

Superior and Inferior Mesenteric Arterial Variations on CT Angiography: Prevalence, Patterns, and Demographic Associations

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Abstract

Objectives: Anatomical variations of the superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) may alter surgical and endovascular vascular landmarks. This study assessed, by computed tomography angiography (CTA), the prevalence and spectrum of these variations and their associations with age and sex.

Methods: In this retrospective single-center study, 686 abdominal CTA examinations were screened; 48 were excluded because of age or inadequate image quality, leaving 638 patients for analysis. CTA was performed using a 128-slice multidetector CT scanner. Proximal SMA configuration, SMA-associated variant hepatic arteries, and IMA origin were evaluated using axial images, multiplanar reformations, and 3D reconstructions. Frequencies were calculated per patient and tested for association with age and sex.

Results: The final cohort comprised 397 men (62.2%) and 241 women (37.8%), with a mean age of 60.5 ± 15.4 years. At least one SMA- or IMA-related variation was present in 88 patients (13.8%). Proximal SMA variations were identified in 17 patients (2.7%), most commonly the hepatomesenteric trunk (1.6%). SMA-associated variant hepatic arteries were present in 77 patients (12.1%); a replaced right hepatic artery (RHA) arising from the SMA was the most frequent pattern (66/638, 10.3%). Variations in IMA origin were identified in five patients (0.8%), including three bimesenteric trunks and two IMAs arising from the SMA. Variant anatomy was more frequent in men than in women (17.1% vs. 8.3%; $p=0.002$), primarily because of a higher prevalence of SMA-associated variant hepatic arteries (15.4% vs. 6.6%; $p=0.001$). Age did not differ significantly between patients with and without arterial variations ($p=0.564$).

Conclusion: SMA- and IMA-related arterial variants were identified in approximately one in seven patients undergoing abdominal CTA. A replaced RHA arising from the SMA was the predominant variation. Anatomic variants, particularly SMA-associated hepatic arterial variants, were more frequent in men, while age showed no association with their frequency. Systematic evaluation of mesenteric arterial anatomy on CTA may improve preprocedural vascular mapping.

Keywords: Computed tomography angiography, superior mesenteric artery, inferior mesenteric artery, anatomical variation, hepatic artery, vascular anatomy

Introduction

The superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) are the principal unpaired visceral arteries supplying the midgut and hindgut, respectively. In the classical configuration, both vessels arise independently from the anterior aspect of the abdominal aorta; however, persistence or regression of embryonic ventral splanchnic arterial channels may result in a broad spectrum of origin and branching variants. Large computed tomography angiography (CTA) series have demonstrated that, although classical anatomy predominates, clinically

relevant variations involving the SMA, IMA, celiac-hepatic arterial system, and their interconnections are not uncommon.¹⁻³

Recognition of these variants is important because the mesenteric and hepatic arterial anatomies directly influence hepatobiliary, pancreatic, colorectal, transplant, and endovascular procedures. Common trunks involving the SMA and celiac or hepatic arterial systems can alter expected vascular landmarks, whereas replaced or accessory hepatic arteries arising from the SMA may be at risk during pancreatic and upper abdominal surgery. Similarly, anomalous IMA origins may modify the arterial supply and collateral pathways of the left colon and

Cite this article as: Akkuş AT, Durmaz Ö. Superior and inferior mesenteric arterial variations on CT angiography: prevalence, patterns, and demographic associations. Adv Radiol Imaging. [Epub Ahead of Print]



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Received: 23.09.2026 **Accepted:** 28.09.2026 **Epub:** 05.10.2026



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rectum, with potential implications for colorectal resection and aortic interventions.⁴⁻⁶

CTA enables non-invasive, high-spatial-resolution evaluation of visceral arterial anatomy and allows detailed assessment of complex vascular configurations using thin-section axial data and multiplanar and three-dimensional reconstructions.⁷ Recent studies have characterized abdominal aortic branch variations in large CTA cohorts,^{2,3} while dedicated work on the common hepatic artery (CHA) has further demonstrated the close anatomical relationship between hepatic arterial variants and the SMA.¹ Nevertheless, most previous studies have either evaluated abdominal arterial variations broadly or concentrated on the hepatic and celiac systems, whereas relatively few have focused specifically on SMA origin patterns, SMA-associated variant hepatic arteries, and IMA origin variants within the same cohort.

