



Analysis of Gastric Antrum Wall Thickness by Abdominal CT: High Diagnostic Accuracy in Differentiating Benign and Malignant Pathologie

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ABSTRACT

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Objectives: Early diagnosis of gastric cancer and the initiation of appropriate treatment are crucial for achieving long-term survival in patients. In this study, we performed a comparative analysis of the antral wall thickness measured by abdominal computed tomography (CT) with endoscopic and pathological evaluation results. The objective of this study is to determine the optimal cut-off value for wall thickness that can distinguish between benign and malignant conditions, thereby accelerating the diagnostic process in clinical practice and aiding in the determination of appropriate treatment strategies.

Methods: A total of 213 patients who underwent endoscopic antral wall sampling between February 2023 and January 2024, and who had an abdominal CT scan performed within two months before or after the endoscopy were included in this study. The patients' demographic characteristics, including age and gender, along with antral wall thickness measurements obtained from abdominal CT scans, were retrospectively compared with histopathological results. Furthermore, a cut-off value was determined using ROC analysis for differentiating benign from malignant pathologies, and sensitivity and specificity rates were calculated.

Results: A total of 213 patients were included in the study, comprising 126 males and 87 females, with a mean age of 60.8 years. Among these patients, 94 (60 males, 34 females; mean age 66.1 years) were classified as malignant, while 119 (66 males, 53 females; mean age 56.6 years) were classified as benign ($p < 0.001$). Using a cut-off value of 12 mm for antral wall thickness to differentiate between benign and malignant conditions, the sensitivity was 100%, and the specificity was 95.7%.

Conclusion: The measurement of antral wall thickness using abdominal CT under optimal conditions provides significant information for differentiating benign and malignant pathologies originating from this region. This measurement plays a critical role in the early diagnosis and treatment of gastric cancer.

Keywords: Antral Wall Thickness, Computed Tomography, Endoscopy, Gastric Cancer.



How to cite this article

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INTRODUCTION

Gastric cancer is the fifth most common cancer worldwide and accounts for a significant proportion of cancer-related deaths [1]. Symptoms of gastric cancer often present as vague and non-specific manifestations such as epigastric pain, nausea, vomiting, and loss of appetite. These symptoms may also be associated with other benign conditions, such as ulcers or gastritis, which can lead to delays in diagnosis [2]. The survival of patients with gastric cancer is directly correlated with the invasion depth of the tumor and the extent of lymph node involvement. For patients with advanced-stage tumors, the five-year survival rate ranges from 7% to 27%. In contrast, for those with early-stage tumors, the rate increases to 85-100% [3]. Consequently, the early detection of gastric cancer and the prompt initiation of appropriate treatment are crucial for improving therapeutic outcomes. Imaging modalities play a pivotal role in assessing the malignant potential of the stomach.

Conventional barium radiographic studies have historically served as the primary diagnostic modality for patients exhibiting signs of gastric carcinoma. Nevertheless, the utilization of this technique has declined in recent years due to its limited capacity to identify solely mucosal lesions. Endoscopic ultrasonography (EUS) is a technique that enables visualization of the distinct layers of the gastric wall; however, its clinical application remains limited due to its restricted penetration depth [4]. Magnetic resonance imaging (MRI) has been demonstrated to be beneficial in specific situations. However, the technology has significant limitations, including prolonged scanning times and high costs. Conversely, multidetector computed tomography (MDCT) facilitates isotropic imaging with thin slices, thereby enabling the acquisition of high-resolution images through multiplanar reconstruction (MPR) views. MDCT provides critical information in assessing the depth of wall invasion, tumor characterization, peritoneal disease, and distant metastases in gastric carcinoma. Consequently, it is regarded as the most efficacious radiological technique, especially for preoperative staging of gastric cancer [4, 5]. Nevertheless, achieving an accurate diagnosis necessitates the utilization of intravenous iodinated contrast agents in conjunction with either negative or positive oral contrast agents to ensure adequate gastric distension [6]. While gastric wall thickening on MDCT is a significant indicator of gastric cancer, it

can also frequently be observed incidentally in benign conditions and in asymptomatic patients. The gastric antrum wall, in particular, has been observed to be thicker in comparison to other regions of the stomach. A body of research has emerged that underscores the variability in measurements of antral wall thickness. However, a standardized approach for managing patients with gastric wall thickening remains to be delineated. Therefore, it is crucial for radiologists to identify potential indications of malignancy on CT scans, enabling them to accurately select cases that necessitate invasive procedures, such as endoscopy. The present study was undertaken with the objective of evaluating antral wall thickness as measured by MDCT, comparing findings between benign and malignant groups as confirmed histopathologically through endoscopic biopsies from the gastric antropyloric region, and identifying associated findings along with the optimal cutoff value for distinguishing malignancy.

