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Case Report

Overcoming the Odds: A Case Report of Pediatric Grade V Liver Injury with Severe Complications

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Abstract

Objective: Blunt liver trauma in pediatric patients presents a significant clinical challenge, especially in high-grade injuries complicated by multiple life-threatening conditions. While non-operative management (NOM) is the standard of care for hemodynamically stable patients, severe complications require an individualized, multidisciplinary approach.

Case Presentation: We present a 15-year-old boy with a grade V blunt liver injury following a car accident. Initially stabilized with non-operative management, he later developed three rare complications: abdominal compartment syndrome, acute kidney injury, and bile leakage. The first two complications were treated with emergency decompressive laparotomy and continuous renal replacement therapy. At the same time, bile leakage from a disrupted right posterior hepatic duct was managed with percutaneous drainage and adjunctive glucagon therapy. With vigilant monitoring and tailored interventions, he showed marked recovery within 2 months, and follow-up imaging confirmed substantial improvement.

Conclusion: This case highlights the delicate balance of managing severe pediatric trauma, blending established protocols with innovative approaches. The occurrence of three rare complications in a single patient underscores the exceptional nature of this case. Successful management of abdominal compartment syndrome, acute kidney injury, and bile leakage demonstrates the importance of early diagnosis, multidisciplinary teamwork, and adaptability in complex trauma care. It exemplifies how integrating evidence-based practices with novel strategies can transform life-threatening conditions into successful recoveries.

Keywords: Liver injury, Children, Abdominal compartment syndrome, Acute kidney injury

Introduction

William Osler aptly stated, "Medicine is a science of uncertainty and an art of probability," capturing the unpredictable nature of complications that can arise in trauma care, even with optimized management.

Blunt liver trauma is a serious and often complex injury in children, typically resulting from high-energy impacts such as car accidents. Over the years, non-operative management (NOM) has become the gold standard for hemodynamically stable patients, a principle that extends to pediatric cases, with success rates exceeding 80% (1,2,3).

However, NOM for high-grade liver trauma is associated with a range of complications, the most commonly reported being hepatic collections and bile leakage. Among the rarer but most critical complications is abdominal compartment syndrome (ACS), which arises from sustained intra-abdominal hypertension (IAH), leading to impaired perfusion and multi-organ dysfunction. In pediatric patients, ACS occurs in 0.6% to 10% of critically ill cases and can result in severe, life-threatening complications, including acute kidney injury (AKI), respiratory failure, and hemodynamic instability. Without timely intervention, it carries an alarming 90–100% mortality rate (4,5,6).

Acute kidney injury (AKI), caused by impaired renal perfusion due to elevated intra-abdominal pressure, significantly contributes to high mortality rates. If not promptly addressed, it can progress to intrinsic renal failure. Interventions such as decompressive laparotomy and continuous renal replacement therapy (CRRT) play a crucial role in stabilizing renal function and supporting recovery of critically ill patients (7).

Biliary complications, particularly bile leakage, are another significant concern in high-grade liver trauma, with an incidence ranging from 0.5% to 22%. Bile leaks can arise from various causes, and their diagnosis is typically confirmed through magnetic resonance

cholangiopancreatography (MRCP). While most cases resolve with conservative management, including percutaneous drainage, high-output leaks or those involving proximal ducts often require endoscopic retrograde cholangiopancreatography (ERCP) with stenting (8,9,10).

Despite extensive literature on pediatric blunt liver trauma, cases involving the concurrent occurrence of ACS, AKI, and bile leakage remain exceedingly rare. Similarly, reports on pediatric extrahepatic bile duct injuries are scarce, with only a few documented cases, and discussions on ACS with associated renal complications in children are limited (5,6,11,12).

This case is notable not only for the rare combination of severe complications but also for the successful use of multidisciplinary care in overcoming life-threatening challenges. It also highlights the potential role of glucagon in managing bile leaks, though its effectiveness remains under-researched and relies on clinical judgment; its successful use in this case suggests a promising, non-invasive approach to pediatric trauma management.

Case Presentation

A 15-year-old boy was transferred to our emergency department after a severe car accident. The patient was seated as a passenger without a seatbelt and was ejected from the vehicle when it fell into a ravine. Upon arrival, he was hemodynamically stable, with a blood pressure of 116/52 mmHg, heart rate of 130 bpm, respiratory rate of 21 breaths per minute, and oxygen saturation of 97% on free air. Neurologically, he was fully alert, with a Glasgow Coma Scale score of 15/15. Clinical examination revealed a large right upper abdominal wall hematoma.

