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ORIGINAL ARTICLE

Retrospective analysis of the sonographic and computed tomographic features of gallbladder empyema

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Abstract
Objective Early detection of complicated cholecystitis, particularly gallbladder empyema, is important. Yet only a handful of patients are correctly diagnosed prior to intervention. The purpose of this study was to evaluate the sonographic and computed tomography features associated with gallbladder empyema compared with the intraoperative findings and histopathological examination.
Materials and methods We retrospectively reviewed ultrasound and CT images for 146 patients with clinical suspicion of cholecystitis from January 2013 until December 2018. Ultrasound criteria reviewed included calculus, wall thickening, pericholecystic fluid, gallbladder distension and presence of echogenic material within the gallbladder. For CT, criteria reviewed were wall thickening, gallbladder distension, mucosal enhancement, pericholecystic fluid and hyperdense bile with an attenuation value of more than 20 HU. Association of these findings was made with intraoperative and pathological findings of 85 patients with proven gallbladder empyema.
Results Sonographic signs that were statistically significantly associated with gallbladder empyema ($p < 0.05$) were thickened gallbladder wall (mean 5.4 versus 3.0 mm), distended gallbladder (mean 8.5 versus 6.4cm), pericholecystic fluid and echogenic material within the gallbladder. No significant association between gallstones and gallbladder empyema. Scores of two and more out of four significant sonographic findings were found to have an association with higher chances of developing gallbladder empyema ($p < 0.05$, odds ratio: 10). None of the CT features was found to be significant with gallbladder empyema ($p > 0.05$).
Conclusion A combination of few ultrasound features has a high significant association with gallbladder empyema. Thus, in the proper clinical setting, these findings should alarm the sonographic operator on the possibility of gallbladder empyema.

Keywords Gallbladder empyema · Acute cholecystitis · Ultrasound · Computed tomography · Cholecystectomy

Introduction

Acute cholecystitis accounts for up to 10% of all patients presented to the emergency department with acute abdomen. The majority of cases of acute cholecystitis results from calculous disease obstructing the cystic duct, otherwise known as calculous cholecystitis. In the early phase of acute uncomplicated cholecystitis, the gallbladder becomes oedematous and later progresses into the necrotizing phase (within 3–5 days) and the suppurative phase (in 7–10 days) [1]. Delay in prompt treatment of acute uncomplicated cholecystitis may result in complicated cholecystitis, such as gallbladder perforation, emphysematous cholecystitis and gangrenous gallbladder in up to 30% of cases, with mortality rates of 9% [2]. Due to persistent obstruction of the cystic duct and stasis of contaminated bile within the gallbladder lumen, empyema (defined as purulent accumulation within the inflamed and distended gallbladder) ensues in many patients [3].

However, determining the diagnosis of acute uncomplicated cholecystitis and complicated cholecystitis is an often challenging endeavour, either from clinical presentations, physical findings or imaging investigations, as there is considerable overlap in similarities between these conditions [3]. This could be challenging, particularly in the

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case of gallbladder empyema or suppurative cholecystitis, as it carries a serious complication typically among the elderly population and people with uncontrolled diabetes, which may lead to greater mortality. A timely and accurate diagnosis of gallbladder empyema is important to avoid potentially harmful delay in patient treatment [3, 4]. In addition, the management of gallbladder empyema is distinct from that of acute uncomplicated cholecystitis. Treatment of the latter in the main involves analgesia, intravenous hydration, correction of electrolyte imbalances and broad-spectrum intravenous antibiotics. Conversely, definitive therapy of the former involves a cholecystectomy, either via the traditional open or currently favoured laparoscopic approach, or in those with comorbidities unfit for surgery, purulent drainage via a percutaneous cholecystostomy [5].

Imaging evaluation, preferably ultrasound, is indicated in patients presenting with clinical features of acute cholecystitis, as clinical findings or laboratory investigations may not be sufficiently conclusive to confirm the diagnosis [6]. Traditionally, ultrasound is considered as the first-line imaging modality in assessing patients with suspected acute cholecystitis, due to its high sensitivity and specificity, real-time character and portability [7]. The sensitivity of ultrasound is reported to be as high as > 95% with a specificity of > 98% [5]. Meanwhile, computed tomography (CT), although not traditionally considered as primary imaging in acute cholecystitis, has been found to be useful particularly in patients with suspicion of complicated cholecystitis or those harbouring other intra-abdominal abnormalities, as well as for pre-surgery planning [8]. Though a handful of publications exist in the literature regarding the imaging of acute cholecystitis [6–19], to our knowledge, this is the first study investigating the radiology of proven cases of gallbladder empyema specifically.

