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A SCOPING REVIEW OF BILIO-PANCREATIC TRAUMA: A CHALLENGE FROM START TO FINISH FOR THE GENERAL SURGEON

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ABSTRACT

Introduction: Biliopancreatic trauma accounts for 3.7-11% of abdominal injuries with significant morbidity (30-45%) and mortality (2-19%). Its diagnosis remains challenging due to nonspecific presentation and retroperitoneal location, requiring high clinical suspicion. **Objective:** To synthesize current evidence on diagnostic and therapeutic management of biliopancreatic trauma in adults, focusing on injury-grade-based strategies. **Methods:** A scoping review was conducted following PRISMA-ScR guidelines. Systematic searches in PubMed/MEDLINE, Scopus and SciELO (2013-2025) included terms "pancreatic trauma", "injury mechanism" and "pancreatic duct injury". Twenty-two English/Spanish studies were selected using predefined eligibility criteria. **Results:** Multiphasic CT emerged as diagnostic gold standard (43-95% sensitivity), though limited for early ductal injuries. AAST-OIS classification guided management: 80% of Grade I-II injuries received non-operative care with serial enzyme monitoring (amylase/lipase q4-6h), while Grade III-V injuries required surgery, with laparoscopic distal pancreatectomy as feasible option in specialized centers (mean operative time 160-214 min). Pancreatic fistulas (10-35%) and pseudocysts (10-20%) were most frequent complications, managed primarily with percutaneous/endoscopic drainage. **Conclusions:** Contemporary management emphasizes minimally-invasive approaches and gland preservation.

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Correlation between imaging findings, AAST-OIS classification and hemodynamic status guides therapeutic decisions, reducing complications and mortality.

KEYWORDS: Pancreatic trauma; biliary tract; AAST-OIS; non-operative management; post-traumatic complications.

REVISIÓN EXPLORATORIA DEL TRAUMA BILIO-PANCREÁTICO: UN RETO DE INICIO A FIN PARA EL CIRUJANO GENERAL

RESUMEN

Introducción: El trauma bilio-pancreático es una condición poco frecuente (3.7-11% de los traumatismos abdominales) pero con alta morbimortalidad (30-45% de complicaciones, 2-19% de mortalidad). Su diagnóstico representa un desafío debido a su presentación clínica inespecífica y localización retroperitoneal, requiriendo un alto índice de sospecha clínica. **Objetivo:** Sintetizar la evidencia actual sobre el manejo diagnóstico y terapéutico del trauma bilio-pancreático en adultos, con énfasis en las estrategias actuales basadas en grados de lesión. **Métodos:** Se realizó una revisión exploratoria siguiendo las guías PRISMA-ScR. La búsqueda sistemática en PubMed/MEDLINE, Scopus y SciELO (2013-2025) incluyó los términos "trauma pancreático", "mecanismo de lesión" y "lesión del conducto pancreático". Se seleccionaron 22 estudios en inglés/español mediante criterios de elegibilidad predefinidos. **Resultados:** La tomografía contrastada multiphasica demostró

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ser el gold standard diagnóstico (sensibilidad 43-95%), aunque con limitaciones en lesiones ductales tempranas. La clasificación AAST-OIS permitió estratificar el manejo: 80% de lesiones grado I-II manejadas conservadoramente con monitoreo de enzimas seriadas (amylasa/lipasa cada 4-6 h), mientras lesiones grado III-V requirieron intervención quirúrgica, destacándose la pancreatectomía distal laparoscópica como alternativa viable en centros especializados (tiempo operatorio promedio 160-214 min). Las complicaciones más frecuentes fueron fístulas pancreáticas (10-35%) y pseudoquistes (10-20%), manejadas principalmente con drenaje percutáneo o endoscópico. **Conclusiones:** El manejo contemporáneo del trauma bilio-pancreático enfatiza estrategias mínimamente invasivas y preservación glandular. La correlación entre hallazgos imagenológicos, clasificación AAST-OIS y estado hemodinámico guía las decisiones terapéuticas, reduciendo complicaciones y mortalidad.

