

Variations in the branching pattern of ventral branches of abdominal aorta- A cadaveric study

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Abstract: *Background:* The three ventral branches of the abdominal aorta namely coeliac trunk (CT), superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) are responsible for supplying blood to the derivatives of primitive foregut, midgut and hindgut respectively. *Objectives:* This study was conducted to assess the frequency of the variations of the ventral branches of Abdominal Aorta in the eastern part of the country. *Methods:* 39 cadavers of both genders and age ranging between 50 - 80 years were dissected. Origin, course and branching pattern of ventral branches of abdominal aorta were carefully observed, results tabulated and inference was drawn. *Results:* Variations found in 29 cadavers(74.35%) were right gastric artery (RGA) arising from the trunk of CT in 23% cadavers (12.8% males and 10.2% of the females), left inferior phrenic artery (LIPA) arising from CT found in 7.7% cadavers (5.1% males and 2.6% females), right colic & ileocolic arising from an abnormal common branch (ACB) from right side of SMA found in 41% cadavers (23% males and 18% females) and CT & SMA arising from a common point from abdominal aorta found in 2.5% cadavers (2.5% males, no females). *Conclusions:* The knowledge of variations in Coeliac trunk is important for hepatic, gastric and splenic surgeries, that of Superior Mesenteric artery is important for intestinal surgeries.

Keywords: Coeliac trunk, Superior mesenteric artery, Left Inferior phrenic artery, Variations, branching pattern.

Introduction

Abdominal aorta (AA) is a broad vessel, lifeline to all viscera and parietal structures in the abdominal cavity. The abdominal aorta begins at the aortic hiatus of the diaphragm, anterior to T12 vertebra, descends anterior to the lumbar vertebrae and bifurcates into two common iliac arteries anterior to the L4 vertebra or the L4/5 intervertebral disc, slightly to the left of the midline. Branches arise from its all four walls and are classified as ventral, dorsal, lateral and terminal branches. The anterior (unpaired) and lateral (paired) branches are distributed to the viscera, while the dorsal branches supply the body wall, vertebral column, and its contents, terminal branches supply pelvis and lower limbs.

The coeliac trunk is the first ventral branch, arises just below the aortic hiatus, usually at the level of the vertebral body of T12. It is 1–3 cm long and passes almost horizontally forwards and slightly to the right above the body of the pancreas and splenic vein. In most individuals, it trifurcates

into the left gastric (LGA), common hepatic (CHA) and splenic (SA) arteries. These arteries supply the derivatives of the primitive foregut namely stomach, liver with hepatobiliary system, parts of duodenum & pancreas and spleen.

The superior mesenteric artery originates from the aorta approximately 1–2 cm below the coeliac trunk, at the level of the L1 vertebra. It lies posterior to the body of the pancreas and splenic vein, and is separated from the aorta by the left renal vein. It passes forwards, inferiorly and to the right, anterior to the uncinate process of the pancreas and the third part of the duodenum, to enter the root of the small bowel mesentery and supply the midgut. From the convex left side, it provides 12 to 15 jejunal and ileal branches which pass between the layers of the mesentery, forming a series of arterial arches. The jejunal and ileal arteries supply the mobile part of the small gut except the terminal 10-12 cm of the ileum; the latter

is supplied by the ileal branch of the ileo-colic artery. From its concave right side, the branches arising from proximal to distal are - Inferior pancreatico-duodenal artery, Middle colic artery (MCA), Right colic artery (RCA), and Ileocolic artery (ICA). These arteries supply the caecum, appendix and part of the large gut upto the junction of right 2/3rd and left 1/3rd of the transverse colon.

The inferior mesenteric artery arises from the left anterolateral aspect of the aorta at about the level of the L3 vertebra, 3 or 4 cm above the aortic bifurcation and posterior to the inferior border of the horizontal part of the duodenum. Branches are: Left colic artery, 4-5 sigmoid arteries and Superior Rectal artery which is a continuation of IMA. These supply the part of the large gut beyond the junction of right 2/3rd and left 1/3rd of the transverse colon and upto the pectinate line of anal canal. The successive anastomosis of the Superior and inferior mesenteric arteries forms a continuous Marginal Artery of Drummond (MAD) from ileocaecal to rectosigmoid junction, vasa longa & brevia arise from MAD in alternate manner and supply the large gut [1]. Inferior phrenic arteries, right inferior phrenic artery (RIPA) & left inferior phrenic artery (LIPA), are the 1st pair of lateral branches of AA and supply the diaphragm from its under surface [1].

