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DIAGNOSTIC ACCURACY OF CONTRAST ENHANCED COMPUTED TOMOGRAPHY IN DETERMINING T STAGE OF GALL BLADDER MALIGNANCY TAKING HISTOPATHOLOGY AS GOLD STANDARD

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Abstract

OBJECTIVE: *To determine the diagnostic accuracy of CT scan in detecting the gallbladder malignancy taking histopathology as gold standard.* ***METHODOLOGY:*** *this study consisting of 132 cases was conducted at Department of Diagnostic Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore during the period from 15 Jan 2025 to 15 April 2025. The age range was 30–70 years with clinical suspicion of GBC underwent CT imaging. Histopathological examination was performed after surgical excision. Diagnostic accuracy parameters including sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated.* ***Results:*** *CT showed 89.8% sensitivity, 72.7% specificity, 86.8% PPV, 78.1% NPV, and an overall diagnostic accuracy of 84.1%. Diagnostic performance was higher in older patients and those with BMI >25. Gender-based analysis revealed higher sensitivity in females and greater specificity in males.* ***Conclusion:*** *CT is a reliable, non-invasive tool for diagnosing gallbladder malignancy, with high sensitivity and moderate specificity. Stratified performance indicates its enhanced utility in specific subgroups. Combining CT findings with histopathology, CEUS, and emerging technologies like AI may further improve diagnostic precision*

INTRODUCTION

Although gallbladder cancer (GBC) accounts for only 4% of gastrointestinal malignancies, it occurs more frequently in regions such as India, Japan, Chile, and Mexico.[1,2] The disease is often asymptomatic in its early stages, leading to late diagnoses in most cases. At this point, the 5-year survival rate is under 10%.[3] GBC is the most prevalent among biliary cancers and is characterized by its aggressive nature and rapid progression. It often spreads early to nearby organs and lymph nodes, which limits the potential for curative treatment.[4,5]

Advancements in imaging technology are reshaping how gallbladder cancer (GBC) is diagnosed. CT scans now provide detailed information on tumor extension, metastatic spread, and portal vein involvement, making them indispensable in clinical evaluation.[6] Their speed, accessibility, and cost-

effectiveness make CT the preferred first-line diagnostic method for GBC. A comprehensive diagnosis requires integrating patient history, imaging results, and expert radiological interpretation.[7] While histopathology continues to be the definitive diagnostic tool, it is invasive and usually limited to postoperative contexts. Conversely, CT imaging, particularly with 3D reconstructions, offers a reliable, non-invasive alternative for both diagnosis and treatment planning.[8]

According to Naz et al. (2016), CT scans correctly diagnosed 274 true positive cases (63.1%), with a sensitivity of 94.2%, specificity of 92.3%, PPV of 96.1%, NPV of 88.6%, and accuracy of 93.5%. CT findings revealed malignancy in 66.6% (285/434) of patients.[9] Haider et al. (2023) reported CECT sensitivity and specificity of 96% and 80%, respectively, for GBC detection.[10] Yasmin et al. (2024) found CT sensitivity at 90.24%, specificity at 75%, accuracy at 88.89%, PPV at 97.37%, and NPV at 42.86%, with 84.44% of patients showing CT-detected malignancy.[11]

The rationale for our study is highlighted by the observed variability in specificity across existing literature, ranging from 75.0% (Yasmin et al.)[11] to 92.3% (Naz et al.)[9] This variation highlights the need for a comprehensive evaluation of CT's performance in a local context, where limited data is available. Our study aims to contribute to the existing literature by providing updated and region-specific insights into the diagnostic capabilities of CT scans for gallbladder malignancy. By establishing clearer scales for sensitivity and specificity, we hope to enhance clinical decision-making and improve patient outcomes. Ultimately, this research will address gaps in knowledge and foster better understanding or CT imaging in gallbladder cancer diagnosis.

METHODOLOGY:

This cross-sectional study was conducted at the Department of Diagnostic Radiology, Shaukat Khanum Memorial Cancer Hospital and Research Centre, Lahore from 15 Jan 2025 to 15 April 2025 following the approval of the synopsis. A total of 132 patients were enrolled using non-probability consecutive sampling. The sample size was calculated based on a 95% confidence interval, an expected CT sensitivity of 90.24% with a 7% margin of error, specificity of 75% with a 13% margin of error, and an assumed disease prevalence of 66.6%. Patients aged 30 to 70 years with clinical suspicion of gallbladder malignancy—manifesting as abdominal pain, jaundice, or unexplained weight loss—who had undergone CT imaging were included in the study. Written informed consent was obtained from each participant. Exclusion criteria included prior gallbladder surgery, other malignancies, renal impairment (GFR <60 mL/min/1.73 m^2), incomplete records, or contrast allergy.

