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INTEGRATED MANAGEMENT OF COMPLICATED GALLBLADDER DISEASE AND COMMON BILE DUCT STONES: ROLE OF MRCP, ERCP, T-TUBE DRAINAGE, AND CHOLEDOCHODUODENOSTOMY IN A COMBINED 41-PATIENT COHORT

Dr. Priyanka Tiwari[1*], Dr. Sanjay Pandey[2], Dr. Dhanesh Saini[3], Dr. Mukesh Kumar Maheshwari[4], Dr. Sunidhi Mishra[5]

[1]MBBS, DNB SURGERY, FNB MAS, FIAGES, Associate Professor, Department of General Surgery, Subharti Medical College, Swami Vivekanand Subharti University, Meerut. Mail id -dr.priyankatiwari@hotmail.com, Orchid Id - 0009-0006-6336-5287,
[2]MBBS, MS, Professor and Head, Department of General Surgery, Subharti Medical, College, Swami Vivekanand Subharti University, Meerut. Mail ID - sanjaypandey2011970@gmail.com,
[3]MBBS, MS, Professor, Department of General Surgery, Subharti Medical College, Swami Vivekanand Subhart, University, Meerut. Mail id - dhaneshsaini1@gmail.com,
[4]MBBS, MS, Professor, Department of General Surgery, Subharti Medical College, Swami Vivekanand Subharti University, Meerut. Mail id - mk_maheshwari58@yahoo.co.in, Orchid Id - 0000-0002-9023-1819,
[5]Assistant Professor, Department of General Surgery, Subharti Medical College, Swami Vivekanand Subharti University, Meerut. Mailid - sunidhimishra546@gmail.com, Orchid Id - 0009-0006-7043-0032
*Corresponding Author: Dr. Priyanka Tiwari, Mail id -dr.priyankatiwari@hotmail.com

ABSTRACT

Background: Management of complicated gallbladder disease and choledocholithiasis requires appropriate use of non-invasive imaging, therapeutic endoscopy, and surgery. MRCP provides non-invasive assessment of the biliary tree, whereas ERCP is principally therapeutic. Open common bile duct (CBD) exploration with T-tube drainage or choledochoduodenostomy (CDD) remains relevant in selected difficult cases.

Methods: Total of 41 patients. Cohort 1 comprised 29 patients who underwent open CBD exploration. MRCP was performed in all 29 patients within one surgical cohort, Group A included 14 patients treated by choledochotomy with T-tube drainage and Group B included 1 5 patients treated by choledochoduodenostomy. Cohort 2 comprised 12 patients with difficult/complicated gallbladder disease managed with individualized combinations of laparoscopic cholecystectomy, MRCP/CECT, ERCP and stenting, percutaneous drainage, conservative management, or open CBD exploration. The two cohorts were combined descriptively; percentages, mean, standard deviation were used .

Results: Of the total 41 patients, 29 (70.73%) belonged to the CBD-exploration cohort and 12 (29.27%) to the complicated-gallbladder cohort. In the 29-patient surgical cohort, T-tube drainage was performed in 14 (48.28% of that cohort; 34.15% of the combined cohort) and CDD in 15 (51 .72% of that cohort; 36.59% of the combined cohort). The 29-patient dataset reported cholelithiasis with choledocholithiasis in 18 (62.06%), CBD stricture in 5 (17.24%), Mirizzi syndrome in 4 (13.79%), pancreatitis in 2 (6.90%), and previous ERCP with CBD stent in situ in 2 (6.90%). The 12-patient difficult- gallbladder series demonstrated selective use of preoperative ERCP when MRCP confirmed CBD stones and postoperative ERCP/stenting for selected biliary complications or persistent biochemical/clinical obstruction.

Conclusion: The 41-patient experience conculded the indication-based approach. MRCP is useful for non-invasive diagnostic clarification and biliary mapping, ERCP is reserved mainly for therapeutic duct clearance or decompression, and surgery remains important for impacted or complex stones, benign distal obstruction, failed endoscopic management, or difficult operative anatomy. Because the two cohorts differ in design, indication, and treatment pathway, the merged analysis is descriptive and should not be interpreted as a randomized or head-to-head comparison of MRCP, ERCP, T-tube drainage, and CDD.

KEYWORDS: MRCP; ERCP; choledocholithiasis; difficult gallbladder; T-tube; choledochoduodenostomy; biliary stenting; CBD exploration

INTRODUCTION

Gallstone disease ranges from uncomplicated cholelithiasis to choledocholithiasis, obstructive jaundice, pancreatitis, cholangitis, Mirizzi syndrome, empyema, mucocele, biliary fistula, and difficult biliary anatomy. Contemporary management increasingly separates diagnostic imaging from therapeutic intervention. MRCP is non-invasive and can delineate ductal anatomy, stones, strictures, and biliary dilatation, while ERCP permits sphincterotomy, stone extraction,

decompression, and stent placement. [1 -4]
The 29-patient CBD-exploration series evaluates T-tube drainage versus CDD after choledochotomy, whereas the 12-patient complicated-gallbladder series illustrates selective preoperative and
postoperative use of MRCP and ERCP around difficult cholecystectomy. Their integration provides a broader descriptive view of 41patients managed across diagnostic, endoscopic, percutaneous,
laparoscopic, and open surgical pathways.

