AP postoperatively. The incidence of acute pancreatitis ranged from 0.2% to 7.4% in the published studies.

The exact cause for postoperative pancreatitis has not been identified, although several mechanisms have been postulated. A study by Curtin et al. found that suboptimal positioning during surgery causing trauma to the pancreas might be a contributing factor. Korovessis et al. identified a prolonged surgical time and the receipt of hypotensive anesthesia, which can cause ischemic injury in the pancreas, as potential causes of acute pancreatitis. A study by Leichtner et al. found that intraoperative blood was significantly higher in patients who developed postoperative pancreatitis than in their counterparts. However, this study failed to demonstrate a relationship with hypotension. Although medications are well-known causes of acute pancreatitis, its true incidence is low, ranging from 0.1% to 2%. Direct trauma in the abdominal region has been found to play a role in the development of acute pancreatitis following gastric and hepatobiliary surgery. However, causes such as perioperative hypotension and reduced cardiac output were identified as major risk factors for postoperative acute pancreatitis in surgeries performed in non-abdominal regions. A study by Rajaraman et al. on acute pancreatitis following anterior lumbar interbody fusion concluded that significant blood loss, the use of hypotensive anesthesia, and an anterior spinal approach should make surgeons take extra caution and stay vigilant concerning a possibility of acute pancreatitis, especially when patients develop prolonged postoperative ileus. Several common risk factors for developing acute pancreatitis were identified in the current review. A prolonged fasting time (13.6%), intraoperative blood loss (9.1%), gastroesophageal reflux disease (9.1%), age >14 years (9.1%), low BMI (9.1%), and an anterior or combined approach (9.1%) were the most common risk factors, whereas the duration of surgery, total parenteral nutrition, feeding difficulty, reactive airway disease, increased TNF alpha levels, urine trypsin-associated peptide levels, male sex, gastrointestinal tube placement, reactive airway disease, anemia, and the duration of surgery were also associated with acute pancreatitis, albeit in fewer patients.

A study by El Bouyousfi et al. on acute pancreatitis following scoliosis surgery revealed that pancreatitis occurred in the first 10 days after surgery, in line with the present study, in which symptoms appeared a mean of 6.2 days after surgery. Furthermore, they concluded that abdominal pain in postoperative acute pancreatitis was less typical and less frequent in
comparison to that caused attributable to other common etiologies including alcohol or gallstones. However, symptoms such as nausea, prolonged ileus, and vomiting were more common in acute pancreatitis following surgery, possibly caused by the combined effect of acute pancreatitis and surgery itself. Among patients receiving systemic opioids after surgery, prolonged ileus beyond 48 to 72 hours after surgery suggests the possibility of pancreatitis because these symptoms typically should regress within 48 to 72 hours. Although the most common symptoms identified in the current review were abdominal pain, nausea and vomiting, and abdominal distention, other symptoms including food intolerance, prolonged ileus, and reduced bowel sounds were described in a minority of patients. It is often difficult to link postoperative fever to acute pancreatitis because postoperative inflammation and infection must be excluded before seeking an alternative diagnosis, including acute pancreatitis.

Biochemical testing for serum lipase and amylase is performed to establish a diagnosis of acute pancreatitis, with serum lipase being superior to serum amylase, even in the postoperative setting. In the present review, only 65% of patients displayed elevated serum lipase levels. Early imaging is unlikely to be useful in patients with typical clinical features of acute pancreatitis, even with supportive abnormal biochemistry to establish a positive diagnosis, in the postoperative setting. Abdominal ultrasonography has proven to be of little benefit in the diagnosis of acute pancreatitis in adults; thus, CT is the most commonly used imaging modality in adults. The drawbacks of abdominal ultrasound include its operator-dependent nature and poor visualization attributable to interposition of the hollow viscera, leading to a higher rate of false negatives that is more pronounced in patients who underwent abdominal surgery.

In the present review, 81.3% (61/75) of patients underwent abdominal ultrasound, and the remaining patients (18.6%, n = 14) underwent CT.

Postoperative acute pancreatitis is associated with a high mortality rate, reaching 12% to 13%, and approximately 27% and 53% of patients develop severe pancreatitis and other major complications associated with pancreatitis, respectively. The mortality rate of patients in the present study was 0.7%, which was considerably lower than the rates reported in the literature. However, complications such as sepsis were relatively more common (28.5%). Only 6.2% of patients in the present review developed severe pancreatitis, which was a much lower rate than those described in the literature for postoperative acute pancreatitis. Other complications of pancreatitis including pancreatic pseudocyst formation, pancreatic ascites, and fluid collection were found in a minority (6.2%) of patients.

