VARIATIONS IN THE ORIGIN AND COLIC BRANCHES OF THE SUPERIOR MESENTERIC ARTERY

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Certificate

This is to certify that the dissertation title, 'Variations in the Origin and Colic branches of the Superior Mesenteric Artery' is an original work done by Dr. M. Nirmaladevi, PG Student, Stanley Medical College, Chennai-1, under my supervision and guidance.

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DECLARATION

I solemnly declare that this dissertation "Variations in the Origin and Colic branches of the Superior Mesenteric Artery" was written by me in the Department of Anatomy, Govt. Stanley Medical College and Hospital, Chennai, under the guidance and supervision of Prof. Dr. Sudha Seshayyan, M.S., Professor and Head of the Department of Anatomy, Govt. Stanley Medical College, Chennai - 600 001.

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CONTENTS

AIM OF THE STUDY

Modern abdominal surgical techniques depend partly on the knowledge of the normal arterial and partly on the anomalous arterial blood supply. Unlike other anatomical variations, anomalous and variant blood supply cannot be ignored for the risk of ligating the wrong vessel or severing an essential artery which may result in ischaemia and gangrene, and of leaking and bleeding from the sites of repair and at anastamotic suture lines.

From the anatomical point of view, arterial variations are verifiable facts of the human constitutions that can be observed time and again. Variations in the arrangement of arteries that supply the abdominal organs are very common.

As a guide and a safeguard to the surgeon in ever increasing, varied and difficult operative procedures like oesophagojejunostomies, intestine transfers, resections of the small and large intestines and appendicectomies a descriptive atlas on the variant arterial supply of the supra and infra colic organs, is urgently needed.

In modern therapeutic techniques like selective arterial chemotherapy in the treatment of liver cancer, we should know the variations of hepatic artery to plan the procedure accordingly.

In liver transplantation, with the knowledge of the variational anatomy of the hepatic pedicle, the extensive damage of the feeding hepatic artery can be definitely prevented.

The veins, lymphatic vessels and lymph nodes draining a part of the large intestine converge on the aortic origin of the vessel supplying that particular part. The extent of bowel resection in carcinoma is thus determined by the length of bowel supplied by the arterial trunk to the area involved by the disease. The vessel is divided proximally so that the resected bowel and mesentery contain the whole of the related lymphatic apparatus including the proximal lymph node group.

The best way to avoid injury to the blood vessels during any invasive procedures such as laparoscopic procedures and resection of colon for cancer or other diseases, is to know them thoroughly and to know how, when and where to ligate them properly.

It is therefore evident that a knowledge of exceedingly variable blood supply of the viscera in the abdomen by the superior mesenteric artery is very important to the operating Surgeon, Radiologist and to the Anatomists as well.

Responsibility of establishing and disseminating knowledge about variations, lies with the Anatomist though the consequence of correct and incorrect informations may depend upon the Surgeon.

Hence, the present study is mainly aimed at

1. Examining the pattern of variations in the origin of the superior mesenteric artery and its colic branches mainly in south-Indian population. The concerned data is obtained from cadaver dissections and from angiographic pictures.
2. Comparing the variation with those obtained by the earlier workers.
3. And analyzing the cumulative information with reference to modern surgical procedures.

ANATOMICAL AND EMBRYOLOGICAL CONSIDERATIONS

Superior mesenteric artery arises from the abdominal aorta (Fig 1) at a level between 1st lumbar and 2nd lumbar vertebrae, 1 cm below the origin of the coeliac trunk. It supplies the second part of the duodenum distal to the major duodenal papilla, the third and fourth part of the duodenum, a portion of the head and frequently, an extreme area of the body of the pancreas, the jejunum, ileum and the large intestine up to the junction of right two third and left one third of transverse colon because it is the artery of midgut.

From its origin about 1 cm below the coeliac trunk, it leaves the front of the aorta and is crossed anteriorly at its origin by the splenic vein and body of the pancreas. It is separated posteriorly from the aorta by the left renal vein. Proceeding downwards and forwards, it runs anterior to the pancreatic uncinate process and the horizontal part of the duodenum. It then descends obliquely in the mesentery near its root to the right iliac fossa. Accompanied by the superior mesenteric vein to its right, the artery is surrounded by the superior mesenteric plexus of nerves.

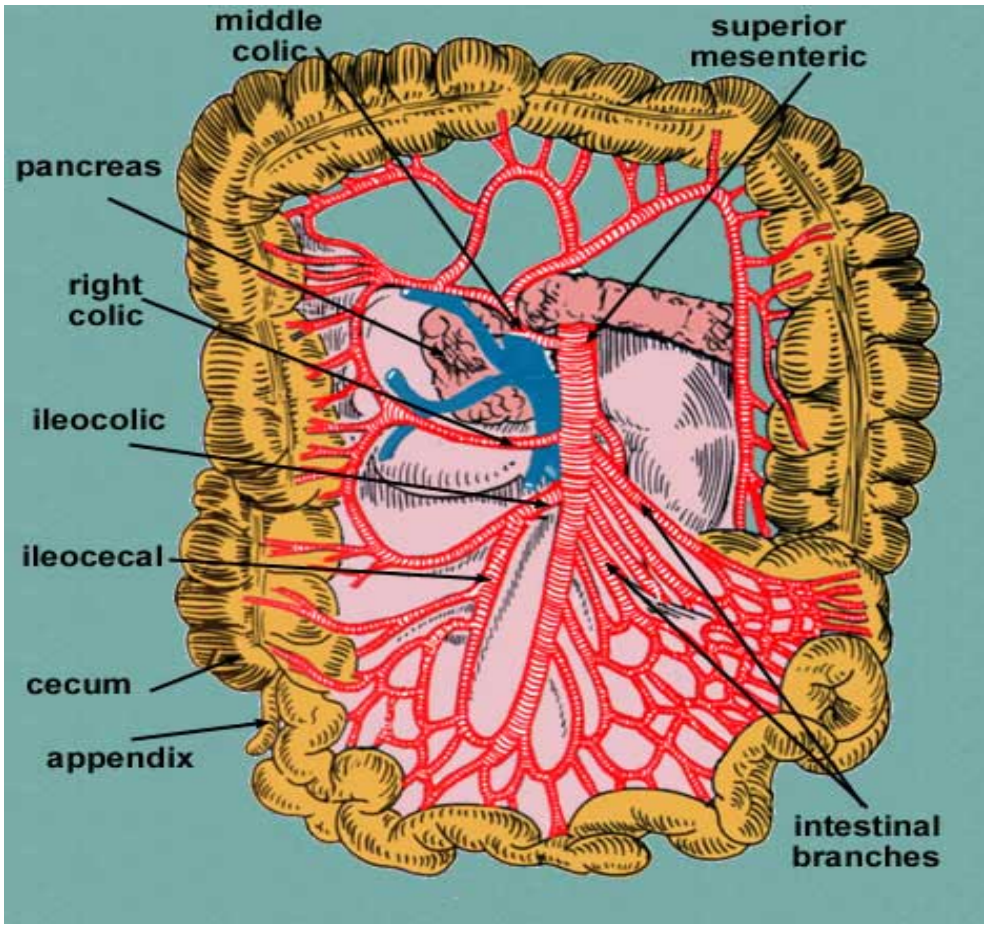


Fig 1 Superior mesenteric artery and its branches

Branches of the Superior mesenteric artery :

Colic branches :

1. Middle Colic Artery: It leaves the superior mesenteric artery just inferior to the pancreas descending in the transverse mesocolon and it divides into a right and left branch. The right branch anastamose with the right colic artery, and the left branch with a branch from the inferior mesenteric artery. Arches thus formed are 3 to 4 cm from the transverse colon, which they supply.

2. Right Colic Artery: It arises near the middle of the superior mesenteric artery and passes to the right behind the parietal peritoneum. Near the colon it divides into a descending branch which anastamose with the middle colic artery. These form arches, from which vessels are distributed to the ascending colon, supplying its upper two-thirds and the right colic flexure.

3. Ileocolic artery: The last branch from the right side of the superior mesenteric artery, descends to the right under the parietal peritoneum to the right iliac fossa, where it divides into a superior branch and inferior branch. Its superior branch anastamose with right colic artery, the inferior branch with the end of the superior mesenteric artery.

Its inferior branch approaches the superior border of the ileocolic junction and branches as a) ascending branch b) anterior and posterior caecal c) an appendicular artery and d) an ileal branch.

Other Branches:

4. Inferior pancreaticoduodenal artery: leaves the superior mesenteric artery, near the superior border of the horizontal part of the duodenum, usually dividing at once into anterior and posterior branches. Both branches supply the pancreatic head, its uncinate process and the adjoining duodenum.

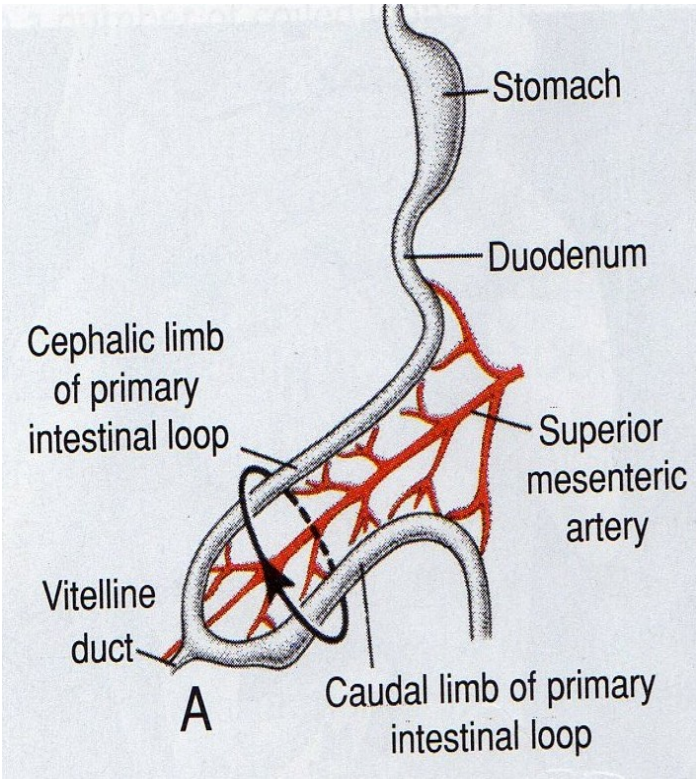
5. Jejunal and Ileal branches: arise from the left side of the Superior mesenteric artery, usually 12-15 branches and are distributed to the jejunum and ileum.

Embryological Considerations:

The superior mesenteric artery shows many embryological irregularities in contour, origin and configuration.

The first part of the artery, for an inch or more, may be indented in spiral form, a vestige of the primitive rotation of the midgut (Fig 2) which takes place counterclockwise around it, as an axis, to 270 degrees, the artery itself making a 180 degree rotation.

As a result of dextro rotation of the midgut around the superior mesenteric artery as its axis and rotation of the latter in the process, the mode in which the superior mesenteric gives off its Intestinal and colic branches in the adult is just the reverse of what the order was in the primitive unrotated, sagittally placed gut.



