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Radiological evaluation of superior mesenteric artery syndrome: are aortomesenteric angle and distance measurements reliable?

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Abstract

Objectives: To evaluate the interobserver and intraobserver consistency of aortomesenteric angle (AMA) and aortomesenteric distance (AMD) measurements in diagnosing superior mesenteric artery syndrome (SMAS), and to assess their reliability as diagnostic parameters.

Methods: This retrospective study analyzed 200 abdominal CT scans of patients (124 females, 76 males; aged 17–42) with a preliminary diagnosis of SMAS between May 2021 and March 2024. AMA and AMD were measured on sagittal and oblique-sagittal images by three radiologists at two different times, independently and blinded to clinical data. Intraobserver and interobserver variability was evaluated using nonparametric statistical tests, with p<0.05 considered significant. Diagnostic thresholds were set at 22° for AMA and 8 mm for AMD.

Results: AMA measurements showed significant interobserver and intraobserver variability (p<0.05), while AMD measurements were reproducible and consistent (p>0.05). Variability in AMA led to diagnostic discrepancies in 9.1–10.4% of cases, compared to only 0.5–1.2% for AMD. These results indicate that AMA is less reliable and prone to user-dependent errors, whereas AMD offers greater diagnostic accuracy.

Conclusion: AMA measurements are influenced by factors such as patient positioning and respiratory phase, contributing to their inconsistency. AMD, in contrast, demonstrates low variability and high reliability, making it a more robust parameter in SMAS diagnosis. The study emphasizes the need to prioritize AMD over AMA in the diagnostic workflow for SMAS. AMD is a consistent and reliable parameter for SMAS diagnosis, while AMA demonstrates significant variability and potential for misdiagnosis.

Keywords: aortomesenteric angle; aortomesenteric distance; computed tomography; reliability; superior mesenteric artery; syndrome

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Introduction

Superior mesenteric artery syndrome (SMAS), a rare condition, is characterized by the obstruction of bowel transit due to the compression of the third portion of the duodenum. This compression occurs between the superior mesenteric artery, which lies anteriorly, and abdominal aorta or vertebrae, which are situated posteriorly.[1,2] The classic symptoms associated with this condition are often nonspecific and may include nausea, vomiting, abdominal pain, loss of appetite, abdominal distension, and weight loss. Recognizing superior mesenteric artery syndrome is crucial, as it can potentially lead to severe complications such as dehydration, metabolic imbalances, and in rare instances, even death.[3,4]

The diagnosis of SMAS relies on clinical presentation and imaging findings, with upper gastrointestinal contrast studies and computed tomography (CT) being a commonly used diagnostic tool. The characteristic signs

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are the presence of an abrupt vertical or oblique compression of the duodenum, and decreased aortomesenteric angle (AMA) and distance (AMD).[5] However, interpreting these findings can be subject to interobserver variability. The lack of a standardized measurement technique due to variations especially in AMA and AMD measurements raises the question of how reliable these parameters are.

This study aimed to make interobserver and intraobserver comparisons of AMA and AMD measurements and thus demonstrate the reliability of these measurement parameters.

Materials and Methods

A retrospective analysis was conducted on clinical data and abdominal CT scans of patients aged 17 to 42 years who were prediagnosed with superior mesenteric artery syndrome (SMAS) between May 2021 and March 2024. A total of 242 scans from different patients were reviewed. Thirty-five scans were excluded due to significant bowel motion or respiratory artifacts, and seven were excluded because the superior mesenteric artery and aortic walls could not be clearly visualized on the same axis. Ultimately, 200 scans from 200 unique patients were included in the study. The flowchart of the study is presented in **Figure 1**.

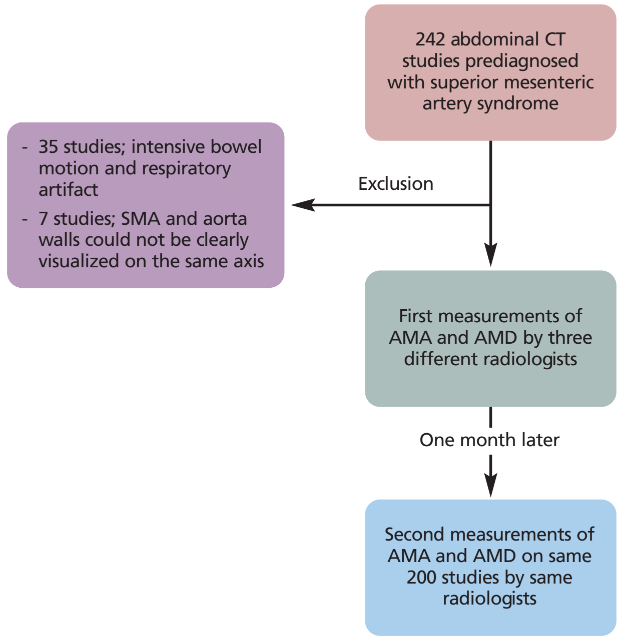

Figure 1. The flowchart of the study.