Gallbladder malignancy on CT scan was defined by the presence of a mass or gallbladder wall thickening greater than 1 cm with irregular margins and post-contrast enhancement, as well as signs of direct invasion into adjacent structures, regional lymphadenopathy exceeding 1 cm, or evidence of distant metastasis. All scans were performed using a Toshiba Activion 60-slice CT scanner, acquiring axial helical sections from the xiphoid process to the pubic symphysis at 120 kVp and 210 mA during the portal venous phase (60–70 seconds post-contrast). A consultant radiologist with at least five years of experience interpreted the images. Surgical excision of the gallbladder was performed subsequently, and specimens were preserved in 10% buffered formalin for histopathological analysis. Gallbladder malignancy on histopathology was defined as the presence of malignant cells in tissue sections, with atypical nuclear morphology, increased mitotic activity, and evidence of stromal invasion. Radiological findings were compared with histopathological results, and data were recorded in a structured proforma. Confounding variables and biases were controlled by strict adherence to inclusion and exclusion criteria.

All data were analyzed using SPSS version 25. Quantitative variables such as age, BMI, and disease duration were summarized as mean ± standard deviation. Categorical variables like gender and malignancy status (on CT and histopathology) were reported as frequencies and percentages. Diagnostic accuracy of CT was evaluated using a 2×2 contingency table with histopathology as the gold standard. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated using standard formulas.

Stratification was performed for age, gender, BMI, and disease duration to control for potential effect modifiers, and diagnostic parameters were recalculated post-stratification.

RESULTS:

Table 1 provides an overview of the demographic and clinical characteristics of the 132 study participants. The mean age was 49.89 ± 12.06 years, with participants evenly divided between the 30–50 years (49.2%) and 51–70 years (50.8%) age groups. The mean BMI was 25.67 ± 3.89, placing most individuals within the normal to slightly overweight range. Gender distribution was nearly equal, with 49.2% males and 50.8% females, ensuring balanced representation. The average duration of disease was 12.59 ± 7.02 months, with 51.5% reporting symptoms for 1–12 months and 48.5% for 13–24 months. This well-distributed sample supports valid comparative analysis across demographic and clinical subgroups.

Table 1: Frequency distribution for age group, gender, and duration of disease is summarized below:

Variable		Frequency	Percent
Age	30-50	65	49.2
	51-70	67	50.8
Gender	Male	65	49.2
	Female	67	50.8
Duration of Disease(Months)	1-12	68	51.5
	13-24	64	48.5

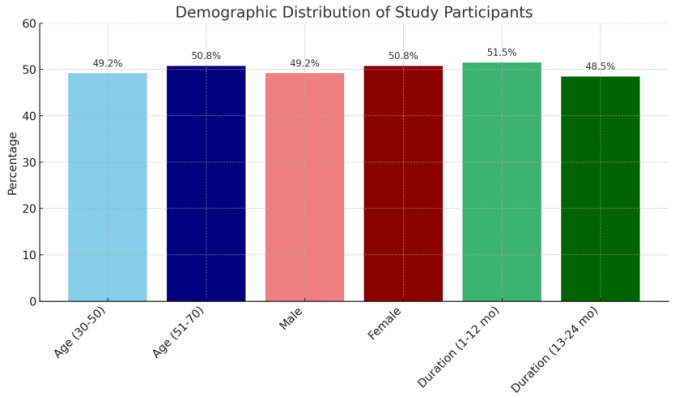

Table 2 presents the diagnostic outcomes for CT scans and histopathology among the 132 study participants. CT imaging identified gallbladder malignancy in 91 cases (68.9%), while 41 cases (31.1%) were CT-negative. Histopathological examination, used as the gold standard, confirmed malignancy in 88 patients (66.7%), and ruled it out in 44 patients (33.3%). These findings indicate a high proportion of malignancy detection across both modalities, supporting the clinical relevance of CT imaging in the preliminary assessment of gallbladder cancer.

Table 2: Frequency distribution of CT and histopathology results:

Diagnostic modality		Frequency	Percent
CT	Yes	91	68.9
	No	41	31.1
Histopathology	Yes	88	66.7
	No	44	33.3

The diagnostic performance of CT scan in detecting gallbladder malignancy was evaluated against the gold standard of histopathology. The overall diagnostic metrics are summarized in Table 3. Out of 132 patients, histopathology confirmed 88 as positive and 44 as negative for malignancy. Among the positive cases, 79 were correctly identified by CT (true positives), while 9 were missed (false negatives). Among the negative cases, 32 were correctly identified (true negatives), and 12 were incorrectly labeled as positive (false positives). These results yielded a sensitivity of 89.8%, specificity of 72.7%, positive predictive value (PPV) of 86.8%, negative predictive value (NPV) of 78.1%, and an overall diagnostic accuracy of 84.1%, indicating good diagnostic reliability of CT in this context.(Table 3)

