Case Report

Successful treatment with decompressive laparotomy for abdominal compartment syndrome induced by asparaginase-associated pancreatitis in a pediatric patient with acute lymphoblastic leukemia: a case report

Huiwen Zhang^, Weifeng Lu^

Department of Surgical Intensive Care Unit, Children's Hospital of Nanjing Medical University, Nanjing, China

Contributions: (I) Conception and design: W Lu; (II) Administrative support: Both authors; (III) Provision of study materials or patients: H Zhang; (IV) Collection and assembly of data: H Zhang; (V) Data analysis and interpretation: H Zhang; (VI) Manuscript writing: Both authors; (VII) Final approval of manuscript: Both authors.

Correspondence to: Weifeng Lu, MBBS. Department of Surgical Intensive Care Unit, Children's Hospital of Nanjing Medical University, No. 72 Guangzhou Road, Nanjing 210008, China. Email: luweifengmm@163.com.

Background: Asparaginase (ASP) has significantly improved the complete remission rate and long-term event-free survival in children with acute lymphoblastic leukemia (ALL). Asparaginase-associated pancreatitis (AAP) is a potentially toxic side effect of ASP, which may even lead to fatal abdominal compartment syndrome (ACS) in extreme cases. Currently, there is no consensus on the indications for decompressive laparotomy (DL), including when to initiate it, what criteria to use for decision-making, or how to perform the procedure. Moreover, available research data remain limited.

Case Description: We present a case of a 2-year-old boy with ALL who developed ACS, a fatal complication of severe acute pancreatitis (SAP) following treatment with pegaspargase (PEG-ASP). Massive transfusion stabilized his hemodynamics and intraluminal contents were evacuated, yet his symptoms progressed. Consequently, the patient underwent DL and continuous venovenous hemodiafiltration (CVVHDF) with ultrafiltration. Postoperative complications including enteroatmospheric fistulas and abdominal abscesses were gradually corrected by negative-pressure wound therapy (NPWT). The boy was discharged from the intensive care unit (ICU) on the 93rd day after hospital admission. During follow-up, the child's abdominal symptoms gradually improved, and bridging therapy with blinatumomab was administered.

Conclusions: In this case, a pediatric ALL patient developed life-threatening complications following PEG-ASP administration, which were ultimately successfully managed through multidisciplinary intervention. When pediatric hematology-oncology patients develop ACS, clinicians should carefully evaluate the oncological context and thoroughly assess the risks of surgical versus conservative management for this potentially fatal condition. Optimal timing of surgical intervention combined with advanced perioperative care is critical for achieving favorable outcomes. We strongly recommend conducting high-quality clinical research to establish evidence-based treatment guidelines.

Keywords: Acute lymphoblastic leukemia (ALL); asparaginase-associated pancreatitis (AAP); abdominal compartment syndrome (ACS); decompressive laparotomy (DL); case report

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^ ORCID: Huiwen Zhang, 0000-0002-8993-8841; Weifeng Lu, 0000-0002-8510-4348.

Introduction

Acute lymphoblastic leukemia (ALL) (1) is a malignant disease caused by abnormal clonal proliferation of precursor B, T, or mature B lymphocytes. It is highly prevalent in the pediatric population, accounting for 76% of leukemias in children under 15 years of age and for 35% of all childhood malignancies. Pegaspargase (PEG-ASP) is a first-line drug for pediatric cases of ALL. Asparaginase-associated pancreatitis (AAP) is a kind of drug-induced pancreatitis (DIP), a well-known local complication of ALL patients who receiving asparaginase (ASP) characterized by abdominal pain, elevated pancreatic enzymes, and/or characteristic imaging findings with high morbidity rates (2–10%), yet low mortality (2).

Though there are numerous reports on cases of AAP currently available, complications of severe acute pancreatitis (SAP) in ALL pediatric patients are relatively uncommon, let alone fatal secondary abdominal compartment syndrome (ACS) complications. ACS is defined as a new onset of organ failure induced by sustained elevated intra-abdominal pressure (IAP). In SAP, the incidence of intra-abdominal hypertension (IAH) and ACS is approximately 40% and 10%, respectively. ACS is a life-threatening condition associated with a mortality rate exceeding 50% (3).

