CASE REPORT

Multiple variations in the branching pattern of the abdominal aorta

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Abstract

We report on a unique clinically and surgically significant case of multiple abdominal aorta variations. Specifically, the left inferior phrenic, left gastric and splenic artery arose in common from the left aspect of the aorta constituting a common phrenogastrosplenic trunk, while the common hepatic artery originated separately from the midline of the anterior aspect of the aorta just inferiorly to the trunk. An accessory right hepatic artery arises from the right-anterior aspect of the abdominal aorta adjacent to superior mesenteric artery origin. On the left side, two renal arteries were observed. Moreover, the left gonadal artery exhibited a high origin, arising inferiorly to the upper left renal artery. We discuss about the embryological development of abdominal aorta arterial abnormalities and we attempt to sort the noticed variations according to existing classification in the literature. It is highlighted that the thorough knowledge of these arterial variations is important for the success of upper abdomen surgical operations such as liver and kidney transplantation, kidney preservation, abdominal aorta related vascular surgery, treatment of hepatocellular carcinoma by transcatheter arterial chemoembolizations as well as imaging interpretation of the region. Preoperative selective angiography or other abdominal aorta imaging studies are helpful for arterial variation demonstration and a precious tool for appropriate surgery planning.

Keywords: abdominal aorta, variations, celiac trunk, gonadal artery, accessory renal artery, common hepatic artery.

Introduction

The abdominal aorta is the continuation of the thoracic aorta after the T12 until L4 vertebra where it divides into left and right common iliac arteries. It serves as the main arterial blood supply vehicle for all the abdominal cavity organs, anterior, posterior and lateral abdominal wall, lower limbs as well as the male and female genitals. The paired and non-paired arteries of the abdominal aorta exhibit wide spectrum of origin variation and they are well documented in the literature since decades [1].

The usual pattern of the celiac trunk constitutes by the left gastric artery, splenic artery and common hepatic artery, and represented the 86% of cases in a total summary of eight studies [2]. The inferior phrenic arteries arise from each side of the abdominal aorta just under the diaphragm, most often between the T12 and L2 vertebra [3]. The renal arteries arise from the lateral wall of the abdominal aorta at the level of L1 or L2 vertebra, 1.5 cm below the superior mesenteric artery [4]. Usually the right renal artery is situated slightly lower than the left. Gonadal artery (testicular in males and ovarian in females) is the paired branch of abdominal aorta that supplies the male or female reproduction glands and it can exhibit a wide range of origin variations. The artery may be found duplicated, tripled or quadrupled [5].

We attempted to classify our findings according to existing classifications, whereas we discuss about the embryological development of the arterial variations observed in our case along referral to the potential clinical implications.

Material, Methods and Results

During routine dissection for educational purposes of a 45-year-old male cadaver, and after careful dissection, we exposed, cleaned and resected the abdominal aorta from its beginning to the end of common iliac arteries. The following multiple abdominal aorta arterial variations were observed (Figure 1): (i) Instead of the typical celiac trunk trifurcation the left inferior phrenic, left gastric and splenic artery formed a common phrenogastrosplenic trunk arising from the anterior-left aspect of the aorta. (ii) The common hepatic artery originated separately from the midline of the anterior aspect of the aorta just above the superior mesenteric artery. (iii) An accessory right hepatic artery was found originating right and at the same level as the superior mesenteric artery at the right-anterior aspect of the abdominal aorta. (iv) Two left renal arteries were observed at the lateral aspect of the abdominal aorta. The upper, which was the main, originated from on the left aspect of the abdominal aorta, 2 cm below the superior mesenteric artery, while the lower, which was an accessory, lied at the midpoint between the right renal and the inferior mesenteric artery on the left aspect of the abdominal aorta representing an accessory inferior polar renal artery. (v) The left testicular artery had a high origin, thus just below the left renal artery, while the right testicular artery displayed a typical origin pattern.