METHODS

This study was conducted in accordance with the principles of the Declaration of Helsinki.

Patient Selection:

A total of 1,884 patients who underwent endoscopy (gastroscopy) and/or gastric antrum biopsy at our hospital for various reasons between February 2023 and January 2024 were retrospectively analyzed. Among these patients, 312 individuals who underwent abdominal computed tomography (CT) examinations in our radiology department, with intravenous and oral contrast administration within two months before or after the date of endoscopy, were included in the study. Patients with contraindications for contrast-enhanced imaging, including those with a history of pregnancy, renal failure, or allergic reactions to contrast agents, as well as those with a history of upper abdominal cancer, surgery, or inflammatory processes, were excluded from the study. Consequently, 213 patients who met the appropriate criteria for measuring gastric antral wall thickness were included and re-evaluated based on their endoscopic findings. The patients were divided into two groups: 94 (44.1%) in the malignant group and 119 (55.9%) in the benign group.

Image Acquisition and Analysis:

All studies were performed on a multidetector

CT scanner following the administration of oral and intravenous contrast agents. Each patient was scanned in accordance with the standard protocol routinely applied for all abdominal CT examinations in our clinic. According to this protocol, patients administered 1,000 mL of water-soluble contrast agent prior to scanning. The subjects were instructed to consume the contrast agent over a period of 45 to 60 minutes by drinking 1 to 2 glasses (200 to 300 milliliters) of the agent every 10 minutes. To ensure optimal gastric distension, the final two glasses of the contrast agent were to be consumed immediately before the imaging procedure.

All patients were positioned in a supine position, and the scanning range extended from the diaphragm to the pubic symphysis. Following the scanning process, a bolus of 100 mL non-ionic iodinated contrast agent was administered via an automatic injector into the antecubital vein at a flow rate of 3 mL/s. CT imaging was then performed during the portal venous phase, with a 75-second delay from the initiation of contrast administration. The images were obtained using a 16-slice multidetector computed tomography (MDCT) scanner (Siemens Somatom go. Now 16, Germany). During the CT acquisition process, the following preset parameters were used: an effective radiation dose of 130 kV, an output current range of 80–120 mAs, a slice thickness of 3.00-5.00 mm, and a matrix size of 512×512 . All CT images were then reconstructed using multiplanar reconstruction (MPR) techniques.

A radiologist with nine years of experience in abdominal radiology, blinded to the patients' endoscopic and clinical data, evaluated the images

for antral wall thickness. The measurements were obtained at the antrum, the region connecting the gastric corpus to the pylorus, at the thickest point in the axial plane using electronic calipers (see Figure 1). In addition to thickness measurements, the presence or absence of perigastric fat stranding and perigastric lymphadenopathy was documented.

Statistical Analysis:

A comparative analysis of descriptive statistics for antral wall thickness was conducted, considering age and sex among the 213 patients who constituted the study sample, regardless of their endoscopy (gastroscopy) and biopsy results. The statistical analysis was conducted using IBM SPSS Statistics for Windows (Armonk, NY, USA, IBM Corp.). Numerical data were presented as means and standard deviations, while categorical data were expressed as counts and percentages. The relationships between categorical variables were evaluated using the chi-square test. The distribution characteristics of continuous variables were assessed using the Kolmogorov-Smirnov test, and differences between groups were analyzed with the Mann-Whitney U test. The optimal cutoff value for predicting malignancy based on antral wall thickness was determined using receiver operating characteristic (ROC) curve analysis. The positive predictive value (PPV) and negative predictive value (NPV) were calculated for each cutoff point. The point with the highest sensitivity and the lowest false-positive rate (closest to the upper left corner of the ROC curve) was proposed as the optimal cutoff. A p-value of less than 0.05 was considered statistically significant for all analyses.