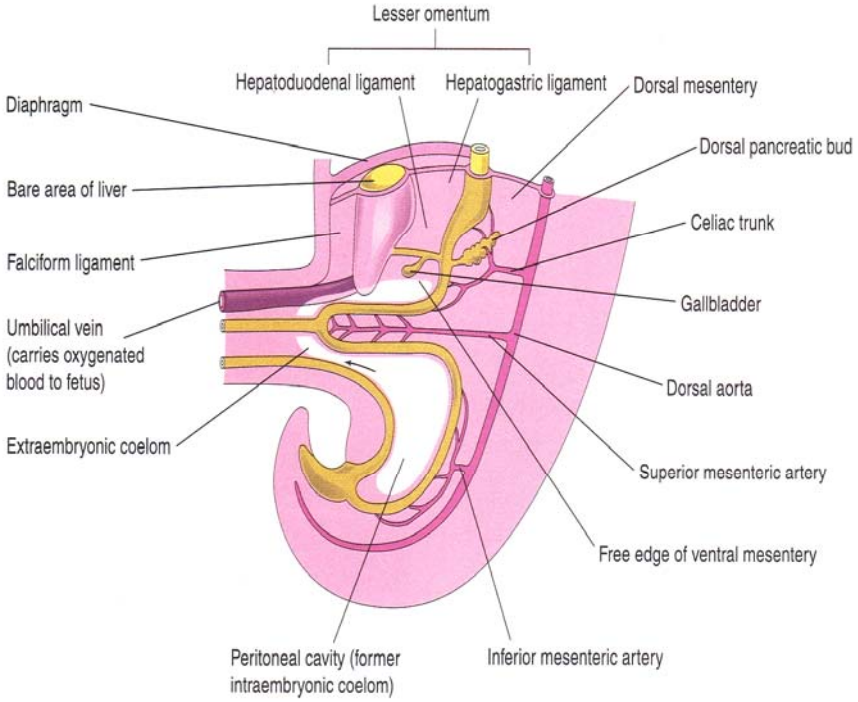


Fig 2 SMA – Artery of Midgut

In the adult, the first branch of superior mesenteric artery, inferior pancreatico duodenal, a remnant of the primitive condition, the artery staying on the right side of the primitive unrotated artery.

Thereafter, from the concave side of the artery, arise the middle colic, the right colic and the ileocolic, the terminal or illeal branch of ileocolic unites with the terminal end of the superior mesenteric artery.

From the convex left side of the artery arise 12-15 jejunal and illeal branches, which, in the unrotated gut, arise from the right side of the superior mesenteric artery and constitute its first branches.

The occurrence of a coeliaco mesenteric trunk has repeatedly been reported in the literature, its average incidence being about 1%. The mode of formation of the coeliaco mesenteric trunk can be accounted for from both an ontogenetic and phylogenetic point of view.

It has been explained (Buhler, 1904) that, in the embryo, the two vessels have a common stem.

REVIEW OF LITERATURE

Galen (121 – 201 AD) was among the first to describe arteries carrying blood and their supply of colon (Buck 1917, Garrison 1929, Singer 1925). This was followed by a period of dark ages when Anatomy remained dormant for several hundred years.

In 1963 Veslingius reported the superior mesenteric artery in his work, which was translated by Culpeper.

It was Von Haler (1803) who between 1759 and 1766 described the main blood supply to the colon by the superior mesenteric artery and its branches. Anatomy text books are in agreement with Von Haler's description of the superior mesenteric artery (Gray's Anatomy 1995, Last's Anatomy Regional and applied, 10th edition 1999).

Richard Quain published " The Anatomy of the Human body " in 1844. In the preface of this classic he wrote :

"The difficulties which have often occurred in the performance of those surgical operations in which the larger arteries are concerned have arisen in great point from want of sufficient acquaintance with the differences in anatomical disposition to which these vessels are subject " .

Quain in his study of 1040 bodies merely named the colic arteries without note of the differences in anatomical disposition.

The vascular supply of the small Intestine was investigated by Cokkin's (1930) in his study of mesenteric thrombosis. He stated that the "Collateral circulation stops with the terminal row of arcades in the mesentery. Beyond this there is absolutely no anastamosis either between the vasa recta in the mesentery or between the ramifying vessels on the gut wall ".

Eisberg (1925) stated that the vasa recta of the small Intestine are not end arteries but do anastamose freely with similar arteries of the opposite side.

Noer (1943), confirmed the findings of Eisberg, with the help of his liquid latex injected specimens.

Origin of the Superior Mesenteric Artery:

Michels (1955) reported the site of origin of superior mesenteric artery from aorta and that of the coeliac trunk varied from 1 to 22 mm (commonly being 1 to 6 mm (60 %) in 200 bodies. The superior mesenteric artery normally comes off the front of the abdominal aorta at the level of the 1st lumbar vertebra about 1.25 cm below the coeliac trunk.

Anson and Mcvay (1936) in a study of 100 cadavers found that in 71% of them, the distance between the coeliac trunk and the superior mesenteric artery ranged from 1.0 to 2.0 cm.

Wright (1959) in a case of left sided vermiform appendix found the superior mesenteric artery to arise from the Aorta 3 cm below the coeliac trunk.

Kao et al studied 24 superior mesenteric artery angiograms. The locations of the origin of the coeliac trunk and the superior mesenteric artery were determined in each case. The superior mesenteric artery arose at the level of 1st lumbar vertebra in 24 angiograms (83 %), below the pedicle of 1st lumbar vertebra in 5 cases (21%), none arose below the 1st lumbar - 2nd lumbar inter space.

Michels (1955) reported the causative factors for arterial variations as

1. variations in constitutional inheritance
2. variations of evolution
3. variations in haemodynamic potential
4. variations of race difference
5. ontogenetic developmental peculiarities

He further stated that the pattern of the arteries are determined by internal and external factors. Developmental peculiarities formed in the arteries to the supramesocolic organs (coeliac and superior mesenteric artery) would be correlated with

a) variations in the degree and the site of gut rotation

b) persistence of differently interrupted sections of the primitive roots of the omphalomesenteric (vitelline) arteries (10, 11, 12, 13 ventral segments) and their longitudinal anastamosis

Adachi (1928) published the book " Das arteriensystem Der Japanese" with an extensive study of variational anatomy of arteries.

Von Haler (Tripod of Haler) reported that the coeliac trunk may arise from superior mesenteric artery. The coeliac trunk give rise only to the splenic and left gastric artery, the hepatic arising from the superior mesenteric artery or the hepatic and left gastric artery form coeliac, the splenic from the superior mesenteric artery.

Tandler (1904) gave the first comprehensive description of the embryogenesis of the coeliacomesenteric trunk in human beings.

Henle (1809 – 1885) and later Delannoy (1923) reported the occurrence of two Superior Mesenteric Arteries.

Coeliacomesenteric trunk was reported by Lipshutz (1917), Munger and Mangoushi (1941). Michels (1955) in his study of 200 dissections described the occurrence to be 1%.

Eaton (1917) studied 206 bodies and reported the origin of the hepatic artery from the aorta or superior mesenteric artery, left gastric and splenic arteries from common trunk and classified this as type 1 coeliac trunk.

Higashi. N and Hirai. K observed that the hepatic artery arising from an unusual hepatomesenteric trunk of aorta immediately inferior to the gastro duodenal trunk was reported as type 2.

Adachi (1928), Professor of Anatomy at the University of Okayama and Kyoto, who spent 30 years, studying the arterial and venous variations in 252 Japanese cadavers observed that

- the hepatic, the splenic and the superior mesenteric artery arise as a common trunk from the abdominal aorta - 1.2 %
- the left gastric, the splenic, the hepatic and the superior mesenteric artery arise as a common trunk from abdominal aorta.

Professor Nicholes A. Michels (1955) of the Daniel Baugh Institute of Anatomy, Jefferson Medical College, Philadelphia, made a detailed study of the arterial supply of the supramesocolic organs. He dissected more than 500 cadavers painstakingly. He statistically analyzed in 200 bodies regarding the origin and distribution of all the arteries in supramesocolic region. He observed that,

- in 0.5 % cases the left gastric arises separately at the level of the coeliac trunk or from the aorta. The hepatic, the splenic and the superior mesenteric artery from a common trunk.

- In 11.5 % cases the left gastric and the hepatic arise from a common trunk and the splenic artery arising from the superior mesenteric artery.

- Coeliacomesenteric trunk (2 / 500 cases). The 4 arteries (hepatic, splenic, left gastric and the superior mesenteric artery) arise from the abdominal aorta by a common trunk.

Dr. Kalavathy, Director, Institute of Anatomy, Madras Medical College, carried out a detailed study in 75 cases (1980) and observed that the superior mesenteric artery with coeliac arising as a common trunk in 3.3 % cases.

Dr. Radhakrishnayya (1990) reported the distance of origin between the coeliac trunk and the superior mesenteric artery in 25 cases.

Yamaki et al (1995) reported a rare case of absence of coeliac trunk in the dissection of a Japanese female cadaver in 1993. In this case the left gastric, the splenic, the hepatic and superior mesenteric artery arose independently in that order from the abdominal aorta.

Middle Colic Artery :

W. Henry Hollinshed, in his book of Anatomy for Surgeons, Vol. 2 states that in 30 to 50 % of cases the common stem which shares middle colic and right colic arteries.