Objectives
1 . To describe the combined 41-patient experience derived from the two cohorts.
2. To compare the roles of MRCP and ERCP in the diagnostic-therapeutic pathway.
3. To describe indications and outcomes of T-tube drainage and choledochoduodenostomy in the 29- patient CBD-exploration cohort.
4. To describe the selective role of ERCP/stenting and other interventions in the 12-patient
complicated-gallbladder cohort. (FIGURE 1)

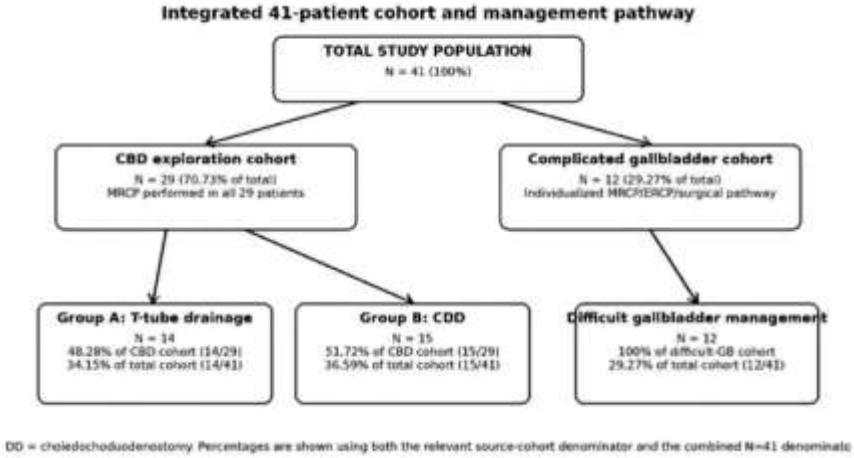

FIGURE 1 . Distribution of the combined 41-patient cohort and management procedures. The CBD- exploration cohort comprised 29 patients (70.73%): Group A, T-tube drainage, n=14 (48.28% of 29; 34.15% of 41), and Group B, choledochoduodenostomy, n=15 (51 .72% of 29; 36.59% of 41). The complicated-gallbladder cohort comprised 12 patients (29.27% of 41).

MATERIALS AND METHODS
Study design: Integrated descriptive analysis of two previously assembled observational datasets. The combined denominator is 41 patients (29 + 12). (TABLE 1)

TABLE 1. Composition of two cohort

Source cohort / group	Clinical focus	N	% of total 41
CBD exploration cohort	Open CBD exploration	29	70.73%
Group A	Choledochotomy + T-tube drainage	14	34.15%
Group B	Choledochotomy + choledochoduodenostomy	15	36.59%
Complicated gallbladder cohort	Difficult/complicate d gallbladder cases	12	29.27%
Total	Combined cohort	41	100%

Group A and Group B are subdivisions of the 29-patient CBD-exploration cohort and together equal 29; the separate 12-patient complicated-gallbladder cohorts.
In the 29-patient CBD-exploration cohort, MRCP was performed in all 29 patients as preoperative biliary imaging. Patients subsequently underwent CBD exploration and were treated with either T-tube
drainage (Group A, n=14) or CDD (Group B, n=15)(FIGURE 1). In the 12-patient complicated-gallbladder cohort, imaging and intervention were individualized according to LFT abnormalities, ultrasonography,
MRCP/CECT findings, difficult anatomy, biliary leak, suspected obstruction, or postoperative complications. [7-10]

RESULTS
Study Population and Distribution
A total of 41 patients were included in the combined study population. Of these, 29 patients (70.73%) constituted the CBD-exploration cohort, while the remaining 12 patients (29.27%) represented the difficult/complicated gallbladder cohort. The composition of the overall study population is summarized in Table 1, and the integrated patient distribution and management pathway are illustrated in Figure 1. Within the 29-patient CBD-exploration cohort, 14 patients underwent

choledochotomy with T-tube drainage (Group A), while 15 patients underwent choledochoduodenostomy (CDD; Group B), representing 48.28% and 51.72% of the CBD-exploration cohort, respectively.

Gender Distribution

Among the 29 patients undergoing CBD exploration, there was a marked female predominance. Group A, comprising 14 patients treated by choledochotomy with T-tube drainage, included 2 males and 12 females. Group B, comprising 15 patients treated by choledochoduodenostomy, included 4 males and 11 females. Overall, females accounted for 23 of the 29 patients in the surgical cohort. The gender distribution of the two groups is illustrated in Figure 2.

