Original Article

The Accuracies of Abdominal Computed Tomography and the Neutrophil-to-lymphocyte Ratio used to Predict the Development of Clinically Severe Acute Cholecystitis in Elderly Patients Visiting an Emergency Department

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ABSTRACT

Background: Mortality in patients with severe acute cholecystitis (AC) remains high, and the prognosis for elderly patients tends to be poor. A comparative analysis of clinical, laboratory, and abdominal computed tomography (CT) parameters was conducted in this study to investigate the effectiveness of each index for predicting clinically severe AC in elderly patients in the emergency department (ED). **Methods:** This was a single-center, retrospective study that included 156 patients (≥65 years of age) with AC who were admitted in the ED between January 2012 and December 2014. Parameters including age, gender, initial clinical findings, laboratory findings, and CT findings in the ED were examined for their ability to predict severity. **Results:** Forty-five patients were diagnosed with clinically severe AC. The white blood cell count, neutrophil count, neutrophil-to-lymphocyte ratio (NLR), C-reactive protein, erythrocyte sedimentation rate, protein, albumin, and prothrombin time/International Normalized Ratio values were significantly higher in the severe group than in the nonsevere group ($P < 0.05$). In addition, the CT parameters of increased pericholecystic fat stranding and pericholecystic fluid collection were significantly higher in the severe group than in the nonsevere group ($P < 0.001$, $P < 0.001$). Increased pericholecystic fat stranding (odds ratio [OR], 8.17; 95% confidence interval [CI], 2.29–29.22; $P = 0.001$), pericholecystic fluid collection (OR, 6.55; 95% CI, 1.39–30.92; $P = 0.018$), and an NLR cutoff value of 9.9 (OR, 4.20; 95% CI, 1.01–17.53; $P = 0.049$) were independent predictors of severe AC in elderly patients. **Conclusions:** The CT parameters of increased pericholecystic fat stranding and pericholecystic fluid collection with an NLR cutoff of 9.9 were useful for predicting the severity of AC in elderly patients in the ED.

Keywords: *Aged, cholecystitis, emergencies, multidetector computed tomography, prognosis*

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Introduction

Computed tomography (CT) and ultrasonography (US) are widely used in the radiological diagnosis of acute cholecystitis (AC), but a limited number of studies have verified the utility of CT because of the likelihood of high cost, radiation exposure, and complications from the administration of intravenous contrast medium.[1-3] However, abdominal CT is used more widely for patients presenting with acute atypical abdominal pain or other suspected diagnoses considered in emergency

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departments (EDs) of the Republic of Korea due to the relatively low cost of CT examinations in the country.

AC is defined as an inflammation of the GB and usually occurs due to obstruction of the cystic duct from stones or sludge, which leads to cholestasis and subsequent mechanical, chemical, or infectious irritation of the GB wall. AC comprises 20% of all surgical biliary tract diseases and is likely to dramatically worsen; therefore, surgery or percutaneous cholecystectomy is recommended.[1,4] The incidence of cholecystitis increases with age, and 50%–70% of all patients are >65 years of age.[5,6]

Elderly patients frequently have comorbidities and display specific physiological changes. Because these patients frequently present to EDs late, and without typical symptoms, severe AC is more likely in elderly versus younger patients.[1] The mortality rate of patients with severe AC remains high, and the prognosis for elderly patients tends to be poor.[7,8] When an elderly patient with abdominal pain due to AC arrives at the ED, the patient's initial symptoms are likely to be ambiguous or minor, but they can develop into a serious, aggravated condition.[9] Morbidity and mortality increase significantly with gangrenous cholecystitis, gallbladder (GB) abscess, and perforation.[10,11] In addition, the white blood cell (WBC) count and C-reactive protein (CRP) level may not increase in elderly patients with severe AC.[1] Therefore, early diagnosis and proper surgical intervention are in this group of patients is crucial. However, no prognostic factor for AC has been proposed to predict severe AC in elderly patients at the time of their arrival at the ED. It is critical to focus on the diagnosis of severe AC in elderly patients and to initiate appropriate management, such as surgery or admission to the Intensive Care Unit (ICU), to improve their prognosis.