Chart 1. Sonneland et al typing and classification of Colic arteries

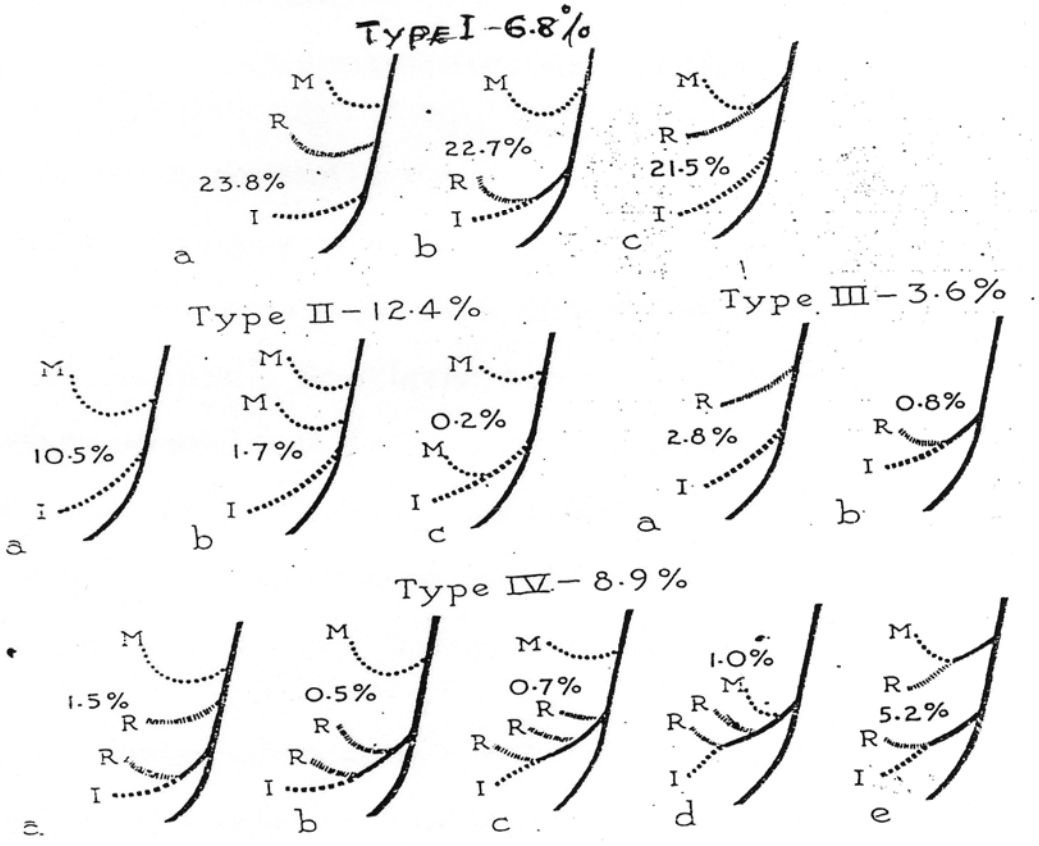
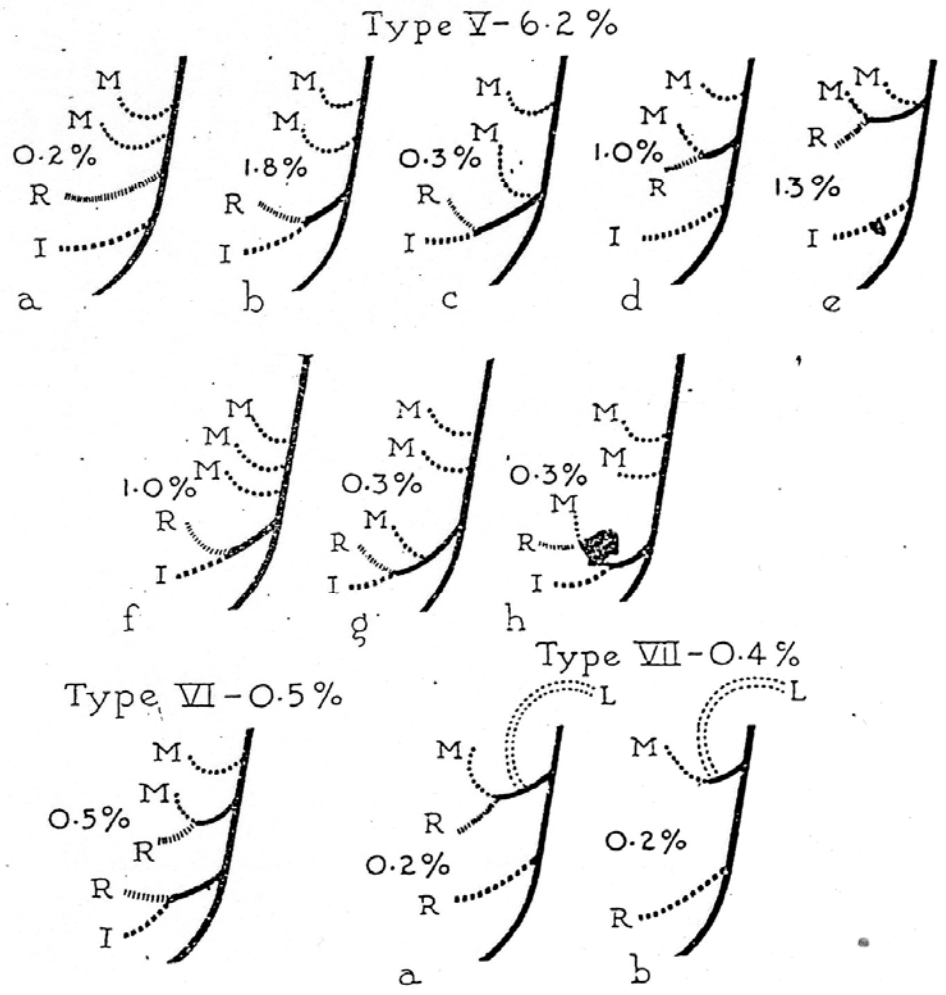


FIG. ●. Types of colic branching of the superior mesenteric artery and varieties within each of 4 categories (types I to IV). Schematized from records on 600 specimens. Abbreviations for arteries: *I*, ileocolic; *L*, left colic; *M*, middle colic; *R*, right colic.

3. Variations in the arterial supply to the colon from the superior mesenteric artery, continued, (types V to VII). In type I (representing 68 per cent of all specimens studied), the 3 typical branches, of approximately equal caliber, arise either independently from the superior mesenteric, and thus as 3 vessels, or from 2 roots (with the right colic derived from ileocolic or middle colic). In type II (12.4 per cent) a right colic artery is wanting and the middle colic is either single or double. The distinguishing feature in type III (3.6 per cent) is the absence of a middle colic in the presence of a right colic of either direct or indirect mesenteric source. In the specimens catalogued as belonging to type IV (8.9 per cent) 2 or 3 right colic arteries occur, accompanied in each variety of subtype by both ileocolic and middle colic branches. Type V (6.2 per cent) is characterized by the occurrence of 2 or 3 middle colic arteries in the presence of a right colic (in contrast, type II) and of an ileocolic artery. In type VI (0.5 per cent) both middle and right colic arteries are doubled. In type VII (0.4 per cent) a left colic artery is added to the typical set of 3 branches.

Chart 1. Sonneland et al typing and classification of Colic arteries



Waldeyar (1989 / 1900) describes a colica media (middle colic artery) and a colica media accessoria, but none of these branches were well defined.

Henle (1876) reported a case of presence of two middle colic arteries and several cases where branches of superior and inferior mesenteric arteries replace the middle colic arteries.

Steward and Rankin (1933) studied 40 specimens injected with a celluloid material or injected with an opaque material and x – rays were taken and they found out the variability of the blood supply to the large bowel. The observations reported were middle colic artery through a large branch or an accessory middle colic artery supply the left side of the transverse colon in 37 % only. Occasionally the middle colic artery trifurcated or had 4 branches. In 2 cases it was absent (2 %) being replaced by large branches from the left colic artery.

Steward and Rankin also reported an accessory middle colic artery (10 %) from the Superior mesenteric artery above the origin of the middle colic artery.

Sonneland et al (1958) studied 600 specimens and demonstrated the classical pattern of the colic arteries in 23.8 %. They observed not only anomalies but described 24 patterns of colic arteries. They reported the absence of middle colic artery in 3.6 % (22 bodies in 600). Single middle colic artery was present in 7 %. Two middle colic arteries with two separate origin was found.

Vandamme and Schuren (1956) explored and reported single middle colic artery in 75 % , Two middle colic arteries with separate origins in 24 % and Three middle colic arteries in 1 % of the cases. In one case, the middle colic artery was absent.

Benton and Coter observed that the superior mesenteric artery gave rise to one major trunk, which was divided into ileocolic and right colic branches only.

Michels (1955) reported that

- the middle colic branch of the superior mesenteric artery is very variant.

- the middle colic artery is often absent and will be replaced by branches of the right colic or by a left colic reaching the hepatic flexure.
- the Middle colic artery may arise from the coeliac, common hepatic or a replaced right hepatic of the superior mesenteric origin.
- It may arise from the coeliac and this branch gave off the dorsal pancreatic and its transverse pancreatic branch.
- In some cases the Middle colic, the superior pancreaticoduodenal and the right gastroepiploic arose from superior mesenteric artery via a common trunk.
- Middle colic artery was absent in 3 % of cases.

Moynhan (1913) reported an accessory middle colic artery running directly toward the middle of the transverse colon.

Ridan found an accessory middle colic (Arc of Riolan) connecting superior mesenteric artery with superior left colic artery.

Koizumi. M and Horiguch.,M reported that an accessory colic artery which arose from the superior mesenteric artery was observed in 32 of 65 subjects (49.2 %).

Dr. Radhakrishnayya (1990) reported the absence of middle colic artery.

Kerofi et al (1995) reported an anomalous middle colic artery from the proximal segment of the splenic artery.

Garcia et al did dissection of superior mesenteric artery in 56 human cadavers and reported the presence of middle colic artery in 55 cases.

Griffith (1956) observed no middle colic artery in 22 % of cases.

Right colic artery

Right colic artery is most variable among the colic arteries.

Steward and Rankin observed that No right colic artery in 18 % of cases. Origins in the 82 % in which they identified the vessel were from superior mesenteric artery in 40 %, with middle colic in 30 % and with ileocolic in 12 %.

Waldeyer (1899 - 1900) stated that the right colic has an independent origin from the superior mesenteric artery in about one half of the cases.

Jamieson (1909) and Dobson found the right colic artery a direct branch of the superior mesenteric artery in 50 % and of the ileocolic artery in 30 %.

Sonneland et al (1958) reported 12.6 % of absence of right colic artery in a series of 600 bodies,

- 78 % - right colic artery arose as a single vessel
- 8.7 % - shows two right colic arteries.
- 0.7 % - had three right colic arteries.

Vandamme and Schuren (1976) reported the presence of 32 % right colic arteries in 156 cases and in 1.5 % of the cases two right colic arteries. In one case it arises from the ileocolic.

Garcia et al (1996) reported the right colic arteries was emanating directly from superior mesenteric artery in 6 cases (10.7 %) out of 56 cases.

Michels and coworkers (1963) failed to identify the right colic artery in only 2 %. They found an origin from the superior Mesenteric artery in 38 %, an origin with middle colic in 52 % and one with the ileocolic in 8 %.

Basmajian (1955) agreed that it arises more commonly with either the middle colic or the ileocolic.

Dr. Radhakrishnayya (1990) reported the normal origin of the right colic artery and its origin from the ileocolic artery.

Ileocolic artery

Vandamme and Schuren (1976) stated that the ileocolic artery is the most constant collateral of the superior mesenteric artery.

Michels (1955) reported the ileocolic artery which divides into three branches and the site of origin of the appendicular artery is extremely varied.

Garcia et al (1996) reported the ileocolic artery to be the constant branch.

Anson (1951) reported different types of origin of appendicular artery :

- from ileal branch – 35 %

- from end branching point of the ileocolic in 28.5 %
- from the anterior caecal - 13.5 %
- from ileocolic in 1 %
- from right colic in 1.5 %

Communications of the Superior Mesenteric artery

Bertelli et al (1991) reported the rare occurrence of three cases (0.4 %) and anastamotic arterial trunk between the coeliac trunk and superior mesenteric artery and its importance for the surgeons in the procedures upon the pancreas.

Feigl et al (1975) noted anastamosis between coeliac trunk and superior mesenteric artery like :

- direct connection
- anastamosis with the hepatic artery
- anastamosis following pre or postnatal stenosis
- pancreatic arcades.

