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Differentiation of acute cholecystitis from chronic cholecystitis
Determination of useful multidetector computed tomography findings

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Abstract

The purpose of this study was to determine the diagnostic value of multidetector computed tomography (MDCT) imaging findings, to identify the most predictive findings, and to assess diagnostic performance in the diagnosis and differentiation of acute cholecystitis from chronic cholecystitis.

In this retrospective study, we enrolled 382 consecutive patients with pathologically proven acute or chronic cholecystitis who underwent computed tomography (CT) within 1 month before surgery. The CT findings were compared and logistic regression analysis was used to identify significant CT findings in predicting acute cholecystitis. Diagnostic performance of each CT finding and of combined findings was also assessed.

Statistically significant CT findings distinguishing acute cholecystitis from chronic cholecystitis were increased gallbladder dimension (85.5% vs 50.6%, $P < .001$), increased wall enhancement (61.8% vs 78.9%, $P = .001$), increased wall thickness (67.9% vs 31.1%, $P < .001$), mural striation (64.9% vs 28.3%, $P < .001$), pericholecystic haziness or fluid (66.4% vs 21.2%, $P < .001$), increased adjacent hepatic enhancement (80.0% vs 32.4%, $P < .001$), focal wall defect (9.2% vs 0, $P < .001$), and pericholecystic abscess (10.7% vs 0, $P < .001$). Subsequent multivariate logistic regression analysis revealed that increased adjacent hepatic enhancement [$P = .006$, odds ratio (OR) = 3.82], increased gallbladder dimension ($P = .027$, OR = 3.12), increased wall thickening or mural striation ($P = .019$, OR = 2.89), and pericholecystic haziness or fluid ($P = .032$, OR = 2.61) were significant predictors of acute cholecystitis. When 2 of these 4 CT findings were observed together, the sensitivity, specificity, and accuracy for the detection of acute cholecystitis were 83.2%, 65.7%, and 71.7%, respectively. When 3 of these 4 CT findings were observed together, the sensitivity, specificity, and accuracy were 56.5%, 84.5%, and 74.9%, respectively. When none of these 4 CT findings were observed, the negative predictive value was 96.4%.

Increased adjacent hepatic enhancement, increased gallbladder dimension, increased wall thickening or mural striation, and pericholecystic fat haziness or fluid were the most discriminative MDCT findings for the diagnosis and differentiation of acute cholecystitis from chronic cholecystitis.

Abbreviations: HU = Hounsfield unit, MDCT = multidetector computed tomography, MRI = magnetic resonance imaging, NPV = negative predictive value, OR = odds ratio, PPV = positive predictive value, ROC = receiver operating characteristic, RUQ = right upper quadrant, THAD = transient hepatic attenuation difference, US = ultrasonography.

Keywords: acute cholecystitis, chronic cholecystitis, multidetector computed tomography

1. Introduction

Acute cholecystitis occurs in about one-third of patients with acute right upper quadrant (RUQ) pain,[1] which can also occur in various diseases, including chronic cholecystitis, acute pancreatitis, diverticulitis, colitis, appendicitis, Fitz-Hugh-Curtis syndrome, ureteral stone, and omental infarction.[2] In 1 study of patients with acute RUQ pain, only about one-third had acute cholecystitis (34.6%), while others had chronic cholecystitis (32.7%) or a normal gallbladder (32.7%).[3] Treatment strategies differ between acute cholecystitis and chronic cholecystitis. The former warrants prompt cholecystectomy or percutaneous cholecystostomy and antibiotic therapy in high-risk patients, whereas the latter can be generally managed with elective cholecystectomy. Thus, to avoid potential complications of emergent surgery or intervention and disease progression to complicated cholecystitis by delayed diagnosis, timely accurate diagnosis and differentiation of acute cholecystitis from chronic cholecystitis is important.