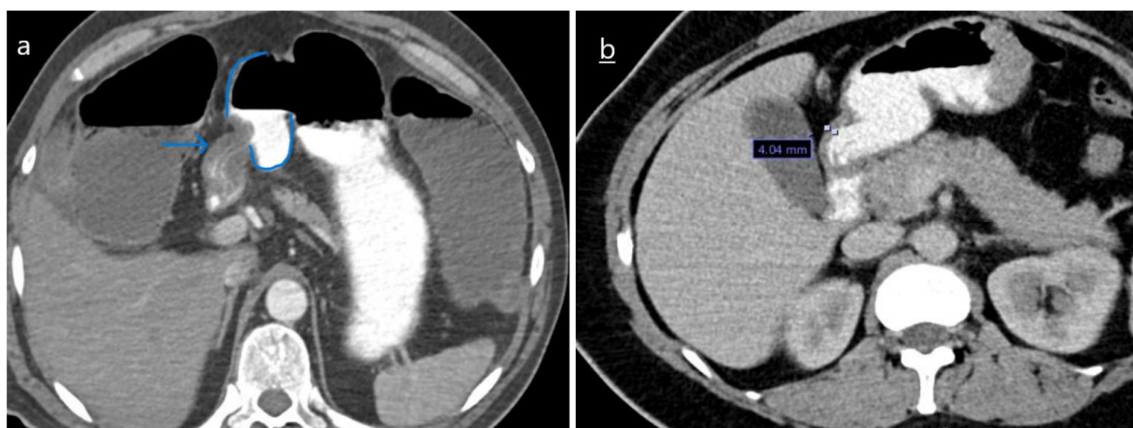


Figure 1. a) The antrum (blue contour) constitutes the lowest section of the stomach, thereby forming a connection between the gastric corpus and the pylorus (blue arrow). b) The measurement of the thickest portion of the antral wall in the axial plane was conducted using electronic calipers.

Table 1. Demographic Characteristics of the Benign and Malignant Groups in the Study

	Benign (n=119)	Malignant (n=94)	Total (n=213) (%)
Sex			
Male	66 (52.4)	60 (47.6)	126 (59.2)
Female	53 (60.9)	34 (39.1)	87 (40.8)
Age (years) \pm SD*	56.6 \pm 15.0	66.1 \pm 12.2	60.8 \pm 14.6

* Note: There is a statistically significant difference between the benign and malignant groups in terms of age (p -value $<$ 0.001).

RESULTS

A histopathological examination of biopsy materials from the 213 patients included in the study (126 males, 87 females; mean age 60.8 years) revealed that 94 (60 males, 34 females) were classified as malignant, and 119 (66 males, 53 females) as benign. The mean age of cancer patients was found to be 66.1 years, which was statistically significantly higher compared to the mean age of 56.6 years in the benign group ($p <$ 0.001). Table 1 presents a comprehensive overview of the demographic characteristics that distinguish the benign and malignant groups. Within the malignant group, a diagnosis of adenocarcinoma was made in

all 94 cases. In the benign group, the diagnoses based on endoscopic findings were distributed as follows: atrophic gastritis (1/119 patients), chronic gastritis (16/119 patients), and active chronic gastritis (102/119 patients).

The mean antral wall thickness in the malignant group was found to be 20.8 ± 6.8 mm (see Figure 2), while in the benign group, this value was 4.6 ± 1.9 mm. A statistically significant difference in antral wall thickness was identified between the benign and malignant groups through statistical analysis ($p <$ 0.001).

