Original article

Multiple vascular variations of abdominal vessels in a male cadaver: embryological perspective and clinical importance

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Abstract

Multiple variations in upper abdominal vessels were observed during routine dissection of abdomen in a 50 year old male Indian cadaver. A long and unusually thick celiac trunk was observed arising ventrolaterally at the level of T12 and L1. The celiac trunk gave rise to four branches out of which left gastric artery was the first branch and the remaining three were common hepatic artery, a tortuous dorsal pancreatic artery and a non-tortuous splenic artery. The right inferior phrenic and right middle suprarenal arteries were found to arise from right renal artery via a common trunk. The left inferior phrenic artery and left testicular artery were found to arise from abdominal aorta via a common trunk just above the left renal artery. In addition, a large left lumbar vein was observed which drained into left renal vein, close to its termination into inferior vena cava. The present paper describes the multiple anatomical variations with embryological basis.

Keywords: celiac trunk, lumbar vein, dorsal pancreatic artery, testicular artery, vascular variations.

1 Introduction

Variations in the abdominal vessels are commonly observed during diagnostic angiography, surgeries or during cadaveric dissection. The most commonly reported variations of the abdominal region are of hepatic artery (PAI, HUNNARGI and SRINIVASAN, 2008), renal artery (TURKVATAN, Ozdemir, Cumhur et al., 2009), celiac trunk and its branches (VANDAMME and BONTE, 1985), suprarenal arteries (TANYELI, UZEL and SOYLUOGLU, 2006) and gonadal arteries (TERAYAMA, YI, NAITO et al., 2008). Even though the vascular variations are common and mostly asymptomatic, they are of utmost clinical importance in patients undergoing invasive interventions such as surgery and transplantation of kidney and liver, surgery for abdominal aortic aneurysms, gastrointestinal surgeries and gonadal surgeries. An adequate knowledge of vascular anomalies will help the radiologists and surgeons in executing a safe and successful surgical procedure. Multiple vascular variations in a person are rarely reported in the literature. In the present report we report the vascular variations involving celiac trunk, inferior phrenic artery, suprarenal arteries, testicular artery and lumbar vein in a male cadaver with their clinical significance and embryological aspects.

2 Materials and methods

2.1 Cadaveric dissection

A 50 year old male cadaver fixed in formalin maintained in the Department of Anatomy, Manipal University was used for routine dissection for teaching purpose. After noticing multiple variations in the vessels of upper abdomen the cadaver was dissected carefully to trace the origin and course of the vessels.

2.2 Vascular variations

A large (4.2 cm long), unusually thick (8 mm thick at its origin) celiac trunk (CT) was observed arising ventrolaterally between T12- L1 instead of its usual position in the midline. All the branches of celiac artery were unusually thick. At 3.5 cm from its origin, it gave rise to its first branch- the left gastric artery (LGA) which had an external diameter of 4 mm. The celiac trunk ran infero-medially to the right hand side and at 4.2 cm from its origin it trifurcated into common hepatic artery (CHA), dorsal pancreatic artery (DPA) and splenic artery (SA). The common hepatic artery (7 mm thick) gave rise to gastroduodenal (GDA) and hepatic artery proper (HAP). The dorsal pancreatic artery (6 mm thick) was slightly tortuous and coursed down in front of splenic vein behind the body of the pancreas were the artery divided into a right and a left branch. The right branch coursed to the right, behind the body and the head of the pancreas and terminated there. The left branch of the dorsal pancreatic artery had a short course on the dorsal surface of the pancreas before piercing its substance. However, the splenic artery (6 mm thick) was not tortuous as it should be (Figures 1 and 2).

The other ventral branches of abdominal aorta- superior mesenteric (SMA) and inferior mesenteric arteries (IMA) were normal in their origin and course. Renal artery (RA) originated from the lateral aspect of abdominal aorta. On right hand side the right renal artery gave rise to right inferior phrenic artery (IPA) and right middle suprarenal artery (MSA) through a common stem. The right superior suprarenal artery (SSA) originated from inferior phrenic and the right inferior suprarenal artery (ISA) from inferior aspect of renal artery. So on right side the right renal artery gave rise to right - IPA, MSA and ISA (Figure 3). The right testicular artery had a normal origin which arose

