AGMR Annals of Geriatric Medicine and Research
2016;20(4):177-184
Original Article

https://doi.org/10.4235/agmr.2016.20.4.177
Print ISSN 2508-4798 On-line ISSN 2508-4909
www.e-agmr.org

Association Between Extrahepatic Duct Diameter on Abdominal Computed Tomography and Severity Classified Using Tokyo Guidelines 2013 in Elderly Patients With Cholangitis

Hyeon Song Kim[1,2], Chang Min Lee[1,2], Byuk Sung Ko[1], Sung Hyuk Park[1,2], Woong Jung[1,2], Myung Chun Kim[1,2], Young Gwan Ko[2]

[1]Department of Emergency Medicine, Kyung Hee University Hospital at Gangdong, Kyung Hee University School of Medicine, Seoul, [2]Department of Emergency Medicine, Kyung Hee University Medical Center, Kyung Hee University School of Medicine, Seoul, Korea

Corresponding Author:
Chang Min Lee, MD
Department of Emergency Medicine, Kyung Hee University Hospital at Gangdong, Kyung Hee University School of Medicine, 892 Dongnam-ro, Gangdong-gu, Seoul 05278, Korea

Tel: +82-2-440-6176
Fax: +82-2-440-7799
E-mail: foxmin76@naver.com

Received: September 8, 2016
Revised: October 21, 2016
Accepted: October 26, 2016

Background: It is important to estimate the severity of early stage cholangitis in elderly patients to determine the most appropriate timing of biliary decompression. Abdominal computed tomography (CT) is the modality of choice for the diagnosis of cholangitis; however, studies evaluating the correlation between cholangitis severity and CT findings, specifically extrahepatic duct (EHD) diameter, are insufficient. Therefore, this study aimed to evaluate the relationship between EHD diameter and disease severity in elderly patients with cholangitis. **Methods:** A total of 155 patients over the age of 65 years, admitted to the Emergency Department, with a diagnosis of cholangitis from January 2010 to December 2015 were retrospectively analyzed. Using the Tokyo Guidelines 2013, patients were grouped into mild and moderate to severe cholangitis groups. We then analyzed the patient's medical backgrounds, vital signs, and CT findings. To evaluate the significance of the CT findings in relation to cholangitis severity, a univariate analysis was performed within each group, using the collected variables. A multiple logistic regression analysis was performed using the variables with $p<0.05$. **Results:** On univariate analysis, EHD diameter ($p<0.001$) and combined cholecystitis ($p=0.009$) were found to be significant CT findings; EHD diameter (odds ratio [OR], 1.235; 95% confidence interval [CI], 1.115–1.368; $p<0.001$) and combined cholecystitis (OR, 2.666; 95% CI, 1.145–6.212; $p=0.023$) were also statistically significant after multiple logistic regression. **Conclusion:** In conclusion, increased EHD diameter was associated with disease severity in elderly patients with cholangitis. EHD diameter is easy to measure on CT and can be helpful in establishing an appropriate treatment plan.

Key Words: Cholangitis, Computed tomography, Geriatrics, Severity, Bile ducts

INTRODUCTION

Cholangitis is an infection of the biliary tract due to an obstruction in the bile duct, and early diagnosis and treatment are essential because inadequate treatment can progress to sepsis[1)]. The most common cause of bile duct obstruction is bile duct stone (or gallstone), and it is reported that elderly patients have a higher risk of bile duct stones[2,3)]. Cholangitis requires antimicrobial therapy and biliary decompression depending on the severity; generally, early initiation of biliary decompression is recommended for moderate to severe cholangitis[4,5)]. Hence, it is fundamental to classify the severity at the time of diagnosis; for elderly patients, prompt judgment is particularly important because the infection can more easily spread throughout the body (e.g., sepsis) compared to younger patients[6)].

The Tokyo Guidelines 2013 (TG13) presented the criteria for diagnosing cholangitis as well as three criteria for severity assessment; TG13 recommended early intervention for moderate to severe cholangitis[7)]. For an accurate diagnosis of cholangitis, it also recommended additional imaging tests, such as a contrast-enhanced abdominal computed tomography (CT)[4,5)]. Significant findings from abdominal CT that indicate acute cholangitis include the following: dilatation of bile duct (or biliary dilatation), thickening and contrast enhancement of the biliary walls, bile duct stone, and temporary transient hepatic attenuation differences (THADs)[8]. Of these, biliary dilatation is one of the TG13 diagnostic criteria for cholangitis.