To ascertain the quantifiable distinction between malignant and benign antral thickening, an ROC

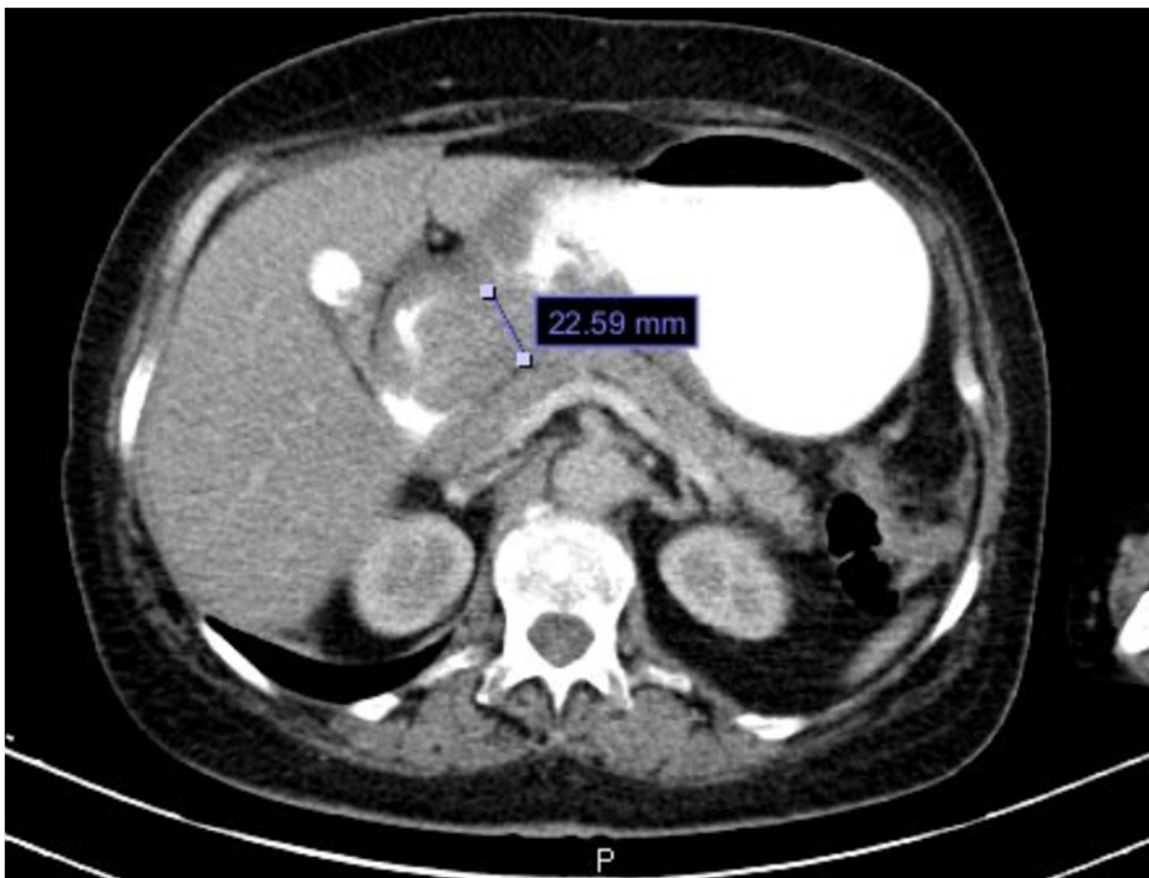


Figure 2. Contrast-enhanced abdominal CT image of a 52-year-old female patient with a diagnosis of adenocarcinoma in the antrum, demonstrating antral wall thickening measured at 22.5 mm.

Table 2. Computed Tomography Findings in Benign and Malignant Groups

Findings	Benign	Malignant	<i>p</i>
Wall Thickness (mm) ± SD	4.6 ± 1.9	20.8±6.8	<0.001
Perigastric Fat Stranding			<0.001
None	119/119 (100%)	67 (%71.3)	
Present	0/119 (0%)	27 (%28.7)	
LAP (Lymphadenopathy)			<0.001
None	119/119 (100%)	67(%71.3)	
Present	0/119 (0%)	27 (%28.7)	
Wall Thickening			<0.001
Smooth	119/119 (%100)	0/94 (%0)	
Asymmetric	0/119 (%0)	94/94 (%100)	

curve analysis was conducted. This analysis yielded an area under the curve of 99.6% ($p < 0.001$). Utilizing a cutoff value of 12 mm for gastric antrum thickness as determined by abdominal CT, the sensitivity for diagnosing malignancy was 95.7%, the specificity was 100%, the negative predictive value (NPV) was 96.7%, and the positive predictive value (PPV) was 100%.

