"OVIDIUS" UNIVERSITY CONSTANŢA

FACULTY OF MEDICINE

DEPARTMENT OF PRECLINICAL DISCIPLINES

VASCULAR TERRITORIES OF THE INFERIOR MESENTERIC VEINS

- PhD THESIS SUMMARY -

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INTRODUCTION

The mesenteric circulation, receiving approximately one third of the cardiac flow and being one of the main sanguine reservoirs of the body, has a special role in the physiologic hemodynamics. The reduction of the arterial or venous circulation at the colon level produces a series of various disorders, related to the installation speed of the diminution or removal of irrigation, by the dimensions of the vascular section in case and the compensation capacity of the vascular deficit through the existent anastomotic vascular branches. The arterial mesenteric circulatory insufficiency generates acute or chronic intestinal disorders. For a long period of time, the enteromesenteric infarct was considered as a unique intestinal pathological vascular manifestation. On the basis of clinical observations, of necroptic statistics related to the morphopathological status of the mesenteric vessels, as well as on the basis of some observations obtained by the study of selective angiographies, other mesenteric vascular pathological forms with intestinal manifestations individualized, such as, for example, the colic ischemic lesions. The intestinal acute ischemia is an abdominal emergency which must be differentiated from other entities, such as pan-peritonitises produced by the perforation of cavity organs. The mesenteric acute ischemia is often lethal, and the intrahospital mortality rate remained increased in the last 20 years within 60-80%. Even if the mesenteric acute ischemia represents only 1-2% of the totality of gastrointestinal diseases, its incidence increased considerably lately. There is a paradox in what concerns the cardiovascular surgeons and general medicine physicians who, even if they are much more familiarised to these abdominal emergencies compared to gastroenterologists, they probably come upon a lot of difficulties in establishing the diagnosis of intestinal acute ischemia in patients submitted to cardiovascular interventions or to haemodialysis. Because of the rare incidence of the acute mesenteric ischemia, it has been underestimated and a clinical guide for the diagnosis and treatment based on the evidence of randomized trials has been established.

The development of vascular explorations means and especially the selective angiography, the colour Doppler ultrasound, the magnetic resonance and computed tomography allow the precise diagnosis of exact location of the vascular obstructive process and

the extinction of the intestinal sector affected by ischemia which for a long period of time could be specified only during exploration laparatomy or after necropsy.

The interest for the knowledge of these intestinal vascular disorders increased with the development of the development of the vascular surgery which allowed the performance of certain interventions which have as purpose the revascularization of the affected territory.

The interpretation of images obtained by imagistic methods and the establishment of the diagnostic, the appropriate therapeutic attitude which must be preferred, as well as the best performance of the surgical intervention, when needed, require a good knowledge of the normal anatomy of the intestinal vascularisation, of morphological variations which it might produce, of the existing anastomoses between the branches of the mesenteric arteries or with the branches of the vicinal arteries, as well as the organic territory served by the two mesenteric arteries and their collateral or terminal branches.

When a surgeon operates on the colon, for a relatively great resection, which also includes the sectioning of a more voluminous arterial branch, he often confronts with different anatomic vascular variations, sometimes different from those described as standards in specialty books.

The mortality rate in pathological intestinal emergencies in the last 15-20 years is of approximately 71%. Once the infarction of the intestinal wall is installed, the mortality rate can be greater than 90%. The patients surviving after a large erectomy confront themselves with a long-term significant morbidity due to a reduced absorption surface. The early recognition and treatment of the non-conclusive entero-mesenteric ischemia leads to the reduction of mortality up to 50-55%. The success of the surgical intervention requires a good knowledge of the colon, its vascularisation having a basic role. This is because the number, the topography, the origin, the tract, the anastomoses and the distribution of colic arteries has such a variety that you might come to wonder if the so-called normal situation really exist. Mayo asserted that “there are not two persons whose blood vessels be identical”, and Sonneland, following his researches on colon vascularisation, reached to the conclusion that “it is established that these variations of the classical models are a rule and not an exception”. This explains why even at present there are contradictions, sometimes major, related to the origin,

distribution, number and even the name of the collateral and terminal branches of the mesenteric arteries, and especially of the branches of the inferior mesenteric artery.

From the extremely rich literature covering this subject and from what I observed from the studied cases related to the distribution of the inferior mesenteric artery, I am the adept of Dufour, who said that “these are not anomalies, but only different types of vascularisation”.

In the specialty literature, the study on inferior mesenteric vessels spreads on over four centuries, the study dedicated to the inferior mesenteric artery being much vaster than the study related to the inferior mesenteric vein, for which a very restricted space was granted. The discoveries being published are sometimes very different even when identical research methods are used.

Accordingly, it is very difficult, even impossible, to make a unique and definitive description of this vascular segment composed of very frequent variations. A lot of authors tried to classify the most common variations of the vascularisation by drawings, photos of the anatomic materials injected and dissected or injected and corroded, and in the last period, by the interpretation of the modern imagistic examinations.

We remark especially the contributions of Sudeck (who might be considered the leader of the modern authors), Mondor, Rubesch, Drummond, Mayo, Sonneland, Dufour, Pikkieff, Steward, Rankin, Balice, Basmajian, Bickham, ImperatI, Tommaseo, Guyader, Martin, Guntz etc.

In order to illustrate the variability of the colon vascularisation, the modern scientific surgical treaties resort to the drawings published centuries ago, from those of Haller up to those of Quain, against the availability of more recent and more systemized researches.

We should note that a large number of anatomists contributed to the study of mesenteric vessels and the German school and especially the French one were distinguishable in particular. Their careful dissections and observations have been carried out with great scrupulousness and endeavour, even if, for each author, they were performed on a limited number of pieces. After a number of observations, there was established a standard based on the most frequent anatomic variations. Actually, these discoveries were often in disagreement with the results of the precursors, for whom the conclusions were the result of researches

on a limited number of cases. Later, the anatomists were completed by the surgeons, because the last had access to new methods of visualization and a rich clinical material for study, and subsequently, new results were brought by the radiologists. Nevertheless, while the methodology used by radiologists, as the selective arteriography, offers high accuracy anatomic details, the surgeon cannot trace and control the vascular tree out of the limits permitted by the operator field. Moreover, the radiological representation of the vascular anatomy is the only bidimensional analysis and, recently, tridimensional, despite of the modern equipment.

I believe that my research may be useful to surgeons and radiologists by the great variety in number, tract and anastomoses of the inferior mesenteric vessels and their branches, illustrated after this study carried out on the arterial-venous vascularity of the left colon and of the superior section of the rectum.

Researches show the necessity for a surgeon to know the manner of distribution of colic vessels of the patient, before he is submitted to a large colon resection, especially if the restitution of the colon continuity is requested.

The thesis begins with a short history of the study of mesenteric vessels, in order to point out the interest of anatomists, but also of the surgeons, in the study of this vascular sector. In order to be able to explain and understand the occurrence of certain morphological variations of the mesenteric vessels, at the beginning of the chapters on the anatomy of the inferior mesenteric artery and vein, the embryological development of these vessels is shortly presented. Next, we describe the anatomy of the inferior mesenteric vessels (artery and vein) on humans, having as model the classical descriptions carried out in the anatomy treaties of Testut, Rouvière, Paturet, Gray, but also from more recent treaties, such as those of Chevrel and Putz and from many studies and articles published in the specialty magazines that I had the possibility to consult. There are presented: the origin, the tract and relations, the collateral and terminal branches, the anastomoses, the served visceral territories, as well as the anatomic variations that the inferior mesenteric vessels might present.

