NORTHWESTERN MEDICAL JOURNAL

Northwestern Med J. 2024;4(1):27-33
DOI: 10.54307/NWMJ.2024.85

RESEARCH ARTICLE

Measurement of cystic artery diameter by computed tomography in the diagnosis of acute cholecystitis

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Cite as: Gür Özcan SG, Zengin N, Özdoğan A, Durak D. Measurement of cystic artery diameter by computed tomography in the diagnosis of acute cholecystitis. Northwestern Med J. 2024;4(1):27-33.

ABSTRACT

Aim: The aim of this study is to measure the diameter of the cystic artery using computed tomography in patients undergoing emergency surgery for the diagnosis of acute cholecystitis, as well as to understand the role of cystic artery diameter in the diagnosis of acute cholecystitis, and to investigate its association with clinical data, laboratory data, and computed tomography findings.

Methods: A total of 187 patients admitted to the general surgery clinic between 2019 and 2023, comprising 123 individuals as the patient group and 64 individuals as the control group, were reviewed in terms of their radiological images, demographic data, and laboratory parameters. The patients' surgical records, laboratory parameters, and computed tomography scans taken during the diagnosis were investigated.

Results: The diameter of the cystic artery was measured, and a cut-off value of cystic artery diameter >1.9 mm was found to be sensitive and specific for the diagnosis of acute cholecystitis (AUC: 0.852, 94% sensitivity, 75% specificity, p <0.001, 95% confidence interval 0.792-0.899).

Conclusion: A cystic artery diameter >1.9 mm was found to be highly specific for the diagnosis of acute cholecystitis. This study suggests that the measurement of cystic artery diameter can be used as an additional criterion in the evaluation of computed tomography for the diagnosis of acute cholecystitis.

Keywords: acute cholecystitis, computed tomography, cystic artery

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Received: 13.08.2023 **Accepted:** 19.12.2023 **Published:** 30.01.2024

INTRODUCTION

Abdominal pain is one of the most common reasons for emergency department visits worldwide (1). Acute cholecystitis (AC) accounts for 3-11% of patients presenting to the emergency department with abdominal pain (1). AC refers to inflammation of the gallbladder and can result from cystic duct obstruction (2), bacterial infection, and chemical stimulation (3). The most common cause is gallstones, accounting for 90-95% of all cases (4,5). Clinical, laboratory, and radiologic findings are used in the diagnosis of AC (6). Clinical findings include severe right upper quadrant pain, fever, tenderness, and a positive Murphy's sign (6). White blood cell count (WBC), C-reactive protein (CRP), and neutrophil count are often increased in laboratory parameters. Among the radiological imaging modalities, ultrasonography (USG) is commonly utilized as the initial and least invasive method due to its accessibility, and ability to effectively visualize the gallbladder lumen and stones (7). However, computed tomography (CT) has become the gold standard due to its ability to provide a clearer visualization of surrounding inflammation and a better understanding of accompanying complications (8). CT criteria for diagnosis include gallbladder wall thickness (GWT) (>4mm), pericholecystic fluid collection, increased gallbladder diameter (long axis ≥8cm, transverse axis ≥4cm), and linear density increase in parallel with inflammation in the pericholecystic fat tissue (8).

In this study, an increase in vessel diameter, which is one of the markers of acute inflammation, was investigated as an indicator for the diagnosis of AC on CT imaging. Currently, there is no study that measures the diameter of the cystic artery (DCA) on CT. There is one study available that measures hepatic artery velocity using ultrasonography (USG) (9). In a previous study conducted by Loehfelm et al., they hypothesized that acute inflammation leads to hyperemia in the gallbladder and adjacent liver, resulting in an increase in cystic artery flow velocity (9). The aim of this study is to measure the diameter of a cystic artery using a similar mechanism to determine whether it can be used as a diagnostic criterion in patients with acute cholecystitis and to determine a cut-off value accordingly.

MATERIALS AND METHODS

The study was conducted in accordance with the Declaration of Helsinki and Turkish Ethical Standards reviewed and approved by the ethics committee of Health Sciences University Bursa High Specialization Training and Research Hospital (Date of approval: 05.07.2023 and No: 2011-KAEK-25 2023/07-24).

Patient population

Between September 2019 and December 2023, a total of 187 patients, including 123 individuals who underwent urgent surgery for AC as a patient group and 64 individuals who underwent elective surgery for cholelithiasis as a control group, were investigated.

The patients were retrospectively reviewed in terms of demographic data (gender, age, height, and weight) and CT scans from the hospital data system.