Table 2 presents a comparative summary of the CT findings between the groups. In the malignant group, wall thickening was observed asymmetrically in all 94 patients, while in the benign group, wall thickening was detected as smooth and symmetric in all patients (see Figure 3). In the malignant group, perigastric fat stranding and perigastric lymphadenopathy were identified in each of 67 patients (71.3%), as illustrated in Figure 4. Furthermore, both perigastric fat stranding and lymphadenopathy were present together in 55 patients (58.5%), while in 14 patients (14.8%), neither

perigastric fat stranding nor lymphadenopathy was observed. Notably, no cases of perigastric fat stranding or lymphadenopathy were detected among patients in the benign group.

DISCUSSION

Gastric wall thickening is a common finding on abdominal CT images, resulting from various etiologies, including malignancies, benign lesions, inflammation, varices, and postoperative changes. Consequently, it is imperative for radiologists to possess the expertise to differentiate between benign and malignant lesions, as this ability can prevent the referral of patients for unnecessary invasive endoscopic examinations. Adenocarcinoma represents the most prevalent histological subcategory of gastric cancer, accounting for approximately 95%

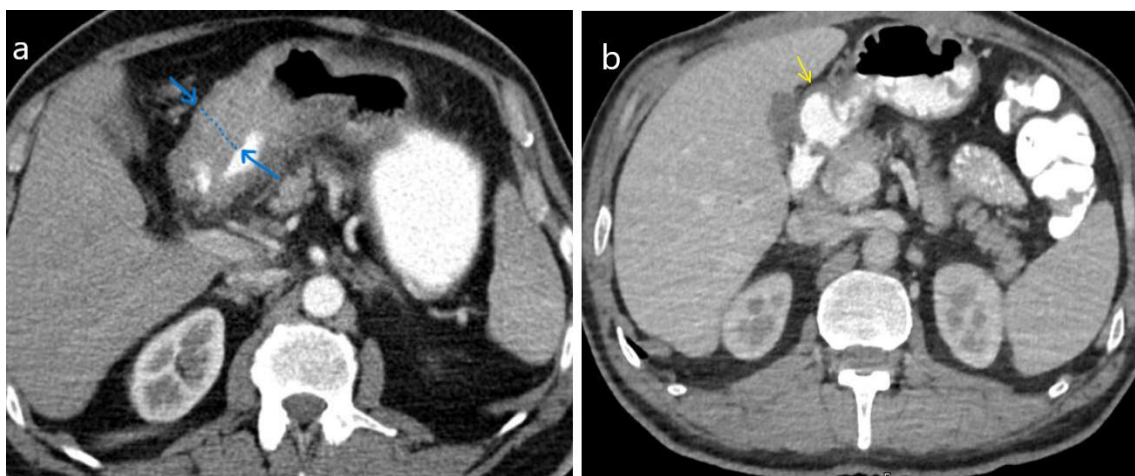


Figure 3. **a)** Axial CT image of the 66-year-old male patient diagnosed with adenocarcinoma in the antrum demonstrates asymmetric wall thickening in the anterior portion of the gastric antrum (blue arrows). The antral wall thickness was measured at approximately 27 mm (indicated by blue dots). **b)** Axial CT image of the 54-year-old male patient diagnosed with chronic gastritis in the antrum demonstrates a smooth wall structure in the gastric antrum (yellow arrow). The antral wall thickness was measured at approximately 2.5 millimeters.