Therefore, we sought to investigate the association between the radiological features of gallbladder empyema using ultrasound and/or CT scan, with the final outcome obtained from intraoperative and histopathological reports. We hope that from this study, we can highlight important radiological features that are specific in detecting gallbladder empyema.

Materials and methods

Ethical issues

Local institutional Research Ethics Board approval was obtained for the study (FF-2018-262). Written patient consent was waived due to the retrospective nature of the study.

Patients

We conducted a retrospective cross-sectional study analysis for a period of 5 years from January 2013 until December 2018. Samples were obtained from the local database Casemix using the ICD-10 code of K-810, which were the codes for the diagnosis of acute cholecystitis. Inclusion criteria included patients who underwent either cholecystectomy or percutaneous cholecystostomy following ultrasound or CT scan for clinical diagnosis of acute cholecystitis, with confirmation of purulent material within the gallbladder detected either intraoperatively or histopathologically. Exclusion criteria included non-operated patients, those treated surgically with acute cholecystitis in the absence of pus within the gallbladder, patients with histopathologically proven gallbladder carcinoma and those with radiological images deemed suboptimal.

Sonographic and computed tomography (CT) examination and assessment

As this was a retrospective study, patients could not be randomized equally into those with sonographic and CT assessments. The majority of patients had a sonographic examination as it is an established modality for the initial evaluation of acute biliary pathology. A minority of patients had a CT examination due to a clinical suspicion of potential non-biliary pathology. All sonographic examinations were performed with either Philips HD11 XE or Toshiba Xario 200 using curvilinear transducers with frequencies ranging from 1 to 6 MHz. All examinations were performed according to the standard hepatobiliary ultrasound protocol established by our institution. This includes proper assessment of the entire gallbladder and its adjacent structures in both transverse and longitudinal views.

The computed tomography (CT) examinations were performed using Siemens Somatom Sensation 64 according to our institution's abdominal CT protocol. Patients were asked to drink 500 ml of 3% diatrizoate meglumine as an oral contrast, followed by intravenous injection of 100 ml iohexol at a rate of 3 ml/s. Scans were performed 60 s after the intravenous injection of the contrast, from the dome of the diaphragm until the proximal femora.

Images were retrieved via the local PACS server. Unfortunately, some of the images were not stored as they were performed as mobile sonographic examinations. The still images of the sonograms were then reviewed to identify gallbladder wall thickness (taken as the thickness of the wall > 3 mm measured orthogonally to the liver surface at the anterior wall), presence of gallbladder calculus, distension of the gallbladder (length of gallbladder > 8 cm) and presence of pericholecystic fluid as well as echogenic material within the gallbladder (Fig. 2a–d). While transverse diameters of gallbladder > 5 cm were noted, these were not utilized in statistical analyses as there is usually greater variability in length measurements in both physiological and pathological processes.

The CT images were reviewed to identify gallbladder wall thickening (> 3 mm), distension of the gallbladder (> 8 cm), gallbladder mucosal enhancement, gallbladder calculus, presence of pericholecystic fluid and hyperdense bile within the gallbladder (> 20 HU, Fig. 3a–d) [17].

All sonograms and CT images were retrospectively reviewed by a single reader, a certified radiologist who has more than 10-year experience in the field.

Intraoperative and histopathology reports

Intraoperative reports were reviewed mainly for the presence of pus within the gallbladder. The type of procedure (percutaneous cholecystostomy or cholecystectomy) was also recorded. Histopathology reports were also reviewed to confirm the gross pathology of the gallbladder and to rule out malignancy. The presence of pus and histopathology report of gallbladder empyema was taken as the gold standard for the final diagnosis. In other words, the visual detection of purulent material (whether aspirated by the interventional radiologist at percutaneous cholecystostomy, evacuated by the surgeon at open cholecystectomy or observed at microscopy by the histopathologist) was the primary indicator we used to categorize the patient into the "gallbladder empyema" group. The absence of purulent material aspirated or evacuated from the gallbladder resulted in the patient being placed in the "acute nonsuppurative cholecystitis" group.

Statistical analysis

All 146 patients were categorized into gallbladder empyema or acute nonsuppurative cholecystitis groups. A descriptive analysis was used to determine the distribution of the variables including frequencies, percentage, means and standard deviation. An unpaired Student *t*-test was used, as appropriate, to compare the radiographic features of gallbladder empyema and non-gallbladder empyema groups.

The association between categorical variables was tested by a χ^2 test or the Fisher exact test. The area under the receiver operating characteristic curve (ROC) was calculated for numeric variables to quantify diagnostic utility.

