ORIGINAL ARTICLE

Angiographic characteristics of the intermesenteric artery

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Abstract

Purpose The literature reports the presence of the intermesenteric artery (IA), an anastomosis connecting the superior mesenteric artery (SMA) to the inferior mesenteric artery (IMA) in 9–18% of human cadaver dissections. This is the first study describing the morphological and demographic characteristics of the IA based on in vivo imaging.

Methods A total of 150 consecutive abdominal computed tomography (CT) angiographies of adult patients identified by sex and age were analyzed. The IA was assessed for its presence, point of origin, pathway, point of insertion, and diameter at its origin. The diameters of the SMA, IMA, and other arteries from which the IA originated and into which it inserted were measured by CT angiography using Radiant™ and Osirix MD™ software.

Results The IA was found in 17 (51.5%) of the females and 60 (51.3%) of the males. The diameters of the SMA and IMA were larger in the males than in the females, but there was no sex difference in the diameter of the IA. The diameter of the SMA was larger than that of the IMA, and the diameter of the IA was smaller than that of the other arteries evaluated. An IA connecting the SMA and IMA trunks was found in 25.9% of the cases, while other connections between the branches of those trunks through an IA occurred less frequently.

Conclusions The intermesenteric artery is more frequently found than the literature refers and in most of cases directly connects the upper and lower arterial mesenteric circulations.

Keywords Intermesenteric artery · Superior mesenteric artery · Inferior mesenteric artery · Villemin arcade · Angiography · Mesenteric blood flow

Introduction

According to the literature, the intermesenteric artery (IA) connecting the superior mesenteric artery (SMA) to the inferior mesenteric artery (IMA) has been found in 9–18% of human cadaver dissections [4, 7, 13, 16, 22, 23]. This communication has also been called Villemin's arch, central intermesenteric anastomosis, accessory intermesenteric artery, or intermesenteric arch [10, 17]. The term intermesenteric artery follows anatomical guidelines. The IA results from persistence of ventral segmental anastomosis between the SMA and the IMA during embryonic week 4 [15, 18].

The IA is considered to arise in the SMA. After crossing the suspensory muscle of duodenum and the duodenojejunal (Treitz) ligament, it runs under the base of the transverse mesocolon, crosses the inferior mesenteric vein, and inserts into the IMA [1, 2]. However, the literature reports that direct communication between both the mesenteric arteries is found in 5–10% of cases. An IA originating from the SMA was observed in 33% of the cases, but it was found to originate more often in the middle colic artery (44%) and the right colic artery (6%) [10, 22]. Among cadaver dissections, direct insertion of the IA into the IMA has been observed in 6% of cases, whereas IA insertion in the left colic artery occurs in 94% of corpses [22].

The direction of blood flow through the IA has been described as running from the IMA to the SMA, but without angiographic evidence [6]. Thus, in the case of an SMA obstruction, blood flow compensation for the entire small intestine and right half of the colon would rely on blood flowing from the IMA through the IA [20]. On the other hand, if there were an obstruction of the IMA, reverse blood

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flow through the IA starting from the SMA would maintain the vitality of the left half of the colon and the rectum. This impression suggests that communication through the IA prevents intestinal necrosis [5].

Knowledge about the morphology and function of the IA has been presumed based on anatomical dissections of human cadavers, but these findings have not been corroborated in vivo. A recent angiotomographic study described an artery connecting the middle colic artery, which is a branch of SMA with the left colic artery, branch of IMA. This connection between the superior and inferior mesenteric blood flows was described by Moskowitz and is found in 16.5% of abdominal angiotomographies [11].

Objective

This study describes the morphological and demographic characteristics of the IA based on in vivo imaging, considering all communications between SMA and IMA or their branches, other than the marginal artery of the colon.

Methods

Ethics

This work is part of a line of research on vascular studies and was approved by the Research Ethics Committee of the Federal University of Minas Gerais, Dossier Nr. 37762620.2.0000.5149.