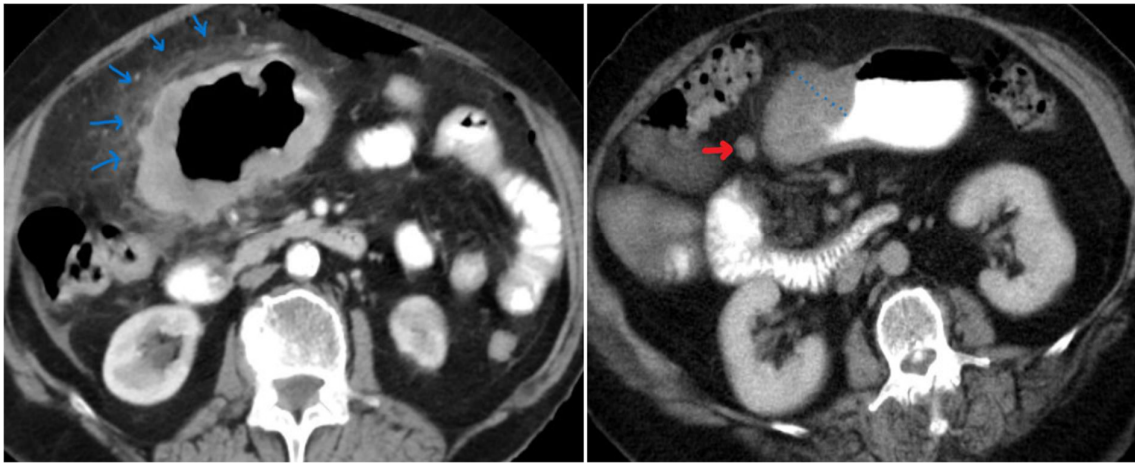


Figure 4. Abdominal CT scans of patients diagnosed with adenocarcinoma of the gastric antrum: **a)** Axial CT images of an 89-year-old female patient, showing asymmetric wall thickening in the gastric antrum and perigastric fat stranding (blue arrows). **b)** Axial CT images of a 74-year-old female patient, showing asymmetric antral wall thickening (blue dots) accompanied by perigastric lymphadenopathy (red arrow).

of all diagnosed cases. Other less common subtypes include lymphomas, stromal-origin tumors, and neuroendocrine tumors. In our study, all malignant lesions were diagnosed as adenocarcinomas, indicating a 100% diagnostic accuracy.

A multitude of studies have examined the effectiveness of MDCT in detecting gastric cancer and accurate preoperative staging, yielding success rates ranging from 69% to 100% [7-9]. A particular study reported that CT with multiplanar reconstruction (MPR) achieved a high specificity of 93% to 97% in detecting all stages of gastric cancer [10]. These findings underscore the significance of early detection of gastric cancer and the pivotal role of abdominal CT in optimal conditions for assessment. However, a common challenge in routine radiology practice is the difficulty in distinguishing between benign and malignant conditions due to the thicker gastric antral wall compared to other regions of the stomach [11]. Some studies have reported that the standard gastric wall thickness on CT scans is generally less than 5 mm; however, this value can often exceed 5 mm and, in some cases, reach up to 12 mm. These findings suggest that greater antral wall thickness compared to the gastric corpus may be a physiological feature [12,13]. A study revealed that the mean gastric wall thickness in the normal group was 12.5 mm, while in the malignant group, it was measured at 19 mm [14]. A separate study revealed that the mean antral wall thickness in patients with gastric cancer was 18.5 mm, while in patients without antral tumors, it was 5.9 mm [15]. It has been posited that an augmentation in

antral wall thickness, exceeding 11.9 mm, serves as a reliable indicator of the presence of an antral tumor on MDCT scans [16]. The present study was undertaken to establish a cutoff value for assessing relative increases in gastric antral thickness, with the objective of providing a clinically useful tool for selectively guiding patients towards endoscopic evaluations. The findings of this study indicate that a cutoff value of 12 mm is highly effective in distinguishing between malignancy and non-malignancy. In this study, no malignancy was detected in patients with wall thickness less than 12 mm, while all malignant cases had antral wall thickness greater than 12 mm.

According to the results of the ROC analysis, MDCT provides a high level of sensitivity and specificity in distinguishing between benign and malignant gastric wall thickening. A study by Tongdee et al. [17] reported that, when a 10 mm wall thickness cutoff was used to diagnose gastric malignancy, the sensitivity of CT was 81.8%, with a specificity of 97.7%. In another study by Insko et al. [18], employing the same 10 mm cutoff, the sensitivity was reported to be 100%, while the specificity was recorded at 42%. In the aforementioned study, an 11 mm cutoff was employed, resulting in an increased specificity of 99.2% and a decline in sensitivity to 77.3%. In the context of screening tests, enhancing sensitivity is paramount in reducing the false-negative rate. In the present study, a 12-mm cutoff for gastric antral thickening was established, yielding 100% sensitivity and 96% specificity. This method has been demonstrated to be highly effective in diagnosing malignancy.