Contingency tables were made to calculate the following parameters: sensitivity, specificity, positive predictive value and negative predictive value of the categorical variables. $P < 0.05$ was considered statistically significant. All statistical analyses were performed with SPSS Statistics version 23.0 software (IBM Corporation, NY).

Results

A total of 146 patients (66 men and 80 women) were eligible for this study. The age range was 21–87 years, with a mean age of 55 years. Compared to patients with acute nonsuppurative cholecystitis, the mean age for patients with gallbladder empyema was older (57.3 versus 50.6). One hundred eighteen (80.8%) of the patients had a cholecystectomy, with the remaining 28 (19.2%) undergoing percutaneous cholecystostomy. Only 71 (48.6%) patients had early intervention within 48 h of imaging. One hundred fourteen (78.1%) patients had only ultrasound prior to intervention, 15 (10.3%) patients had CT scan and 17 (11.6%) had both ultrasound and CT. Of these 146 patients, 85 (58.2%) had proven gallbladder empyema. The remaining 61 patients were diagnosed as acute cholecystitis or chronic cholecystitis and grouped as acute nonsuppurative cholecystitis. Four patients had a liver abscess. No gallbladder malignancies were found.

Sonographic criteria of gallbladder empyema and acute nonsuppurative cholecystitis

Five sonographic criteria were evaluated in both groups and presented in Table 1. Four out of five assessed criteria were found to be significant in between these groups: gallbladder wall thickness, gallbladder distension, presence of pericholecystic fluid and echogenic materials within the gallbladder, with a p value of < 0.001. Gallbladder calculus was not found to be statistically significant between the two groups.

Using ultrasound, the mean thickness of the gallbladder wall was found to be 5.4 mm for the gallbladder empyema group and 3.0 mm for the acute nonsuppurative cholecystitis group. Similarly, mean diameters of the gallbladder for these groups were 8.5 cm and 6.4 cm respectively. Sensitivity and specificity of the gallbladder wall thickness and gallbladder diameter for the gallbladder empyema group have been calculated with receiver operating characteristic curves, as shown in Fig. 1a.

The areas under the curve were 0.85 for gallbladder wall thickness ($p < 0.001$) and 0.80 for diameter of gallbladder ($p < 0.001$). The optimal cutoff point according to this ROC curve for gallbladder wall thickness corresponds to 3.9 mm with a sensitivity of 76% and specificity of 79%. As for gallbladder distention, the optimal cutoff point corresponds to 7.3 cm with a sensitivity of 73% and specificity of 84%. Based on these cutoff points, a χ^2 test was performed for both gallbladder wall thickening and diameter, which both

Table 1 Sonographic criteria associated with gallbladder empyema and acute nonsuppurative cholecystitis groups

Sonographic criteria	Gallbladder empyema	Acute nonsuppurative cholecystitis	*p* value	Odds ratio
Wall thickening				
Yes	65 (73.9)	23 (26.1)	< 0.001	10.7
No	9 (20.9)	34 (79.1)		
Thickness of wall (mm)	5.4 ± 2.3	3.0 ± 1.1		
Gallbladder distension				
Yes	44 (89.8)	5 (10.2)	< 0.001	15.3
No	30 (36.6)	52 (63.4)		
Diameter (cm)	8.5 ± 2.2	6.4 ± 1.1		
Gallbladder calculus				
Yes	54 (62.1)	33 (37.9)	0.07	
No	20 (45.5)	24 (54.5)		
Pericholecystic fluid				
Yes	43 (76.8)	13 (23.2)	< 0.001	5.6
No	31 (41.3)	44 (58.7)		
Echogenic material				
Yes	26 (83.9)	5 (16.1)	< 0.001	4.7
No	48 (48.0)	52 (52.0)		

Data are presented as number (percentage) and mean ± SD where applicable

were statistically significant ($p < 0.001$) with an odds ratio of 10.7 and 15.3 respectively.

However, as for CT scan, none of these criteria assessed was found to be significantly different between the groups, as shown in Table 2. The mean CT thickness of the gallbladder wall was found to be 4.0 mm for the gallbladder empyema group and 2.9 mm for the acute nonsuppurative cholecystitis group, while the diameter of the gallbladder was 8.2 cm and 7.3 cm respectively.

The sensitivity, specificity, positive predictive value and negative predictive value of categorical variables of both ultrasound and CT scan features associated with gallbladder empyema are presented in Table 3.