This case presents the first documented successful treatment of an ALL pediatric patient developing fulminant and fatal ACS after receiving PEG-ASP. The therapeutic approach employed emergency decompressive laparotomy (DL) following the failure of medical management; continuous venovenous hemodiafiltration (CVVHDF) to stabilize hemodynamics; negative-pressure drainage to manage postoperative, complications followed by bridge therapy with blinatumomab to replace chemotherapy. The patient exhibited sustained disease control, enhanced treatment adherence, and no significant adverse events, which were notably superior to the outcomes observed with chemotherapy. This case aims to summarize the experience of diagnosis and treatment of extremely critical adverse drug reactions of PEG-ASP. We present this case in accordance with the CARE reporting checklist (available at https://tp.amegroups.com/article/view/10.21037/tp-24-440/rc).

Highlight box

Key findings

- Pediatric acute lymphoblastic leukemia (ALL) patients may develop life-threatening abdominal compartment syndrome (ACS) secondary to asparaginase-associated pancreatitis (AAP) following pegaspargase (PEG-ASP) administration, with concurrent persistent inflammation-immunosuppression and catabolism syndrome (PICS) during the disease course.
- Timely decompressive laparotomy (DL) combined with negative pressure wound therapy effectively halts ACS progression and manages postoperative complications.
- The management of fatal complications in pediatric hematologic malignancies requires a multidisciplinary approach and demonstrates the healthcare facility's advanced clinical capabilities.

What is known and what is new?

- AAP is a recognized complication of asparaginase therapy, but progression to life-threatening ACS remains rare. ACS carries high mortality, and surgical decompression remains controversial, particularly in pediatric populations.
- This represents the first documented case of successful DL for ACS secondary to AAP in a pediatric ALL patient.

What is the implication, and what should change now?

- Early recognition of ACS and timely surgical intervention, combined with comprehensive perioperative care, are critical for pediatric oncology patients. PICS should be considered as a potential contributor to disease progression in severe cases.
- Clinicians should maintain heightened vigilance for ACS in pediatric ALL patients with AAP. High-quality research is needed to establish evidence-based guidelines for DL timing, criteria, and perioperative management in this population. Multidisciplinary collaboration and standardized monitoring protocols should be prioritized to optimize outcomes.

Case presentation

A male patient, aged 2 years and 11 months, with no past medical history, was admitted to Pediatric Hematology, Oncology and Transplantology Department of a Grade A tertiary hospital on July 10, 2024, with a 1-month history of pallor and generalized weakness. He was diagnosed with B-cell acute lymphoblastic leukemia (B-ALL) on the basis of a series of workups, including bone marrow cytomorphology, immunophenotyping, cytogenetics, and molecular genetics. Induction therapy was initiated on July 13 per the revised Chinese Children's Cancer Group (CCCG-ALL-2020) low-risk protocol with administration of 1,140 IU (2,500 IU/m^2) PEG-ASP on July 18.

On day 14 post-PEG-ASP administration (August 1), the patient developed epigastric pain with persistent vomiting and pre-existing constipation since the previous day. Abdominal examination revealed mild distension without muscular guarding or rigidity. Laboratory findings including elevated pancreatic enzymes in both blood (lipase 965 U/L, amylase 659 U/L), urine (trypsin positive, amylase 3,494 U/L) and elevated triglycerides (8.63 mmol/L) suggested acute pancreatitis

