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Closing the Diagnostic-Therapeutic Gap in Post-Cholecystectomy Biliary Complications: Impact of Endoscopic Ultrasound on Diagnostic Reclassification and Therapeutic Decision-Making in a Multidisciplinary Hepatopancreatobiliary Pathway

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ABSTRACT:

Background & Aim: Post-cholecystectomy biliary complications present diagnostic challenges due to frequent discordance between non-invasive and invasive imaging. This study evaluates the impact of Endoscopic Ultrasound (EUS) on diagnostic reclassification and therapeutic decision-making within a structured multidisciplinary hepatopancreatobiliary (HPB) pathway.

Methods: A retrospective observational cohort study of 50 patients with suspected post-cholecystectomy biliary complications was conducted. Patients underwent Ultrasonography (US), Magnetic Resonance Cholangiopancreatography (MRCP), EUS, and Endoscopic Retrograde Cholangiopancreatography (ERCP) when indicated. Diagnostic reclassification was categorized into Confirmation, Upgrading, Downgrading, and Additional Pathology.

Results: EUS resulted in a diagnostic reclassification rate of 50% (25/50). MRCP findings were downgraded by EUS in 22% of cases, upgraded in 22%, and revealed additional pathology in 6%. Imaging concordance (Cohen's Kappa) was moderate between MRCP and EUS ($\varkappa = 0.58$) but almost perfect between EUS and ERCP ($\varkappa = 0.88$). EUS altered the therapeutic plan in 50% of patients, significantly reducing unnecessary ERCPs.

Conclusion: EUS significantly improves diagnostic accuracy, reclassifies indeterminate biliary pathology, and optimizes therapeutic decision-making. Its integration into a multidisciplinary HPB pathway is essential for closing the diagnostic-therapeutic gap.

1 INTRODUCTION

Post-cholecystectomy biliary complications, including retained common bile duct (CBD) stones, bile leaks, and iatrogenic biliary strictures, represent a significant clinical challenge in hepatopancreatobiliary (HPB) practice [1]. The traditional diagnostic pathway relies on transabdominal ultrasonography (US) as the initial modality, followed by Magnetic Resonance Cholangiopancreatography (MRCP) as the non-invasive reference standard, and Endoscopic Retrograde Cholangiopancreatography (ERCP) for therapeutic intervention [2]. However, a critical diagnostic-therapeutic gap frequently exists in this pathway.

MRCP, while highly sensitive, can overestimate or misclassify biliary pathology. Motion artifacts, postoperative anatomical changes, or thickened bile can mimic filling defects or strictures, leading to false-positive interpretations [3]. Conversely, MRCP may miss subtle common hepatic duct (CHD) strictures, complex fluid collections, or periampullary lesions that require targeted evaluation [4]. ERCP, though therapeutic, carries a substantial risk of severe complications, including post-ERCP pancreatitis, hemorrhage, and perforation, with overall complication rates ranging from 5% to 9.8% in large prospective studies [5]. Performing ERCP based solely on equivocal MRCP findings increases the rate of non-therapeutic procedures, exposing patients to unnecessary risks and increasing healthcare costs [6].

Endoscopic Ultrasound (EUS) has emerged as a high-resolution, minimally invasive intermediate modality. By providing detailed sonographic visualization of the distal biliary tree, periampullary region, and surrounding vasculature, EUS can accurately differentiate true pathology from imaging artifacts, with reported sensitivity and specificity exceeding 89% and 96% for choledocholithiasis, respectively [7]. Despite its proven diagnostic utility, the systematic integration of EUS into a structured multidisciplinary team (MDT) framework, incorporating specialized radiology, gastroenterology, and anesthesiology risk stratification, remains underexplored in the existing literature [8].

This study aims to evaluate the impact of EUS on diagnostic reclassification and therapeutic decision-making in a structured, multidisciplinary HPB pathway. We hypothesize that EUS significantly alters clinical management, reclassifies indeterminate biliary pathology, and optimizes resource utilization by preventing unnecessary invasive procedures.