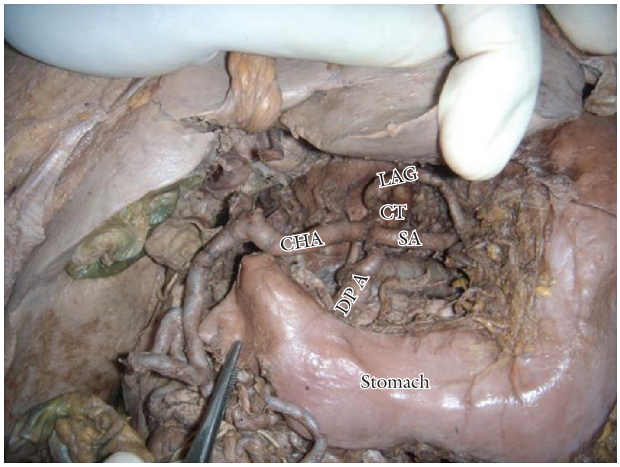

Figure 1. Photograph showing multiple anomalies of celiac trunk and its branches with stomach in position.

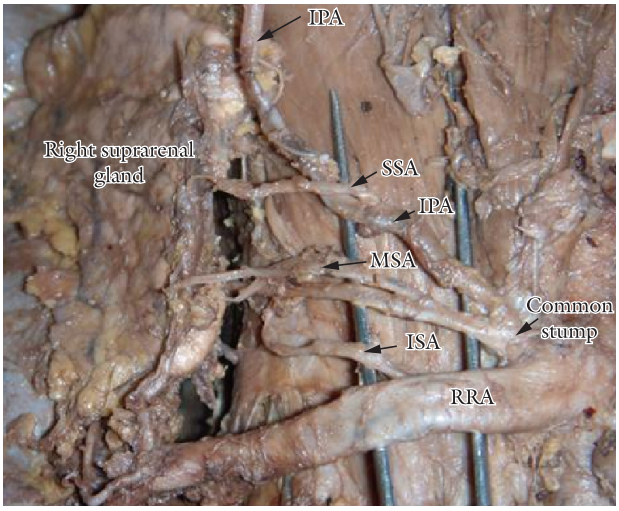

Figure 3. Photograph showing anomalies of right suprarenal arteries.

Figure 2. Photograph showing multiple anomalies of celiac trunk and its branches with stomach and pancreas retracted.

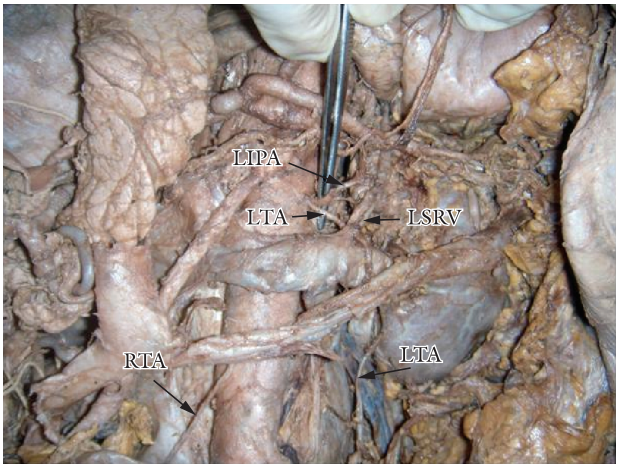

Figure 4. Photograph showing anomalies in testicular artery and inferior phrenic artery on the left side.

from ventral aspect of abdominal aorta little inferior to the renal artery. On left hand side, just above left renal artery a common trunk was noted arising from abdominal aorta which later divided into superior and inferior branches. The superior branch supplying the diaphragm was left IPA which also gave rise to left SSA. The inferior branch, the left testicular artery, ran below left suprarenal vein but above left renal vein towards the deep inguinal ring (Figure 4). In addition, we observed an unusually large left lumbar vein which hooked around left renal artery and drained into left renal vein near its termination into inferior vena cava (IVC) caudodorsally (Figure 5). So the tributaries of left renal vein in this case were left suprarenal vein, left testicular vein and a large lumbar vein. The left MSA and ISA had normal origin and course.

3 Discussion

Celiac trunk (CT) is a ventral visceral branch of aorta which arises just below the aortic hiatus superior to pancreas. Since the branches of celiac trunk supplies the gastrointestinal tract and its associated glands derived from foregut, variations of these arteries and their relationship to the surrounding structures are important from surgical point of view. In 75-90% of individuals it runs horizontally forwards approximately for 1.25 cm and divides into left gastric artery, splenic artery and common hepatic artery (WILLIAMS, BANNISTER, BERRY et al., 1995). In the present case we observed a long and stout celiac trunk (4.2 cm in length and external diameter of 8 mm), which also had unusual branching pattern. It gave rise to four branches out of which left gastric artery was the first branch and the remaining three were common hepatic artery, a tortuous dorsal pancreatic artery (DPA) and a non-tortuous splenic artery. Presence of a large celiac trunk measuring up to 4.3 cm long (CAVDAR, GURBUZ, ZEYBEK et al., 1998; YUKSEL,

YALIN and WEINFELD, 1998) and its unusual branching pattern of celiac trunk has been reported in earlier studies (VANDAMME and BONTE, 1985; KAHRAMAN, Marur, Tanyeli et al., 2001; Saeed, Murshid, Rufai et al., 2003).