A recent meta-analysis reported that cholescintigraphy has the highest diagnostic accuracy for detection of acute cholecystitis, and ultrasonography (US) and magnetic resonance imaging (MRI) show considerable diagnostic accuracy; however, computed tomography (CT) was underevaluated due to scarce data.[4] Furthermore, a recent comparison study of CT and MRI in the differentiation of acute from chronic cholecystitis showed
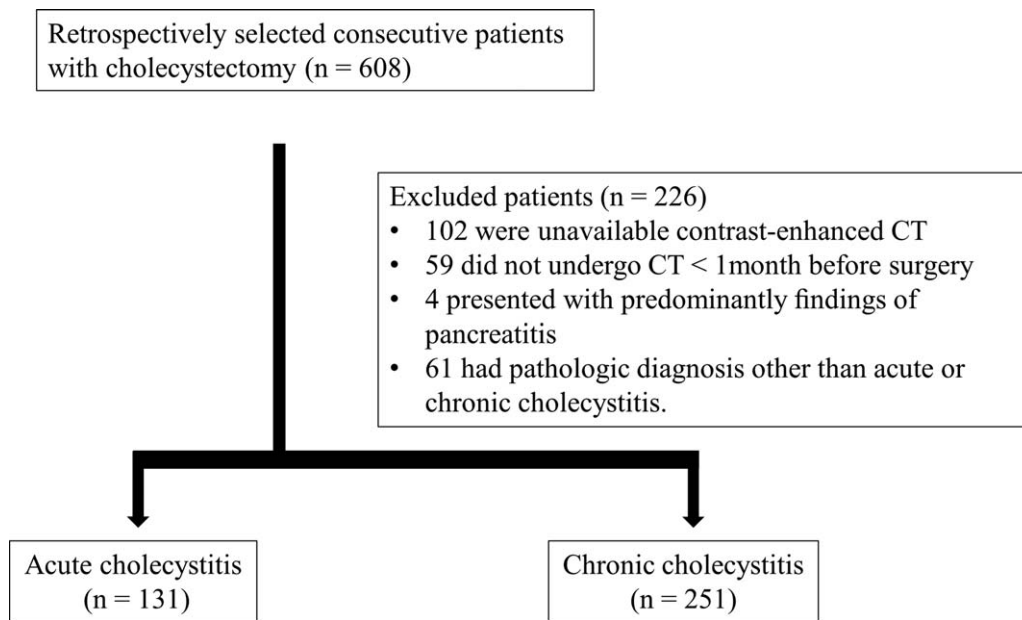
Figure 1. Flowchart illustrates the patient selection process.

better sensitivity and accuracy in individual findings on MRI compared to CT.[5] Although several studies reported moderate-to-excellent diagnostic performance by CT,[6–10] most of them occurred 15 years ago before the widespread use of multidetector CT (MDCT) and only observed the frequency of a specific variable, not the overall capacity of CT.

In the era of MDCT, CT is frequently performed in the acute abdomen setting because of its large field of view for differential diagnosis, fast scan time, and high temporal and spatial resolution.[4] To our knowledge, no reports have described all the imaging findings for acute and chronic cholecystitis on MDCT with regard to diagnostic performance, unlike MRI.[11]

Typical CT findings of acute cholecystitis have been well described, with overlapping findings between acute and chronic cholecystitis.[12,13] Therefore, it has been challenging to routinely differentiate between acute and chronic cholecystitis, compared with the ease of differentiating cholecystitis from normal gallbladder.

Thus, the present study was conducted on a large number of populations to determine the diagnostic value of individual imaging findings, to identify the most predictive findings, and to assess the sensitivity, specificity, accuracy, positive predictive value (PPV), and negative predictive value (NPV) of MDCT in the diagnosis and differentiation of acute from chronic cholecystitis, with pathologic results as the gold standard.

2. Materials and methods

2.1. Patients

This retrospective study was approved by our Institutional Review Board, and patient informed consent was waived. From January 2014 to September 2016, cholecystectomy was performed on 608 patients. Two hundred twenty-six patients were excluded for the following reasons: 87 did not undergo CT, 15 underwent unenhanced CT, 59 underwent surgery more than 30 days after CT, 4 presented with predominant findings of pancreatitis, and 61 had other pathologic results such as xanthogranulomatous cholecystitis (n=13), adenomyomatosis

(n=6), gallbladder cancer (n=20), a Klatskin tumor (n=2), or no pathologic gallbladder (n=20). Thus, we enrolled 382 consecutive patients with acute or chronic cholecystitis proven pathologically by surgery who underwent preoperative contrast-enhanced CT within 1 month before surgery. There were 82 men and 49 women in the acute cholecystitis group (n=131) and 107 men and 144 women in the chronic cholecystitis group (n=251) (Fig. 1). The mean age was 60 (range, 14–93 years) and 57 (range, 18–93 years) years, respectively. The mean time interval between CT and surgery was 6±5 [SD] and 10±8 days, respectively (Table 1).

2.2. Image acquisition

CT images were acquired with a 64- or 128-channel MDCT (Sensation 64 and Somatom Definition Flash; Siemens, Erlangen, Germany) with the following scanning parameters: beam collimation 0.6 to 1.2 mm; pitch 1.2 to 1.4; tube voltage, 100 to 120 kVp; and tube current and rotation time, 160 to 210 mAs. Contrast-enhanced images were obtained after infusion with 110 to 120 mL of iopromide (Ultravist 300; Bayer-Schering Pharma,

Table 1

Characteristics of study population (n=382).

Characteristic	Acute cholecystitis group (n=131)	Chronic cholecystitis group (n=251)
Age, y[*]	60±15	57±16
Sex		
Male	82	107
Female	49	144
Liver cirrhosis	6	7
Chronic kidney disease	4	7
Time interval between CT imaging and surgery, d[*]	6±5	10±8

Data are the number of humans, numbers in parentheses are percentages.
CT = computed tomography.
[*] Mean value ± standard deviation.