PALABRAS CLAVE: Trauma pancreático; conducto biliar; AAST-OIS; manejo conservador; complicaciones postraumáticas.

INTRODUCTION

Pancreatic trauma is an uncommon but clinically significant condition, accounting for approximately 3.7–11% of all abdominal traumatic injuries (1). Among these, the body and tail of the pancreas are the most frequently affected anatomical sites, involved in nearly 65%

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of cases (2). The condition is associated with a high morbidity rate (30–45%) and a variable mortality rate ranging from 2% to 19%, irrespective of the trauma mechanism (1,3,4). Early mortality is often related to concomitant vascular or multi-organ injuries, whereas late mortality tends to result from sepsis, respiratory failure, or multiorgan dysfunction syndrome (1,3,4).

In contrast, injuries to the extrahepatic biliary tree are much rarer, observed in only 0.1% of trauma patients (5). When they do occur, they are typically associated with injuries to the liver, pancreas, or duodenum, with blunt abdominal trauma being the most common mechanism of injury (5,13).

The diagnosis of pancreatic trauma remains a considerable clinical challenge due to its nonspecific symptomatology and often delayed presentation. This diagnostic difficulty is largely attributable to the retroperitoneal position of the pancreas, which may mask signs of injury during initial assessment (5). The primary mechanism of pancreatic injury is blunt abdominal trauma, typically caused by a sudden compressive force against the vertebral column—frequently resulting from motor vehicle accidents, which account for up to 60% of such cases (1,4,6). While blunt pancreatic injuries are relatively infrequent (0.2–0.3% incidence), penetrating pancreatic trauma—including injuries caused by firearms or stab wounds—affects between 1–12% of trauma patients and is

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associated with higher mortality due to the frequent involvement of critical vascular structures such as the portal vein, inferior vena cava, superior mesenteric vessels, pancreaticoduodenal arteries, and the splenic vessels (4,6,7,8,9).

Pancreatic trauma rarely occurs in isolation. It is commonly associated with additional intra-abdominal injuries in 55–100% of cases, often involving the stomach (58%), liver (57%), duodenum (28%), or major blood vessels (35%) (10,11). Isolated pancreatic injuries are uncommon and account for only 0.7% of all abdominal trauma presentations (12).

Given its low incidence but high clinical complexity, pancreatic trauma requires an informed, systematic approach. The nonspecific nature of the symptoms, coupled with the potential for delayed complications, underscores the need for heightened clinical suspicion and the judicious use of diagnostic modalities.

This scoping review aims to synthesize current knowledge regarding the initial management of pancreatic trauma, including mechanisms of injury, clinical presentation, diagnostic strategies, and therapeutic interventions. By mapping and consolidating existing literature, this review seeks to provide a practical framework to aid general surgeons in navigating the diagnostic and therapeutic challenges posed by biliopancreatic trauma.

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Materials and Methods

Protocol

This scoping review was conducted in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR) guidelines.

Eligibility Criteria

We included peer-reviewed studies published between January 2013 and March 2025 that focused on pancreatic and/or extrahepatic biliary trauma in humans. Articles in English or Spanish were considered, and all epidemiological designs (case series, retrospective and prospective cohorts, cross-sectional studies, and narrative reviews) were eligible. Studies focusing exclusively on pediatric populations or non-traumatic pancreatic conditions were excluded.

Information Sources and Search Strategy

A comprehensive search was conducted in three electronic databases: PubMed/MEDLINE, Scopus, and SciELO. The search terms used were: "pancreatic trauma", "mechanism of injury", and "pancreatic duct injury", including both English and Spanish equivalents. The search spanned publications from 2013 to 2025.

Selection of Sources of Evidence

Two independent reviewers screened titles and abstracts for relevance. Full-text articles were retrieved for those that met the inclusion criteria or required further

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evaluation. Discrepancies between reviewers were resolved through discussion or consultation with a third reviewer.

