Exploring the Role of Percutaneous Transhepatic Biliary Drainage in the Interim Management of Paediatric Choledochal Cysts with Cholangitis: A Pilot Study

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Abstract

Background: Choledochal cysts are congenital anomalies of the bile ducts that can lead to significant complications, such as cholangitis, liver fibrosis, and biliary obstruction. This study aims to evaluate the effectiveness and safety of percutaneous transhepatic biliary drainage (PTBD) in managing choledochal cysts with cholangitis in children. **Methods**: This non-randomized interventional study included twelve paediatric patients with choledochal cysts and cholangitis treated over two years. Percutaneous transhepatic biliary drainage was performed to relieve biliary obstruction and stabilize patients before definitive surgical repair. Data were collected on patient demographics, clinical presentation, haematological and biochemical profiles, imaging findings, procedural details, and outcomes. **Results**: Of the 12 children, 8 (66.7%) were female, with a mean age of 55 ± 55 months. Jaundice was present in 11 (91.7%), abdominal pain in 10 (83.3%), vomiting in 9 (75.0%), and fever in 6 (50.0%). Baseline bilirubin and liver enzymes were elevated in all cases. Following PTBD, bilirubin levels decreased by 56% (median) by day 7, with 90% symptom resolution. Eight patients proceeded to surgery, while three had unfavorable outcomes. No major PTBD-related complications occurred. At follow-up, all surgically treated patients had normalized liver function, with histopathology showing periportal fibrosis in 50% of cases. **Conclusion**: Percutaneous transhepatic biliary drainage was associated with clinical and biochemical stabilization in selected high-risk patients and may serve as an interim strategy before definitive surgery. Larger controlled studies are required to clarify its impact on outcomes.

Keywords: Choledochal cysts, Cholangitis, Drainage, Liver function test

Introduction

Choledochal cysts (CCs) are congenital anomalies of the biliary tree, characterized by abnormal dilatation of the intrahepatic and/or extrahepatic bile ducts. These cysts can lead to biliary stasis, recurrent cholangitis, hepatobiliary malignancies, and progressive liver dysfunction if left untreated.[1] The standard treatment for choledochal cysts is complete surgical excision with bilio-enteric reconstruction, most commonly Roux-en-Y hepaticojejunostomy.[2] However, in cases complicated by cholangitis, obstructive jaundice, or hepatic dysfunction, immediate surgical intervention may be associated with increased risk. In such scenarios, an interim decompressive procedure such as PTBD can be employed within the same clinical setting to stabilize the patient, improve liver function, and allow for safer definitive surgery. Percutaneous transhepatic biliary drainage is a minimally invasive technique that has been widely used for preoperative biliary decompression in various hepatobiliary conditions, including malignant biliary strictures and bile duct obstructions.[3] While PTBD has been extensively studied in adults, its role in paediatric patients with choledochal cysts remains less explored. Studies suggest that PTBD can effectively relieve biliary obstruction, improve liver function, and reduce the severity of cholangitis before definitive cyst excision.[4,5] However, PTBD is also associated with risks such as bile leakage, infection, and catheter dislodgement, warranting careful patient selection and monitoring.[6]

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Resubmitted after revision: 26-05-2026 **Accepted:** 27-05-2026 **Available Online**: 11-09-2026

Access this article online

Quick Response Code:

Website: https://www.afrjpaedsurg.com

DOI: https://doi.org/10.67481/ajps.v23i1.883

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How to cite this article: Rashi R, Kumar A, Sinha AK, Kumar B, Priyadarshi RN. Exploring the Role of Percutaneous Transhepatic Biliary Drainage in the Interim Management of Paediatric Choledochal Cysts with Cholangitis: A Pilot Study. Afr J Paediatr Surg 2026;23(1):7-14.

The timing of intervention for neonatal and infantile choledochal cysts remains a subject of debate. While some studies advocate early surgical excision, others recommend a delayed approach in asymptomatic cases to minimize perioperative risks.[2] In this context, PTBD offers a potential bridging strategy, allowing stabilization of patients before definitive surgical repair. Several studies have demonstrated its utility in restoring bile flow, reducing inflammation, and preventing further liver damage.[7]

Despite the well-established role of surgical excision in the definitive management of choledochal cysts, there remains a paucity of data exploring the role of PTBD as an interim stabilizing measure in critically ill paediatric patients presenting with cholangitis or liver dysfunction. Most available literature focuses on surgical outcomes in stable patients, with limited focus on real-world challenges in acutely ill children who may be unfit for immediate surgery.