Berlin, Germany) or iohexol (Iobrix 350; Taejoon Pharmaceutical, Kyungkido, South Korea) injected at 3 to 4 mL/s using a power injector. The contrast-enhanced images were obtained 20 seconds after achieving 100-Hounsfield unit (HU) attenuation of the descending aorta, as measured with a bolus-tracking technique for the arterial phase images. For the portal venous phase, a 70-second fixed delay was adopted. All 382 patients involved in the study had performed portal phase CT, but the arterial images were obtained in part (acute cholecystitis, n = 45; chronic cholecystitis, n = 136). Axial CT images were reconstructed with a 3 mm section thickness and a 3-mm interval, and then coronal and sagittal multiplanar reconstruction images were reconstructed with a 3 mm section thickness and a 3-mm interval.

2.3. Image analysis

To prevent recall bias, CT images were reviewed 2 weeks after patient enrollment. One gastrointestinal radiologist (D.M.Y, with 5 years of experience) who was blinded to the clinical information, imaging reports, and final pathologic type of cholecystitis (though aware that cholecystitis was present) reviewed the images retrospectively in random order using picture archiving and communication system software (Maroview 5.4; Infinite, Seoul, South Korea). CT imaging findings of acute cholecystitis were evaluated according to the following criteria[7,13,14]: gallstone, increased bile attenuation within the gallbladder including measurement of bile CT number (HU), short and long diameters of the gallbladder lumen, increased gallbladder dimension, increased gallbladder wall enhancement (mucosal or mural enhancement), increased gallbladder wall thickening (>3 mm[9]), measurement of the wall thickness, mural striation, pericholecystic fat stranding or fluid, increased adjacent hepatic enhancement on the arterial phase, focal wall defect, pericholecystic abscess, and sloughed membrane.

Gallstones were deemed present if a sufficient attenuation difference (higher or lower) from bile was visualized. Bile was evaluated for increased attenuation relative to the fluid density within the bowel.[15] Bile attenuation was measured at least 5 times. Then, the highest CT number was achieved. The luminal diameter was measured without including the wall. The presence of increased gallbladder dimension was assessed by cutoff values, which were determined by using receiver operating characteristic (ROC) curve analysis for differentiating acute from chronic cholecystitis. GB wall enhancement was considered to be increased when it was equal to or greater than liver parenchymal enhancement on portal phase images in patients with normal renal function.[15] In the 11 patients with chronic kidney disease, gallbladder wall enhancement was evaluated solely on the basis of the reviewer's experiences. Mural striation was identified if a central hypodense halo was present between the inner and outer margin enhancement of the wall. Given that acute cholecystitis is a progressive disease (mild edematous disease to a suppurative form[16]), we assumed that 2 findings of mural striation (subserosal edema) or increased thickness (>3 mm) of the gallbladder wall could be considered associated with a spectrum of gallbladder wall inflammation. Pericholecystic fat stranding was defined as increased fat attenuation around the gallbladder as well as loss of the sharp fat plane between the gallbladder and the liver. Increased adjacent hepatic enhancement was assessed if arterial phase CT images were available (acute cholecystitis, n = 45; chronic cholecystitis, n = 136) and was deemed present if a thin or thick curvilinear shape around the gallbladder fossa was present, as opposed to a geographic pattern at the expected location of focal fat sparing or deposition on a nonenhanced CT image.[17] Sloughed membrane was considered when the presence of internal irregular linear soft-tissue densities was observed within the gallbladder.

2.4. Statistical analysis

All statistical analyses were performed using statistical software R, version 3.2.1.[18] Pearson Chi-square tests were used for comparisons of CT findings between acute and chronic cholecystitis groups with the moonBook package.[19] The Student t test was used to evaluate differences in bile attenuation, gallbladder wall thickness, and luminal diameter between the 2 groups. The cut-off values for short and long luminal diameters were determined by ROC curve analysis.[20] Univariate logistic regression analysis was used to determine the significance of each CT finding in predicting acute cholecystitis by odds ratio (OR) evaluation. Multivariate stepwise logistic regression analysis with backward elimination was used to determine the most significant CT findings for diagnosing acute cholecystitis. Variables with a P value of <.2 in the univariate analysis were used as input variables for multivariate stepwise logistic regression. The diagnostic performance (sensitivity, specificity, accuracy, PPV, NPV) of each CT finding and of combined findings in the diagnosis and differentiation between acute and chronic cholecystitis was calculated on the basis of the pathologic diagnosis as a reference standard. For all tests, $P < .05$ was considered indicative of a statistically significant difference.