2 METHODS

2.1 Study Design and Setting

This retrospective, observational cohort study was conducted at a tertiary care HPB center between January 2022 and December 2024. The study was approved by the Institutional Review Board, Faculty of medicine, Al-Azhar University (IRB approval number: HepGid-M-R-6-0063) and was conducted in strict adherence to the ethical principles of the Declaration of Helsinki for medical research involving human subjects [9]. All patient data were anonymized and handled in compliance with institutional data protection protocols. Informed consent was waived due to the retrospective, observational nature of the study, consistent with the Declaration of Helsinki provisions for retrospective research.

2.2 Study Population

The study included 50 consecutive patients who underwent evaluation for suspected post-cholecystectomy biliary complications. Inclusion criteria were: (a) previous cholecystectomy, (b) clinical suspicion of biliary complication based on biochemical or imaging findings, and (c) completion of US, MRCP, and EUS within the diagnostic pathway. ERCP was performed when clinically indicated following MDT discussion. Exclusion criteria included incomplete clinical or imaging data, missing EUS reports, and known pancreaticobiliary malignancy prior to referral.

2.3 Data Collection

All eligible cases were retrospectively retrieved and compiled into standardized case dossiers. To minimize interpretation and incorporation bias, US and MRCP were independently reviewed by consultant radiologists blinded to EUS and ERCP results, while EUS and ERCP were reviewed by senior endoscopists blinded to prior imaging. Patients followed a structured diagnostic workflow: Clinical suspicion → US → MRCP → EUS → ERCP/Surgery/Observation. The MDT framework included gastroenterology, diagnostic radiology, HPB surgery, internal medicine, interventional radiology, and anesthesiology. Anesthesiology provided pre-procedural risk stratification using the American Society of Anesthesiologists (ASA) classification, airway evaluation, and optimization for high-risk patients, ensuring safe sedation planning. Comprehensive geriatric assessment was done for patients more than 60 years old.

2.4 Outcome Definitions

The primary outcome was the Diagnostic Reclassification Rate, categorized into four indices: (1) Confirmation (MRCP diagnosis confirmed by EUS), (2) Upgrading (more severe pathology detected by EUS than suggested by MRCP), (3) Downgrading (false-positive MRCP findings excluded by EUS), and (4) Additional Pathology (new findings identified on EUS not seen on MRCP). Secondary outcomes included the Therapeutic Impact Rate, defined as the proportion of patients whose management plan was modified following EUS, and the Incremental Diagnostic Yield across sequential imaging modalities.

2.5 Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range [IQR]), and categorical variables as frequencies and percentages, with no comparator group; therefore baseline characteristics in Table 1 are reported descriptively without between-group hypothesis testing. Agreement between imaging modalities was assessed using Cohen's Kappa (κ), interpreted as: <0.20 poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 substantial, and 0.81–1.00 almost perfect. Paired comparisons for categorical data were analyzed using the McNemar test. Diagnostic performance of MRCP against the final consensus diagnosis (established by EUS, ERCP/surgical findings, or composite clinical follow-up) was expressed as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy, with 95% Confidence Intervals (CI). A p-value < 0.05 was considered statistically significant. All analyses were performed using IBM SPSS Statistics (Version 26).

3 RESULTS

3.1 Characteristics of Participants

The study cohort comprised 50 patients. The mean age was 46.2 ± 11.4 years, with a male predominance (58%, n = 29). The median postoperative interval was 4.5 weeks (IQR: 2.0–12.0). The most common clinical indications were obstructive jaundice (44%) and assessment of biliary strictures (28%). Comorbidities included hypertension (24%), diabetes mellitus (18%), and Hepatitis C infection (12%). Biochemical parameters revealed a median total bilirubin of 3.8 mg/dL (IQR: 1.2–7.6). Baseline demographic and clinical characteristics are detailed in Table 1.