Biliary dilatation is seen in many patients with cholangitis and is associated with increased internal pressure in the bile duct, which is the main cause of cholangitis[9]. While it is well known that biliary pressure is associated with morbidity and severity[10,11], few studies on the correlation between extrahepatic duct (EHD) diameter and severity have been conducted. In particular, there have not been studies on cholangitis in elderly patients. Without a doubt, the severity can be predicted by clinical manifestation and blood tests; however, an imaging-based indicator for severity assessment can more simply and intuitively classify severity. Usually, many elderly patients with cholangitis are transferred to an Emergency Department (ED) of a university hospital from other medical facilities after undergoing abdominal CT. Therefore, if an independent imaging indicator is present, it can help physicians understand a patient's condition and establish a timely treatment plan on arrival at the ED. We conducted this study to investigate whether bile duct diameters in abdominal CT change according to the severity of cholangitis in elderly patients and to confirm whether there are additional CT findings related to this.

MATERIALS AND METHODS

1. Subjects

Among the hospitalized patients who were admitted to the ED of a university hospital with a clinical suspicion of acute cholangitis between January 1, 2010 and December 31, 2015, those over 65 years of age who met the TG13 diagnostic criteria for cholangitis and underwent endoscopic retrograde cholangiopancreatography (ERCP) to confirm the cause of cholangitis were included in this retrospective observational study. The TG13 diagnostic criteria for acute cholangitis are presented in Table 1. This study was approved by the institutional review board before proceeding.

Table 1. TG13 diagnostic criteria for acute cholangitis

A. Systemic inflammation
- A-1. Fever and/or shaking chills
- A-2. Laboratory data: evidence of inflammatory response

B. Cholestasis
- B-1. Jaundice
- B-2. Laboratory data: abnormal liver function tests

C. Imaging
- C-1. Biliary dilatation
- C-2. Evidence of the etiology on imaging (stricture, stone, stent etc.)

Suspected diagnosis: One item in A + one item in either B or C
Definite diagnosis: One item in A, one item in B and one item in C
Note:
A-2: Abnormal white blood cell counts, increase of serum C-reactive protein levels, and other changes indicating inflammation.
B-2: Increased serum ALP, γGTP (GGT), AST and ALT levels.
Other factors which are helpful in diagnosis of acute cholangitis include abdominal pain (right upper quadrant [RUQ] or upper abdominal) and a history of biliary disease such as gallstones, previous biliary procedures, and placement of a biliary stent.
In acute hepatitis, marked systematic inflammatory response is observed infrequently. Virological and serological tests are required when differential diagnosis is difficult.

Thresholds			
A-1	Fever		BT >38℃
A-2	Evidence of inflammatory response	WBC (x1,000/μL)	<4 or >10
		CRP (mg/dL)	≥1
B-1	Jaundice		T-Bil ≥2 (mg/dL)
B-2	Abdominal liver function tests	ALP	>1.5 x STD
		γGTP (IU)	>1.5 x STD
		AST (IU)	>1.5 x STD
		ALT (IU)	>1.5 x STD

Adapted from Kiriyama S, et al. J Hepatobiliary Pancreat Sci 2012;19:548-56 [7].
TG13, Tokyo Guidelines 2013; ALP, alkaline phosphatase; γGTP (GGT), γ-glutamyltransferase; AST, aspartate aminotransferase; ALT, alanine aminotransferase; BT, body temperature; WBC, white blood cell; CRP, C-reactive protein; T-Bil, total bilirubin; STD, upper limit of normal value.

2. Methods

1) Data collection

By reviewing the medical records of the participants, we examined the medical history, signs and symptoms, and physical examination, blood test, and imaging test findings. We recorded the age, sex, vital signs at the time of ED visit, history of chronic illness, early symptoms, and medical staff's opinions on physical examination; then, we checked the blood test performed during the ED visit and collected data essential for classifying the severity. Aside from these, we also checked the following variables: detection of bacterium from blood culture study, previous cholecystectomy, duration of hospital stay, and time spent from ED visit to ERCP and from ERCP to discharge.

Imaging findings were summarized on the basis of the radiologist's reading of the abdominal CT scans performed at the ED. The diagnostic criteria from abdominal CT scan were as follows: (1) EHD diameter, (2) common bile duct wall thickening, (3) intrahepatic biliary dilatation, (4) bile duct stone, (5) intrahepatic stone, (6) cholecystitis, (7) gall bladder stone, (8) THADs, (9) papillary edema and duodenal diverticulum, (10) pancreatitis, (11) pancreatic duct dilatation, and (12) hepatic abscess. Through early studies, the aforementioned criteria have been proven to be either significant in diagnosing cholangitis or relevant to the severity[8,12].