There were several limitations in the present review. The main limitation was that the patient populations, clinical characteristics, types of spinal surgery, and outcomes varied widely across the included studies. Furthermore, there was considerable variability in the quality of studies because most studies were cohort studies and there were no published randomized control trials providing high-quality evidence. However, the risk of bias of the selected studies was minimal.

Conclusions

Although uncommon, acute pancreatitis remains an important postoperative complication of spinal surgery because of its associated morbidity and mortality. Avoiding major risk factors including prolonged fasting and minimizing intraoperative blood loss can help to reduce the incidence of acute pancreatitis in patients
undergoing spinal surgery. Delays in diagnosis because of masked symptoms in patients after spinal surgery remain a challenge. A high index of suspicion and a low threshold for both biochemical and radiological investigations could facilitate an earlier diagnosis and thereby minimize both short- and long-term complications.

**Author contributions**

UJ and SS conceived the research idea. RJ, SR, CK, and UJ were involved in data curation, analysis, investigation, methodology, and initial draft writing. CK was involved in the formal academic literature search and methodology. SS was the senior author and supervisor, and he revised the final manuscript. All authors have read and agreed to the published version of the manuscript.

**Data availability statement**

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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**Declaration of conflicting interest**

All authors declare that there is no conflict of interest.

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**Supplemental files**

S1: PRISMA flowchart

Table S1: Risk of bias analysis of the included studies

S2: PRISMA checklist

**References**

1. Ponka J, Landrum S and Chaikof L. Acute pancreatitis in the postoperative patient. *Arch Surg* 1961; 83: 475–490.
2. White TT, Morgan A and Hopton D. Postoperative pancreatitis: a study of seventy cases. *Am J Surg* 1970; 120: 132–137.
3. Haas GS, Warshaw AL, Daggett WM, et al. Acute pancreatitis after cardiopulmonary bypass. *Am J Surg* 1985; 149: 508–515.
4. Reeve TS and Delbridge LW. Pancreatitis following parathyroid surgery. *Ann Surg* 1982; 195: 158.
5. Levine SR, Gambill EE and Greene LF. Acute pancreatitis following transurethral prostatic resection: report of six cases. *J Urol* 1962; 88: 657–663.
6. Bragg LE, Thompson JS, Bumett DA, et al. Increased incidence of pancreas-related complications in patients with postoperative pancreatitis. *Am J Surg* 1985; 150: 694–697.
7. Dervenis C, Johnson CD, Bassi C, et al. Diagnosis, objective assessment of severity, and management of acute pancreatitis. *Int J Pancreatol* 1999; 25: 195–210.
8. Feng F, Tan H, Li X, et al. Incidence and Risk Factors of Acute Pancreatitis After Scoliosis Surgery. *Spine* 2018; 43: 630–636.
9. Banks PA, Bollen TL, Dervenis C, et al. Classification of acute pancreatitis—2012: revision of the Atlanta classification and definitions by international consensus. *Gut* 2013; 62: 102–111.
10. Laplaza FJ, Widmann RF, Fealy S, et al. Pancreatitis after surgery in adolescent idiopathic scoliosis: incidence and risk factors. *J Pediatr Orthop* 2002; 22: 80–83.
11. Debi U, Kaur R, Prasad KK, et al. Pancreatic trauma: a concise review. *World J Gastroenterol* 2013; 19: 9003–9011.
12. Page MJ, Moher D, Bossuyt PM, et al. PRISMA 2020 explanation and elaboration: updated guidance and exemplars for reporting systematic reviews. *BMJ* 2021; 372: n160.
13. Downs SH and Black N. The feasibility of creating a checklist for the assessment of the methodological quality both of randomised and non-randomised studies of health care interventions. *J Epidemiol Community Health* 1998; 52: 377–384.
14. Abousamra O, Nishnianidze T, Rogers KJ, et al. Risk factors for pancreatitis after posterior spinal fusion in children with cerebral palsy. *J Pediatr Orthop B* 2018; 27: 163–167.

15. Borkhuu B, Nagaraju D, Miller F, et al. Prevalence and risk factors in postoperative pancreatitis after spine fusion in patients with cerebral palsy. *J Pediatr Orthop* 2009; 29: 256–262.

16. El Bouyousfi M, Leveque C, Miladi L, et al. Acute pancreatitis following scoliosis surgery: description and clinical course in 14 adolescents. *Eur Spine J* 2016; 25: 3316–3323.