Angiotomographic study

All angiotomographies were performed using a multislice CT scanner with 64 detectors (Toshiba-Aquilion). CT parameters of the abdominal angiography scan included 0.5 mm section thickness, 120 kV, 70–200 mA, 0.5 s of a gantry rotation time, and 512×512 matrix size. All patients received contrast medium intravenously through a 16–18-gauge angiographic catheter placed in the forearm vein using a mechanical injector at a flow rate of 4 ml/s, with the total volume of ranging from 1 to 2 ml/kg. Arterial phase images were obtained after a 25-s scan delay from IV contrast agent injection.

Patients

This study was performed on 150 consecutive abdominal CT angiographies of adult patients with vascular disorders (screening and surveillance), identified by sex and age. The total arterial vascularization of the entire small and large bowels was studied in DICOM tomographic images presentation uploaded to the Osirix MD™ and Radiant™

softwares. All the 150 angiographies were analyzed by authors altogether, describing all the connecting arteries between the SMA and IMA, including their branches. Analysis and measurements were performed on axial, coronal, and sagittal images for all cases. The origin pathway and insertion of each IA was completely described. The single exclusion criteria was the presence of any abdominal arterial obstruction.

Image processing

IA was considered as any communication between the SMA and the IMA or their branches, except the marginal artery of the colon. The IA was traced from its point of origin up to its point of insertion using 3D volume rendering. The diameters of the IA, SMA, and IMA were measured on both the latero-lateral and antero-posterior axes using 3D MPR. When the IA originated or was inserted in SMA and IMA branches, those diameters of those branches were measured as well. Prevalence of the IA was investigated. If present, the following were assessed: artery of origin, pathway, insertion artery, and diameter at its point of origin. In addition, the diameters were measured of the SMA, IMA, and other arteries that gave rise to the IA or into which it inserted.

Statistics

Categorical variables were expressed as frequencies and percentages. Numerical variables were expressed as the mean and standard deviation. The mean was used for those with normal distribution, and the median, with first and third quartiles, for those with non-normal distribution. The normal distribution of the numerical variables was verified by the Shapiro–Wilk test. Student's t test was used to compare the means; the Mann–Whitney U test was applied to compare the medians; and the Kruskal–Wallis non-parametric test was used to compare the median IA between two groups. Pearson's chi-squared test or Fisher's exact test was used to check for correlation between the independent categorical variables, and the chi-squared test was used with the Spearman correlation coefficient to check for correlation between the ordinal variables using SPSS software, ver. 23. The level of significance was greater than 95%, corresponding to $p < 0.05$.

Results

A total of 33 female and 117 male consecutive CT angiographies were assessed. The age of patients ranged between 63 and 76 years, with no difference between the two groups ($p = 0.684$). The IA was found in 17 (51.5%) of the females and 60 (51.3%) of the males ($p = 0.981$). Digital subtraction

angiographies were carried out in 52 of these patients due to endovascular aneurysm repair ($n = 37$) and visceral arterial disease ($n = 15$).

Table 1 shows the diameters of the IA, SMA, and IMA. The diameters of the SMA and the IMA were greater in the males than in the females, but the diameters of the IA showed no difference between genders ($p = 0.172$). The diameter of SMA was larger than that of IMA ($p < 0.001$). The diameter of the IA was smaller than that of the SMA ($p < 0.001$) and was not different from that of the IMA in females ($p = 0.214$). In males, the diameter of the IA was smaller than that of the IMA ($p = 0.023$). There was no significant difference in the diameter of the IA with respect to its origin and insertion.

Table 2 shows the points of origin and insertion of the IA. The IA connected directly to the trunks of the SMA and the IMA in 25.9% of the CT angiographies (Fig. 1), followed by connection between the middle colic artery and the IMA (23.4%). Other origins and insertions occurred in much smaller percentages.