Table 1. Baseline Demographic and Clinical Characteristics of the Study Cohort (N = 50)

Variable	Value / Category	n (%) or Mean ± SD / Median (IQR)
Age (years)	Mean ± SD	46.2 ± 11.4
Sex	Male / Female	29 (58%) / 21 (42%)
Post-op Interval (weeks)	Median (IQR)	4.5 (2.0 – 12.0)
Total Bilirubin (mg/dL)	Median (IQR)	3.8 (1.2 – 7.6)
Comorbidities	Hypertension	12 (24%)
	Diabetes Mellitus	9 (18%)
	Hepatitis C Infection	6 (12%)
Indication	Obstructive Jaundice	22 (44%)
	Biliary Stricture	14 (28%)
	CBD/Cystic Duct Injury	8 (16%)
	Distal CBD Tapering	6 (12%)

Note. CBD = common bile duct; CHD = common hepatic duct; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasound; MRCP = magnetic resonance cholangiopancreatography; SD = standard deviation; IQR = interquartile range; CI = confidence interval.

3.2 Imaging Concordance and Diagnostic Yield

MRCP identified suspected pathology in 42 patients (84%), while EUS identified pathology in 35 patients (70%). ERCP confirmed therapeutic targets in 25 patients (50%). Cohen's Kappa analysis demonstrated moderate agreement between US and EUS ($\kappa = 0.42$, $p < .001$) and moderate-to-substantial agreement between MRCP and EUS ($\kappa = 0.58$, $p < .001$). The highest concordance was observed between EUS and ERCP ($\kappa = 0.88$, $p < .001$), indicating near-perfect agreement. McNemar's test revealed a statistically significant difference in the detection of choledocholithiasis between MRCP and EUS ($p = .004$), highlighting MRCP's tendency to overcall stones. The imaging concordance analysis is summarized in Table 2.

Table 2. Imaging Concordance and Agreement Analysis Between Modalities

Modality Comparison	Cohen's κ	95% CI	p-value	McNemar p (Stones)
US vs. EUS	0.42	0.28 – 0.56	< .001	.112
MRCP vs. EUS	0.58	0.45 – 0.71	< .001	.004*
EUS vs. ERCP	0.88	0.79 – 0.97	< .001	.650

*Note. *p < .05. CBD = common bile duct; CHD = common hepatic duct; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasound; MRCP = magnetic resonance cholangiopancreatography; SD = standard deviation; IQR = interquartile range; CI = confidence interval.*

3.3 Diagnostic Reclassification by EUS

EUS significantly altered the diagnostic classification in 50% (25/50) of patients. MRCP findings were confirmed by EUS in 25 patients (50%), demonstrating diagnostic concordance. Downgrading occurred in 11 patients (22%), where EUS refuted MRCP findings of stones or tight strictures, reclassifying them as normal CBD or benign postoperative tapering. Upgrading occurred in 11 patients (22%), where EUS detected more severe pathology, such as periampullary masses or complex CHD strictures, that were missed or underestimated by MRCP. Additional pathology, including complex operative bed fluid collections, was identified in 3 patients (6%). The Diagnostic Reclassification Index is presented in Table 3, and the distribution is illustrated in Figure 1.

Table 3. Diagnostic Reclassification Index (DRI) by EUS (N = 50)

DRI Category	Definition	n (%)	Clinical Examples
Confirmation	MRCP diagnosis confirmed by EUS	25 (50%)	MRCP stone → EUS stone; MRCP stricture → EUS stricture
Downgrading	False-positive MRCP excluded by EUS	11 (22%)	MRCP filling defect → EUS normal CBD; MRCP stricture → benign tapering
Upgrading	More severe pathology detected by EUS	11 (22%)	MRCP tapering → EUS periampullary mass; MRCP distal stricture → EUS CHD stricture
Additional Pathology	New findings detected on EUS	3 (6%)	MRCP stricture → EUS complex operative bed collection / biloma

Note. CBD = common bile duct; CHD = common hepatic duct; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasound; MRCP = magnetic resonance cholangiopancreatography; SD = standard deviation; IQR = interquartile range; CI = confidence interval.