Given this gap, and recognizing the ethical and logistical constraints of conducting randomized studies in emergency paediatric settings, exploratory observational studies like the present one are valuable in generating early insights. This pilot experience aims to inform future protocols and support decision-making in complex clinical scenarios where biliary decompression may serve as a necessary bridge to definitive treatment.

Methods

Study Design and Allocation

This was a non-randomized, prospective exploratory study where allocation to PTBD, PTBD followed by surgery, or primary surgery was based on the clinical stability of the child and caregiver's consent, rather than predefined randomization.

Setting and Duration

The study was conducted in the department of paediatric surgery at a tertiary care hospital. Both in-patient and out-patient units were involved, allowing for comprehensive perioperative monitoring. The study was carried out over a two-year period (January 2022 – December 2023), ensuring adequate follow-up and assessment of post-intervention outcomes.

Patient Selection

Inclusion criteria for this study included paediatric patients diagnosed with choledochal cysts complicated by cholangitis, presenting with fever (>38°C), jaundice (total bilirubin ≥2 mg/dL), and/or abdominal pain. Patients were also required to have biochemical evidence of cholestasis, including elevated direct bilirubin, alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and transaminases (SGOT/SGPT), along with radiological confirmation of bile duct dilatation on ultrasound and CECT abdomen/or magnetic resonance cholangiopancreatography (MRCP). Only those in whom immediate definitive surgery was not feasible due to acute infection, organ dysfunction, or other medical concerns were considered for PTBD intervention. Exclusion criteria included patients with choledochal cysts without cholangitis, those who had undergone previous biliary interventions such as surgical or endoscopic drainage, and those with congenital or syndromic anomalies affecting the hepatobiliary system. Patients with uncorrectable coagulopathy and those lost to follow-up before definitive surgery were also excluded from the study.

Intervention

Percutaneous transhepatic biliary drainage was considered only in children who demonstrated persistent clinical deterioration despite adequate intravenous antibiotic therapy and supportive care. Indications included ongoing fever with biochemical evidence of cholestasis, worsening liver function parameters, or signs of sepsis with hemodynamic instability rendering them high-risk for immediate definitive surgery. Thus, PTBD was not performed routinely for all cholangitis cases but selectively in children with inadequate response to medical management.

Nine out of 12 patient underwentunderwent PTBD as a preoperative intervention to relieve biliary obstruction and stabilize liver function before definitive surgical excision of the choledochal cyst. Prior to the procedure, patients received intravenous antibiotics to control infection, and coagulation parameters (INR, PT, aPTT) were assessed and corrected if necessary. Percutaneous transhepatic biliary drainage was performed under ultrasound and fluoroscopic guidance by an experienced interventional radiologist. After placing the patient in a supine position, local anaesthesia (1% lidocaine) was administered at the puncture site. Using real-time ultrasound guidance, a Chiba needle was inserted percutaneously into a dilated intrahepatic bile duct, and bile was aspirated to confirm proper placement. A hydrophilic guidewire was then advanced into the bile duct, followed by the insertion of a 6F or 8F drainage catheter over the guidewire. Contrast was injected under fluoroscopy to ensure accurate placement and bile duct decompression. The catheter was secured externally and connected to a drainage bag to facilitate bile flow.

Post-procedurally, bile drainage was maintained for 7–10 days, with careful monitoring of bile output, color, and patient condition.

Liver function tests (bilirubin, SGOT, SGPT, ALP, and GGT) were repeated at 24 hours, 72 hours, and prior to catheter removal to assess biochemical improvement. Patients continued intravenous antibiotics for 5–7 days, and complications such as infection, catheter displacement, and bile leakage were closely monitored. The decision for catheter removal or internalization was based on clinical and biochemical improvement. Once patients exhibited resolution of cholangitis and stabilization of liver function, they were scheduled for definitive surgical excision of the choledochal cyst with Roux-en-Y hepaticojejunostomy, which was performed 2–4 weeks post-PTBD.

Definitive Surgical Procedure: Once cholangitis resolved and liver function improved, definitive surgical repair (excision of the choledochal cyst and Roux-en-Y hepaticojejunostomy) was performed. Surgery was planned 2–4 weeks after PTBD to ensure optimal preoperative conditions.