The personal section of the thesis includes first the presentation of the work material and the methods, after which I present the results of the morphological results obtained after the performance of this study on a number of approximately 300 cases. The various work methods used offered me the possibility to

compare and correlate the results, as well as to obtain a very qualitative personal iconography.

In chapter of discussions, there are made comparisons with the results obtained by other authors who approached the study of inferior mesenteric vessels, classical authors, as well as more recent authors, following their literary works that I had the possibility to consult.

In the chapter of conclusions, there are made a series of mentions on the morphological and surgical importance of the study undertaken on arterial-venous vascularisation of the colon, with the scope of explaining, at the same time, the causes of the eventual differences, sometimes considerable, between the personal results and the literary data.

The personal results have been developed by scientific communications presented at various national and international manifestations: The Congress of the Romanian Society of Anatomy (2011, 2012, 2013), The Congress of the Montpellier French Society of Morphology of 2011, The Congress Anatomische Gesellschaft of 2012 Frankfurt and 2013 Magdeburg, the summaries of the works presented being published in the volumes of those manifestations, but also in ISI magazines (Anatomy, Germany and Surgical & Radiologic Anatomy, of Springer-Verlag Publishing House). I mention the two works published in extenso in the Romanian Magazine of Functional and Clinical, Macro- and Microscopic Anatomy and of Anthropology, the first published in the no. 4, 2012 and the second in no. 1, 2013.

I express my sincere gratitude to Mister Ph. D. Professor Bordei Petru, the scientific coordinator of my Ph.D. thesis, who granted me his precious support in obtaining the morphological results of the inferior mesenteric vessels and who offered me his permanent coordination, directing me competently during the whole period I prepared my PhD thesis.

I would also like to express my profound gratitude to the members of the anatomy department of the Constanţa Medicine Faculty, who helped me in the elaboration of the practical part of the thesis and to the members of the imagistic services within the Constanţa County Emergency Clinical Hospital (*Pozimed*, directed by Mister university lecturer Baz Radu and *Medimar*, directed by Mrs. Dr. Bărdaş Mariana), who made available for me to consult ultrasounds, NMRs, simple angiographies or computed tomographies-angiographies.

WORK MATERIAL AND METHODS

The study on the arterial-venous vascularisation of the left colon has been carried out on a total number of 298 cases, of which 209 cases were for the inferior mesenteric artery and 89 cases for the inferior mesenteric vein.

Of the 209 cases of mesenteric arteries traced, 29 were on fresh and fixed in formalin human foetuses, whose age was between 4 and 9 months; 21 on human corpses dissected in the dissection room of the anatomy laboratory of the Constanţa Medicine Faculty; 7 were on organic eviscerated sub diaphragmatic blocks (digestive tract, liver, spleen, kidneys, aorta and inferior vena cava), collected at the Legal Medicine Service of Constanţa, of which 3 were dissected and 4 injected by plastic, followed by corrosion; 72 abdominal aortic angiographies and 89 computed tomographies-angiographies were also consulted.

Of the 89 cases of inferior mesenteric veins I studied, 28 were on human foetuses, 21 on adult human corpses, 4 were on eviscerated organic blocks and 36 cases on computed tomography images.

The angiographies that I could examine came from the Pozimed Diagnosis Centre, being performed on a tomography computer GE LightSpeed VCT64 Slice CT. I also had at my disposal angiographies performed at the Medimar Explorations' Centre within the Emergency Clinical Hospital of Constanţa, being performed on a tomography computer GE Light Speed 16 Slice CT.

PERSONAL RESULTS AND DISCUSSIONS

INFERIOR MESENTERIC ARTERY

ORIGIN

The origin of the inferior mesenteric artery was studied on 161 cases represented by simple abdominal aortic angiographies and computed tomographies angiographies, being performed in relation to the spinal cord, as well as in relation to the branches of the abdominal aorta: the celiac trunk, the superior mesenteric artery, the renal arteries (right and left) and the terminal bifurcation of the abdominal aorta. There were also monitored: the level of the artery detachment from the anterior side of the aorta, in relation to its median plane; the tract of the inferior mesenteric artery in its initial portion near the origin; the aspect of the inferior mesenteric artery on the whole, from the origin up to the origin of the superior rectal artery.

In relation to the spinal cord, the origin of the inferior mesenteric artery was traced on 124 cases, founding it comprised between the upper 1/2 of the L2 vertebra and the lower part of the L4 vertebra.

At the level of the L2 vertebra 16 arteries has their origin (12,90% of cases). At the same time, in 16 cases (12,90% of the cases), the inferior mesenteric artery had its origin at the level of the intervertebral disk L2-L3. The most frequent, in 70 cases (56,45% of the cases), the origin of the inferior mesenteric artery was situated at the level of the L3 vertebra. At the level of the intervertebral disk L3-L4, 18 arteries had their origin (14, 52% of the cases), and at the level of the L4 vertebra, a 4 arteries had their origin (3, 23% of the cases).

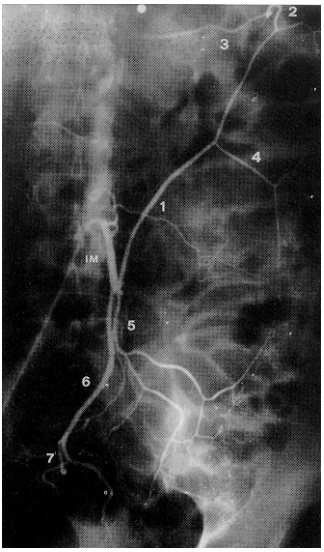


Fig. 26. The origin of the inferior mesenteric artery at the level of the inferior margin of the L2 vertebra.

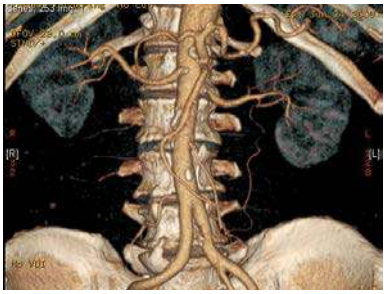


Fig. 27. The origin of the inferior mesenteric artery at the level of the intervertebral disk L2-L3.

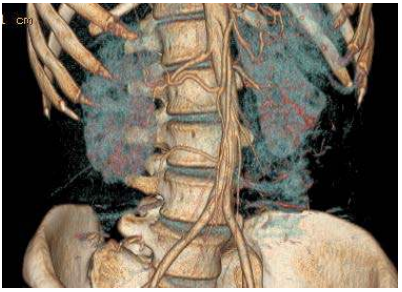


Fig. 28. The origin from the aorta of the inferior mesenteric artery situated at the level of the ½ upper part of the L2 vertebra.

