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Variations In The Branching Pattern Of Abdominal Aorta - A Cadaveric Study

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Abstract:

Introduction: Abdominal aorta and its major branches supply oxygenated blood to all the organs in the abdominal cavity. The purpose of the present study is to explore the different anatomical arrangements amongst the branches of abdominal aorta which are important for clinicians dealing with surgical and radiological procedures in this region. Methods: During a study of 20 cadavers, branches of abdominal aorta were explored and the morphological variations in its branching pattern were noted. Multiple variations in the branching pattern of abdominal aorta were found in a male cadaver. Results: We found that the inferior suprarenal artery originated bilaterally as a direct branch of abdominal aorta. It showed bilateral presence of accessory renal artery for the respective kidneys. Anomalous origin of the left testicular artery from the left accessory renal artery was also present. All other branches of abdominal aorta showed normal origin and course. Conclusion: The possible etiology of these variations can be explained by embryological development of vasculature of kidneys, suprarenal glands and gonads from the lateral mesonephric branches of the dorsal aorta. Anatomical knowledge of such variations is useful for academic, surgical as well as radiological procedures.

Keywords: Abdominal aorta, inferior suprarenal artery, accessory renal artery

Introduction:

The abdominal aorta and its branches supply oxygenated blood to all the organs in the abdominal cavity. The renal arteries usually arise from the anterolateral or lateral aspect of the abdominal aorta just below the origin of the superior mesenteric artery.[1] Usually one renal artery supplies each kidney which enters through its hilum.[2]

The suprarenal glands are highly vascular and are supplied by three small arteries: superior, middle and inferior suprarenal arteries. Normally, the superior suprarenal artery is a branch of inferior phrenic artery which is a lateral branch of abdominal aorta; middle suprarenal artery is a lateral branch of abdominal aorta while inferior suprarenal artery is a branch of the renal artery. These arteries are end arteries.[3]

The inferior suprarenal arteries are considered to be very important because they supply most of the gland. They may be grouped, according to their point of origin from the renal artery, as proximal, middle, or distal. They are often multiple; they are larger and always branch before entering the organ.[4]

The testicular arteries are two long slender vessels which usually arise anteriorly from the abdominal aorta at the level of the second lumbar vertebra, a little inferior to the origin of renal arteries. Each

passes inferolaterally under the parietal peritoneum into the pelvic cavity. The right testicular artery lies anterior to the inferior vena cava. It may originate from the renal artery or as a branch from a suprarenal or lumbar artery.[5] Variations in the pattern of renal arteries have been reported more frequently than other large vessels in the literature. The most common variation of renal artery is the presence of an accessory renal artery, which may enter through the hilum or through the surfaces of the kidney.

Detection of vascular anomalies is important in patients undergoing diagnostic angiography for gastrointestinal bleeding or prior to an operative procedure. Hence, thorough knowledge of the branching pattern of abdominal aorta is essential for both the radiologists as well as the surgeons before performing any intervention in this region.

Aim:

The aim of the present study is to explore the different anatomical arrangements among branches of abdominal aorta which are important for clinicians dealing with surgical and radiological procedures in this region.

Material and methods:

The embalmed cadavers from the department of anatomy G.M.C, Miraj constituted the material for the study. During routine abdominal dissection conducted as per Cunningham's Manual of Practical Anatomy Volume -2 (Thorax and Abdomen), the branches of abdominal aorta were explored and the morphological variation in its branching pattern was noted.

Observations:

Here we describe an unreported case of multiple variations of branches of abdominal aorta which includes variations of renal artery, inferior suprarenal artery and testicular artery in a male cadaver.

Out of the 20 cadavers studied for anomalous branching pattern of abdominal aorta, we found out the following variations among the branches of abdominal aorta in a single male cadaver (figure 1 and figure 2):

1. Inferior suprarenal artery originated bilaterally from the abdominal aorta.
2. Bilateral accessory renal arteries were found for each kidney.
3. Left testicular artery was found to arise from the left accessory renal artery.