17. He Z, Tonb DJ, Dabney KW, et al. Cytokine release, pancreatic injury, and risk of acute pancreatitis after spinal fusion surgery. *Dig Dis Sci* 2004; 49: 143–149.

18. Kobayashi K, Imagama S, Ito Z, et al. Hyperamylasemia and pancreatitis following posterior spinal surgery. *J Orthop Sci* 2015; 20: 967–972.

19. Nishnianidze T, Bayhan IA, Abousamra O, et al. Factors predicting postoperative complications following spinal fusions in children with cerebral palsy scoliosis. *Eur Spine J* 2016; 25: 627–634.

20. De la Garza Ramos R, Goodwin CR, Abu-Bonsrah N, et al. Patient and operative factors associated with complications following adolescent idiopathic scoliosis surgery: an analysis of 36,335 patients from the Nationwide Inpatient Sample. *J Neurosurg Pediatr* 2016; 18: 730–736.

21. Bendon AA, George KA and Patel D. Perioperative complications and outcomes in children with cerebral palsy undergoing scoliosis surgery. *Paediatr Anaesth* 2016; 26: 970–975.

22. Tsirikos AI, Lipton G, Chang WN, et al. Surgical correction of scoliosis in pediatric patients with cerebral palsy using the unit rod instrumentation. *Spine* 2008; 33: 1133–1140.

23. Leichtner A, Banta J, Etienne N, et al. Pancreatitis following scoliosis surgery in children and young adults. *J Pediatr Orthop* 1991; 11: 594–598.

24. Hewavitharane CG and Jayathilaka S. A rare case of pancreatitis following scoliosis correction. *Sri Lankan Journal of Anaesthesiology* 2020; 28:45–47.

25. Farley FA and Caird MS. Pancreatitis after posterior spinal fusion for adolescent idiopathic scoliosis. *J Spinal Disord* 2001; 14: 268–270.

26. Ghisi D, Ricci A, Giannone S, et al. Acute pancreatitis after major spine surgery: a case report and literature review. *Scoliosis Spinal Disord* 2018; 13: 24.

27. Rajaraman V, Heary RF and Livingston DH. Acute pancreatitis complicating anterior or lumbar interbody fusion. *Eur Spine J* 2000; 9: 171–173.

28. Tauchi R, Imagama S, Ito Z, et al. Acute pancreatitis after spine surgery: a case report and review of literature. *Eur J Orthop Surg Traumatol* 2014; 24: S305–S309.

29. Juricic M, Pinnagoda K, Lakhal W, et al. Pancreatic fracture: a rare complication following scoliosis surgery. *Eur Spine J* 2018; 27: 2095–2099.

30. Korovessis PG, Stamatakis M and Baikousis A. Relapsing pancreatitis after combined anterior and posterior instrumentation for neuropathic scoliosis. *J Spinal Disord* 1996; 9: 347–350.

31. Fernández-del Castillo C, Harringer W, Warshaw AL, et al. Risk factors for pancreatic cellular injury after cardiopulmonary bypass. *N Engl J Med* 1991; 325: 382–387.

32. Steinberg WTS. Acute pancreatitis. *The New England journal of medicine* 1994; 330: 1198–1210.

33. Curtin WA, Lahoti OP, Fogarty EE, et al. Pancreatitis after alar-transverse fusion for spondylolysisis. A case report. *Clin Orthop Relat Res* 1993: 142–143.

34. Lankisch P, Dröge M and Gottesleben F. Drug induced acute pancreatitis: incidence and severity. *Gut* 1995; 37: 565–567.

35. Nitsche CJ, Jamieson N, Lerch MM, et al. Drug induced pancreatitis. *Best Pract Res Clin Gastroenterol* 2010; 24: 143–155.

36. Malka D and Rosa-Hezode I. Positive and etiological diagnosis of acute pancreatitis. *Gastroenterol Clin Biol* 2001; 25: 1S153–1S168.

37. Yeung CY, Lee HC, Huang FY, et al. Pancreatitis in children—experience with 43 cases. *Eur J Pediatr* 1996; 155: 458–463.
38. Bai HX, Lowe ME and Husain SZ. What have we learned about acute pancreatitis in children? *J Pediatr Gastroenterol Nutr* 2011; 52: 262–270.

39. De Gastro-Entérologie SNF. Consensus conference: acute pancreatitis. *Gastroenterol Clin Biol* 2001; 25: 177–192.

40. Park AJ, Latif SU, Ahmad MU, et al. A comparison of presentation and management trends in acute pancreatitis between infants/toddlers and older children. *J Pediatr Gastroenterol Nutr* 2010; 51: 167–170.