A scoring system is proposed by using all four statistically significant sonographic criteria, in which a positive finding will be given 1 point, thus making a maximum point of 4 (Table 4). A χ^2 test showed this scoring system was significant ($p < 0.001$).

Sensitivity and specificity of this scoring system were further calculated with receiver operating characteristic curves and presented in Fig. 1b. The areas under the curve were 0.86 ($p < 0.001$) with OR of 10. The optimal cutoff point according to this ROC curve corresponds to 1.5 with a sensitivity of 85% and specificity of 77%. Therefore, a total score of above 2 points was considered sensitive in predicting gallbladder empyema.

Table 4 showed that with a total score of 1, only 72.4% had a positive prediction of developing gallbladder empyema. Expectedly, with a score of 4, the positive predictive value was 100%, indicating a higher possibility of having gallbladder empyema. A similar pattern was observed with specificity: with a score of 1, the specificity was 52.6%, increasing to 100% if the score was 4.

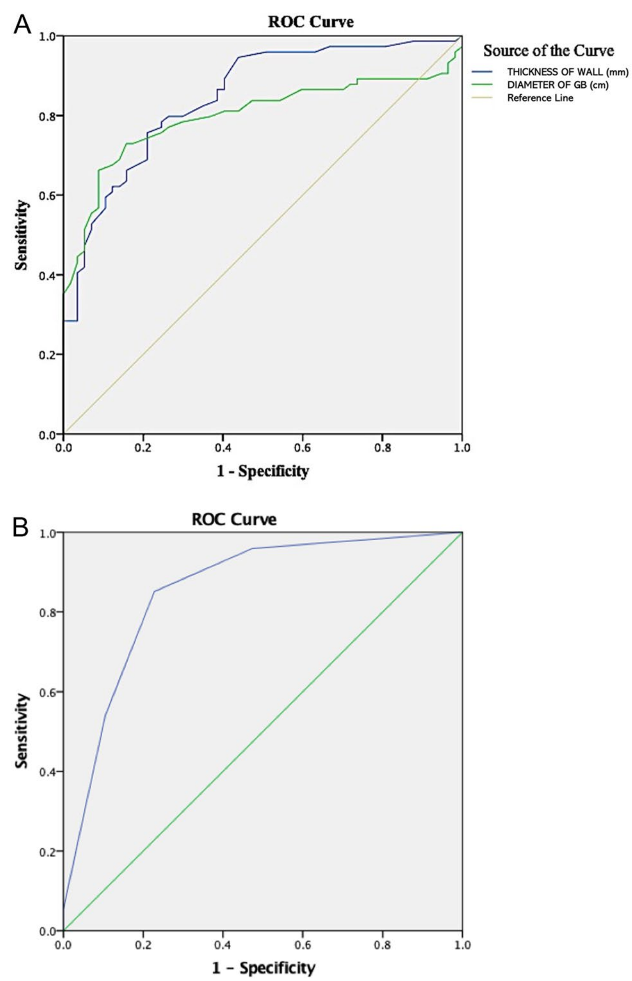

Fig. 1 **a** Receiver operating curve (ROC) for the mean thickness of gallbladder wall and gallbladder diameter; **b** receiver operating curve (ROC) for the scoring system for significant sonographic features

Table 2 CT Scan criteria associated with gallbladder empyema and acute nonsuppurative cholecystitis groups

CT scan criteria	Gallbladder empyema	Acute nonsuppurative cholecystitis	*p* value
Gallbladder wall thickness			
Yes	20 (87.0)	3 (13.0)	0.05
No	5 (55.6)	4 (44.4)	
Thickness of wall (mm)	4.0 ± 1.3	2.9 ± 1.2	
Gallbladder distension			
Yes	13 (81.3)	3 (18.8)	0.5
No	12 (75.0)	4 (25.0)	
Diameter (cm)	8.2 ± 1.9	7.3 ± 3.5	
Gallbladder calculus			
Yes	15 (71.4)	6 (28.6)	0.2
No	10 (90.9)	1 (9.1)	
Pericholecystic fluid			
Yes	17 (85.0)	3 (15.0)	0.2
No	8 (66.7)	4 (33.3)	
Mucosal enhancement			
Yes	16 (88.9)	2 (11.1)	0.09
No	9 (64.3)	5 (35.7)	
Hyper attenuating bile			
Yes	10 (76.9)	3 (23.1)	0.9
No	15 (78.9)	4 (21.1)	
Attenuation value (HU)	22.9 ± 20.5	23.7 ± 9.9	

Data are presented as number (percentage) and mean ± SD where applicable

Table 3 Sensitivity, specificity and predictive values of sonographic and CT criteria associated with gallbladder empyema