Among the MDCT findings, perigastric lymphadenopathy and perigastric fat stranding are other significant indicators frequently associated with malignancy. Conventional wisdom, based on prior studies, suggests that the presence of perigastric fat stranding typically indicates extramucosal tumor spread. Nevertheless, it is noteworthy that such findings can occasionally arise from inflammatory processes, a circumstance that can result in false-positive results when interpreted as tumor spread [19-21]. In the study by Tongdee *et al.* [17], perigastric fat stranding and lymphadenopathy were rarely observed in normal or benign groups. In contrast, our study revealed that these findings were not observed in the benign group, while they were detected in 71.3% of the malignant group. The evaluation of these findings could be particularly valuable in cases with limited gastric distension, such as inadequate stomach expansion, where assessment might be challenging. This could increase the specificity and accuracy of diagnosing antral malignancy. Therefore, the presence of perigastric fat stranding and lymphadenopathy should be considered critical findings when distinguishing between malignancy and non-malignancy.

This study has several limitations. Firstly, this study employs a retrospective design, and the sample population comprises patients who underwent gastroscopy and had available CT images. The exclusion of early or advanced gastric cancer cases that did not undergo CT imaging may introduce selection bias. Secondly, the evaluation of symptomatic patients rather than a random sample of the population may limit the generalizability of the study's findings.

Additionally, the staging of tumors is influenced by factors such as tumor size, including thickness. However, the present study focused on distinguishing between benign and malignant lesions based on antral wall thickness, and the relationship between thickness and tumor staging was not directly assessed. A further limitation is that CT scans were reviewed by only a single examiner, and only single measurements were taken. This methodological choice precludes the assessment of variability in interpretation among observers (inter-observer variability) and within observers (intra-observer variability). Consequently, future studies that address these limitations and adopt a more comprehensive design could enhance the reliability of the findings.

CONCLUSION

In our study, statistically significant differences in wall thickness were identified between gastric cancer cases originating from the antrum and benign pathologies. In light of these findings, we propose a cutoff value of 12 mm to differentiate between benign and malignant processes. Furthermore, when antral wall thickness measured by CT exceeds 12 mm, particularly when accompanied by perigastric fat stranding and lymphadenopathy, it is considered a strong indicator of antral malignancy. These findings underscore the potential of antral wall thickness as a crucial diagnostic marker, particularly in clinical contexts where precise patient management is imperative. The incorporation of this cutoff value into clinical practice is crucial for ensuring the appropriate referral of patients for further diagnostic procedures.

Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical Approval

In this retrospective study, computed tomography images and endoscopic pathology data were used and no retrospective permission was requested from the ethics committee.

Authors' Contribution

Study Conception: BSA, AK, BG, FY, US; Study Design: BSA, AK, BG, FY, US; Literature Review: BSA, AK, BG, FY, US; Critical Review: BSA, AK, BG, FY, US; Data Collection and/or Processing: BSA, AK, BG, FY, US; Analysis and/or Data Interpretation: BSA, AK, BG, FY, US; Manuscript preparing: BSA, AK, BG, FY, US.

REFERENCES

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2018;68(06):394–424
2. Levine MS, Megibow AJ, Kochman ML. Carcinoma of the stomach and duodenum. In: Gore RM, Levine MS (Eds.). *Textbook of gastrointestinal radiology*. 2nd edition Philadelphia: Saunders Elsevier; 2008: 619-43.
3. Thrumurthy SG, Chaudry MA, Hochhauser D, Mughal M. The diagnosis and management of gastric cancer. *BMJ*.