Inclusion criteria are: Patients aged 18 years or older; patients with a diagnosis of AC based on pathological findings; the presence of CT images, demographic data, and laboratory in the hospital system.

Exclusion criteria are: Patients with no contrast-enhanced Abdominal CT scans in the hospital system prior to surgery; patients with artifact-laden CT scans preventing the evaluation of the DCA; patients under 18 years of age.

Analyses of CT images

Abdominal CT scans were performed using a 128-slice multi-detector-row CT scanner (Toshiba Aquillion, Japan). Contrast-enhanced, thin-slice (1.25 mm slice thickness), and soft-tissue window abdominopelvic CT images were measured. The measured parameters were gallbladder transverse and cranio-caudal diameter, GWT, presence of stones in the gallbladder lumen, and pericholecystic inflammation were investigated. According to the Tokyo criteria, gallbladder transverse diameter (GTD) ≥4cm, cranio-caudal diameter ≥8cm, and wall thickness ≥4mm were considered positive signs of AC (8). The cystic artery, a branch of the right hepatic artery originating from the aorta (Figure 1), was measured at its origin and recorded numerically in both groups by a single radiologist.

Statistical analysis

The IBM Statistical Package for the Social Sciences software (SPSS ver. 27 for Windows, Chicago, IL, USA) was used for all statistical analyses. The Kolmogorov-Smirnov test was performed to assess the homogeneity of distribution between groups. Mean values, standard deviations, and median values were calculated for normally distributed and non-normally distributed groups. The mean ages of both groups were compared using the t-test, and the homogeneity of distribution was examined using the independent samples test. The Mann-Whitney test was used to evaluate the difference in DCA between the groups. A cut-off value for DCA in the patient group was determined using Receiver Operating Characteristic (ROC) analysis. The correlation and mean values between blood parameters, CT findings, and DCA increase were analyzed using the independent samples t-test and the Mann-Whitney test. A p-value of <0.05 was considered statistically significant.

RESULTS

In this study, a total of 123 individuals (70 females - 56.91% and 53 males - 43.08%) in the patient group and 64 individuals (43 females – 67.18% and 21 males – 32.81%) in the control group were included. The mean age of the patient group was 57.33±16.01 years, whereas it was 51.36±13.95 years for the control group.

The mean DCA was measured 2.35±0.42 mm in the patient group and 1.86±0.34 mm in the control group. ROC analysis was performed to determine the cut-off value for the DCA as >1.9 mm (AUC: 0.852, 94% sensitivity, 75% specificity, p <0.001, 95% confidence interval 0.792-0.899) (Figure 2).

In terms of the cut-off for the DCA, patients were classified as group 1 with DCA >1.9 mm and control group 2 with DCA ≤1.9 mm. In the patient group, 116 patients (94.30%) had a DCA >1.9 mm, while only 16 patients (37.20%) in the control group. The patient group included 7 patients (5.70%) with a CAD ≤1.9 mm, while 48 patients (62.80%) in the control group.

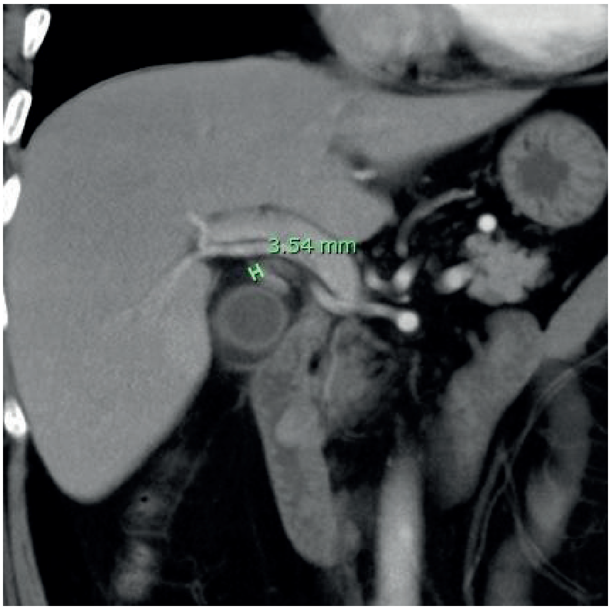

Figure 1. Measurement of cystic artery diameter in a 65-year-old male patient with pain in the right upper quadrant.

