Internal Medicine and Medical Investigation Journal
E-ISSN: 2474-7750
Homepage: www.imminv.com

Computed Tomographic Evaluation of the Angle and Distance between the Superior Mesenteric Artery and the Abdominal Aorta: Normal Values in Iranian Population Across Different Body Mass Index Categories

Saleh Jafarpisheh[1], Maryam Nasri, Hosein Ahrar[1]
1. Radiology Department, Isfahan University of Medical Sciences, Isfahan, Iran.
2. Medical Student, Student Research Committee, Isfahan University of Medical Sciences, Isfahan, Iran.

Corresponding author: Saleh Jafarpisheh, email: Maryam_nasri1992@yahoo.com

ARTICLE INFO

Received 2018-07-12
Accepted: 2018-08-21
Published: 2019-02-30
Volume: 4
Issue: 1

Conflicts of interest: None
Funding: None

Keywords:
Abdominal Aorta,
Body Mass Index,
superior mesenteric artery,
Computed Tomographic Scan,

ABSTRACT

The present study aimed to prove that the angle and distance between the superior mesenteric artery (SMA) and the aorta are significantly correlated with the body mass index (BMI) in order to establish a strong etiological role of the BMI in the development of SMA syndrome. SMA syndrome is characterized by the compression of the third segment of the duodenum by the mesentery at the SMA level, resulting in duodenal compression, occasionally accompanied by gastric compression. The syndrome is closely associated with the depletion of the fat pad between the vessels, which reduces the angle and distance between the vessels. This prospective study included 300 patients [163 males and 137 females; mean age, 51 (range, 40–70) years] who underwent multislice detector computed tomography (CT) scan in Alzahra Hospital in 2017 for various complaints other than SMA syndrome. CT scans were performed by the standard protocol including a plain phase scan, followed by arterial and venous phase scans, to measure the SMA–aorta angle. The patients were categories as per their BMI into four categories defined by WHO. The mean values for the distance and angle were calculated, with P values of 5% (95% confidence intervals) indicating significant difference. Pearson coefficients between the parameters and BMI were also determined, and the t-test was performed for comparisons. A strong positive correlation was observed between BMI and the SMA–aorta angle, indicating that the angle increases with increasing BMI, which reduces the risk of developing SMA syndrome.

Intoduction

Superior mesenteric artery (SMA) syndrome, also called as Wilkie syndrome, Cast syndrome, and arterio-mesenteric duodenal compression syndrome, is a rare and life-threatening condition that causes upper gastrointestinal obstruction (1, 2). The prevalence of this syndrome varies from 0.1% to 0.3%. The syndrome is caused by external compression of the third portion of the duodenum between the SMA and the abdominal aorta. The symptoms are early satiety, nausea, vomiting, abdominal pain after eating, abdominal distension, burping, diarrhea, and other obstructive symptoms (3). Ultrasound and barium studies are commonly used to diagnose this syndrome, but computed tomography (CT) scan has been proven to be more effective (4-6).

Duodenal compression between the SMA and the aorta occurs due to mechanical and anatomical factors, such as the amount of retroperitoneal fat. The amount of retroperitoneal fat, in turn, is influenced by several factors, including weight loss, anorexia nervosa, malabsorption, and hypercatabolic conditions (e.g., burns, surgeries, severe trauma, and malignancies) (7). The loss of retroperitoneal fat leads to the formation of an acute angle between the aorta and the SMA, likely causing duodenal obstruction and stenosis at

Published by Mehrabani Publishing LLC.

http://dx.doi.org/10.24200/imminv.v3i4.8

that site (8). Thus, it is widely acknowledged that these angle and distance are determined by the amount of retroperitoneal fat (4, 9-12).

Several studies have investigated the role of the angle and distance between the SMA and the aorta in the development of SMA syndrome. The results of various studies have suggested ideal mean values for the SMA–aorta angle and distance, which vary from 38° to 65° and 13 to 34 mm, respectively, across studies (12). Studies have also shown that a reduction of 6°–16° and 5–11 mm in the angle and distance increase the risk of SMA syndrome (13).

These results highlight the importance of measuring and determining normal values of the angle and distance using CT scan to help evaluate the anatomical risk factors for SMA syndrome, especially in patients with abdominal pain. Consequently, more suitable treatment approaches could be determined for high risk patients. The present study aimed to measure the normal values of the angle and distance between the SMA and the abdominal aorta in Iranian population and investigate their association with the body mass index (BMI).