3. Results

Out of 382 enrolled patients, there were 14 liver cirrhosis patients (acute cholecystitis, n = 6; chronic cholecystitis, n = 7). One patient was Child-Pugh class C and the rest were Child-Pugh class A, and 4 patients had minimal ascites only in the pelvic cavity (acute cholecystitis, n = 6; chronic cholecystitis, n = 7). The 1 Child-Pugh class C patient did not show mural striation of the gallbladder or pericholecystic fluid, which could be produced by decreased liver function due to cirrhosis.

3.1. Comparison of MDCT findings between acute cholecystitis and chronic cholecystitis groups

The distribution of MDCT findings between the 2 groups is summarized in Table 2. There were significant differences in CT findings of increased gallbladder dimension ($P < .001$), increased wall enhancement ($P = .001$), increased wall thickness ($P < .001$), mural striation ($P < .001$), pericholecystic haziness or fluid ($P < .001$), increased adjacent hepatic enhancement ($P < .001$), focal wall defects ($P < .001$), and pericholecystic abscess ($P < .001$) between the 2 groups. Of these, increased gallbladder dimension showed the highest frequency in the acute cholecystitis group [85.5% (112 of 131)]. There was also a high frequency of increased adjacent hepatic enhancement [80.0% (36 of 45)], but this finding was assessed in the small number of patients who underwent arterial phase imaging. Combined findings of increased thickness or mural striation [70.2% (92 of 131)] showed higher frequencies in the acute cholecystitis group than each finding separately [67.9% (89 of 131) and 64.9% (85 of 131), respectively].

However, the presence of gallstones ($P = .800$), increased bile attenuation ($P = .065$), and sloughed membrane ($P = .739$) were not statistically different by group. Sloughed membrane was seen in only 1 patient with acute cholecystitis.

Table 2

The distribution of CT findings between acute cholecystitis group and chronic cholecystitis group.

CT finding	Acute cholecystitis ($n=131$)	Chronic cholecystitis ($n=251$)	P
Gallbladder lumen			
Gallstones	93 (71.0)	181 (72.1)	.800
Increased bile attenuation*	14.7±9.8	12.7±10.1	.065
Increased gallbladder dimension†	112 (85.5)	127 (50.6)	<.001
Short diameter*	3.7±0.9	2.9±1.1	<.001
Long diameter*	9.6±2.1	7.6±2.3	<.001
Gallbladder wall			
Increased enhancement	81 (61.8)	198 (78.9)	.001
Increased wall thickening	89 (67.9)	78 (31.1)	<.001
hairline or imperceptible	32 (24.4)	140 (55.8)	<.001
thickness in the measurable group	4.5±1.8	4.3±2.6	.586
Mural striation	85 (64.9)	71 (28.3)	<.001
Increased wall thickening or mural striation	92 (70.2)	81 (32.3)	<.001
Pericholecystic area			
Fat haziness or fluid collection	87 (66.4)	53 (21.2)	<.001
Increased adjacent liver enhancement	36 (80.0)‡	44 (32.4)‡	<.001
Focal wall defect	12 (9.2)	0	<.001
Pericholecystic abscess	14 (10.7)	0	<.001
Sloughed membrane	1 (0.8)	0	.739

Data are the number of humans, numbers in parentheses are percentages.

CT = computed tomography.

* Mean value ± standard deviation.

† Increased GB dimension was defined as short diameter ≥ 3.5 or long diameter ≥ 8.2. The cutoff values of short diameter and long diameter of the gallbladder were determined by using receiver operating characteristic curve analysis.

‡ Based on a denominator of 45 patients and 136 patients, respectively, who were examined CT including arterial phase images.

The mean short and long diameter of the gallbladder in acute cholecystitis was significantly larger than in chronic cholecystitis (short diameter, 3.7±0.9 vs 2.9±1.1 cm; long diameter 9.6±2.1 vs 7.6±2.3 cm) (all, $P<0.001$). Gallbladder wall thickness and bile attenuation did not exhibit significant differences between the groups. However, hairline or imperceptible gallbladder wall was seen at a significantly higher frequency in the chronic cholecystitis group [acute cholecystitis, 24.4% (32 of 131); chronic cholecystitis, 55.8% (140 of 251)] ($P<.001$) (Figs. 2 and 3).

3.2. Univariate and multivariate logistic regression analysis

Univariate logistic regression analysis showed that increased gallbladder dimension, increased wall enhancement, wall thickening, mural striation, pericholecystic haziness or fluid, and increased adjacent hepatic enhancement were significant predictors of acute cholecystitis (Table 3). Multivariate logistic regression analysis revealed that increased adjacent hepatic enhancement ($P=.006$, OR=3.82), increased gallbladder dimension ($P=.027$, OR=3.12), increased wall thickening or mural striation ($P=.019$, OR=2.89), and pericholecystic haziness or fluid ($P=.032$, OR=2.61) were the most discriminative MDCT findings for the diagnosis of acute cholecystitis and the differentiation between acute and chronic cholecystitis (Fig. 4).