MATERIALS AND METHODS

Materials

A total number of 50 superior mesenteric arteries were studied from various sources.

- Eighteen (18) superior mesenteric arteries were collected from the cadavers in the dissection hall, Department of Anatomy .

- Twenty two (22) superior mesenteric arteries were collected from the Mortuary during Postmortem.

- Five (5) superior mesenteric artery pictures of CT angiogram were studied.

- Three (3) superior mesenteric arteries of Foetuses were obtained from the Department of Obstetrics & Gynaecology.

- Two (2) clinical cases with history of injury to the superior mesenteric arteries from the Department of Surgery.

Methods

1. Dissection :

Specimens were collected from the cadavers during routine dissection programme. Specimens were cleaned by removing the remains of peritoneum , fat and blood. The specimens were washed thoroughly in tap water. The origin of the superior mesenteric artery and its colic branches were traced and photographs were taken.

2. Specimens from the Forensic department :

Specimens were collected from the Forensic department and cleaned well in running water. Specimens were preserved in 10 % formalin and then taken for dissection. The sex , age and cause of death were noted in all cases.

3. CT Angiogram :

Patient positioned in supine position, after the test dose, 150 ml of omnipaque which is an iodinated contrast is injected at a rate of 3 ml per second by pressure injection. Using Spiral CT scan the scan performed. The interval time was 30 seconds and the scan time was 15 seconds. After acquiring all slices using maximum intensity projection technique, the superior mesenteric artery is mapped out.

4. Foetal specimens :

Foetal specimens (Fig 8) collected and were Embalmed routinely and dissected to find out the origin and Colic branches of the Superior Mesenteric Artery.

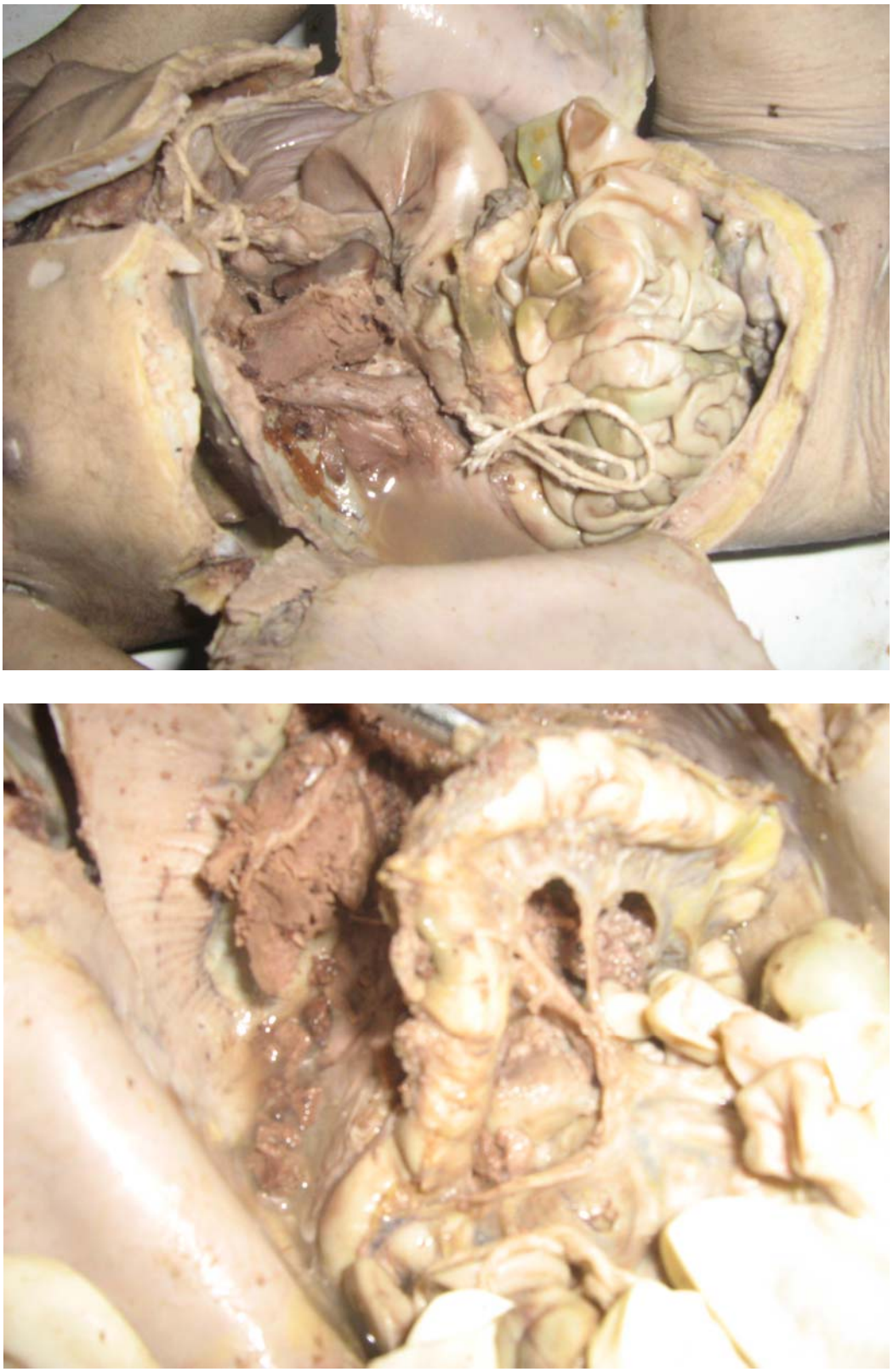


Fig 8 Foetal SMA

The following findings were observed and noted down from the Dissection, CT angiogram pictures and Surgeries :

1. The origin of the superior mesenteric artery from the abdominal aorta with the vertebral level.

2. The distance between the origins of the coeliac trunk and the superior mesenteric artery from the abdominal aorta was measured using a thread, marker and scale. The thread was placed on the origin of the coeliac trunk and the other end was stretched towards the origin of the superior mesenteric artery and the markings were made on the thread. The marked distance was measured using a scale.

3. Branching pattern of the middle colic , the right colic and the ileocolic arteries.

4. Anastamosing pattern of all the colic arteries.

5. Abnormal origin and branching pattern of the superior mesenteric artery and its colic branches supplying the neighbouring organs.

Diagrammatic representations were made to compare with the previous studies mentioned in the Review of Literature. The observations were analyzed with reference to age , sex , normal and abnormal patterns. Necessary photographs were taken pertaining to the observations made.

Data analysis was carried out using relevant statistical tables and charts.

OBSERVATION

In the present study of 50 superior mesenteric arteries studied, the origin of the superior mesenteric artery (Tab 1 & Chart 1) was normal in 43 specimens.

No abnormal site of origin was observed in the study.

In three specimens, the superior mesenteric artery and the splenic artery both arising from the abdominal aorta by a common trunk (Fig 3a). The coeliac trunk had only the hepatic and the left gastric artery.

In two specimens, the superior mesenteric artery and the hepatic artery arising from the abdominal aorta by a common trunk (Fig 3b). The coeliac trunk had only the splenic and the left gastric artery.

In two specimens the superior mesenteric artery and the inferior pancreatico duodenal artery arising from the abdominal aorta by a common trunk (Fig 4a).