Discussion

This is the first in vivo study of the IA using imaging exams. CT angiography showed that the IA was present in 51.3% of the patients studied, with no difference between genders.
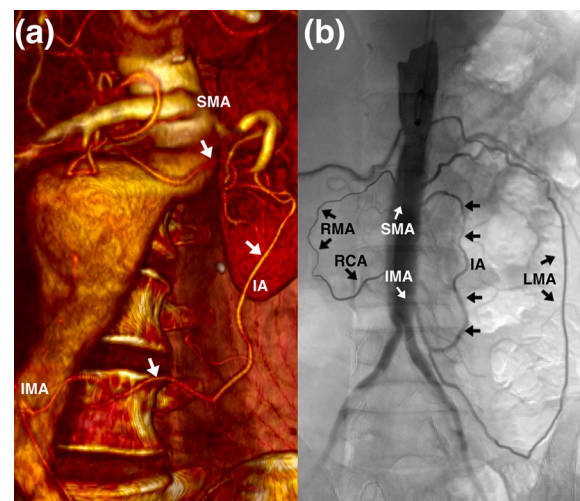

Fig. 1 Two different angiographic images of visceral arteries. **a** CT angiography showing the intermesenteric artery (IA) (arrows), the superior mesenteric artery (SMA), the inferior mesenteric artery (IMA), and their branches. Observe the IA originating from the middle colic artery and running directly to insert in the left colic artery. **b** Digital subtraction angiography showing the IA (4 arrows) originating from the SMA (arrow) and inserting in the IMA (arrow). Observe the right marginal artery (RMA) (2 arrows) originating in the right colic artery (RCA) and the left marginal artery (LMA) (2 arrows), which is originating from the IMA

This prevalence is much higher than the figures reported in the literature, which have been based solely on studies of dissected human cadavers, in which presence of the IA was reported in 9–18% of the cases [16, 22, 23].

In the in vivo imaging study, an IA originating from the SMA was found in 46% of the patients, or 33% more frequently than observed in anatomical dissection. Insertion of the IA in the IMA was 51.9% more frequent than the 6% reported in dissected cadavers [22]. The results of this study were confirmed by subtraction digital angiographies.

Table 1 Diameter (mm) and mean ± standard deviation of the intermesenteric artery (IA), superior mesenteric artery (SMA), and inferior mesenteric artery (IMA) in CT angiographies of both male and female patients

Artery	Total ($n = 150$)	Females ($n = 33$)	Males ($n = 117$)	p *
IA	2.58 ± 0.65	2.39 ± 0.58	2.64 ± 0.66	0.172
SMA	7.77 ± 1.69	6.54 ± 1.15	8.11 ± 1.66	0.001
IMA	3.23 ± 0.87	2.78 ± 0.87	3.36 ± 0.83	0.040

*p = Student's t test

Table 2 Points of origin and insertion of the intermesenteric artery (IA) in absolute numbers and percentages of 150 CT angiographies of both male and female patients

Origin → Insertion	Total ($n = 77$)	Females ($n = 17$)	Males ($n = 60$)	p*
RCA → IMA	1 (1.3)	0	1 (1.7)	0.478
MCA → LCA	15 (19.5)	3 (17.6)	12 (20.0)	
MCA → ALCA	6 (7.8)	0	6 (10.0)	
MCA → IMA	18 (23.4)	3 (17.6)	15 (25.0)	
ICA → IMA	1 (1.3)	0	1 (1.7)	
SMA → LCA	4 (5.2)	0	4 (6.7)	
SMA → ALCA	12 (15.6)	3 (17.6)	9 (15.0)	
SMA → IMA	20 (25.9)	8 (47.1)	12 (20.0)	

RCA right colic artery, *IMA* inferior mesenteric artery, *MCA* middle colic artery, *LCA* left colic artery, *ALCA* ascending branch of left colic artery, *ICA* ileocolic artery, *SMA* superior mesenteric artery

*p = Fisher's test

Contrary to the IA blood flow described in the literature, this study indicates that blood flow through the IA must run from the SMA, which has a larger caliber, to the IMA. Therefore, blood from the SMA may partially supply the IMA territory and prevent ischemia of the left half of the colon and rectum, which is an extremely rare event [6, 20].