Method

This descriptive, analytical, cross-sectional study included all patients who visited Alzahra Hospital for a CT scan for any reason other than SMA syndrome in 2017. The sample size was calculated using the formula for comparison of four means. The confidence level was 95% (Z = 2 − a/1 = 1.96), and the test power coefficient was 80%, which was considered as 0.84 in this study. Standard deviation was estimated as 0.31, and a sample size of 300 patients was selected by non-probability and random (simple) sampling methods.

Inclusion criteria were all patients who visited Alzahra Hospital for a CT scan for any reason other than SMA syndrome and agreed to participate in the study. Exclusion criteria were lack of cooperation of the individual to answer the questions, unavailable height and weight data of patients, and patients in the acute postoperative phase.

Data on the age, sex, height, and weight of all participating patients were collected. The BMI of all patients was calculated using the following standard formula: weight in kg/height in m^2. All participants were divided into four BMI categories according to the WHO definition: Group 1: BMI < 18.5 kg/m^2, Group 2: 18.5 kg/m^2 < BMI < 24.09 kg/m^2, Group 3: 25 kg/m^2< BMI < 29.9 kg/m^2, and Group 4: BMI > 30 kg/m^2.

CT scan procedure

All patients underwent multislice detector CT scans using a 64-slice detector CT scanner (Lightspeed VCT, GE Healthcare, USA) under the following settings: gantry rotation time = 0.5 s, tube voltage = 140 kVp, and tube current = 100–380 mA depending on the size of the patient.

All patients were administered intravenous injections of 320-mg Visipaque and 300-mg Ultravist, and CT scans were performed within 40–50 seconds after injection. According to the standard CT protocol for the abdomen, 10-mm-thick sections at 8-mm intervals were obtained with the patients lying flat on their stomachs. Axial images were reconstructed using a medium-sharp convolution kernel (B30f) with an image matrix of 512 × 512 pixels and a slice thickness of 2 mm.

CT findings were interpreted by a radiologist. Sagittal images were used to study the branches of SMA originating from the abdominal aorta. The angle and distance between the SMA and the aorta were evaluated by two radiologists, and the values were recorded. The SMA–aorta distance was measured as the maximum distance between the anterior margin of the aorta and the posterior border of the SMA at the site where duodenum crosses. The aorta–SMA angle was measured by drawing a line between the root of the SMA and a hypothetical point on the SMA at the site where the artery descends parallel to the aorta. The angle between this line and aortic line was measured by the device. Finally, the mean values of the SMA–aorta angle and distance and compared between women and men and between BMI categories.

Statistical analysis

All data on the demographic factors and paraclinical parameters of the patients were recorded in a checklist by an executive and entered in the SPSS v.18 statistical software. Statistical analyses included descriptive and analytical sections. In the descriptive section, mean and standard deviation of the studied angles were presented as the main variable. All demographic characteristics were reported based on descriptive statistics. In the analytical section, parametric and nonparametric tests were used if the preliminary assumptions were accepted. The chi-square test was used to analyze qualitative findings. Independent t-test and Pearson correlation coefficient were used to compare quantitative data. If the preliminary assumptions including normal distribution were rejected, the non-parametric Mann–Whitney test was performed. All tests were examined at 5% error level.

Results

Of the 300 patients who underwent CT scan, 163 (54.3%) were male and 137 (45.7%) were female, with the average age of 51.25 ± 7.67 (40–70) years and the mean BMI of 25.62 ± 4.99 (15.6–36.6) kg/m^2. The mean values for the SMA–aorta distance and angle were 2.85 ± 0.45 (1.4–3.6) cm and 54.95° ± 8.53° (34°–68°), respectively.

The lowest SMA–aorta distance (1.69 ± 0.33 cm) was found in patients with BMI < 18.5 kg/m^2, whereas the highest SMA–aorta distance (3.27 ± 0.15 cm) was found in patients with BMI > 30 kg/m^2 ($P < 0.001$). Further, the lowest SMA–aorta angle (79.5° ± 25.38°) was found in patients with BMI < 18.5 kg/m^2, whereas the highest SMA–aorta angle (87.3° ± 66.61°) was found in patients with BMI > 30 kg/m^2 ($P < 0.001$). Pearson correlation analysis also showed that the BMI was directly and significantly associated with both the SMA–aorta distance (r = 0609 and $P < 0.001$) and the SMA–aorta angle (r = 0.505 and $P < 0.001$) (Table 1).

