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The abdominal aorta and its branches: anatomical variations and clinical implications

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Background: *Vascular variations regarding the branching pattern of the aorta are important in different laparoscopic surgeries, liver and kidney transplantation, oncologic resections, and various interventional radiological procedures in the abdominal region. The present work was undertaken on cadavers to examine the prevalence of vascular patterns of the important branches of the abdominal aorta.*
Material and methods: *A total of 50 properly embalmed and formalin fixed cadavers were dissected in the abdominal region, and viscera were mobilised to expose the origin of important branches of the abdominal aorta. Celiac trunk, superior mesenteric, inferior mesenteric, right and left renal, left and right gonadal arteries, and the division of the abdominal aorta into right and left common iliac arteries were observed regarding their level of origin and for presence of any anatomical variations.*
Results: *The celiac trunk origin was located at the level of the T12 vertebra in 64% of cadavers, superior mesenteric at L1 in 76%, inferior mesenteric at L3 in 68%, left and right renal at L1 in 82% and 80%, respectively, and left and right gonadal at L2 in 84% and 86%, respectively; whereas the aortic bifurcation was most common at the level of the L4 vertebra in 54% of cadavers. Important anatomical variations were photographed.*
Conclusions: *Defective fusion of the vitelline arteries during the embryonic stage resulted in the aforementioned anatomical variations. Knowledge of aortic variations is useful for appropriate radio diagnostic interventions and is helpful to decrease complications like vascular bleeding while ligating and anastomosing blood vessels, which is an integral part of many abdominal surgeries.* (Folia Morphol 2011; 70, 4: 282–286)

Key words: aorta, anatomy, cadaver, origin, variation

INTRODUCTION

The thoracic aorta continues as the abdominal aorta after piercing the thoracoabdominal diaphragm at the level of twelfth thoracic vertebra. The abdominal aorta continues until the level of the fourth lumbar vertebra and bifurcates into the right and left common iliac arteries. The celiac trunk and the superior and inferior mesenteric arteries supply the parts of the gastrointestinal tract derived from the foregut, midgut, and the hindgut, respectively, which are endodermal in origin. The vascular pattern of the branches of the abdominal aorta exhibit a wide range of anatomical variations related to their origin from the aorta, something which has been reported time and again by

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Table 1. Level of origin regarding the important branches of the abdominal aorta with reference to the vertebral column

SN	Name of branch from abdominal aorta	Origin at vertebral level T12 (%)	Origin at vertebral level L1 (%)	Origin at vertebral level L2 (%)	Origin at vertebral level L3 (%)	Origin at vertebral level L4 (%)	Origin at vertebral level L5 (%)
1	Celiac trunk	64	36	0	0	0	0
2	Superior mesenteric	20	76	04	0	0	0
3	Inferior mesenteric	0	0	14	68	18	0
4	Left renal	8	82	10	0	0	0
5	Right renal	8	80	12	0	0	0
6	Left gonadal	0	10	84	06	0	0
7	Right gonadal	0	08	86	06	0	0
8	Bifurcation into right and left common iliac	0	0	0	20	54	26

various authors [1–28]. Knowledge of the vascular variations regarding the aorta is important in different laparoscopic surgeries, liver and kidney transplantation, and oncologic resections in the abdominal region. Anatomical variations of the abdominal aorta should be considered by interventional radiologists before diagnostic imaging procedures like angiography and therapeutic procedures like transcatheter arterial chemoembolisation for treatment of hepatocellular carcinoma [23]. Prior knowledge of aortic variations is required to successfully accomplish aortic replacement with implantation of the celiac trunk, mesenteric arteries, and renal arteries [23]. Ugurel et al. [25] investigated the anatomical variations of the abdominal aorta with multidetector computed tomography angiography on a Turkish population and concluded that there was statistically significant correlation between renal artery variations and celiac trunk hepatic arterial system variations. Ferrari et al. [4] studied the variations of the abdominal aorta branches with 64-row computed tomography angiography and opined that the prevalence of vascular abnormalities is higher in the Italian population than that reported in the literature. A cadaver study is relevant and important even today in the present era of modern radio diagnostic techniques. Hence the present study was performed on cadavers from an Indian population regarding the origin of important branches of the abdominal aorta.