All CT scans were acquired on a 128-slice CT (GE Revolution EVO, GE Medical Systems, Milwaukee, WI, USA) with the patient in the supine position during inspiration and without an intravenous contrast agent. Image acquisition parameters included a tube voltage of 100 kV, a tube current of 180–300 mA, a spiral step factor of 0.98, a collimation thickness of 0.625 mm, a slice thickness of 1.3 mm and sharp kernel reconstruction with a 512×512–pixel image matrix. For image clarity. Also sagittal, axial, or oblique-sagittal multiplanar reconstruction (MPR) images were obtained to assess the branching configuration of SMA from abdominal aorta.

All images were sent electronically to a workstation (GE Medical Systems, Milwaukee, WI, USA) for evaluation. Images were evaluated blinded to patient information and clinical data by two radiology specialists (BEÇ: 10 years of abdominal radiology experience; EÇ: 7 years of general radiology experience) and one radiology resident (BE: 3 years of radiology residency). Radiologists performed the initial measurements on anonymized images independently and at different times, without knowledge of each other's assessments. Similarly, the order of the anonymized images was shuffled and the same measurements were performed again approximately one month later by all radiologists at different times without each other's knowledge.

The distance between SMA and abdominal aorta was measured as the maximum distance between the anterior margin of abdominal aorta and the posterior aspect of the superior mesenteric artery at the level where the duodenum crosses (**Figure 2**). The angle between these vessels was measured on reformatted sagittal or oblique sagittal images at the same level. To measure the angle, a line was drawn between the root of SMA and an imaginary point

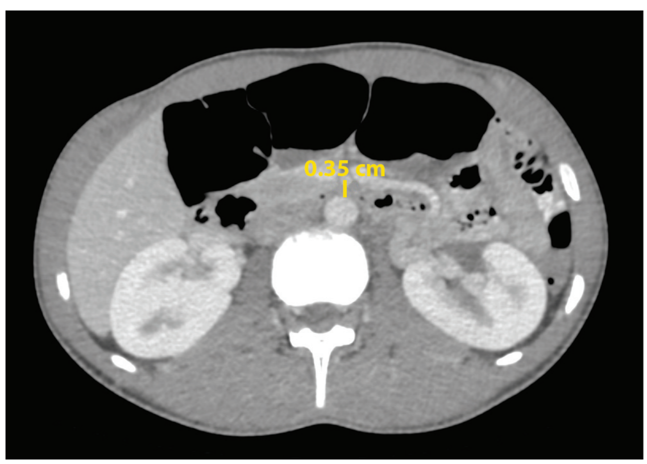

Figure 2. Measurement of aortomesenteric distance (AMD).