A study by Fagenholz *et al*.[2] showed that US is more sensitive than CT for detecting cholelithiasis, but CT is more sensitive than ultrasound for diagnosing AC. CT is particularly useful in patients without the typical clinical signs or symptoms.

Many surgical studies have been conducted to identify predictors of conversion from laparoscopic cholecystectomy to open cholecystectomy.[7,12-14] In particular, patients >51 years of age are more likely to develop severe AC than are younger patients.[10] In a previous Korean study, Kim identified age > 60 years, male gender, and collection of pericholecystic fluid as independent predictors of conversion to open cholecystectomy.[12] Therefore, we assessed the usefulness of CT performed in the ED on elderly patients with AC and tried to identify clinical, laboratory, and CT parameters to predict clinically severe AC.

Methods

This was a single-center, retrospective study that enrolled 156 patients (≥65 years of age) with AC who were admitted to the ED of Incheon St. Mary's Hospital of the Republic of Korea between January 2012 and December 2014. Admitted patients who were clinically diagnosed with AC in the ED were included in the present study. AC diagnoses were made by biliary surgeons or internal medicine physicians by reference to clinical signs, laboratory findings, and CT imaging data.

Patients were excluded from the study if they did not undergo a CT examination in the ED; had a vague diagnosis; were admitted as an outpatient for elective cholecystectomy; showed evidence of an immunocompromised state (e.g., malignancy); or had taken antibiotics within 14 days before the ED visit.

The protocol was approved by the Institutional Review Board of our hospital. Clinical measurements were included in routine patient management in the ED. This hospital is a tertiary teaching hospital and is located in the capital of the Republic of Korea, where 50,000 patients are treated annually. Informed consent was waived due to the retrospective nature of the study, as confirmed by the Institutional Review Board.

The demographic data and clinical characteristics of the patients were collected at the time of their initial visit to the ED. Age; gender; initial vital signs (blood pressure, heart rate, respiratory rate, and temperature); final diagnosis; cholecystectomy operation; ICU admission; duration of hospital stay; and histopathology reports were recorded. Clinical findings, including fever; duration of symptoms; right upper quadrant (RUQ) pain; epigastric pain; Murphy's sign; diffuse abdominal pain; and early blood examination (WBC count, neutrophil count, neutrophil-to-lymphocyte ratio [NLR], platelet, red cell distribution width [RDW], aspartate aminotransferase [AST], alanine transaminase [ALT], CRP, erythrocyte sedimentation rate [ESR], protein, albumin, and PT INR), were obtained within 2 h of ED arrival. An abdominal CT (contrast or noncontrast) was performed in the ED within 6 h. Two radiologists performed a retrospective CT evaluation of all patients with consensus reading, and CT findings (GB stone, GB distension, GB wall thickening, perihepatic hyperattenuation, increased density of pericholecystic fat stranding, and pericholecystic fluid collection) were collected. Wall thickness (>4 mm); and the short-and long-axis diameters of the GB (>5 cm and >8 cm, respectively), were measured at the widest points. Pericholecystic fluid collection was diagnosed when free or loculated fluid surrounded the GB. Pericholecystic fat stranding was diagnosed when fat

surrounding the GB exhibited regions of increased linear attenuation.[15]

All patients were divided into two groups (severe and nonsevere AC) on the basis of clinical and pathological findings. Clinically, severe AC was defined as the presence of pathologic gangrenous, necrotizing, suppurative, and perforated cholecystitis. If a patient did not have a cholecystectomy, they were classified according to the 2007 Tokyo Guidelines (TG07) for diagnosing severe AC (Grade III).[16] Therefore, the clinically severe AC group included patients with at least one organ dysfunction. Organ dysfunction is defined as the presence of an abnormality in any one of the following organs or systems: cardiovascular dysfunction (hypotension requiring treatment with ≥5 μg of dopamine per kilogram of body weight per minute or any dose of dobutamine); neurologic dysfunction (decreased level of consciousness); respiratory dysfunction (PaO_2/FiO_2 ratio <300); renal dysfunction (oliguria, creatinine level >2.0 mg/dL); hepatic dysfunction (prothrombin time and international normalized ratio >1.5); or hematologic dysfunction (platelet count <100,000/mm^3). All other patients were included in the nonsevere AC group.