Radiologic criteria	Sensitivity, %	Specificity, %	PPV, %	NPV, %
Sonographic criteria				
Gallbladder calculus	73.0	42.1	62.1	54.5
Pericholecystic fluid	58.1	77.2	76.8	58.7
Echogenic material in GB	35.1	91.2	83.9	52.0
CT scan criteria				
Gallbladder wall thickness	60.0	14.3	71.4	9.1
Gallbladder distension	80.0	57.1	87.0	44.4
Gallbladder calculus	52.0	57.1	81.3	25.0
Pericholecystic fluid	64.0	71.4	88.9	35.7
Mucosal enhancement	68.0	57.1	85.0	33.3
Hyper attenuating bile	40.0	57.1	76.9	21.1

PPV indicates positive predictive value and NPV indicates negative predictive value

Table 4 Sensitivity, specificity and predictive values of tabulated score for significant sonographic findings

Total score	Sensitivity, %	Specificity, %	PPV, %	NPV, %
1	95.9	52.6	72.4	90.9
2	85.1	77.2	82.9	80.0
3	54.1	89.2	87.0	60.0
4	5.4	100	100.0	44.9

Discussion

Gallbladder empyema or suppurative cholecystitis is defined as a distended and inflamed gallbladder that contains pus [19, 20]. Lamki et al. reported that in patients with acute cholecystitis, approximately 25–30% might progress into complicated cholecystitis including empyema or gangrenous cholecystitis [9]. Early and accurate diagnosis of simple or complicated cholecystitis is essential and will influence patients' outcomes. Unfortunately, establishing an accurate diagnosis of complicated cholecystitis has proven difficult for both radiologist and physician, with relatively high false-negative rates. The clinical presentations of acute uncomplicated cholecystitis and gallbladder empyema often overlap [3]. Furthermore, laboratory investigations are often not helpful in differentiating these conditions. Shapira-Rootman et al. found that only 10% of patients were correctly diagnosed using ultrasound and physical examination [11]. Wu et al. also reported low detection rates of complicated cholecystitis, with only 9% of patients diagnosed accurately [21]. Ong et al. therefore advised for early cholecystectomy in acute gallbladder disease [22]. There is growing evidence for early cholecystectomy, which is defined as within 72 h, that is beneficial for these patients [23, 24]. Apart from traditional cholecystectomy, percutaneous cholecystostomy is also being practiced and proved to be safe and effective, particularly in critically ill patients who are unfit for surgery [25]. In our study, close to 81% of patients had a cholecystectomy, while the remaining 19% had percutaneous cholecystostomy.

Ultrasound is considered the first choice of imaging in assessing patients with acute gallbladder disease. Computed tomography (CT) is considered when there is suspicion of complicated cholecystitis or other intra-abdominal abnormality is suspected [4, 8]. Concurrent with few previous pieces of literature, we evaluated five sonographic criteria of complicated cholecystitis particularly gallbladder empyema to be assessed, which include gallbladder wall thickness, gallbladder diameter, calculus, pericholecystic fluid and echogenic material within the gallbladder (Fig. 2) [13, 14]. Our study found no significant statistical association between the presence of calculus and gallbladder empyema, with *p* value of 0.07. The rest of the sonographic findings showed significant association with the outcome of gallbladder empyema, with p value < 0.001 each. Gore et al. reported that gallbladder calculus is the most specific indicator of acute cholecystitis with a positive predictive value (PPV) of 92% [19]. We found that gallbladder distension and the presence of echogenic material within the gallbladder to be the most specific, with PPV of 90% and 84% respectively. Conversely, only 62% PPV was generated for gallbladder calculus from our