MATERIAL AND METHODS

In our present study properly embalmed and formalin fixed cadavers were selected for dissection. A total of 50 cadavers including 38 men and 12 women with ages ranging from 16 to 74 years were studied in the abdominal region. Skin incision was followed by fascia (superficial and deep) and muscles to open the peritoneal cavity. Abdominal viscera were mobilised to expose the origin of some important branches of the abdominal aorta. The celiac trunk, superior mesenteric, inferior mesenteric, right and left renal, and left and right gonadal arteries along with the division of the abdominal aorta into the right and left common iliac arteries, were examined regarding their level of origin and the presence of any anatomical variations. Observations were recorded and important findings were photographed.

RESULTS

Celiac trunk origin was most commonly (in 64% of cadavers) located at the level of the T12 vertebra, the superior mesenteric in 76% at L1, inferior mesenteric in 68% at L3, left and right renal in 82% and 80%, respectively, at L1, left and right gonadal in 84% and 86%, respectively, at L2, whereas the aortic bifurcation was most common at 54% at the level of the L4 vertebra (Table 1). Figure 1 shows that the origin of the left testicular artery was placed higher at the level of the origin of the superior mesenteric artery and was located lateral to it; on the other hand the origin of the right testicular was placed higher, midway between the origin of the superior mesenteric and the right renal artery. Figure 2 shows that the bifurcation of the aorta was located higher at the level of the L3 vertebra. Figure 3 shows that the origin of the left testicular artery was placed lower at the level of the L3 vertebra. Figure 4 shows that the origin of the inferior mesenteric artery was placed on a higher level at the L2 vertebra.

Figure 1. Origin of the left testicular artery; CT — celiac trunk; SM — superior mesenteric artery; LTA — left testicular artery; RTA — right testicular artery; LRA — left renal artery; RRA — right renal artery; AA — abdominal aorta; IM — inferior mesenteric artery; LCI — left common iliac artery; RCI — right common iliac artery.

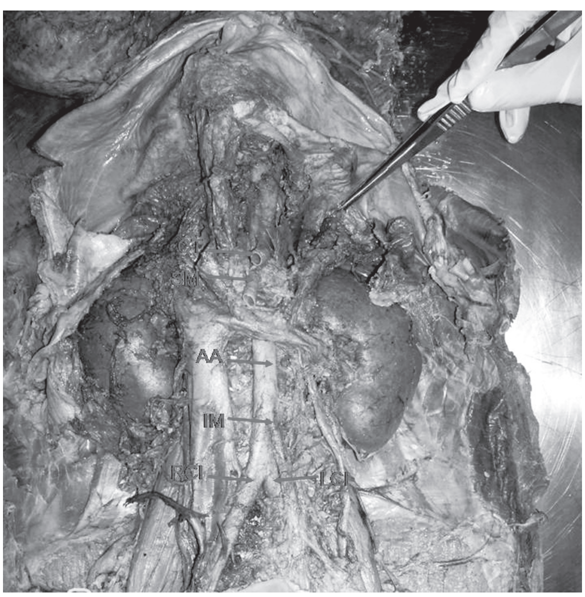

Figure 2. Bifurcation of the aorta; CT — celiac trunk; SM — superior mesenteric artery; AA — abdominal aorta; IM — inferior mesenteric artery; LCI — left common iliac artery; RCI — right common iliac artery.

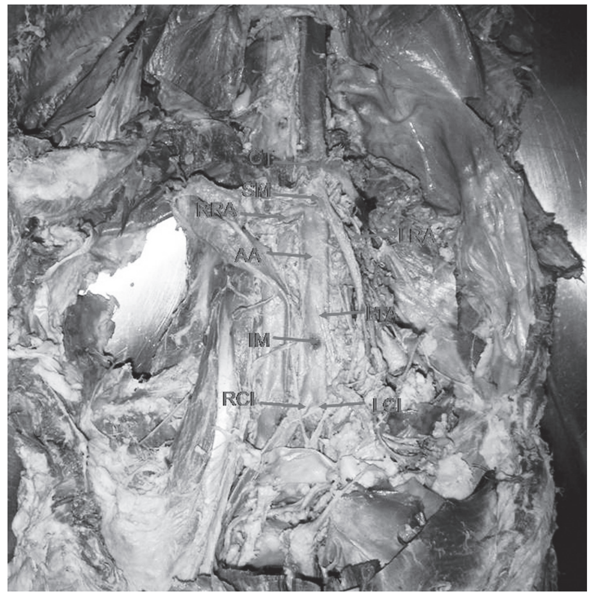

Figure 3. Origin of the left testicular artery; CT — celiac trunk; SM — superior mesenteric artery; LTA — left testicular artery; LRA — left renal artery; RRA — right renal artery; AA — abdominal aorta; IM — inferior mesenteric artery; LCI — left common iliac artery; RCI — right common iliac artery.