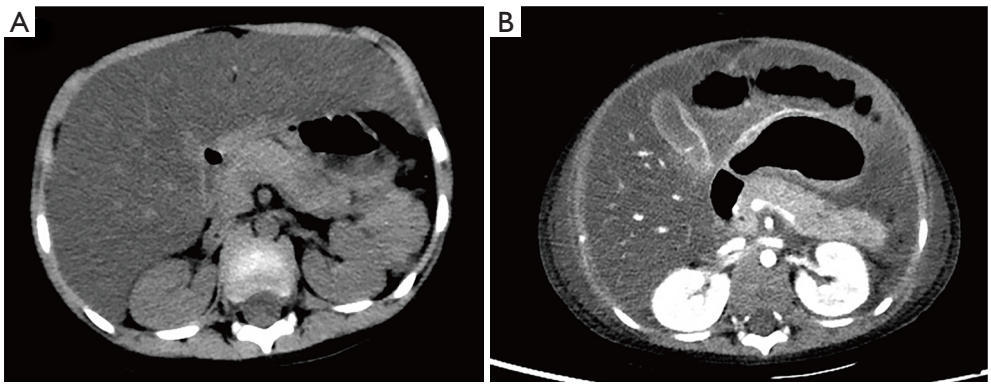

Figure 1 Abdominal CT scan of an ALL boy suffering from AAP. (A) Plain CT scan performed on August 1 revealed a mildly hypodense area in the pancreatic tail without focal swelling. (B) Contrast-enhanced CT scan performed on August 9 showed multiple hypodense areas consistent with necrotizing pancreatitis (poorly demarcated), accompanied by peritoneal and pleural effusions. AAP, asparaginase-associated pancreatitis; ALL, acute lymphoblastic leukemia; CT, computed tomography.

(AP), which was validated by an abdominal computed tomography (CT) scan revealed a mildly hypointense area in the pancreatic tail without increased volume associated with hepatic hypodensity and thickening of the gallbladder wall (*Figure 1A*). The diagnosis of AAP was established based on Atlanta criteria for adults, including: (I) characteristic abdominal symptoms; (II) a serum amylase and/or lipase level at least 3 times the upper normal limit; and (III) abdominal imaging features consistent with AP (3). Immediate treatment, which included fasting, fluid resuscitation, broad-spectrum empirical antibiotics (imipenem), and the inhibition of pancreatic enzyme secretion (octreotide), was initiated.

On August 2, due to progressive shock manifestations (persistent fever, tachycardia, tachypnea, and refractory hypotension) despite ongoing treatment, the patient was transferred to intensive care unit (ICU). Physical examination revealed lethargy, pallor, marked abdominal distension with diffuse tenderness, and hyperactive bowel sounds. Characteristic hemorrhagic signs were observed, including both Grey Turner sign and Cullen sign, presenting as blue petechiae on the right side of the abdominal wall on August 9, an abdominal contrast-enhanced CT scan performed (*Figure 1B*) revealed multiple hypodense foci consistent with necrotizing pancreatitis (NP) and plasmacytoid fluid accumulations as well as significant thoraco-abdominopelvic effusions. Comparative analysis revealed progressive hepatic steatosis (mean attenuation –26 Hounsfield units) and worsening pancreatic necrosis compared to prior imaging.

Despite aggressive fluid resuscitation and symptomatic treatment, the patient developed clinical deterioration manifested by refractory hypotension, escalating serum lactate levels and progressive ACS features. The patient was diagnosed with ACS on the basis of IAP of 35 mmHg measured indirectly via the intravesical route according to the 2013 World Society of Abdominal Compartment Syndrome (WSACS) (4). The patient met the diagnostic criteria for persistent inflammation-immunosuppression and catabolism syndrome (PICS): (I) prolonged ICU stay (>10 days) and hospitalization duration (30 days); (II) C-reactive protein (CRP) concentration of >20 mg/L; (III) lymphopenia (total lymphocyte count 0.73×10^9/L); (IV) serum albumin concentration of 26.8 g/L, prealbumin concentration of 0.07 g/L, retinol-binding protein concentration of 16.11 mg/L, >10% weight loss and admission body mass index (BMI) <18 kg/m^2.

IAP remained persistently elevated and abnormally high (>25 mmHg), precipitating hemodynamic instability requiring vasopressor support. The patient underwent DL on post-ICU day 11 following multidisciplinary consensus. DL was performed through a 12-cm vertical midline incision extending from the xiphoid process to the suprapubic region, incorporating full-thickness division of the skin, fascia, and peritoneum. Intraoperative exploration revealed abnormal edema of the intestines, a necrotic focus, and a large amount of brown fluid from a bluntly detached necrotic focus in the tail of the pancreas. Due to the combination of massive bowel edema (circumferential increase >50%) and loss of abdominal wall