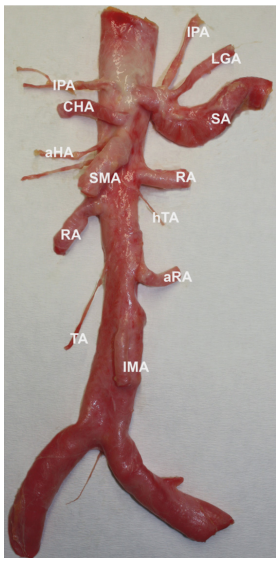

Figure 1 – ***Multiple variations of the branching pattern of a cadaveric abdominal aorta (CHA: Common hepatic artery; IPA: Inferior phrenic artery; LGA: Left gastric artery; SA: Splenic artery; aHA: Accessory hepatic artery; hTA: High testicular artery; TA: Typical testicular artery; SMA: Superior mesenteric artery; IMA: Inferior mesenteric artery; RA: Renal artery; aRA: Accessory renal artery).***

The above-mentioned arterial variations have been solely reported in the literature, whilst to our best of knowledge the combination of all these variations in one individual has not been issued in the literature before.

Written informed consent was obtained from the cadavers' next of kin for the publication of the article and accompanying images.

Discussion

Inferior phrenic, renal, gonadal arteries as well as celiac trunk are all highly variable in pattern. Chen H *et al.*, in an extensive cadaveric study on 974 abdominal aortas made an effort to mention all possible trunks that could be formed between celiac trunk branches [6], but no debate is done about inferior phrenic artery involvement in these trunks. On the contrary, Gwon DI *et al.*, in a study on 383 arterial triple-phase dynamic CT-scans, emphasized that the inferior phrenic arteries originated with almost equal frequency from the celiac trunk as well as directly from the abdominal aorta, thus reported an incidence of 39.7% and 38.6% respectively [7]. We could not find any appropriate classification proposal in the literature that could identify with our case. The precise localization of the inferior phrenic artery is significant during attempt to control effectively hepatocellular carcinoma by transcatheter arterial chemoembolizations and during transarterial embolization in patients with severe hemoptysis [7]. The typical trifurcated type of the celiac trunk has a frequency of 89.8% with no statistically significant difference between males and females. Furthermore, the common hepatic artery constitutes a separate branch in 10% of cases [6]. In rare instances, the common hepatic artery may arise from the superior mesenteric artery [8]. Non-typical incomplete branching pattern of celiac trunk is noticed in 11.8% of total cases [2]. The complete absence of celiac trunk is very rare with an incidence of 0.4% [9]. Celiac trunk branches diameter exhibits similarities as well as differences between typical and variational anatomy [10]. The celiac trunk has a mean diameter of 0.79 cm and 0.71 cm in typical and variational anatomy respectively, while splenic artery has identical diameter in both instances. Common hepatic artery diameter is greater in variational anatomy than in typical, thus 0.52 cm and 0.50 cm respectively [11]. The reduced diameter in arteries with variational anatomy has clinical value for liver transplantation procedures.

An additional renal artery termed alternatively as accessory, aberrant, anomalous or supplementary, it may arise from various portions of the aorta and terminate in variant locations of the kidney. An additional renal artery was more common on the left side (27.6%) as it occurred in our case, than the right side (18.6%). In a study, the length and diameter of the first additional renal artery was 4.5 cm and 0.4 cm on the right side and 4.9 cm and 0.3 cm on the left side respectively [12]. According to Banowsky LHW, multiple unilateral renal arteries can be encountered in 23% of the population, while an additional 10% have bilateral multiple arteries. The same author confirms the fact that these multiple arteries are more common on the left side [13]. Similarly, Singh G *et al.* stated that the accessory renal arteries are more common on the left side, occurring in as many as 30–35% of the studied cases and usually entering the upper or lower pole of the kidney [14]. The knowledge of such accessory artery assists the surgeon during procedures of the region and renal transplantation as well as the radiologist during interpretation of renal angiograms. Moreover, an accessory renal artery of the lower pole, as it occurs in our case, may evoke ureter obstruction with secondary hydronephrosis [14].

Typical gonadal artery origin pattern has an incidence of 85.3%, whereas a variational anatomy was observed in 14.7% of cases of a relevant study [15]. Other studies report an incidence of single artery on each side of the aorta in 75% of cases [16]. The gonadal arteries may arise from other arteries such as the renal, suprarenal or lumbar arteries. More anatomical variations include branching of arteries from common trunk or from higher or lower origin spot than normal [4]. The high origin pattern of testicular artery in our case belongs to type III according to Ciçekcibaşi AE *et al.* classification [17]. The gonadal arteries derive from nine lateral mesonephric arteries in the 18 mm embryo. These primitive arteries are divided in cranial, middle and caudal groups. It is accepted that in typical branching pattern the gonadal arteries derive from the caudal group, while origin near to celiac trunk suggests a cranial derivation [18]. Persistence of many mesonephric arteries may lead to multiple gonadal arteries. The high origin of gonadal artery may be responsible for hemodynamic insufficiency in kidney and gonads, while the decreased blood may lead to varicocele in men and testicular atrophy [19].