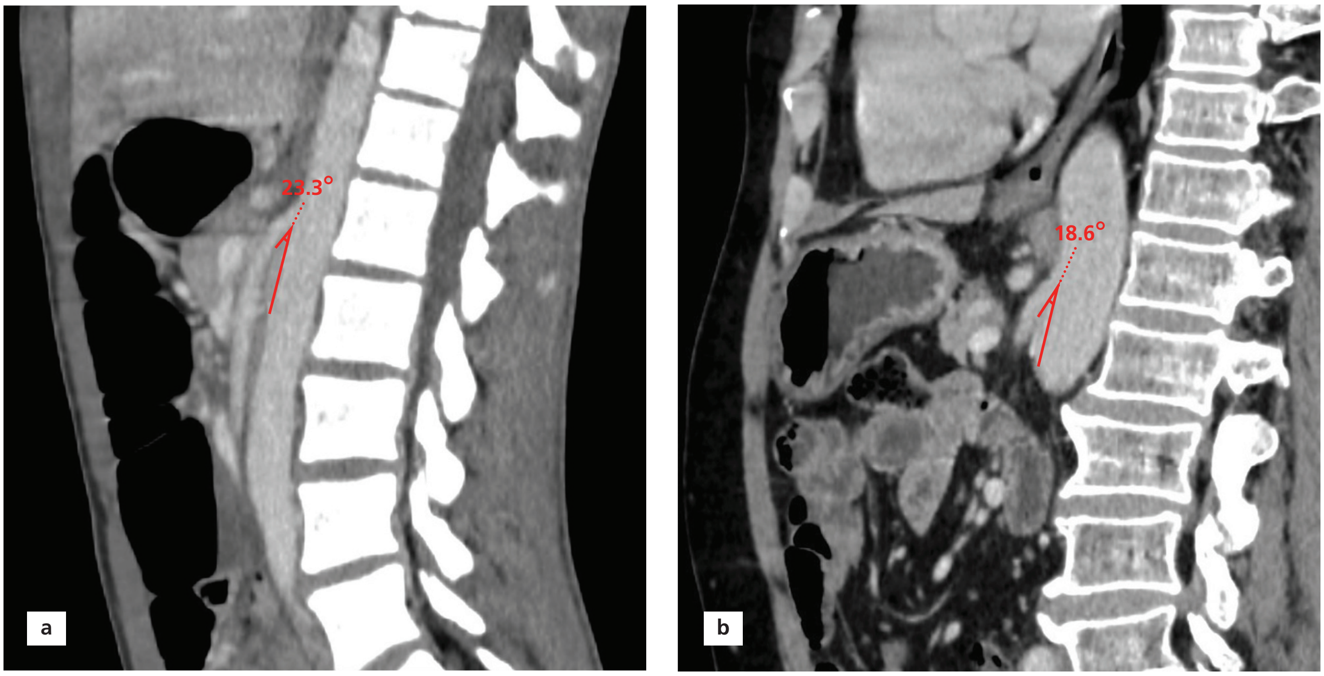

Figure 3a,b. Measurement of aortomesenteric angle (AMA).

on SMA where it begins to descend parallel to the abdominal aorta (**Figures 3a** and **b**). Measurements were taken using electronic calipers, and angles were obtained through manual tracing with automatic degree calculation. Cutoff values for the radiological diagnosis of SMAS were accepted as 22 degrees for AMA and 8 mm for AMD.[6]

Data were analyzed using SPSS version 26 (IBM Corp, Armonk, NY, USA). Descriptive statistics for continuous (quantitative) variables; were expressed as median, standard deviation, minimum, and maximum values, and categorical variables were expressed as numbers (n) and ratio (%). The normality of the variables was assessed using the Kolmogorov–Smirnov and Shapiro–Wilk tests. Since the data did not follow a normal distribution, nonparametric tests were applied. The Kruskal–Wallis test was used for comparisons among three or more dependent groups, while the Wilcoxon test was employed for subgroup analyses. A p-value of ≤0.05 was considered statistically significant, and Bonferroni correction was applied for multiple comparisons.

Results

A total of 200 patients were included in the study, comprising 124 females and 76 males. The descriptive characteristics of the study population are presented in **Table 1**.

There was a significant difference between the first and second AMA measurements of all three radiologists ($p<0.05$), but no significant difference was found in the first and second AMD measurements ($p>0.05$) (**Table 2**). Similarly, an interobserver significant difference was found in the statistical analyses performed for AMA measurements, whereas no interobserver significant dif-

Table 1
Descriptive data of the patients included in the study.

Age	Mean (interval)	26.37 (17–42)
	Median	20
Sex	Female	124 (63.3%)
	Male	76 (36.7%)

Table 2
Intraobserver consistency assessment of AMA and AMD measurements made by radiologists at different times.

	Asymp. Sig. (2-tailed) AMA	Asymp. Sig. (2-tailed) AMD
Radiologist 1	p<0.05	p=0.170
Radiologist 2	p<0.05	p=0.200
Radiologist 3	p=0.002	p=0.350

AMA: aortomesenteric angle; **AMD:** aortomesenteric distance.

ference was found in both measurements performed at different times for AMD measurements (Table 3).

The proportion of patients whose AMA and AMD measurements crossed the diagnostic cut-off values (22° for AMA and 8 mm for AMD) between the first and second assessments is presented in Table 4. While both intraobserver and interobserver variations in AMA measurements showed statistically significant differences at the 22° threshold, no significant variation was observed for AMD at the 8 mm cut-off. These findings indicate that AMA measurements lack reliability for diagnostic use, whereas AMD demonstrates high reproducibility, consistency, and diagnostic reliability.

Table 3

Interobserver consistency assessment of AMA and AMD measurements made by radiologists at different times.

	AMA	AMD
First measurement	p<0.001	p=0.170
Second measurement	p=0.021	p=0.238

AMA: aortomesenteric angle; **AMD:** aortomesenteric distance.