2) Patient group classification based on the severity

The severity of cholangitis was classified on the basis of the TG13 criteria and is shown in Table 2. First, the patients were divided into 3 groups based on the severity scale of the TG13 (mild, moderate, and severe). Second, the groups were recategorized into 2 groups: the mild cholangitis group that does not need early biliary decompression and the moderate to severe cholangitis group that needs early decompression.

3) Comparison between the mild cholangitis group and the moderate to severe cholangitis group

After dividing the subjects into the mild cholangitis group and the moderate to severe cholangitis group, the team compared the groups in terms of demographic variables, hemodynamic variables, blood culture study results, and radiologist's interpretation. The variables of the TG13 diagnostic criteria for cholangitis and severity classification were excluded from the analysis. Continuous variables in normal distribution were marked with mean and standard deviations and compared using the Student t-test; variables that are not in normal distribution were marked with median and interquartile ranges

Table 2. TG13 severity assessment criteria for acute cholangitis

Grade III (Severe) acute cholangitis "Grade III" acute cholangitis is defined as acute cholangitis that is associated with the onset of dysfunction in at least one of any of the following organs/systems:	
1. Cardiovascular dysfunction	Hypotension requiring dopamine ≥50 μg/kg/min, or any dose of norepinephrine
2. Neurological dysfunction	Disturbance of consciousness
3. Respiratory dysfunction	PaO_2/FiO_2 ratio<300
4. Renal dysfunction	Oliguria, serum creatinine >2.0 mg/dL
5. Hepatic dysfunction	PT-INR >1.5
6. Hematological dysfunction	Platelet count <100,000/mm^3
Grade II (moderate) acute cholangitis "Grade II" acute cholangitis is associated with any two of the following conditions: 1. Abnormal WBC count (>12,000/mm^3,<4,000/mm^3) 2. High fever (≥39℃) 3. Age (≥75 years old) 4. Hyperbilirubinemia (total bilirubin ≥5 mg/dL) 5. Hypoalbuminemia (<STD x 0.7)	
Grade I (mild) acute cholangitis "Grade I" acute cholangitis does not meet the criteria of "Grade III (severe)" or "Grade II (moderate)" acute cholangitis at initial diagnosis.	
Notes Early diagnosis, early biliary drainage and/or treatment for etiology, and antimicrobial administration are fundamental treatments for acute cholangitis classified not only as Grade III (severe) and Grade II (moderate) but also Grade I (mild). Therefore, it is recommended that patients with acute cholangitis who do not respond to the initial medical treatment (general supportive care and antimicrobial therapy) undergo early biliary drainage or treatment for etiology.	

Adapted from Kiriyama S, et al. J Hepatobiliary Pancreat Sci 2012;19:548-56 [7].
TG13, Tokyo Guidelines 2013; PaO_2, partial oxygen tension in arterial blood; FiO_2, fraction of inspired oxygen; PT-INR, prothrombin time-international normalized ratio; WBC, white blood cell; STD, upper limit of normal value.

(IQRs) and compared using the Mann-Whitney test. When comparing categorical variables, the Pearson chi-square test or Fisher exact test was used. The variables with p-values under 0.05 in the univariate analysis of the 2 groups were reanalyzed using the multivariate logistic regression analysis to confirm the radiologist's evaluation regarding the severity. All statistical analyses were performed using the PASW statistics version 18.0 (SPSS Inc., Chicago, IL, USA) software; p-values under 0.05 were considered significant.

RESULTS

During the study period, a total of 414 patients were admitted to the ED, with a clinical suspicion of cholangitis; among them, there were 260 patients over the age of 65 years. We selected 155 patients after excluding 24 patients who did not meet the TG13 diagnostic criteria for cholangitis, 71 who did not undergo ERCP, 9 who did not have sufficient data, such as abdominal CT scan findings, and one who had an infection from a different cause.