Therefore, the present study aimed to determine the prevalence and spectrum of anatomical variations on CTA involving the proximal configuration of the SMA, the SMA-associated variant hepatic artery, and the origin of the IMA. A secondary aim was to assess whether the overall prevalence of these variations differed by age and sex.

Methods

Study Design and Population

This retrospective single-center study screened 686 abdominal CTA examinations performed on different patients between 01.08.2026 and 01.09.2026. Patients younger than 18 years of age, examinations with significant motion artifacts, repeated examinations, and examinations in which the arterial structures could not be optimally assessed because of an inappropriate contrast phase were excluded. A total of 48 patients met one or more exclusion criteria, leaving 638 patients for the final analysis. The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Ethics Committee of Kastamonu University Faculty of Medicine (approval number E-93763328-050.04-2600103477, date: 31.08.2026). Owing to the retrospective design, the requirement for additional written informed consent was waived.

Computed Tomography (CT) Angiography Acquisition Protocol

Abdominal CTA examinations were acquired using a 128-slice multidetector CT scanner (Somatom go.Top, Siemens Healthcare, Forchheim, Germany) according to the institutional protocol previously described by Tokur and Bingol.² Tube voltage was maintained at 80 kVp, and tube current (180-220 mAs) was automatically adjusted by the scanner according to patient characteristics. A non-ionic iodinated contrast agent was administered intravenously at a dose of 1.5-2 mL/kg, using an automatic injector at a flow rate of 4 mL/s, followed by a saline flush.

The scan range extended from approximately 2 cm above the diaphragm to 4-5 cm below the symphysis pubis. Arterial-phase acquisition was performed using automated bolus tracking. A region of interest was positioned in the proximal abdominal aorta, and scanning was initiated when attenuation reached 150 HU, corresponding to an average acquisition delay of approximately 20-30 s. Axial images were initially reconstructed at a slice thickness of 2 mm, followed by thin-section reconstruction at 0.625 mm for detailed vascular evaluation.

Image Analysis

Thin-section axial CTA images were evaluated by a single radiologist with seven years' experience in abdominal imaging, who was blinded to patients' age and sex during image evaluation. Coronal and sagittal reformations were generated on the workstation, and three-dimensional vascular reconstructions were obtained using the volume-rendering technique. Sectional images were reviewed on the PACS system (Akgün PACS Viewer v7.5; Akgün Software, Ankara, Türkiye), consistent with the previously described institutional image-analysis approach.²

For each patient, the arterial anatomy was assessed systematically, with particular attention to (1) the proximal origin and trunk configuration of the SMA; (2) the SMA-associated variant hepatic artery; and (3) the origin and configuration of the IMA. Uncommon configurations were confirmed on multiplanar and three-dimensional reconstructions.

Classification of Arterial Variations

SMA-associated findings were evaluated in two categories to distinguish proximal trunk configurations from variant arteries arising from or associated with the SMA. Proximal SMA configurations were categorized as classical independent SMA origin, celiacomesenteric trunk, hepatomesenteric trunk, bimesenteric trunk, splenomesenteric trunk, or other configurations. The two splenomesenteric cases were classified as common splenomesenteric trunks and were not counted separately as SMA branch variants.

SMA-associated variant hepatic arteries were categorized as replaced right hepatic artery (RHA), replaced left hepatic artery (LHA), replaced CHA, accessory RHA, or other uncommon branch variants. More than one anatomically distinct feature could be recorded in the same patient. In particular, a hepatomesenteric trunk and a coexisting replaced CHA were considered two separate morphological features.

The IMA origin was categorized as classical independent aortic origin, bimesenteric trunk, IMA arising from the SMA, double IMA, or other configuration. A bimesenteric trunk was regarded as a single anatomical variation in patient-level analyses, although it was represented in both the SMA and IMA classification sections.