The SMA–aorta distance and angle were further assessed based on the sex and age of the patients, which also showed significant differences across age and sex ($P < 0.001$). No significant difference was found in the distance and angle between men and women (P = 0.539 and 0.225, respectively), indicating no association with the sex of the patients. However, the SMA–aorta distance and angle were significantly higher in patients younger than 50 years than in those older than 50 years (2.91 cm vs 2.8 cm, P = 0.03; and 56.29° vs. 53.9°, P = 0.024, respectively), indicating a significant negative correlation between these parameters and the age of the patients.

Discussion

This study revealed that the distance and angle between the SMA and the abdominal aorta are directly and significantly associated with the BMI of the patients. The angle and distance increase as BMI increases. The relationships of these two parameters with age and sex were also significant. In particular, the angle and distance were negatively associated with age but showed no significant difference between males and females. These findings are consistent with those of three previous studies (9, 14, 15).

Ozkurt et al. (2007) performed abdominal CT scans on 524 Turkish patients and investigated the relationship of the SMA–aorta distance and angle with category-wise BMI of patients of both sexes (9). In both sexes, they found a moderate but significantly positive correlation between the SMA–aorta distance and BMI, whereas a low but significantly positive correlation between the SMA–aorta angle and BMI (9). In their study, the mean values for the SMA–aorta distance in women were 7.0 ± 2.1 cm in the first BMI category, 6.0 ± 5.1 cm in the second BMI category, 6.0 ± 5.1 cm in the third BMI category, and 7.0 ± 9.1 in the fourth BMI category cm. Those for the SMA–aorta distance in men were 6.0 ± 1.2 cm in the first BMI category, 6.0 ± 3.1 cm in the second BMI category, 8.0 ± 2 cm in the third BMI category, and 7.0 ± 3.2 cm in the fourth BMI category. Further, the mean values for the SMA–aorta angle in women were 25° ± 6.42° in the first BMI category, 6.20° ± 3.45° in the second BMI category, 9.21° ± 5.49° in the third BMI category, and 1.21° ± 8.60° in the fourth BMI category, and those for the SMA–aorta angle in men were 5.18° ± 6.43° in the first BMI category, 9.2° ± 3.46° in the second BMI category, 6.24° ± 8.63° in the third BMI category, and 3.22° ± 2.63° in the fourth BMI category (9). These findings are consistent with those of the present study.

In a similar study, Desai et al. (2015) found a significant positive correlation between BMI and the SMA–aorta angle as well as a moderate positive correlation between BMI and the SMA–aorta distance, indicating that a higher BMI is associated with a wider angle and greater distance (14). This reduces the likelihood of duodenal compression and consequently the risk of developing SMA syndrome (14). These results are consistent with those of the present study. This study also found that older age and lower BMI increased the risk of SMA syndrome.

In another study on an Indian population, Kalyani et al. (2017) investigated the normal values of the SMA–aorta distance and angle in both sexes across the four BMI categories (15). They found that the mean values for the angle and distance were different across the BMI categories as well as between sexes of the same BMI categories. In particular, the mean values tended to be higher in men than in women (15). Consistent with these results, the mean values for the SMA–aorta angle and distance were higher in men than in women in the present study, but this difference was not statistically significant. This difference in the significance of the results may be due to confounding factors such as different demographic characteristics, race, and inclusion and exclusion criteria.

Reportedly, a 6°–16° reduction in the SMA–aorta angle and a 5–11 mm decrease in the SMA–aorta distance increase the risk of SMA syndrome (13). Taken together, the findings indicate that as the values for the SMA–aorta angle and distance tend to be lower in older adults, people with lower BMI, and females, the incidence of the SMA syndrome tend to be higher in older age, people with low BMI, and females (milder symptoms of the disease). Normal values for the SMA–aorta distance and angle established for different population in the present and previous studies can help in not only diagnosing SMA syndrome but also predicting patients at risk of developing this syndrome. Preventive measures and screening for high-risk patients should be implemented to prevent the development of this syndrome and increase their quality of life.

Conclusion

The results of this study showed a direct and significantly positive relationship between the BMI of the Iranian patients and the SMA–aorta distance and angle. Further, a significant negative correlation was found between these two parameter and the age of the patients, but no significant association was found between sexes and the parameters. Given the high incidence of SMA syndrome, knowledge of the normal values of the SMA–aorta distance and angle is essential to aid its diagnosis using CT scan as well as to predict the patients at risk of developing this syndrome. Consideration of demographic characteristics, such as BMI, age, and sex, that influence the SMA–aorta distance and angle is essential to screen patients with high accuracy and implement effective preventive measures for those at high risk. The mean values for the SMA–aorta angle and distance obtained in Iranian patients in this study across the four BMI categories can be useful in diagnosing and predicting the risk of SMA syndrome in the Iranian population.