Data Collection

Data were collected at three key time points: baseline (pre-intervention), post-intervention (at discharge), and follow-up (1-month and 3-months post-surgery). At baseline, patient demographics (age, sex, weight) and clinical presentation (fever, jaundice, abdominal pain, and abdominal distension) were documented. Biochemical parameters, including total and direct bilirubin, aspartate aminotransferase (SGOT), alanine aminotransferase (SGPT), alkaline phosphatase (ALP), gamma-glutamyl transferase (GGT), and inflammatory markers such as C-reactive protein (CRP) and total leukocyte count (TLC), were recorded to assess liver function and infection status. Imaging findings from ultrasound, CECT abdomen and magnetic resonance cholangiopancreatography (MRCP) confirmed bile duct dilatation and cyst classification.

Following PTBD, liver function tests were repeated at 24 hours, 72 hours, and before discharge to monitor biochemical improvement. Symptomatic relief, including resolution of fever, jaundice, and abdominal pain, was also noted. Any procedure-related complications such as catheter dislodgement, bile leakage, or infection were systematically recorded. At follow-up (1-month and 3-months post-surgery), patients underwent clinical assessment and laboratory testing to evaluate long-term liver function improvement and overall recovery. Postoperative outcomes, including cholangitis recurrence, anastomotic integrity, and any late complications such as bile stasis or strictures, were documented. Imaging studies, when indicated, were used to assess biliary drainage and cyst resolution.

Outcome Measures

The primary outcomes of this study included liver function improvement, assessed through reductions in total and direct bilirubin levels, along with the normalization of SGOT, SGPT, ALP, and GGT following PTBD. Additionally, resolution of cholangitis symptoms, including improvement in fever, jaundice, and abdominal pain, was monitored post-intervention. Another key outcome was the successful transition to definitive surgery, evaluating whether PTBD effectively stabilized patients for elective excision of the choledochal cyst with Roux-en-Y hepaticojejunostomy.

Secondary outcomes included procedure-related complications, such as bile leakage, catheter dislodgement, infection, or bleeding following PTBD. The length of hospital stays post-PTBD, and post-surgical recovery was also assessed to evaluate the intervention's impact on overall treatment duration. Long-term liver function recovery was monitored through serial liver function tests at 1-month and 3-months post-surgery, ensuring sustained biochemical normalization.

Ethical Considerations

This study was approved by the Institutional Ethics Committee (IRC Approval No. AIIMS/Pat/IEC/2020/475) and conducted in accordance with ethical guidelines for biomedical research involving human participants. Written informed consent was obtained from parents or legal guardians before enrollment. Percutaneous transhepatic biliary drainage and surgical interventions followed standard paediatric surgical and interventional radiology protocols, ensuring patient safety. Radiation safety and sedation were administered under strict supervision. Confidentiality was maintained by de-identifying patient data, with restricted access to authorized personnel. All data were securely stored and used solely for research purposes. No financial incentives were provided, and there were no conflicts of interest.

Results

Given the exploratory nature of the study, small sample size, and clinically determined group allocation, no statistical comparisons were performed, and findings are presented descriptively to illustrate clinical trends rather than infer causal associations. Although the original study protocol intended all eligible children with choledochal cyst and cholangitis to undergo PTBD followed by definitive surgical excision, the final grouping emerged naturally due to variations in clinical courses and parental consent. Imaging revealed giant choledochal cysts (diameter >10 cm) in four patients (Figure 1a). Of the 12 enrolled cases, 3 children underwent upfront definitive surgery without preceding PTBD, as their caregivers declined the drainage procedure. In 5 cases, PTBD was successfully performed, followed by scheduled cyst excision surgery, as originally planned. In two of these patients, a preoperative PTBD cholangiogram was additionally performed to delineate the biliary anatomy and to confirm appropriate positioning of the PTBD catheter prior to definitive surgery (Figure 1b-1c). However, in 4 children, definitive surgery could not be undertaken following PTBD. Two children unfortunately died during the early post-procedure period, both children had presented with severe sepsis, marked coagulopathy, and haemodynamic instability at admission. PTBD was undertaken as a salvage decompressive measure due to their inability to tolerate major surgery. No procedure-related complications such as haemorrhage, bile leak, or catheter-related sepsis were documented. Clinical deterioration in these cases was attributed to progressive septic shock and multi-organ dysfunction rather than technical failure of the drainage procedure. Two left the hospital against medical advice (LAMA). As a result, the study population was categorized into three distinct groups for analysis: Group 1 (PTBD only), Group 2 (PTBD followed by surgery), and Group 3 (primary surgery without PTBD). The outcomes and clinical parameters were subsequently analysed and presented across these three groups to reflect the real-world distribution and capture meaningful differences in clinical progression and response to interventions. All children in the PTBD plus surgery group and surgery-alone group had satisfactory postoperative outcomes and were clinically stable at discharge.

