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ORIGINAL ARTICLE

Diagnostic Value of Computed Tomography in Gallbladder Perforation

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Abstract

Objective: Preoperative diagnosis of gallbladder perforation is difficult; some cases are still diagnosed intraoperatively. In this study, we aimed to research the value of computed tomography findings in gallbladder perforation diagnosis.

Methods: Eighty-nine patients who underwent emergency cholecystectomy with the diagnosis of acute cholecystitis or gallbladder perforation between 2018 and 2022 were evaluated retrospectively. Multidetector computed tomography scan findings of all patients were examined by a radiology specialist. Demographic, clinical data, and computed tomography findings were statistically compared between the perforated group (n = 19) and the nonperforated group (n = 72).

Results: In the diagnosis of gallbladder perforation, the positive predictive value of computed tomography was 100%, the negative predictive value was 97.2%, sensitivity was 89.4%, and specificity was 100%. The mean age and the incidence of chronic obstructive pulmonary disease were significantly higher in the perforated group ($P < .05$). In the computed tomography findings related to the gallbladder, gallbladder wall thickening, pericholecystic fluid collection, abscess/biloma, pericholecystic free air, intraluminal gas, and wall defect findings were observed to be significantly higher in the perforated group ($P < .05$) In the computed tomography findings related to extra-gallbladder organ, free intraperitoneal fluid and ileus, were significantly more common in the perforated group ($P < .05$).

Conclusion: Multidetector Computed Tomography (MDCT)has high sensitivity, specificity, and predictive value in the diagnosis of gallbladder perforation. Wall defect, increased wall thickening, pericholecystic free fluid or air, abscess or biloma, intraluminal gas, free intraperitoneal fluid, and ileus are significant computed tomography findings in the diagnosis of gallbladder perforation.

Keywords: Acute cholecystitis, computed tomography, early diagnosis, gallbladder perforation

Introduction

Gallbladder perforation (GBP) is one of the most serious complications of acute cholecystitis, associated with high morbidity and mortality. Delayed surgical intervention to GBP is also associated with long hospital stay and increased intensive care unit admission rate.[1] This fatal risk can be avoided by performing an early cholecystectomy with the early diagnosis or prediction of GBP.

Preoperative diagnosis of GBP is difficult, and some cases are still diagnosed intraoperatively. Gallbladder perforation can be diagnosed with a good physical examination, laboratory tests, and imaging methods. Ultrasound (US) findings in acute cholecystitis, such as GB distension, GB wall thickening, pericholecystic free fluid, and positive sonographic Murphy sign, may also be present in GBP cases.[2,3] However, the US has limited value in evaluating underlying complications of acute cholecystitis. Computed tomography (CT) is superior to the US with its high accuracy rate in diagnosing GBP.[4] Computed tomography also is often obtained to evaluate for complications of acute cholecystitis. Computed tomography findings of poorly enhancing walls, intraluminal membranes, striated and reduced mural enhancement, focal mural defects, and pericholecystic abscesses have been described in cases of gangrenous cholecystitis, with specificity close to 90%.[5] However, there is not enough literature about which CT findings are useful in the diagnosis of GBP.

In this study, we aimed to research the diagnostic value of CT in the diagnosis of GBP in acute cholecystitis and which CT findings are helpful in diagnosing GBP.

Methods

Eighty-nine patients who underwent an emergency cholecystectomy with the diagnosis of acute cholecystitis or GBP in Sancaktepe Şehit Prof Dr İlhan Varank Training and Research Hospital's emergency surgery department between May 2018 and January 2022 were evaluated retrospectively. Ethics committee approval was obtained for the study (Date: July 14, 2021, Number: 2021/182). All patients over the age of 18, who underwent preoperative contrast-enhanced CT imaging, and who underwent laparoscopic or open cholecystectomy with the diagnosis of acute cholecystitis or GBP were included in the study. Patients with GBP without preoperative CT imaging, patients with noncontrast CT findings, patients with nonoptimal CT image quality, patients with >12 hours between CT imaging and surgery, patients under 18 years of age, and patients who underwent elective cholecystectomy were excluded from the study.

