Original Article
DOI: https://doi.org/10.70749/ijbr.v3i7.1474

INDUS JOURNAL OF BIOSCIENCE RESEARCH
https://induspublishers.com/IJBR
ISSN: 2960-2793/ 2960-2807

Diagnostic Accuracy of Computed Tomography Scan in Diagnosing Common Bile Duct Calculi Taking Endoscopic Retrograde Cholangiopancreatography as Gold Standard

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ARTICLE INFO

Keywords: Common Bile Duct Calculi, Computed Tomography, Endoscopic Retrograde Cholangiopancreatography, Diagnostic Accuracy.

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Declaration
Authors' Contribution
All authors equally contributed to the study and approved the final manuscript

Conflict of Interest: No conflict of interest.

Funding: No funding received by the authors.

Article History
Received: 02-06-2025 Revised: 18-06-2025
Accepted: 03-07-2025 Published: 15-07-2025

ABSTRACT

Background: Common bile duct stones are a frequent cause of obstructive jaundice, leading to significant morbidity. Accurate non-invasive diagnosis is key to timely treatment. Whereas endoscopic retrograde cholangiopancreatography remains the reference standard, subsequent use of computed tomography offers a less invasive alternative, though accuracy differs among populations. **Objective:** To determine diagnostic accuracy of computed tomography scan in diagnosing common bile duct calculi taking endoscopic retrograde cholangiopancreatography as gold standard. **Study Design:** Cross-sectional validation study. **Duration and Place of Study:** This study was conducted from January 2025 to May 2025 at the Radiology Department of Ayub Teaching Hospital, Abbottabad. **Methodology:** A group of 218 individuals between the ages of 20 and 60, all exhibiting symptoms of obstructive jaundice, were included in the study. Each participant received a computed tomography (CT) scan prior to undergoing endoscopic retrograde cholangiopancreatography (ERCP). The CT scans were examined for the presence of common bile duct stones, and key diagnostic metrics—such as sensitivity, specificity, positive predictive value, negative predictive value, and overall accuracy—were determined by contrasting the CT outcomes with those obtained from ERCP. **Results:** The mean age of patients was 39.21 ± 9.36 years, with a female predominance (62.8%). CT demonstrated a sensitivity of 80.3%, specificity of 85.5%, and overall diagnostic accuracy of 83.9% for detecting CBD stones. **Conclusion:** Computed tomography is a reliable, non-invasive imaging modality with high diagnostic accuracy for detecting common bile duct calculi.

INTRODUCTION

Common bile duct (CBD) stones, also known as choledocholithiasis, refer to calculi located within the common bile duct or those that have migrated from the gallbladder. These stones are present in approximately 15% to 20% of individuals suffering from symptomatic gallstone disease.[1] CBD stones can lead to potentially dangerous conditions like obstruction of the bile duct, cholangitis (infection of the bile duct), and pancreatitis and therefore need early identification and treatment.[2] Fever, abdominal pain, and jaundice are the symptoms but can also be absent with the stones.[3] Because of the potential harm to the patient, proper identification of the stones is vital in the course of treatment.

Diagnosis of common bile duct stones typically employs a combination of imaging techniques and laboratory and clinical evaluation.[4] Blood testing early will reveal elevated enzymes in the liver and also bilirubin and infection signs.[5] Imaging techniques are also employed to directly visualize the stones, although no imaging technique is perfect.[6] Ultrasonography is typically the first imaging technique employed due to its accessibility and non-invasive nature but is insensitive to CBD stones.[7] More advanced imaging techniques such as MRCP, CT imaging, and endoscopic methods are employed to establish more accurate diagnoses in borderline cases or in cases where the diagnosis is complex.[8]

Endoscopic retrograde cholangiopancreatography is the gold standard for the diagnosis of common bile duct calculi.[9] ERCP is an invasive technique involving endoscopy and fluoroscopy used to directly observe the pancreatic and biliary ducts and to allow simultaneous treatment like stone extraction or stenting.[10] ERCP is extremely sensitive and specific in the detection of CBD stones and is therefore extremely useful in the confirmation of diagnoses.[10] ERCP is reserved for those with high suspicion of stone or where intervention is indicated since ERCP is invasive and can result in complications like pancreatitis.[11]