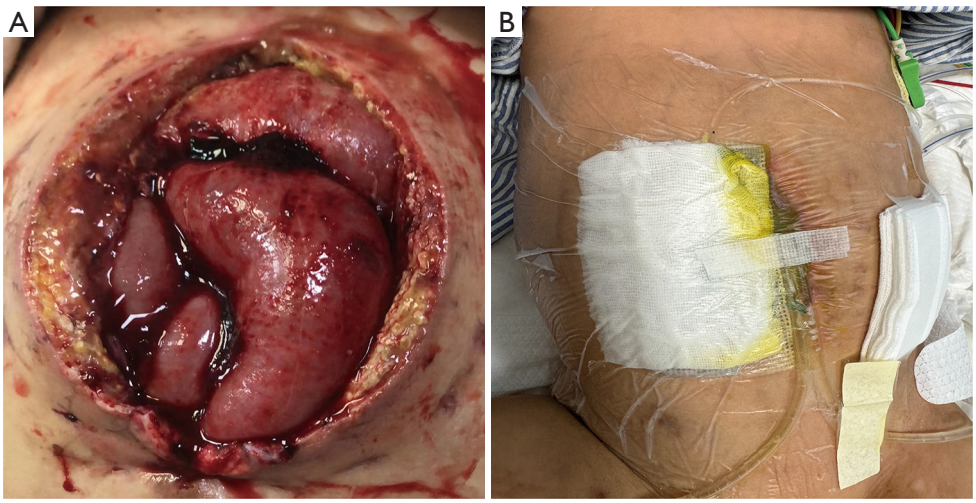

Figure 2 Abdominal appearance following DL. (A) Delayed abdominal closure due to severe postoperative bowel edema. (B) NPWT management of open abdomen using a customized VSD device with low-pressure suction. DL, decompressive laparotomy; NPWT, negative-pressure wound therapy; VSD, vacuum sealing drainage.

compliance, the decision was made for delayed closure with temporary abdominal containment (*Figure 2A*). Postoperative management incorporated CVVHDF to primarily maintain hemodynamic stability and metabolic equilibrium, while secondarily mitigating systemic inflammatory responses through cytokine clearance. Successful weaning from mechanical ventilation was achieved on postoperative day (POD) 6, with completion of the planned hemodiafiltration course by POD 9. The open abdomen was managed with negative-pressure wound therapy (NPWT) using a customized vacuum sealing drainage (VSD) device (*Figure 2B*), with delayed primary closure planned for subsequent phase. On POD 9, an enteroatmospheric fistula was found in the exposed intestinal wall at the abdominal wall incision and was treated with localized irrigation and suction at a low negative pressure. The next day, enteral nutrition through a jejunal tube was initiated and was well tolerated. By POD 20, the patient developed recurrent fever, progressive abdominal distension, leukocytosis, and elevated CRP level (*Table 1*). The results of bacterial culture of ascites and pus from peritoneal puncture were positive for Klebsiella pneumoniae subspecies. The anti-infective regimen was therefore adjusted according to the results of the pathogenetic drug susceptibility tests (linezolid, cefoperazone, and sulfadiazine). Abdominal magnetic resonance imaging (MRI) demonstrated left retroperitoneal liquefactive necrosis with infected pancreatic pseudocyst formation (*Figure 3*). On September 20, surgical debridement of necrotic pancreatic tissue and drainage of the retroperitoneal abscess were performed under general anesthesia, achieving source control.

After a 3-month ICU stay, the child was transferred to the hematology ward. Under the guidance of the general surgery and clinical nutrition departments, the pediatric patient initiated enteral nutrition via a nasojejunal feeding tube while commencing subsequent therapy for ALL. With hematology-oncology specialist supervision, blinatumomab (Blincyto®) was administered as an alternative to chemotherapy starting October 24, 2024, followed by inotuzumab ozogamicin (Besponsa®) therapy on February 10, 2025 (*Figure 4*). Recent follow-up revealed marrow differential report (MDR) remission and absence of severe adverse events.

All procedures performed in this study were in accordance with the Declaration of Helsinki and its subsequent amendments. The study was approved by the Ethics Committee of Children's Hospital of Nanjing Medical University (ethics approval No. 202411009-1). Written informed consent was obtained from the patient's parents for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