The diagnosis of GBP was based on the operative findings. The patients were divided into 2 groups, GBP and non-GBP. Age, sex, comorbidity, preoperative abdominal multidetector CT findings, length of hospital stay (day), and mortality rate of the patients were examined. All abdominal MDCT images were retrospectively

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evaluated by a radiologist with 8 years of experience. The radiologist knew that these patients had acute cholecystitis before reviewing these CT scans and did not know which patients had GBP. Computed tomography scans were performed using an MDCT scanner (Brilliance 64; Philips Medical Systems, Cleveland, Ohio, USA) without oral contrast administration. The technical parameters of CT were as follows: collimation 0.625 mm; table speed 50.8 mm rotation^{-1}; pitch 1.014; rotation time 0.5 s; 140-175 mA; voltage 120 kV (peak). We performed a postcontrast scan of the entire abdomen with a 60-70-second delay after starting the infusion of 120 mL nonionic contrast material through an antecubital vein at 4 mL s^{-1}. The axial section data were reconstructed at a thickness of 5 mm with 5 mm increments and at a thickness of 2 mm with 1 mm increments. The second data set was reformatted coronally at a thickness of 3 mm with 3-mm increments.

In the evaluation of abdominal CT; gall stones, wall thickening, GB distension, pericholecystic fluid collection, pericholecystic abscess or biloma, intraperitoneal free air or fluid, intramural or intraluminal gas, wall defects, location of perforation, pericholecystic liver enhancement, mural thickening of colon hepatic flexure and ileus were examined. The normal value of gallbladder wall thickness was accepted as <3 mm.[6] Transverse diameter >4 cm and longitudinal diameter >9 cm were considered as gallbladder distension.[7]

Statistical Analysis

The statistical analyses were performed with the Statistical Package for Social Sciences version 25.0 (IBM SPSS Corp.; Armonk, NY, USA). The conformity of the variables to normal distribution was examined by histogram graphics and the Kolmogorov–Smirnov test. Mean, standard deviation, median, IQR, min-max values were used in presenting descriptive analyses. Categorical variables were compared with Pearson's chi-squared test. The Mann–Whitney *U* test evaluated nonnormally distributed (nonparametric) variables between the 2 groups. Cases with a *P*-value < .05 were considered statistically significant results.

Results

The mean age of 89 patients included in the study was 57.1 years, 58% were male and 41% were female. The most common comorbidity in the patients was diabetes mellitus (DM), with 51.7% (n = 46). The 4 most common CT findings were gallbladder distension (89.9%), gallstones (70.8%), pericholecystic fluid collection (59.5%), and pericholecystic liver contrast enhancement (49.4%), respectively (Figures 1 and 2). Gallbladder perforations were most common in the fundus (73.6%). The mean hospitalization duration for all cases was 3.8 ± 4.1 days, and mortality was 2.2% (n = 2) (Table 1). Two patients died of sepsis and multiple organ failure in the early postoperative period.

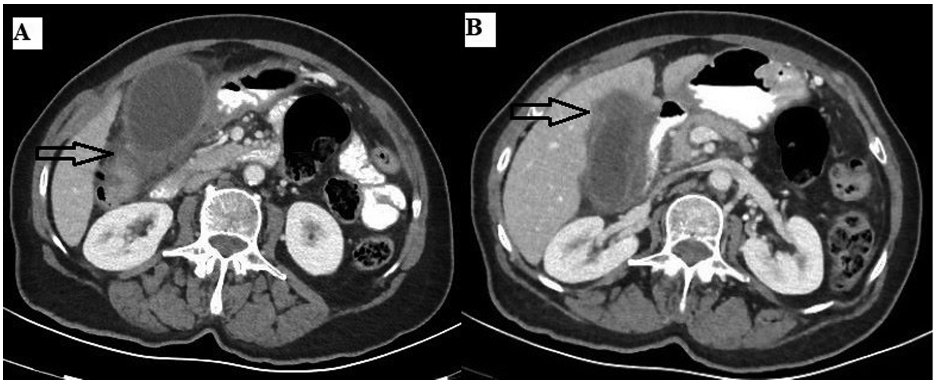

Figure 1. Abdominal CT images were taken at the first admission of a 61-year-old female patient diagnosed with gallbladder perforation intraoperatively. (A, B): Axial CT image, postcontrast venous phase. It shows significant contrast enhancement in the gallbladder wall, wall thickening, and pericholecystic diffuse edema and inflammation in the adipose tissue. CT, computed tomography.