1. General Characteristics

We investigated all patients' demographic characteristics, history of chronic illness, vital signs, blood culture findings, the cause of bile duct obstruction identified through ERCP, duration of hospital stay, and time spent from ED visit to ERCP and from ERCP to discharge. The results are shown in Table 3. There were 70 male patients (45.2%). With regard to the history of chronic illness, 32 patients (20.6%) had diabetes mellitus, 88 (56.8%) had hypertension, 20 (12.9%) had malignant tumors, and 43 (27.7%) had previous cholecystectomy. In the vital signs, the average pulse rate was 86.48 beats per minute (±15.72), and the median breathing rate was 20 cycles per minute (IQR, 18–20). With regard to the blood culture study, 49 patients (31.6%) were found to have bacteria

Table 3. Comparison of the general characteristics, culture study and ERCP findings, and outcomes between TG13 grades I, II, and III groups in acute cholangitis

Variable	All patients (n=155)	Patient groups		p-value
		Grade I (mild) (n=82)	Grade II, III (moderate, severe) (n=73)	
Male sex	70 (45.2)	30 (36.6)	40 (54.8)	0.023*
Medical history				
Diabetes mellitus	32 (20.6)	14 (17.1)	18 (24.7)	0.244*
Hypertension	88 (56.8)	45 (54.9)	43 (58.9)	0.614*
Cancer	20 (12.9)	12 (14.6)	8 (11.0)	0.496*
Previous cholecystectomy	43 (27.7)	20 (24.4)	23 (31.5)	0.323*
Social history				
Smoking	27 (17.4)	14 (17.1)	13 (17.8)	0.904*
Alcohol	29 (18.7)	10 (12.2)	19 (26.0)	0.028*
Vital sign				
Heart rate (/min)	86.48±15.72	81.87±12.71	91.66±17.19	<0.001†
Respiratory rate (/min)	20 (18-20)	20 (18-20)	20 (18-20)	0.077‡
Laboratory				
Culture Study	49 (31.6)	22 (26.8)	27 (37.0)	0.175*
ERCP finding				0.473*
Stone	123 (79.4)	68 (82.9)	55 (75.3)	
Sludge	13 (8.4)	6 (7.3)	7 (9.6)	
Cancer	10 (6.5)	3 (3.7)	7 (9.6)	
Others	9 (5.8)	5 (6.1)	4 (5.5)	
Outcomes				
Length of hospital stay (day)	10 (7-16)	9 (7-13.25)	11 (8-19)	
Door to ERCP time (day)	1 (1-4)	1 (1-3)	1 (1-4)	
Day from ERCP to discharge (day)	7 (4-11)	6 (3.75-9)	7 (4-14.5)	

Values are presented as number (%), mean±standard deviation, median (interquartile range).
ERCP, endoscopic retrograde cholangiopancreatography; TG13, Tokyo Guidelines 2013.
*p-values obtained using the Pearson chi-square test or Fisher exact test. †p-values obtained using the Student t-test. ‡p-values obtained using the Mann-Whitney test.

Table 4. Comparison of the abdominal CT scan findings between TG13 grades I, II, and III groups in acute cholangitis

Variable	All patients (n=155)	Patient groups		p-value
		Grade I (mild) (n=82)	Grade II, III (moderate, severe) (n=73)	
Extrahepatic bile duct diameter (mm)	12 (9-15)	10 (8-13.5)	13 (10.25-16)	<0.001*
CBD wall thickening	54 (34.8)	24 (29.3)	30 (41.1)	0.123†
Intrahepatic duct dilatation	110 (71.0)	54 (65.9)	56 (76.7)	0.137†
CBD stone	100 (64.5)	52 (63.4)	48 (65.8)	0.761†
Intrahepatic stone	13 (8.4)	7 (8.5)	6 (8.2)	0.943†
Cholecystitis	44 (28.4)	16 (19.5)	28 (38.4)	0.009†
GB stone	52 (33.5)	28 (34.1)	24 (32.9)	0.867†
THADs	42 (27.1)	20 (24.4)	22 (30.1)	0.422†
Papillary edema	11 (7.1)	4 (4.9)	7 (9.6)	0.254†
Pancreatitis	11 (7.1)	5 (6.1)	6 (8.2)	0.608†
Pancreatic duct dilatation	13 (8.4)	4 (4.9)	9 (12.3)	0.095†
Hepatic abscess	2 (1.3)	1 (1.2)	1 (1.4)	>0.999†

Values are presented as median (interquartile range) or number (%).
CT, computed tomography; TG13, Tokyo Guidelines 2013; CBD, common bile duct; GB, gallbladder; THADs, transient hepatic attenuation differences.
*p-values obtained using the Mann-Whitney test. †p-values obtained using the Pearson chi-square test or Fisher exact test.

in their blood culture.