Computed tomography scanning has emerged as a worthwhile, non-invasive imaging method for the detection of common bile duct stones in emergent and complicated cases and in straightforward situations.[12] CT scanning provides high-quality cross-sectional imaging able to detect stones, ductal dilatation, and concomitant complications such as pancreatitis or cholangitis.[13] While universally available and capable of rapidly imaging the abdomen, sensitivity of CT scanning for CBD stones varies depending upon stone type, size, and location.[14] CT scanning is safer and less invasive than ERCP but typically inferior in accuracy for the purpose of making a diagnosis.[15]

In an investigation assessing the effectiveness of CT scans for identifying bile duct stones, the results showed a sensitivity of 87%, specificity of 88%, positive predictive value of 72%, and negative predictive value of 95%. The overall diagnostic accuracy was calculated to be 88%, using ERCP as the definitive reference method.[16]

Proper determination of common bile duct stones is critical to begin management early enough to prevent cholangitis and pancreatitis complications. Various imaging modalities are available for this purpose, and while CT scans are readily available and are non-invasive in nature, they possess varying sensitivity to detect CBD stones. Performing a study comparing the ability of CT scans to accurately diagnose will define their sensitivity and place in comparison with other imaging techniques and will guide clinicians in choosing the most suitable imaging option.

METHODOLOGY

This validation research was carried out in the Radiology Department of Ayub Teaching Hospital, Abbottabad, spanning from January 2025 through May 2025. A total of 218 patients, aged between 20 and 60 years, of both genders presenting with obstructive jaundice were enrolled using a consecutive non-probability sampling method. Obstructive jaundice was identified in patients exhibiting right upper quadrant abdominal pain with a severity greater than 5 on the visual analog scale lasting at least two days, accompanied by yellowing of the eyes, dark urine, and pale stools. Patients diagnosed with acute pancreatitis confirmed by ultrasound or those unwilling to undergo endoscopic retrograde cholangiopancreatography were excluded. Prior to participation, informed consent was obtained following ethical approval from the hospital review board. Demographic information including age, gender, and duration of jaundice was recorded.

All patients underwent computed tomography scanning using a 4-MDCT scanner (MX 8000, Philips Medical Systems), acquiring images in a craniocaudal direction with parameters set at 3.2 mm slice thickness, 3 mm reconstruction interval, pitch factor of 6, 120 kVp tube current, and 200–300 mAs. The presence of common bile duct stones was determined by the identification of hyperdense areas within the duct, as reported by a consultant radiologist with over five years of post-fellowship experience. Following CT, patients were referred for ERCP, which served as the definitive diagnostic procedure; a positive result was established when photographic documentation showed filling defects in the bile duct or when the endoscopist's report noted the presence of stones or sludge. ERCP findings were collected directly by the researcher to ensure data accuracy.

Data were entered and analyzed using SPSS version 22. Quantitative variables such as age and jaundice duration were summarized as mean ± standard deviation, while categorical variables including gender and diagnostic outcomes were presented as frequencies and percentages. Diagnostic accuracy was assessed by comparing CT results to ERCP findings, calculating sensitivity (the proportion of patients with CBD stones correctly identified by CT), specificity (the proportion without stones correctly identified), positive predictive value (the likelihood that a positive CT truly indicates stones), negative predictive value (the likelihood that a negative CT truly excludes stones), and overall accuracy (the proportion of all correct diagnoses by CT). To address confounding factors, data were stratified by age, gender, and jaundice duration, and chi-square tests were performed post-stratification with statistical significance set at $p \leq 0.05$.

RESULTS

In this study assessing the diagnostic accuracy of computed tomography scan for detecting common bile duct calculi, 218 patients were evaluated with a mean age of 39.21 ± 9.36 years and a mean duration of jaundice of 7.04 ± 2.79 days; the cohort comprised 37.2% males and 62.8% females (Table-I).