Clinical Diagnosis and Presentation

The commonest clinical presentation in the CBD-exploration cohort was cholelithiasis associated with choledocholithiasis, documented in 18 patients (62.06%). CBD stricture was present in 5 patients (17.24%), followed by Mirizzi syndrome in 4 patients (13.79%). Pancreatitis was recorded in 2 patients (6.90%), while 2 patients (6.90%) had previously undergone ERCP with a CBD stent in situ. Thus, stone-related CBD disease constituted the predominant pathology requiring operative CBD exploration. The distribution of diagnoses and clinical presentations is summarized in Table 2 and graphically represented in Figure 3.

Surgical Procedure Distribution

Of the 29 patients undergoing open CBD exploration, 14 patients (48.28%) underwent choledochotomy followed by T-tube drainage (Group A), while 15 patients (51.72%) underwent choledochoduodenostomy (Group B). When calculated against the complete 41-patient cohort, these represented 34.15% and 36.59%, respectively. The nearly equal distribution between the two procedures indicates that operative management was individualized rather than dominated by a single surgical technique. The procedure distribution is presented in Table 3 and Figure 4.

CBD Diameter and Choice of Surgical Procedure

A distinct difference in CBD diameter was observed between the two surgical groups. The mean CBD diameter in Group A (T-tube drainage) was 8.82 ± 1.23 mm, whereas patients undergoing CDD (Group B) had a considerably larger mean CBD diameter of 13.55 ± 1.39 mm. The source study reported this difference to be statistically significant ($t = -2.52$, $p = 0.01789$). The comparison of CBD diameter between the two groups is presented in Table 2 and Figure 5, with error bars representing standard deviation.

The significantly larger CBD diameter observed in the CDD group was consistent with the clinical selection of CDD in patients with a markedly dilated CBD, large or impacted stones, or CBD stricture. Conversely, T-tube drainage was used following choledochotomy in patients with a relatively smaller CBD. Therefore, the difference in CBD diameter primarily reflects differences in the anatomical and pathological characteristics influencing operative selection rather than a direct comparison of efficacy between the two procedures.

Difficult/Complicated Gallbladder Cohort

The remaining 12 patients (29.27%) represented a heterogeneous group of difficult or complicated gallbladder cases. The clinical spectrum included empyema with postoperative biliary leakage, xanthogranulomatous cholecystitis associated with intra-abdominal abscesses, pancreatitis, anomalous right posterior sectoral duct anatomy, intrahepatic gallbladder with suspected duct of Luschka leakage, Mirizzi-type compression, confirmed CBD stones, persistent postoperative LFT derangement, incidental gallbladder malignancy, a large impacted lower-CBD stone requiring open CBD exploration, and an accessory hepatic mass.

Because of this clinical heterogeneity, management was individualized according to the underlying pathology and anatomical findings. Treatment included different combinations of laparoscopic cholecystectomy, MRCP/CECT, ERCP with stenting, percutaneous drainage, conservative treatment, and open CBD exploration. The principal operative and endoscopic approaches employed in difficult gallbladder disease are illustrated in Figure 6. (Table 4)

Role of MRCP

In the 29-patient CBD-exploration cohort, MRCP was performed in all patients before surgery. MRCP was principally utilized for non-invasive assessment of the biliary tree and for defining CBD stones, ductal dilatation, strictures, and relevant biliary anatomy before operative intervention. In the 12 difficult-gallbladder patients, imaging was individualized according to LFT abnormalities, ultrasonographic findings, suspected obstruction, biliary leakage, difficult anatomy, and postoperative complications. A representative MRCP demonstrating evaluation of the biliary tree is shown in Figure 7.

Role of ERCP and Biliary Stenting

ERCP was used selectively and primarily as a therapeutic intervention rather than as a routine diagnostic investigation. Importantly, deranged liver function tests alone did not constitute an indication for ERCP. When MRCP demonstrated a dilated CBD containing multiple CBD stones, preoperative ERCP with stenting was performed. Postoperative ERCP/stenting was selectively employed in patients with persistent biliary drainage, suspected residual obstruction, biliary complications, or failure of liver function tests to normalize. A representative ERCP image demonstrating endoscopic biliary evaluation/intervention is presented in Figure 8.

Operative and Postoperative Findings

The operative techniques of choledochotomy with T-tube drainage and choledochoduodenostomy are illustrated in Figure 9. Among patients managed with T-tube drainage, two patients developed bile leakage following T-tube removal. Both were managed conservatively. In the CDD group, no sump syndrome was reported during the study observations. A representative postoperative T-tube cholangiogram is shown in Figure 10, while the choledochoscopic appearance of the CBD is demonstrated in Figure 11.

These postoperative findings should be interpreted descriptively because the two procedures were not randomly allocated. Selection of T-tube drainage or CDD depended on CBD diameter, stone burden, presence of stricture or obstruction, and intraoperative anatomy.