Table 3: Diagnostic accuracy of CT scan in detecting gallbladder malignancy compared to histopathology (gold standard):

		CT Positive	CT Negative	Total
Histopathology	Positive (n=88, 66.7%)	TP = 79 (59.8%)	FN = 9 (6.8%)	88
	Negative (n=44, 33.3%)	FP = 12 (9.1%)	TN = 32 (24.2%)	44
	Total	91	41	132
	Sensitivity=89.8%, Specificity=72.7%, PPV=86.8%, NPV=78.1% and diagnostic accuracy=84.1%			

Table 4 stratifies diagnostic accuracy by age groups. In the 30–50 years group, CT showed a sensitivity of 88.9% and specificity of 65%, with a diagnostic accuracy of 81.5%. The PPV and NPV were 85.1% and 72.2%, respectively, indicating slightly lower specificity compared to older patients. In the 51–70 years group, CT performance was better, with sensitivity of 90.7%, specificity of 79.2%, PPV of 88.6%, and NPV of 82.6%.

Table 4: Diagnostic accuracy of CT scan in detecting gallbladder malignancy compared to histopathology (gold standard) according to age groups:

Age Group			CT Positive	CT Negative	Total
30-50	Histopathology	Positive (n=45, 69.2%)	TP = 40 (61.5%)	FN = 5 (7.7%)	45
		Negative (n=20, 30.8%)	FP = 7 (10.8%)	TN = 13 (20.0%)	20
	Sensitivity=88.9%, Specificity=65%, PPV=85.1%, NPV=72.2% and diagnostic accuracy=81.5%				
51-70	Histopathology	Positive (n=43, 64.2%)	TP = 39 (58.2%)	FN = 4 (6.0%)	43
		Negative (n=24, 35.8%)	FP = 5 (7.5%)	TN = 19 (28.4%)	24
	Sensitivity=90.7%, Specificity=79.2%, PPV=88.6%, NPV=82.6% and diagnostic accuracy=86.6%				

Table 5 presents diagnostic metrics stratified by gender. Among males, CT demonstrated a sensitivity of 84.4% and specificity of 85.0%, with a high PPV of 92.7%, suggesting that when CT indicates malignancy in males, it is highly likely to be correct. However, the NPV was lower (70.8%), and overall diagnostic accuracy was 84.6%.

Table 5: Diagnostic accuracy of CT scan in detecting gallbladder malignancy compared to histopathology (gold standard) according to gender groups:

Gender Group			CT Positive	CT Negative	Total
Male	Histopathology	Positive (n=45, 69.2%)	TP = 38 (58.5%)	FN = 7 (10.8%)	45
		Negative (n=20, 30.8%)	FP = 3 (4.6%)	TN = 17 (26.2%)	20
	Sensitivity=84.4%, Specificity=85.0%, PPV=92.7%, NPV=70.8% and diagnostic accuracy=84.6%				
Female	Histopathology	Positive (n=43, 64.2%)	TP = 41 (61.2%)	FN = 2 (3.0%)	43
		Negative (n=24, 35.8%)	FP = 9 (13.4%)	TN = 15 (22.4%)	24

	Sensitivity=95.3%, Specificity=62.5%, PPV=82.0%, NPV=88.2% and diagnostic accuracy=83.6%

Table 6 focuses on performance by BMI group. In individuals with normal BMI (18–25), CT had sensitivity of 81.1% and specificity of 71.4%, with diagnostic accuracy of 77.6%. The PPV and NPV were 83.3% and 68.2%, respectively. In patients with BMI >25, CT performance was significantly better, with sensitivity of 96.1%, specificity of 73.9%, PPV of 89.1%, and NPV of 89.5%, resulting in the highest diagnostic accuracy of 89.2% among all subgroups. This indicates that CT scanning may be particularly effective in detecting gallbladder malignancy in overweight individuals.

Table 6: Diagnostic accuracy of CT scan in detecting gallbladder malignancy compared to histopathology (gold standard) according to BMI groups:

BMI Group	Histopathology		CT Positive	CT Negative	Total
18-25		Positive (n=37, 63.8%)	TP = 30 (51.7%)	FN = 7 (12.1%)	37
		Negative (n=21, 36.2%)	FP = 6 (10.3%)	TN = 15 (25.9%)	21
	Sensitivity=81.1%, Specificity=71.4%, PPV=83.3%, NPV=68.2% and diagnostic accuracy=77.6%				
>25	Histopathology	Positive (n=51, 68.9%)	TP = 49 (66.2%)	FN = 2 (2.7%)	51
		Negative (n=23, 31.1%)	FP = 6 (8.1%)	TN = 17 (23.0%)	23
	Sensitivity=96.1%, Specificity=73.9%, PPV=89.1%, NPV=89.5% and diagnostic accuracy=89.2%				

DISCUSSION

Gallbladder carcinoma (GBC) is a highly aggressive malignancy that is frequently diagnosed at an advanced stage due to vague clinical presentation and limited early detection tools. In our study, contrast-enhanced computed tomography (CECT) demonstrated strong diagnostic performance, with a sensitivity of 89.8%, specificity of 72.7%, and overall accuracy of 84.1%, validating its role as a frontline diagnostic tool.