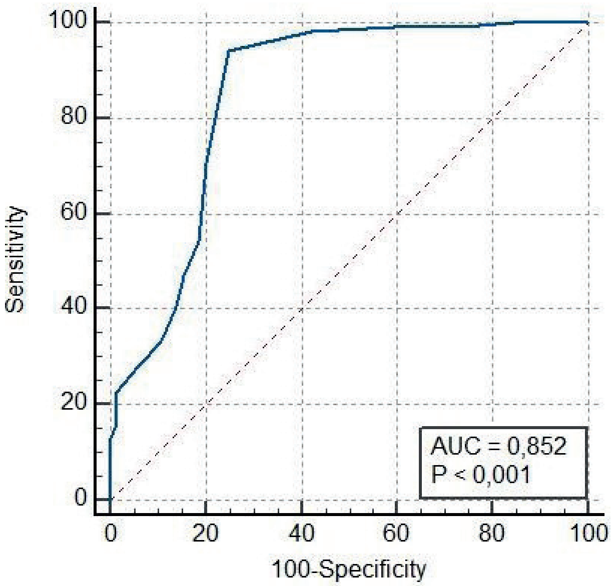

Figure 2. Receiver Operating Characteristic (ROC) analysis depicting the Area Under the Curve (AUC) for cystic artery diameter in the diagnosis of acute cholecystitis.

Detailed measurement parameters for group 1 and group 2 are given in Table 1.

According to Tokyo criteria, 70 patients (56.91%) with GTD ≥4 cm, 110 patients (89.43%) with gallbladder cranio-caudal length ≥8 cm, and 35 patients (28.46%) with GWT ≥4 mm were obtained. Furthermore, 105 individuals (85.36%) in the patient group presented evidence of adjacent inflammation.

Table 1. Mean values and standard deviations of blood parameters and parameters obtained from CT.

	Cutoff- Artery Diameter*	n**	Mean	Standard Deviation	Standard Error Mean
WBC					
Group 1	>1.9	132	12,71	4,86	423.7
Group 2	≤1.9	55	10,96	5,41	730.79
Lymphocyte					
Group 1	>1.9	132	25.46	10.81	8.77
Group 2	≤1.9	55	24.36	12.60	1.70
Neutrophil					
Group 1	>1.9	132	207.49	1.50	131.09
Group 2	≤1.9	55	68.10	15.19	1.91
CRP					
Group 1	>1.9	132	251.06	151.13	13.15
Group 2	≤1.9	55	65.13	105.56	14.23
AST					
Group 1	>1.9	132	120.23	251.13	21.86
Group 2	≤1.9	55	114.27	235.42	31.74
ALT					
Group 1	>1.9	132	121.59	250.16	21.77
Group 2	≤1.9	55	89.47	168.39	22.71
GWT					
Group 1	>1.9	132	3.29	1.24	0.11
Group 2	≤1.9	55	1.83	0.62	0.08
Gallbladder Length					
Group 1	>1.9	132	97.23	16.30	1.42
Group 2	≤1.9	55	78.42	16.94	2.29
GTD					
Group 1	>1.9	132	40.33	40.33	0.80
Group 2	≤1.9	55	29.44	29.44	1.04

WBC: White blood cell, CRP: C-reactive protein, AST: aspartate aminotransferase, ALT: alanine amino transaminase, GWT: gallbladder wall thickness, GTD: gallbladder transverse diameter. * mm, ** number of patients.

DISCUSSION

According to the measurements performed, DCA is significantly higher in the patient group compared to the control group. Furthermore, a cut-off value for DCA in AC patients was determined with high sensitivity and specificity. DCA >1.9 mm was highly specific for the diagnosis of AC (94% sensitivity, 75% specificity). Moreover, DCA was higher in patients with complicated AC compared to the non-complicated group. However, statistical analysis could not be performed due to the small sample size of only 4 patients with complicated cholecystitis.

In this study, the measurement of DCA is proposed as an alternative criterion when the findings described in the Tokyo criteria (8) on CT imaging are insufficient for the diagnosis of suspected AC. A positive correlation was found between the significant increase in CT findings and the DCA in patients with AC. This study is the first to measure the DCA in patients with acute cholecystitis, and there is no existing study in the literature that measures the DCA using CT and determines a cut-off value for it. In this study, a similar mechanism was employed as in the study conducted by Loehfelm et al., which measured hepatic artery velocity in patients with acute cholecystitis (9). Loehfelm hypothesized that the increase in cystic artery diameter was related to the increased blood flow due to inflammation, sinusoidal obstruction, and venous congestion (9). In another study by Yamashita et al., contrast-enhanced abdominal CT scans in patients with acute cholecystitis revealed increased attenuation in the adjacent liver parenchyma to the inflamed gallbladder, which was attributed to hyperemia (10). A similar inflammatory mechanism was suggested in a study investigating appendicitis by Sirik et al., where the diameter of the ileocolic artery was measured (11). In their study, the diameter of the ileocolic artery was 3.79±0.7 mm in patients, while it was 2.75±0.31 mm in the control group ($p<0.01$) (11). In our study, there was a significant difference in DCA between the patient and control groups, with 2.35±0.42 mm in the patient group and 1.86±0.34 mm in the control group. The previous study by Sirik et al. attributed the increase in vascular diameter to an increase in blood flow due to inflammation, microvascular changes that permit extravasation of plasma proteins and leukocytes (11).