A FAST sonography showed diffuse liver heterogeneity and extensive intra-abdominal fluid collections, indicative of hemoperitoneum. A subsequent CT scan confirmed grade V liver injury involving multiple hepatic sections (IV, V, VI, VII, and VIII), right-sided fractures of the 10th and 11th ribs, a grade III right kidney injury, and significant hemoperitoneum. At the same time, the major vessels remained intact (Figure 1).

Initial laboratory tests revealed anemia (hemoglobin 10.5 g/dL, hematocrit 31.3%) and leukocytosis (white blood cell count 20,100/μL, with 80.1% neutrophils). Renal and liver function tests were significantly abnormal, with elevated creatinine (1.52 mg/dL) and notable increases in SGOT (894 U/L), SGPT (754 U/L), γ-GT (37 U/L), CPK (3952 U/L), and LDH (2131 U/L), indicative of cellular injury and cytolysis. The coagulation profile showed a prolonged prothrombin time of 18.2 seconds and an INR of 1.81, consistent with impaired liver function.

Following initial assessment, the hemodynamically stable patient was admitted to the ICU for close monitoring and NOM. However, within the first 48 hours, his condition deteriorated, presenting with progressive abdominal distension and increased intra-abdominal pressure (up to 17 mmHg), and declining renal function, consistent with ACS. The hemoglobin had fallen to 8.2 g/dL; thus, the creatinine was up to 3 mg/dL, and the liver enzymes were tripled. Urine output decreased dramatically and progressively over 24 hours to 10 mL/h. The patient was very stressed, with an elevated systolic pressure up to 160 mmHg and in need of opioids due to severe estimated abdominal pain.

Persistent ACS symptoms and worsening hemodynamic instability, progressive anuria, and a new abdominal ultrasound, in which a considerable amount of fluid in the abdominal cavity was identified, necessitated emergency laparotomy. Intraoperatively, a large amount of hemorrhagic fluid (approximately 3000 mL) was aspirated, and crushed fragments of the liver were excised. The posterior surface of the right liver was seriously damaged, without signs of acute bleeding of the big vessels. Hemostatic matrix was applied to the posterior surface of the right hepatic lobe. The small and large intestines were vital and intact from the ligament of Treitz to the rectum. The right kidney exhibited a small hematoma, though no active bleeding was detected. The left kidney was intact. Two drains were placed in the subhepatic region and Morrison's space, and the abdomen was left open with a vacuum-assisted closure (VAC) device (Table 1).

Postoperatively, urine output remained low (< 10

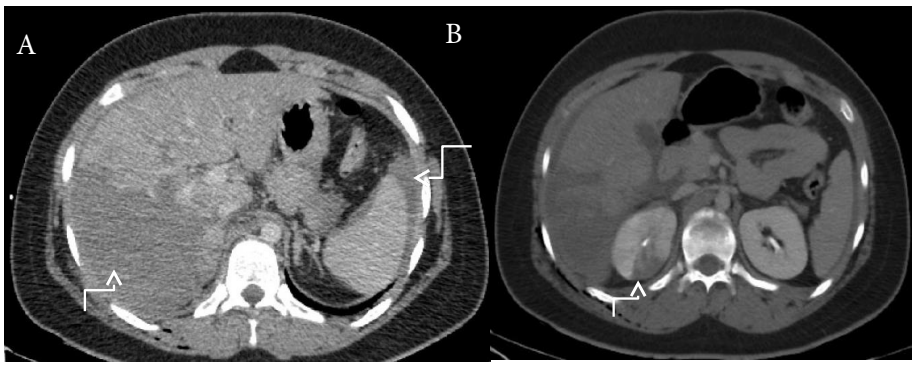

Figure 1. CT scan on admission day: A grade V liver injury involving multiple hepatic sections (IV, V, VI, VII, and VIII) and perisplenic fluid collection with intact spleen (A)
A grade III right kidney injury, and significant hemoperitoneum, while the major vessels remained intact (B).