Conclusions

The combination of multiple variations concerning the branching pattern of the abdominal aorta presented in this study, to our best of knowledge, is unique in the literature. The awareness of these variations is of great importance for surgeons in order to be identified early and preserved during interventions, as well as for radiologists for precise interpretation of arteriograms.

References

[1] McMinn RHM (ed), *Last's anatomy, regional and applied*, 8th edition, Churchill Livingstone, Edinburgh, 1990.

[2] Bergman RA, Afifi AK, Miyauchi R, Gonadal arteries. In: *Arteries* [online], available at http://www.anatomyatlases.org/AnatomicVariants/Cardiovascular/ext/Arteries/Gonadal.shtml, Accessed May 1st, 2006.

[3] Pick JM, Anson BJ, *The inferior phrenic artery: origin and suprarenal branches*, Anat Rec, 1940, 78:413–427.

[4] Tsikaras P, Paraskevas G, Natsis K, *[Descriptive and applied anatomy – The circulatory system]*, University Studio Press, Thessaloniki, 2005.

[5] Williams PL, Warwick R, Dyson M, Bannister LH (eds), *Gray's Anatomy*, Churchill Livingstone, Edinburgh, 1989.

[6] Chen H, Yano R, Emura S, Shoumura S, *Anatomic variation of the celiac trunk with special reference to hepatic artery patterns*, Ann Anat, 2009, 191(4):399–407.

[7] Gwon DI, Ko GY, Yoon HK, Sung KB, Lee JM, Ryu SJ, Seo MH, Shim JC, Lee GJ, Kim HK, *Inferior phrenic artery: anatomy, variations, pathologic conditions, and interventional management*, Radiographics, 2007, 27(3):687–705.

[8] Piquand G, *Recherches sur l'anatomie du tronc coeliaque et de ses branches*, Bibliographie Anatomique, 1910, 19(4):159–201.

[9] Poynter CWM, *Congenital anomalies of the arteries and veins of the human body with bibliography*, The University Studies of the University of Nebraska, 1922, 22:1–106.

[10] Tandler J, *Über die Varietäten der Arteria coeliaca und deren Entwicklung*, Anat Hefte, 1904, 25:475–500.

[11] Silveira LA, Silveira FBC, Fazan VPS, *Arterial diameter of the celiac trunk and its branches. Anatomical study*, Acta Cir Bras, 2009, 24(1):43–47.

[12] Satyapal KS, Haffejee AA, Singh B, Ramsaroop L, Robbs JV, Kalideen JM, *Additional renal arteries: incidence and morphometry*, Surg Radiol Anat, 2001, 23(1):33–38.

[13] Banowsky LHW, Surgical anatomy. In: Novick AC, Streem SB, Pontes JE (eds), *Stewart's operative urology*, Williams & Wilkins, Baltimore, 1989.

[14] Singh G, Ng YK, Bay BH, *Bilateral accessory renal arteries associated with some anomalies of the ovarian arteries: a case study*, Clin Anat, 1998, 11(6):417–420.

[15] Pai MM, Vadgaonkar R, Rai R, Nayak SR, Jiji PJ, Ranade A, Prabhu LV, Madhyastha S, *A cadaveric study of the testicular artery in the South Indian population*, Singapore Med J, 2008, 49(7):551–555.

[16] Bordei P, Sapte E, Iliescu D, Dina C, *The morphology and the surgical importance of the gonadal arteries originating from the renal artery*, Surg Radiol Anat, 2007, 29(5):367–371.

[17] Çiçekcibaşı AE, Salbacak A, Seker M, Ziylan T, Büyükmumcu M, Uysal II, *The origin of gonadal arteries in human fetuses: anatomical variations*, Ann Anat, 2002, 184(3):275–279.

[18] Felix W, Mesonephric arteries. In: Keibel F, Mall FP (eds), *Manual of the human embryology*, Vol. 2, J.B. Lippincott, Philadelphia–London, 1912, 820–825.

[19] Notkovich H, *Variations of the testicular and ovarian arteries in relation to the renal pedicle*, Surg Gynecol Obstet, 1956, 103(4):487–495.

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