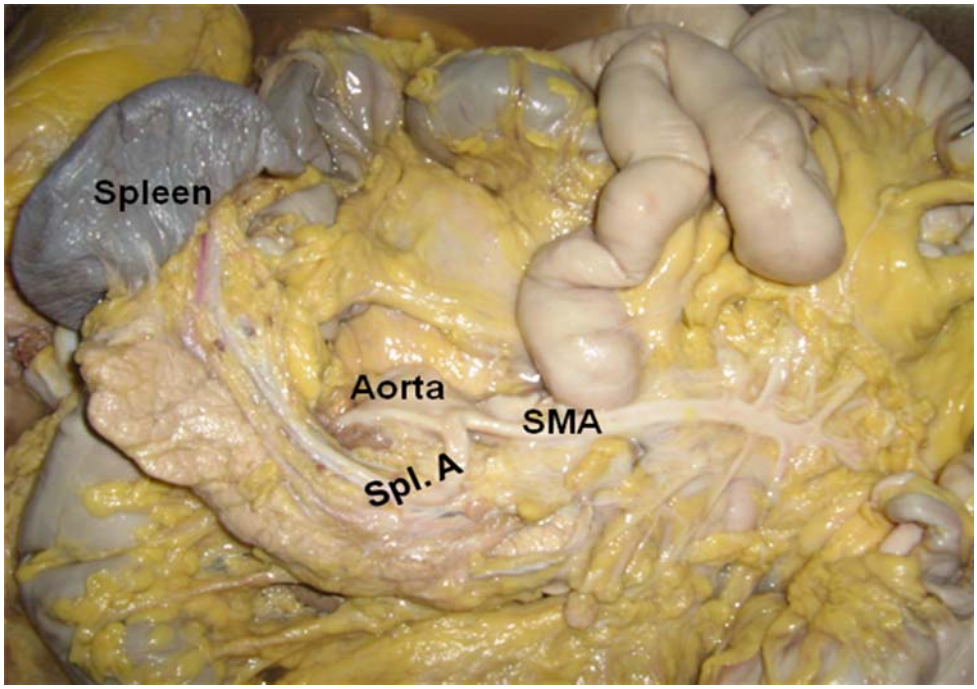


Fig. 3a SMA and Splenic Artery as a common trunk

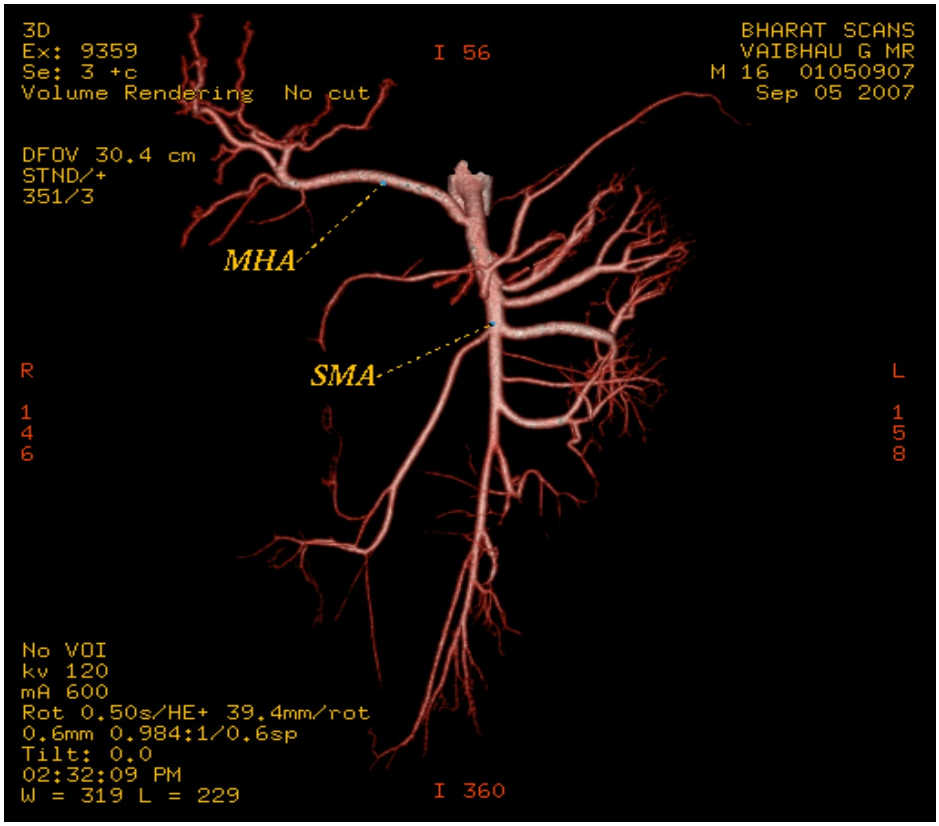


Fig 3b (CT Angiogram) SMA and Hepatic artery as a common trunk

Origin of Superior Mesenteric Artery

Normal	43
SMA + Splenic A	3
SMA + Hepatic A	2
SMA + Inf.P.D.A	2

Table 1 Origin of Superior Mesenteric Artery

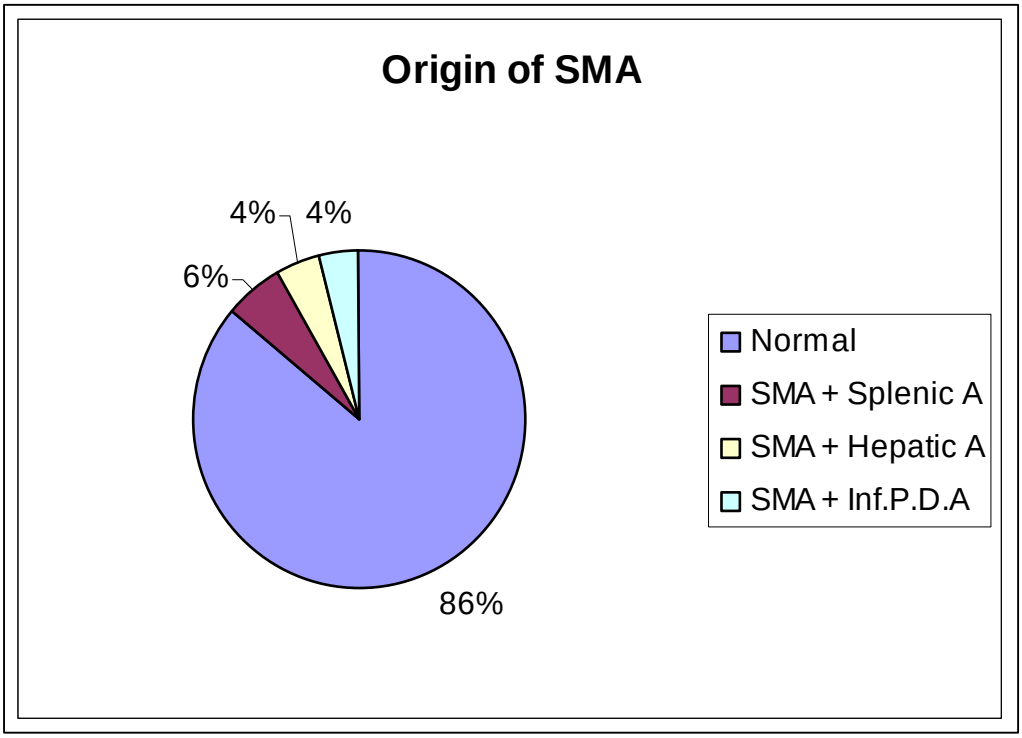


Chart 1 Origin of Superior Mesenteric Artery

The distance between the origin of the coeliac trunk and the superior mesenteric artery from the aorta (Tab 2 & Chart 2), ranged from the 2 mm to 20 mm.

The distance between the coeliac trunk and the superior mesenteric artery, from the aorta was 2 mm in 3 specimens, 3 mm in 3 specimens, 5 mm in 11 specimens, 8 mm in 1 specimen, 10 mm in 20 specimens, 15 mm in 11 specimens and 20 mm in 1 specimen. It was observed that the prevalent distances were 5 mm (11), 10 mm (20) and 15 mm (11).

Branching Pattern of Superior Mesenteric Artery

Inferior Pancreatico duodenal Artery

Out of 50 superior mesenteric arteries studied, 45 (90 %) had the normal origin of the inferior pancreatico duodenal artery from the right side of the superior mesenteric artery.

Distance of SMA from Coeliac Trunk

Distance (in mm)	Male	Female	Percentage
2	2	1	6
3	3	0	6
5	8	3	22
8	1	0	2
10	14	6	40
15	8	3	22
20	1	0	2
Total	37	13	100

Table . 2 Distance of SMA from Coeliac Trunk

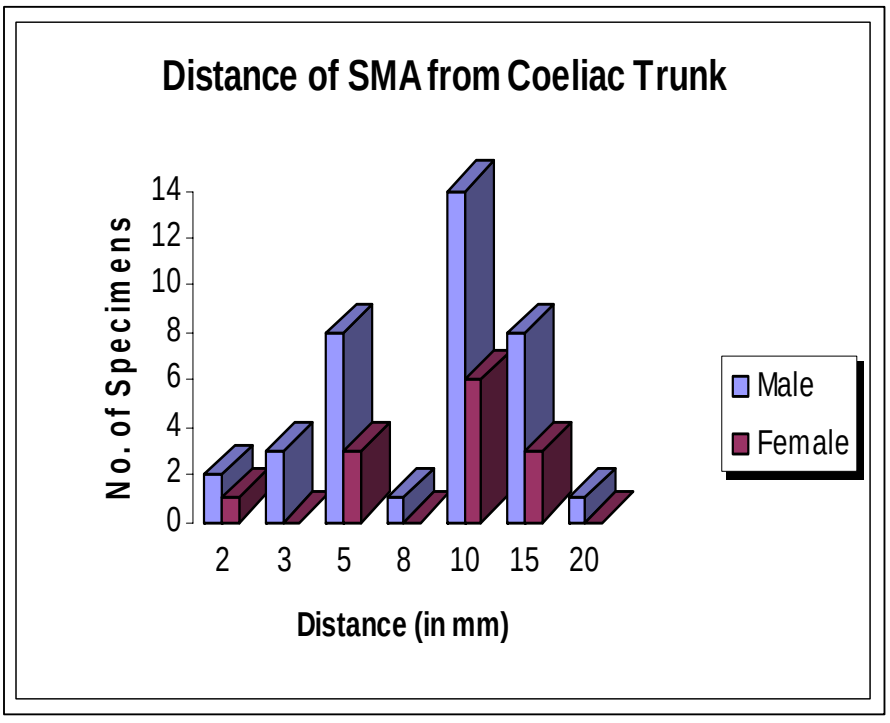


Chart 2 Distance of SMA from Coeliac Trunk

In two specimens, the inferior pancreatic duodenal artery, had a common origin along with the superior mesenteric artery from the abdominal aorta.

In one specimen, the origin was from the posterior surface of the superior mesenteric artery.

In two specimens, it was from the first jejunal branch.

In this study it was observed that 48 of the inferior pancreatico duodenal artery took origin above the level of the first jejunal branch.

Middle Colic Artery

In the present study of 50 superior mesenteric arteries , 48 (96 %) middle colic arteries (Tab 4 & Chart 3) were present and in 2 specimens (4 %) it was absent (Fig 4a). The specimens in which the middle colic arteries were absent, a large branch from the left colic artery was observed instead of middle colic artery.