Variations are common in the origin and branching pattern of above mentioned arteries.

The knowledge of this variation is important for gastroenterology surgeons, oncologists, radiologists etc. This study was conducted to assess the frequency of these variations in the eastern part of the country.

Material and Methods

An observational study was conducted in the department of anatomy, Burdwan Medical college, West Bengal after receiving clearance from college scientific and ethical committees (BMC/IEC/174). 39 cadavers of both genders and age ranging between 50 - 80 years were dissected. The dissection was conducted as per Cunningham’s manual of practical anatomy. After opening the abdominal cavity, the peritoneum and viscera were carefully separated and cleaned from the field of vision. Ventral branches of abdominal aorta namely coeliac trunk (CT), superior mesenteric artery (SMA) and inferior mesenteric artery (IMA) were traced proximally and distally. Their origin, course and branching pattern were carefully observed. The findings were tabulated and percentages found.

Results

Variations in branching patterns of ventral branches of abdominal aorta were found in 29 cadavers out of 39 (74.35%) as mentioned in Table 1 and 2.

Table-1: Variations in the branching of ventral branches of abdominal aorta					
	Abnormal CT (RGA branch of CT)	Abnormal CT (LIPA arising from CT)	Abnormal SMA (ICA & RCA arising as a common trunk)	CT & SMA arise from same point from AA	Total
Males	5	2	9	1	17
Females	4	1	7	0	12
Total	9	3	16	1	29

Table-2: Normal branching of ventral branches of abdominal aorta	
	Normal branching pattern
Males	6
Females	4
Total	10

The variations found were- right gastric artery (RGA) arising from the trunk of CT (Fig 1), Left Inferior phrenic artery (LIPA) arising from CT (Fig 2), right colic & ileocolic arising from an abnormal common branch (ACB) from right side of SMA (Fig 3) and CT & SMA arising from a common point from the ventral surface of AA (Fig 4).

Fig-1: Showing Right Gastric Artery arising as a branch of Coeliac trunk

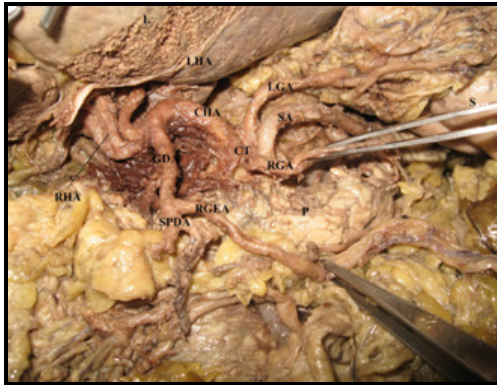


Fig-2: Showing the left inferior phrenic artery arising as a branch of Coeliac trunk

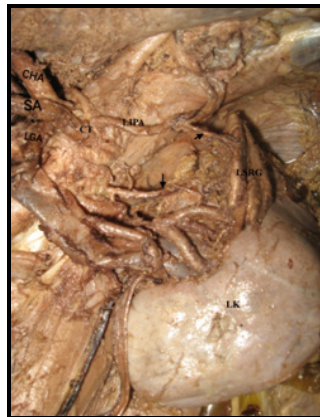
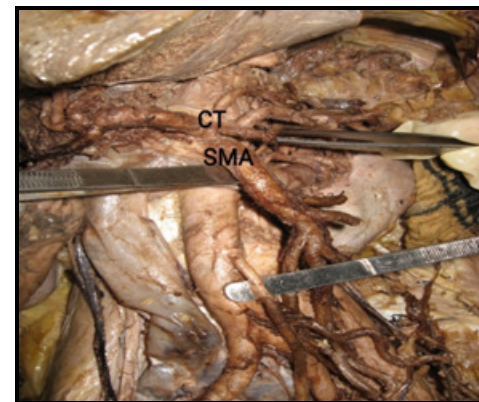


Fig-3: Showing an Abnormal common branch for the Right colic and Ileocolic arteries arising from the Superior Mesenteric Artery.



Fig-4: Showing Coeliac trunk and Superior Mesenteric Artery arising from the common point of Abdominal Aorta.