Statistical Analysis

The primary outcome was the patient-based prevalence of any SMA- or IMA-related anatomical variation. The frequencies of individual SMA proximal configurations, SMA-associated variant hepatic arteries, and IMA origin variants were also calculated. Secondary analyses assessed associations of variant anatomy with sex and age.

Continuous variables were summarized as mean $\pm$ standard deviation and range; median and interquartile range (IQR) were additionally reported where appropriate. Categorical variables were expressed as numbers and percentages. Normality of age distributions was assessed using the Shapiro-Wilk test. Because age was not normally distributed within the comparison groups, it was compared between patients with and without arterial variations using the Mann-Whitney U test. Associations between categorical variables were evaluated using Fisher's exact test because of the modest sample size and the low frequency of several variant categories. In a substantial proportion of the contingency tables, more than 20% of cells had expected frequencies below 5, and some had expected frequencies below 1. Rare individual variants were analyzed descriptively. All tests were two-sided; $p < 0.05$ was considered

statistically significant. Statistical analyses were performed using Python 3.13 with SciPy 1.17.0.

Results

Study Population

Of the 686 abdominal CTA examinations initially screened, 48 were excluded according to the predefined eligibility and image-quality criteria, resulting in a final cohort of 638 patients. The cohort included 397 men (62.2%) and 241 women (37.8%). Mean age was 60.5±15.4 years (range, 21-92 years), and median age was 62 years (IQR, 53.25-72 years). Overall, 88 patients (13.8%) had at least one SMA- or IMA-related anatomical variation, whereas 550 patients (86.2%) had classical anatomy across the evaluated categories (Table 1).

Superior Mesenteric Artery Proximal Configuration

The SMA arose independently from the abdominal aorta in 621 of 638 patients (97.3%). A non-classical proximal SMA configuration was identified in 17 patients (2.7%). The most frequent proximal variation was a hepatomesenteric trunk (10/638, 1.6%), followed by a bimesenteric trunk (3/638, 0.5%), a celiacomesenteric trunk (2/638, 0.3%), and a splenomesenteric trunk (2/638, 0.3%) (Table 2). No gastromesenteric trunk was identified. A representative splenomesenteric trunk is shown in Figure 1.

Superior Mesenteric Artery-associated Variant Hepatic Arteries

A distinct SMA-associated variant of the hepatic artery was present in 77 patients (12.1%). The most frequent pattern, observed in 66 patients (10.3%), was a replaced RHA arising from the SMA. A replaced LHA and a replaced CHA were each identified in four patients (0.6%), and an accessory RHA was present in three patients (0.5%). After reclassifying the two splenomesenteric cases as common trunks, 561 patients (87.9%) had no separate variant hepatic or visceral branch arising from the SMA (Table 2). An example of an accessory RHA arising from the SMA is shown in Figure 2.

Coexisting anatomically distinct variants were observed in eight patients. Of the 10 patients with a hepatomesenteric trunk, six had a replaced RHA, two had a replaced CHA, and two had no additional hepatic artery variant. Among the 66 cases of replaced RHA, 60 had a classical SMA origin and 6 had a hepatomesenteric trunk. Of the four replaced CHA cases, two had a classical SMA origin and two had a hepatomesenteric trunk.

Table 1. Demographic characteristics and overall variant status	
Characteristic	Value
Final study population	638
Male	397 (62.2%)
Female	241 (37.8%)
Age, mean ± SD	60.5±15.4 years
Age, median (IQR)	62 (53.25-72) years
Age range	21-92 years
At least one SMA/IMA-related variation	88 (13.8%)
Classical anatomy in all evaluated categories	550 (86.2%)
SMA: Superior mesenteric artery, IMA: Inferior mesenteric artery, SD: Standard deviation, IQR: Interquartile range	

Inferior Mesenteric Artery Origin Variations

The IMA originated independently from the aorta in 633 patients (99.2%). Five patients (0.8%) had a variation in IMA origin: three (0.5%) had a bimesenteric trunk, and two (0.3%) had an IMA arising from the SMA (Table 2). The three bimesenteric trunks represented the same anatomical configurations recorded in the SMA-origin classification, and were therefore counted only once in the patient-level prevalence calculation. The classical independent origins of the major anterior visceral branches are illustrated in Figure 3.