Data Charting Process

A data extraction form was developed and piloted to standardize the collection of relevant variables. Extracted data included authors, year of publication, study design, population characteristics, type of trauma, diagnostic methods, therapeutic interventions, and reported outcomes.

Data Items

Key data points extracted included mechanisms of injury (blunt vs. penetrating), anatomical site of trauma (pancreas, biliary tree), diagnostic tools utilized, management strategies (surgical or non-operative), and clinical outcomes such as morbidity, mortality, and complications.

Results

The findings were synthesized narratively, categorizing evidence according to diagnostic approaches, treatment modalities, and severity classification systems. Quantitative synthesis (meta-analysis) was not conducted due to the heterogeneity of study designs and outcome measures.

Clinical picture and diagnostic approach

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The diagnostic approach to pancreatic trauma requires a high index of clinical suspicion, given its low incidence and the nonspecific or sometimes absent clinical manifestations. Early and accurate diagnosis, appropriate classification of the injury, and timely therapeutic intervention are essential to improving patient outcomes, particularly in reducing the associated morbidity and mortality.

Evaluation of patients with abdominal trauma should follow the principles of Advanced Trauma Life Support (ATLS), beginning with a structured primary and secondary survey.

Patients with pancreatic trauma often present with vague symptoms. Pain is typically localized to the upper abdomen and may appear between 6- and 24-hours post-injury, though cases have been reported where pain onset is delayed up to five days. Additional signs may include ecchymosis on the flanks or around the periumbilical region, as well as excoriations resulting from the mechanism of blunt trauma (1,9,13).

In hemodynamically stable patients without evidence of penetrating trauma or signs of peritoneal irritation, diagnostic tools such as laboratory tests and imaging studies can be employed to aid in diagnosis. In contrast, hemodynamically unstable patients presenting with penetrating injuries or signs of peritonitis should undergo immediate surgical exploration, and diagnostic delays should be avoided.

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Among the laboratory tests used for pancreatic trauma, the measurement of pancreatic enzymes—amylase and lipase—is common, though both have significant limitations. Elevations in these enzymes can result from trauma to other abdominal organs, even in the absence of direct pancreatic injury (1,9). Additionally, amylase levels may be elevated in various non-traumatic conditions that do not involve the pancreatic parenchyma, such as head trauma or hepatic and intestinal injuries (1). Lipase has demonstrated greater utility than amylase in the evaluation of pancreatic injury, with a negative predictive value of 99.8% and a positive predictive value of only 3.3%, underscoring its limited sensitivity for detecting true pancreatic damage.

According to the guidelines of the World Society of Emergency Surgery (WSES) and the American Association for the Surgery of Trauma (AAST), both recommend with level of evidence Ib that if imaging is not performed immediately, serial enzyme levels should be measured every 4–6 hours within the first 24 hours post-trauma. Persistently elevated enzyme levels, or rising trends across serial tests, should raise suspicion for occult pancreatic injury. This approach yields a specificity of 100% and a sensitivity of 85% in detecting pancreatic trauma. In such cases, imaging studies are necessary to confirm the diagnosis (10,13–15).

These laboratory trends are also valuable in monitoring nonoperative management. A declining trend in enzyme levels is

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generally predictive of successful conservative treatment (10,13–15).

As discussed, the limited diagnostic accuracy of pancreatic enzymes necessitates further imaging, especially in hemodynamically stable patients (1). In the trauma setting, the extended Focused Assessment with Sonography for Trauma (FAST) is part of the primary assessment and is helpful in detecting intra-abdominal free fluid. However, its utility in pancreatic trauma is limited due to the retroperitoneal position of the pancreas (4,5,10).

Therefore, the imaging modality of choice is contrast-enhanced multiphasic computed tomography (CT), which includes arterial and portal venous phases. The portal venous phase is particularly effective in identifying parenchymal lesions. The sensitivity of CT for detecting pancreatic trauma ranges from 43% to 95%, with a specificity of 90%. However, CT has a lower sensitivity (50–54%) in detecting pancreatic duct injuries, although specificity remains high (90–95%) (1,11,13).