Acute cholecystitis is an acute inflammatory condition that typically results from obstruction of the gallbladder neck and cystic duct. Three mechanisms may trigger inflammation in the gallbladder, which is a luminal organ: obstruction and circulatory disturbance of the gallbladder, compromised blood supply leading to necrosis of the gallbladder wall, and chemical stimulation and inflammation due to the obstruction of the lumen. This condition is similar to bowel obstruction and associated infectious mechanisms, and its definitive treatment is surgery (12). Although the main cause of acute cholecystitis is cystic duct obstruction, not all cases of cystic duct obstruction may progress to acute cholecystitis. In addition to cystic duct obstruction, it has been suggested that there is ischemic necrosis and inflammation accompanied by obstruction in the branches of the cystic artery (12).

In this study, a significant increase in laboratory parameters such as neutrophils, WBC, and CRP in patients with AC, which positively correlated with an increase in DCA.

Despite the common diagnosis of AC based on clinical investigation and laboratory parameters, USG and CT scans are valuable tools in reducing misdiagnosis rates and protecting healthcare professionals from malpractice issues. USG is considered the gold standard for visualizing the lumen structure of the gallbladder and is usually sufficient for the diagnosis (9). However, CT imaging, including diameter measurements, assessment of accompanying tissue inflammation, and identification of complications, is an indispensable method (6). In a previous study referencing the study conducted by Van Randen et al., CT scans are more sensitive (73%) compared to USG in diagnosing AC (7).

The cut-off values in the Tokyo criteria are determined as 40 mm for the transverse diameter of the gallbladder, 80 mm for the craniocaudal length, and 4 mm for the GWT which were similar for this study. According to the Tokyo criteria, 56.91% of patients had enlarged transverse diameter, 89.43% had increased craniocaudal length, and 35% had increased in wall thickness (8).

Craniocaudal length, which is one of the indicators of hydrops, was significantly high compared to other criteria. In addition to the relatively lower increase in transverse diameter and wall thickness, DCA is also proposed to be used as a supporting criterion. In a similar previous study, the peak systolic velocity of the hepatic artery was significantly higher in patients with AC (114 cm/s) compared to the control group (66 cm/s), moreover, it is stated that using the peak systolic velocity of the hepatic artery as a diagnostic criterion was rapid and easily measurable, and it was a more objective criterion compared to subjective examination findings such as Sonographic Murphy's sign (9). There are some limitations in this study. Firstly, our study is the pioneer study conducted in this context, and conducting a study with a larger patient population to determine a cut-off value would greatly contribute to our study and the literature. We look forward to further studies with a larger patient population and multicenter studies to introduce the DCA as a new criterion in the literature. Additionally, the number of patients with complicated AC in this study was limited, and although the DCA was higher in complicated cases compared to non-complicated cases, statistical analysis could not be performed due to the limited number of cases. Further studies including a larger quantity of complicated patients could contribute to determining a cut-off value in this regard.

CONCLUSION

In this study, DCA >1.9 mm was found as highly specific for the diagnosis of acute cholecystitis and, it is proposed that, alongside the established Tokyo Guidelines criteria for CT, the elevation in DCA may be regarded as an supplementary criterion for diagnosis.

Ethical approval

This study has been approved by the Ethics Committee of Health Sciences University Bursa High Specialization Training and Research Hospital (approval date 05.07.2023, number 2011-KAEK-25 2023/07-24). Written informed consent was obtained from the participants.

Author contribution

Surgical and Medical Practices: SGGÖ; Concept: SGGÖ; Design: SGGÖ, DD; Data Collection or Processing: NZ, AÖ; Analysis or Interpretation: SGGÖ, DD; Literature Search: NZ, AÖ; Writing: SGGÖ, DD. All authors reviewed the results and approved the final version of the article.

Source of funding

The authors declare the study received no funding.

Conflict of interest

The authors declare that there is no conflict of interest.

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