Table I

Patient Demographics

Demographics	Mean ± SD	
Age (years)	39.21±9.36	
Duration of Jaundice (days)	7.04±2.79	
Gender	Male n (%)	81 (37.2%)
	Female n (%)	137 (62.8%)

CT scan identified calculi positively in 34.4% of cases, compared to 30.3% detected by endoscopic retrograde cholangiopancreatography, the gold standard (Table-II).

Table II

Overall results of CT Scan and ERCP in diagnosis

Diagnosis	CT Scan	ERCP
Positive	75 (34.4%)	66 (30.3%)
Negative	143 (65.6%)	152 (69.7%)
Total	218 (100%)	218 (100%)

When CT scan findings were compared to ERCP results (Table-III), it demonstrated 53 true positives, 130 true negatives, 22 false positives, and 13 false negatives. Overall, CT scan showed a sensitivity of 80.3%, specificity of 85.5%, diagnostic accuracy of 83.9%, positive predictive value (PPV) of 70.7%, and negative predictive value (NPV) of 90.9% in diagnosing common bile duct stones (Table-IV).

Table III

Comparison of CT Scan versus ERCP in diagnosis

CT Scan	ERCP		Total
	Positive	Negative	
Positive	53 (TP)	22 (FP)	75
Negative	13 (FN)	130 (TN)	143
Total	66	152	218

Table IV

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CT Scan in diagnosis

Diagnostic Parameter	Result
Sensitivity	80.30%
Specificity	85.50%
Diagnostic Accuracy	83.90%
PPV	70.70%
NPV	90.90%

Stratified analysis revealed variation in diagnostic performance: patients aged ≤40 years had lower sensitivity (63.2%) but higher specificity (93.3%) and accuracy (88.1%) compared to those older than 40 years, who exhibited higher sensitivity (87.2%) but reduced specificity (74.2%) and accuracy (79.8%). Gender-wise, males showed greater sensitivity (88.9%) but lower specificity (75.9%) and accuracy (80.2%) than females, who had sensitivity of 74.4%, specificity of 90.8%, and accuracy of 86.1%. Duration of jaundice also influenced CT scan performance, with patients symptomatic for ≤7 days showing notably lower sensitivity (58.8%) and PPV (41.7%), but higher specificity (86.5%) and NPV (92.8%), while those with jaundice >7 days had improved sensitivity (87.8%), specificity (83.3%), PPV (84.3%), and accuracy (85.6%) (Table-V and Graph-I).

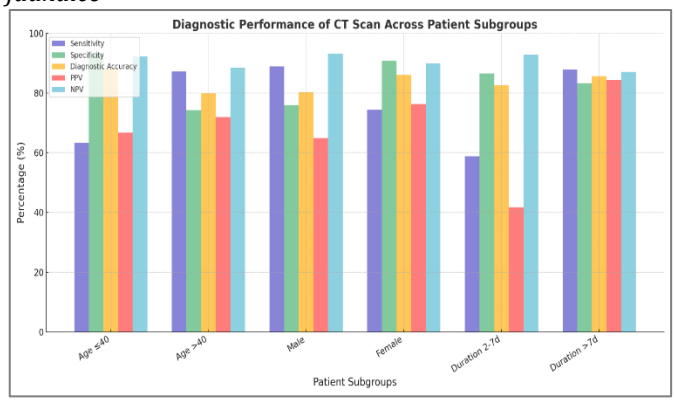
Table V

Stratified analysis of Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CT Scan in diagnosis with age, gender and duration of jaundice

Variables	Groups	Diagnostic Parameter	Result
Age (years)	≤40	Sen	63.20%
		Spec	93.30%
		DA	88.10%
		PPV	66.70%
		NPV	92.30%
	>40	Sen	87.20%
		Spec	74.20%
		DA	79.80%
		PPV	71.90%
		NPV	88.50%
Gender	Male	Sen	88.90%
		Spec	75.90%
		DA	80.20%
		PPV	64.90%
		NPV	93.20%
	Female	Sen	74.40%
		Spec	90.80%
		DA	86.10%
		PPV	76.30%
		NPV	89.90%
Duration of Jaundice (days)	≤7	Sen	58.80%
		Spec	86.50%
		DA	82.60%
		PPV	41.70%
		NPV	92.80%
	>7	Sen	87.80%
		Spec	83.30%
		DA	85.60%
		PPV	84.30%
		NPV	87.00%