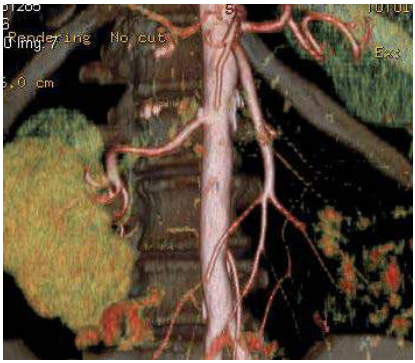


Fig. 32. The origin of the inferior mesenteric artery at the level of the intervertebral disk L3-L4.

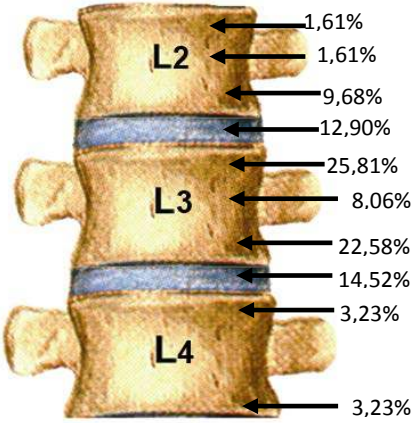


Fig. 33. The origin of the inferior mesenteric artery in relation to the spinal cord

The distance between the origin of the inferior mesenteric artery and the origin of the celiac trunk was found between 75,7 mm and 87,4 mm, between the origin of the superior and inferior mesenteric arteries was comprised between 58,8 mm and 77,6 mm, between the origin of the inferior mesenteric artery, the right renal artery was of 53,2 – 73,3 mm, between the origin of the inferior mesenteric artery and the origin of the left renal artery we found a distance of 43,9-57,1 mm, and between the origin of the inferior mesenteric artery in relation to the terminal bifurcation of the aorta, we found a distance of 30-40 mm.

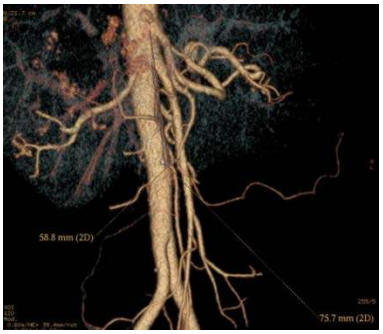


Fig. 34. The distance between the origin from the aorta of the inferior mesenteric artery and the origin of the celiac trunk is of 75,7 mm, and from the origin of the superior mesenteric artery is of 58,3 mm.

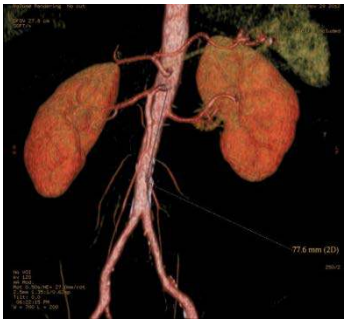


Fig. 35. The distance between the origin from the aorta of the inferior and superior mesenteric arteries is of 77,6 mm.

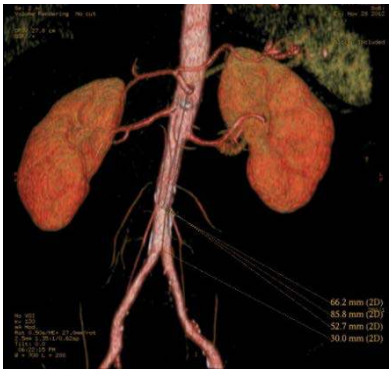


Fig.36. The distance between the origin of the inferior mesenteric artery and the celiac trunk, the renal arteries and the terminal bifurcation of the aorta.

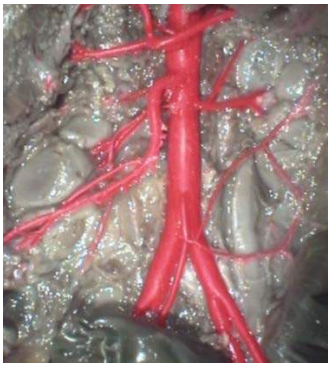


Fig. 41. The origin of the mesenteric artery on the median line of the anterior side of the aorta, the artery having a vertical and rectilinear tract up to its terminal bifurcation.

The inferior mesenteric artery detaches from the anterior side of the abdominal aorta, in 112 cases (86, 15% of the cases) at the left of the median line of the aorta, in 14 cases (10, 77% of the cases) the origin of the artery was situated on the median line of the aorta, and only in 4 cases (3, 08% of the cases) the inferior mesenteric artery has its aortic origin at the right of its median line.

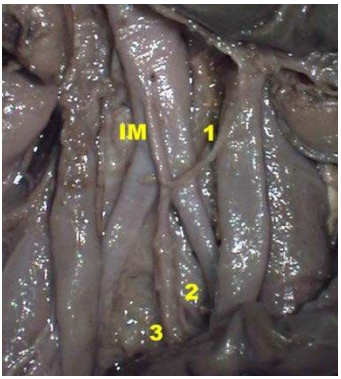


Fig. 42. The origin of the inferior mesenteric artery is situated at the right of the median line of the abdominal aorta, the artery not leaving the anterior side of the aorta. . IM. The inferior mesenteric artery; 1. The left colic artery; 2. The sigmoidian trunk; 3. The superior rectal artery.

TABLE NO. 2 - THE ORIGIN OF THE INFERIOR MESENTERIC ARTERY IN RELATION TO THE SPINAL CORD

AUTHOR	THE LEVEL OF THE ORIGIN
Adachi	1/3 inf L2-1/3 inf L4
Paturet	inf.end L3
Rouvière	L3,disk L3-L4, L4
Pillet	L3
Gray	L3
Lippert-Pabst	1/3 inf L3
Pennington	1/3 inf L3
Kamina	disk i.v. L3-L4
Dahmani	disk i.v. L3-L4
Personal cases	1/2 sup. L2 - inf. end L4

TABLE NO. 3 – THE ORIGIN OF THE INFERIOR MESENTERIC ARTERY IN RELATION TO THE MEDIAN LINE

AUTHOR	THE LEVEL OF THE ORIGIN
Testut	at the left of the median line
Paturet	at the left of the median line (occasionally)
Rouvière	at the left of the median line
Pillet	at the left of the median line
Gray	at the left of the median line
Dahmani	at the left of the median line
Personal cases	- at the left of the median line: 86,15%; - on the median line: 10,77%; - at the right of the median line: 3, 08%.

TABLE NO. 4 - THE ORIGIN OF THE INFERIOR MESENTERIC ARTERY IN RELATION TO THE AORTIC ORIGIN OF THE SUPERIOR MESENTERIC ARTERY, OF THE RENAL ARTERIES AND OF THE TERMINAL BIFURCATION OF THE AORTA.