We divided elderly AC patients into three stages (Grades I, II, and III) using the 2007 Tokyo guidelines and compared the severe and nonsevere AC groups. Grade I cases exhibited no organ dysfunction and only mild inflammatory changes in the GB. Grade II cases had one of the following conditions: WBC count >18,000/mm3, a palpable tender mass in the RUQ, pain duration >72 h, or marked local inflammation. Grade III cases had AC accompanied by organ/system dysfunction. Severe Grade III AC was diagnosed when one or more symptoms of organ or functional failure was/were evident.[16]

Statistical analysis

Statistical analysis was performed using SPSS 12.0 (SPSS Inc., Chicago, USA). Differences between the severe and nonsevere AC groups were compared using Student's *t*-test to analyze continuous variables. Median and quartile values were measured when the continuous variables were not normally distributed, and the Mann–Whitney U-test was used. The Chi-square and Fisher's exact tests were used to assess categorical variables. P <0.05 was considered to be statistically significant.

The prediction of severe cholecystitis was analyzed using receiver operating characteristic curves (ROCs). A cutoff value with a 95% confidence interval (CI), which was the maximum area under the curve (AUC), was selected. A multivariate logistic regression model for independent risk factors was used. The results were presented as odds ratios (ORs), 95% CIs, and 'p' values.

Results

Clinical characteristics of elderly acute cholecystitis patients

A total of 156 patients (>65 years old) with AC evaluated in the ED were enrolled in this study. Forty-five patients (28.8%) were diagnosed with severe AC in the ED. The mean age of the patients was 76.9 ± 6.7 years. Seventy-one patients (45.5%) were male, and 85 (55.5%) were female. Gender did not differ significantly between the two groups; however, age did differ significantly (P = 0.002). Blood pressure at the time of arrival was found to be significantly lower in the severe group than in the nonsevere group (P < 0.001) [Table 1].

The clinical findings of fever, duration of symptoms, RUQ pain, epigastric pain, Murphy's sign, and diffuse abdominal pain did not differ between the two groups. Eighty-eight patients (79.3%) in the nonsevere group and 29 (64.4%) in the severe group underwent cholecystectomies (P = 0.053). Thirty-nine patients (25.0%) were treated nonoperatively due to older age, hemodynamic instability, or (familial) operative refusal. Six patients underwent percutaneous transhepatic GB drainage after admission.

Pathologically, patients with severe AC included 9 with gangrenous AC, 19 with suppurative necrotizing AC, and 1 with a perforation.

According to the TG07 severity grading, in the severe group, there were 34 patients (75.6%) of Grade III and 11 patients (24.4%) of Grade II (P < 0.001). Thirty-five patients (77.8%) of severe group were transferred to the ICU from the ED. Median hospital stay was 11 days in the severe group and 6 days in the nonsevere group (P < 0.001). After 28 days, 149 patients (95.5%) were still alive, and seven (4.5%) had died [Table 1].

Comparison of the laboratory and computed tomography findings of elderly acute cholecystitis patients

The median WBC counts were 13.8 (9.9–22.0) (10^9/L) in the severe group and 9.9 (7.6–14.0) (10^9/L) in the nonsevere group, and the difference was statistically significant (P < 0.001). In addition, the median neutrophil count was significantly higher in the severe group 11.8 (7.8–19.4) (10^9/L) (P < 0.001). The NLR was significantly higher in the severe group than in the nonsevere group (13.2 vs. 7.2, P < 0.001). The ESR differed significantly between the two groups (54.0 mm/h in the severe group vs. 30.0 mm/h in the nonsevere group, P < 0.001). The median CRP level of 158.7 mg/L in the severe group was significantly higher than 29.6 mg/L of the nonsevere group (P < 0.001). PT INR, protein, and albumin were all significantly higher in the severe group than in the nonsevere group (P < 0.001).