Integrated Management Pattern

The overall findings demonstrate a sequential and indication-based approach to the management of complicated gallbladder disease and CBD stones. MRCP primarily provided non-invasive diagnostic clarification and anatomical mapping, whereas ERCP was reserved predominantly for patients requiring therapeutic stone extraction, biliary decompression, or stenting. Surgical treatment remained necessary in patients with large or impacted stones, CBD strictures, substantially dilated CBDs, difficult anatomy, or disease unsuitable for or not resolved by endoscopic intervention.

The respective roles, advantages, limitations, and positions of MRCP, ERCP with stenting, T-tube drainage, CDD, and definitive surgery in the management pathway are summarized in Table 5.

Overall, CDD was used slightly more frequently than T-tube drainage (51.72% vs 48.28%), and patients selected for CDD had a significantly larger CBD diameter (13.55 ± 1.39 mm vs 8.82 ± 1.23 mm; p = 0.01789). These observations support the clinical selection of CDD for patients with a more dilated CBD and complex ductal pathology. However, the two surgical procedures were not randomly allocated, and the difficult-gallbladder cohort represented a heterogeneous clinical series. Therefore, the findings should be interpreted as a description of individualized clinical decision-making rather than as evidence that one therapeutic modality is superior to another.(Table 2)

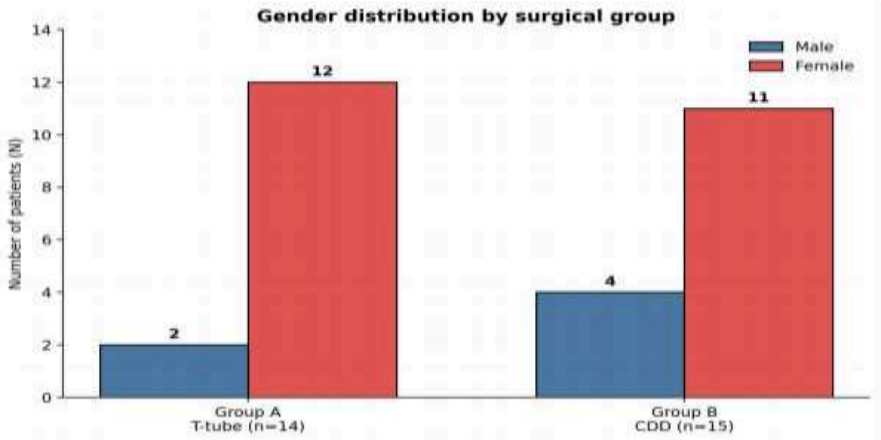

FIGURE 2 . Gender distribution in Group A and Group B. Group A: 2 male and 12 female patients; Group B: 4 male and 1 1 female patients.

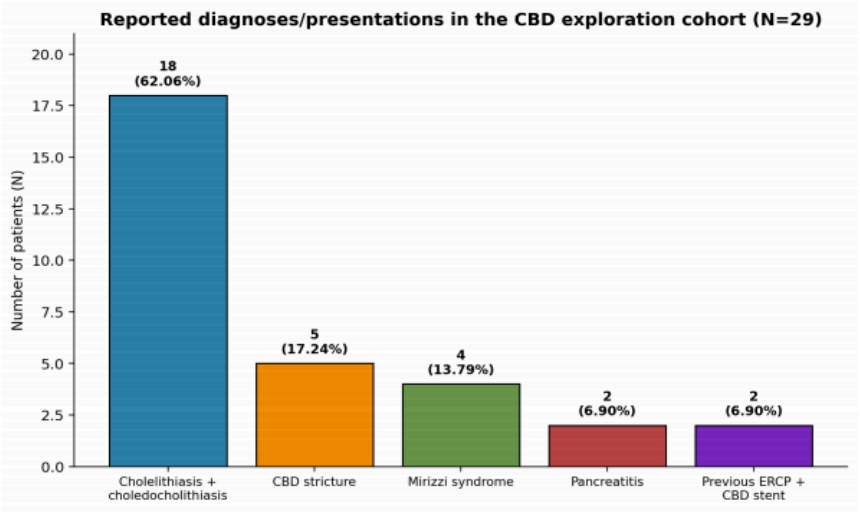

FIGURE 3. Diagnoses/presentations reported in the 29-patient CBD exploration cohort.

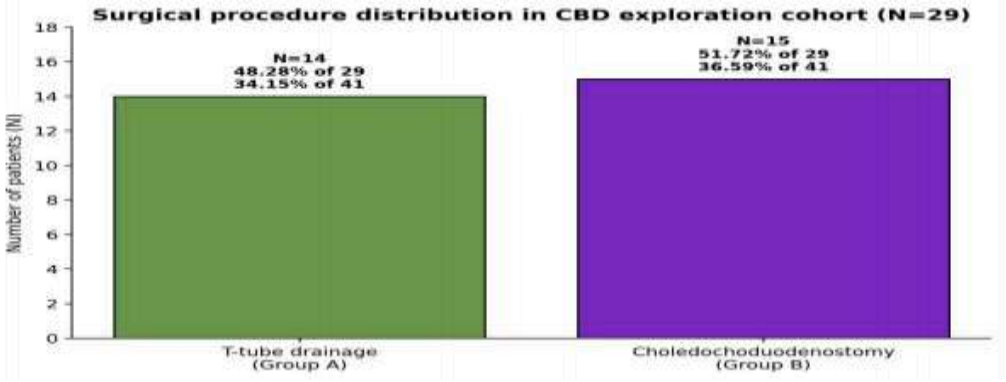

FIGURE 4 Procedure distribution within the 29-patient CBD exploration cohort: T-tube drainage n=14 (48.28%) and choledochoduodenostomy n=15 (51 .72%).