AUTHOR	DIST. FROM THE SUP. MES. A.	DIST. FROM THE REN. A.	DIST. FROM THE AORTIC BIF.
Paturet	70-80 m	-	40-50 mm
Rouvière	-	-	40-50 mm
Okinczyc	-	-	30-40 mm
Testut	-	-	50-60 mm
Gray	-	-	30-40 mm
Pennington	-	56+/-10 mm	-
Pillet	-	56,8+/-10 mm	30-40 mm
Kamina	-	-	40 mm
Dahman	-	-	50 mm
Personal cases	58,8- 77,6 mm	53,2-73,3 mm right 43,9-73,3 mm left	30-40 mm

TABLE NO. 5 - THE ORIGIN OF THE INFERIOR MESENTERIC ARTERY IN RELATION TO THE DUODENUM

AUTHOR	THE LEVEL OF THE ORIGIN
Adachi	post. duodenum III, frequent in the lower part
Rouvière	post. duodenum III
Paturet	post. duodenum III
Gray	post. duodenum III, sparsely in the lower part
Pillet	post. duodenum III
Personal cases	post. duodenum III: most frequent; more frequent retro pancreatic; more sparsely lower duodenum III.

TABLE NO. 6 – THE CALIBRE OF THE ARTERIAL DIGESTIVE TRUNKS IN COMPARISON TO THE AORTIC ORIGIN

AUTHOR	DIAMETER OF THE CELIAC TRUNK	DIAMETER OF THE SUPERIOR MESENTERIC ARTERY	DIAMETER OF THE INFERIOR MESENTERIC ARTERY
Paturet	5-8 mm	8-9	4-5 mm
Gray	-	-	4,5 mm
Pennington	7,6 +/- 2mm	9,1 +/- 2mm	4,5 +/-1 mm
Kamina	7 mm	8-9 mm	5 mm
Dahmani	-	-	4 mm
Personal cases	5-12,5 mm	5,7-10,2mm	2,7-4 mm

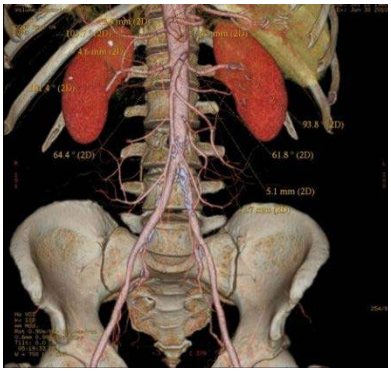


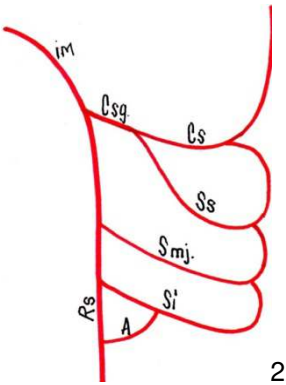
Fig.44. The calibre of the inferior mesenteric artery in comparison to the calibre of the other visceral branches of the abdominal aorta.

COLLATERAL AND TERMINAL RAMIFICATION OF THE INFERIOR MESENTERIC ARTERY

Following the termination mode of the inferior mesenteric artery and the detachment mode of its collateral branches on a number of 127 cases, I described the superposed detachment of its collateral branches, the termination by bifurcation and the termination by trifurcation. These variations of ramification of the inferior mesenteric artery explain the origin variations of the colic, sigmoid and upper rectal arteries.

I have found ***the superposition of the collateral branches*** of the inferior mesenteric artery in 88 cases, describing more variations:

1. the colosigmoid trunk in which the left colic and superior sigmoid arteries have their origin, under which the middle and inferior sigmoid arteries have their origins separately from the inferior mesenteric, aspect found in 28 cases (22,05% of the cases);



22.83%

Fig.48. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

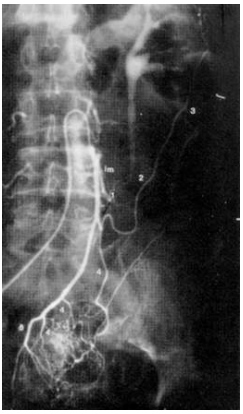
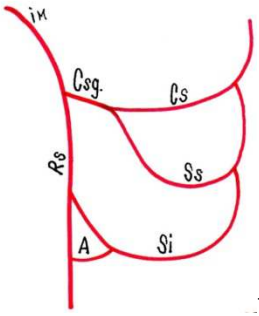


Fig. 49. Superior sigmoid artery with its origin in colosigmoid trunk and middle and inferior sigmoid arteries with their origins in the inferior mesenteric a.: im. inferior mesenteric a.; 1. Colosigmoid trunk; 2. left colic a.; 3. Left colic a.; 4. Sigmoid aa.; 5. Superior rectal a..

2. Colosigmoid trunk in which the left colic and superior sigmoid arteries have their origins, the inferior sigmoid having its origin in the inferior mesenteric, aspect found in 21 cases (16, 54% of the cases);



16.54%

Fig.50. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Ss: superior sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

These variant is described by (2) in a percentage of 30% of the cases.

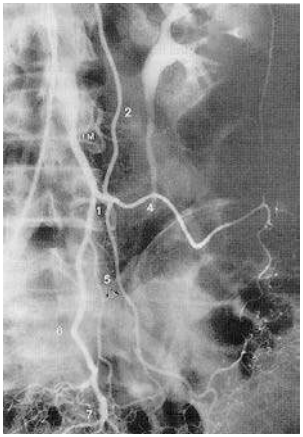
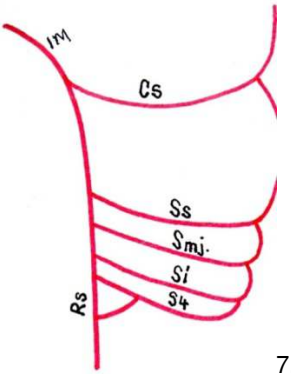


Fig.51. From the inferior mesenteric artery detach: a colosigmoid trunk from which are formed the left colic and superior and inferior sigmoid arteries. IM: inferior mesenteric a.; 1.the colosigmoid trunk; 2. the left colic a.; 4. the superior sigmoid a.; 5. the middle sigmoid a.; 6. The inferior sigmoid a.; 7. The superior rectal a. terminated by trifurcation.

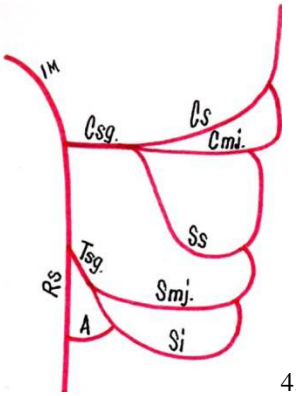
3. Under the left colic artery, separated from the inferior mesenteric artery, four sigmoid arteries have their origin, aspect found in 9 cases (7, 09% of the cases);



7.09%

Fig.52. IM: inferior mesenteric; Cs: left colic; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; S4: the fourth sigmoid artery; Rs: superior rectal; A: recto-sigmoid anastomosis.