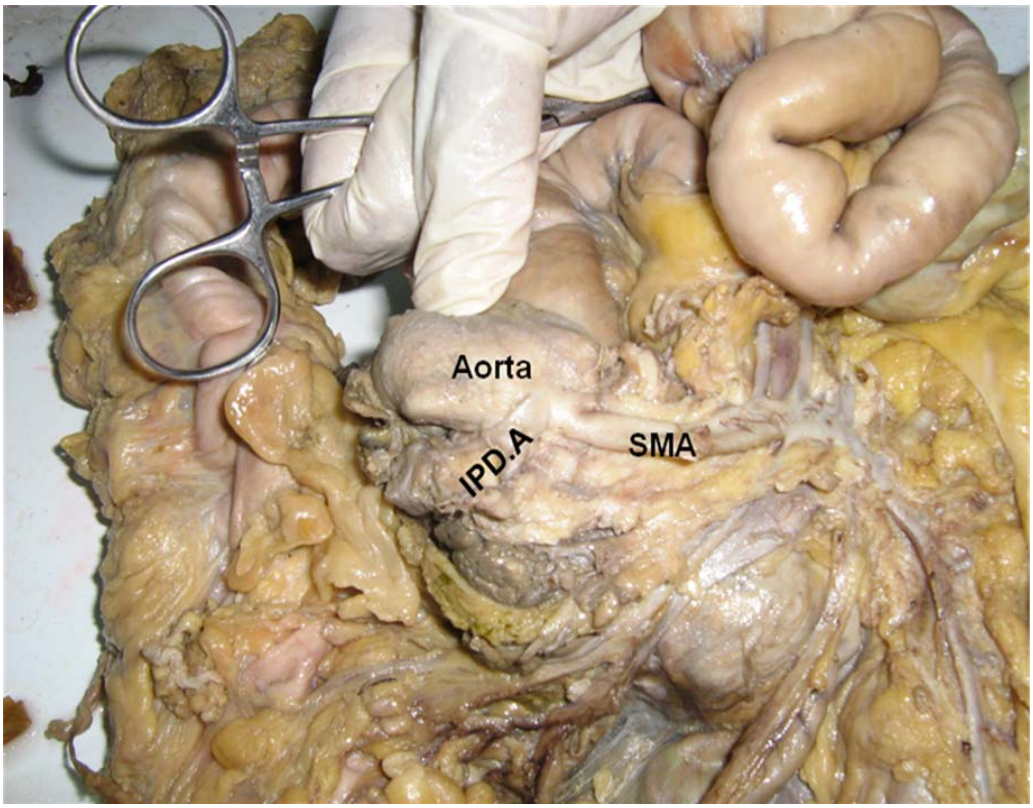


Fig 4a SMA and Inf. Pancreatico duodenal artery as a common trunk

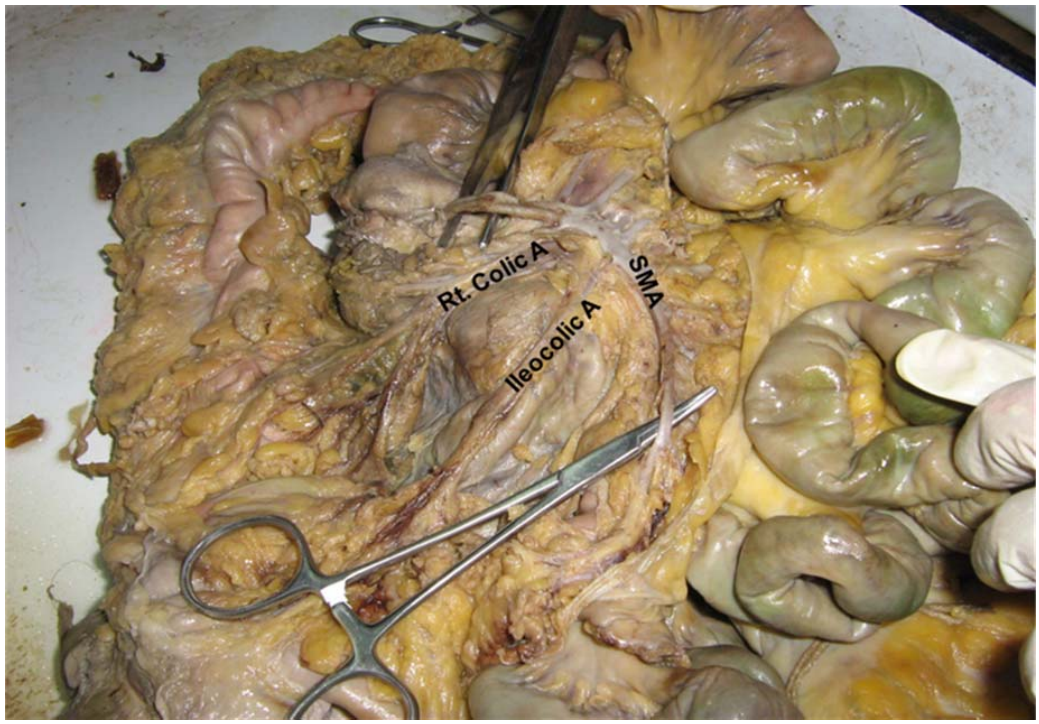


Fig 4b Absence of Middle colic artery

Middle Colic Artery

Present	48
Absent	2
Common with Rt. Colic A	6
Double	4

Table 4 Middle Colic Artery

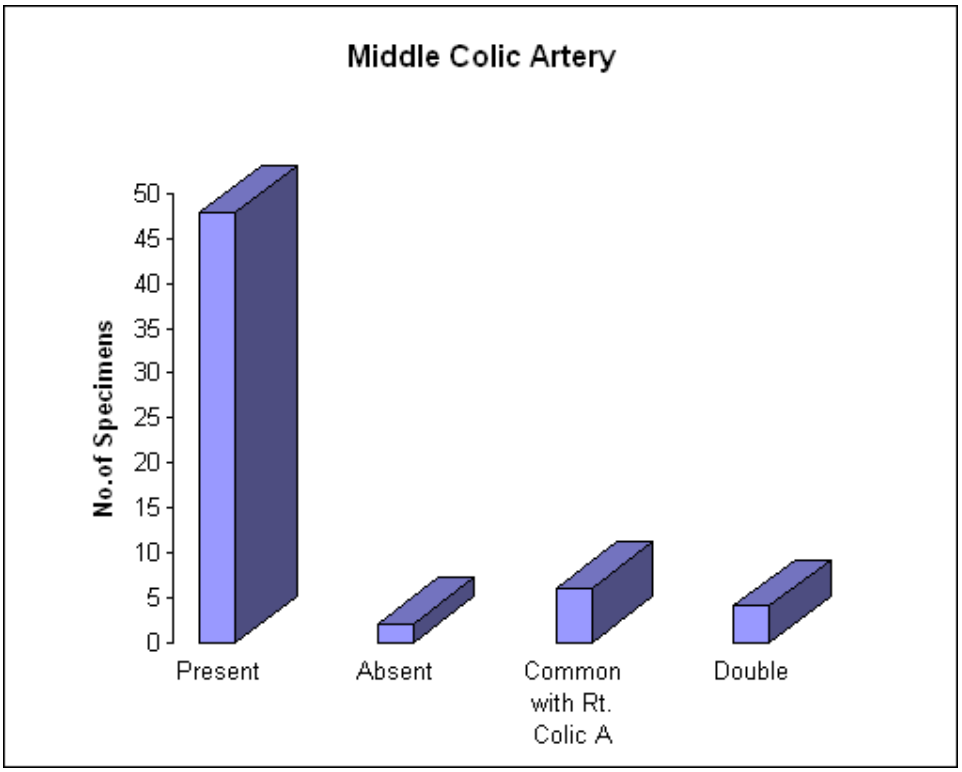


Chart 3 Middle Colic Artery

Fig 5a Middle and Right colic artery as a common trunk

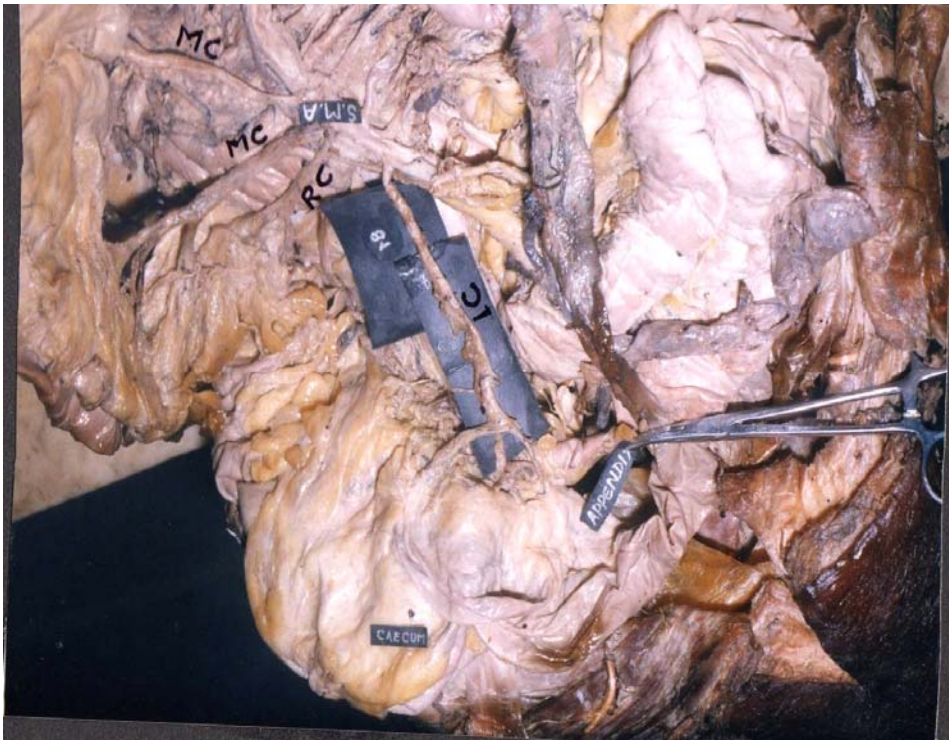


Fig 5b Double Middle colic artery

In six specimens (12 %) both middle colic artery and right colic artery arose as a common trunk (Fig 5a) from the superior mesenteric artery.

Double middle colic arteries (Fig 5b) were observed in 4 specimens (8 %). Out of this form, 2 middle colic arteries (4 %) had their common origin directly from the superior mesenteric artery. In 1 specimen (2 %), 2 middle colic arteries were observed to take origin from the superior mesenteric artery and the right colic artery had its origin from the ileocolic artery. In another specimen, 1 middle colic artery (2 %) from the superior mesenteric artery and the other middle colic artery from the right colic artery.

Right Colic Artery

In the present study of 50 superior mesenteric arteries , right colic artery (Tab 5& Chart 4) was present in 43 specimens (86 %) and absent in 7 specimens (14 %).

Out of 43 right colic arteries, 34 (68 %) had normal site of origin whereas 9 (18 %) of them showed abnormal origin.