Among the causes of bile duct obstruction identified through ERCP, stone was the most common cause (123 patients, 79.4%), which was similar to the previous study findings related to cholangitis. The median hospital stay duration was 10 days (IQR, 7–16 days); the time spent from ED visit to ERCP was 1 day (IQR, 1–4 days), and that from ERCP to discharge was 7 days (IQR, 4–11 days).

2. Imaging Characteristics

By referring to the radiologist's reading of the abdominal CT scans performed during the ED visit, the aforementioned 12 criteria were examined; the results are presented in Table 4.

The median extrahepatic bile duct diameter was 12 mm (IQR, 9–15); 44 patients (34.8%) showed thickening of the bile duct walls. There were 110 patients (71%) with intrahepatic biliary dilatation, and 100 (64.5%) with bile duct stone revealed via the abdominal CT. There were 13 patients (8.4%) with intrahepatic stone, 44 (28.4%) with cholecystitis, and 52 (33.5%) with gallstone. THADs was found in 42 patients (27.1%), and papillary edema, duodenal diverticulum, and pancreatitis in 11 patients (7.1%). Pancreatic duct dilatation was observed in 13 patients (8.4%) and hepatic abscess in only two patients (1.3%).

3. Comparison Between the Mild Cholangitis Group and the Moderate to Severe Cholangitis Group

The mild cholangitis group consisted of 82 patients (52.9%), and the moderate to severe cholangitis group consisted of 73 patients (47.1%). The results of the comparison between the two groups are presented in Tables 3, 4. Aside from the imaging characteristics, the variables that displayed statistically significant results include, sex (p=0.023), pulse rate (p<0.001), and drinking history (p=0.028). Among the characteristics of the imaging tests, only 2 variables showed statistically significant results: EHD diameter (p<0.001) and presence of cholecystitis (p=0.009).

Table 5. Multivariate logistic regression analysis between TG13 grades I, II, and III groups in acute cholangitis

Variable	OR	95% CI	p-value
Gender	0.409	0.184-0.908	0.028
Heart rate	1.048	1.019-1.077	0.001
Alcohol	2.710	0.977-7.517	0.055
EHD diameter	1.235	1.115-1.368	<0.001
Cholecystitis	2.666	1.145-6.212	0.023

TG13, Tokyo Guidelines 2013; OR, odds ratio; CI, confidence interval; EHD, extrahepatic duct.
p-values obtained using the multivariate binary logistic regression analysis.

To identify a significant factor among the diagnostic imaging criteria related to severity, the variables that showed significant results in the univariate analysis were reanalyzed using the multivariate logistic regression analysis. The results confirmed that the extrahepatic bile duct diameter, among all diagnostic imaging criteria, was a significant diagnostic finding in relation to the disease severity (odds ratio [OR], 1.235; 95% confidence interval [CI], 1.115–1.368; p<0.001), and that the co-occurrence of cholecystitis was also statistically significant (OR, 2.666; 95% CI, 1.145–6.212; p=0.023). The result of the multivariate logistic regression analysis is presented in Table 5.

DISCUSSION

Cholangitis is an inflammatory disease that occurs when the internal pressure in the bile duct rises due to partial or complete obstruction in the common bile duct for various reasons, including bile duct stone, stricture, and tumor[1,10,11]. Under a normal condition, the common bile duct functions as follows: (1) maintains the muscular valve (Sphincter of Oddi), which prevents ascending infection by stopping the reflux of digestive juices from the duodenum; (2) continuously releases bile and keeps it sterile or bacteriostatic; and (3) maintains the defense wall against bacterial infection through many defense mechanisms, such as inhibition of bacterial growth by releasing IgA antibodies and biliary mucin[13].

However, when the pressure within the common bile duct rises, the penetrability of the bile duct cells increases, leading to the transposition of bacteria and endotoxin from the duodenum[4]; moreover, the production of defense factors, such as Kupffer cells and IgA is inhibited, and the bacteria or endotoxin can eventually cause septicemia through the biliary tract blood vessels[13]. The most common cause of bile duct obstruction is bile duct stone, which is known to occur more frequently with the increase of age. An animal experiment confirmed that the overexcretion of bile along with the crystallization of cholesterol or calcium bilirubinate increased the risk of gallstones[14].

