Cross-sectional Study

ANNALS OF MEDICINE & SURGERY

OPEN

Evaluating aortomesenteric parameters in a tertiary center of Nepal for superior mesenteric artery syndrome diagnosis and risk factors: cross-sectional study

Diwas Sapkota, MD[a], Bikash Bikram Adhikari, MD[a], Aimandu Shrestha, MD[a], Shailendra Katwal, MD[b,*]

Background and objectives: This study examines aortomesenteric angle (AMA) and distance (AMD), which are critical in superior mesenteric artery (SMA) syndrome. Addressing the scarcity of SMA cases, the research explores potential links with lower BMI and aims to establish normative data for diagnostic and predictive purposes, using contrast-enhanced computed tomography (CT) scans across various BMI and sex categories.

Methodology: A retrospective quantitative cross-sectional study was conducted on 189 patients undergoing abdominal contrast-enhanced CT scans between December 2019 and December 2020. Ethical clearance was obtained, and participants provided informed consent. Exclusion criteria targeted specific medical histories. Patient demographics, BMI categories, and imaging data were recorded. Helical 128-slice CT scans were employed, with sagittal-oblique multiplanar reconstructions for parameter assessments. Statistical analysis utilized SPSS 26.0, including Pearson correlation coefficients and mean calculations.

Results: The study reveals a mean AMA of 54.07° ± 8.53° and a mean distance of 16.25 ± 3.44 mm. Elevated BMI is found to positively correlate with AMA and distance, indicating that higher BMI values may augment these parameters, with an additional positive correlation observed between AMA and distance. No significant correlations are found with patient age or sex.

Conclusion: The study concludes that decreased BMI may pose a potential risk for SMA syndrome, as evidenced by the observed correlations with aortomesenteric parameters. Understanding these normal values in the Nepalese population is critical for accurate diagnoses and predictions using CT scans. The research highlights the impact of demographic factors on these parameters and emphasizes their significance in clinical assessments related to SMA syndrome.

Keywords: aortomesenteric angle, aortomesenteric distance, BMI correlation, superior mesenteric artery syndrome

Introduction

The superior mesenteric artery (SMA) is a crucial ventral branch of the abdominal aorta, originating behind the pancreas at the first or second lumbar vertebra[1]. Positioned ~1 cm below the coeliac trunk, it traverses anteriorly to the uncinate process of the pancreas and crosses the third part of the duodenum. Typically, the SMA departs from the aorta at an angle of 25°–60°, providing sufficient space for the passage of the left renal vein, the third part of the duodenum, and the uncinate process of the pancreas[2]. The distance between the SMA and aorta typically ranges from 10 to 28 mm, with retroperitoneal fat influencing this norm[3]. Factors such as rapid weight loss, increased lordosis, and external pressure can disrupt retroperitoneal fat, elevating the risk of superior mesenteric artery syndrome[4].

Superior mesenteric artery syndrome, a rare cause of upper gastrointestinal obstruction, occurs when the third part of the duodenum is compressed between the aorta and the SMA[5]. Initially described by Rokitansky in 1842, it is also known as Cast syndrome, Arteriomesenteric duodenal compression syndrome, or Wilkie's syndrome. The disorder is rare, with around 400 cases

HIGHLIGHTS

- This study investigates aortomesenteric parameters in the Nepalese population, revealing a mean aortomesenteric angle of 54.07° ± 8.53°and a mean distance of 16.25¬ ± 3.44 mm.
- Correlations between decreased BMI and increased aortomesenteric angle and distance suggest a potential risk association with superior mesenteric artery syndrome (SMAS).
- These normative findings contribute crucial insights for clinicians, enhancing diagnostic accuracy and proactive management strategies for SMAS in the Nepalese demographic.

[a]Department of Radiology, National Academy of Medical Sciences, Kathmandu and [b]Department of Radiology, Dadeldhura Subregional Hospital, Dadeldhura, Nepal

Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

*Corresponding author. Address: Department of Radiology, Dadeldhura subregional Hospital, Dadeldhura, 10300. Tufandada. Tel.: +977 984 9149 630. E-mail: shailendrakatwal@gmail.com(S. Katwal).