4. colosigmoid trunk in which the left colic and the middle and superior sigmoid arteries have their origin, the middle and inferior sigmoid arteries having their origin in a sigmoid trunk with the origin in the inferior mesenteric artery, aspect found in 6 cases (4,72% of the cases);



4.72%

Fig.53. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Cs: middle colic; Ss: superior sigmoid; Tsg: sigmoid trunk; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

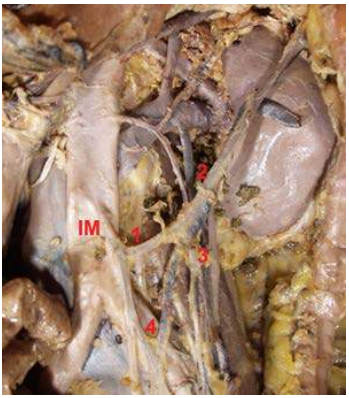
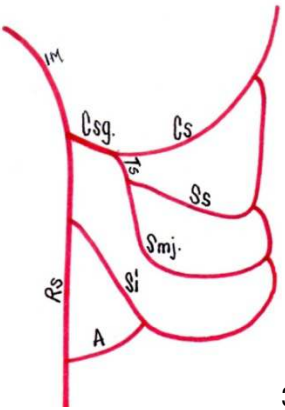


Fig.54. From the inferior mesenteric artery are formed a colosigmoid trunk (1) from which are detached the left colic aa. (2), and the superior sigmoid (3) and a sigmoid trunk (4), which form the middle and inferior sigmoid aa.; IM: inferior mesenteric a..

5. Colosigmoid trunk in which the left colic, middle and a sigmoid trunk which form the superior and middle sigmoid arteries, the inferior sigmoid having its origin in the inferior mesenteric artery, aspect found in 5 cases (3, 94% of the cases);



3.94%

Fig.55. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Ts: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

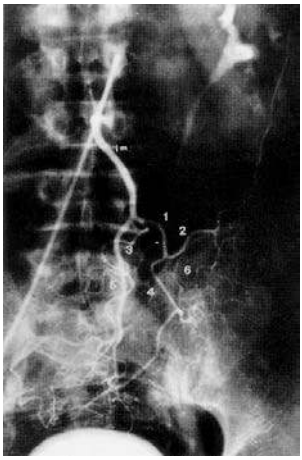
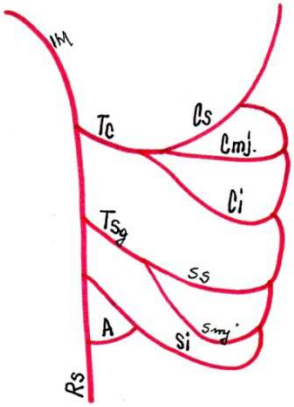


Fig. 56. The superior and middle sigmoid arteries with their origin in the colosigmoid trunk: im. inferior mesenteric a.; 1. colosigmoid trunk; 2. Left colic artery; 3. Inferior sigmoid a.; 4. sigmoid trunk from which detach the superior and middle arteries; 5. Superior rectal a.; 6. Vascular arcade.

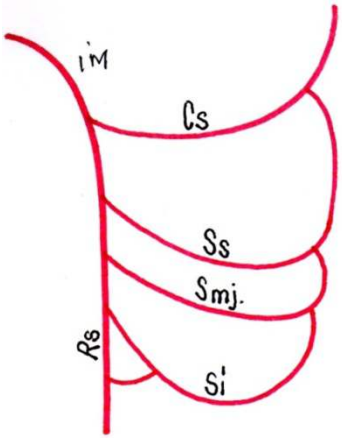
6. Colic trunk in which the left colic, middle and inferior arteries have their origin, a un sigmoid trunk in which the superior and middle arteries have their origin, the inferior sigmoid having its origin in the inferior mesenteric artery, aspect found in 4 cases (3,15% of the cases);



3.15%

Fig.57. IM: inferior mesenteric; Tc: colic trunk; Cs: left colic; Cmj: middle colic; Ci: inferior colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

1. Left colic with its origin in the inferior mesenteric, the three sigmoid arteries having their origin under it, directly from the inferior mesenteric, aspect found in 4 cases (3,15% of the cases);



3.15%

Fig.58. IM: inferior mesenteric; Cs: left colic; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

This variant is described by (2) in 25% of the cases, but only with two sigmoid arteries.

2. The left and middle colic arteries have their origin separately, directly from the inferior mesenteric, a sigmoid trunk having its origin under the middle colic artery, from which the three sigmoid have their origin, aspect found in 3 cases (2,36% of the cases);

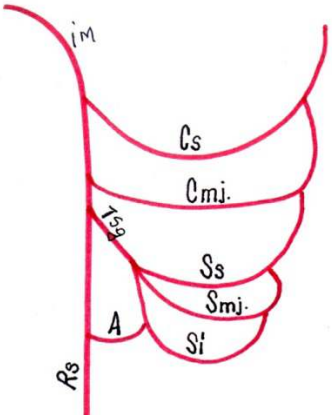


Fig.59. IM: inferior mesenteric; Cs: left colic; Cmj: middle colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

2.36%

9. colic trunk bifurcated in the left colic and middle arteries, under which a sigmoid trunk has its origin, which form the three sigmoid arteries, aspect found in 3 cases (2,36% of the cases);

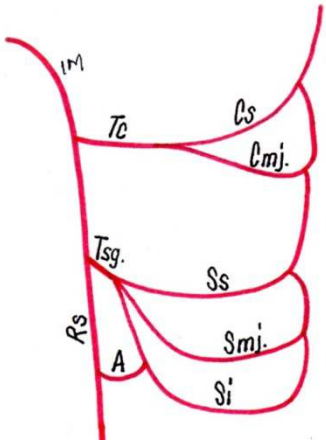
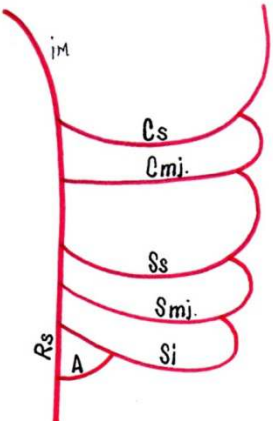


Fig.60. IM: inferior mesenteric; Tc: colic trunk; Cs: left colic; Cmj: middle colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

2.36%

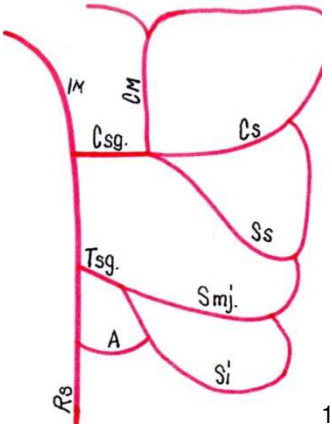
10. The left colic and middle arteries and the three sigmoid arteries have their origin separately in the inferior mesenteric artery, aspect found in 2 cases (1,58% of the cases);



1.58%

Fig.61. IM: inferior mesenteric; Cs: left colic; Cmj: middle colic; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

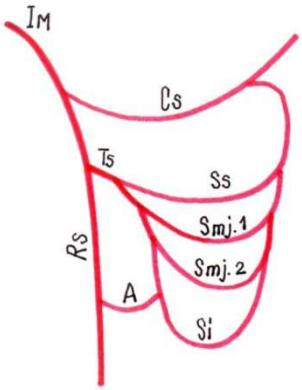
11. colosigmoid trunk in which the middle and left colic arteries and the superior sigmoid artery have their origin, under which a sigmoid trunk has its origin, which form the superior and inferior sigmoid arteries, aspect found in 2 cases (1,58% of the cases);



1.58%

Fig.62. IM: inferior mesenteric; Csg: colosigmoid trunk; CM: middle colic; Cs: left colic; Ss: superior sigmoid; Tsg: sigmoid trunk; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

12. Only in one case (0, 79% of the cases), under the left colic a sigmoid trunk was forming, from which 4 sigmoid arteries were detaching.