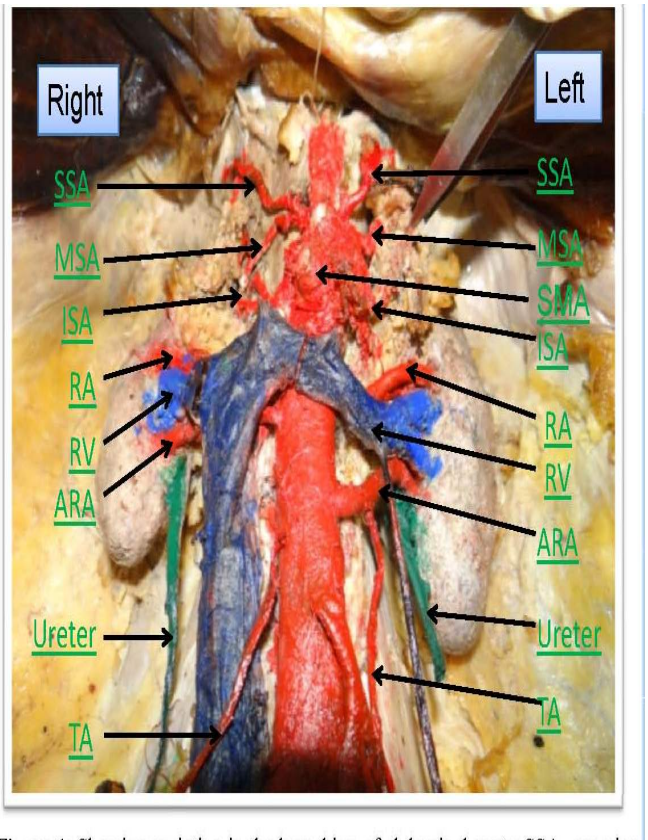

Figure 1: Showing variation in the branching of abdominal aorta; SSA- superior suprarenal artery, MSA- middle suprarenal artery, ISA-inferior suprarenal artery, RA- renal artery, RV- renal vein, ARA- accessory renal artery, TA- testicular artery, SMA- superior mesentric artery

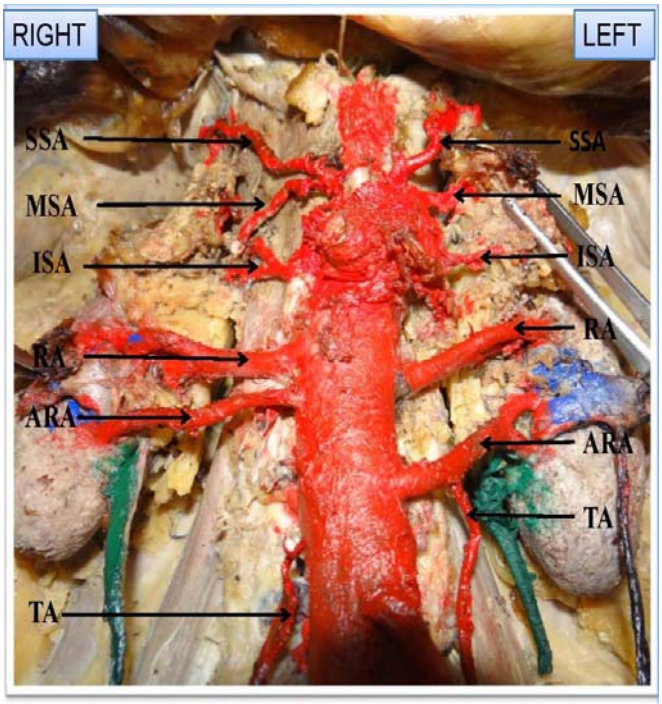

Figure 2: Showing the same variation in the branching of abdominal aorta as in Figure.1 after removal of inferior vena cava

The inferior suprarenal arteries on both sides originated from the abdominal aorta at the level of origin of the superior mesenteric artery (at the level of lower border of L1 vertebra). Each artery passed laterally and upwards to enter into the hilum of the respective suprarenal gland (figure 3).