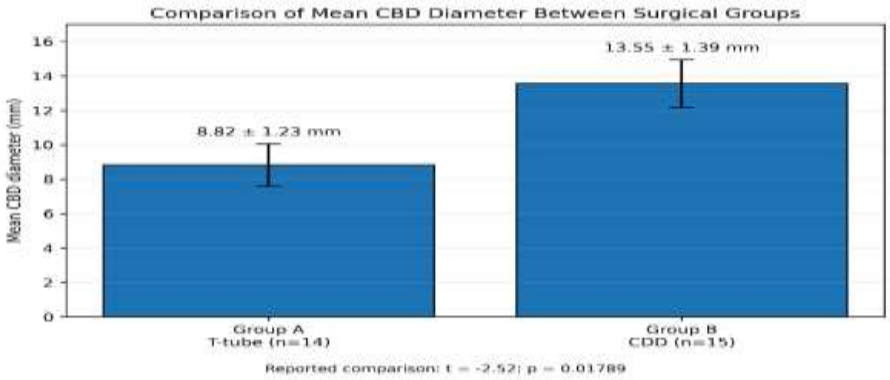

FIGURE 5. Comparison of mean CBD diameter in Group A (T-tube drainage) and Group B (choledochoduodenostomy). Error bars represent SD.

CBD diameter was significantly greater in the CDD group (13.55 ± 1 .39 mm) than in the T-tube group (8.82 ± 1 .23 mm). The original study reported t = -2.52 and p = 0.01789.

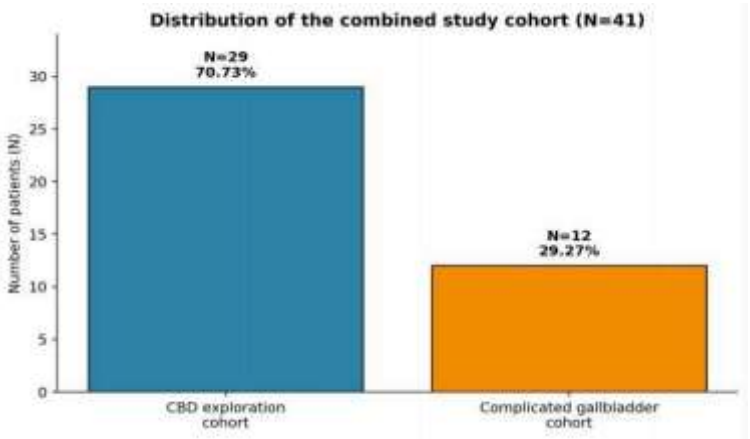

FIGURE 6. Distribution of the combined 41-patient cohort: CBD exploration n=29 (70.73%) and complicated gallbladder n=12 (29.27%). choledochoduodenostomy n=1 5 (51 .72%) . Percentages relative to the combined cohort are 34.1 5% and 36. 59%, respectively. the source dataset and are not necessarily mutually exclusive.1 1 female patients.

CBD diameter comparison in the CBD-exploration cohort

Among the 29 patients undergoing open CBD exploration, the mean CBD diameter was 8.82 ± 1 .23 mm in Group A (choledochotomy with T-tube drainage; n=14) and 13.55 ± 1 .39 mm in Group B (choledochoduodenostomy; n=15). The source study reported a statistically significant difference between the groups (reported t = _2.52, p = 0.01789), with CDD preferentially used in patients with a more dilated CBD, including large/impacted stones or CBD stricture.

TABLE 2 : CBD diameter comparison in the CBD-exploration cohort

Parameter drainage	Group A: T-tube	Group B: CDD comparison	Statistical
N	14	15	—
Mean CBD diameter (mm)	8.82 ± 1 .23	13.55 ± 1 .39	Reported t = _2.52; p = 0.01789
Clinical selection	CBD exploration with T-tube drainage	CDD for dilated CBD, large/impacted stones or CBD stricture	Significant difference reported (p < 0.05)

TABLE 3. Procedure distribution

Procedure / category	N	% within relevant source cohort	% of total 41
T-tube drainage (Group A)	14	48.28% of 29	34.15%
Choledochoduodenostomy (Group B)	15	51 .72% of 29	36.59%
Difficult/complicate d gallbladder series	12	100% of 12	29.27%
Total patients	41	-	100%