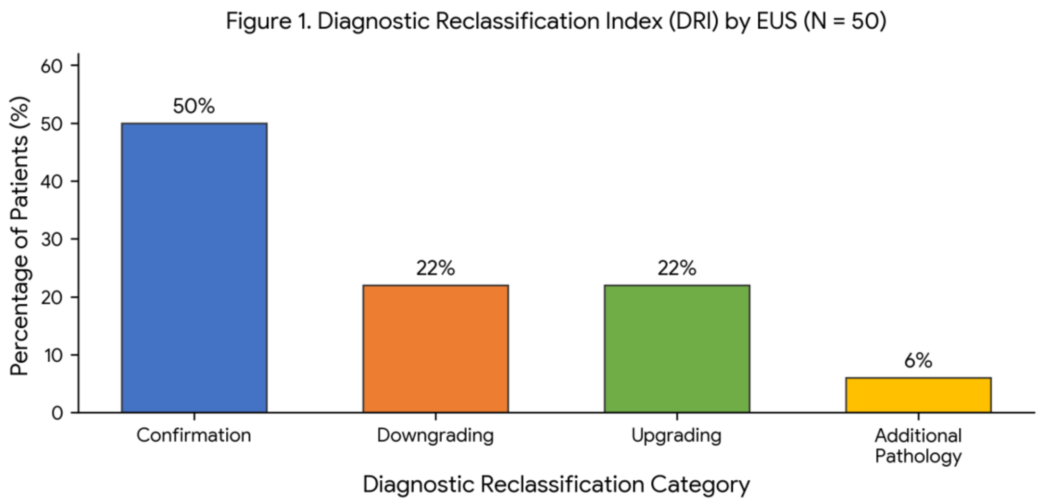

Figure 1. Diagnostic Reclassification Index (DRI) by EUS (N = 50). EUS confirmed MRCP findings in 50% of cases, while reclassifying the remaining 50% through downgrading (22%), upgrading (22%), or identification of additional pathology (6%).

3.4 Therapeutic Impact of EUS

EUS altered the primary therapeutic plan in 25 patients (50%). In the 11 downgraded patients, EUS prevented unnecessary ERCPs, shifting management to conservative observation and serial follow-up. In the 11 upgraded patients, EUS redirected management toward surgical resection or oncological pathways, facilitating timely referral for periampullary masses and complex strictures. In the 3 patients with additional pathology, EUS facilitated targeted interventional radiology drainage for operative bed collections and bilomas. Among the 25 patients with confirmed MRCP diagnoses, targeted ERCP was performed with a 100% therapeutic success rate. The therapeutic impact and management modifications are detailed in Table 4.

Table 4. Therapeutic Impact and Management Modification Post-EUS (N = 50)

Therapeutic Modification	**n (%)**	**Primary Driver (DRI Category)**
ERCP Avoided (Conservative)	11 (22%)	Downgrading (False-positive MRCP)
Surgical / Oncological Referral	11 (22%)	Upgrading (Occult mass / complex stricture)
IR Drainage / Surgical Revision	3 (6%)	Additional Pathology (Collections / leaks)
Targeted ERCP Proceeded	25 (50%)	Confirmation (True stones / strictures)
Total Altered Management	25 (50%)	

Note. CBD = common bile duct; CHD = common hepatic duct; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasound; MRCP = magnetic resonance cholangiopancreatography; SD = standard deviation; IQR = interquartile range; CI = confidence interval.