The presence of the IA in more than half the population may explain the low incidence of intestinal necrosis (0.09–0.2% of all emergency service admissions), despite the high incidence of SMA thromboembolism (8.6 per 100,000 population) and an embolism / thrombosis ratio of 1.4 [1, 3, 5, 8]. When an SMA obstruction occurs, reverse flow from the IMA to the SMA territory through the IA, due to reduced blood pressure in the SMA and its branches, is able to supply the entire small bowel and the right half of the colon [5, 8].

The difficulty in identifying the IA in anatomical studies on human cadavers could be explained by its tortuous path in most cases and its variation from one individual to the next characteristics that can be visualized in CT angiography (Fig. 1). The IA frequently passes through the splenic flexure of the colon before inserting in the IMA. The origin and insertion points of the IA in the SMA and IMA or their branches are sometimes difficult to identify, even in 3D CT angiographies. The challenge to identify the IA is greater in studies based on dissected cadavers and may account for the lower incidence of the IA described in the literature compared with the present work (Fig. 1b).

Another existing communication between the SMA and the IMA is through the marginal arch of the colon, described by Albrecht von Haller in 1743 based on studies by the French anatomist Jean Riolan (1580–1657) [2, 12, 14, 19, 21]. This arch, sometimes called the Drummond arcade, runs along the border of the entire colon, and may connect branches originating from the SMA and the IMA. The connection occurs in the distal part of the transverse colon, which corresponds to the embryonic transition between the middle and caudal intestines. Branches of the middle and left colic arteries may be connected, but their calibers are very small and the blood flow through these vessels is not sufficient to maintain the viability of the intestine in event of an SMA or IMA obstruction [9, 12].

The marginal arch, which is longer, more distal, and parallel to the colon, should not be mistaken for the IA. During invasive angiography, selective SMA branch catheterization is often performed by introducing the catheter through the IMA ostium. Although many professionals consider introducing the catheter through the arc of Riolan or marginal artery of Drummond, in reality, it follows a much shorter and more direct route through the IA. This misinterpretation is due to limited knowledge of IA morphology, which is rarely described in the vascular anatomy of the abdomen.[4]

There is also communication between the ascending branch of the left colic artery and the middle colic artery, which corresponds to an arch from the transverse colon to the sigmoid and is present in 63% of the population [10, 12]. Because of its small caliber, this arch is only able to supply a small part of colon in event of an arterial obstruction [12].

This study did not investigate the diseases of the patients who underwent CT angiography. However, there was no cases of arterial obstructive disorder, which was the exclusion criteria. This was an anatomical assessment of an abdominal artery, characterized exclusively by its morphological aspects unrelated to any illness.

Conclusion

The intermesenteric artery is more frequently found than the literature refers and in most of cases directly connects the upper and lower arterial mesenteric circulations.

Author contributions GCdMM: Project development, Data Collection, Data analysis, Manuscript writing, Ethics Committee submission. LGR: Project development, Data Collection, Data analysis, Manuscript writing, Ethics Committee submission. TPN: Project development and Protocol, Ethics Committee submission, Data analysis, Manuscript revision, Manuscript approval. APe: Conceived the project, Project development and Protocol, Manuscript writing, Manuscript revision, Manuscript approval wrote, Manuscript submission for publication.

Data availability statement All data used in this work are available for verification upon request.

Declarations

Conflict of interest All authors declare no conflict of interest.

Ethical statement This work was approved by the Research Ethics Committee of the Federal University of Minas Gerais, Dossier No. 37762620.2.0000.5149. Written informed consent was not required.

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