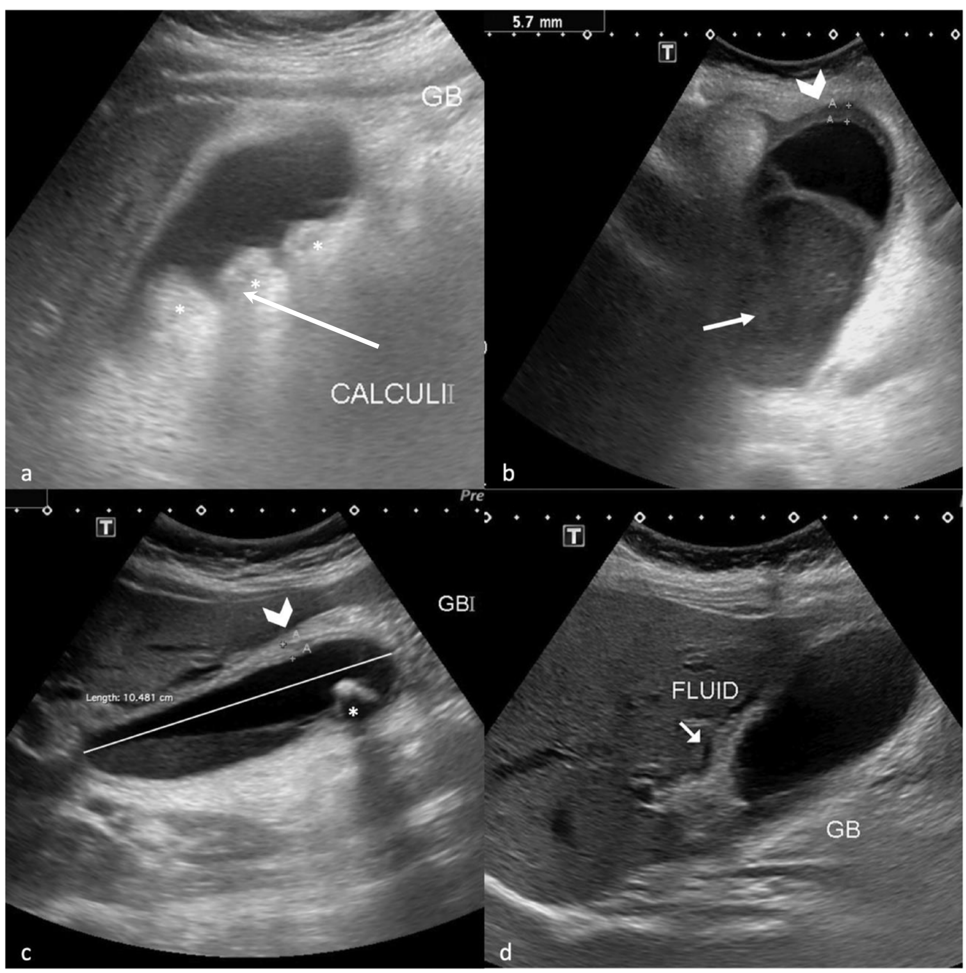

Fig. 2 Sonographic features of acute cholecystitis. **a** gallbladder calculi (asterisks); **b** gallbladder wall thickening (arrowhead and callipers) and intraluminal echogenic material (arrow); **c** gallbladder length (straight line), calculus (asterisk) and gallbladder wall thickening (arrowhead and callipers); **d** pericholecystic fluid (arrow)

study. This is likely explained by the presence of calculi in both acute and complicated cholecystitis.

A study by De Vargas Macciucca et al. had classified all sonographic criteria of simple and complicated acute cholecystitis into three groups: minor, major and complication criteria. Wall thickening, overdistension of the gallbladder and sonographic Murphy's sign were considered major criteria. Complication criteria included pericholecystic fluid and aerobilia. Gallstones and biliary tract dilatation were considered minor criteria. They found that the presence of two major criteria with at least one minor or complication criteria have a higher probability of developing complicated cholecystitis, including empyema [17]. Chawla further described findings of small pericholecystic fluid as associated with simple cholecystitis, whereas a large amount of pericholecystic fluid implied complicated cholecystitis or perforated gallbladder [15].

These studies are in line with our findings, in which both wall thickening and gallbladder distension (major criteria) were found to be highly correlated with gallbladder empyema. In particular to gallbladder wall thickening and distension, the calculated odds ratios for both features were 11 and 15 respectively. Seen another way, in the presence of thickened gallbladder wall, there is an 11-time risk of developing gallbladder empyema; this rises to a 15-time risk for gallbladder distension. On the other hand, for intraluminal echogenic material (which was considered as minor criteria), the odds ratio was 5, while pericholecystic fluid (which falls into the complication criteria) had an odds ratio of 6.

Although we found that gallbladder wall thickening was statistically significant ($p < 0.01$), van Breda Vriesman et al. have suggested that it is in fact non-specific and can be found in many conditions unrelated to gallbladder disease, such as liver cirrhosis, cardiac or renal failure. It can also occur in both symptomatic and asymptomatic patients, which may lead to misdiagnosis and mismanagement. Therefore, although significant, this finding is not pathognomonic and should be supported with additional imaging criteria [7].

Therefore, based on these data, we propose our own mini scoring system, in which 1 point will be given for each positive sonographic finding, thus making a total of 4 points. We found that a score of 2 and above was significant, in particular in the presence of both gallbladder wall thickening and distension, which had an odds ratio of 23 ($p < 0.01$) and was found to be highly correlated with the outcome of gallbladder empyema.