Discussion

Historically, French anatomist Jean Riolan (1580-1657) supposedly wrote the first anatomic treatise in which colon vascularity was described in detail [2]. It was not until the 19th century, especially when abdominal surgery began to develop, that scientific and technical advances led to the appreciation of wide variations in mesenteric circulation [3]. As the field of intestinal surgery advanced, over the present century, the challenge of performing more complex resections and anastomoses highlighted the presence of vascular variants. This brought more detailed and careful anatomic studies. Several of them form the basis of our current anatomic concepts on blood supply to the colon.

In our present study, a few variations were found in the branching pattern of two main ventral branches of abdominal aorta namely CT and SMA. No variations were found in IMA in any of the 39 cadavers dissected. Variation in origin of

LIPA was also found which is usually a lateral branch of AA. The root as well as branching pattern of the celiac trunk are essential for proper vascular ligation and anastomosis during laparoscopic abdominal surgery and procedures such as liver transplantation. [4]. In gastric surgeries and radiological procedures as well as surgeries related to hepatobiliary system also this knowledge is needed.

We found two types of variations in CT branches- first group showed tetrafurcation of CT into CHA, SA, LGA and RGA. The Right Gastric Artery (RGA) arising as a direct branch of the CT was found in 23% of the dissected cadavers (12.8% males and 10.2% of the females) (Fig 1). The second group showed the Left Inferior Phrenic Artery originating from the Coeliac trunk in 7.7% of the dissected cadavers (5.1% males and 2.6% females) (Fig 2).

Variations in the branching pattern of CT have been mentioned in many studies [4-6], but most have not mentioned about the tetrafurcation of CT with RGA as the fourth branch. LIPA arising as a direct branch from CT was found in one subject out of 60 (10 cadavers & 50 CECT images) by Vidya CS et al [7]. İlke Ali Gürses et al in 26 cadavers found that LIPA originated from the abdominal aorta in 9 sides and the coeliac trunk in 6 sides [8]. B Szewczyk et al in their cadaveric study found RIPA originating from the AA and LIPA from CT in 6 cases (12.48%) whereas we found this in only 3 cases (7.7%). The most common type found by them was also the RIPA and LIPA originating from the abdominal aorta (AA) (14 = 29.12%) [9].

We found the normal arrangement of both RIPA & LIPA arising from AA in 36 out of 39 cases i.e. 92.31%. J K Chandrachari et al dissected 50 cadavers and found that both inferior phrenic arteries arose from AA in 43 cadavers (86%), LIPA originated from the CT in 4 cadavers (8%) [10]. The Jodhar Pulakunta et al found that both the inferior phrenic arteries showed normal origin in 28 out of 32 cases (87.50%), only in 2 cases LIPA arose directly from the CT (6.25%) [11]. part from being the main arterial supply to the diaphragm, RIPA and LIPA are extrahepatic collateral arterial pathways that supply hepatic malignancies, because they neighbour hepatic segments as they traverse the bare area of the liver. Both RIPA and LIPA are used during transcatheter arterial chemoembolization of liver malignancies. Furthermore, LIPA gives branches that supply the stomach and oesophagus and can be a source of arterial bleeding at the oesophagogastric junction [8].

Variations were also found in the branching pattern of SMA. There was presence of an abnormal common branch (ACB) arising from the right side of SMA in 41% of the dissected cadavers (23% males and 18% females). It ran transversely and divided into RCA and ICA, each further divided into ascending and descending branches. These were seen to anastomose with the descending branch of MCA and terminal end of SMA respectively forming marginal artery of Drummond (Fig 3). Gamo E et al dissected 50 cadavers, 28 males and 22 females and collected 560 CTs, 399 males and 161 females. Common trunk between RCA and ICA was found in 32%

cadavers and 15% CT findings. According to them, although the independent origin of the three colic arteries have been classically described as the most frequent, the right colic artery is responsible for major variations [12].

Antonio García-Ruiz MD et al performed detailed dissections of the SMA in 56 human cadavers. They found the ICA in all of their cases and MCA in 55 out of 56 cadavers but only 6 cases of a RCA emanating directly from SMA. Hence, they concluded that in the vast majority of cases there are only two independent branches arising from SMA that supply the large intestine, the ileocolic and the middle colic arteries. The right colic artery directly arising from SMA is unusual (10.7 percent) contrary to what is described in major anatomy books [13]. Robert S Benton & William B Cotter dissected the cadaver of a male, Negro, 71 years old, estimated stature and weight: 6'1" and 180 lbs. They documented that the superior mesenteric artery gave rise to one major trunk to the colon, which was divided into ileocolic and right colic branches only [14].