Patient-level Prevalence and Demographic Associations

The primary endpoint was patient-level variant anatomy, defined as the presence of at least one mesenteric arterial variant. Each patient was counted once, regardless of how many variants were present. By this definition, 88 of 638 patients (13.8%) had variant anatomy. Because anatomically distinct abnormalities could coexist in the same patient, the 88 patients had a total of 96 variant morphological features: 80 patients had one variant, and 8 patients had two (a hepatomesenteric trunk with an additional SMA-associated variant hepatic artery). All prevalence figures and statistical comparisons below refer to patients, not to morphological features. Patient-level variant anatomy was significantly more frequent in men than in women (68/397, 17.1% vs. 20/241, 8.3%; Fisher’s exact p=0.002). This difference was primarily attributable to SMA-associated variant hepatic arteries, which were present in 61 men (15.4%) and 16 women (6.6%; p=0.001). In contrast, the prevalence of proximal SMA variations did not differ significantly between men and women (3.3% vs. 1.7%; p=0.312), and IMA origin variations were similarly uncommon in both groups (0.8% vs. 0.8%; p=1.000) (Table 3).

Among individual patterns, a replaced RHA was observed in 54 men and 12 women; a hepatomesenteric trunk in six men and four women; a replaced LHA in two men and two women; a replaced CHA in two men and two women; and an accessory RHA in three men and none in women. Both cases of IMA arising from the SMA occurred in women. Because of the small number of observations in these rare subgroups, no separate inferential testing was performed for individual variant types.

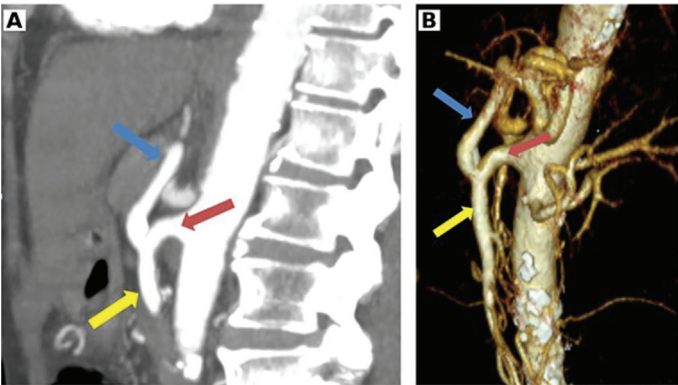


Figure 1. Splenomesenteric trunk in the same patient. (A) Sagittal maximum-intensity-projection CT angiography image and (B) three-dimensional volume-rendered image demonstrate a common splenomesenteric trunk (red arrows), with the splenic artery (blue arrows) and superior mesenteric artery (yellow arrows)

CT: Computed tomography

Age distributions were not normally distributed in both the variant-anatomy and classical-anatomy groups. The median age was 66 years (IQR, 38-73 years) in patients with at least one arterial variation and 62 years (IQR, 55-71 years) in those with classical anatomy. There was no statistically significant difference in age between the two groups (Mann-Whitney U test, $p=0.564$).

Table 2. Distribution of SMA- and IMA-related anatomical patterns

Anatomical pattern	n	%
SMA proximal configuration		
Classic independent SMA origin	621	97.3
Hepatomesenteric trunk	10	1.6
Bimesenteric trunk	3	0.5
Celiacomesenteric trunk	2	0.3
Splenesenteric trunk	2	0.3
SMA-associated hepatic branch pattern		
No separate variant branch	561	87.9
Replaced RHA from SMA	66	10.3
Replaced LHA from SMA	4	0.6
Replaced CHA from SMA	4	0.6
Accessory RHA from SMA	3	0.5
IMA origin		
Classic independent aortic origin	633	99.2
Bimesenteric trunk	3	0.5
IMA arising from SMA	2	0.3

Percentages are calculated using $n=638$. The three bimesenteric trunks are shown in both SMA and IMA classification sections but represent the same three anatomical configurations. The two splenesenteric trunks were not counted as separate SMA branch variants
 RHA: Right hepatic artery, LHA: Left hepatic artery, CHA: Common hepatic artery, SMA: Superior mesenteric artery, IMA: Inferior mesenteric artery