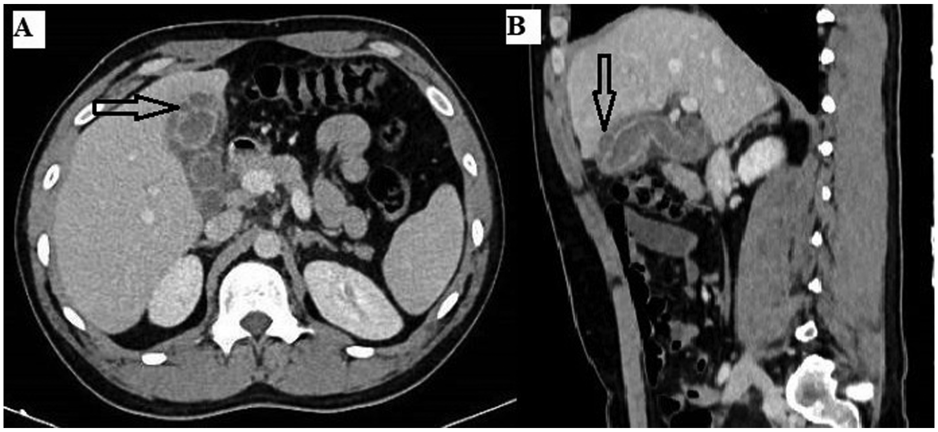

Figure 2. Abdominal CT images were taken at the first admission of a 50-year-old male patient diagnosed with gallbladder perforation intraoperatively. (A) Axial CT image, postcontrast venous phase. (B) Sagittal CT image, postcontrast venous phase. It shows significant thickening and contrast enhancement in the gallbladder wall; diffuse edema in the pericholecystic area; irregularity in the gallbladder wall and a focus of perforation. CT, computed tomography.

Table 1. Demographic, Clinical Data, and CT Findings of 89 Patients

		n (%)
Age*		57.1 ± 11.12
Gender	Male	52 (58.4)
	Female	37 (41.5)
DM		46 (51.7)
HT		29 (32.6)
CVD		9 (10.1)
COPD		22 (24.7)
Gall stones		63 (70.8)
Wall thickening		35 (39.3)
Gallbladder distension		80 (89.9)
Pericholecystic fluid collection		53 (59.5)
Abscess or biloma		10 (11.2)
Pericholecystic free air		9 (10.1)
Intramural gas		3 (3.3)
Intraluminal gas		3 (3.3)
Intraperitoneal free fluid		35 (39.3)
Wall defect		13 (14.6)
Single wall defect		9 (10.1)
Multiple wall defect		4 (4.5)
Pericholecystic liver enhancement		44 (49.4)
Mural thickening of hepatic flexure colon		15 (16.8)
Ileus		22 (24.7)
Perforation site	Fundus	14 (73.6)
	Corpus	4 (21.0)
	Infundibulum	1 (5.2)
Length of hospital stay (day)*		3.80 ± 4.14
Mortality		2 (2.2)

*Mean ± SS instead of n given.
COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; DM, diabetes mellitus; HT, hypertension.

With operative findings, 19 patients (21.35%) were diagnosed with GBP. On the other hand, perforation was observed in 17 patients (19.1%) with CT. Therefore, the number of patients who were found to be nonperforated intraoperatively was 70. In the diagnosis of GBP, the positive predictive value of CT was 100%, the negative predictive value was 97.2%, the sensitivity was 89.4%, and the specificity was 100%.