TABLE 4 Findings in the 29-patient CBD-exploration cohort

Diagnosis / presentation	N	% of 29
Cholelithiasis + choledocholithiasis	18	62.06%
CBD stricture	5	17.24%
Mirizzi syndrome	4	13.79%
Pancreatitis	2	6.90%
Previous ERCP with CBD stent in situ	2	6.90%

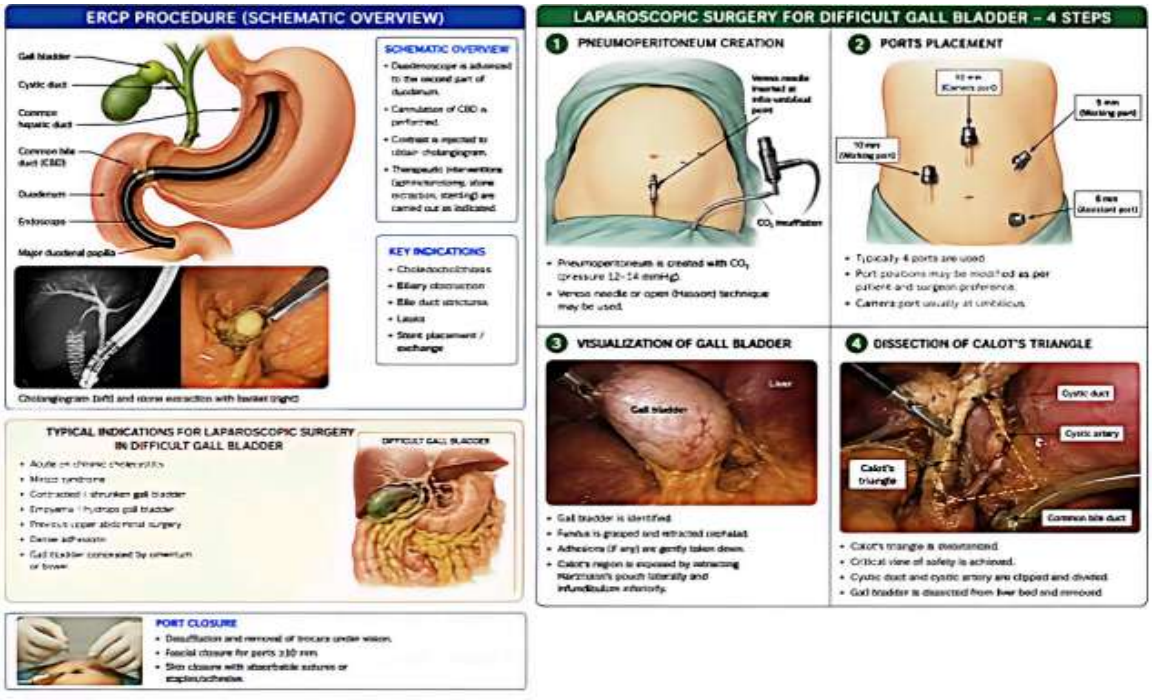

FIGURE 7. ERCP schematic overview and laparoscopic management of a difficult gallbladder, including pneumoperitoneumcreation, port placement, gallbladder visualization/Calot's triangle dissection, and port closure.

Clinical and procedural observations from the 1 2-patient difficult-gallbladder cohort

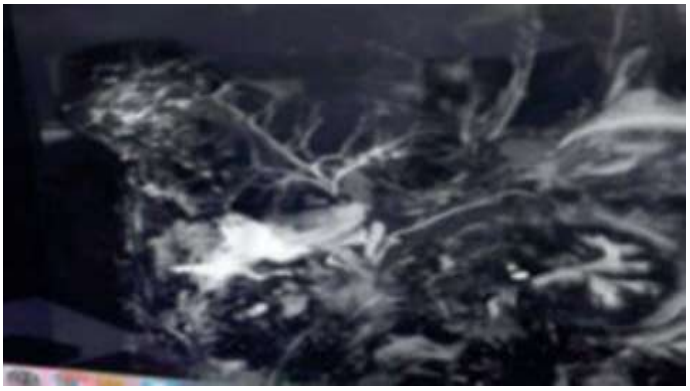

FIGURE 8. MRCP image from the complicated-gallbladder source series demonstrating biliary-tree evaluation.