Figure 2. Accessory right hepatic artery arising from the superior mesenteric artery. Coronal oblique maximum-intensity-projection CT angiography image demonstrates an accessory right hepatic artery (orange arrow) arising from the superior mesenteric artery (yellow arrow); the celiac trunk is indicated by the black arrow

CT: Computed tomography

Discussion

The present study provides a focused CTA-based assessment of SMA- and IMA-related anatomical variation in 638 adults. The principal findings were that 13.8% of patients had at least one mesenteric arterial variant; 2.7% had non-classical proximal SMA configurations; 12.1% had SMA-associated variant hepatic arteries; and 0.8% had IMA origin variants. The replaced RHA arising from the SMA was by far the most frequent individual finding (10.3%). In addition, anatomical variants were significantly more frequent in men than in women, whereas no significant association with age was observed. These findings reinforce the concept that the mesenteric arterial system is predominantly stable at the level of its major aortic origins but remains clinically relevant because uncommon trunk configurations and more frequent hepatic arterial variants may coexist in the same patient.^{2,3}

The prevalence of classical SMA origin in our cohort was 97.3%, which closely parallels the 97.1% reported by Tokur and Bingol² in a 1174-patient CTA series. The distribution of individual proximal variants was also remarkably similar: the hepatomesenteric trunk was the most common non-classical configuration in both studies, followed by the bimesenteric, the celiacomesenteric, and the splenesenteric trunks. An earlier Turkish CTA study of 200 patients reported a somewhat lower rate of classical SMA origin (95.5%), with hepatomesenteric and bimesenteric trunks in 2.5% and 1.0%, respectively.³ In a recent Vietnamese 128-slice CT study, classical SMA anatomy was identified in 96.3% of patients.⁸ Taken together, these data suggest that the classical SMA origin is observed in approximately 95-97% of adults across CTA cohorts, whereas individual common-trunk variants generally remain below 2-3%. However, these prevalence values should be interpreted with caution because definitions and classification criteria are not uniform across studies. Some series use mutually exclusive categories, while others record coexisting variants separately. The criteria for distinguishing a true common trunk from closely adjacent separate origins also vary, as does the way complex celiac-hepatic-mesenteric configurations are assigned. Part of the apparent variation in prevalence may result from methodological factors, such as sample size, population characteristics, and imaging technique, rather than from true anatomical or population differences.

Our findings also highlight the value of distinguishing the configuration of the proximal SMA trunk from arteries that arise from or are associated with the SMA. This distinction prevents a hepatomesenteric or splenesenteric common trunk from being conflated with a replaced or accessory hepatic artery and permits coexisting abnormalities to be retained as distinct morphological findings. The practical relevance of this approach is supported by contemporary three-dimensional CTA literature. Zhao et al.⁹ demonstrated close correspondence between preoperative 3D-CT angiographic assessment of superior mesenteric vascular anatomy and operative findings during laparoscopic right hemicolectomy, supporting the reliability of detailed preoperative vascular mapping for surgical planning. In the present cohort, eight patients had a hepatomesenteric trunk accompanied by an additional variant hepatic artery, which illustrates why a single, mutually exclusive classification may underestimate the true anatomical complexity in individual patients.

Among SMA-associated hepatic arterial variants, a replaced RHA was the dominant pattern, occurring in 10.3% of this cohort. This rate is almost identical to the 10.0% reported in the large CTA series by Tokur and Bingol.² The broader literature also confirms that hepatic

arterial variation is common. Choi et al.⁴, in a combined CT and digital subtraction angiography study of 5625 patients, reported aberrant RHAs in 15.6% of patients when multiple origins and courses were included. More recently, Bingol and Celik¹ found conventional hepatic arterial anatomy in only 64.7% of 1347 CTA examinations and documented a hepatomesenteric origin of the CHA in 2.3%. These figures are not directly interchangeable with our 10.3% replaced-RHA prevalence because the definitions and arterial territories assessed differ; however, they consistently show that hepatic arterial anatomy is substantially more variable than the primary aortic origin of the SMA.