Annals of Medicine & Surgery (2024) 86:2612–2618

Received 31 January 2024; Accepted 4 March 2024

Published online 15 March 2024

http://dx.doi.org/10.1097/MS9.0000000000001962

reported in the literature and a prevalence of ~0.1–0.3%[6]. There is a lack of precise prevalence data in Nepal. Nonetheless, few studies, including case reports, have been conducted in Nepal, most of which are post-2020[7].

The radiograph discloses a distended stomach containing fluid and gas, while barium studies and ultrasound contribute to the diagnostic process, albeit with nonspecific findings[8]. Additionally, angiography and sonography aid diagnosis by assessing the angle and distance between the SMA and the aorta. An angle less than 25° and distance less than 10 mm is associated with SMA syndrome[9]. Endoscopy is employed to rule out mechanical duodenal obstruction. Contrast-enhanced computed tomography (CT) stands out as a comprehensive and noninvasive method for assessing abdominal structures, proving effective in evaluating aortomesenteric relationships and visualizing retroperitoneal and mesenteric fat[10].

The study's objective is to measure the AMA and AMD using CT scans in the Nepalese population across various BMI and sex categories, providing normative data valuable for research and clinical applications requiring objective determinations of these parameters.

Methodology

This study was a retrospective quantitative cross-sectional study conducted on 189 patients referred to the Department of Radiology and Imaging for obtaining a contrast-enhanced computed tomography scan of the abdomen between December 2019 and December 2020. Ethical clearance for the study was obtained from the Institutional Review Board, reference number (456/0761077), and informed written consent was obtained from all participating patients after explaining the study to them.

The sample size was determined based on findings from a similar study conducted by Ozkurt *et al.*[11], with a level of significance of 5% and a standard deviation of 0.7 with 10% precision.

Out of the selected 200 patients, individuals with duodenal obstruction, specifically Willkie's syndrome, those with a history of gastrointestinal surgery or abdominal vascular intervention, patients exhibiting allergic reactions to iodinated contrast, and those unwilling to participate in the study were excluded, resulting in a final sample size of 189 patients. Patients undergoing a contrast-enhanced CT abdomen scan of any sex with age more than 20 years, and normal serum creatinine values (≤ 1.5 mg %) without prior history of gastrointestinal or abdominal vascular interventions and who provided consent were included in the study (Fig. 1).

Patient demographics, including age, sex, weight, and height, were recorded using a pre-designed pro forma. BMI was calculated using the formula BMI = weight [kg]/height [m^2]. BMI categories were established for both sexes: Category A (underweight): BMI < 18.5 kg/m^2, Category B (Normal): BMI 18.5–24.9 kg/m^2, Category C (Overweight): BMI 25–29.9 kg/m^2, Category D (Obese): BMI ≥ 30 kg/m^2[12].

Axial and cross-sectional abdomen images were collected using a helical 128-slice CT scan machine (Ingenuity 128, Philips). A tube voltage of 100–140 kVp and tube current between 100 and 380 mAs were utilized based on patient size. Patients received 80–100 ml of iohexol 350 mg per ml iodinated contrast media, injected either by an automated injector or hand bolus injection. The standard abdominal CT protocol involved acquiring 7 mm sections with increments of 7 mm in the supine position.