Up to 40% of pancreatic injuries may be missed on CT scans performed within the first 12 hours post-injury due to subtle findings. Thus, in patients with high clinical suspicion and a normal initial CT scan, repeat imaging is recommended between 12 and 48 hours after the trauma (4,5,15,16). Reported radiological

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findings include pancreatic laceration, contusions affecting one or more anatomic regions (Figure 1), focal or diffuse edema, intrapancreatic hematoma, active hemorrhage, ductal dilatation, peripancreatic fat stranding, pseudocyst formation, fluid collections, wall thickening greater than 4 mm, and peripancreatic fluid (10,16).

Pancreatic duct injury should be strongly suspected in cases involving complete transection of the pancreas, lacerations involving more than 50% of the pancreatic parenchymal thickness, or extensive pancreatic disruption (Figure 2) (16).

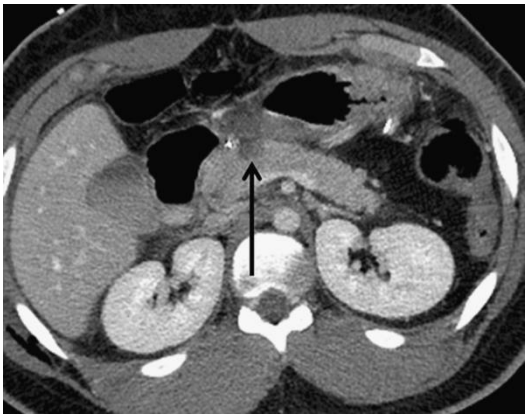


Figure 1. Axial CT scan, with an arrow indicating a hypoattenuation area in the pancreatic head, grade I injury (AAST) (16).

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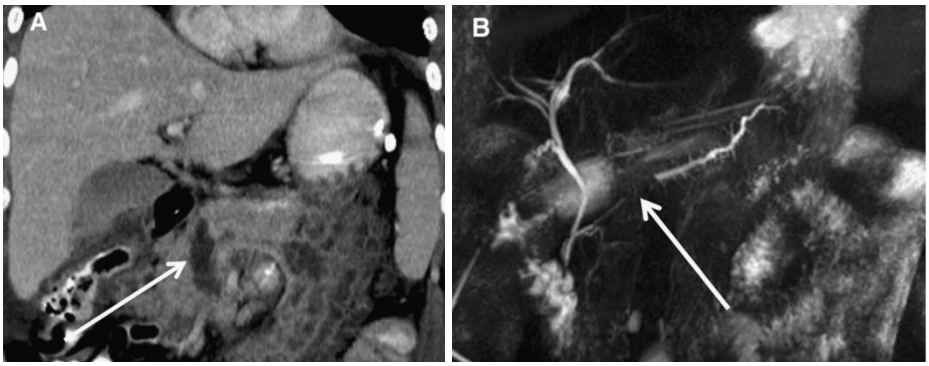


Figure 2. A. Coronal CT scan, showing a laceration in the pancreatic head, involving >50% of the parenchyma. **B.** MRCP reveals complete rupture of the main pancreatic duct (16).

Other described diagnostic aids include endoscopic retrograde cholangiopancreatography (ERCP) and magnetic resonance cholangiopancreatography (MRCP), which are primarily used to evaluate the pancreatic duct (11). MRCP has a sensitivity of 97% for diagnosing pancreatic duct involvement in the pancreatic body and 83% in the pancreatic tail. It is considered the noninvasive modality of choice for evaluating the pancreatic duct and biliary tree. When stimulated by secretin, MRCP not only identifies pancreatic duct injury but also detects continuous pancreatic duct leakage. Its limitations include high cost and limited availability in some healthcare settings (6,11,16).

ERCP is an invasive procedure. Its main advantage is the ability to perform a

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directly guided intervention in hemodynamically stable patients with suspected pancreatic duct or extrahepatic biliary tree injury. Early performance may be difficult due to distortion at the papilla caused by edema or hematoma secondary to trauma. ERCP is also useful in managing complications related to pancreatic trauma, such as persistent pancreatic duct leakage, pseudocysts, bile duct strictures, and peripancreatic collections (11,16).