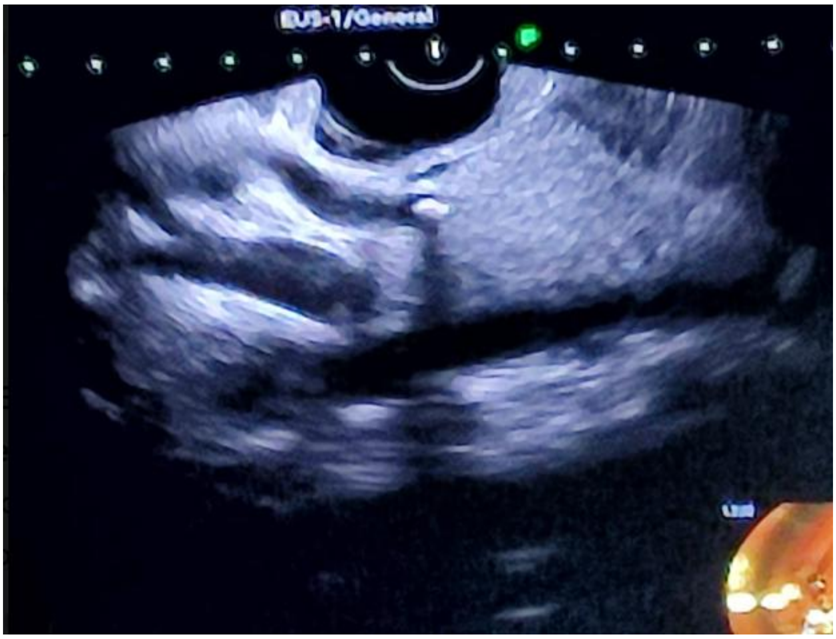

Figure 2. Endoscopic ultrasound appearance of choledocholithiasis, showing an echogenic intraluminal focus within the common bile duct, consistent with a biliary stone

3.5 Diagnostic Performance of MRCP Against Final Consensus Diagnosis

Because this was a single-arm diagnostic-pathway study without a disease-negative control population (every patient was enrolled on the basis of clinical suspicion of a biliary complication), classical two-group hypothesis testing was not applicable to baseline comparisons (Table 1), and specificity/negative predictive value for MRCP could not be reliably estimated, since virtually all enrolled patients had at least one imaging abnormality prompting further work-up. Using the final consensus diagnosis (established by EUS, ERCP/surgical findings, or composite clinical follow-up) as the reference standard, MRCP correctly identified true pathology (Confirmation and Upgrading categories combined, 36/39) with a sensitivity of 92.3% (95%

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CI: 79.7–97.3), a positive predictive value of 76.6% (95% CI: 62.8–86.4), and an overall accuracy of 72.0% (95% CI: 58.3–82.5) against the composite reference standard. The 11 Downgrading cases represent false-positive MRCP calls later excluded by EUS. Diagnostic performance indices are presented in Table 5.

Table 5. Diagnostic Performance of MRCP Against the Final Consensus Diagnosis (N = 50)

Diagnostic Parameter	Value (%)	95% CI	Numerator / Denominator
Sensitivity	92.3	79.7 – 97.3	36 / 39
Positive Predictive Value (PPV)	76.6	62.8 – 86.4	36 / 47
Overall Accuracy	72.0	58.3 – 82.5	36 / 50
Specificity / NPV	Not estimable		0 true-negative reference cases

Note. CBD = common bile duct; CHD = common hepatic duct; ERCP = endoscopic retrograde cholangiopancreatography; EUS = endoscopic ultrasound; MRCP = magnetic resonance cholangiopancreatography; PPV = positive predictive value; NPV = negative predictive value; CI = confidence interval. Specificity and NPV are not estimable because the cohort contains no disease-negative (imaging-normal) control patients — all patients were referred for suspected pathology.

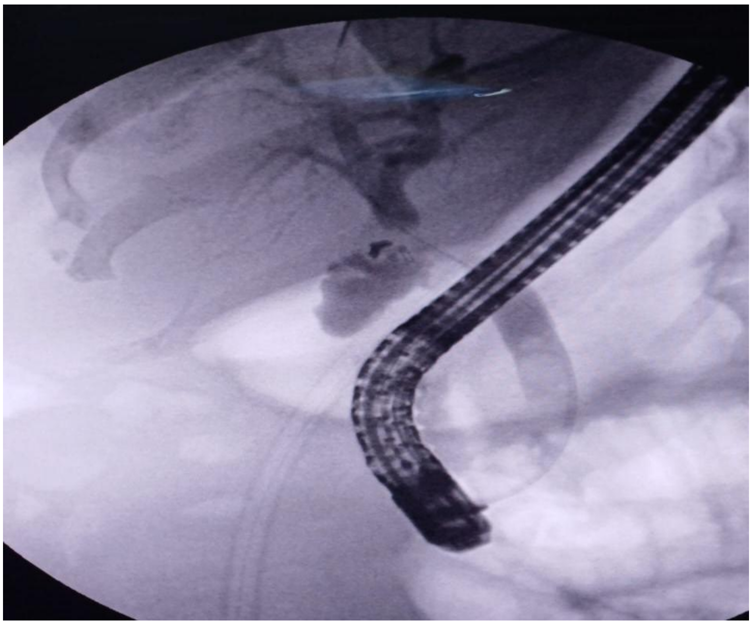

Figure 3. ERCP findings and endoscopic management of post-cholecystectomy biliary injury. ERCP cholangiography demonstrates a mild common bile duct injury with contrast extravasation consistent with a biliary leak. Endoscopic sphincterotomy was performed, followed by placement of a 10-Fr × 10-cm plastic biliary stent to facilitate biliary drainage and promote leak resolution