Cholangitis in elderly patients is more serious because of the following reasons: bile duct stone, which is the main cause of bile duct obstruction, occurs more frequently in older adults; when a stone exists, the chance of developing acute suppurative cholangitis increases[15]. Apart from this, elderly patients with early stage of cholangitis as opposed to younger adults, tend to exhibit nontypical clinical manifestations or hematological findings and often fail to receive proper treatment in a timely manner[16]. Furthermore, because of increased comorbidities, weak immunity, nutrition deficiency and socio-economic factors with age[17], the failure of proper treatment in the early stage of cholangitis can most likely progress this disease to critical conditions that could threaten the elderly patient's life: septicemia and septic shock from acute cholangitis and hepatobiliary cancer from chronic cholangitis[18]. Therefore, it is imperative to establish proper treatment plans for elderly patients through instantaneous diagnosis and early classification of severity.

In diagnosing cholangitis, the Charcot's triad (jaundice, fever, and upper abdominal pain) and Reynolds' pentad (septic shock, confusion, jaundice, fever, and upper abdominal pain) were used for a long time. These criteria were widely used in diagnosing cholangitis and determining the treatment before blood tests and imaging tests became readily available; however, it was difficult to make an accurate diagnosis and administer treatment in the early stage because only 26.4%–72% patients showed all three or five signs[1]. Thereafter, blood tests became common; however, white blood cell count and liver function test had different ranges of normal conditions depending on the type of inflammatory disease and hepatic diseases[19]; further, blood culture test has a 20%–30% of positive predictive rate[20], which could not be used as a single criterion to make a definite diagnosis.

To provide a guideline for cholangitis diagnosis, severity assessment, and treatment, the Tokyo Guidelines were initially published in 2007; in 2013, a newly revised version was published after collaborative multicenter studies. Nevertheless, a recent study pointed out that the TG13 does not subcategorize the severity levels and fails to identify the patient types that require early biliary decompression in comparison with the TG07 classification[21,22]. Furthermore, it provides a complicated checklist with many items, which may be inappropriate for an ED that demands a prompt judgment. Nonetheless, owing to the high sensitivity (87.6%) and specificity (77.7%) and absence of other alternative criteria for severity classification, it has been most widely used by clinicians[5].

According to the TG13, severity is divided into three levels. It recommends early intervention for moderate to severe cases; for prompt diagnosis of cholangitis, it recommends imaging tests, such as contrast-enhanced abdominal CT or ultrasound scan.

First, the advantage of ultrasound scan is its relatively low cost and easy accessibility to the upper abdominal area of a patient; it is an imaging test with high sensitivity and specificity in confirming the presence of a gallstone and dilatation of the biliary tract. However, locating the exact lesion in the biliary tract using this test is difficult; the visibility is limited, and the results may vary depending on the skill level of the operating clinician[23]. Moreover, another disadvantage is that it relies on the patient's cooperation for proper posture and movement.

By contrast, with the rapid advancement of hardware and software, CT has 80%–84% sensitivity, 97%–98% specificity, and 90%–92% accuracy in confirming the exact lesion in the biliary tract; it can also identify other complications such as pancreatitis and hepatic abscess and can be performed in a prompt and objective manner[8,24]. For these reasons, abdominal CT is generally performed to diagnose cholangitis, and the CT scan findings in an ED, in particular, play a decisive role.

Many studies have been conducted using abdominal CT in patients with cholangitis, and there have been studies on CT findings regarding the severity. Nevertheless, no recent study has compared and analyzed abdominal CT findings of elderly patients in terms of the TG13 severity scale. The research team hypothesized that EHD diameter reflects the biliary pressure, which is closely related to the pathogenesis of cholangitis and disease severity. Through this study, the team confirmed that the EHD diameters in elderly patients with cholangitis with moderate to severe cases using the TG13 severity scale were bigger than those of the patients with mild cholangitis.

Burdiles et al.[9] reported that the patients with gallstone-induced acute suppurative cholangitis have bigger bile duct diameters and higher biliary pressures and that these findings are related to biliary septicemia. Although the criteria for classifying the disease severity were not similar as those used in the present study, the results appeared to be consistent with those of this study, since the clinical severity of suppurative cholangitis was high.

In addition, Zheng et al.[25,26] discovered that a high biliary pressure in a mammal experiment causes not only infection due to bile stasis but also hypotension as well as spasm of the muscular valve (Sphincter of Oddi) from the stimulation of the intestinal nerves, which indicates that a high biliary pressure is related to the clinical severity and ultimately to the increase in bile duct diameter.