In the present case the fourth terminal branch of the celiac trunk, the dorsal pancreatic artery was highly tortuous and was 6 mm in thickness. It is highly variable with respect to its origin, course, and size. Bergman, Thompson, Afifi et al. (1988) have reported some of the variations of the dorsal pancreatic artery which arose from the splenic artery (37%), the celiac trunk (33%), the superior mesenteric (21%), and the common hepatic artery (8%). Similarly Kadir (1991) has reported that it can arise from superior mesenteric (40%), celiac artery (22%), CHA (20%) or aorta (14%). Since DPA is the dominant artery supplying the pancreas, the present variation is of importance in pancreatic surgeries. In addition, the large caliber of the DPA and its participation in the formation of pancreatic arches provides a massive collateral circulation. When a dilated, tortuous artery is encountered during surgery, very close attention is necessary for a safe operative procedure since these vessels are highly fragile to surgical procedures.

It is difficult to explain the reason for unusually thick celiac trunk and its branches observed in this case. Silveira, Silveira and Fazan (2009) conducted a study on 21 formalin fixed cadavers and observed that in presence of anatomical variations of celiac trunk and its branches, the main branches of celiac trunk had a smaller diameter compared to those which had a normal branching pattern of celiac trunk. However, in the present case we have observed that both CT and its branches had a thicker diameter than normal.

The vascular anomalies in human can be explained with embryological basis. The anatomical variations in celiac trunk related to its diameter, length or location are thought to be due to the developmental changes in ventral splanchnic artery (TANDLER, 1904; CAVDAR, GURBUZ, ZEYBEK et al., 1998). In a developing embryo, each metamer gives rise to 3 paired arteries that originate from the aorta. The posterior ones are parietal arteries, lateral ones are urogenital arteries and ventral ones are intestinal arteries. 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 and fourth root forms the superior mesenteric artery (Figure 6a-c). Retention or disappearance of parts of this primitive arterial plexus could give rise to numerous anatomical variations in celiac trunk. In the present case retention of primitive arterial plexus must have lead to long celiac trunk and disappearance of initial part of splenic artery or its fusion with the celiac trunk gave rise to dorsal pancreatic artery arising directly from the celiac trunk.

In addition to the variations observed in celiac trunk, careful dissection of the cadaver further revealed that it had variation in suprarenal and testicular artery. Variations in the origin of suprarenal arteries with respect to their origin and position are very common especially, middle suprarenal artery (GAGNON, 1957; MERKLIN and MICHELS, 1958; MANSO and DIDIO, 2000; TANYELI, UZEL and SOYLUOGLU, 2006) and inferior suprarenal artery (BORDEI, ANTOHE, SAPTE et al., 2003) with respect to their origin and number. In the present case we observed that a common stump was arising from right renal artery which bifurcated into MSA and the other branch which ran further bifurcated into superior suprarenal artery (SSA) and inferior phrenic artery (IPA). The inferior phrenic arteries (IPA) which commonly arise from abdominal aorta supply the diaphragm and known to have multiple variations in their origin. Loukas, Hullett and Wagner

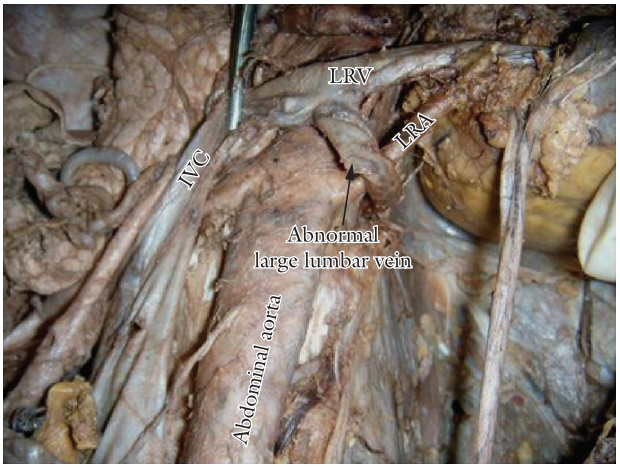

Figure 5. Photograph showing anomaly in lumbar vein.