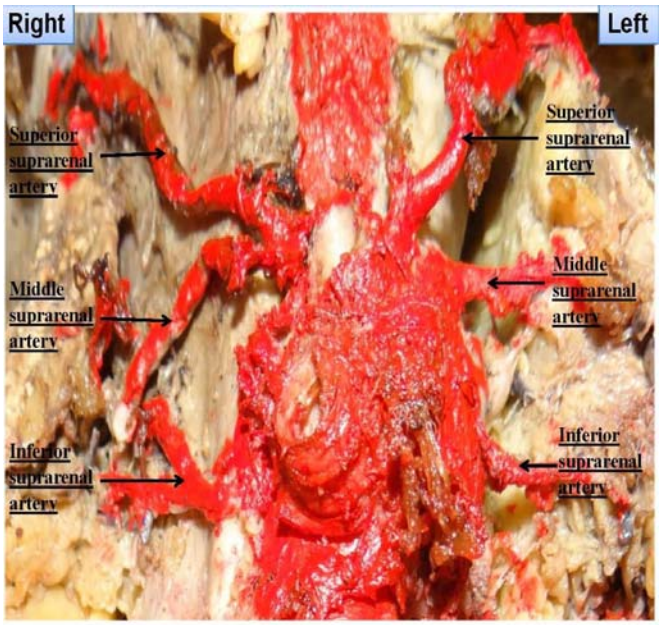

Figure 3: Showing the suprarenal arteries

The renal arteries originated from the abdominal aorta at the level of second lumbar vertebra about 1 – 1.5 cm below the origin of the superior mesenteric artery. The arteries passed laterally to enter the respective kidney at the hilum superior to the opening of the renal veins at the hilum.

The accessory renal artery for the right kidney originated from the aorta just below (0.5 -1 cm below) the main renal artery. It passed laterally to enter the kidney at the hilum below the opening of the renal vein (figure 4).

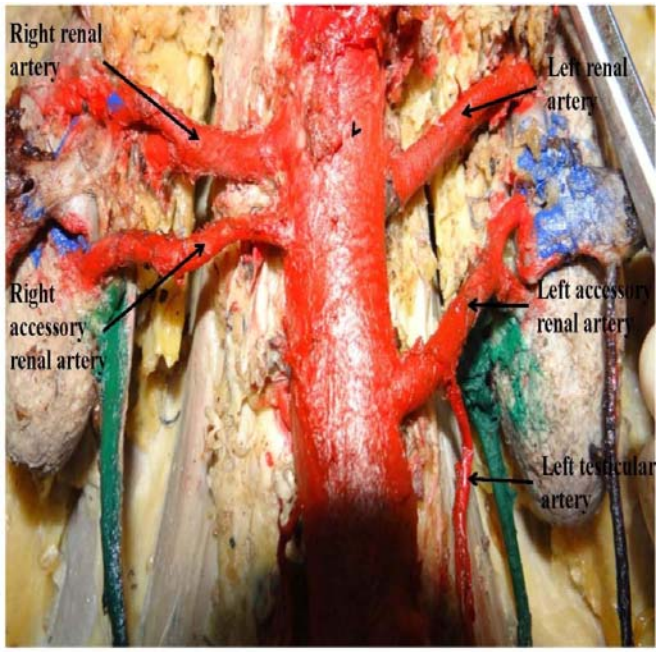

Figure 4: Showing the accessory renal arteries and the left testicular artery.

The accessory renal artery for the left kidney took origin about 2 – 3 cm below the origin of left renal artery from the aorta. It passed upwards and laterally to enter the hilum below the opening of the renal vein. Before entering the hilum, it crossed the ureter which was posterior to it and was going downwards (figure 4).

The left accessory renal artery after its origin from aorta passed laterally upwards for about 1 cm and then gave the testicular branch. This testicular artery then passed obliquely downwards following a normal course into the pelvic cavity (figure 4).

Rest of the branches of abdominal aorta was found to arise normally and had normal course.

In the present study, we have found the incidence of
1. Bilateral accessory renal arteries,
2. Bilateral origin of inferior suprarenal artery from abdominal aorta,
3. Origin of left testicular artery from the left accessory renal artery to be 5 % (1/20) each.
All these variations are very rarely found in a single cadaver.

Discussion:

Usually one renal artery supplies each kidney which enters through its hilum.[2] Near the renal hilum, each artery then divides into an anterior and a posterior division, and the anterior division divides into apical, anterior upper, anterior middle and lower segmental arteries supplying the renal segments. The right renal artery is usually at higher level than the left and the same was observed in the present case.