When the perforated group was compared with the nonperforated group, the mean age of the perforated group was significantly higher ($P < .001$) (Table 2). While other comorbidities had no significant relationship with perforation, the incidence of COPD was significantly higher in the perforated group ($P = .001$). The CT findings related to the gallbladder, increased gallbladder wall thickening, pericholecystic fluid collection, abscess/biloma, pericholecystic free air, intraluminal gas, and wall defect findings, were observed to be significantly higher in the perforated group (Table 2). The CT findings related to other peripheral organs and abdominal region, free intraperitoneal fluid and ileus, were significantly more common in the perforated group ($P = .003$ and $P < .001$, respectively). Pericholecystic liver contrast enhancement and inflammation findings in the hepatic flexure of the colon were similar in both groups ($P > .05$). The hospitalization duration and mortality were significantly higher in the perforated group (Table 2).

Discussion

In acute cholecystitis, distension of the organ with a consequent rise in intraluminal pressure impedes venous and lymphatic drainage, leading to vascular compromise and ultimately to necrosis and perforation of the gallbladder wall. Gallbladder perforation is seen in 2%-11% of cases with acute cholecystitis.[8] Andersen et al[10] who modified the Niemeier classification, described 4 clinical types of perforation: type I, acute free perforation; type II, subacute pericholecystic abscess; type III, chronic cholecystoenteric fistulation; type IV, cholecystobiliary fistula formation.[9,10] Our study includes only x perforation subtypes I and II.

Advanced age, male gender, DM, and cardiovascular comorbidity have been reported as risk factors for GBP.[11,12] In our study, the incidence of GBP was significantly higher in elderly and COPD patients. Although perforation was more common in men and patients with DM, this difference was not considered statistically significant. Gallbladder perforation occurs most commonly in the fundus due to the least blood supply.[3] In the present study, the most frequent site of perforation was the fundus (73.6%) in accordance with the literature.

Many clinical studies have emphasized the importance of early diagnosis and early cholecystectomy to avoid the mortal complications of acute cholecystitis.[2,13,14] It has been reported that early surgical intervention ensures shorter hospitalization, less mortality, less postoperative complications, and is cost-effective. Therefore, early radiological diagnosis and early prediction of perforation are important. Abdominal US is superior to CT in the diagnosis of acute cholecystitis and gallstones. Harvey et al[15] reported that US proved to have significantly higher sensitivity (83% vs. 39%), positive predictive value (75% vs. 50%), and negative predictive value (97% vs. 89%) than CT, with both techniques showing similar specificity (95% vs. 93%). However, in the presence of acute cholecystitis complications such as gangrenous cholecystitis, emphysematous cholecystitis, perforation, and pericholecystic abscess, US alone is not sufficient.[16] The ability of MDCT, which is increasingly used in emergency departments all over the world and can offer the opportunity to examine the abdominal cavity in more detail with many thin sections, is very important at this point to predict perforation in acute cholecystitis. However, the value of CT in GBP is still controversial.

Gallbladder distension, wall thickening increase, pericholecystic or intraperitoneal free fluid, and the presence of gas in the gallbladder wall on CT are among the early signs of GBP.[17] Wall defect and extraluminal position of gallstones are direct findings of GBP, and it has been reported in the literature that they can be demonstrated in US.[4] However, CT scan is more sensitive than US in detecting and localizing wall defects and the extraluminal position of gallstones.[4,18] In a comparative study in which Kim et al[19] compared CT and US, they found the focus of perforation in 50%

Table 2. Comparison of CT Findings and Clinical Data Between Perforated and Nonperforated Groups