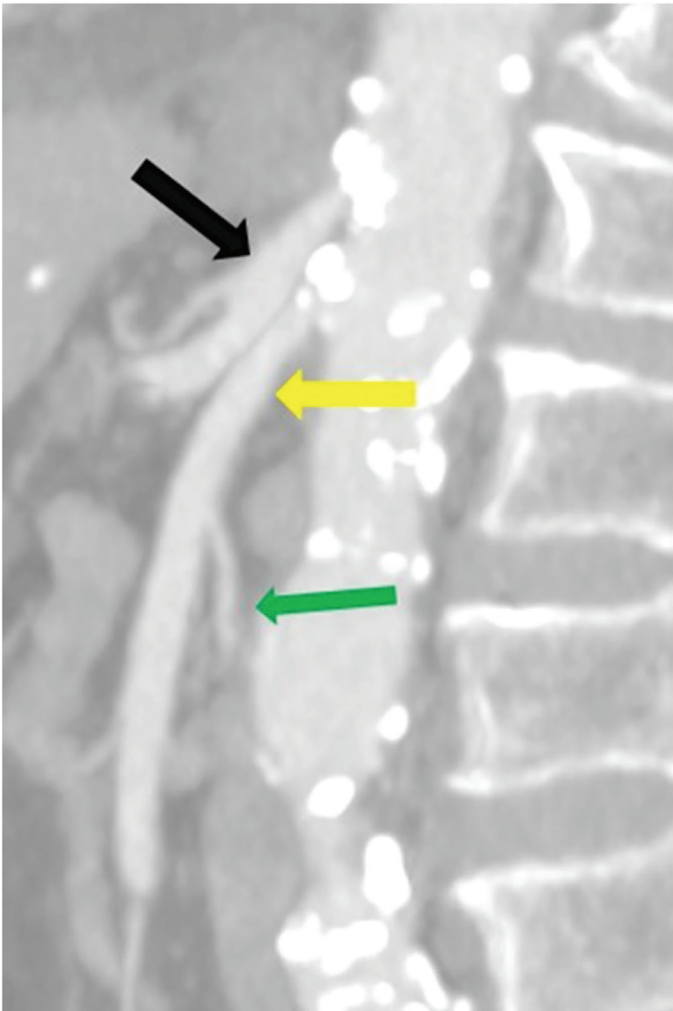


Figure 3. Classical independent origins of the major anterior visceral branches. Sagittal oblique maximum-intensity-projection CT angiography image demonstrates separate origins of the celiac trunk (black arrow), superior mesenteric artery (yellow arrow), and inferior mesenteric artery (green arrow) from the abdominal aorta

The clinical relevance of an SMA-derived RHA is particularly important in pancreatic and hepatobiliary surgery because the vessel frequently courses in close proximity to the pancreatic head, the portal venous structures, and the bile duct. Recognition before pancreaticoduodenectomy may influence the dissection strategy and the decision to preserve, reconstruct, or in selected circumstances, sacrifice the artery. A systematic review and meta-analysis by Ricci et al.¹⁰ encompassing 20 pancreaticoduodenectomy studies reported an overall aberrant RHA rate of 20.5%; although the presence of an aberrant RHA did not independently worsen major surgical or oncological outcomes, arterial injury and reconstruction were documented, emphasizing the importance of preoperative recognition and deliberate intraoperative management. Thus, the value of identifying these variants lies not in implying that every anomaly leads to complications, but in providing a vascular roadmap that permits the operative or interventional strategy to be adapted in advance.^{5,10}

IMA origin was more stable than SMA-associated hepatic branching in this population: 99.2% of patients had a classical independent aortic origin. The overall IMA origin-variation rate (0.8%) comprised three bimesenteric trunks and two IMAs arising from the SMA. This finding is concordant with previous Turkish data, in which classical IMA origin was reported in 98.4-98.5% of patients,^{2,3} and with the recent Vietnamese study reporting classical IMA anatomy in 97.4%.⁸ The 2025 systematic review and meta-analysis of IMA anatomy further demonstrated substantial variation in the level of origin and distal branching pattern, even though the artery most frequently originates around the L3 level.⁶ Our study focused on the vessel's origin rather than its distal branching morphology; therefore, the low prevalence of IMA origin anomalies should not be interpreted to indicate that the IMA system as a whole is anatomically invariant. Rare configurations such as an IMA arising from the SMA may be especially relevant in colorectal or aortic procedures because dependence on an atypical inflow pathway can change the expected pattern of colonic perfusion and collateralization.^{6,8}