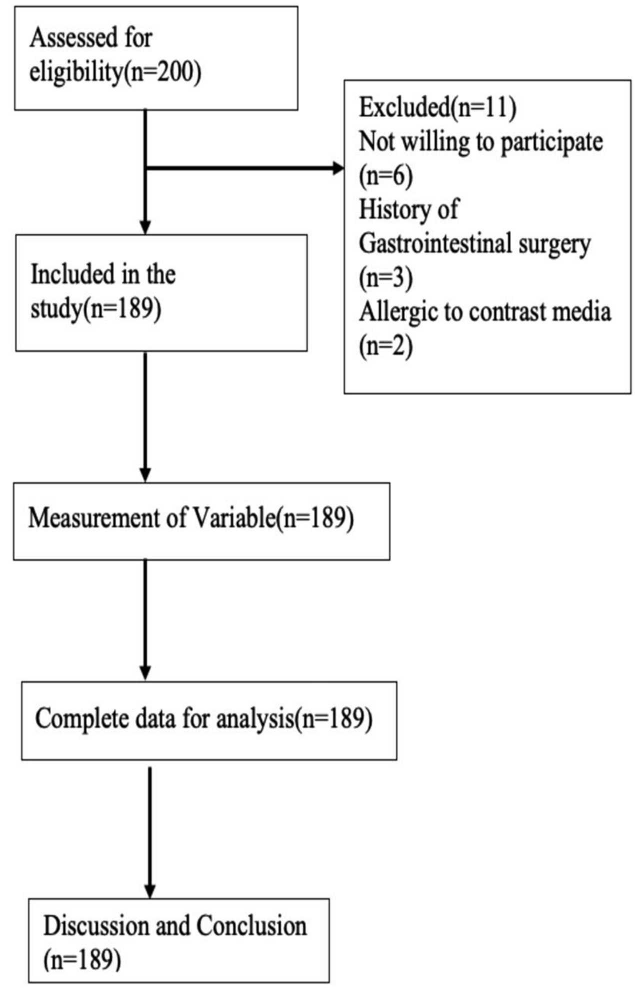

Figure 1. STROCSS flow diagram of the participant for evaluation of aorto-mesenteric parameters in a tertiary care centre of Nepal.

Sagittal or oblique-sagittal multiplanar reconstruction images in the arterial phase were obtained to assess the branching configuration of the SMA from the aorta. The distance between the SMA and the aorta was measured as the distance between the anterior margin of the aorta and the posterior aspect of the SMA, where the duodenum crossed on axial scans (Fig. 2). The angle between these vessels was measured on reformatted sagittal-oblique images. Measurements were performed using electronic calipers, and the angles were obtained through manual tracing with automatic degree calculation (Fig. 3). Measurements were performed by a specialized radiologist with significant experience, averaging 450 examinations (Contrast abdominal CT) annually, demonstrating proficiency and familiarity with the technique. The collected data were subjected to statistical analysis for further interpretation.

This study followed the STROCSS (Strengthening the Reporting of Cohort Studies in Surgery) 2021 checklist for cross-sectional studies[13]. The study is registered retrospectively in the

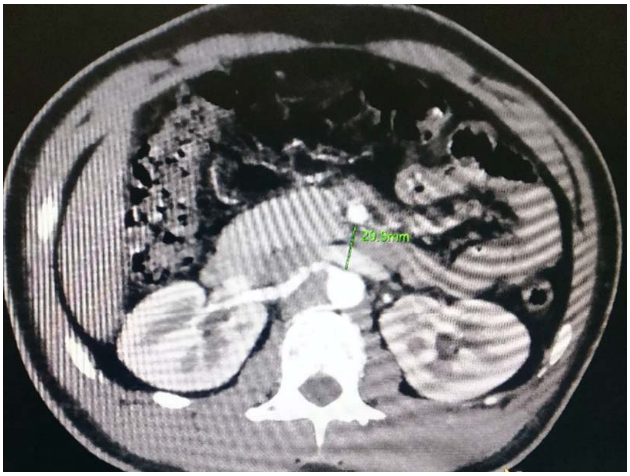

Figure 2. Axial computed tomography image of the abdomen showing measurement of aortomesenteric distance at the level of crossing of third part of duodenum.

research registry with a unique identification number (UIN) of researchregistry9971.

Patients and the public actively engaged in shaping the research objectives, design, and outcome measures, contributing to recruitment, feedback, meetings, dissemination, and knowledge translation activities throughout the study. Regular meetings and continuous monitoring were done for quality control.