Table 1: A comparison of the clinical characteristics of elderly patients (>65 years) with acute cholecystitis in the emergency department

	Nonsevere group (*n*=111)	Severe group (*n*=45)	*P*
Gender, *n* (%)			0.599
Male	52 (46.8)	19 (42.2)	
Female	59 (53.2)	26 (57.8)	
Age (years)	75.8±6.6	79.5±6.2	0.002
Initial vital signs			
SBP (mmHg)	142.4±27.4	119.4±26.8	<0.001
DBP	76.2±12.5	67.4±13.2	<0.001
HR (beats/min)	82.3±15.5	92.7±18.3	<0.001
BT (°C)*	36.6 (36.0-37.1)	36.7 (36.3-37.5)	0.127
Duration of symptom (h)*	24 (8-72)	41 (8-72)	0.503
Fever, *n* (%)	42 (37.8)	20 (44.4)	0.445
RUQ pain, *n* (%)	85 (76.6)	28 (62.2)	0.069
Epigastric pain, *n* (%)	68 (61.3)	20 (44.4)	0.055
Murphy's sign, *n* (%)	43 (38.7)	11 (24.4)	0.089
Diffuse abdominal pain, *n* (%)	36 (32.4)	9 (20.0)	0.120
Cholecystectomy, *n* (%)	88 (79.3)	29 (64.4)	0.053
TG07 severity grading			
III (severe)	0	34 (75.6)	<0.001
II (moderate)	40 (36.0)	11 (24.4)	
I (mild)	71 (64.0)	0	
ICU admission, *n* (%)	0	35 (77.8)	<0.001
Death, *n* (%)	1 (0.9)	6 (13.3)	0.002
Hospital stay (days)*	6.0 (4.0-10.0)	11.0 (7.0-16.0)	<0.001

*Median value with interquartile range, statistical analyses were performed by Mann-Whitney U-test. SBP=Systolic blood pressure; DBP=Diastolic blood pressure; HR=Heart rate; BT=Body temperature; RUQ=Right upper quadrant; TG=TOKYO guideline; ICU=Intensive Care Unit

Table 2: A comparison of laboratory findings and computed tomography findings for elderly patients (>65 years) with acute cholecystitis in the emergency department

	Nonsevere group (*n*=111)	Severe group (*n*=45)	*P*
WBC count ($\times 10^9$/L)*	9.9 (7.6-14.0)	13.8 (9.9-22.0)	<0.001
Neutrophil count ($\times 10^9$/L)*	7.6 (5.6-12.1)	11.8 (7.8-19.4)	<0.001
NLR*	7.2 (3.3-12.8)	13.2 (7.4-20.5)	<0.001
Platelet ($\times 10^3$/uL)*	220.0 (172.0-267.0)	197.0 (165.0-243.0)	0.086
RDW (%)*	12.8 (12.4-13.5)	13.2 (12.7-13.9)	0.065
AST (U/L)*	47.0 (23.0-132.0)	35.0 (21.5-122.5)	0.359
ALT (U/L)*	39 (17.0-135.0)	25.0 (16.0-75.5)	0.173
PT INR*	1.1 (1.0-1.1)	1.2 (1.1-1.3)	<0.001
ESR (mm/h)*	30.0 (14.8-49.3)	54.0 (28.3-72.5)	<0.001
CRP (mg/L)*	29.6 (4.0-98.3)	158.7 (65.5-175.9)	<0.001
Protein (g/dL)*	6.8 (6.5-7.2)	6.2 (5.8-6.8)	<0.001
Albumin (g/dL)*	3.9 (3.7-4.2)	3.4 (3.0-3.8)	<0.001
GB stone, *n* (%)	70 (63.1)	27 (60.0)	0.721
GB distension, *n* (%)	64 (57.7)	33 (73.3)	0.067
GB wall thickening, *n* (%)	50 (45.0)	22 (48.9)	0.663
Perihepatic hyperattenuation, *n* (%)	17 (15.3)	6 (13.3)	0.736
Increased pericholecystic fat stranding, *n* (%)	15 (13.5)	30 (66.7)	<0.001
Pericholecystic fluid collection, *n* (%)	5 (4.5)	22 (48.9)	<0.001

*Median value with interquartile range, statistical analyses were performed by Mann-Whitney U test. WBC=White blood cell; NLR=Neutrophil to lymphocyte ratio; RDW=Red cell distribution width; AST=Aspartate aminotransferase; ALT=Alanine transaminase; ESR=Erythrocyte sedimentation rate; CRP=C-reactive protein; GB=Gall bladder; PT=Prothrombin time; INR=International normalized ratio

However, platelets, RDW, AST, and ALT did not differ significantly between the two groups [Table 2].