According to Graves[6] (1956), any artery arising from the aorta in addition to the main renal artery should be named 'accessory' and the renal arteries arising from sources other than the aorta should be called 'aberrant'.

Merklin and Michels[7] classified these supernumerary renal arteries depending upon origin as supernumerary renal arteries originating from aorta, supernumerary renal arteries originating from the main renal artery, and supernumerary renal arteries originating from other arterial sources, but in their study none of the hilar supernumerary renal artery took origin from renal artery.

Accessory renal arteries are not uncommon. They are derived from the persistence of embryonic vessels that are formed during the ascent of kidney.

Kidneys develop in three stages of development pronephros, mesonephros and metanephros during this process the kidneys ascend from pelvic to the lumbar region. When the kidneys are situated in the pelvic cavity, they are supplied by the branches of common iliac arteries. While the kidneys ascend to lumbar region, their arterial supply also shifts from common iliac artery to abdominal aorta.[8] Accessory renal arteries arise from the abdominal aorta either above or below the main renal artery and follow it to the hilum.

Arterial supply of kidneys, adrenal glands and gonads is derived from rete arteriosum urogenitale, which is formed by lateral splanchnic branches of dorsal aorta.[9,10] Before fusion of two dorsal aortas, there arises numerous segmental branches at right angle to the long axis of the aorta and are arranged in three different groups i.e. ventral splanchnic, lateral splanchnic and somatic intersegmental arteries. Lateral splanchnic branches supply to the derivatives of the intermediate mesoderm i.e. kidney, suprarenal and gonad. Most of the lateral splanchnic branches undergo regression except gonadal artery and 3 suprarenal arteries on each side. The inferior phrenic artery buds out from the highest suprarenal artery, the permanent renal artery sprouts from the lowest suprarenal artery and the middle suprarenal artery remains as it is, supplying the suprarenal gland.[11] Renal artery, inferior phrenic artery and gonadal arteries each represent one of the series of vessels, which at one developmental stage, supplied the structures of the urogenital ridge (mesonephros, gonad and suprarenal gland)[12] (figure 5)[13]. Because of this, a variation in number and arrangement of these arteries and their branches is very common.[14]

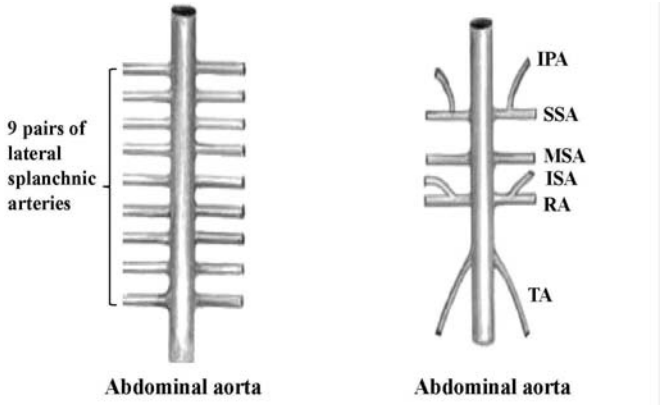

Figure 7: a, b) Schematic diagram showing normal development of lateral splanchnic arteries[18]
IPA- inferior phrenic artery, SSA- superior suprarenal artery, MSA- middle suprarenal artery, ISA-inferior suprarenal artery, RA- renal artery, TA-testicular artery.

Embryo has three sets of lateral mesonephric arteries namely cranial, middle and caudal. One of the caudal arteries usually persists and differentiates into the definitive gonadal arteries. Cicekcibasi et al[15] revealed that the middle group of lateral mesonephric arteries gave rise to a gonadal artery that originated from the renal artery, while that of cranial group gave rise to a gonadal artery that originated from the suprarenal artery or from a more superior aortic level. Arey[16] (1965) coined that the accessory renal artery arises embryologically from retention of the early series of mesonephric or segmental lateral splanchnic arteries. Perhaps persistence of one branch other than normal one, may explain the cause of anomalous origin of artery as stated by Kocabiyik N et al[17] (2004) to explain embryological basis of accessory renal artery.