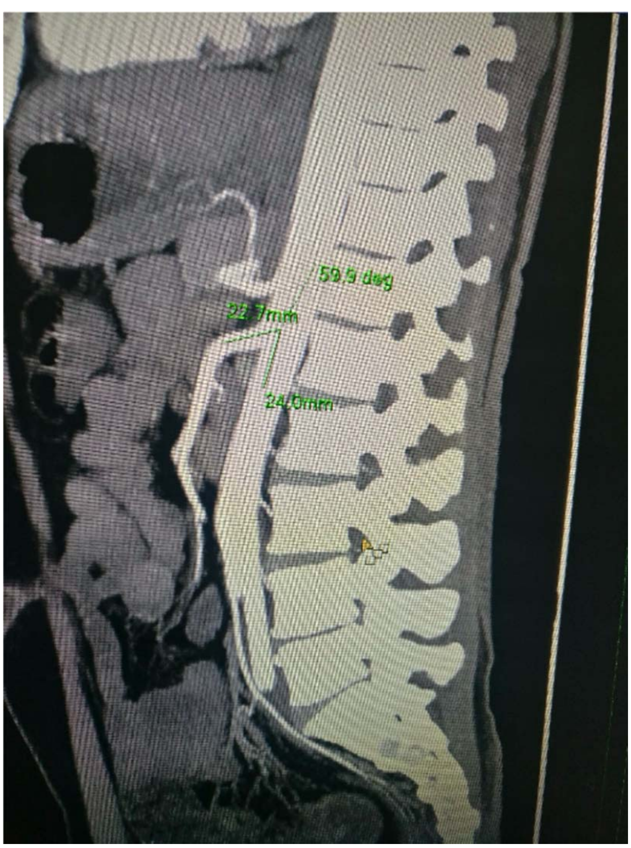

Figure 3. Sagittal section computed tomography image of the abdomen showing measurement of the aortomesenteric angle.

Statistical analysis

The data were analyzed using SPSS 26.0 for Windows, with Pearson correlation coefficients calculated for each sex group. Mean values of distance and angle measurements were calculated with standard deviations and 95% CIs. *P* values were calculated under a predetermined significance level (0.05), and a 95% CI was constructed. Results were expressed as percentages, mean ± standard deviation for variables. Appropriate tables were used during data analysis.

Result

An analysis of 189 abdominal CT scans revealed a male-to-female ratio of 1.05:1, with a mean patient age of 48.22 ± 15.8 years. Predominantly in the 31–40 age group, the mean weight was 61.56 kg overall, 63.98 kg in males, and 59.01 kg in females. The study categorized patients into BMI groups, showing that most males and females fell into the normal (B) category (18.5–24.99 kg/m^2. with mean ages of 49.59 and 50.98 years, respectively (Table 1).

In our study, the mean AMA and AMD were elevated in the 41–50 age group compared to others. The overall mean AMA and AMD were 54.07 ± 8.53° and 16.25 ± 3.44 mm, respectively (Table 2). No significant correlations were found between AMA and age (r = – 0.048, $P = 0.2$) or AMD and age (r = – 0.109, $P = 0.06$) (Fig. 4).

In our gender-diverse study (97 males, 92 females), males displayed a mean AMD of 16.30 ± 3.55 mm and an angle of 53.24° ± 7.53°, while females had 16.19 ± 3.34 mm and 54.95° ± 9.44°, respectively. No significant correlations were found between AMA or AMD with sex (r = 0.1 and – 0.015,

Table 1

Clinico-demographic profile of the participants referred to the radiology department

Characteristics	Number, *n* (%)
Sex	
Male	97 (51.32)
Female	92 (48.68)
Age	
> 80 years	4 (2.11)
71–80 years	12 (6.35)
61–70 years	34 (18)
51–60 years	36 (19.05)
41–50 years	36 (19.05)
31–40 years	39 (20.63)
21–30 years	28 (14.81)
BMI categories for male	
A	6 (6.18)
B	44 (45.36)
C	40 (41.24)
D	7 (7.22)
BMI categories for female	
A	11 (11.96)
B	43 (46.74)
C	21 (22.83)
D	17 (18.47)