CT findings showed a significant increase in pericholecystic fat stranding and pericholecystic fluid

Table 3: Diagnostic value of the age and biomarkers in predicting severe cholecystitis of elderly patients in the emergency department

	AUC (95% CI)	Cut-off value	Sensitivity (%)	Specificity (%)	*P*
Age	0.656 (0.576-0.730)	>76	71.1	55.9	<0.001
WBC count (×10^9/L)	0.679 (0.600-0.752)	>14.9	48.9	78.4	
Neutrophil count (×10^9/L)	0.699 (0.621-0.770)	>7.2	86.7	43.2	
NLR	0.703 (0.625-0.773)	>9.9	71.1	71.2	
PT INR	0.728 (0.651-0.796)	>1.2	60.0	82.0	
ESR (mm/h)	0.701 (0.620-0.774)	>51.0	54.5	80.4	
CRP (mg/L)	0.762 (0.688-0.827)	>69.3	75.6	70.3	
Protein (g/dL)	0.715 (0.635-0.786)	≤6.2	51.1	85.3	
Albumin (g/dL)	0.776 (0.701-0.840)	≤3.6	73.3	72.6	

WBC=White blood cell; NLR=Neutrophil to lymphocyte ratio; ESR=Erythrocyte sedimentation rate; CRP=C-reactive protein; PT=Prothrombin time; INR=International normalized ratio; CI=Confidence interval; AUC=Area under the curve

Table 4: Multivariate logistic regression model for independent risk factors for elderly patients (>65 years) with acute cholecystitis in the emergency department

	Univariate analysis			Multivariate analysis			
	OR	95% CI	*P*	Cut-off value	OR	95% CI	*P*
Age	1.09	1.03-1.15	0.003	>76	1.56	0.48-5.09	0.465
WBC count (×10^9/L)	1.14	1.06-1.21	<0.001	>14.9	1.45	0.38-5.61	0.59
Neutrophil count (×10^9/L)	1.0	1.0-1.0	<0.001	>7.2	0.97	0.20-4.69	0.967
NLR	1.03	1.0-1.06	0.038	>9.9	4.20	1.01-17.53	0.049
PT INR	9.43	1.76-50.40	0.009	>1.2	1.71	0.48-6.12	0.411
ESR (mm/h)	1.03	1.02-1.05	<0.001	>51.0	1.28	0.30-5.45	0.742
CRP (mg/L)	1.01	1.01-1.02	<0.001	>69.3	1.42	0.34-5.87	0.631
Protein (g/dL)	0.48	0.29-0.78	0.003	≤6.2	1.59	0.39-6.48	0.515
Albumin (g/dL)	0.21	0.10-0.43	<0.001	≤3.6	1.86	0.44-7.91	0.403
Increased pericholecystic fat stranding	12.80	5.61-29.20	<0.001		8.17	2.29-29.22	0.001
Pericholecystic fluid collection	20.28	6.95-59.15	<0.001		6.55	1.39-30.92	0.018

WBC=White blood cell; NLR=Neutrophil to lymphocyte ratio; ESR=Erythrocyte sedimentation rate; CRP=C-reactive protein; PT=Prothrombin time; INR=International normalized ratio; CI=Confidence interval; OR=Odds ratio

collection in the severe group compared to the nonsevere group. Thirty patients (66.7%) in the severe group had increased pericholecystic fat stranding, and 22 (48.9%) had pericholecystic fluid collection ($P < 0.001$, $P < 0.001$). The frequency rates of GB stones, GB distension, GB wall thickening, and perihepatic hyperattenuation did not differ between the two groups.