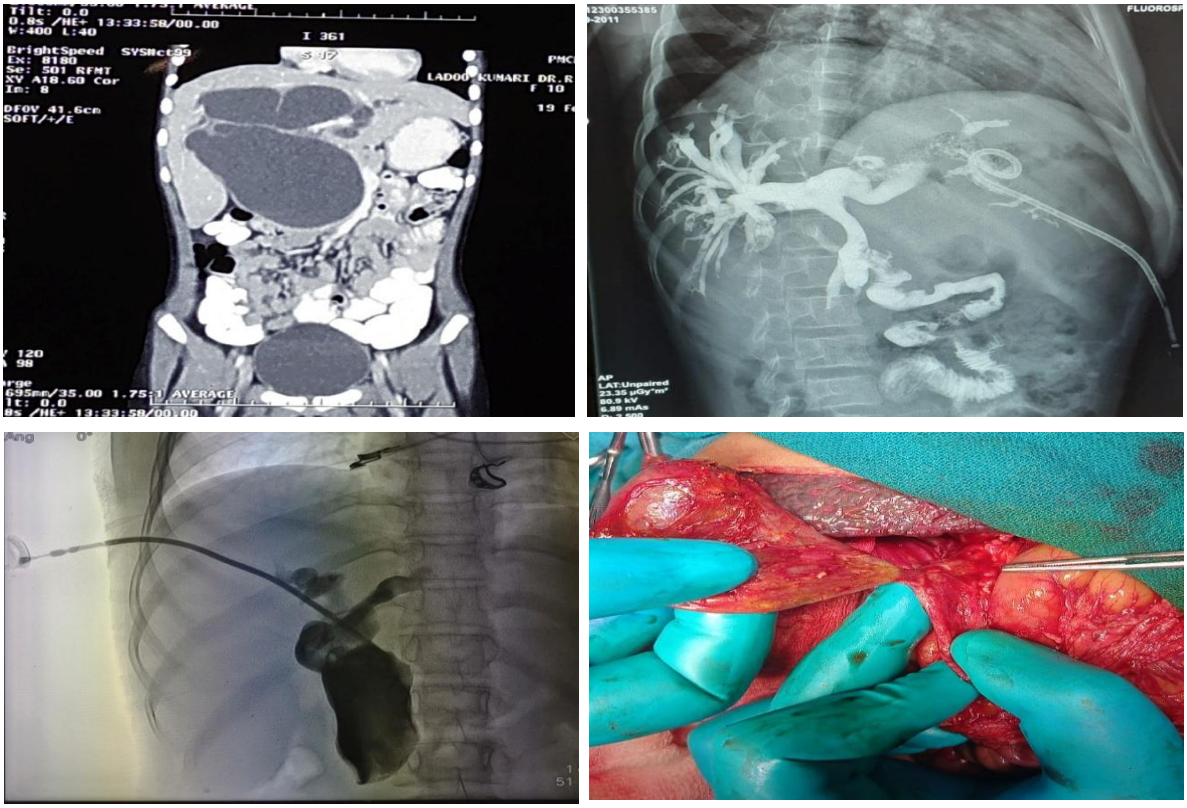


Figure 1a: CECT abdomen demonstrating a giant choledochal cyst in a 9-year-old female presenting with cholangitis.
Figure 1b: PTBD cholangiogram showing dilatation of the intrahepatic biliary radicals.
Figure 1c: PTBD catheter positioned in the right hepatic duct demonstrating the morphology of a choledochal cyst.
Figure 1d: Intraoperative photograph showing liver fibrosis and the excised cyst in a case of infantile choledochal cyst.