Table 2

Mean values (±SD) of aortomesenteric angle and distance in different age groups

Age group (years)	Total no. patients	Mean aortomesenteric angle (degrees) ± SD	Mean aortomesenteric distance (mm) ± SD
21–30	28	50.33 ± 7.21	14.69 ± 2.15
31–40	39	55.53 ± 8.86	17.49 ± 4.18
41–50	36	57.95 ± 10.69	17.82 ± 3.44
51–60	36	54.48 ± 6.06	16.45 ± 2.93
61–70	34	52.03 ± 7.87	14.97 ± 3.14
71–80	12	52.13 ± 7.64	14.56 ± 2.22
> 80	4	50.72 ± 4.76	14.92 ± 3.21
Total	189	54.07 ± 8.53	16.25 ± 3.44

respectively). Regarding BMI categories, higher categories (e.g. D) showed increased AMD (20.64 ± 3.61 mm) and angle (67.15° ± 8.85°) in both males and females. Significant positive correlations were identified between AMA and BMI (r = 0.78) as well as between AMD and BMI (r = 0.74), as confirmed by one-tailed tests ($P < 0.001$, 5% level of significance) (Table 3).

Discussion

The superior mesenteric artery is a major non-paired visceral artery in the abdominal cavity, supplying the midgut. The mean AMA in this study was 54.07° ± 8.53°, aligning with similar findings in studies by Adhikari and colleagues, Jafarpisheh and colleagues, and Albayrak and colleagues (56° ± 65.50°)[14–16]. It was lower than Ozbulbul and colleagues' study (62.77° ± 6.50°) but higher than Bahadir and colleagues (47.78° ± 25.54°), Arthurs and colleagues (45.6° ± 19.6°), and Konen and colleagues (44.4°, range 28–65°)[17–20]. This difference in results may be due to confounding factors such as different demographic characteristics and race. This might also be due to varying imaging techniques used for determining the SMA angle. There might also be a difference in the population race and body fat content, which are not taken into consideration in this study. In those studies, samples were taken from extreme age groups, which might have influenced the mean AMA in those studies.

In this study, the mean AMD was 16.25 ± 3.44 mm, ranging from 8 to 29.5 mm. Comparable findings were observed in studies by Bahadir and colleagues (16.34 ± 9.46 mm), Ozbulbul and colleagues (15.92 ± 3.5 mm), Unal and colleagues, and Ozkurt and colleagues[11,17,18,21]. It exceeded the mean distance in studies by Adhikari and colleagues and Konen and colleagues (19.6 mm, range 13.4–34.3 mm)[14,20] (Table 4). Differences may be attributed to varying demographic characteristics and inclusion/exclusion criteria, emphasizing the impact of confounding factors on study outcomes.

In a study by Cho *et al.*[22], the mean AMA and AMD were 28.73° ± 8.35° and 6.03 ± 1.28 mm, respectively, lower than our study. Fu and colleagues reported different values of 90 ± 10° and 12 ± 1.8 mm for the angles and distances between the SMA and the aorta, possibly influenced by the age group (children and adolescents) and small sample sizes (15 and 26 patients)[23]. Our study demonstrates that AMA and AMD increase with higher BMI categories, showing significant positive correlations (Pearson coefficients of 0.78 and 0.74, respectively). Categories A to D (underweight to obese) exhibit increasing mean values for AMA and AMD. Comparable positive correlations between BMI and these parameters were found in other studies, including those by Desai and colleagues and Ozkurt and colleagues, supporting the notion that higher BMI values are associated with increased angles and distances between the SMA and aorta[11,24].

In a study by Adhikari *et al.*[14], a positive correlation was found between BMI and aortomesenteric angle (AMA) and