0.79%

Fig.63. IM: inferior mesenteric; Cs: left colic; Ts: sigmoid trunk; Ss: superior sigmoid; Smj 1, 2: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

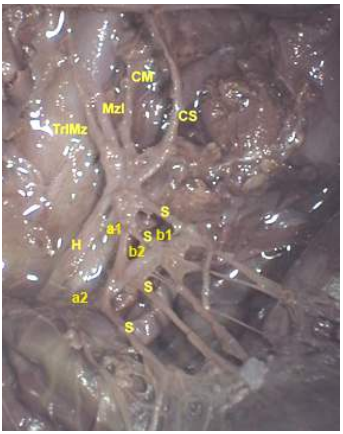
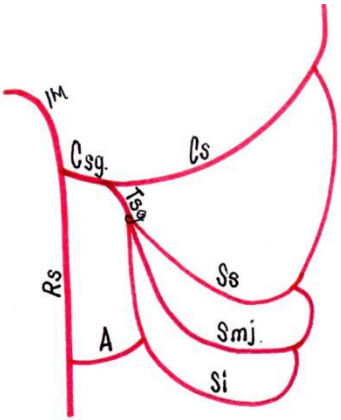


Fig.64. In the inferior mesenteric artery have their superposed origins the middle and left colic arteries, the sigmoid trunk, which form four sigmoid arteries and the superior rectal artery: MzI: inferior mesenteric a.; CM: middle colic a.; CS: left colic a.; H: superior rectal a.; S: 4 sigmoid aa.; a1: anastomosis between the sigmoid trunk and the superior rectal a.; a2: anastomosis between the inferior sigmoid a. and the superior rectal a.; b1, b2: anastomoses between the sigmoid arteries.

I found the terminal ***bifurcation*** of the inferior mesenteric artery in 29 cases (22, 84% of the cases), forming the colosigmoidian trunk (from which the left colic artery and the sigmoid arteries are detaching) and the superior rectal artery. In relation to ramification mode of the colosigmoid trunk, I found three variants:

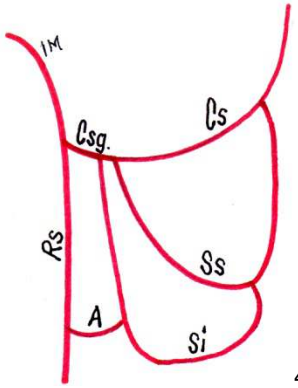
1. the colosigmoid trunk splits in the superior colic and the sigmoid trunk, which gives birth to the three sigmoid arteries, aspect found in 20 cases (15,75% of the cases);



15.75%

Fig.65. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

2. colosigmoid trunk which gives birth to the superior colic artery and to the superior and inferior sigmoid arteries, existing only two sigmoid arteries, variant found in 6 cases (4,72% of the cases);

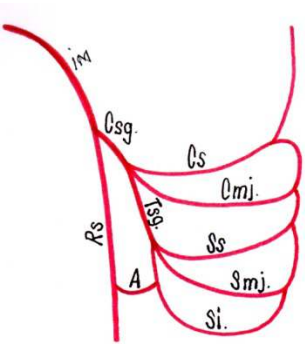


4.72%

Fig.66. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Ss: superior sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

This variant is found at (2) in 9% of the cases.

3. colosigmoid trunk ramified in the left and middle colic arteries and the sigmoid trunk, which gives birth to the three sigmoid arteries, aspect found in 3 cases (2,36% of the cases);



2.36%

Fig.67. IM: inferior mesenteric; Csg: colosigmoid trunk; Cs: left colic; Cmj: middle colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

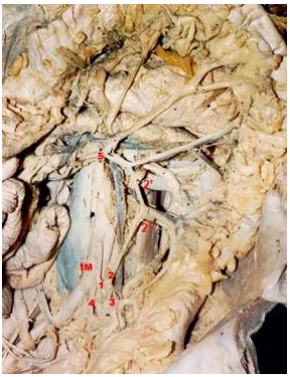
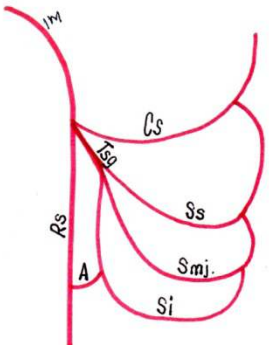


Fig.68. Colosigmoid trunk from which the left and middle left colic arteries and the sigmoid trunk are detaching, which gives birth to the three sigmoid arteries. IM. inferior mesenteric a.; 1. colosigmoid trunk; 2. Colic trunk from which are formed the left colic (2') and middle (2'') arteries; 3. sigmoid trunk from which are formed the three sigmoid arteries; 4. The superior rectal a.; 5. The left branch of the left colic a..

I found the ***trifurcation*** in 10 cases (7, 87% of the cases), the inferior mesenteric artery ending with the left colic artery, the sigmoid trunk (which gives birth to the three sigmoid arteries) and the superior rectal artery. In the trifurcation cases, three variants can be met: 1. Three branches of the same calibre can be formed; 2. Two branches of the same calibre and one of smaller calibre are formed, which can be the sigmoidian trunk, or, more scarcely, the colic trunk; 3. Three branches of different calibres are formed.



7.87%

Fig.69. IM: inferior mesenteric; Cs: left colic; Tsg: sigmoid trunk; Ss: superior sigmoid; Smj: middle sigmoid; Si: inferior sigmoid; Rs: superior rectal; A: recto-sigmoid anastomosis.

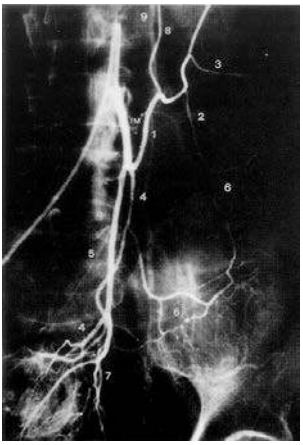


Fig. 70. Sigmoid trunk with its origin by the trifurcation of the inferior mesenteric artery: IM. inferior mesenteric a.; 1. Left colic a.; 3. Middle colic a.; 4. Sigmoid trunk; 5. Superior rectal a.; 6. The arterial arcade; 7. The posterior rectal a.. 8. The superior branch of bifurcation of the left colic a.; 9. The inferior mesenteric vein.

This variant of the inferior mesenteric artery (terminal trifurcation of the artery) is found at (2) in 25% of the cases.

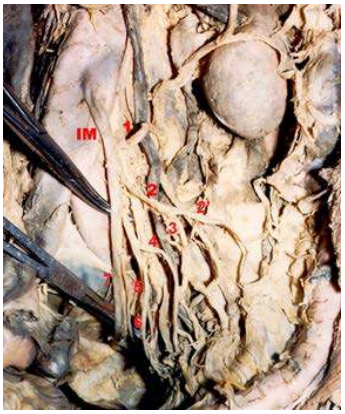


Fig. 103. The origin of four sigmoid arteries directly from the inferior mesenteric artery: IM. inferior mesenteric a.; 1: left colic a.; 2: colosigmoid trunk; 2': superior sigmoid a.; 3: middle sigmoid a.; 4: inferior sigmoid a.; 5: the 4th sigmoid a.; 6: posterior rectal a. ; 7: anterior rectal a..