In predicting severe AC of elderly patients in the ED through ROC curve analysis, the AUC value for age was 0.656 (95% CI = 0.576–0.730, $P < 0.001$), and the cutoff value was 76 years (sensitivity 71.1% and specificity 55.9%). The laboratory results for the severe group were as follows: the AUC value for albumin was 0.776 (95% CI = 0.701–0.840, $P < 0.001$), and the cutoff value was 3.6 (sensitivity 73.3% and specificity 72.6%); and for CRP and PT INR, the AUC values were 0.762 (95% CI = 0.688–0.827, $P < 0.001$) and 0.728 (95% CI = 0.651–0.796, $P < 0.001$), and the cutoff values of CRP and PT INR were 69.3 mg/L (sensitivity 75.6% and specificity 70.3%) and 1.2 (sensitivity 60.0% and specificity 82.0%), respectively. Albumin and CRP had higher AUC values than did the other factors. The additional diagnostic value of the AUC for predicting severe AC in elderly patients in the ED is shown in Table 3. The AUC values for the CT parameters of increased pericholecystic fat stranding and pericholecystic fluid collection were 0.766 (95% CI, 0.676–0.856, $P < 0.001$) and 0.722 (95% CI, 0.623–0.821, $P < 0.001$); [Figure 1], respectively.

Prognostic factors for predicting the severity of acute cholecystitis in elderly patients

A univariate analysis using a logistic regression model revealed that PT INR (OR = 9.43, $P = 0.009$), increased pericholecystic fat stranding (OR = 12.80, $P < 0.001$), and pericholecystic fluid collection (OR = 20.28, $P < 0.001$) were significantly associated with severity and showed high ORs [Table 4]. The significant factors ($P < 0.05$) from the univariate analysis were included in the multivariate analysis. The most significant independent factor associated with the severe AC group was increased pericholecystic fat stranding (OR, 8.17; 95% CI, 2.29–29.22; $P = 0.001$). In addition, pericholecystic fluid

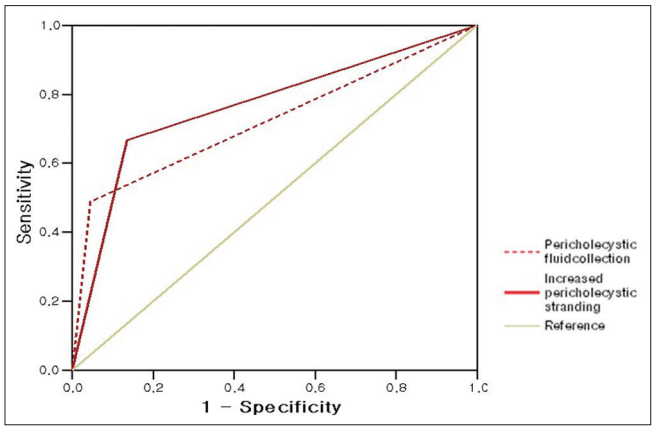

Figure 1: In predicting severe acute cholecystitis of elderly patients, the area under the curve s of CT parameters reflecting increased pericholecystic fat stranding and fluid collection were 0.766 (95% confidence interval, 0.676–0.856) and 0.722 (95% confidence interval, 0.623–0.821), respectively

collection (OR, 6.55; 95% CI, 1.39–30.92; P = 0.018) and a NLR cutoff value of 9.9 (OR, 4.20; 95% CI, 1.01–17.53; P = 0.049) were independent predictors of severe AC in elderly patients [Table 4].

Discussion

The diagnosis of AC in the ED is generally achieved through clinical history-taking, medical examination, blood tests, US, and CT. However, it is often difficult to identify the disease history of elderly patients due to unclear clinical status, mild or no peritoneal irritation signs, and inconsistent WBC counts and other blood tests indicative of severe clinical conditions.[9] Thus, US and CT are useful in helping to diagnose AC in this population. In the present study, increased pericholecystic fat stranding (OR = 8.17) and pericholecystic fluid collection (OR = 6.55) detected on abdominal CT showed significantly associated with severe AC independent factor in elderly patients presenting to the ED. Furthermore, NLR cutoff value of 9.9 (OR = 4.20) of additional laboratory data was useful for prediction of severe AC in elderly patients.

AC can lead to potentially life-threatening complications, such as empyema, GB gangrene, GB perforation, or a pericholecystic abscess.[10,11] The diagnosis of AC in elderly patients is often difficult, and therapy may be delayed such that the risk of morbidity and mortality increases.[4,8,12] AC is often a relative indication for emergency surgery or intervention in the elderly.[1] The prediction of fatality from AC varies because diagnostic standards and severity guidelines in the elderly are limited. This situation emphasizes the significance of appropriate standard guidelines. In a previous study, a high WBC, high CRP level, and old age were associated with gangrenous cholecystitis or severe cholecystitis. In addition, the CRP level (cut-off >20 mg/L) reliably predicted gangrenous cholecystitis, with high sensitivity and specificity.[17] In this study, WBC and neutrophil counts had cutoff values of 14.9 × 10^9/L and 7.2 × 10^9/L, respectively, and CRP was at 69.3 mg/L, all of which represent higher values than those reported previously. In other words, the present study, which focused on elderly patients aged ≥65 years, detected a higher CRP level than that in a previous study due to the difference in age of the cohorts. However, the present study found no difference in severity based on gender.