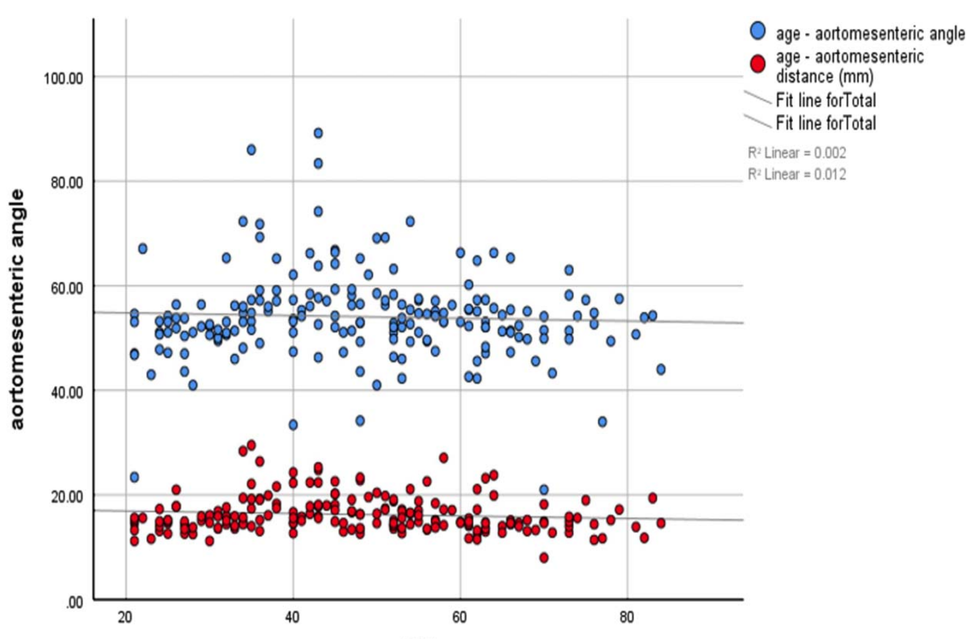

Figure 4. Scatter diagram showing the aortomesenteric angle and distance according to age.

Table 3

Pearson correlation coefficient of AMA and AMD with BMI and with each other

Pearson correlation coefficient	AMA	AMD
BMI	0.78	0.74
AMA	1	0.673

AMA, aortomesenteric angle; AMD, aortomesenteric distance.

distance, with Pearson correlation coefficients of 0.122 and 0.086, respectively. Similarly, Kalyani *et al.*[25] demonstrated increasing AMA and distance values with higher BMI. Jafarpisheh *et al.*[15] reported a direct and significant association between BMI and both SMA–aorta distance (r = 0.609) and SMA–aorta angle (r = 0.505). Alzewri and colleagues and Sinagra and colleagues also observed significant correlations between BMI and AMA/AMD, affirming our study's findings[26,27].

In a study by Biank *et al.*[28], contrary to our findings, a low BMI was not deemed necessary for superior mesenteric artery syndrome (SMAS) development, as only 50% of patients experienced weight loss and decreased BMI before diagnosis. Bahadir *et al.*[18] reported differing results, asserting that visceral fat volume strongly correlates with AMD and AMA, more so than BMI. They proposed that BMI does not consistently estimate visceral fat tissue volume accurately and recommended cross-sectional imaging for precise evaluation in SMAS patients. Similarly, Lee *et al.*[29] observed SMAS occurrences in patients with normal BMIs, suggesting a possible link between a growth spurt and SMA configuration changes. Wee and colleagues and Wang and colleagues also contradicted our findings, indicating that low BMI is not always a prerequisite for decreased AMA and AMD in SMAS cases[30,31].

In our study, no correlation was found between AMA or AMD with age (r = −048, P = 0.2; r = −0.109, P = 0.06). Mean values were higher in the 30–40 and 40–50 age groups. A study by Arthurs *et al.*[19] yielded similar results with no significant SMA angle-age correlation (P = 0.53). Conversely, Jafarpisheh *et al.*[15] found negative associations between angle/distance and age, possibly influenced by racial and nutritional differences. In Bahadir *et al.*[18]'s study, a significant positive correlation was observed between age and AMA/AMD, likely affected by the study's distribution of underweight and normal-weight patients.

In our study, there was no significant correlation between AMD and sex (r = −0.015, P = 0.417), nor between AMA and sex (r = 0.1, P = 0.086). Similar findings were observed by Jafarpisheh *et al.*[15], where no significant differences in distance and angle were noted between men and women (P = 0.539 and 0.225, respectively). Arthurs *et al.*[19] also reported no significant sex difference in SMA angle. However, Kalyani *et al.*[25] found higher overall mean values for distance and angle in males than females within the same BMI category. In contrast, Bahadir and colleagues and Biank and colleagues observed lower AMA and distance in females, potentially linked to differences in visceral and subcutaneous fat distribution[18,28]. Biank *et al.*[28] reported a higher incidence of SMAS in females than males.