3.3. Diagnostic performance in differentiating acute cholecystitis from chronic cholecystitis

Table 4 lists the sensitivity, specificity, accuracy, PPV, and NPV of each finding and combined findings for the diagnosis and differentiation of acute cholecystitis. Considering each finding alone, increased gallbladder dimension had the highest sensitivity for the detection of acute cholecystitis (85.5%), the lowest specificity (50.6%), and low accuracy (62.6%). Pericholecystic haziness or fluid collection had the highest specificity (78.8%), the lowest sensitivity (66.4%), and moderate accuracy (74.5%). When at least 1 of these 4 CT findings was detected, the sensitivity was 97.7%. When 2 of these 4 CT findings were observed in combination, the sensitivity, specificity, and accuracy for the
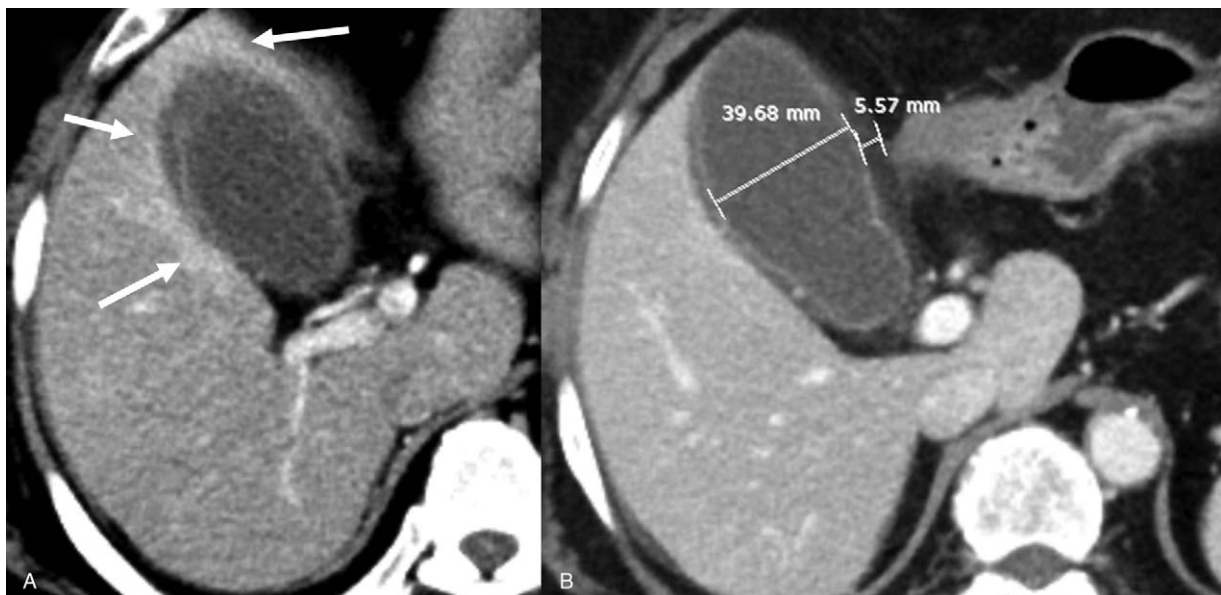
Figure 2. A 72-year-old woman with acute cholecystitis. (A) The arterial phase CT image shows an area of thick rim-like enhancement around the gallbladder in all directions. (B) The portal phase CT image shows mural striation with a thickened wall (5.57 mm) and luminal distension (3.97 cm) of the gallbladder.
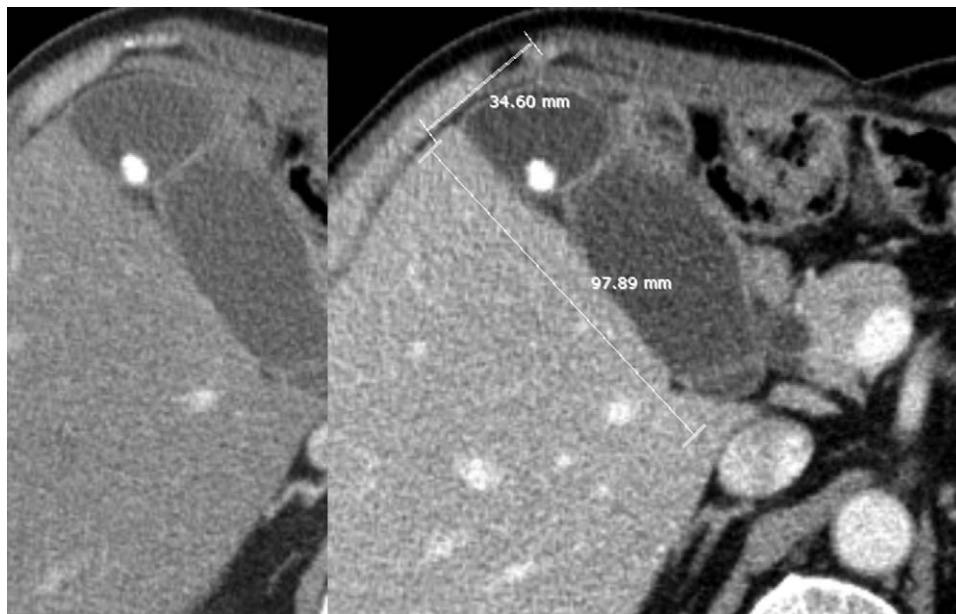
Figure 3. A 65-year-old man with chronic cholecystitis. CT images show gallstones and a distended gallbladder (short axis 3.46 cm, long axis 9.79 cm). However, the arterial phase CT image (left) does not display increased adjacent liver hyperenhancement around the gallbladder. Increased gallbladder wall thickening or mural striation is also not seen.