Once the diagnosis of pancreatic trauma has been established, the integrity of the pancreatic duct must be verified, as its compromise increases the mortality rate to 3%. Failure to detect or incorrectly diagnosing the injury can lead to complications such as abscesses and/or fistulas (1,16).

As previously described, there are cases where diagnostic aids should not be used, and urgent surgical intervention is required. Therefore, it is crucial to understand the definition of hemodynamic instability to determine which patients will benefit from immediate surgical management. Patients with a systolic blood pressure (SBP) <90 mmHg, cutaneous hypoperfusion, altered neurological status, and/or difficulty breathing, or patients with an SBP >90 mmHg requiring blood product transfusion or vasopressor support, and/or base excess (BE) < -5 mmol/L, shock index >1, and transfusion of >4-6 units of red blood cells within the first 24 hours, should undergo emergency laparotomy. A

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diagnosis will be made intraoperatively, and concomitant injuries to other organs will be assessed (13).

Classification

The most widely used classification for pancreatic and biliary trauma is the one described by the American Association for the Surgery of Trauma—Organ Injury Scaling (AAST-OIS) (Tables 1-2). It stratifies injuries based on type, location (head, body, or tail), and the presence or absence of main pancreatic duct involvement. In this classification, the pancreas is divided into proximal and distal components relative to the axis of the superior mesenteric vein and portal vein. The proximal pancreas is defined as the parenchyma to the right of this axis, while the distal pancreas refers to the parenchyma to the left.

The frequency of pancreatic trauma by injury grade is 80% for low-grade (Grade I: 60%, Grade II: 20%) and 20% for high-grade (Grades III-IV) (1,13). Mortality rates by pancreatic trauma grade are 7% for mild trauma (Grades I-II), 29% for Grades III-IV, and 30% if associated with vascular injury (1,16).

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Table 1. Pancreatic trauma classification. American Association for the Surgery of Trauma (AAST-OIS).

Grade	Type	Injury description
I	hematoma	Minor contusion without ductal injury
	laceration	Superficial laceration without ductal injury
II	hematoma	Major contusion without ductal injury or tissue loss
	laceration	Major laceration without ductal injury or tissue loss
III	laceration	Distal transection or parenchymal injury with ductal involvement
IV	laceration	Proximal transection or parenchymal injury involving the ampulla of Vater
V	laceration	Massive disruption of the pancreatic head

It should be clarified that the AAST classification considers the type of injury in relation to anatomical location and pancreatic duct involvement but does not account for the patient's hemodynamic status. The World Society of Emergency Surgery (WSES) classifies pancreatic trauma based on the AAST grading: mild (AAST Grades I-II), moderate (AAST Grade III), and severe (AAST Grades IV-V). Additionally, any pancreatic trauma (Grades I-IV) in hemodynamically

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unstable patients is classified as severe according to WSES (13).

Figure 3. AAST-OIS classification illustration.

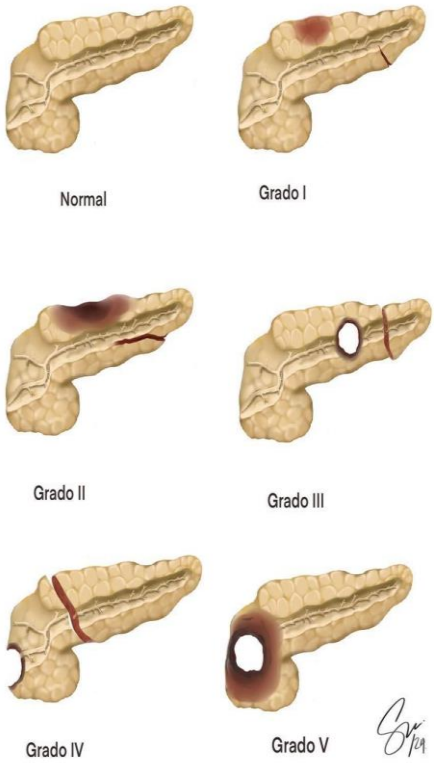


Table 2. Classification of extrahepatic biliary tree trauma. American Association for the Surgery of Trauma (AAST-OIS).