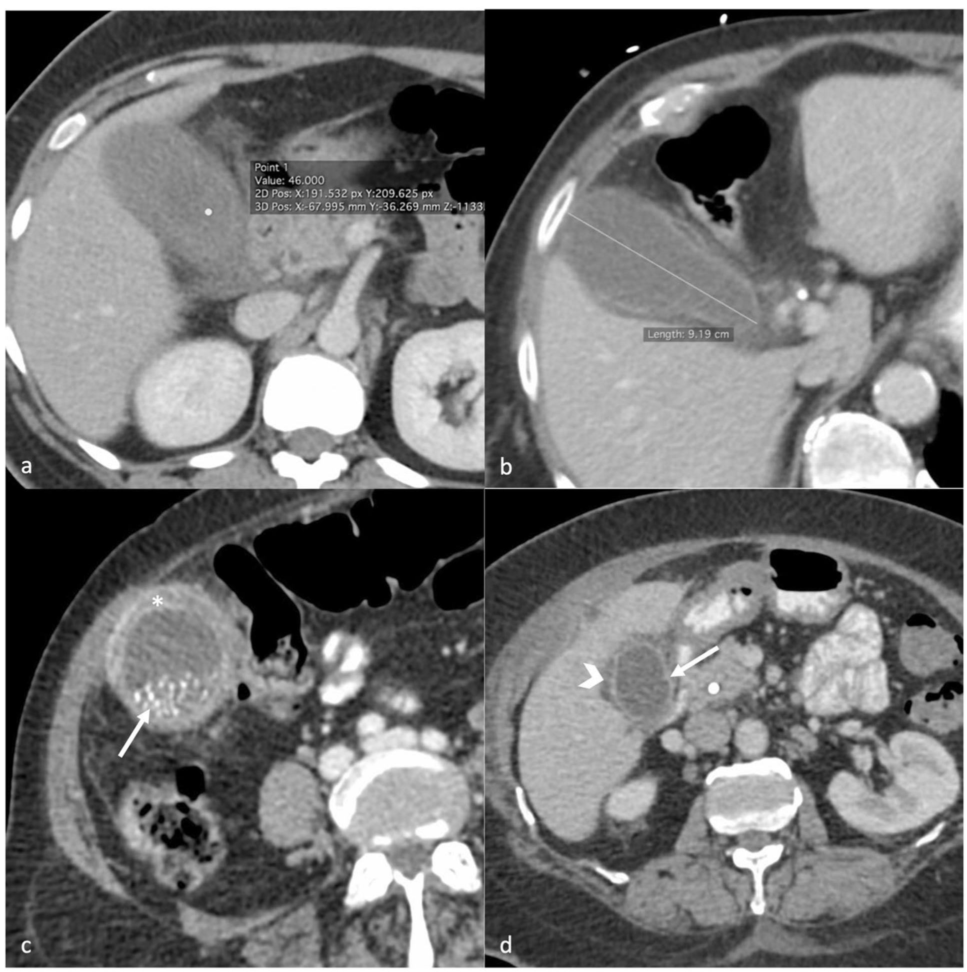

Fig. 3 CT features of acute cholecystitis. **a** hyperdense bile of attenuation 46HU; **b** gallbladder length; **c** gallbladder calculi (arrow) and wall thickening (asterisk); **d** pericholecystic fluid (arrowhead) and mucosal enhancement (arrow)

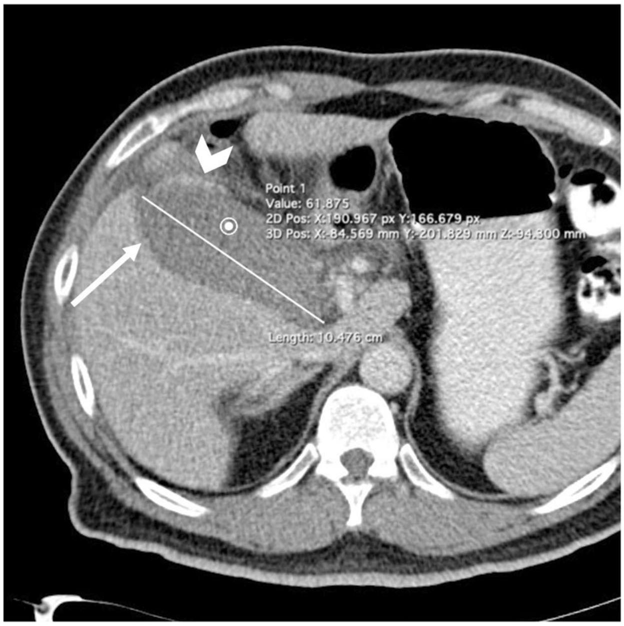

Fig. 4 Axial CT of a patient exhibiting distended gallbladder length of 10.5 cm (straight line), presence of pericholecystic fluid (arrow), hyperdense bile of attenuation 61HU (bullseye circle) and mucosal enhancement (arrowhead), features previously reported as associated with acute cholecystitis in the literature. Although acute gangrenous cholecystitis was eventually discovered at cholecystectomy and the gallbladder lumen had been distended with infected bile, no purulent material was aspirated