Discussion

Asparagine is an amino acid needed for cell growth and

Table 1 Laboratory values trend on operation

Variable	Pre-op 7 d	DOS	Post-op 14 d	Post-op 20 d
Hematology				
CRP (mg/L)	47.83	38.76	9.19	66.34
Total lymphocyte count (10^9/L)	0.73	0.77	2.38	2.49
Biochemistry				
Lipase (IU/L)	956	62	34	–
Pancreatic amylase (IU/L)	659	36	50	155
Lactate (mmol/L)	3.16	1.78	1.22	1.58
Albumin (g/L)	26.8	30.8	36.1	43.6
Prealbumin (g/L)	0.2	0.09	0.08	0.21
Retinol binding protein (mg/L)	75	16.11	22.22	55.85
ALT (IU/L)	44	23	10	61
AST (IU/L)	56	132	43	69
Creatinine (μmol/L)	26.3	21	19	30
Total bilirubin (μmol/L)	14.81	19.6	20.9	36.9
Direct bilirubin (μmol/L)	3.52	14.3	18.9	30.9
Potassium (mmol/L)	4.11	3.11	3.73	4.63
Sodium (mmol/L)	137	153.7	140.4	136.6
Chloride (mmol/L)	97.8	109.4	99.3	98.3
Calcium (mmol/L)	2.29	2.15	2.1	2.47
Magnesium (mmol/L)	1.09	0.71	0.81	0.77
Triglyceride (mmol/L)	8.63	2.55	2.11	2.32
Total cholesterol (mmol/L)	8.17	1.85	2.07	3.35
Coagulation status				
PT (sec)	20	12.9	14	12.1
PT-INR	1.74	1.11	1.21	1.04
APTT (sec)	53.7	39.2	35.1	35.7
Fibrinogen (g/L)	0.93	2.67	2.82	3.59
TT (sec)	24.9	13.6	13.8	12.9
D-dimer (ng/mL)	2,491	355	3,071	921
FDP (μg/mL)	52.45	3.18	20.66	7.69

ALT, alanine aminotransferase; APTT, activated partial thromboplastin time; AST, aspartate aminotransferase; CRP, C-reactive protein; DOS, day of surgery; FDP, fibrin degradation product; Post-op 14 d, postoperative day 14; Post-op 20 d, postoperative day 20; Pre-op 7 d, preoperative day 7; PT, prothrombin time; PT-INR, prothrombin time-international normalized ratio; TT, thromboplastin time.

proliferation, normal cells can synthesize it through their own asparagine enzyme, but leukemia cells with low activity of the enzyme can only take it up exogenously; using the feature of depleting aspartic acid in the body, leukemia cells are blocked from taking up asparagine, and ASP exerts specific anti-tumor effects (5). The Nordic Society of Pediatric Hematology and Oncology (NOPHO) ALL 2008 protocol reported a 5.7–10.0% incidence of AAP in children and adolescents with ALL (6). The incidence and mortality of AAP caused by ASP vary significantly across healthcare institutions, regimens, and chemotherapy protocols. The incidence of AAP in ALL patients treated

with ASP was reported as 2–18% (7) while 3% (24/796) with imiglucerase (8).

IAH is a critical pathophysiological factor contributing to *de novo* organ failure in SAP patients. The condition progresses relentlessly to ACS, characterized by persistently elevated IAP exceeding 20 mmHg, accompanied by at least one newly developed organ dysfunction. Approximately 4–27% of patients with SAP develop ACS. In patients with elevated IAP, the development of multiple organ dysfunction syndrome (MODS) and systemic inflammatory response significantly increases mortality (9).

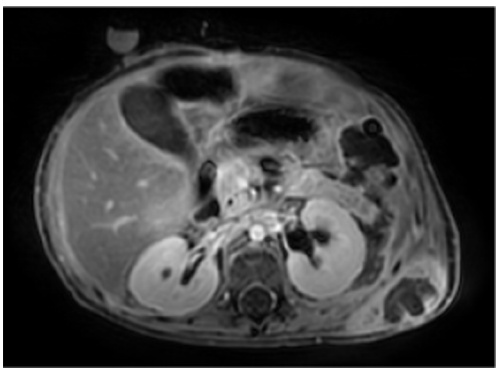

Figure 3 MRI of the abdomen suggested liquefaction and necrosis of the left retroperitoneal tissue with infection and the formation of a small pseudocyst in the body of the pancreas. MRI, magnetic resonance imaging.

A literature search revealed only two studies documenting the occurrence of the potentially lethal complication of ACS in ALL patients to date. An 11-year-old boy with ALL secondary to ACS died due to severe lactic acidosis (10). Moreover, a 54-year-old male with ALL and ACS was successfully treated by abdominal DL after failure of standard therapy with antibiotics, fluid resuscitation, and vasopressors (11). Despite documented cases of successful treatment, certain difficulties persist.