Table 1. Overview of Clinical Management Strategies

Condition	Diagnosis	Treatment
Blunt Liver Trauma (Grade V)	CT scan	Non-operative management (NOM)
Abdominal Compartment Syndrome (ACS)	Clinical signs (abdominal distension, anuria) and intravesical pressure 17mmHg	Emergency decompressive laparotomy
Acute Kidney Injury (AKI)	Elevated creatinine, reduced urine output	Emergency laparotomy, Continuous Renal Replacement Therapy (CRRT)
Bile Leakage	MRCP confirming disruption of the posterior right hepatic duct	Percutaneous drainage, adjunctive glucagon therapy

mL/h), with creatinine, blood urea, and CPK levels all exceeding the normal range, despite fluid management in line with international guidelines. The patient required CRRT for 2 weeks to manage the AKI, which led to a gradual renal function recovery and the eventual restoration of spontaneous diuresis. The patient remains stable.

On the 20th day of admission, bile leakage was observed from the subhepatic drain, and MRCP confirmed a disruption of the right posterior branch of the right hepatic duct (Figure 2). Conservative management was initiated, including percutaneous drainage and adjunctive glucagon therapy (Table 1).

Additional challenges included a large right pleural effusion requiring chest tube placement and a *Pseudomonas aeruginosa* infection, which was successfully treated with targeted antibiotics. Throughout his ICU stay, he required multiple transfusions of packed red blood cells, fresh frozen plasma, and platelets to manage ongoing blood loss and organ damage.

After 31 days, the patient's liver enzymes and renal function had improved, with total bilirubin peaking at 1.7 mg/dL and direct bilirubin at 1.2 mg/dL before normalization. While bile leakage persisted, the volume steadily decreased. Gradual refeeding with a fat-free diet was initiated, supported with total parenteral nutrition (TPN).

Following a two-month hospitalization, the patient achieved clinical stability and was discharged. His hospital course was managed by a multidisciplinary team, including psychological counseling and physiotherapy. Follow-up imaging confirmed a reduction in intra-abdominal fluid collections and stabilization of hepatic and renal injuries. Two months post-discharge, no evidence of bile duct dilation or new fluid collections was identified in a new MRCP.

Discussion

The understanding and management of blunt liver trauma and abdominal compartment syndrome (ACS) have evolved significantly over the centuries. Until two to three decades ago, surgical intervention was the standard approach for managing hepatic trauma. However, the shift toward NOM began when its success was demonstrated in pediatric splenic injuries, eventually leading to its adoption for blunt liver trauma. Today, NOM is the preferred approach in hemodynamically stable patients, with success rates exceeding 80% (2,3).

Figure 2. MRCP Disruption the right posterior branch of the right hepatic duct

Parallel to advancements in liver trauma management, the understanding of intra-abdominal pressure (IAP) and its physiological consequences has also progressed. This progress led to the establishment of the World Society of Abdominal Compartment Syndrome (WSACS) in 2004, which standardized definitions for IAH, ACS, and IAP monitoring (13,14).

Blunt Liver Trauma and Non-operative Management (NOM)

The liver is the most frequently injured organ in blunt abdominal trauma, with motor vehicle accidents, observed in up to 72% of cases. The liver's high vascularity and anatomical location make it particularly vulnerable, leading to injuries that range from minor contusions to life-threatening hemorrhage, necessitating a management approach tailored to the patient's hemodynamic stability and imaging findings (3,8).

According to the WSES guidelines, extended-focused abdominal sonography for trauma (E-FAST) and contrast-enhanced CT remain the gold standard for diagnosing liver trauma and assessing injury severity. Advances in imaging and critical care have reinforced NOM as the standard care for liver trauma in hemodynamically stable patients. This approach significantly reduces morbidity and mortality by avoiding the risks associated with surgical intervention. However, the widespread adoption of NOM for blunt liver trauma has also been

associated with a higher incidence of late complications. The most commonly reported complications are hepatic collections (3.1%) and bile leakage (1.5%), with a higher incidence in patients with high-grade liver injuries. Additional potential complications include persistent or delayed hemorrhage, fistula formation, abdominal compartment syndrome, hepatic hematoma or necrosis, or abscess formation, peritonitis, and pseudoaneurysm development. Rather than being viewed as a failure of conservative management, the occurrence of these complications and their treatment should be considered an anticipated and integral aspect of NOM (1,2,3,4).