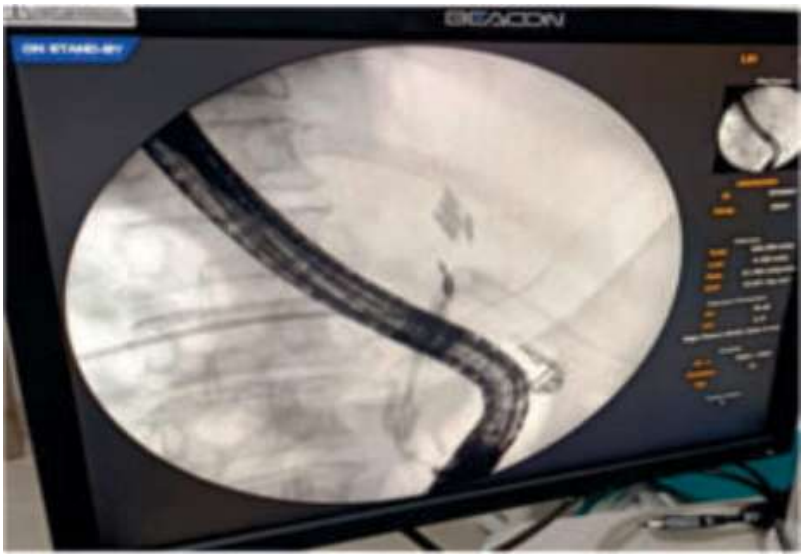

FIGURE 9 ERCP image from the complicated-gallbladder source series illustrating endoscopic biliary evaluation/intervention.

Our study described 12 heterogeneous difficult gallbladder cases including empyema with postoperative biliary leakage, xanthogranulomatous cholecystitis with intra-abdominal abscesses, pancreatitis, anomalous right posterior sectoral duct anatomy, intrahepatic gallbladder with suspected duct of Luschka leak, Mirizzi-type compression, confirmed CBD stones requiring preoperative ERCP/stenting, persistent postoperative LFT derangement requiring ERCP/stenting, incidental gallbladder malignancy, a large impacted lower-CBD stone requiring open CBD exploration, and an accessory hepatic mass. [6,11 ,12] (FIGURE 10)

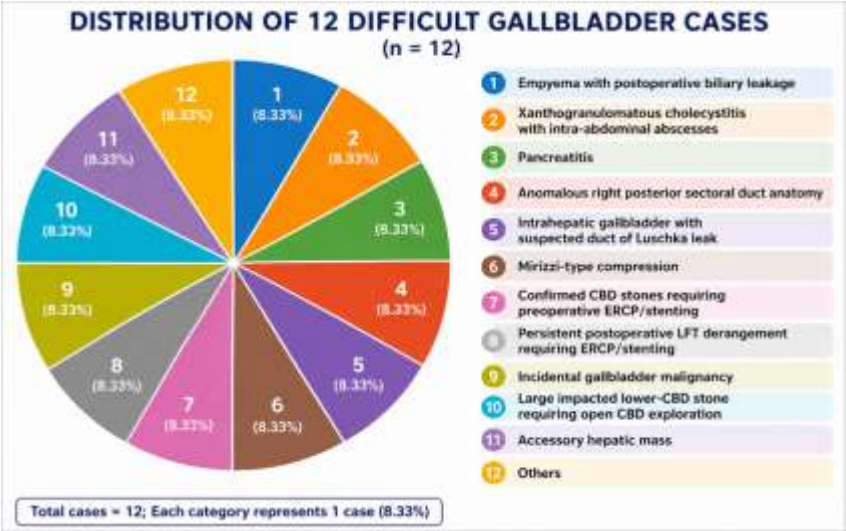

FIGURE 10 Distribution of difficult Gall Bladder

Our data specifically showed that deranged LFT alone should not trigger ERCP. When MRCP demonstrated dilated CBD with multiple CBD stones, preoperative ERCP/stenting was used; postoperative ERCP/stenting was used in selected cases of biliary injury, persistent biliary drainage, suspected residual obstruction, or failure of LFTs to normalize. [6-10]

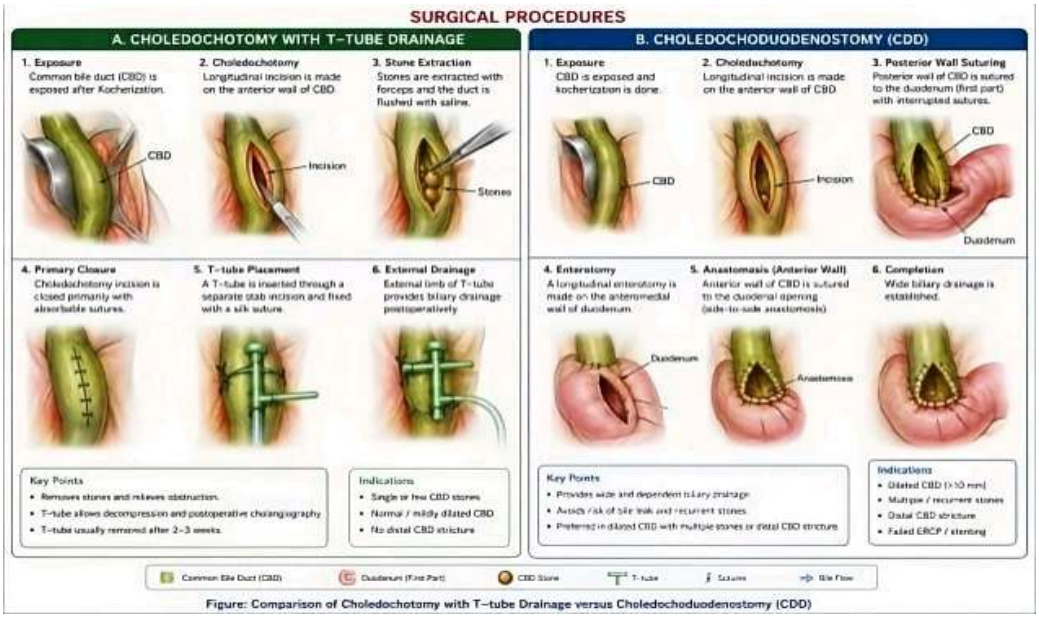

FIGURE 11. Operative schematic comparing choledochotomy with T-tube drainage and choledochoduodenostomy (CDD).