detection of acute cholecystitis were 83.2%, 65.7%, and 71.7%, respectively. When 3 of these 4 CT findings were observed in combination, sensitivity, specificity, and accuracy were 56.5%, 84.5%, and 74.9%, respectively. When none of these 4 CT findings were observed, the NPV was 96.4%.

4. Discussion

Our study revealed significant imaging findings for acute cholecystitis, identified the most discriminative findings by logistic regression analysis, and quantified the performance of MDCT to diagnose and differentiate acute from chronic cholecystitis by calculating the sensitivity, specificity, accuracy, PPV, and NPV of individual or combined findings.

Typical CT findings of acute cholecystitis have been described as gallstones, high-attenuated bile, gallbladder distension, increased wall thickening, increased wall enhancement, mural striation, pericholecystic stranding or fluid, and increased hyperenhancement of the adjacent liver.[7,12,13] Of these, gallstones and high-attenuated bile were not statistically different between acute and chronic cholecystitis, and the chronic cholecystitis group revealed more frequent hyperenhancement of the gallbladder wall than the acute cholecystitis group. Acute cholecystitis is related to gallstones in about 90% to 95% of cases and chronic cholecystitis is also almost always associated with the presence of gallstones. The ability to detect gallstones by CT is approximately 75%, due to the gallstones isodense to bile.[13] Our study showed 71.0% and 72.1% sensitivities for the detection of gallstones in acute and chronic cholecystitis, respectively. High-attenuated bile and gallbladder wall hyperenhancement have been described as common findings in acute cholecystitis patients, compared with the normal population. However, as gallbladder dysmotility is commonly present in chronic cholecystitis, increased bile CT attenuation due to concentrated bile was also frequently seen in the chronic cholecystitis group. Furthermore, in a recent study, CT attenuation of gallbladder bile did not differ between acute cholecystitis patients and a control group.[15] The present study noted gallbladder wall hyperenhancement in both groups, but it was seen more frequently in chronic cholecystitis. Chronic

Table 3

Results of univariate and multivariate analysis for diagnosis of acute cholecystitis.

CT finding	Univariable odds ratio	P	Multivariable odds ratio	P
Gallstones	0.95 (0.60–1.52)	.818		
Increased bile attenuation	0.98 (0.96–1.00)	.060		
Increased gallbladder dimension	6.04 (3.57–10.68)	<.001	3.12 (1.17–9.02)	.027
Increased enhancement	0.43 (0.27–0.69)	<.001	0.43 (0.14–1.31)	.135
Increased wall thickening or mural striation	4.95 (3.15–7.90)	<.001	2.89 (1.20–7.13)	.019
Pericholecystic haziness or fluid collection	7.35 (4.61–11.89)	<.001	2.61 (1.08–6.30)	.032
Increased adjacent liver enhancement	8.36 (3.85–19.90)	<.001	3.82 (1.51–10.34)	.006
Focal wall defect		.978		
Pericholecystic abscess		.980		
Sloughed membrane		.979		