- 2013 Nov 4;347:f6367.
4. Hallinan JT, Venkatesh SK. Gastric carcinoma: imaging diagnosis, staging and assessment of treatment response. *Cancer Imaging*. 2013 May 30;13(2):212-27.
 5. Dixon M, Cardoso R, Tinmouth J, Helyer L, Law C, Swallow C, et al. What studies are appropriate and necessary for staging gastric adenocarcinoma? Results of an international RAND/UCLA expert panel. *Gastric Cancer* 2014 Apr;17(2):377-82.
 6. Coburn N, Seevaratnam R, Paszat L, Helyer L, Law C, Swallow C, et al. Optimal management of gastric cancer: results from an international RAND/UCLA expert panel. *Ann Surg* 2014 Jan;259(1):102-8
 7. Shen Y, Kang HK, Jeong YY, Heo SH, Han SM, Chen K, et al. Evaluation of Early Gastric Cancer at Multidetector CT with Multiplanar Reformation and Virtual Endoscopy. *Radiographics* 2011 Jan-Feb;31(1):189-99.
 8. Akagi T, Shiraishi N, Kitano S. Lymph node metastasis of gastric cancer. *Cancers (Basel)* 2011 Apr 26;3(2):2141-59.
 9. Fawzi SY, Momjian RLB, Khaleel IA. The Role of Spiral Computed Tomography in the Detection & Staging of Gastric Malignancy. *IJGE Issue 5 Vol 1* 2005
 10. Zytoon A, El-Atfey S & Hassanein SH. Diagnosis of gastric cancer by MDCT gastrography: diagnostic characteristics and management potential. *Egypt J Radiol Nucl Med* 51, 30 (2020).
 11. Makino T, Fujiwara Y, Takiguchi S, Tsuboyama T, Kim T, Nushijima Y et al. Preoperative T staging of gastric cancer by multi-detector row computed tomography. *Surgery*.2011 May;149(5):672-9.
 12. Pickhardt PJ, Asher DB. Wall thickening of the gastric antrum as a normal finding: multidetector CT with cadaveric comparison. *AJR Am J Roentgenol* 2003 Oct;181(4): 973-9.
 13. Kul S, Sert B, Sari A, Arslan M, Kosucu P, Ahmetoglu A, et al. Effect of subclinical *Helicobacter pylori* infection on gastric wall thickness: multislice CT evaluation. *Diagn Interv Radiol* 2008 Sep;14(3): 138-42.
 14. Cho SG, Kim WH, Lee KH, Kim MY, Han H, Ok CS, et al. Wall thickening of the gastric antrum: Is it a pseudolesion or a tumor? *J Korean Radiol Soc* 1999 Feb;40(2): 281-7.
 15. Matzek W, Bastati N, Baroud S, Muin D, Herold C, Ba-Ssalamah A, et al. The Value of HMDCT in Differentiation between Normal and Pathologic Antral Wall Thickening of the Stomach. *Radiological Society of North America 2010 Scientific Assembly and Annual Meeting, Nov 28-Dec 3, 2010, Chicago IL*.
 16. Yavuz A, Akdemir Z, Bora A, Alptekin C, Dülger AC. Abdominal Bilgisayarlı Tomografi Tetkikinde Ölçülen Mide Antropilör Cidar Kalınlığının Benin ve Malin Mide Patolojilerinin Ayırımındaki Etkinliği. *Van Tıp Dergisi* 2015;22(3): 166-172.
 17. Tongdee R, Kongkaw L, Tongdee T. A study of wall thickness of gastric antrum: comparison among normal, benign and malignant gastric conditions on MDCT scan. *J Med Assoc Thai*. 2012 Nov;95(11):1441-8.
 18. Insko EK, Levine MS, Birnbaum BA, Jacobs JE. Benign and malignant lesions of the stomach: evaluation of CT criteria for differentiation. *Radiology* 2003 Jul;228(1):166-71.
 19. Barros RH, Penachim TJ, Martins DL, Andreollo NA, Caserta NM. Multidetector computed tomography in the preoperative staging of gastric adenocarcinoma. *Radiol Bras*. 2015 Mar-Apr;48(2):74-80.
 20. Chen CY, Wu DC, Kang WY, Hsu JS. Staging of gastric cancer with 16-channel MDCT. *Abdom Imaging*. 2006 Sep-Oct;31(5):514-20. Epub 2006 Feb 7. Erratum in: *Abdom Imaging*. 2014 Apr; 39(2):440.
 21. Balfe DM, Koehler RE, Karstaedt N, Stanley RJ, Sagel SS. Computed tomography of gastric neoplasms. *Radiology* 1981 Aug; 140(2): 431-6.