Graph I

Sensitivity, Specificity, Diagnostic Accuracy, PPV and NPV of CT Scan in diagnosis with age, gender and duration of jaundice



DISCUSSION

The results demonstrate that CT scan has a high sensitivity (80.3%) and specificity (85.5%), confirming its value as a non-invasive diagnostic modality for CBD stones. The variability in sensitivity and specificity observed across age groups may be attributed to anatomical and physiological differences; younger patients (≤40 years) showed higher specificity possibly due to less biliary tract calcification and fewer confounding pathologies, whereas older patients had higher sensitivity likely because of more pronounced stone calcification making them easier to detect on CT. Gender differences, with males exhibiting higher sensitivity but lower specificity compared to females, may reflect differences in disease presentation or stone characteristics, such as size or density, which can affect CT visualization. Furthermore, the duration of jaundice influenced diagnostic performance, where longer symptom duration (>7 days) correlated with improved sensitivity and PPV, possibly due to more established stone formation and associated biliary changes enhancing CT detectability.

Our study findings are comparable to those reported by Mathew et al. [17], who demonstrated high overall accuracy of MDCT in obstructive jaundice evaluation, reinforcing CT's role in detecting biliary obstruction causes. Hashmi et al. [18] highlighted ultrasound's utility but noted limitations in sensitivity and specificity, especially for small stones, emphasizing CT and MRCP advantages in such cases. Petrescu et al. [19] observed CT's effectiveness increases with stone size, aligning with our finding that jaundice duration positively correlates with CT diagnostic performance due to increased stone calcification and ductal dilation over time.

Khalid et al. [20] reported CT sensitivity around 87% for benign biliary conditions, consistent with our results for older patients, suggesting CT performs better in patients with more advanced disease. Singh et al. [21] and Khalid et al. [20] also documented superior MRCP accuracy (~98%) compared to CT, consistent with our acknowledgment of MRCP as the current non-invasive gold standard for biliary imaging.

Anderson et al. [22] found MDCT sensitivity and specificity near 85%, close to our overall CT sensitivity

(80.3%) and specificity (85.5%), supporting CT's moderate reliability. Tongdee et al. [23] demonstrated MDCT cholangiography's high accuracy for biliary obstruction, corroborating our data on CT's clinical value. Kim et al. [24] identified stone size and composition as key factors influencing MDCT detectability, echoing our stratified analysis results showing diagnostic performance varies by patient factors affecting stone characteristics.

Gender-based differences in diagnostic accuracy seen in our study, with males showing higher sensitivity but lower specificity, have not been deeply explored in prior literature, suggesting a potential area for further research.

The variability in diagnostic accuracy across different patient subgroups further highlights the importance of individualized imaging strategies based on clinical presentation and patient characteristics. Future advances in imaging technology and standardized protocols may help reduce these discrepancies and improve early detection of biliary calculi.

This study has some notable limitations. Being performed at a single tertiary care facility, the results may not be broadly applicable to other hospitals or diverse patient populations. Additionally, the retrospective nature of some of the comparative data and potential selection bias may have influenced the diagnostic performance outcomes. Variations in CT scanner types, imaging protocols, and radiologist experience were not controlled for and could also affect diagnostic accuracy. Multi-center prospective studies with larger, more diverse cohorts are needed to validate and expand upon these results.

CONCLUSION

Our research has found that computed tomography scan shows excellent diagnostic performance in diagnosing common bile duct calculi compared to endoscopic retrograde cholangiopancreatography as the gold standard. Computed tomography is an excellent non-invasive imaging modality in the assessment of biliary stones, especially in circumstances where ERCP or MRCP is not easily available. The diagnostic efficacy of CT, however, can be affected by patient parameters and symptom duration, making complementary imaging important for maximal diagnosis.

Acknowledgments

The meticulous dedication of the Department's medical staff in ensuring accurate documentation and systematic management of patient data is highly commendable and deeply appreciated.

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