Discussion

SMAS is a rare but significant condition involving the compression of the third part of the duodenum between the superior mesenteric artery and the aorta, which leads to symptoms such as nausea, vomiting, and weight loss.[7,8] Diagnosis can be very challenging most of time.[3,4,9] Santer et al.[10] and Applegate et al.[11] pioneered the description of CT findings in SMAS and advocated dynamic thin-slice CT with sagittal reconstruction as an excellent imaging modality due to its safety, speed, and relatively non-invasive nature. Reduced AMA and AMD measurements are key CT diagnostic criteria for SMAS.[12–14] However, the reliability of these measurements has long been questioned, particularly in relation to interobserver and intraobserver variability. Although ranges for AMA and AMD have been reported in the literature for both the normal population and patients with SMAS ,to the best of our knowledge, there is no study in the literature that evaluates intraobserver and interobserver consistency to determine the reliability of these measurements.[13,15,16] This study is unique in terms of demonstrating intra- and interobserver consistency of these measurements.

The results of this study reveal critical insights into the variability of AMA and AMD measurements among experienced radiologists. AMA showed significant interobserver and intraobserver variability, suggesting it may not be a reliable diagnostic tool for SMAS. A major problem with the AMA is that the measurement varies depending on the patient's position, the tortuous course of the SMA, variations of the angle of exit from the its origin, or changes in respiration. In addition, the need for precise and user-dependent line generation for AMA measurement, where both the aorta and the SMA wall must be parallel, may also contribute to this discrepancy. Studies have also highlighted the technical difficulties of measuring AMA consistently, as it is very difficult to show the origin of the SMA on the same axis as the aorta, even on multiplanar reformatted images, and this is difficult to identify as a technical difficulty in measuring AMA.[17,18]

Conversely, AMD showed minimal variability, both between observers and within the same observer across different time points, making it a more consistent and reliable measure for diagnosing SMAS. The reproducibility of AMD makes it a more reliable parameter for SMAS, particularly when compared to AMA, which has demonstrated significant inconsistencies.

Another important result of our study is that in approximately %9.1–10.4 of the patients, measurement

Table 4

The percentage of patients in whom one radiologist found a different result according to the cut off value and the percentage of patients in whom the same radiologist found a different result in two measurements.

	AMA first and second measurement different results	AMA measurement interobserver different results	AMD first and second measurement different results	AMD measurement interobserver different results
Radiologist 1	9.1%	9.3%	1.1%	1.2%
Radiologist 2	9.7%	8.8%	0.5%	1%
Radiologist 3	10.4%	8.2%	0.9%	1.1%

AMA: aortomesenteric angle; **AMD:** aortomesenteric distance.

results were obtained on different sides of the cut-off value for radiological diagnosis of SMAS for two different AMA measurements performed by the same radiologist at different times. Similarly, for approximately %8.2–9.3 of patients, one radiologist measures different results for AMA measurement from three different radiologists, depending on the cut-off value. Beyond variability, this inconsistency shown by AMA may cause the patient to be misdiagnosed based on radiological evaluations. For AMD, these rates are only between %0.5–1.2 and are relatively acceptable. Therefore, this study underscores the need for more standardized imaging planes and radiological parameters for patients with prediagnosed SMAS to minimize variability in radiological measurements and to contribute to correct diagnosis.

The implications of these findings are significant for the clinical evaluation of patients suspected of having SMAS. Given the variability in AMA measurements, relying completely on this parameter may lead to unnecessary diagnostic errors, potentially affecting patient care. The consistency of AMD makes it a more robust radiological parameter. Clinicians must be careful to incorporate AMD as the primary measurement when evaluating potential SMAS cases, while remaining cautious about the inherent limitations of AMA.

This study has some limitations. The patients included in the study were not patients with a preliminary diagnosis of SMAS, whose diagnosis of SMAS was surgically confirmed. In addition, the patients were compared without subcategorizing them according to their body mass index (BMI). In patients with low BMI, the measurement consistency may be affected since the assessment of AMA and AMD will be more challenging, which is more evident in the measurement of AMA.

Conclusion

In conclusion, while repeated AMD measurements demonstrate clear intra- and interobserver consistency, the reliability of AMA measurements remains questionable. Future large-scale, multi-center studies incorporating both clinical and radiological correlations will be essential to standardize measurement techniques and establish robust diagnostic parameters for SMAS.

Conflict of Interest

The authors declare that there is no conflict of interest and this study was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Author Contributions

EÇ: design, data processing, materials, analysis and /or interpretation, literature review, writing, critical review; BE: data colletion and processing, literature review, writing; BEÇ: conception, data processing, supervision, critical review; MD: materials, analysis and /or interpretation, critical review.

Ethics Approval

The study was approved by Ankara City Hospital, Ethics Committee with approval number TABED-1-24-245.

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