In our study, a significant positive correlation was found between AMA and distance AMD, with a Pearson correlation coefficient of 0.673 ($P < 0.001$). This mirrors the results of a study by Adhikari *et al.*[14], where the correlation coefficient between AMA and AMD was 0.668 ($P < 0.001$). While our study utilized contrast-enhanced computed tomography (CECT) for measurements, Bernotavičius *et al.*[32] emphasized the role of ultrasound, particularly Doppler ultrasound, in assessing the reduced AMA.

This hospital-based cross-sectional study, lasting one year, may lack generalizability due to its limited duration and single-centre focus. A multicentric approach would enhance representativeness. Excluding patients under 20 aimed at aligning with previous findings; however, the potential impact on correlation estimation within age and BMI groups is acknowledged. Lack of follow-up on patients with low BMI and altered aortomesenteric parameters is noted.

Conclusion

The study discerned a noteworthy connection between the distance and angle differentiating the SMA and the aorta, signifying a potential risk link with decreased BMI as a plausible SMA syndrome risk factor. Notable correlations were established for these parameters, while patient age and sex showed no significant associations. Understanding typical SMA–aorta values, influenced

Table 4

Findings in different studies about mean SMA angle and distance

Author	No. patients	Modality of study	Mean AMA degrees (°)	Mean AMD (mm)	SMA angle correlated with
This study	189	CT	M:53.24 ± 7.53 F: 54.95 ± 9.44	M:16.30 ± 3.55 F: 16.19 ± 3.34	BMI
Neri *et al.*[3]	950	USG, CT	25–60	8–25	—
Ozkurt *et al.*[10]	524	CT	M:42.6 ± 25 F:43.6 ± 18.5	M:15.2 ± 3 F:19.2 ± 2	BMI
Jafarpisheh *et al.*[14]	300	CT	54.95° ± 8.53	28.5 ± 4.5	BMI
Adhikari *et al.*[13]	210	CT	54.7 ± 16.91	13.30 ± 4.75	BMI
Arthurs *et al.*[18]	205	CT	M:45.8 ± 18.2 F:45.3 ± 21.6	M:11.5 ± 5.3 F: 11.5 ± 4.5	Body fat
Ozbulbul *et al.*[16]	130	CT	M:63.97 ± 20.53 F:57.81 ± 25.63	M:14.21 ± 7.7 F:17.64 ± 6.92	BMI
Cho *et al.*[21]	15	USG, CT	28.7 ± 8.4	6.03 ± 1.28	—
Fu *et al.*[22]	10	CT	90 ± 10	12 ± 1.8	—
Unal *et al.*[20]	89	USG, CT	50.9 ± 25.4	16 ± 1.5	BMI

AMA, aortomesenteric angle; AMD, aortomesenteric distance; CT, computed tomography; F, female, M, male; SMA, superior mesenteric artery; USG, ultrasonography.

by demographic factors, proves vital in diagnosing and predicting SMA syndrome using CT scans, with Nepali-specific mean values aiding risk assessment in this population.

Ethical approval

We have conducted an ethical approval base on the Declaration of Helsinki with registration research at the Institutional Review Board of the National Academy of Medical Sciences (NAMS), Nepal.

Consent

Written informed consent was obtained from the patient for the publication of this case report and the accompanying images. A copy of the written consent is available for review by the Editor-in-chief of this journal on request.

Sources of funding

None.

Author contributions

D.S.: conceptualization, as mentor and reviewer for this original article and for data interpretation. B.B.A.: conceptualization and reviewer for this case. A.S.: reviewer and data interpretation. S.K.: contributed in performing literature review, writing the paper and editing. All authors have read and approved the manuscript.

Conflicts of interest disclosure

All the authors declare that they have no competing interest.

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Guarantor

Shailendra Katwal is the person in charge of the publication of our manuscript.

Provinence and peer review

Not commissioned, externally peer-reviewed.

Data availability statement

Data sharing is not applicable to this article.

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