Grade	Injury description
I	Hematoma/Contusion of the gallbladder Contusion of the portal triad
II	Partial avulsion of the gallbladder from the hepatic bed, intact cystic duct Laceration or perforation of the gallbladder
III	Complete avulsion of the gallbladder from the hepatic bed Laceration of the cystic duct
IV	Partial or complete laceration of the right hepatic duct

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	Partial or complete laceration of the left hepatic duct Partial laceration of the common hepatic duct (<50%) Partial laceration of the common bile duct (<50%)
V	Transection of the common hepatic duct (>50%) Transection of the common bile duct (>50%) Combined injuries of the right and left hepatic ducts / Injuries to the intraduodenal or intrapancreatic bile duct

Other mortality scales for pancreatic trauma include the Pancreatic Injury Mortality Score (PIMS), which considers five variables with a total score of 20. A score of 0-4 indicates low mortality risk (<1%), 5-9 medium risk (15% mortality), and 9-10 high risk (50% mortality) (16,17).

In a retrospective study by J.E.J. Krige et al., the overall mortality among 432 patients was 15.7%, with a morbidity rate of 66%. Prognostic factors included age, AAST injury grade, presence of shock, number of blood transfusions, number of laparotomies, associated vascular injuries, postoperative complications, and ICU stay, all of which were significant predictors of mortality (8). Other reviews identify poor prognostic factors such as delayed diagnosis, associated abdominal injuries, and pancreatic duct involvement (3).

Conservative and surgical management

Current management favors minimally invasive interventions, with initial treatment depending on hemodynamic

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status, pancreatic injury location, ductal integrity, associated organ injuries, trauma mechanism (blunt or penetrating), and the need for damage control procedures. A study by Ragulin-Coyne et al. (1998–2009) noted a decline in surgical management of pancreatic trauma and an increase in conservative treatment, with improved overall mortality (18).

For Grade I-II injuries on diagnostic imaging without other organ injuries or gallbladder hematomas (without perforation), nonoperative management is recommended. Key components include clinical monitoring, fasting, analgesia, and serial pancreatic enzyme measurements every 4-6 hours. Peripancreatic collections may require percutaneous or endoscopic drainage or no intervention (7,10,14). Continuous surveillance is crucial, as clinical deterioration or new imaging findings may indicate an occult pancreatic injury, necessitating further intervention (13).

This approach has been described in selected patients with moderate-grade pancreatic injuries and no other surgically treatable abdominal injuries, supplemented by endoscopic therapy in high-experience centers. It has shown reduced severe complications and fewer laparotomies, though further studies are needed to validate its use in moderate-grade injuries (5,19).

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Surgical intervention involves hemostatic maneuvers, pancreatic packing, wound suturing, and closed surgical drainage (20). Damage control surgery is reported in 20-63% of cases, typically for high-grade pancreatic injuries with vascular involvement (13).

Different maneuvers are required for pancreatic visualization: the Mattox maneuverfor the body and tail, and the Cattell-Braasch and Kocher maneuvers for the head or uncinate process (10). A thorough evaluation of abdominal organs, the pancreatic duct, and adjacent vessels is essential.

Surgical management is guided by injury grade:

- Grade I:Hemostasis, with or without closed suction drainage (9,13,20).

- Grade II: Hemostasis; if persistent, repair with 3-0 nonabsorbable monofilament suture, with or without drainage (13,20).

- Grade III: Hemostasis; for proximal or distal injuries, crossed 3-0 monofilament suture with proximal and distal duct ligation and closed drainage. Distal pancreatectomy ± splenectomy is also described. Splenic preservation remains controversial, as it does not significantly affect morbidity, mortality, or hospital stay (13,19,20).