Numbers in parentheses are 95% confidence intervals.
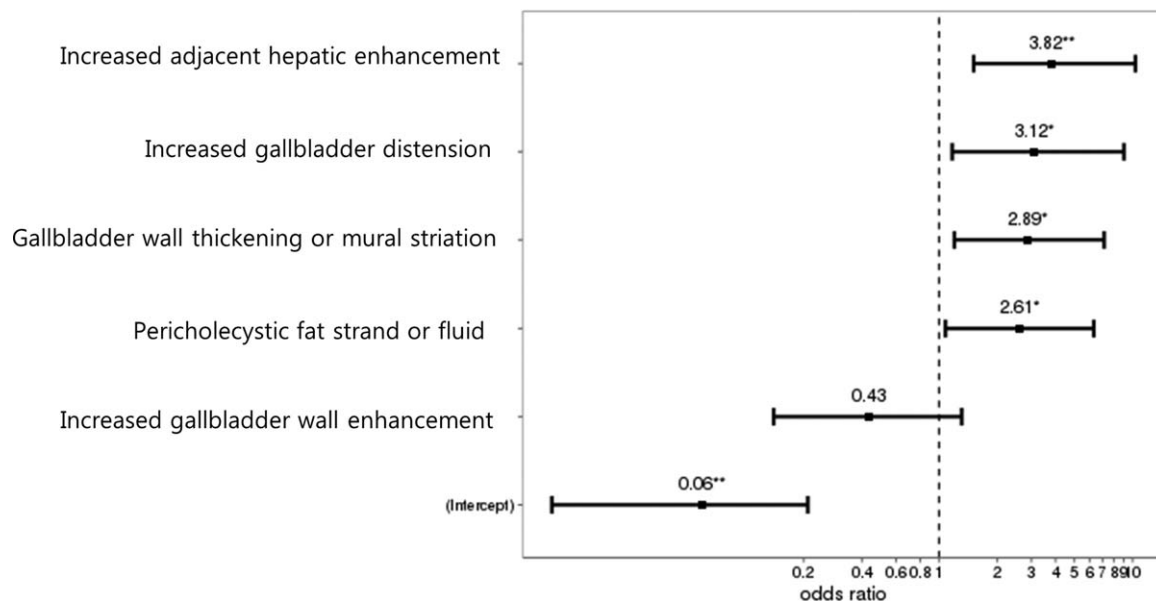CT = computed tomography.

Figure 4. Plot illustrates the odds ratio of significant CT findings for the diagnosis and differentiation of acute cholecystitis from chronic cholecystitis.

cholecystitis is thought to be the result of mechanical irritation or recurrent acute cholecystitis leading to chronic inflammation, fibrosis, and thickening of the gallbladder wall, which explains increased wall enhancement of the gallbladder compared with acute cholecystitis with edematous, necrotizing, or suppurative gallbladder wall, which leads to fluid or microabscess lowering CT attenuation.

With the ORs obtained via multivariate logistic regression analysis, the diagnostic value for each finding was in the following order: increased adjacent liver enhancement, pericholecystic fat haziness and fluid, increased gallbladder dimension, and increased wall thickening or mural striation. In 1 recent case-control study of acute cholecystitis versus normal population on helical CT, the most discriminating findings by univariate analysis were pericholecystic fat stranding, mural stratification, pericholecystic hypervascularity, hyperattenuated gallbladder wall, short and long gallbladder axis enlargement, and gallbladder wall thickening, which were similar results.[10]

Increased adjacent liver enhancement is well known to be a transient hepatic attenuation difference (THAD) on arterial phase CT, which is induced by increased arterial flow secondary to adjacent gallbladder inflammation and portal inflow reduction due to interstitial edema.[21] Although THAD is also induced by accessory veins, especially in segment IV, it is generally

geographic or localized and is frequently identified as fat deposition in normal liver or sparing in fatty liver by persistent hemodynamic change at a corresponding area on nonenhanced imaging.[22] Hence, this can be carefully differentiated from the THAD of acute cholecystitis, which has a rim-like or thicker enhancement surrounding the gallbladder in all directions. The high sensitivity and moderate specificity of THAD in our study is also in close agreement with previous reports. One of these reports suggested that THAD is the most predictive finding in early or mild cholecystitis.[11,15] However, THAD should be assessed only in the arterial phase due to rapid change from isodense to normal hepatic parenchyma. Therefore, arterial phase CT is recommended for patients with suspected gallbladder disease.

Pericholecystic fat haziness or fluid collection and increased wall thickening or mural striation show moderate sensitivity and specificity. We considered increased wall thickening or mural striation as gallbladder wall inflammation. There are several explanations for this. Because increased wall thickening was defined as thicker than 3 mm based on previous reports, a mildly thickened wall was not included, although the normal gallbladder wall is thin-hairline or imperceptible. As acute cholecystitis is a progressive inflammatory disease from the edematous phase to the necrotizing phase to the suppurative phase, CT features can

Table 4

Diagnostic performance of CT findings for diagnosis and differentiation of acute cholecystitis.