Previous authors had decided that the cutoff point measurements for gallbladder wall thickness and gallbladder distension ought to be 3 mm and 8 cm respectively [11, 14, 15, 19]. From our calculation using receiver operating curve (ROC) and unpaired Student *t*-test, we found that adjusting the cutoff point for both criteria to 3.9 mm and 7.3 cm respectively yielded sensitivity and specificity of more than 75%.

Few other sonographic features have been described in previous literature, among them sonographic Murphy's sign, intraluminal or intramural air and free intraperitoneal fluid. Positive sonographic Murphy's sign in particular has been reported to contribute to higher PPV, thus reflecting a good specific indicator for gallbladder disease [6, 11, 19]. O'Connor et al. suggested that eliciting positive sonographic Murphy's sign could distinguish the cause of distended gallbladder, whether due to cholecystitis or prolonged fasting [16]. Unfortunately, as our study was retrospective, only a handful of sonographic reports recorded sonographic Murphy's sign findings. Our data showed that only 9 reports mentioned sonographic Murphy's sign, in which 8 of them are positive for gallbladder empyema.

Many studies have described the role of CT in complicated cholecystitis in the past. CT features reportedly associated with cholecystitis include wall thickening, gallbladder distension, gallstone, hyperdense bile (> 20 HU), mucosal enhancement and pericholecystic fluid (Fig. 3). Some authors also reported additional findings including liver abscess and aerobilia, due to perforated gallbladder [6, 14, 17, 18]. Our study found that none of the criteria above showed significant statistical association with gallbladder empyema (see Fig. 4). This is largely contributed by a smaller number of patients that had CT scan prior to intervention. Although not significant, we found that 87% of patients with thickened gallbladder walls developed gallbladder empyema. A similar pattern is also shown with mucosal enhancement (89%) and gallbladder distension (81%) of patients diagnosed with gallbladder empyema.

There are limitations to our study. First, since our study is a retrospective design, some of the sonographic images could be considered suboptimal in diagnostic quality, thus resulting in inaccurate or even loss of data. Few other valuable features are also not included or documented in the final reports, including positive Murphy's sign and wall striations.

Secondly, only a small number of patients had CT scan prior to intervention, thus making the data outcome not significant for CT per se. Most of the patients only had an ultrasound as it was considered sufficient in the majority of cases; CT investigation was often only requested if a suspicion of complications or adjacent organ involvement arose.

In the future, we hope to conduct a prospective study, with standardized imaging and reporting systems in all patients with suspected cholecystitis. Although promising data from analysing sonographic images, we also hope to obtain larger sample sizes for CT scan to enable further statistical analysis. We also would like to extend our study to evaluate the length of stay, types of pathogen isolated from the gallbladder empyema, cost of treatment and complications from the interventional procedures.

Conclusion

Establishing a diagnosis of complicated cholecystitis, specifically gallbladder empyema, has proven to be difficult due to similarities in clinical presentation and radiological findings with those of acute uncomplicated cholecystitis. However, our study has shown that ultrasound remains the first line of imaging modality for patients with suspected acute or complicated cholecystitis. Our data also showed that ultrasound alone is sufficient in assisting the radiologist to establish a diagnosis of gallbladder empyema, particularly in the presence of gallbladder wall thickening and gallbladder distension. Therefore, using our scoring system of positive sonographic findings, coupled with relevant clinical presentation and physical assessment, would enable accurate diagnosis thus leading to prompt and precise treatment for the patient.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Azzaki Zainal Isa, Thean Yean Kew and Azrin Othman Hairol. The first draft of the manuscript was written by Azzaki Zainal Isa and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability Our database is accessible to all employees of the tertiary center from which electronic medical records were obtained.

Code availability Not applicable.

Declarations

Ethics approval Local institutional Research Ethics Board approval was obtained for the study.

Consent to participate Written patient consent was exempted by the ethics board due to the retrospective design of the study.

Conflicts of interest The authors no competing interests.

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