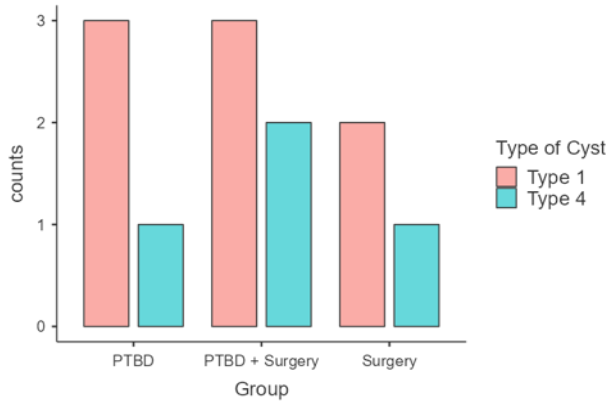


Figure 2: Type of cyst across intervention group

Table 1 presents the clinical profile of the 12 enrolled patients distributed across the three intervention groups. Female children constituted 8 (66.7%) of the total sample, with all 5 (100%) patients in the PTBD + surgery group being female. The mean age was lowest in the PTBD group (11 months), compared with 96 months in the PTBD + surgery group and 47 months in the surgery group. Jaundice was the most common clinical feature, present in 11 (91.7%) patients, followed by pain in 10 (83.3%) and vomiting in 9 (75.0%) patients. Fever was reported in 6 (50.0%) patients overall and was most frequent in the PTBD + surgery group, occurring in 4/5 (80.0%) patients. Clay-coloured stools were observed in 9 (75.0%) patients, while pallor and icterus were each present in 10 (83.3%) patients.

Figure 2 shows the distribution of choledochal cyst types across the three intervention groups. Type 1 cysts were more common overall and predominantly observed in all groups, including PTBD, PTBD + surgery, and surgery groups. Type 4 cysts were less frequent. The figure shows the absolute count of each cyst type within each intervention group.

Table 2 displays the trend in biochemical parameters across the three intervention groups at Day 0 (baseline), Day 3, and Day 7. At baseline, the PTBD group had the highest mean total leukocyte count (25,827/mm³) and CRP (151.4 mg/L), while the lowest haemoglobin was also noted in this group (8.8 g/dL). By Day 7, haemoglobin improved in the PTBD + surgery and surgery groups (11.8 and 11.2 g/dL, respectively),

Table 1: Patient Profile and Clinical Features Across Groups (n = 12)

Variable	PTBD (n=4)	PTBD+ Surgery (n=5)	Surgery (n=3)	Total (n=12)
Gender [Female]	2 (50%)	5 (100%)	1 (33.3%)	8 (66.7%)
Age in months, Mean (SD)	11 (9)	96 (53)	47 (55)	55 (55)
Birth Order				
1st	3 (75%)	2 (40%)	2 (66.7%)	7 (58.3%)
2nd	1 (25%)	3 (60%)	0 (0%)	4 (33.3%)
3rd	0 (0%)	0 (0%)	1 (33.3%)	1 (8.3%)
Fever [Yes]	2 (50%)	4 (80%)	0 (0%)	6 (50%)
Jaundice [Yes]	4 (100%)	4 (80%)	3 (100%)	11 (91.7%)
Lump [Yes]	3 (75%)	4 (80%)	1 (33.3%)	8 (66.7%)
Pain [Yes]	3 (75%)	4 (80%)	3 (100%)	10 (83.3%)
Clay Stools [Yes]	3 (75%)	3 (60%)	3 (100%)	9 (75%)
Pruritus [Yes]	2 (50%)	3 (60%)	0 (0%)	5 (41.7%)
Vomiting [Yes]	2 (50%)	4 (80%)	3 (100%)	9 (75%)
Pallor [Yes]	4 (100%)	4 (80%)	2 (66.7%)	10 (83.3%)
Icterus [Yes]	4 (100%)	4 (80%)	2 (66.7%)	10 (83.3%)

Table 2: Descriptive Statistics [Mean (SD)] of Biochemical Profile on Day 0, Day 3, and Day 7 Across PTBD, PTBD + Surgery, and Surgery Groups