		Nonperforated Group (n = 70)		Perforated Group (n = 19)		
		n	%	n	%	*P*
Age*		54.63 ± 10.23	55 (45-62)	66.05 ± 9.74	69 (58-74)	**<.001**[1]
Gender	Male	40	(57.14)	12	(63.16)	.637
	Female	30	(42.86)	7	(36.84)	
DM		34	(48.57)	12	(63.16)	.259
HT		23	(32.86)	6	(31.58)	.916
CVD		7	(10.00)	2	(10.53)	.946
COPD		12	(17.14)	10	(52.63)	**.001**
Gall stones		49	(70.00)	14	(73.68)	.754
Wall thickening		18	(25.71)	17	(89.47)	**<.001**
Gallbladder distension		63	(90.00)	17	(89.47)	.946
Pericholecystic fluid collection		37	(52.86)	16	(84.21)	**.014**
Abscess or biloma		2	(2.86)	8	(42.11)	**<.001**
Pericholecystic free air		0	(0.00)	9	(47.37)	**<.001**
Intramural gas		1	(1.43)	2	(10.53)	.051
Intraluminal gas		0	(0.00)	3	(15.79)	**.001**
Wall defect		3	(4.29)	10	(52.63)	**<.001**
Intraperitoneal free fluid		22	(31.43)	13	(68.42)	**.003**
Pericholecystic liver enhancement		37	(52.86)	7	(36.84)	.216
Mural thickening of colon hepatic flexure		10	(14.29)	5	(26.32)	.214
Ileus		11	(15.71)	11	(57.89)	**<.001**
Length of hospital stay (day)*		1.96 ± 1.29	2 (1-2)	10.58 ± 3.95	10 (8-13)	**<.001**[1]
Mortality		0	(0.00)	2	(10.53)	**.006**

*n was replaced by mean ± SS, and % was replaced by median (IQR). [1]Mann–Whitney *U* test.
COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; DM, diabetes mellitus; HT, hypertension; IQR, interquartile range.

of the cases with CT, but they could not show the focus of perforation in any of the patients with US.

Intramural gas, intraluminal gas, and intraluminal membrane findings on CT are helpful in the diagnosis of gangrenous and emphysematous cholecystitis.[5] In the literature, pericholecystic abscess or biloma has also been associated with GBP.[4] Infective bile or microorganisms pass through the perforation focus, causing first local pericholecystic inflammation and then pericholecystic abscess or biloma formation. In our study, wall thickening, pericholecystic free fluid and air, pericholecystic abscess or biloma, intraluminal gas, and wall defect findings were associated with GBP.

Apart from the CT findings mentioned above, extra-gallbladder organ findings may also give an idea for the diagnosis of GBP. Findings such as ileus, inflammation in the hepatic flexure of the colon, intraperitoneal free fluid (ascites), or free air are other helpful CT findings for GBP. Reactive hyperemia in hepatic parenchyma of gallbladder fossa may present as hyperenhancement on CT and can be seen in almost all acute cholecystitis and cholecystitis-associated complications.[2,16] Intraperitoneal free fluid (ascites) is thought to occur as a result of peritoneal irritation secondary to bile leakage.[4] In the present study, we determined from the extra-gallbladder organ findings that the presence of free intraperitoneal fluid and ileus were associated with GBP.

There were some limitations to this study. First, the study was retrospective, and the radiologist knew that all cases were diagnosed with acute cholecystitis before evaluating CTs. However, the radiologist did not know who had perforation. In this case, it differs from daily practice as it will be a gallbladder-focused CT image reading. Secondly, the study included a small number of patients. Thirdly, patients diagnosed with US and operated were excluded from the study. Thus, we could not evaluate US and CT comparatively.

Conclusion

In conclusion, cross-sectional imaging is critical in identifying the complications associated with acute cholecystitis. MDCT has high sensitivity, specificity, and predictive value in the diagnosis of GBP. Wall thickening, pericholecystic fluid collection, abscess/

biloma, pericholecystic free air, intraluminal gas, wall defect, free intraperitoneal fluid, and ileus are significant CT findings in the diagnosis of GBP. Moreover, the risk of GBP increases significantly in elderly and patients with COPD.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Sancaktepe Prof Dr. İlhan Varank Training and Research Hospital (Date: July 14, 2021, Number: 2021/182).

Informed Consent: Informed consents were not required for retrospective review of the medical and radiological data of the patients.

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