Conflict of intrest:
None

Authors contribution
All authors contributed equally

Acknowledgments
This research was based on PhD thesis No. 395296 in Professional Medicine. We would like to thank the Deputy Department of Isfahan University of Medical Sciences for the financial support extended for this study.

References

1. Redaelli CA, Schilling MK, Büchler MW. Intra-operative laser Doppler flowmetry: a predictor of ischemic injury in acute mesenteric infarction. Digestive surgery. 1998;15(1):55-9.

2. Hegde A, Desai S. Superior mesenteric artery syndrome demonstrated by computed tomography. J HK Coll Radiol. 2009;11:161-3.

3. Roy A, Gisel JJ, Roy V, Bouras EP. Superior mesenteric artery (Wilkie's) syndrome as a result of cardiac cachexia. Journal of general internal medicine. 2005;20(10):958.-

4. Unal B, Aktas A, Kemal G, Bilgili Y, Guliter S, Daphan C, et al. Superior mesenteric artery syndrome: CT and ultrasonography findings. Diagn Interv Radiol. 2005;11(2):90-5.

5. Neri S, Signorelli SS, Mondati E, Pulvirenti D, Campanile E, Di Pino L, et al. Ultrasound imaging in diagnosis of superior mesenteric artery syndrome. Journal of internal medicine. 2005 Apr;257(4):346-51. PubMed PMID: 15788004. Epub 2005/03/25. eng.

6. Applegate GR, Cohen AJ. Dynamic CT in superior mesenteric artery syndrome. Journal of computer assisted tomography. 1988 Nov-Dec;12(6):976-80. PubMed PMID: 3183134. Epub 1988/11/01. eng.

7. Matheus CdO, Waisberg J, Zewer MHdT, Godoy ACd. Syndrome of duodenal compression by the superior mesenteric artery following restorative proctocolectomy: a case report and review of literature. Sao Paulo Medical Journal. 2005;123(3):151-3.

8. Payawal JH, Cohen AJ, Stamos MJ. Superior mesenteric artery syndrome involving the duodenum and jejunum. Emergency radiology. 2004;10(5):273-5.

9. Ozkurt H, Cenker MM, Bas N, Erturk SM, Basak M. Measurement of the distance and angle between the aorta and superior mesenteric artery: normal values in different BMI categories. Surgical and Radiologic Anatomy. 2007;29(7):595-9.

10. Desai AB, Shah DS, Bhatt CJ, Vaishnav KU, Salvi B. Measurement of the Distance and Angle Between the Aorta and Superior Mesenteric Artery on CT Scan: Values in Indian Population in Different BMI Categories. Indian Journal of Surgery. 2013:1-4.

11. Baltazar U, Dunn J, Floresguerra C, Schmidt L, Browder W. Superior mesenteric artery syndrome: an uncommon cause of intestinal obstruction. Southern medical journal. 2000;93(6):606-8.

12. Santer R, Young C, Rossi T, Riddlesberger MM. Computed tomography in superior mesenteric artery syndrome. Pediatric radiology. 1991;21(2):154-5. PubMed PMID: 2027727. Epub 1991/01/01. eng.

13. Laffont I, Bensmail D, Rech C, Prigent G, Loubert G, Dizien O. Late superior mesenteric artery syndrome in paraplegia: case report and review. Spinal cord. 2002;40(2):88-91.

14. Aditi Bhagirath Desai, Dharita Sandeep Shah, Chhaya Jagat Bhatt, Kavita Umesh Vaishnav, Bharat Salvi. Measurement of the Distance and Angle Between the Aorta and Superior Mesenteric Artery on CT Scan: Values in Indian Population in Different BMI Categories. Indian J Surg. 2015 Dec; 77(Suppl 2): 614–617.

15. Jethlia Kalyani, Kachewar Sushil, Lakhkar. D.L, Daga Soniya, Itai Abhijeet. Study Of Distance And Angle Between The Aorta And Superior Mesenteric Artery On Computerised Tomography Scan For Calculating Normal Values In Different Body Mass Index Categories And Sex In Indian Population. Sch. J. App. Med. Sci., 2017; 5(3B):846-851