Presence of sufficient quantities of signal molecules and growth factors are essential for normal development of any organ. These signals must be recognized and interpreted by the developing and migrating cells of embryo.[18] Shoja MM et al[19] (2007) mentioned, the particular signal which is responsible for development of an aberrant artery is unknown. However, certain known factors may play a role to develop vascular anomalies like: teratogenic chemical agents, hemodynamic process, growth factors, genetic factor.[16, 20]

Various factors are being identified for branching of vessels:

(i) a new branch may sprout due to angiogenic stimulus from the surrounding mesenchyme,
(ii) transendothelial cell bridges may divide the vessel,
(iii) intussusception is a process by which vessels may branch.[21, 22]

Variations of renal arteries included multiple arteries in 24%, bilateral multiple arteries in 5% and early division in 8% of cases. Additional renal arteries on the right side were found in 16% and on the left side in 13% of the cases studied by Ozkan et al.[23] Satyapal et al[24] reported additional renal arteries on right side in 18.6% and on left side in 27.6% of the cases (1244 pairs of kidneys) analysed. Dhar et al[25] studied 40 cadavers and found multiple renal arteries in 20% where unilateral cases were more commonly encountered (15%) rather than bilateral cases. In present study, we found the incidence of bilateral accessory renal arteries to be 5%.

In 18%, right inferior suprarenal artery and in 6%, left inferior suprarenal artery originated from the gonadal artery. In 6%, right inferior suprarenal artery originated from lateral margin of abdominal aorta and in 35%, left inferior suprarenal artery was absent. There was presence of more than one inferior suprarenal artery, in absence of middle suprarenal artery.[26] In our study, the incidence of bilateral origin of inferior suprarenal artery from abdominal aorta was found to be 5%.

Anatomical variations of testicular arteries with regard to their origin have been reported in 4.7% of cases. They were found to take origin either from unusually high level of aorta or from the renal artery.[27] The incidence of origin of testicular artery from accessory renal artery was found in 5% of cases in our study.

Accessory renal arteries, which are the most common and clinically important variations of the renal circulatory system, are encountered in approximately one third of anatomic dissection series.[28] Detection of these accessory arteries is of great importance when the accurate depiction of renal arterial anatomic structures is required, such as in cases of renal transplantation, surgical reconstruction of the abdominal aorta, and renovascular hypertension.[29,30] It is important to be aware that accessory renal arteries are end arteries; therefore if an accessory renal artery is damaged, the part of kidney supplied by it is likely to become ischaemic.[31] Lower polar supernumerary renal arteries of aortic or renal origin can be a cause of ureteropelvic junction obstruction.[32] Recent reports have also stressed the fact that the patients with

galactosemia need to be thoroughly investigated for the presence of any renal vascular anomalies.[33]
Awareness of variations of the gonadal arteries such as those presented here becomes important during surgical procedures like varicocele and undescended testes. A gonadal artery with origin from an inferior polar renal artery may be injured during the percutaneous treatment of the syndrome of pielo-ureteral junction, so it becomes a major contraindication. Also, this anatomical variation enhances the importance of the arteriography or Doppler ultrasound examination of the renal hilum.

Conclusion:

In the present study, we found out the incidence of
1.bilateral accessory renal arteries,
2.bilateral origin of inferior suprarenal artery from abdominal aorta,
3.origin of left testicular artery from the left accessory renal artery is 5% (1/20), which is comparable to the previous studies.[23, 26 ,27]

Such a combination of vascular anomalies in a single cadaver is a rare occurrence.

Certain vascular and developmental anomalies of kidneys can be associated with variations in the course of the gonadal arteries. The possible aetiology of these variations has been explained by embryological development of vasculature of kidneys, suprarenal glands and gonads from the lateral mesonephric branches of the dorsal aorta. While vascular anomalies are usually asymptomatic, they may become important in patients undergoing diagnostic angiography for gastrointestinal bleeding or prior to an operative procedure or transcatheter therapy.
The anatomical knowledge of such variations may be important for academic, surgical as well as radiological procedures and the present study is a humble effort to highlight the same.

Conflicts of Interest: All authors have none to declare.

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