The study by Hong et al.[27] compared and analyzed the clinical and radiological characteristics of patients with cholangitis with bile duct dilatation and those without bile duct dilatation; the results showed that the patients without bile duct dilatation had lower bilirubin levels and shorter hospital stays. In the same context, biliary dilatation was closely related to the increase in bile duct diameter; thus, the study findings of Hong et al.[27] also support the results of the present study.

In addition, the present study confirmed that the co-occurrence of cholecystitis was a significant result; however, the correlation between cholangitis severity and cholecystitis has not been clearly identified. This requires further verification although more severe cases of cholangitis appear to have higher biliary pressures and impact the internal pressure in the gallbladder, leading to cholecystitis.

The present study has the following limitations. First, the present study did not specify the extrahepatic bile duct diameters for severity classification; the specification would have a more clinical significance. Nevertheless, with regard to extrahepatic bile duct diameter and severity classification, the present study findings showed that the area under the curve (AUC) of the receiver operation characteristic curve was 0.687 (95% CI, 0.603–0.770; $p<0.001$) with a cutoff value at 12.250 (sensitivity, 0.575; specificity, 0.707). It was difficult to present a cutoff value for severity classification with the study results because the accuracy was low, although AUC was significant and close to 0.7. It is probable that the results may have been the outcome of the small sample size and the influence of other factors on severity classification apart from extrahepatic bile duct diameter. To confirm this speculation, a follow-up study is needed. Second, the results of the present study cannot be applied to all patients with cholangitis because the study was performed at an ED of a single organization and the study targeted only elderly patients over 65 years of age. In the future, the study findings need additional verification through a collaborative research targeting all age groups by multiple organizations. Third, there may have been a bias in patient selection. The number of patients who did not undergo ERCP was 71; in other words, a considerable number of patients were excluded from the study. These patients manifested various conditions ranging from mild cholangitis to malignant tumors in the final stage. If they had been included in the study, then the results may have been different. Fourth, the present study could not obtain any findings on morbidity and prognosis because there was only one case of death while it is reported that the morbidity rate of cholangitis is 2.7%–10% since the 2000s[2].

Despite these limitations, the significance of the present study can be found in the following areas: we analyzed the abdominal CT findings related to the severity of cholangitis in elderly patients for the first time and confirmed the correlation between the increase in bile duct diameter and disease severity. If the aforementioned limitations are corrected in a further study, the patients in the same category based on the TG13 severity scale can be subclassified and more reliable results for determining the priority in treatment can be obtained even from imaging tests alone.

In particular, there are many elderly patients with cholangitis transferred from other medical facilities in the ED of university hospital. Most of the transferred patients arrive at the ED after undergoing abdominal CT at a previous hospital. In this case, the results of the present study can be useful in judging the severity based on medical images. Moreover, measuring of the EHD diameter can be done relatively easily using abdominal CT, and its actual application will also be simple; thus, the diameter measurement will be a helpful indicator for clinicians to establish treatment plans in early stages.

Conflicts of Interest Disclosures: The authors claim no conflicts of interest.

REFERENCES

1. Boey JH, Way LW. Acute cholangitis. Ann Surg 1980;191:264-70.
2. Yoon H, Lee DH. Gastrointestinal changes according to the aging. In: Kim CH, editor. Textbook of geriatric medicine. 3rd ed. Seoul: Panmun Education; 2015. p. 369-74.
3. Reshetnyak VI. Concept of the pathogenesis and treatment of cholelithiasis. World J Hepatol 2012;4:18-34.
4. Kimura Y, Takada T, Strasberg SM, Pitt HA, Gouma DJ, Garden OJ, et al. TG13 current terminology, etiology, and epidemi-