Group		Hb (g/dL)	CRP (mg/L)	T. Bil (mg/dL)	D. Bil (mg/dL)	SGOT (U/L)	SGPT (U/L)	PT (sec)	ALP (U/L)	INR	PTBD Output (mL)
PTBD	**Day 0**	8.8 (1.8)	151.4 (39.9)	7.3 (1.7)	3.6 (0.4)	160.6 (50.2)	181.6 (151.3)	33.3 (37.8)	767.3 (281.5)	2.7 (3.3)	NA
	Day 3	11.0 (1.3)	62.6 (53.3)	3.5 (0.3)	1.6 (0.2)	67.7 (12.9)	51.7 (17.0)	12.7 (1.3)	477.7 (139.0)	1.1 (0.2)	327.5 (125.8)
	Day 7	9.0 (0.5)	99.1 (1.6)	3.3 (0.9)	1.6 (0.4)	86.5 (29.0)	75.5 (68.6)	16.4 (4.7)	311.5 (94.1)	1.3 (0.3)	465.0 (NA)
PTBD + Surgery	**Day 0**	9.5 (1.7)	84.1 (39.7)	7.9 (5.0)	4.1 (2.5)	241.5 (132.5)	245.2 (155.4)	24.3 (20.1)	713.2 (362.6)	2.2 (2.2)	-
	Day 3	11.1 (0.8)	35.8 (28.7)	5.9 (3.4)	2.9 (1.9)	146.5 (110.2)	152.5 (132.0)	13.3 (1.9)	527.2 (243.4)	1.2 (0.5)	424.0 (222.8)
	Day 7	11.8 (0.4)	12.7 (20.9)	3.9 (2.7)	2.0 (1.4)	68.8 (27.5)	67.2 (28.8)	11.3 (1.1)	314.9 (147.1)	0.9 (0.2)	253.0 (121.3)
Surgery	**Day 0**	10.6 (1.7)	60.3 (52.4)	5.6 (4.7)	2.5 (2.4)	124.2 (74.0)	184.5 (94.0)	14.4 (3.5)	423.8 (78.3)	1.2 (0.2)	NA
	Day 3	11.1 (1.3)	29.2 (40.0)	4.3 (4.5)	1.9 (2.1)	79.3 (44.4)	92.7 (47.4)	11.5 (0.7)	302.7 (67.4)	0.9 (0.2)	NA
	Day 7	11.2 (0.6)	9.6 (14.2)	2.2 (2.6)	0.6 (0.9)	56.7 (15.3)	57.7 (15.5)	10.3 (0.4)	199.2 (73.0)	0.8 (0.0)	NA

Hb; Hemoglobin (g/dL); CRP: C-reactive Protein (mg/L); T. Bil: Total Bilirubin (mg/dL); D. Bil: Direct Bilirubin (mg/dL); SGOT: Serum Glutamic-Oxaloacetic Transaminase (U/L); SGPT: Serum Glutamic-Pyruvic Transaminase (U/L); PT: Prothrombin Time (seconds); ALP: Alkaline Phosphatase (U/L); INR: International Normalized Ratio; PTBD Output: Bile Drainage Output (mL).

while remaining low in the PTBD-only group (8.95 g/dL). Total and direct bilirubin levels decreased steadily in all groups, with the most marked reduction observed in the surgery group (from 5.6 to 2.2 mg/dL for total bilirubin). SGOT, SGPT, ALP, PT, and INR values also showed improvement over time, particularly in the PTBD + surgery and surgery groups. PTBD output was recorded in PTBD-related groups, with higher average output at Day 7 in the PTBD-only group (465 mL) compared to the PTBD + surgery group (253 mL).

Intraoperative assessment and histopathological evaluation

were available for eight patients who underwent surgical excision of choledochal cysts (Table-3). Mild fibrosis was noted in 2 cases (one each in PTBD + surgery and surgery groups), while cirrhotic changes (Figure 1d) or heterogeneous liver texture were reported in 4 cases, predominantly among those who underwent PTBD followed by surgery. Type 1 cyst was the most common cyst type (n=5), followed by Type 4/4A (n=2) and a single case of Type 6 cyst with dilated cystic duct. Histopathological examination revealed periportal fibrosis with or without hepatocyte ballooning in 4 cases and mild portal fibrosis with bile duct proliferation in 1 case.

Table 3: Intraoperative and Histopathological Findings in PTBD + Surgery and Surgery Groups (n = 8)

Findings	PTBD + Surgery (n=5)	Surgery (n=3)	Total
Intraoperative (IOF) Findings			
Mild fibrosis	1	1	2
Cirrhotic changes / Heterogeneous liver	3	1	4
Normal liver	0	1	1
Type 1 Cyst	3	2	5
Type 4 / Type 4A Cyst	2	0	2
Type 6 Cyst (Dilated cystic duct)	0	1	1
Histopathological (HPE) Findings			
Periportal fibrosis ± Hepatocyte ballooning	4	0	4
Marked bile duct proliferation, nodules, fibrotic bands	0	1	1
Mild portal fibrosis + Bile duct proliferation	1	0	1
Chronic cholecystitis + Choledochal cyst	5	2	7
Normal liver (No fibrosis/steatosis)	0	1	1

Table 4: Biochemical Profile at One-Month Follow-Up in Surgically Treated Patients (n = 8)

Variable	PTBD + Surgery (n = 5)	Surgery (n = 3)
Hemoglobin (g/dL)	11.86 (0.86)	11.83 (0.97)
Total Leukocyte Count (/mm³)	8600 (1655)	8266 (2468)
Total Bilirubin (mg/dL)	1.13 (1.22)	0.70 (0.36)
Direct Bilirubin (mg/dL)	0.30 (0.38)	0.04 (0.03)
Prothrombin Time (sec)	10.90 (0.62)	10.67 (0.42)
INR	0.86 (0.05)	0.84 (0.05)