In terms of demographics, our study population had a mean age of 49.89 ± 12.06 years, with an almost equal gender distribution (49.2% male, 50.8% female). This contrasts slightly with studies like Nazir et al. (2025),[12] which reported a higher female predominance (66%) and a slightly lower mean age (45.00 ± 8.87 years). Similarly, Noureen et al. (2025)[13] found a male predominance and a higher mean age of 58.74 years among cholecystectomy patients. These demographic variations may influence diagnostic accuracy and presentation patterns. For instance, our finding of better CT accuracy in patients aged 51–70 years is consistent with the observed higher GBC prevalence in older populations across studies. Gender-based diagnostic variations in our study, with higher sensitivity in females and greater specificity in males, may reflect anatomical or hormonal differences, warranting further investigation.

Our findings align well with Haider et al (2023),[10] who reported sensitivity and specificity values of 96% and 80% for CECT, respectively. Similarly, Naz et al. (2016)[14] found CECT sensitivity of 94.2% and specificity of 92.3%. Yasmin et al. (2024) supported these findings with a diagnostic accuracy of 88.89%, though with slightly lower specificity. These studies collectively affirm the utility of CECT in initial diagnosis and treatment planning.

Stratified analysis in our dataset showed improved diagnostic accuracy in older patients and those with higher BMI (>25), with the latter subgroup demonstrating the highest diagnostic accuracy (89.2%). This could be due to clearer visualization of tumor margins in adipose-rich tissues, which facilitates radiological detection. CT performance also varied by gender, with higher sensitivity in females but greater specificity in males, suggesting that patient demographics may influence interpretative accuracy.

Other malignancy-focused studies also demonstrate high CT accuracy. For instance, Amin and Zahoor (2022)[15] reported 93.24% diagnostic accuracy in bronchogenic carcinoma, while Bhund et al. (2020)[16] found 94.2% in ovarian cancer—highlighting CT's reliability across multiple cancer types. However,

Struckmeier et al. (2024)[17] emphasized caution due to artifacts and false interpretations in bone invasion for oral cancers, which is relevant when evaluating dense hepatic-gallbladder interfaces.

Differentiation between GBC and benign conditions like xanthogranulomatous cholecystitis (XGC) remains challenging. Bozer and Durgun (2024)[18] found that imaging features such as continuous mucosal lines and hypoattenuating nodules were more characteristic of XGC, whereas hepatic invasion and large lymph nodes favored GBC. Our study employed features like irregular wall thickening, post-contrast enhancement, and adjacent organ invasion to identify malignancy—criteria also emphasized by Neculoiu et al. (2024).[19] Patkar et al. (2023)[20] highlighted the role of intraoperative frozen section (FS), reporting 95.1% diagnostic accuracy and its utility in surgical decision-making. While CT facilitates preoperative planning, FS provides real-time histological confirmation. Meanwhile, Mencarini et al. (2024)[21] and Qu et al. (2021)[22] proposed using CEUS and 3D-CEUS for microvascular evaluation and differentiation of complex lesions.

Our findings are also supported by risk factor data. Nazir et al. (2025)[12] confirmed a significant association between large gallstones (>3 cm) and GBC, particularly in older women—a subgroup that also showed better CT performance in our study. Noureen et al. (2025)[13] further noted high comorbidity burden among older patients with gallbladder disease, which may complicate diagnosis and prognosis. The case report by Sabih et al. (2025) of adolescent GBC emphasizes the importance of early recognition and diagnosis even in atypical age groups.

Future directions for diagnostic improvement include the integration of artificial intelligence and molecular diagnostics. As Burud et al. (2025)[24] and Rana et al. (2024)[25] noted, the role of AI, advanced ultrasound, and radiomics is evolving, and their incorporation into routine practice may soon enhance diagnostic precision. Limitations of our study include its single-center design and lack of interobserver variability analysis. While our results are consistent with broader literature, multicentric validation with a larger sample and AI-integrated imaging workflows would enhance reliability.

CONCLUSION:

Contrast-enhanced CT is a highly sensitive and moderately specific tool for diagnosing GBC. Its non-invasive nature, accessibility, and staging capabilities make it a critical component in initial clinical evaluation. Integration with histopathological tools, CEUS, and emerging technologies like AI will further optimize diagnostic and therapeutic pathways for gallbladder cancer.

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