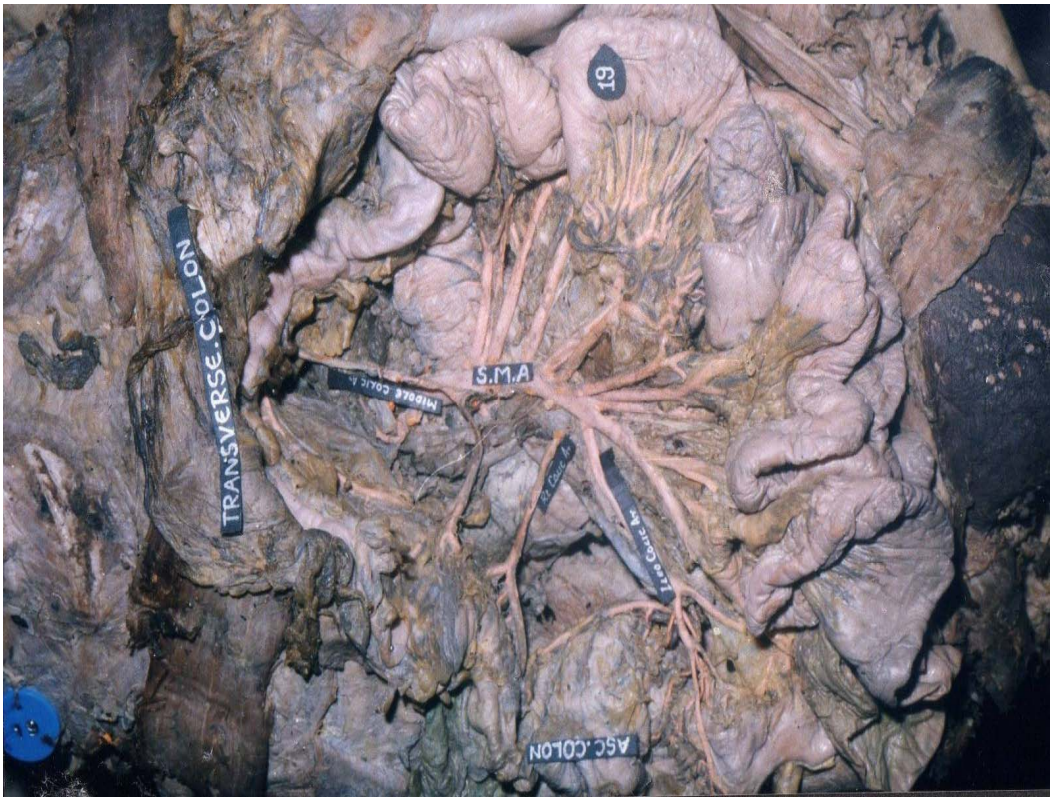


Fig 6a Double Right colic artery

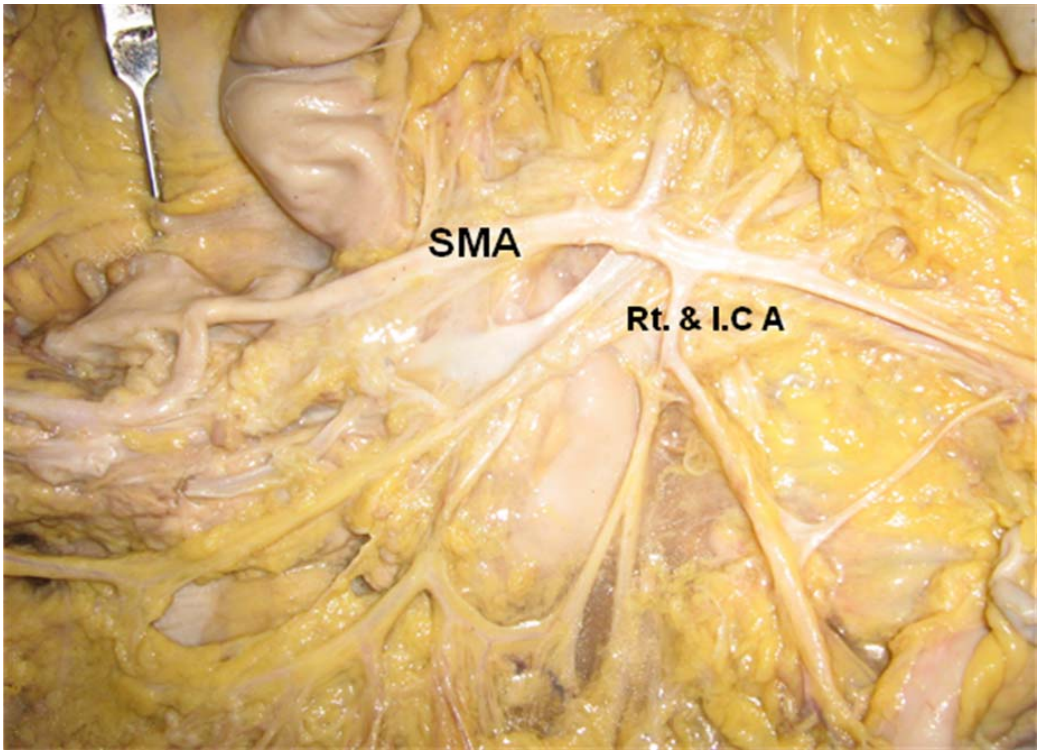


Fig 6b Rt. Colic and ileocolic as a common trunk

Right Colic Artery

Present	43
Absent	7
Double	6
Common with Ileocolic A	1
From Ileocolic A	2

Table 5 Right Colic Artery

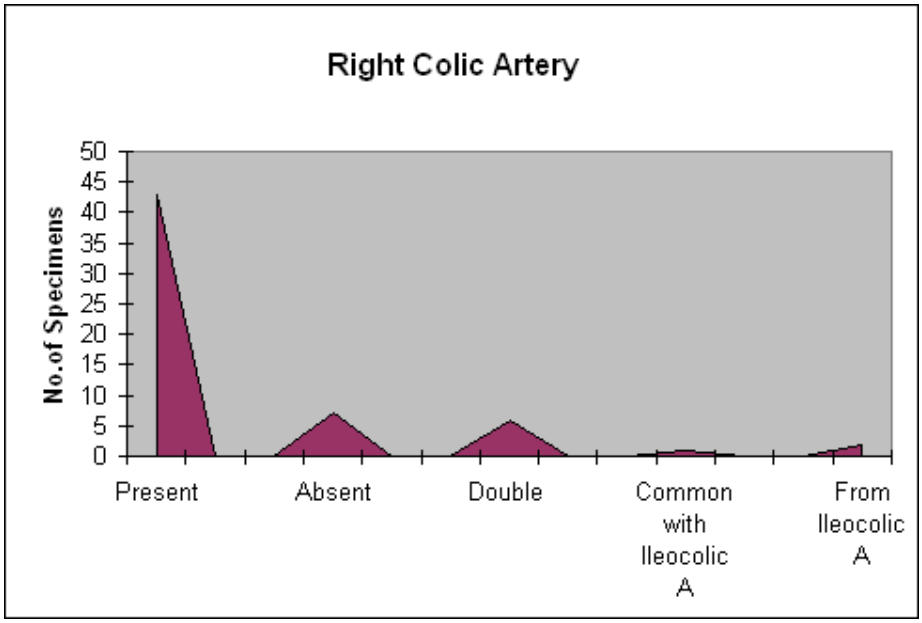


Chart 4 Right Colic Artery

The right colic artery was double (Fig 6a) in six specimens (12 %) and both were taking origin from the superior mesenteric artery.

In one specimen (2 %) the right colic artery and the ileocolic artery had common origin (Fig 6b) from the superior mesenteric artery.

In two specimens (4 %), the right colic artery took origin from the ileocolic artery.

In the specimens where the right colic artery was absent, it was replaced by branches from the middle colic artery and ascending branches of ileocolic artery.

Ileocolic Artery

Ileocolic Artery (Tab 6 & Chart 5) was present in all the 50 superior mesenteric artery. In two specimens (4 %) the right colic artery was given off from the ileocolic artery. In one specimen (2 %) the ileocolic artery and the right colic arteries had common origin.

Ileocolic Artery

Present	**50**
Common with Right Colic A	**1**
From Right Colic A	**6**

Table 6 Ileocolic Artery

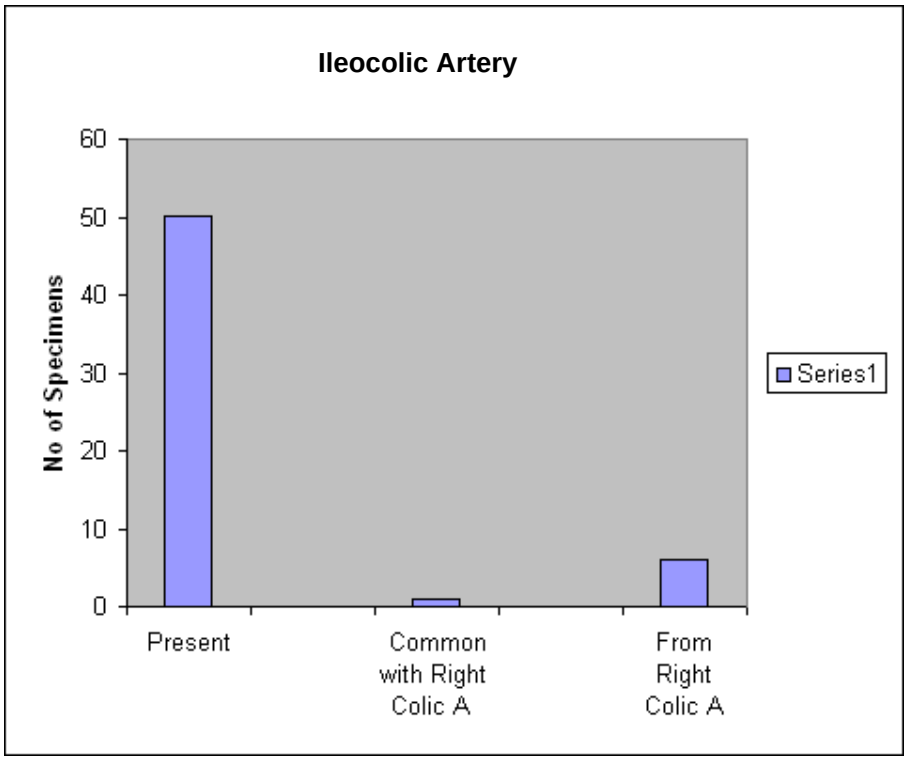


Chart 5 Ileocolic Artery

The appendicular branch of the ileocolic artery (Tab 7 & Chart 6) varied in its origin. In 31 specimens (62 %) the appendicular branch took origin from the ileocolic artery before its division.

In nine specimens (18 %) there were 2 appendicular branches, 1 from the ileocolic artery before division and the other from the inferior division of the ileocolic artery.

In four specimens (8 %) a single branch (Fig 7b) was observed to arise from the inferior division of the ileocolic artery.

In three specimens (6 %) the appendix was supplied by 2 branches, 1 from the ileocolic artery and another from the posterior caecal artery.

In two specimens (4 %) dual arterial supply (Fig 7a) was observed to arise from the ileocolic artery before division and another from the anterior caecal artery.

Fig 7a Double Appendicular Artery

Fig 7b Appendicular A from inf. Division of Ileocolic A

Appendicular Artery

Appendicular Artery	No. of Specimens	Percentage (%)
Ileocolic	31	62
Inferior Div. of Ileocolic	4	8
Ileocolic+Inferior Div	9	18
Ileocolic+Anterior Caecal	2	4
Ileocolic+Posterior Caecal	3	6
Nil	1	2

Table 7 Appendicular Artery

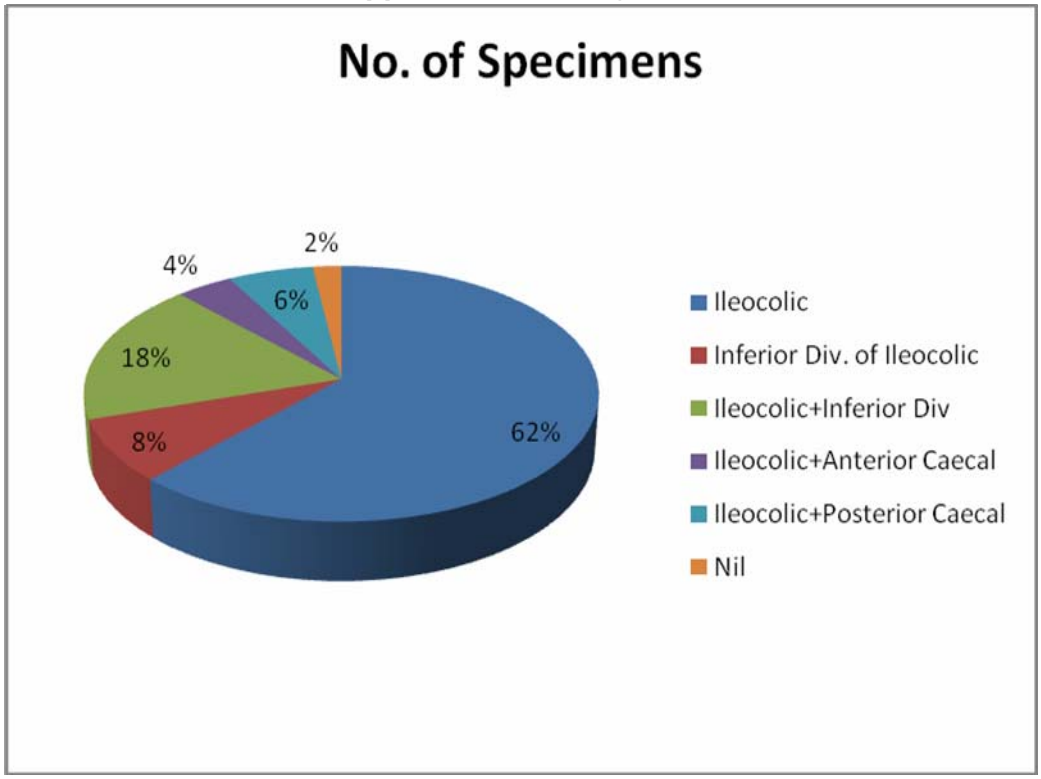


Chart 6 Appendicular Artery

In one specimen (2 %) appendix was absent may be due to appendicectomy. In this specimen the branches of the ileocolic artery, the ileal, anterior and posterior caecal and colic branches were normally present but the appendicular artery were absent. In the same specimen, the middle colic artery was also absent.