CT finding	Sensitivity	Specificity	Accuracy	Positive predictive value	Negative predictive value	Odds ratio	AUC
1. Increased gallbladder dimension	85.5	50.6	62.6	47.5	87.0	6.037	
2. Increased wall thickening or mural striation	70.2	67.7	68.6	53.2	81.3	4.951	
3. Pericholecystic fat haziness or fluid collection	66.4	78.8	74.5	62.1	81.7	7.349	
4. Increased adjacent liver enhancement	80.0	67.6	70.7	45.0	91.1	8.364	
1 of 4 findings	97.7	31.9	54.5	42.8	96.4	19.961	0.648
Combined 2 of 4 findings	83.2	65.7	71.7	55.9	88.2	9.506	0.745
Combined 3 of 4 findings	56.5	84.5	74.9	65.5	78.8	7.057	0.705

Sensitivity, specificity, accuracy, positive predictive value, and negative predictive value are percentages.
CT = computed tomography.

be subserosal edema without thickening or wall thickening without edema, depending on timing of the disease progression. Therefore, to include various stages of acute cholecystitis, any 2 findings were assessed as a spectrum of gallbladder wall inflammation.

However, single imaging finding of mural striation is nonspecific that could be observed in a variety of disease states, including hypoalbuminemia, hepatitis, and other inflammatory processes in the abdomen such as pancreatitis.[13,23] And because chronic cholecystitis can lead to chronic inflammation, fibrosis, and thickening of the gallbladder wall, imaging feature of inflamed wall overlaps significantly between acute and chronic cholecystitis. The previous report regarding gallbladder wall findings on MRI in acute and chronic cholecystitis also mentioned that mural striation is a common finding between the 2 groups, with marginal differences showing ill-defined or sharply demarcated striation, respectively.[24] Although our results showed statistically significant differences of gallbladder wall thickening or mural striation between the acute and chronic cholecystitis groups, radiologists should keep in mind inherent weakness and unavoidable overlap of these findings between these groups when interpreting images.

Increased gallbladder distension showed the highest sensitivity but low specificity. Increased gallbladder size has been defined as a transverse diameter > 4 cm or a longitudinal diameter > 8 cm based on previous studies.[7,11,13] Our study showed that the cut-off values for differentiating acute from chronic cholecystitis were 3.5 and 8.2 cm, respectively. Although the cut-off of the transverse diameter was slightly smaller, this is consistent with that of the earlier study, which reported that mild or early acute cholecystitis shows less than 4 cm of axial diameter (range, 3.0–4.3 cm; mean, 3.7 cm) in most cases,[15] This suggests that mild or early acute cholecystitis probably could be included in our cases.

In daily practice, we observe partial or all of CT findings of increased adjacent liver enhancement, pericholecystic fat haziness or fluid, increased gallbladder dimension, and increased wall thickening or mural striation in patients. In addition, if these CT findings appear, it is necessary to distinguish them from those of other diseases or clinical situations mentioned above, including hypoalbuminemia associated with liver or kidney disease, hepatitis, pancreatitis, or long fasting by considering clinical and laboratory information. Furthermore, after excluding other situations, even if cholecystitis is strongly suspected in the patient, there is another obstacle that overlaps clinical and imaging features between acute and chronic cholecystitis. Thus, to provide sufficient diagnostic performance to differentiate these entities, we used a combination of findings as well as individual findings. If at least 1 of these 4 CT findings was not detected, the possibility of acute cholecystitis was quite low due to high sensitivity and NPV. This is consistent with an earlier study, which showed that CT was more sensitive than ultrasonography for the diagnosis of acute cholecystitis if any of the typical CT findings were considered as acute cholecystitis.[25] A combination of 2 or 3 of the 4 CT findings could provide diagnosis and differentiation of acute cholecystitis from chronic cholecystitis with appropriate confidence.

Our study had several limitations. First, this is a retrospective study. Although we recruited consecutive patients, there was an unavoidable selection bias. In addition, we did not calculate the interobserver agreement of CT evaluation. However, the CT findings of cholecystitis are well known, and the difference of interpretation between radiologists is not expected to be significant. Second, the inclusion of only patients who had

pathologic results from cholecystectomy may have resulted in the exclusion of severe complicated cases or clinically severely ill patients who underwent only interventional procedures such as percutaneous drainage. Third, our data included acute cholecystitis complicated by gangrene, which might display specific findings such as lack of gallbladder wall enhancement, intraluminal membrane, and pericholecystic abscess. As gangrenous cholecystitis is a form of acute cholecystitis, exclusion of these cases was not appropriate for practical circumstances, and the relatively large population of the present study might have led to the significance of study results.

In conclusion, increased adjacent liver enhancement, increased gallbladder dimension, increased wall thickening or mural striation, and pericholecystic fat haziness or fluid are the most discriminative MDCT findings of acute cholecystitis. As the clinical and radiological findings of acute cholecystitis and chronic cholecystitis overlap, the combination of 2 or 3 of the 4 CT findings can provide efficient performance for the diagnosis and differentiation of acute from chronic cholecystitis.

Author contributions

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Formal analysis: Dong Myung Yeo.
Supervision: Seung Eun Jung.
Writing – original draft: Dong Myung Yeo.
Writing – review & editing: Dong Myung Yeo, Seung Eun Jung.

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