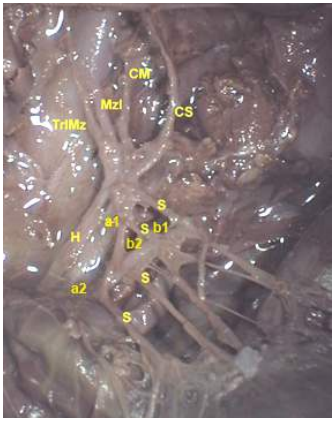


Fig.118. In the inferior mesenteric artery have their origin, superposedly, the middle and left colic arteries, the sigmoid trunk, which gives birth to four sigmoid arteries and the superior rectal artery: Mzl: inferior mesenteric a.; TrIMz: intermesenteric trunk; CM: middle colic a.; CS: left colic a.; H: superior rectal a.; S: 4 the sigmoid aa.; a1: anastomosis between the sigmoid trunk and the superior rectal a.; a2: anastomosis between the inferior sigmoid a. and the superior rectal a.; b1, b2: anastomoses between the sigmoid arteries.

A particular case (1,19% of the cases), that I never found quoted in the specialty literature consulted, is that in which a voluminous middle colic artery forms a single transverse marginal arcade; the middle colic artery ends by bifurcation in a right branch and a left branch; its left branch is anastomosed with the right branch of the left colic artery, and its right branch is anastomosed with the colic branch of the ileocolic artery.

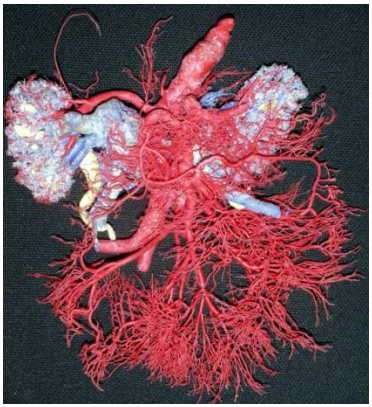


Fig.123. Plastic cast which lacks the arteries of the right colic angle and the right colic; the middle colic artery provides the vascularisation of the transverse colon and of the upper part of the ascendant colon, by anastomosis with the colic branch of the ileocolic artery and the ascendant branch of the superior left colic artery.

INFERIOR MESENTERIC VEIN

TERMINATION MODE OF THE INFERIOR MESENTERIC VEIN

I examined the termination mode of the inferior mesenteric vein on 38 cases, finding 4 variants:

1. The most frequent, in 31 cases (81,58% of the cases), the inferior mesenteric vein ends in the splenic vein;

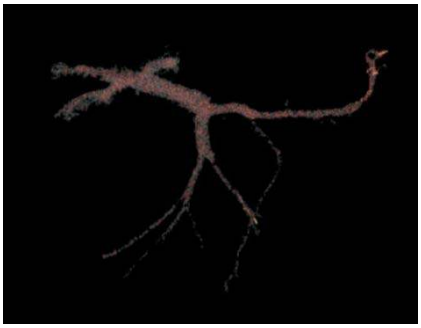


Fig.142. The inferior mesenteric vein ends in the splenic vein closer to the origin of the haematic portal vein.

2. in 4 cases (10,53% of the cases), the superior mesenteric veins, the inferior mesenteric and splenic were anastomosing at the same level a to form the hepatic portal vein;

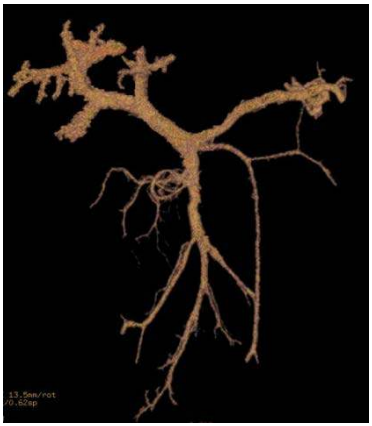


Fig.143. The convergence at the same level of the three veins: superior mesenteric, inferior mesenteric and splenic to form the hepatic portal vein.

3. in 3 cases (7,89% of the cases), the inferior mesenteric vein converged with the superior mesenteric vein, forming a *mesenteric trunk*, which was anastomosing with the splenic vein to form the hepatic portal venous trunk;

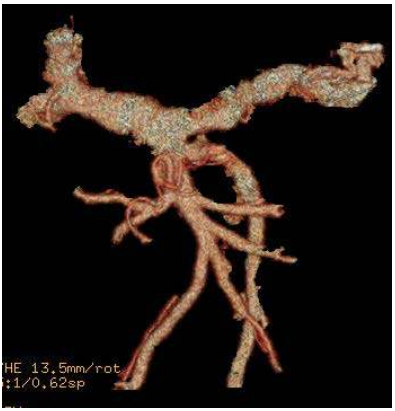


Fig.144. The superior and inferior mesenteric veins converge to form a mesenteric trunk which is anastomosing with the splenic vein forming the hepatic portal vein.

4. Only in one case (2, 63% of the cases) I found *3 mesenteric veins: superior, middle and inferior,* which were forming by convergence a mesenteric *trunk*, it anastomosing subsequently with the splenic vein to form the hepatic portal vein.

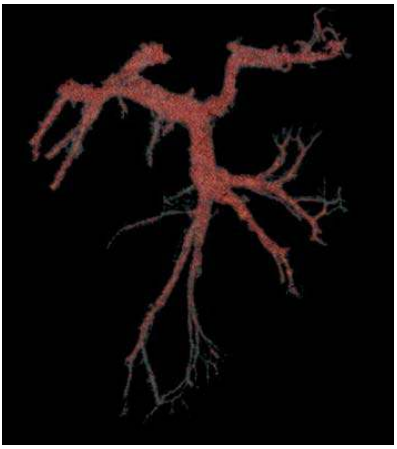


Fig.145. The existence of three mesenteric veins: superior, middle and inferior, which, by convergence, form a mesenteric trunk, by whose anastomosis with the splenic vein forms the hepatic portal vein.

TABLE NO. 7 – FORMATION TYPES OF THE PORTAL VEIN

AUTHOR	NO. CASES	I	II	III	IV
Douglas (1950)	92	38%	29,3%	32,7%	-
Purcell (1951)	100	44%	53%	3%	-
Couppié (1957)	200	47,5%	45,5%	7%	-
Barry (1968)	103	30%	29%	41%	-
Papadopoulos (1981)	50	70%	24%	6%	-
Kamina (1996)	74%	-	-	-	-
Personal cases (2012)	38	81,58%	7,89%	10,53%	2,63%

CONCLUSIONS

The study carried out on the morphology of the inferior mesenteric vessels proves especially the great variability the inferior mesenteric artery, while the homonym vein has the most important variability in what concerns the termination mode, having a clinical importance related to the formation of the hepatic portal vein. The own particularities of the colic vascular system express by the multitude of the branches with different lengths, calibres and emerging angles, with an elastic – muscular structure and a disposition in parallel, factors which contribute to the preservation of a high blood pressure. “Any modification of the organisation, structuralization and functioning parameters of the collateral subsystem leads inevitably to the diminution of the arterial pressure with the installation of the ischemic colitis. The macroscopic organisation of the distributive system of the colic branches is structured on the basis of the vessels with well-defined parietal territories, with a quantitative and qualitative disposition, disposition which is also preserved in the intraparietal territory at the level of the microcirculator sector.”