Abnormal Hepatic Artery

In this study of 50 superior mesenteric arteries , 5 specimens (10%) had the accessory right hepatic artery arising from the superior mesenteric artery.

DISCUSSION

A total of fifty (50) superior mesenteric arteries were studied in the different age group in the south Indian population by Dissection , Angiogram pictures and Surgeries.

The observations have been recorded, summarized and discussed with reference to their surgical application with special reference to the intestine transfers , that are becoming popular. The observations of the normal and abnormal branching pattern gains greater importance in the specialty of Gastroenterology where these data were of greatest importance in major abdominal surgeries.

The data obtained in the present study was correlated with the data of the previous workers in this field.

Origin of the Superior Mesenteric Artery

Classical description of the superior mesenteric artery origin was found in 86 % in the present study. This was in confirmity to the normal description of the text books (Gray's Anatomy 38th edition, Cunningham's manual of practical Anatomy 15th edition, Last's Anatomy regional and applied 10th edition).

In three specimens (6 %) of the present study, the common origin of the superior mesenteric artery and the splenic artery from the abdominal aorta was observed. Michels (1955) in his study of 200 specimens stated that, in 11.5 % of his specimens the common origin was found. Van haler (Tripod of Haler) also recorded the common origin.

The distance between the site of origin of the superior mesenteric artery and the coeliac trunk from the aorta in the present study of 50 specimens ranged from 2 to 20 mm. Michels (1955) in his study of 200 specimens stated the range to be 2 to 22 mm. The common pattern in

Michels (1955) study ranged from 1 to 6 mm (60 %). In the present study it was observed only in seventeen specimens (34 %) the distance ranged from 2 to 5 mm.

Anson and Mcvay (1936) reported in their study that 71 % of the cases ranged from 1 to 2 cm. In the present study the range was 0.2 to 2cm.

The study of Radhakrishnayya (1990) revealed that in 18 specimens (72 %) , the distance found to be 12.5 mm (1.25 cm) out of 25 specimens. He had also found the minimum range to be 2 mm and the maximum to be 12.5 mm in the south Indian population. The variation range between Radhakrishnayya's and the present study was minimal.

When compared with the study of Michels (1955), Anson and Mcvay (1936) and Radhakrishnayya (1990), the observations of the present study (2 to 20mm) were almost similar to that of Anson and Mcvay's report of 71 % range in 1 to 2 cm distance.

The variations in the distance observed in the present study suggests that this range had to be observed during major abdominal surgical procedures.

Inferior Pancreatico duodenal Artery

The present study indicated that the pattern of the origin of the inferior pancreatico duodenal artery (**Tab 3)** was normal in 45 (90%) out of 50 superior mesenteric arteries examined.

Michels (1955) reported this type of origin in 60 % of his 200 cases studied.

Text books and some workers (Gray's Anatomy 38th edition, Michels etc..) have reported the origin of the inferior pancreatico duodenal artery from the first jejunal branch to be normal. The same is observed in the present study in 2 cases (4 %). So in the present study the total percentage of normal origin of Inferior pancreatico duodenal artery is 94 %.

Origin of Inferior Pancreatico duodenal Artery

Normal				From Aorta with SMA		From posterior Surface of SMA	
From SMA		From 1st Jejunal Branch					
No	%	No	%	No	%	No	%
45	90	2	4	2	4	1	2

Table 3 Origin of Inferior Pancreatic Duodenal Artery

Middle colic Artery

In the present study the Middle colic artery (Tab 8) was absent 2 specimens (4 %).

Vandamme and Schuren (1976) in the series of 156 specimens reported the absence of middle colic artery in only one specimen(0.64 %). Steward and Rankin (1933) in their series of 40 cases of Radiological studies by injecting celluloid material reported the absence of middle colic artery in 2 cases (5 %).

The study of Radhakrishnayya (1990) was also in the south Indian population with absence of middle colic artery in 4 %.

In the present study, out of 48 middle colic arteries in 6 (12 %) it was duplicated (12 %). Of the 6, 5 of them had their origin from the superior mesenteric artery except one pair, in which one was from superior mesenteric artery and the other was from the right colic artery.

Comparison Table showing the Absence of Middle Colic Artery

Middle Colic Artery							
Vandamme 156 cases		**Steward & Rankin 40 cases**		**Radhakrishnayya 25 cases**		**Present Study 50 cases**	
No	**%**	**No**	**%**	**No**	**%**	**No**	**%**
1	0.64	2	5	1	4	2	4

Table 8 Absence of Middle Colic Artery

Henle (1876) also reported duplication of the middle colic artery in his studies.

Steward and Rankin (1933) reported 7 % of double middle colic artery in 40 cases. They also reported the presence of duplication of middle colic artery in 10 % of cases. Radhakrishnayya (1990) in his study of south Indian population reported the double middle colic artery in 1 case (4 %).

Sonneland et al (1958) reported absence of middle colic arteries which was 10 % less than the present study.

The common stem giving rise to the middle colic and right colic artery was observed in 6 cases (12 %) in the present study. The same was observed in the study of Sonneland et al (1958) in 0.5 % out of 600 cases.

Trifurcation branching pattern reported by Steward and Rankin (1933) was not observed in the present study.

Right colic Artery

In the present study the right colic artery (Tab 9) was present in 43 specimens (86 %) and absent in 7 cases (14 %). Out of the 43 right colic arteries studied, 2 of them had abnormal origin (4 %). 6 double right colic arteries were observed in the present study.

Waldeyer (1899 – 1900) reported the origin of the right colic artery from the superior mesenteric artery in 50 % of cases. Steward and Rankin (1933) reported the presence of right colic artery in 40 % of cases.

Sonneland et al (1958) reported the presence of right colic artery in 78 % of cases. Radhakrishnayya (1990) in his study reported the normal origin of right colic artery in 23 specimens (92 %).

The report of Sonneland et al (1958) is almost comparable with the present study. It is interesting to note, that the present study of south Indian population matched the report by Sonneland et al whose subjects had been white males.

Classification of Pattern of Right Colic Artery

S.No	Type	Sonneland Typing		Present Study	
		No (200)	%	No (50)	%
1	Type IIA	63	10.5	7	14
2	Type IVA	9	1.5	1	2

Table 9 Right Colic Artery

The comparative study between Radhakrishnayya and the present study were pertaining to the south Indian population but variation in observation was high as 10 %.

The common origin of right colic and ileocolic artery as a common trunk (2 %) or right colic artery arising as a branch from the ileocolic artery (2 %) were observed in the present study.
Radhakrishnayya (1990) reported the origin of the right colic artery from the ileocolic artery in 4 % but he found no common origin.

Steward and Rankin (1933) in their studies reported the origin of right colic artery from the ileocolic artery in 12 % and from the middle colic artery in 30 %, which was not observed in the present study.

The report of Sonneland et al (1958) was the origin of right colic artery from the ileocolic artery in 9.7 %.

However the pattern of right colic artery arising from the ileocolic artery fitted with the pattern of Sonneland et al Type IV a.

Double right colic artery was observed in 6 specimens (12 %) in the present study. A similar observation was reported by Sonneland et al (1958) in 8.2 % out of 600 cases. Vandamme and Schuren (1976) observed the occurrence of 1.5 % in 156 specimens. Radhakrishnayya did not report any occurrence of such a double right colic artery.

In the present study, the 6 double right colic arteries were arising only from the superior mesenteric artery (12 %) whereas Sonneland et al (1958) observed in their study the second right colic artery to arise from the Ileocolic in 1.5 % and the same was reported by Vandamme and Schuren.

Triple right colic artery arising from the ileocolic artery in the Sonneland et al (1958) report is 0.7 %, which was not observed in the present study.

The double right colic arteries of the present study was not present in the Sonneland et al typing or any other worker. Hence, this pattern is classified to be " unique " observed in the present study.

Ileocolic Artery

In the present study the ileocolic artery was observed in all the specimens.

Though the pattern of origin was normal, the branching pattern presented few variations. It was observed in 1 specimen that the ileocolic artery was giving origin to the right colic artery (2 %). The similar observations was reported by Sonneland et al (6.7 %) and Radhakrishnayya's (4 %).

The Triple branching of the Ileocolic artery was reported by Sonneland et al was not observed in the present study.

Appendicular Artery

The present study of appendicular artery was observed in 49 cases (98 %) and it was absent in 1 case (2 %). In this case appendix was absent and possibility if an appendicectomy could not be ruled out.

The appendicular artery arising from the ileocolic artery was observed in 31 cases (62 %) and from the inferior division of ileocolic artery in 4 cases (8 %).

The double arterial supply was found in 14 cases in which 9 (18 %) derived from the ileocolic and its inferior division. In 3 cases (6 %) the branches were from ileocolic and posterior caecal branch, and in 2 cases (4 %) the branches were from ileocolic and anterior caecal branch. These observations were also reported by Shah and Shah (1946) in 30 % of cases.

SUMMARY

A study was done in 50 superior mesenteric arteries for finding its different pattern of origin and colic branches.

The observatory findings are more or less coinciding with that of the observations of the eminent scientists in the field.

The following findings have been observed :

- Superior mesenteric artery and Splenic artery arising as a common trunk from the abdominal aorta.
- Superior mesenteric artery and hepatic artery arising as a common trunk from the abdominal aorta.
- Superior mesenteric artery and inferior pancreatico duodenal artery arising as a common trunk from the abdominal aorta.
- Distance between the origin of coeliac trunk and superior mesenteric artery, ranged from 2mm to 20mm.

- Inferior pancreatico duodenal artery arising from the posterior surface of superior mesenteric artery and also from the 1st jejunal branch.
- Middle colic artery and right colic artery arising as a common trunk from superior mesenteric artery.
- Double middle colic arteries, both from the superior mesenteric artery or one from superior mesenteric artery and the other from the right colic artery.
- Double right colic artery.
- Right colic artery and ileocolic artery arise as a common trunk from superior mesenteric artery.
- Right colic artery arising from the ileocolic artery.
- Ileocolic artery and right colic artery had a common trunk from superior mesenteric artery.
- Ileocolic artery arising from the right colic artery.
- Appendicular artery arising from inferior division of ileocolic artery.

- Double appendicular arteries, one from ileocolic artery before division and other from inferior division of the ileocolic artery or one from the ileocolic artery and other from anterior or posterior caecal artery.

With the knowledge about the aberrant vessels by their origin or by their branches and termination, the surgeon can take adequate precautions against the bleeding vessels in the operating field.

The anatomists can stress these variant occurrence and their clinical importance while teaching and guiding the medical students.

Hereby I hope this analysis of mine about the variational and surgical anatomy of the superior mesenteric artery will be of definite use and guide to the operating surgeons, radiologists and anatomists in the medical field.

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