Firstly, by rapidly lowering IAP, urgent surgical DL is an effective and life-saving treatment for ACS, especially in those patients with refractory ACS. Based on the guideline recommendations of the 2013 consensus management guidelines (4) of the Abdominal Compartment Society on IAH and ACS, we took surgical decompression for this ALL boy who was refractory to medical management and percutaneous drainage of intra-abdominal collections. A particularly significant aspect of this case study lies in the paucity of reported cases involving surgical decompression for acute pancreatitis-associated ACS (12,13), with particularly limited reference data available for pediatric populations. To our knowledge, this represents the first documented case of successful surgical decompression in a pediatric patient with this condition. Current evidence regarding pediatric ACS management is still nascent, lacking unified clinical guidelines, expert consensus recommendations, or robust research evidence to inform practice.

Next, decompressive intervention was found to be related

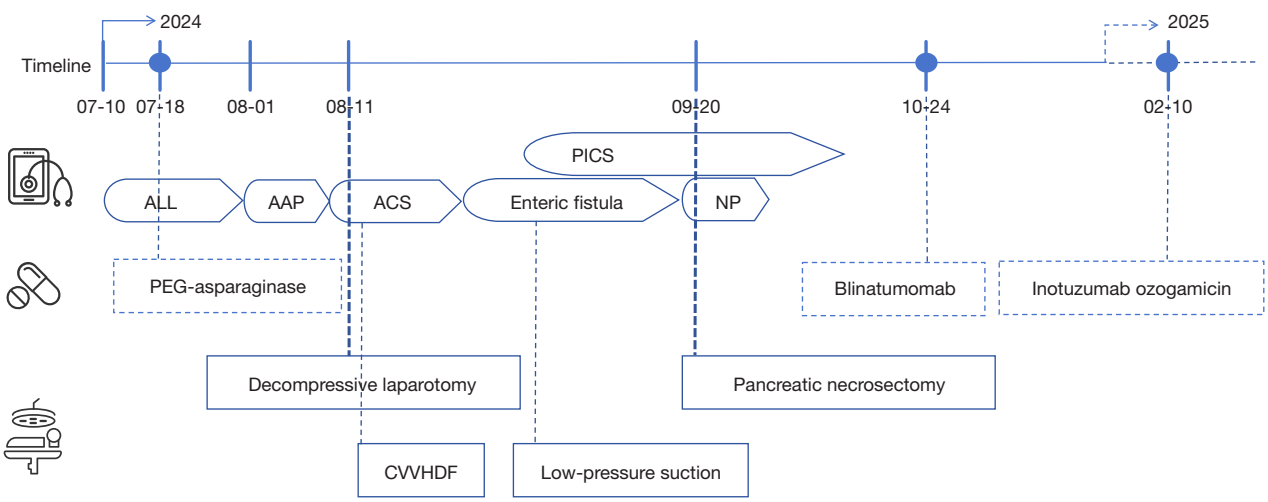

Figure 4 Timeline figure to depict the whole progression, treatment and major events of this case. AAP, asparaginase-associated pancreatitis; ACS, abdominal compartment syndrome; ALL, acute lymphoblastic leukemia; CVVHDF, continuous venovenous hemodiafiltration; NP, necrotizing pancreatitis; PICS, persistent inflammation-immunosuppression and catabolism syndrome.

to reduced mortality (9,14). Despite these recommendations, the guidelines also recognize the significant morbidity associated with open abdomen management, including complications like frozen abdomen and enterocutaneous fistula formation. Current evidence demonstrates that NPWT for open abdomen management may directly contribute to the development of entero-atmospheric fistulas and intra-abdominal abscesses, while simultaneously delaying early fascial closure. A clinical investigation revealed that the presence of entero-atmospheric fistulae in open abdomen cases elevates mortality rates from 6% to 14% (15,16). In a meta-analysis, the mortality rates were 49.7% and 60.8% for adults and children, respectively, who underwent DL (17). As the effectiveness of DL for ACS has not been established, its indications remain debated. To objectively evaluate the efficacy of DL versus percutaneous catheter drainage in ACS patients with SAP, the multicenter randomized controlled DECOMPRESS trial was initiated. However, as of the latest update, no results have been published on the study's official platform (18). These findings underscore the need for clinicians to maintain a balanced perspective regarding the therapeutic efficacy of DL, carefully weighing its benefits against potential complications.