The reason why NLR is associated AC severity has been undetermined. Neutrophilia is part of the inflammatory response, and the NLR could represent overwhelming inflammatory and severity of infectious condition.[18,19] Because the NLR can be easily calculated in the ED, previous studies have described the relationship between the NLR and severe infectious disease in the ED. A higher NLR is associated with bacteremia and is superior to other inflammatory markers in the ED.[20] In a study by Beliaev *et al*.,[21] an analysis comparing 111 patients with moderately severe AC with 45 control patients showed that the NLR cutoff value was 4.17 (95% CI, 3.76–4.58; P < 0.0005). They found a positive association between the NLR and a diagnosis of AC.[21] In the present study, the NLR cutoff value of 9.9 (OR, 4.20; 95% CI, 1.01–17.53; P = 0.049) was an independent predictive factor for severe AC in elderly patients in the ED. This result is concordant with Beliaev's study, and the NLR can be considered a predictive inflammatory biomarker for severe AC. Thus, the NLR can be easily examined and assessed, thus this will be considered as a predictive tool for suspected severe AC in elderly patients in the ED.

Among the elderly, severe cholecystitis is more likely to develop into multiple organ dysfunction syndrome compared with mild AC. Therefore, it is necessary to take an active approach to surgical treatment and upgrade symptoms by predicting the severity of AC in the elderly. If inflammation is severe, or if necrotizing cholecystitis develops, increased density of pericholecystic fat stranding or fluid collection can occur around the GB.[15,22] CT is more useful for identifying complications, such as emphysematous cholecystitis and GB perforation, than for diagnosing AC or differentiating AC from other diseases with similar symptoms.[15,23] McGillicuddy reported that CT and US findings may be complementary for diagnosing AC in elderly patients.[24] Most studies on severe cholecystitis are related to the pathological classification and are limited to gangrenous cholecystitis or perforations.[25-27] One study that focused on gangrenous and phlegmonous cholecystitis was done by Borzellino, but his study analyzed predictive factors

for diagnosing severe AC using clinical parameters and US data.[27] The present study went beyond the clinical parameters to include CT parameters and was designed to predict the severity of AC clinically in the elderly. CT parameters (such as increased pericholecystic fat stranding and pericholecystic fluid collection) showed higher ORs than other inflammatory biomarkers for identifying severe AC among patients >65 years of age.

However, a limitation of our study is that we did not analyze the utility of US data. The costs of US and CT performed in the ED do not differ significantly in South Korea; surgeons and physicians thus prefer to schedule CT to increase the accuracy and cost-effectiveness of differential diagnosis when elderly patients present with ambiguous acute abdominal pain. Thus, US was seldom used in the ED to evaluate elderly patients with AC; we could not explore whether the predictive utilities of US and CT differed when these modalities were utilized to diagnose AC. Future prospective studies are needed to assess the relative predictive efficacies of US and CT in elderly patients with AC who present to the ED. The limitations of this study included selection bias (exclusion of elderly patients whose vital signs were too unstable for CT scanning) and the small sample size. In addition, the excluded subjects included patients who underwent noncontrast abdominal CT or US examinations because of the risk of abnormal renal function from contrast sensitivity. A future prospective study on elderly patients with AC evaluated via US and CT after the presentation to the ED is needed.

Conclusions

Increased pericholecystic fat stranding and pericholecystic fluid collection detected on abdominal CT, along with NLR (>9.9), were significantly associated with severe AC in elderly patients presenting to the ED. Therefore, we suggest that abdominal CT and NLR performed in the ED will be helpful for predicting severe AC in elderly patients with clinically suspected AC.

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Conflicts of interest

There are no conflicts of interest.

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