Knowing the normal morphology of the inferior mesenteric vessels and their branches and, especially, the variants these vascular systems may present, has a great importance not only for the morphologist and the radiologist, but especially a surgical importance in the practise of hemicolectomies, of the segmentary colectomies, oesophagus plastic surgeries with oesophagus with ileocolic intestinal loop or with isoperistaltic transverse colon. This importance results from the fact that the study extracted its conclusions on own cases proved by the iconography from the contents of the thesis. The great variability of the morphology of the inferior mesenteric vessels does not allow the drawing of a standard diagram of the mode of their collateral and terminal ramification, aspect signalled by the majority of authors, but the possible morphological variants important to be known in the medical practise can be established by percentages. At present, the modern imagistics makes possible the pre-operatory discovery of these

variants, resulting in the mandatory necessity to perform the radiological examination preceding the surgery, forewarning the surgeon in case of the existence of some vascular variants. " the modalities of differentiated ligatures should not be practised by the mechanic; the surgeon can opt for any other type of ligature and arteriolar sectioning, provided that he knows perfectly the distribution mode of the vascular system and the notions of hemodynamics and rheology which allow a good nutrition of the colic wall. In order to ensure this desideratum, the performance of the selective pre-operatory arteriography of the inferior mesenteric artery is imposed." (1).

The ultrasonography and the echo-Doppler test have a great diagnostic value, being practised before the angiography, detecting the stenoses and the flux modifications in the mesenteric vessels. The sensitivity of the method is 90% when more than 50% of the vascular bed is occupied by stenoses. The results of the ultrasonography depend also on the qualification of the person performing it, as well as on certain anatomic details of the patient, such as the adipose tissue of the abdomen and the quantity of intestinal gas.

At present, related to the angiographic exploration are used a series of new techniques such as the angiography with tridimensional magnetic resonance and the cine NMR angiography with contrast phases, which have a very high accuracy in detecting the vascular, arterial and venous lesions, as well as the detection of structural modifications, but also variations in the blood flow.

The selective angiography plays an important role in the precocious diagnostic of the acute intestinal ischemia. The differentiation of the three forms of mesenteric arterial obstruction can be done only by the lateral incidences at a transfemoral aortic injection. The embolism of the superior mesenteric artery is caused by intestinal infarction in 35% of the cases of arterial infarction, being favoured by the orientation of the superior mesenteric artery almost parallel with the axis of the abdominal aorta and by certain atheromatous stenoses or atheromatous plaques. Generally, the mesenteric emboli are blocked at the left colic arteries or at the level of the sigmoidian trunk aperture or of a sigmoid artery, generating the arteriogram of a proximal inferior mesenteric artery with normal appearance, ended under the form of the "*meniscus sign*", at a few centimetres from its aortic origin. The angiography may also have

therapeutic valences and is not useful in the presence of peritoneal signs when the laparotomy shall not be delayed.

The vascularisation of the transverse colon, even it is considered almost fully dependent on the branches of the superior mesenteric artery, is often provided in a greater percentage by the inferior mesenteric artery, either by a middle colic artery with the origin in the inferior mesenteric artery or in the left colic artery.

The paracolic marginal arcade is constant, but features various particularities related to the mode of anastomosis of the participant arteries, to the distance at which it is situated against the colic wall, to the calibre, to its general appearance and, sometimes, even to its discontinuity or duplication.

From the literary data it results that the paracolic arcade can be heteronymous at the level of the colon flexes, as well as at the level of the sigmoid, but I also found this heteronymous feature, partially or totally, at the level of the transverse colon, more frequently in its left half.

The existence of vascular areas, especially at the level of the descendent colon, does not create colic areas with precarious vascularisation, even when the anastomosis between the colic and superior sigmoid arteries misses.

The sigmoid arteries do not vascularise the segments of the descendent colon according to their name, their vascularisation territory depending on the left colic artery and on the existence of the middle and inferior left colic arteries.

I agree that the inferior mesenteric vein does scarcely participate to the formation of the portal vein, it being most frequently a tributary of the splenic vein and having a more reduced calibre in relation to the other two veins. Hence, it is right to be considered that the hepatic portal vein is formed by the superior and splenic mesenteric veins, the *Anatomical Terminology* (1988) not mentioning neither the denomination of *mesenteric - splenic trunk*, because, after the termination of the superior mesenteric vein in the splenic vein, an insignificant development of the venous calibre is detected.

It can be considered that the hepatic portal vein is formed of the superior and splenic mesenteric veins, the inferior mesenteric vein being a tributary of the splenic vein or, more scarcely, of the superior mesenteric vein, it having a calibre much more reduced in relation to the other two veins. The *Anatomical Terminology* (1988) does neither use the denomination of *mesenteric - splenic trunk*, because, after the termination of the superior mesenteric vein in the

splenic vein, an insignificant development of the venous calibre is detected.

The differences existing among the various authors related to the percentages found regarding various reference points of the inferior mesenteric vessels and their branches are due to used working methods (the dissection, the injection of contrast or plastic substances) and the measuring methods used (centimetre, magnetic resonance imaging, CT).

Furthermore, the differences might be due to the reduced number of cases on which the respective authors worked. In the classical anatomic descriptions, the number of cases is very limited (1-10) and in some situations, the number of cases is not even mentioned, as it is specified, from which result the comparison difficulties between the personal results and the literary ones. This feature is also proved by the fact that there are contradictions between results even at the same author, but at greater or smaller time intervals, which allowed him to develop his casuistic.

The different percentages existing in the specialty literature related to the frequency of various morphological features of the celiac trunk and its branches, determined Nguyen Huu to infer the existence of some characteristics in the morphology of the vascular systems related to the geographic area and the human race. I totally agree with this author and I add that the vascular-nervous variability would also depend, within the same habitat, of the environmental factors which might act during the organogenesis period. This would explain the morphological differences encountered at the population of the same geographical area in different periods of time. Moreover, the great statistical differences between authors are due to the total number of personal cases and to the different criteria in appreciating the level of detachment of the collateral and terminal branches, as well as the appreciation of the intestinal segment to which the respective vessel is addressed.

When approaching a subject, it is impossible to exhaust it, regardless of the multitude of cases studied and thus it is explained why I have not found in the study carried out a series of variants signalled in the specialty literature. I would like to quote only a few examples: the absence of the inferior mesenteric artery (Sonneland), common trunk superior mesenteric artery- inferior mesenteric artery (Basmajian), celiac - bimesenteric trunk (Cabanier), double inferior mesenteric artery (Stewart) etc.

I would like to highlight once again the variability of the

inferior mesenteric vessels, which proves once again that the vascular system features the most complex and the most varied morphological organisation, its variants exceeding numerically those of the nervous or visceral system. The inferior mesenteric vessels do only confirm this reality, their anatomic polymorphism being considerable.

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