In accordance with current WSES guidelines, our patient was initially managed non-operatively, considering hemodynamic stability, with contrast-enhanced CT confirming a Grade V liver injury, guiding early clinical decisions. Despite initial stabilization, ACS and bile leakage developed, ultimately necessitating surgical intervention, underscoring the limitations of NOM in high-grade liver trauma.

Abdominal Compartment Syndrome (ACS)

Abdominal compartment syndrome (ACS) occurs when rising intra-abdominal pressure (IAP) surpasses critical thresholds, leading to organ dysfunction. Intra-abdominal hypertension (IAH), defined as a sustained IAP above 12 mmHg, is classified into four grades and can progress to ACS when pressures exceed 20 mmHg and organ failure develops (Table 2). If left untreated, ACS has an exceptionally high mortality rate of 90–100% (6).

Though rare, ACS is a serious complication of NOM in blunt liver trauma, with an incidence in pediatric trauma cases ranging from 0.6% to 10%. Several risk factors, including high BMI, hemoperitoneum, massive fluid resuscitation, and significant trauma, all of which were present in our patient, predispose patients to ACS (5).

The pathophysiology of ACS is driven by elevated IAP, which impairs organ perfusion and oxygenation, setting off a cycle of ischemia, capillary leakage, and progressive organ failure. If left untreated, ACS can lead to severe, life-threatening complications such as AKI, respiratory failure, and hemodynamic instability. Definitive treatment involves decompressive laparotomy, often supplemented with VAC therapy, which helps minimize secondary complications and facilitates gradual abdominal closure (14).

In our case, the patient exhibited hallmark signs of ACS, including abdominal distension, progressive oliguria to anuria, and respiratory compromise. Intravesical pressure monitoring confirmed Grade II IAH, with an IAP of 17 mmHg. Emergency decompressive laparotomy was performed, effectively reducing IAP and stabilizing the patient. The use of VAC therapy in managing the open abdomen is aligned with evidence-based ACS management, promoting wound healing and reducing the risk of entero-atmospheric fistulas. Timely diagnosis and intervention were critical in preventing further deterioration, underscoring the importance of protocolized IAP monitoring in high-risk trauma cases, as emphasized in the World Society of Abdominal Compartment Syndrome guidelines (15).

Acute Kidney Injury (AKI)

AKI is a rapid decline in glomerular filtration rate (GFR), leading to creatinine accumulation, reduced urine output, and disturbances in fluid, electrolyte, and acid-base balance, with short-term mortality rates often exceeding 50%. It can arise from various causes and may be primary or secondary to systemic conditions (7,9).

In ACS, elevated IAP compromises renal perfusion by compressing renal vessels and activating the renin-angiotensin-aldosterone system, resulting in impaired glomerular filtration and progressive renal dysfunction (6,14). Early intervention is crucial to prevent the transition from prerenal azotemia to intrinsic renal injury.

For AKI secondary to established ACS, decompressive laparotomy remains the primary treatment. In critically ill patients, CRRT is also commonly used, offering hemodynamic stability and controlled, gradual fluid removal. Emerging evidence suggests that CRRT may additionally help lower IAP (7).

In our patient, AKI developed as a secondary complication of ACS, evidenced by rising creatinine levels and anuria. Despite decompressive laparotomy, renal function continued to decline, requiring CRRT for nearly 20 days to restore hemodynamic balance and support renal recovery. This case highlights the importance of early recognition and intervention in ACS-associated

Table 2. Definitions, World Society of the Abdominal Compartment Syndrome [15]

Term	Description
Intra-Abdominal Pressure (IAP)	IAP is the steady-state pressure concealed within the abdominal cavity.
IAP Measurement Standard	The reference standard for intermittent IAP measurements is via the bladder.
IAP Monitoring Frequency	Monitor IAP with serial measurements at least every 4 hours while the patient is critically ill.
Intra-Abdominal Hypertension (IAH) Definition	IAH is defined by a sustained or repeated pathological elevation in IAP ≥ 12 mmHg.
IAH Classification	Grade I: IAP 12–15 mmHg Grade II: IAP 16–20 mmHg Grade III: IAP 21–25 mmHg Grade IV: IAP > 25 mmHg
Abdominal Compartment Syndrome (ACS) Definition	ACS is defined as a sustained IAP > 20 mmHg that is associated with new organ dysfunction or failure.

AKI, aligning with the literature emphasizing CRRT's role in stabilizing critically ill patients.