A notable finding was the higher patient-level prevalence of variant mesenteric anatomy in men than in women (17.1% vs. 8.3%). The difference was driven mainly by SMA-associated variant hepatic arteries (15.4% vs. 6.6%), whereas proximal SMA- and IMA-origin variants did not differ significantly by sex. This pattern is consistent with the large series by Tokur and Bingol,² in which classical arterial configurations were more frequent in women and replaced/accessory hepatic arterial variants were more frequent in men. In their data, replaced RHA was present in 13.0% of men and 4.7% of women; in our cohort, the corresponding proportions were 13.6% and 5.0%, respectively. Nevertheless, the present results demonstrate an association rather than a biological mechanism. The observed sex association should be considered exploratory and requires validation in independent populations. Sex-related differences in arterial development remain incompletely understood, and population structure, referral patterns,

Table 3. Sex-based comparison of patient-level arterial variations			
Finding	Men (n=397)	Women (n=241)	p value
Any SMA/IMA-related variation	68 (17.1%)	20 (8.3%)	0.002
Proximal SMA variation	13 (3.3%)	4 (1.7%)	0.312
SMA-associated variant hepatic artery	61 (15.4%)	16 (6.6%)	0.001
IMA origin variation	3 (0.8%)	2 (0.8%)	1.000
P values were calculated using Fisher's exact test SMA: Superior mesenteric artery, IMA: Inferior mesenteric artery			

and sampling may contribute to observed differences. Consequently, sex should not be used to infer an individual patient's vascular anatomy; direct CTA assessment remains necessary.

No statistically significant association was identified between age and the presence of mesenteric arterial variation. This is anatomically plausible because the origin and branching pattern of major visceral arteries are primarily determined during embryologic vascular development rather than being acquired later in life. At the same time, the absence of an association between age and categorical variation should not be conflated with the absence of age-related vascular remodeling. Bingol and Celik¹ demonstrated age-related changes in several morphometric arterial parameters. Accordingly, congenital branching pattern and age-dependent vessel morphology represent related but distinct aspects of CTA vascular assessment.

From an imaging perspective, the present data support the systematic review of visceral arterial anatomy on thin-section CTA, rather than limiting interpretation to the primary clinical indication for the examination. Multiplanar reformations and three-dimensional volume-rendered images are particularly useful for verifying short common trunks and complex relationships among the SMA, hepatic arteries, and IMA. Contemporary studies using 128-slice CT and 3D reconstructions have similarly demonstrated reliable depiction of mesenteric arterial variants and clinically useful correlation with operative anatomy.^{8,9} A structured reporting approach that separately describes proximal SMA configuration, SMA-associated hepatic arterial variants, and IMA origin may therefore improve the clarity of preoperative communication.

Study Limitations

This study has several strengths. First, it evaluates a relatively large cohort of 638 CTA examinations with a dedicated focus on the SMA and IMA, rather than combining all abdominal arterial variants into a single heterogeneous endpoint. Second, the analysis deliberately separates proximal SMA trunk configurations from SMA-associated hepatic arterial variants, while preserving coexisting morphologies as independent findings. This hierarchical approach reduces conceptual overlap and avoids double-counting of a common trunk in patient-level prevalence estimates. Third, the use of thin-section CTA with multiplanar and three-dimensional reconstructions provides a detailed assessment of uncommon vascular configurations. Finally, reporting both morphology-level frequencies and patient-level prevalence, together with sex- and age-based analyses, provides complementary anatomical and demographic information.