FIGURE 12. T-tube cholangiogram from the CBD-exploration

FIGURE 13. Choledochoscopic view from the CBD-exploration source manuscript.

TABLE 5. Integrated comparison of MRCP, ERCP and surgery

Modality	Main role	Advantages	Limitations	Position in pathway
MRCP	Non-invasive diagnostic imaging and biliary mapping [7-10,19]	No papillary instrumenta t ion; demonstrat e s stones, ductal dilatation , strictures and anatomy [7- 10]	Diagnostic only; source data do not document MRCP in every one of the 1 2 difficult- gallbladder cases	Use before intervention when diagnostic clarification/ana t omical mapping is needed
ERCP ± stent	Therapeutic duct clearance/decomp r ession [8,13,18,25- 27]	Stone extraction, sphincteroto my, drainage and stenting [13,25-27]	Invasive; procedure- related complications; may fail with large impacted stones/anatomy	Use when therapeutic intervention is required
T-tube drainage	External drainage after choledochotom y [20-24]	Decompress ion and postoperati v e cholangiogr aphic access	Tube-related morbidity and bile leak after removal [20-24]	Selective surgical option
Choledochoduoden ostomy	Permanent internal drainage [5,14,15]	Durable drainage without external tube	Sump syndrome/cholangitis / stenosis are recognized concerns	Selected dilated CBD, distal benign obstruction or complex/recurre n t stones
Laparoscopic/ope n surgery	Definitive gallbladder/CBD treatment [13,16,17,28,29]	Direct treatment of gallbladder disease and difficult stones	Operative morbidity; depends on anatomy and expertise	Used according to stone burden, anatomy, failed endoscopy and complication profile

DISCUSSION

The total 41-patient dataset broadens the clinical spectrum beyond a single procedure comparison.

The 29-patient cohort demonstrates how T-tube drainage and CDD were selected after CBD exploration, while the 12-patient cohort demonstrates how MRCP, ERCP, drainage procedures, laparoscopic cholecystectomy, and open surgery can be sequenced in difficult gallbladder disease. [5,6,13-17] FIGURE 11.

A key conceptual distinction is that MRCP and ERCP are not equivalent competing procedures. MRCP is principally diagnostic, whereas ERCP is primarily therapeutic. This distinction is particularly relevant when LFTs are abnormal but the cause may be inflammatory compression, cystic duct/Hartmann pouch pathology, or transient obstruction rather than a retained CBD stone. The difficult-gallbladder series supports selective ERCP after imaging confirmation or when postoperative biliary complications require decompression. [7-10,18,19] Within the 29-patient surgical cohort, T-tube drainage was used in 14 patients and CDD in 15. The CDD was preferentially used for a dilated CBD with multiple/impacted stones or CBD stricture. Two bile leaks after T-tube removal were described that were managed conservatively , while no sump syndrome was reported after CDD. These observations should be interpreted descriptively because treatment allocation was non-random and determined by anatomy and operative indication. [5,20-24] FIGURE 12, FIGURE 13.

CBD diameter also differed between the two surgical groups in the study: 8.82 ± 1 .23 mm in the T-tube group versus 13.55 ± 1 .39 mm in the CDD group. The source reported this difference as statistically significant (reported t = _2.52, p = 0.01789), supporting the observed selection of CDD in patients with a more dilated CBD.

The 41 patients the same variable was measured and reported in both source datasets. For example, the 29-patient dataset provides a structured diagnostic distribution and CBD-drainage procedure groups, whereas the 12-patient dataset is a heterogeneous case series.

CONCLUSION

In this descriptive cohort of 41 patients, 29 underwent open CBD exploration and 12 represented difficult/complicated gallbladder cases. Within the CBD-exploration cohort, 14 patients underwent T-tube drainage and 15 underwent choledochoduodenostomy. MRCP was performed in all 29 patients in that cohort and used as a diagnostic modality, while ERCP was used selectively as a therapeutic intervention in the difficult-gallbladder pathway and in patients requiring ductal clearance or decompression. The combined experience supports selective escalation from non-invasive imaging to endoscopic or surgical therapy according to ductal stones, anatomy, obstruction, operative difficulty, and postoperative

biliary complications. Because of heterogeneity between the two datasets, conclusions should remain descriptive rather than comparative claims of superiority. [5-10,13-18,20-24]

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