INR= International normalized ratio

One case in the surgery group showed marked bile duct proliferation with nodules and fibrotic bands, indicating advanced biliary pathology. Chronic cholecystitis associated with choledochal cyst was identified in 7 out of 8 cases, reflecting chronic inflammation, whereas only one patient (surgery group) demonstrated normal liver histology without fibrosis or steatosis. At one-month follow-up, all surgically treated patients, including those in the PTBD + surgery and surgery-only groups, demonstrated substantial improvement in their biochemical profiles (Table 4). The mean haemoglobin levels were similar between groups (11.86 ± 0.86 g/dL vs. 11.83 ± 0.97 g/dL), and both groups showed normalization of total and direct bilirubin levels, with slightly higher values in the PTBD + surgery group (T. Bil: 1.13 ± 1.22mg/dL vs. 0.70 ± 0.36 mg/dL; D. Bil: 0.30 ± 0.38 mg/dL vs. 0.04 ± 0.03 mg/dL). Coagulation parameters, including PT and INR, also normalized a cross both groups. Importantly, 100% clinical recovery was noted in all patients at one month, with no residual jaundice, cholangitis, or other complications reported during follow-up.

Discussion

This pilot non-randomized interventional study was designed to assess the role of PTBD as a preoperative stabilizing measure in children with choledochal cysts presenting with cholangitis.

Although the intended protocol involved performing PTBD followed by definitive surgical excision in all eligible cases, variations in parental consent and clinical progression led to natural grouping of patients. Three children underwent primary surgery without prior PTBD, five underwent PTBD followed by surgery, and four underwent PTBD but could not proceed to surgery due to clinical deterioration (n=2) or discharge against medical advice (n=2).

Clinical and biochemical improvement was most pronounced in children who underwent surgery—either following PTBD or directly—with all such cases showing normalization of liver function and stable clinical condition at one-month follow-up. In contrast, cases where surgery could not be completed after PTBD experienced poor outcomes, highlighting the necessity of timely definitive intervention. The role of PTBD as an interim strategy in paediatric choledochal cysts with cholangitis has been highlighted by our study. Percutaneous transhepatic biliary drainage resulted in rapid clinical stabilization, with marked improvement in jaundice, fever, and signs of sepsis, along with a reduction in total and direct bilirubin, CRP, and improvement in coagulation parameters. This role of PTBD as a temporizing measure until definitive surgery is

consistent with reports from adult literature, where PTBD has been successfully employed to manage acute suppurative cholangitis and obstructive jaundice in high-risk patients.[4] Paediatric studies, however, are scarce.

A retrospective review, also emphasized the importance of biliary decompression in complicated choledochal cysts, although endoscopic retrograde cholangiopancreatography (ERCP) is often preferred when feasible.[8] However, ERCP may not be technically possible or safe in younger children or in the presence of severe infection, making PTBD a valuable alternative. Soares *et al.*[9] also noted that while biliary drainage methods are critical in managing cholangitis, there is no consensus on the best approach in children, especially in emergency settings. Our findings support that PTBD can effectively stabilize children by decompressing the biliary system, thereby controlling infection and improving liver function, facilitating safer subsequent surgical excision.

Our study also highlights the critical limitation of PTBD when not followed by definitive surgical excision. All cases with the poorest outcomes in this study; two deaths and two LAMA were infants under one year of age. These patients presented with severe cholangitis, elevated inflammatory markers, and deranged liver function, and were managed with PTBD alone due to clinical instability or inability to proceed with definitive surgery. This pattern aligns with previous literature suggesting that infantile-type choledochal cysts often present more aggressively, with earlier onset of hepatic dysfunction and higher risk of adverse outcomes if not promptly managed.[10] Our findings are consistent with the broader literature, which underscores the necessity of complete cyst excision to prevent recurrent biliary obstruction, cholangitis, and malignant transformation.[9,11] Even Nakayama *et al.,*[8] who advocated biliary decompression in critically ill children, stressed the need for prompt definitive surgery once the acute crisis is managed. Thus, while PTBD is a valuable bridge to surgery, our study reaffirms that timely surgical intervention is indispensable to achieve long-term survival and prevent fatal complications in children with choledochal cysts complicated by cholangitis. The two mortalities in our cohort occurred in infants who presented with advanced sepsis and significant hemodynamic compromise. Percutaneous transhepatic biliary drainage in these cases was performed as a rescue decompressive intervention because definitive surgical excision was deemed unsafe in the acute setting. No immediate procedural complications were identified, and deterioration was consistent with progressive septic physiology. While it remains theoretically possible that any intervention in critically ill children may contribute to instability, the clinical course in these patients suggests that the severity of underlying disease rather than the drainage procedure itself was the primary determinant of outcome. While the observed improvement in clinical and biochemical profiles among patients who underwent PTBD followed by surgery is encouraging, these findings must be interpreted with caution. The non-randomized design, small sample size, and natural group allocation based on clinical severity and parental consent limit the ability to draw causal inferences regarding the effectiveness of PTBD alone. Additionally, the heterogeneity of presentation across groups precludes meaningful statistical comparison. Therefore, the results of this study should be viewed as exploratory and hypothesis-generating, intended to inform future prospective studies rather than establish definitive treatment recommendations.