- Grade IV: Damage control surgery with hemostasis, 3-0 absorbable suture, duct

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ligation, packing, drainage, and pancreatoduodenectomy, with staged reconstruction (13,20,21).

- Grade V: Damage control surgery, duct ligation, and pancreatoduodenectomy, with definitive staged reconstruction by a hepatobiliary team (15,21).

Biliary tree injuries:

- Grade I (60% of cases) is often diagnosed intraoperatively.

- Grades I-III: Cholecystectomy is preferred for lacerations, avulsions, or perforations; hematomas are managed nonoperatively.

- Grades IV-V: Typically associated with severe hepatic, duodenal, or pancreatic injuries. Initial damage control surgery is followed by staged reconstruction (hepaticojejunostomy or choledochojejunostomy). Intraoperative cholangiography is recommended if biliary injury is suspected but not identified (13).

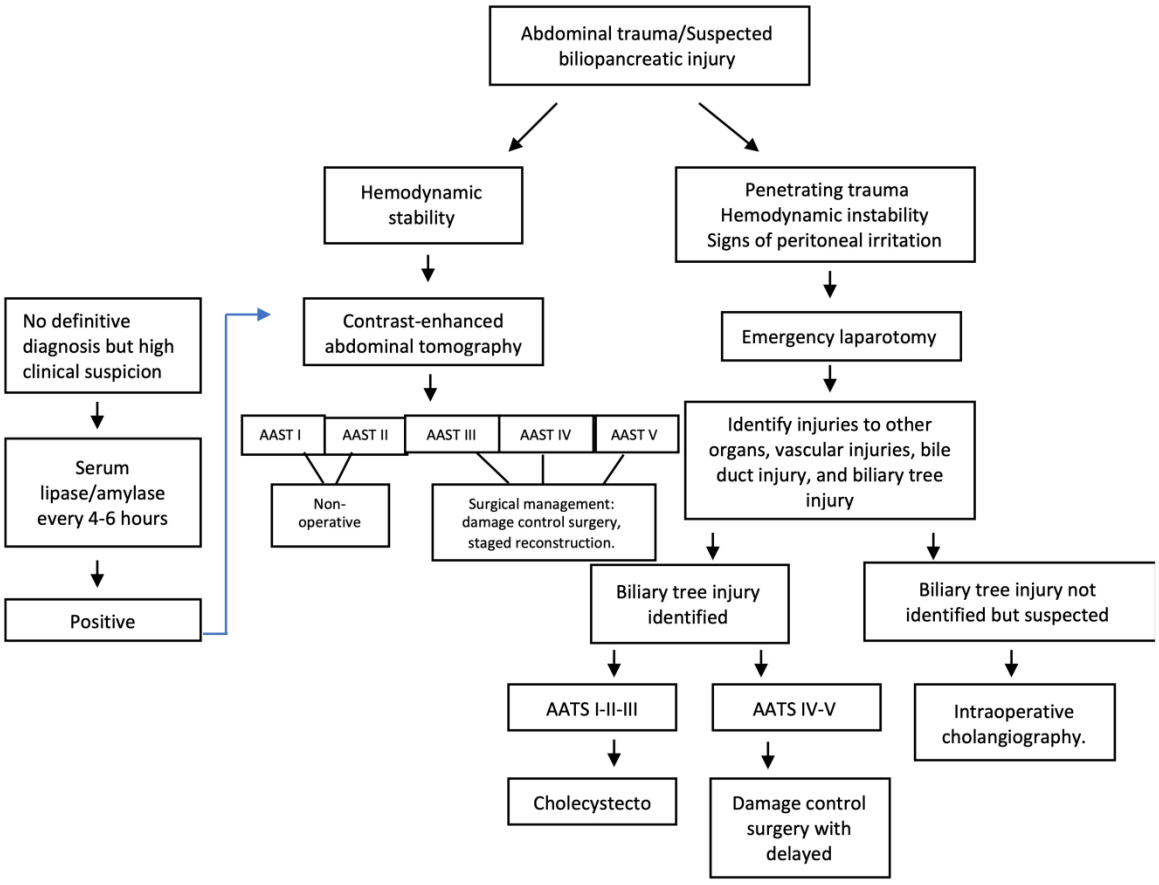
Laparoscopic Approach:

Laparoscopy has diagnostic and therapeutic potential in hemodynamically stable patients with blunt pancreatic trauma. A 2023 review by Barbara Catellani et al. included 30 patients (10 adults, 20 pediatric) who underwent diagnostic/therapeutic laparoscopy: 2 distal pancreatosplenectomies, 22 spleen-preserving distal pancreatectomies, and 6 laparoscopic drainages. Mean operative times were 160.6 min (adults) and 214.5

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min (pediatric), with estimated blood loss of 400 mL and 75 mL, respectively, and mean hospital stays of 14.9 and 9 days. Minimally invasive management by experienced teams is feasible and safe, though further studies are needed to define its role in diagnosis, staging, and treatment (12,22).

Figure 4. Diagnostic and Management Algorithm.



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Complications

Complications secondary to pancreatic trauma occur in 24–50% of cases, primarily in high-grade injuries (1).

Pancreatic fistula is the most frequent complication, with an incidence of 10–35%. It is defined as an abnormal communication between the ductal epithelium and another epithelial surface, resulting in persistent pancreatic drainage (>3 days postoperatively) with amylase levels hree times higher than serum amylase. Management includes closed drainage and nutritional therapy tailored to the patient's condition and fistula output. 90% of fistulas resolve with conservative management, but persistent cases may require endoscopic intervention (1,10).

Pancreatic pseudocysts are more common in nonoperatively managed patients (incidence: 10–20%). They may arise from pancreatic fistulas, edema, or hemorrhage, with abdominal CTas the initial diagnostic tool.

Pancreatic duct integrity must be assessed:

- Intact duct + symptoms→ Conservative management ± endoscopic intervention.

- Duct disruption→ Endoscopic or surgical management (1,7,10).

Traumatic pancreatitis occurs in 10% of pancreatic trauma cases. Diagnostic criteria are not well-defined, but suspicion should arise with rising serum amylase or levels >3x baseline.

ACTA BIOCLINICA

Artículo de Revisión

Giraldo-Campillo y Col.

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Complications mirror those of non-traumatic acute pancreatitis (16).

Other complications include:

- Venous thrombosis

- Arterial pseudoaneurysms (splenic, gastroduodenal, or common hepatic arteries)

- Pancreatic duct stenosis → Chronic pancreatitis

- Exocrine/endocrine insufficiency (after total pancreatectomy or >90% parenchymal resection) (2).

Diabetes prevalence post-total pancreatectomy is 16% (vs. general population) (2).

Conclusions

Biliopancreatic trauma is rare, with nonspecific and delayed clinical presentation, posing significant challenges in initial evaluation, diagnosis, and management. High suspicion is essential for timely diagnosis and treatment to reduce morbidity and mortality. Note its frequent association with other intra-abdominal injuries (solid organ, hollow viscus, or vascular damage).

Advances in imaging, endoscopy, and radiology have reshaped nonoperative management of injuries and complications. Current strategies favor selective surgery with maximal gland preservation to minimize complications. Hemodynamically unstable patients

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require damage control laparotomy to address bleeding/contamination, delaying definitive reconstruction for staged procedures with hepatobiliary surgery teams.

Despite surgical interventions and specialized trauma care, this trauma carries high complication rates, prolonged ICU stays, and significant mortality.

Conflict of Interest: The authors have no conflicts of interest to declare

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Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Conceptualization

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Methodology

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Data curation

Daniela Giraldo-Campillo and Carlos M. Ardila: Writing- Original draft preparation.

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Visualization

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Investigation.

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Validation and supervision.

Daniela Giraldo-Campillo, Mateo Zuluaga-Gomez and Carlos M. Ardila: Writing- Reviewing and Editing.

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