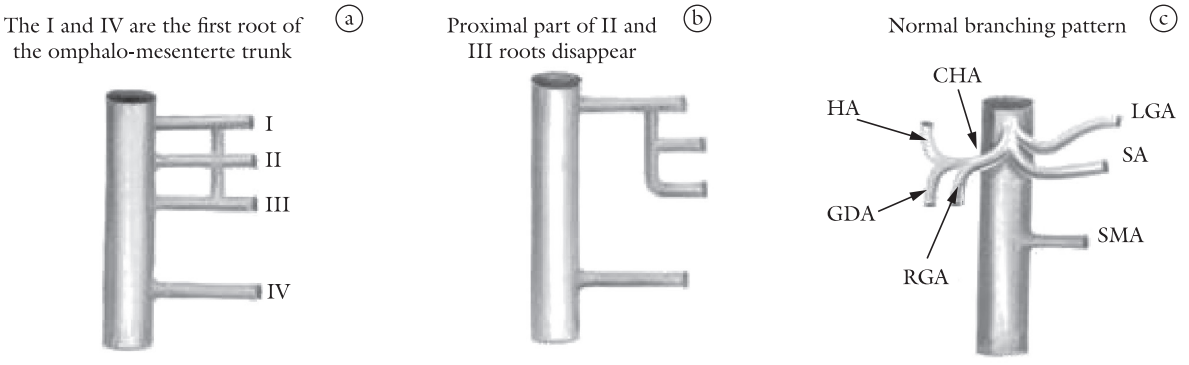

Figure 6. diagram showing normal (a-c) development of celiac trunk.

(2005) conducted a large study on 300 human cadavers and studied the variation in the origin of IPA. He observed that in 40% of the cases right IPA originated from celiac trunk, from aorta in 38% of the cadavers, from renal artery in 17%, from left gastric artery in 3%, and from hepatic artery proper in 2% of the cadavers. Similarly the left IPA originated from the celiac trunk in 47%; aorta in 45%; renal artery in 5%; left gastric artery in 2%; and hepatic artery proper in 1% of the cadavers. In the present case the right IPA originated from right renal artery via a common stump and left IPA from abdominal aorta below superior mesenteric artery but above renal artery via a common stump. On either side the origin of IPA was at a much lower level than the normal.

Gonadal arteries, supplying the testes and ovaries usually arise from the anterolateral (or lateral) aspect of the abdominal aorta at a level caudal to the renal artery. The vertebral level of their origin varies from the level of the first to the third lumbar vertebral level. The anatomy and course of the testicular arteries has assumed importance because of the development of new operative techniques for operations such as varicocele and undescended testes. The variations of the testicular artery that have been documented include the absence of one of the arteries, common origin of both arteries, double arteries, high origin from the aorta and origin from lumbar, renal, middle and superior suprarenal arteries (ONDEROGLU, YUKSEL and ARIK, 1993; ASALA, CHAUDHARY, MASUMBUKO-KAHAMBA et al., 2001; BROHI, SARGON and YENER, 2001). However, the high origin of testicular artery via common stump and the abnormal course observed in the present study is rarely reported in the literature. In 5-20% of cases, this vessel has a more superior origin i.e., arising superior to the L2 vertebral level (BROHI, SARGON and YENER, 2001) from abdominal aorta and in 5-6% of individuals it originates from the main or accessory renal artery (Asala, Chaudhary, Masumbuko-Kahamba et al., 2001). The right testicular artery giving rise to the inferior phrenic and the superior suprarenal arteries has been reported (ONDEROGLU, YUKSEL and ARIK, 1993). In the present case it was the left testicular artery arising via a common stump from abdominal aorta above the left renal artery giving rise to left IPA and superior suprarenal artery. In addition, the left testicular artery had an abnormal course which passed behind the left suprarenal vein and above left renal vein. This entrapment of testicular artery is of surgical and clinical importance since it can be a pathologic factor in compression of the renal vein which may directly influence the direction of the blood flow from the kidney leading to orthostatic hypertension or may possible be an aetiological factor in idiopathic varicocele in men (NOTKOVICH, 1956; MERKLIN and MICHELS, 1958).