3.6 Procedural Safety and Anesthesia Outcomes

All EUS and ERCP procedures were performed under anesthesia guidance. Deep sedation was required in 30% of patients (n = 15), while 12% (n = 6) required general anesthesia due to high ASA scores or sepsis. The remaining 58% (n = 29) underwent moderate sedation. No severe anesthesia-related adverse events occurred. Procedural tolerance was excellent, with only one mild case of post-ERCP pancreatitis (2%), which was managed conservatively with complete resolution. There were no instances of perforation, clinically significant hemorrhage, or procedure-related mortality.

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4 DISCUSSION

This retrospective cohort study demonstrates that integrating EUS into a multidisciplinary HPB pathway significantly closes the diagnostic-therapeutic gap in post-cholecystectomy biliary complications. With a diagnostic reclassification rate of 50%, EUS proved indispensable in refining MRCP interpretations, preventing unnecessary invasive procedures, and uncovering occult pathology that would have otherwise been missed on conventional cross-sectional imaging. The almost-perfect concordance between EUS and ERCP ($\varkappa = 0.88$) validates EUS as a reliable gatekeeper for therapeutic decision-making, while the moderate agreement between MRCP and EUS ($\varkappa = 0.58$) underscores the inherent limitations of MRCP in the postoperative setting.

A major finding of this study is the 22% downgrading rate. MRCP is highly sensitive but lacks specificity in the postoperative setting, where post-cholecystectomy anatomical changes, pneumobilia, or thickened bile can mimic filling defects, leading to false-positive interpretations of choledocholithiasis [10]. Griffin et al. described multiple MRCP pitfalls, including technique-related artifacts, normal variants mimicking pathology, and intraductal factors such as sludge or blood products that may be indistinguishable from calculi on T2-weighted sequences [3]. In our cohort, MRCP suggested CBD stones or tight strictures in several cases that EUS definitively excluded, reclassifying them as benign postoperative tapering or normal CBD. By preventing 11 unnecessary ERCPs, EUS directly reduced the risk of post-ERCP pancreatitis and optimized healthcare resource utilization. This finding aligns with current guidelines advocating for EUS as a first-line diagnostic tool in patients with intermediate probability of choledocholithiasis, where either EUS or MRCP is recommended prior to ERCP [6].

Conversely, EUS upgraded the diagnosis in 22% of cases, highlighting its superior spatial resolution for evaluating the proximal biliary tree and periampullary region. The most critical clinical impact was the detection of periampullary masses masquerading as benign distal CBD strictures on MRCP. Guo et al. demonstrated that EUS has a significantly higher detection rate (87%) for periampullary tumors smaller than 1 cm compared with MRI-MRCP (59%) and CT (44%) [11]. MRCP often struggles to differentiate malignant strictures from benign postoperative scarring or extrinsic compression [4]. EUS allows for direct visualization of the pancreatic head and duodenal wall and facilitates fine-needle aspiration (FNA) when needed, with studies showing EUS-FNA to have higher sensitivity (75%) and accuracy (79%) compared to conventional ERCP brush cytology for diagnosing malignant biliary strictures [12]. Furthermore, EUS accurately identified complex CHD strictures and operative bed collections that guided surgical and interventional radiology referrals, proving its value in comprehensive biliary mapping beyond the distal CBD.