Bile Leakage

Bile leakage remains rare, with an incidence ranging from 0.5% to 22%, although it is one of the most commonly reported complications following conservative management of high-grade blunt liver trauma (8,16,17). The most common causes are traumatic biliary tract laceration, parenchymal disruption, ductal ischemia, delayed rupture of subcapsular bile collections, or persistent leakage after hepatorrhaphy or hepatic resection during laparotomy (10).

Magnetic resonance cholangiopancreatography (MRCP) is often used as a diagnostic modality to identify and localize bile leaks, providing detailed visualization of biliary anatomy and potential disruptions (16).

The optimal treatment approach for traumatic bile leaks remains uncertain, with management decisions influenced mainly by the extent and mechanism of injury, concurrent organ damage, and available expertise. Conservative management is the first-line approach for peripheral ductal injuries, with most cases resolving spontaneously (16,17,18). In cases where conservative measures fail or when high-output leaks or proximal duct involvement are present, endoscopic retrograde cholangiopancreatography (ERCP) with stenting is frequently used. Advances in minimally invasive techniques, such as percutaneous drainage, have significantly improved patient outcomes, reducing the need for surgical intervention (10,13). Adjunctive therapies, such as glucagon—which relaxes the sphincter of Oddi and enhances bile drainage—have been explored for the management of bile leaks. However, their direct impact on resolution remains under-researched and heavily reliant on clinical judgment.

In our case, bile leakage was identified later in the patient's clinical course and confirmed through MRCP, which revealed a disruption of the right posterior hepatic duct. Conservative management, including percutaneous drainage and subcutaneous glucagon therapy, successfully resolved the leakage within three weeks. The use of glucagon to facilitate bile excretion highlights its potential as an adjunctive therapy, particularly in complex trauma cases where invasive procedures should be avoided or are unavailable, as in our case, due to the lack of ERCP in our hospital. This management strategy aligns with the literature, which supports the efficacy of non-operative approaches in resolving bile leaks in most cases.

Conclusion

This case report highlights the complexity of managing high-grade blunt liver trauma in a pediatric patient complicated by the simultaneous occurrence of abdominal compartment syndrome, acute kidney injury, and bile leakage. While each of these complications has been individually reported in the literature, their simultaneous occurrence in a single patient is rare. This case underscores the importance of a flexible treatment strategy, in which evolving clinical parameters guided timely transitions between non-operative management and surgical intervention.

The successful resolution of ACS through decompressive laparotomy, the treatment of AKI with continuous renal replacement therapy, and the management of bile leakage with percutaneous drainage and adjunctive glucagon therapy emphasize the critical role of multidisciplinary care. Advanced imaging, minimally invasive techniques, and continuous monitoring were key to optimizing recovery, reinforcing the need for early recognition and targeted intervention in pediatric trauma.

This report provides valuable insights into the application of established guidelines, such as those from the World Society of Emergency Surgery (WSES) and the World Society of Abdominal Compartment Syndrome (WSACS), while demonstrating the necessity of individualized, adaptive approaches in severe trauma management. It highlights the importance of precision in diagnosis, proactive decision-making, and collaborative, team-based care.

Furthermore, our case underscores a research gap regarding the role of glucagon in the management of bile leaks. While its use contributed to clinical improvement, the lack of robust evidence highlights the need for further studies to evaluate its therapeutic potential in this setting.

Ultimately, our case exemplifies the resilience of both patient and medical team in overcoming life-threatening complications through a dynamic, evidence-based approach. It serves as a testament to the power of multidisciplinary care, innovative problem-solving, and clinical adaptability in the face of extraordinary challenges—truly overcoming the odds in pediatric trauma management.

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Authors' Contribution

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Formal analysis: Despoina Panayiotou, Adelais Tzortzopoulou
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Competing Interests
The authors have no conflicts of interest to declare.

Ethical Approval
This case report was conducted in compliance with ethical principles and institutional guidelines. The study did not require formal ethical approval, as retrospective case reports are exempt from review by the Ethics Committee of the General Children's Hospital of Athens, "P.&A. Kyriakou." Written informed consent was obtained from the patient's legal guardians for publication of the case details and accompanying images. All patient data have been fully anonymized to protect confidentiality, and no personally identifiable information is included in the manuscript. The authors adhered to the ethical standards outlined in the Declaration of Helsinki and the COPE guidelines for publication ethics. No additional ethical concerns were identified in the preparation of this report.

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