ology of acute cholangitis and cholecystitis. J Hepatobiliary Pancreat Sci 2013;20:8-23.
5. Kiriyama S, Takada T, Strasberg SM, Solomkin JS, Mayumi T, Pitt HA, et al. TG13 guidelines for diagnosis and severity grading of acute cholangitis (with videos). J Hepatobiliary Pancreat Sci 2013;20:24-34.
6. Diane MB. The elder patient. In: Marx JA, editor. Rosen's emergency medicine. 8th ed. Philadelphia (PA): Elsevier Saunders; 2014. p. 2351-5.
7. Kiriyama S, Takada T, Strasberg SM, Solomkin JS, Mayumi T, Pitt HA, et al. New diagnostic criteria and severity assessment of acute cholangitis in revised Tokyo Guidelines. J Hepatobiliary Pancreat Sci 2012;19:548-56.
8. Catalano OA, Sahani DV, Forcione DG, Czermak B, Liu CH, Soricelli A, et al. Biliary infections: spectrum of imaging findings and management. Radiographics 2009;29:2059-80.
9. Burdiles P, Csendes A, Díaz JC, Smok G, Bastias J, Palominos G, et al. Histological analysis of liver parenchyma and choledochal wall, and external diameter and intraluminal pressure of the common bile duct in controls and patients with common bile duct stones with and without acute suppurative cholangitis. Hepatogastroenterology 1989;36:143-6.
10. Hanau LH, Steigbigel NH. Acute (ascending) cholangitis. Infect Dis Clin North Am 2000;14:521-46.
11. Kimura Y, Takada T, Kawarada Y, Nimura Y, Hirata K, Sekimoto M, et al. Definitions, pathophysiology, and epidemiology of acute cholangitis and cholecystitis: Tokyo Guidelines. J Hepatobiliary Pancreat Surg 2007;14:15-26.
12. Kim SJ, Wang JH, Lee JD, Moon ES, Kim KR, Lee TU, et al. Cholestatic jaundice associated with juxtapapillary diverticula without common bile duct stones. J Korean Geriatr Soc 2007;11:17-23.
13. Sung JY, Costerton JW, Shaffer EA. Defense system in the biliary tract against bacterial infection. Dig Dis Sci 1992;37:689-96.
14. Flati G, Flati D, Jönsson PE, Porowska B, Tuscano D, Amicucci G, et al. Role of cholesterol and calcium bilirubinate crystals in acute postoperative acalculous cholecystitis. Ital J Surg Sci 1984;14:333-6.
15. Tsujino T, Sugita R, Yoshida H, Yagioka H, Kogure H, Sasaki T, et al. Risk factors for acute suppurative cholangitis caused by bile duct stones. Eur J Gastroenterol Hepatol 2007;19:585-8.
16. Tomizawa M, Shinozaki F, Sugiyama T, Yamamoto S, Sueishi M, Yoshida T. Acute cholangitis in elderly patients exploring diagnostic clues and clinical signs. J Gastroenterol Hepatol Res 2012;1:223-5.
17. Kim CO. Antibiotic agents in elderly. In: Kim CH, editor. Textbook of geriatric medicine. 3rd ed. Seoul: Panmun Education; 2015. p. 453-8.
18. Fillit H, Rockwood K, Woodhouse KW, Brocklehurst JC. Brocklehurst's textbook of geriatric medicine and gerontology. 7th ed. Philadelphia (PA): Elsevier Saunders; 2010. p. 626-34.
19. Mosler P. Diagnosis and management of acute cholangitis. Curr Gastroenterol Rep 2011;13:166-72.
20. Qureshi WA. Approach to the patient who has suspected acute bacterial cholangitis. Gastroenterol Clin North Am 2006;35:409-23.
21. Schneider J, Hapfelmeier A, Thöres S, Obermeier A, Schulz C, Pf?rringer D, et al. Mortality risk for acute cholangitis (MAC): a risk prediction model for in-hospital mortality in patients with acute cholangitis. BMC Gastroenterol 2016;16:15.
22. Nishino T, Hamano T, Mitsunaga Y, Shirato I, Shirato M, Tagata T, et al. Clinical evaluation of the Tokyo Guidelines 2013 for severity assessment of acute cholangitis. J Hepatobiliary Pancreat Sci 2014;21:841-9.
23. Hanbidge AE, Buckler PM, O'Malley ME, Wilson SR. From the RSNA refresher courses: imaging evaluation for acute pain in the right upper quadrant. Radiographics 2004;24:1117-35.
24. Kim SW, Shin HC, Kim HC, Hong MJ, Kim IY. Diagnostic performance of multidetector CT for acute cholangitis: evaluation of a CT scoring method. Br J Radiol 2012;85:770-7.
25. Zheng QC, Qi LH, Hu YH, Guan ML, Wang DX. Effect of increasing biliary tract pressure on house rabbit blood dynamics in acute cholangitis of severe type. J Tongji Med Univ 1994;14:230-4.
26. Zheng Q, Sun J, Wei B, Hu Y. Effects of biliary tract pressure on dynamics of the Oddi's sphincter and its nerve mechanism. J Tongji Med Univ 1998;18:54-7, 64.
27. Hong MJ, Kim SW, Kim HC, Yang DM. Comparison of the clinical characteristics and imaging findings of acute cholangitis with and without biliary dilatation. Br J Radiol 2012;85:e1219-25.