During embryonic development, nine lateral splanchnic arteries exist on each side of the abdominal aorta which supplies the mesonephros, metanephros, gonad (testis or ovary), and the suprarenal gland (Figure 7a,b). All these structures develop, in whole or part, from the intermediate mesenchyme of the mesonephric ridge. In adults these branches are represented by phrenic, suprarenal, renal and gonadal arteries (testicular or ovarian arteries). In later part of the development, one testicular or ovarian artery and three suprarenal arteries persist on either side. The renal artery branches from the most caudal artery and the phrenic from highest suprarenal artery (FELIX, 1912; WILLIAMS, BANNISTER, BERRY et al., 1995). Persistence, fusion or early disappearance of these lateral branches gives rise to various anomalies. In the present case out of 3 suprarenal arteries on the right side the upper two must have fused to form common stump which again later fused with the caudal most suprarenal artery which gave rise to renal artery. On the left side the cranial most suprarenal artery must have fused with the gonadal artery to form a common stump. The origin of testicular artery either from renal or suprarenal could be due to obliteration of the root of the original vessel and the enlargement of the anastomosis between the intermediate visceral arteries of adjacent segments (Figure 7c).

Most anatomists describe the lumbar vessels to be regular and symmetric, which can be quite misleading. The lumbar segmental veins terminate in a pattern which may vary not only with the segments but from side to side. In the present case the lumbar vein was large which emerged between L1 and L2 vertebrae and later hooked around the renal artery to drain into the left renal vein. According to Davis, Milloy and Anson (1958) there are 5 segmental lumbar veins at the level of lumbar vertebral bodies, posterior to psoas muscle. They reach their destination in 4 ways a) into IVC, b) into lumbar veins, c) left renal veins or d) terminate in nonvascular structure, such as bone, intervertebral disks or prevertebral connective tissue. Baniel, Foster and Donohue (1995) have documented in 43% of cases the lumbar vein to drain in left renal vein posterior to left gonadal vein.

During embryonic development the lumbar veins are at first tributaries of postcardinal vein. As the postcardinal vessels degenerate, these veins connect secondarily with

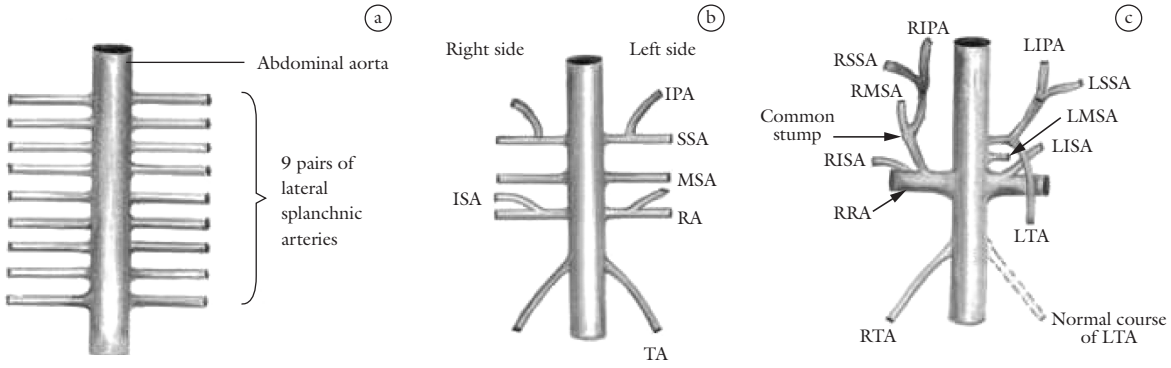

Figure 7. a, b) Schematic diagram showing normal development of lateral splanchnic arteries; c) Schematic diagram showing normal development of lateral splanchnic arteries.

the replacing supracardinal veins and later drain into the IVC (AREY, 1959). Subcentral veins which form directly dorsal to aorta communicate freely with each other and with azygous line veins, and these connections ultimately form retroaortic parts of left lumbar veins and hemiazygous veins (WILLIAMS, BANNISTER, BERRY et al., 1995). In the present case the retroaortic part of subcentral vein on left side after anastomosing with the supracardinal vein might have joined the intersubcardinal anastomosis instead of joining the dorsal aspect of left subcardinal vein. The left subcardinal and intersubcardinal anastomosis forms the left renal vein. In doing so it might have hooked the splanchnic artery coming from abdominal aorta which later persists as renal artery.

4 Conclusions

The multiple anatomical variations of vessels observed in present case with their embryological basis will help the anatomists to understand the developmental basis of vascular abnormalities, and will help the radiologists and surgeons in planning and executing a safe surgical procedure in human. In addition, it will be interesting to know whether multiple vascular variations are due to abnormal expression of genes required for vascular development during fetal period.

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