Furthermore, the current evidence base remains insufficient to establish consensus on three critical aspects of surgical decompression: (I) definitive IAP thresholds; (II) optimal intervention timing; and (III) standardized technical criteria for procedure initiation. Mentula *et al.* demonstrated that early surgical decompression performed within 4 days of diagnosis for patients with IAP >25 mmHg significantly reduced mortality rates (18% *vs.* 46%) (14). Vieille and colleagues proposed that clinicians should consider DL even when IAP falls below this threshold, as non-occlusive mesenteric ischemia (NOMI) may still occur. Their research team reported a 16.7% mortality rate among 18 patients with an ACS complicating SAP who underwent DL (19).

In the present case, surgical intervention was actively pursued based on the following clinical indicators despite the absence of direct IAP measurements exceeding 25 mmHg: documented impairment in oxygenation and ventilation, hemodynamic instability and clinical evidence suggesting reduced abdominal perfusion pressure. This decision was consistent with current clinical practice guidelines that emphasize comprehensive evaluation of physiological parameters beyond absolute IAP thresholds when managing ACS, particularly in pediatric cases where compensatory mechanisms may mask conventional diagnostic criteria. The characteristic that a more compliant abdominal wall of infants and children may better compensate for increased abdominal tension, delaying timely diagnosis of ACS, increases difficulty in therapy, and may therefore contribute to the still unacceptably high mortality of ACS in children.

Finally, in the two aforementioned case reports describing ALL complicated by ACS, the authors explored potential pathophysiological mechanisms involving the insulin-like growth factor (IGF)/IGF-binding protein (IGFBP) system and *Clostridioides difficile* infection identified through fecal culture as possible triggers for rapid disease progression. We hypothesize that PICS may serve as an underlying driver for the progression from SAP to ACS. The PICS concept, first proposed as an evolution of the systemic inflammatory response syndrome-compensatory anti-inflammatory response syndrome-mixed antagonist response syndrome continuum (SIRS-CARS-MARS), manifests in patients with chronic critical illness (CCI) following trauma, sepsis, or other major insults. These patients demonstrate persistent inflammation, profound immunosuppression, and metabolic disturbances, leading to clinical manifestations such as recurrent infections, malnutrition, and impaired wound healing (20-23). A retrospective study of 214 adult SAP patients revealed a PICS prevalence of 69.6% (149/214), with the PICS cohort showing significantly prolonged ICU length of stay (LOS) and higher post-discharge mortality. An exploratory study analyzing 153 pediatric ICU patients using adult diagnostic criteria similarly confirmed PICS characteristics in critically ill children and established correlations with hospital LOS and duration of mechanical ventilation (23).

In our case, PICS consideration not only facilitated disease severity assessment but also highlighted the need for immunomodulatory support and multimodal interventions to address nutritional and metabolic derangements. The treatment protocol developed through multidisciplinary consultation with critical care specialists demonstrated marked efficacy in this patient. We therefore recommend PICS evaluation for AAP patients to mitigate mortality risk and improve long-term quality of life.

Conclusions

While the reported rate of fulminant DIP adverse events in children and adolescents receiving PEG-ASP therapy remains low, these effects may not only alter the chemotherapy regimen but also have threatening

consequences for the children. We describe a severe case of SAP with ACS triggered by PEG-ASP in an ALL pediatric patient who was successfully healed by midline fasciotomy.

ACS management requires a multidisciplinary team-based strategy. It would be beneficial to regularly monitor immunological parameters and other relevant considerations once ASP chemotherapy is initiated in paediatric oncology group. Besides, the selection of optimal surgical timing combined with high-level perioperative care and management is criterion for the successful treatment. Performing the DL should be weighed prior to the procedure against the potentially lethal inadequately treated ACS. There is an urgent need to identify the risk factors through prospective clinical research, complement guidelines and training for physicians and nurses.

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Footnote

Reporting Checklist: The authors have completed the CARE reporting checklist. Available at https://tp.amegroups.com/article/view/10.21037/tp-24-440/rc

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All procedures performed in this study were in accordance with the Declaration of Helsinki and its subsequent amendments. The study was approved by the Ethics Committee of Children's Hospital of Nanjing Medical University (No. 202411009-1). Written informed consent was obtained from the patient's parents for publication of this case report and accompanying images. A copy of the written consent is available for review by the editorial office of this journal.

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