We found SMA and CT having common origin from AA in one male cadaver (2.56%) (Fig 4). Lipshutz first described ramifications of the coeliac trunk in 83 cadavers, only two had single origin for SMA & CT. He coined the term 'truncus coeliaco-mesenterica" for such cases [15]. The coeliacmesenteric trunk (CMT) is a rare anatomic variant that is reported to be present in 0.42% – 2.7% of individuals [16-17]. In the study done on the Polish population by Torres K et al, a CMT was observed in 0.5% of cases (8/1569) [18]. In the retrospective evaluation carried out on 1,500 abdominal MDCT angiography images, Yi Wang et al noted normal aortic origins of CT and SMA in 1,347 (89.8%) patients but a CMT was found only in 51 patients (3.4%) [19]. More recently, Srivastava A et al in Jaipur, India, found 2 cadavers (5%) out of 40 with common CMT [20] and Silva NG et al found 2 out of 18 cases (11.11%) with the same [21]. Gardner MT et al also found it in 1.5% dissected cases in an Afro-Caribbean population from Jamaica [22].

The present study did not show any variations in the inferior mesenteric artery. Variations in the developmental pattern can be the reason behind the varied variations seen in the origins and the branching pattern of the CA, the SMA and inferior phrenic arteries. According to some authors, initially three groups of arteries arise from the paired dorsal aortae, which arise as de novo vessels- ventral splanchnic arteries to the gut and its derivatives, lateral splanchnic arteries to the derivatives of intermediate mesoderm and dorso-lateral somatic intersegmental branches to the parities. At first the ventral branches are paired. With the fusion of dorsal aortae, the ventral branches are fused and form a series of unpaired segmental vessels, which run forwards through the dorsal mesentery of the primitive gut and divide into ascending and descending branches along the dorsal aspect of the gut.

These vessels eventually form dorsal and ventral longitudinal anastomotic channels. Only some parts of these anastomotic channels persist in later life. Also, numerous ventral splanchnic branches of the aorta are withdrawn below the diaphragm and only three trunks persist as the coeliac artery for the foregut, the superior mesenteric artery for the midgut, and the inferior mesenteric artery for the hind gut. Remains of dorsal and ventral longitudinal anastomotic channels form branches of these three trunks, other branches develop as new stems. The origins of three arterial trunks migrate caudally from their primitive positions due to successive growth of the new caudal stems and take their adult positions [1, 23].

According to some others, the vitelline arteries, initially a number of paired vessels supplying the yolk sac, gradually fuse and form the arteries in the dorsal mesentery of the gut. In the adult, they are represented by the celiac and superior mesenteric arteries. The inferior mesenteric arteries are derived from the umbilical arteries [24]. The inferior phrenic artery buds out from the highest suprarenal artery which is a lateral

splanchnic branch from aorta. [1] According to another point of view, the dorsal aorta in the thorax and lumbar region, gives thirty pairs of arteries, which pass in between the successive somites as dorsal intersegmental arteries. So the diaphragm which is developed from muscular ingrowths from the lateral body wall is supplied by the dorsal branches of abdominal aorta through inferior phrenic arteries [25-26].

Some authors also believe that the intestinal /vitelline arteries are connected by longitudinal anterior anastomosis and are four in number, among which the proximal part of the 2nd and 3rd root disappears and distal portion joins with the first root to form classical three branches of celiac artery [27]. The celiac axis and the inferior phrenic artery are derived from the 6th pair of ventral splanchnic vessels. During foetal development, these arteries span and disappear but if these longitudinal channels between the primitive vessels persist it may lead to vascular variations [28].

Conclusion

Variations are common in the origin and branching pattern of ventral branches of abdominal aorta which can be explained by the variations in the embryological mechanism of their development. In this study variations were found in the branching pattern of CT and SMA. RGA arising as the fourth branch of CT was found which is not mentioned in most of the previous studies. The most common variation found was RCA and ICA arising as an abnormal common trunk from SMA. A detailed knowledge of normal & abnormal pattern of origin and branching of CT & SMA is of immense use for correct radiological diagnosis and surgical treatment of pathologies related to derivatives of foregut and midgut.

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