Histopathological examination and intraoperative findings in our study further reinforce the need for timely surgical intervention in children with choledochal cysts and cholangitis. Among children who underwent surgery, intraoperative assessment revealed that the liver was often fibrotic or had heterogeneous texture suggestive of chronic biliary obstruction. Notably, cirrhotic changes were documented in two cases, and periportal fibrosis and ballooning of hepatocytes were common histological features. These findings align with previous reports that have demonstrated significant hepatic fibrosis and even cirrhosis in children with delayed management of choledochal cysts.[10,12] Furthermore, all cyst specimens showed features of chronic cholecystitis along with the choledochal cyst, indicating a long-standing inflammatory process. Our data support earlier studies, including those by Kahriman *et al*.[5] and Hamada *et al.,* emphasizing that persistent biliary stasis and infection can lead to irreversible liver damage if definitive excision is delayed. Hence, intraoperative and histopathological findings in our series highlight the progressive nature of hepatic injury associated with choledochal cysts and underscore the importance of timely surgery to prevent chronic liver disease and its complications.

At one-month follow-up, all children who underwent PTBD followed by surgery, as well as those managed with primary surgery, demonstrated marked improvement in both clinical status and biochemical parameters, with normalization of liver function tests and resolution of cholangitis. Importantly, 100% clinical recovery was observed in these groups, underscoring the effectiveness of combining biliary drainage with definitive surgical excision. These findings align with previous reports where initial biliary decompression followed by surgical excision has led to favourable outcomes in complicated cases.[8,12] Our results are consistent with the observations by Inoue *et al*.,[7] who reported that preoperative drainage improves surgical safety and reduces perioperative complications in choledochal cysts complicated by cholangitis. Furthermore, no major surgical complications or recurrence of symptoms were noted at one month, suggesting that PTBD is a safe bridging procedure when used appropriately. However, our data also emphasize that this favourable outcome is contingent on subsequent surgical excision, as patients managed with PTBD alone had poor outcomes. Overall, our findings reinforce the role of PTBD as a temporizing but not definitive solution, and when followed by timely surgery, may support clinical

recovery and prevent progression to chronic liver disease. This study offers valuable insights as one of the few prospective analyses evaluating the role of PTBD in paediatric choledochal cysts with cholangitis, highlighting both its potential benefits and limitations. A key strength is the detailed biochemical and clinical monitoring at multiple time points, along with histopathological correlations in surgical cases, providing a comprehensive understanding of disease progression and response to intervention.

Limitations of study

This study is limited by its small sample size, non-randomized design, and heterogeneity in clinical presentation across groups. The absence of statistical comparisons and reliance on descriptive outcomes restrict the generalizability of findings. Despite these limitations, the study offers preliminary insights into the potential role of PTBD in acute stabilization and highlights the need for further prospective research.

This pilot study underscores the potential value of PTBD as an interim stabilization strategy in children with choledochal cysts complicated by cholangitis, particularly in those unfit for immediate surgery. While our findings demonstrate clinical and biochemical improvement following PTBD, especially when followed by definitive surgical excision, the absence of surgery was associated with unfavourable outcomes. Therefore, PTBD should be considered a temporizing intervention, not a substitute for cyst excision. It is important to emphasize that this study was not designed to compare PTBD versus surgery or to establish statistical superiority of one intervention over another. Rather, it reflects real-world clinical decision-making in critically ill children where immediate surgery may not be feasible. The descriptive trends observed should therefore be interpreted as observational insights rather than evidence of treatment effect.

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