The structured MDT pathway was vital to the success of this diagnostic framework. Diagnostic radiology's blinded reassessment of MRCP minimized incorporation bias, ensuring that initial imaging interpretations were rigorously challenged before MDT consensus. Furthermore, the integration of anesthesiology into the MDT framework ensured that high-risk, jaundiced, or septic patients were optimally prepared for sedation. Zhang et al. demonstrated that anesthesiologist-administered sedation during ERCP is safe, with high procedural success rates and shorter recovery times [13]. Henriksson and Thakrar emphasized that general anesthesia is increasingly indicated for complex ERCP procedures and high-risk patients, with sedation-related adverse events and conversion rates significantly higher in ASA grade III–IV patients [14]. The collaborative MDT approach ensures that the decision to proceed to ERCP is based on consolidated, high-confidence data rather than isolated imaging reports [8].

Strengths

This study has a significant strength of a structured, blinded MDT review process that limits interpretation bias and is reflective of real-world clinical decision-making. Adopting a uniform Diagnostic Reclassification Index (DRI) enables a reproducible and quantifiable evaluation of the impact of EUS in various clinical settings. Moreover, the incorporation of anesthesiology parameters points towards the complexity of patient safety in high-risk HPB groups, which is often not taken into account in endoscopic research [15]. The complete US to MRCP to EUS to ERCP diagnostic workflow offers a full view of the incremental gain in diagnostic information at each step.

Limitations

There are some limitations to this study. The single-center and retrospective design may cause selection bias and restrict the generalizability of our results in other populations [16]. The sample size of 50 patients was adequate for descriptive analyses and agreement statistics, though estimates such as sensitivity and PPV carry correspondingly wide confidence intervals [17]. In addition, although ERCP was used as the reference standard for patients who had the procedure, patients with downgrade of

EUS results did not receive ERCP, but rather a composite reference standard of clinical follow-up, which may lead to verification bias [18]. A limitation of the study design is that clinical follow-up, as opposed to a universal gold standard, is used for all patients [19]. Further multicenter prospective studies with more uniform follow-up and larger numbers of patients are warranted to confirm these results and to provide generalizable guidelines for the incorporation of EUS into HPB pathways [20].

5 CONCLUSION

Endoscopic Ultrasound is a revolution in the diagnosis and management of post-cholecystectomy biliary complications. The results of this study prove that EUS can successfully reclassify the diagnosis in half of the cases and can prevent unnecessary ERCPs (with their associated risk of 5-9.8% complications) in 22%, while also providing timely surgical or oncological intervention for previously missed diagnoses in another 22% of the patients. EUS was strongly correlated with ERCP ($\varkappa$ = 0.88), supporting its use as a reliable gatekeeper, but ERCP was significantly different from MRCP ($p = 0.004$), indicating that MRCP is less helpful in the postoperative setting. Against the final consensus diagnosis, MRCP demonstrated a sensitivity of 92.3% but a positive predictive value of only 76.6%, underscoring its tendency toward false-positive calls in the postoperative setting and reinforcing the role of EUS as a confirmatory gatekeeper before ERCP is undertaken. All patients had no severe adverse events reported, and the use of EUS as a structured multidisciplinary pathway with specialized radiology and anesthesiology risk stratification allows for comprehensive evaluation and patient safety. These evidence-based conclusions support the use of EUS as an intermediate diagnostic tool regularly between MRCP and ERCP, closing the gap in diagnosis and treatment, decreasing health-care costs, and improving clinical outcomes in this difficult patient population.

DECLARATIONS

Ethics Approval and Consent to Participate

The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Institutional Review Board approval was obtained from the Faculty of Medicine, Al-Azhar University, Egypt: (IRB approval number: HepGid-M-R-6-0063). Patient confidentiality was maintained through anonymization of the clinical data analyzed.

Data Availability Statement

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

Conflicts of Interest: The authors declare that they have no conflicts of interest related to this study.

Funding: No specific funding was received for this study. The study was conducted without external financial support.

Declaration of Use of Artificial Intelligence

AI-based tools were used for language editing, grammar, stylistic refinement, organization, and improvement of clarity. They were not used to generate, analyze, or interpret study data or to perform statistical analyses

Author Contributions:

All authors contributed to study conception and design, data acquisition, statistical analysis, manuscript drafting, and critical revision. All authors have approved the final version for submission

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