Figure 4. Origin of the inferior mesenteric artery; CT — celiac trunk; SM — superior mesenteric artery; LRA — left renal artery; RRA — right renal artery; AA — abdominal aorta; IM — inferior mesenteric artery; LCI — left common iliac artery; RCI — right common iliac artery.

DISCUSSION

The embryological basis of the aforementioned variations can be explained as follows. The yolk sac is supplied by a number of paired vessels called omphalomesenteric or vitelline arteries at the end of the fourth week of intrauterine life [19]. The aforementioned vessels gradually fuse in the latter part of the embryonic life, and in the dorsal mesentery of the gut they form arteries which in adult life are represented as the celiac, superior mesenteric, and inferior mesenteric arteries [19]. Defective fusion of the omphalomesenteric arteries during the embryonic stage can be an important factor manifesting as the anatomical variations observed in our present work. According to Sadlar [19], accessory renal arteries are derived as a result of persistence of embryonic vessels that formed during the ascent of the kidneys. A textbook by Moore et al. [10] describes the celiac trunk, superior mesenteric, inferior mesenteric, renal arteries, gonadal arteries origin from abdominal aorta and aortic bifurcation as being placed at the level of T12, L1, L3, L1, L2, and L4, respectively, with reference to the human vertebral column. Pennington and Soames [15], based on their study on an English population, opined that the origin of the celiac trunk, superior mesenteric, inferior mesenteric, renal arteries, and the level of the bifurcation of the aorta was located in relation to T12/L1, L1, L3, L1, and L4 vertebra, respectively. Lakchayapakorn and Siriprakarn [9] reported that the bifurcation of the aorta was most commonly located at the level of the L4 vertebral body in 63% of cadavers in a Thai population. The aforementioned observations recorded in our study are different from those already reported in the literature, including books and periodicals. Race, region of study, mode of study, and nature of the specimens can be assigned as the various factors contributing to the manifestations of different anatomical variations of the abdominal aorta. The anatomy of the branches of the abdominal aorta including the inferior phrenic artery should be known for the surgical treatment of hepatocellular carcinoma as the inferior phrenic artery is the most common source of extrahepatic collateral blood supply to the aforementioned tumour as it frequently supplies the hepatocellular carcinomas located in the bare area of the liver [21]. Identification of vasculature variations is an important factor determining success in laparoscopic surgery where the operative field and view are limited; further aforementioned knowledge can be useful in reducing interventional radiological complications [13]. Surgeons should be able to detect and protect observed anatomical variations, partitions, and extensions which can complicate an unnoticed haematoma as an outcome of cutting the blood vessels or ischaemia caused by ligature of a vessel during surgical operations [26]. Unpredictable complications such as segmental or total visceral ischaemia and failure can follow after surgical operations like nephrectomy, laparotomy, kidney transplantation, arterial reconstruction, and correction of obturator hernias, when variant vessels are ligated or damaged [1, 6]. Knowledge of anatomical variations may provide safety guidelines for endovascular interventions like angioplasties and therapeutic embolisation [22]. Additional renal arteries are end arteries; hence their damage can lead to ischaemia of the part of the kidney supplied by them [22]. Accessory renal arteries can compress the ureter, which can complicate into hydronephrosis. Vascular anomalies on hand are important in surgeries related to the posterior abdominal wall, ureter, and vascular pedicles of the kidney, but are important practically for the correct interpretation of roentgenographic examinations in angiographic procedures [22]. Knowledge of aortic variations is important to avoid inadvertent vascular injury while performing appropriate ligation of blood vessels and correct vascular anastomosis, which is an integral part of many abdominal surgeries.

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