Several limitations should also be acknowledged. First, the retrospective single-center design introduces the possibility of selection bias, as the study population consisted of patients referred for abdominal CTA and therefore is not representative of a randomly sampled general population. Extrapolation of prevalence estimates to the asymptomatic population is limited, as the CTA population was referral-based. Second, all examinations were evaluated by a single radiologist. Although the use of an experienced abdominal radiologist and multiplanar/3D reconstructions supports consistency, interobserver agreement could not be assessed. Third, CTA findings were not routinely confirmed by surgery, digital subtraction angiography, or cadaveric dissection, and very small-caliber arterial branches may, therefore, have been underdetected. Fourth, the study was designed around SMA origin, SMA-associated hepatic arterial branches, and IMA origin; it did not

systematically assess vertebral origin level, vessel diameter, origin angle, distal SMA branching, IMA branching patterns, or collateral pathways. Fifth, clinical and operative outcomes were unavailable, preventing direct assessment of the consequences of individual variants. Finally, several uncommon variants were observed in only a few patients, limiting meaningful subtype-specific statistical comparisons and necessitating descriptive interpretation of these findings. Multicenter studies with independent readers and correlation with surgical findings would be useful for validating the observed frequencies and sex-related associations in different populations.

Conclusion

In this CTA cohort, the proximal origins of the SMA and IMA were highly conserved; however, hepatic arterial variants associated with the SMA were considerably more frequent. A replaced RHA arising from the SMA was the predominant variant, and rare common-trunk configurations were readily characterized using thin-section CTA. Variant anatomy was more frequent in men, primarily due to differences in SMA-associated hepatic arterial branching, whereas age was not associated with the presence of a variation. Systematic preprocedural assessment of both mesenteric origins and associated hepatic arterial branches can provide clinically relevant vascular mapping for abdominal surgical and endovascular procedures.

Ethics

Ethics Committee Approval: Approved by the Institutional Ethics Committee of Kastamonu University Faculty of Medicine (approval number E-93763328-050.04-2600103477, date: 31.08.2026).

Informed Consent: Owing to the retrospective design, the requirement for additional written informed consent was waived.

Footnotes

Authorship Contributions

Concept: A.T.A., Design: A.T.A., Data Collection or Processing: Ö.D., Analysis or Interpretation: A.T.A., Literature Search: Ö.D., Writing: A.T.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

References

1. Bingol K, Celik E. Anatomical variations and morphometric characteristics of the common hepatic artery: a computed tomography angiography study in 1347 patients. *Surg Radiol Anat.* 2026;48:226.
2. Tokur O, Bingol K. Anatomical variations in major abdominal aortic branches and sex-related differences: a large-scale analysis of 1174 patients. *Tomography.* 2026;12:51.
3. Bingöl K, Aydın S, Memiş KB. Abdominal aorttaki anatomik varyasyonlar. *TJCL.* 2024;15:509-17.
4. Choi TW, Chung JW, Kim HC, et al. Anatomic variations of the hepatic artery in 5625 patients. *Radiol Cardiothorac Imaging.* 2021;3:e210007.
5. Malviya KK, Verma A. Importance of anatomical variation of the hepatic artery for complicated liver and pancreatic surgeries: a review emphasizing origin and branching. *Diagnostics (Basel).* 2023;13:1233.
6. Triantafyllou G, Belimezakis N, Lyros O, et al. The anatomy of the inferior mesenteric artery: a systematic review with meta-analysis. *Surg Radiol Anat.* 2025;47:144.

7. Kumamaru KK, Hoppel BE, Mather RT, Rybicki FJ. CT angiography: current technology and clinical use. *Radiol Clin North Am.* 2010;48:213-35, vii.
8. Khoa NX, Huy VT, Thai NT, Hien NX. Anatomical characteristics and variations of the abdominal aorta and its visceral branches on 128-slice computed tomography in Vietnamese adults. *Folia Morphol (Warsz).* 2026;85:e01726121.
9. Zhao B, Ding Y, Hu X, Guo P, Yu B. Assessing anatomical variations of the superior mesenteric artery via three-dimensional CT angiography and laparoscopic right hemicolectomy: a retrospective observational study. *ANZ J Surg.* 2024;94:2251-7.
10. Ricci C, Alberici L, Minghetti M, et al. The presence of an aberrant right hepatic artery did not influence surgical and oncological outcomes after pancreaticoduodenectomy: a comprehensive systematic review and meta-analysis. *World J Surg.* 2023;47:3308-18.