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CASE REPORT

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Bilateral inferior renal polar arteries with a high origin from the abdominal aorta

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Bilateral multiple renal arteries are not-so-rare variations. However, inferior renal polar arteries with a high origin from the abdominal aorta have rarely been reported. We found bilateral inferior renal polar arteries with a high origin from the abdominal aorta in an 84-year-old Korean female cadaver. Two right and three left renal arteries were seen with the lowest as the main renal artery bilaterally. The highest artery crossed the main renal artery and penetrated into the inferior pole of the kidney, respectively. After dissection, each inferior polar artery could be classified as the inferior segmental branch. A further understanding on its embryogenesis might be important since variations in renal arteries are of particular interest to clinicians as well as anatomists. (Folia Morohol 2020; 80, 1: 215–218)

Key words: multiple renal arteries, inferior renal polar artery, inferior segmental branches, anatomical variation, cadaver

INTRODUCTION

The renal vascular system is extensive and has significant variability, and detailed anatomical knowledge of renovascular varieties is important for clinical and radiologic procedures. The reported incidence of multiple renal arteries is approximately 20% and varies with ethnicity ranging from 4% in a Malaysian population to 61.5% in a Brazilian population [8]. The frequency is lowest in eastern and southern Asia (from 4% to 18.4%), reported to be 13.0% in Korean. Double and triple renal arteries have been reported, with respective incidences of 18.7% and 3.0% [18], 17.4% and 0.9% [10], and 19.7% and 3.6% [19]. The incidence of bilaterality was much lower, reported in approximately one-fifth of multiple renal arteries [14].

Among these variations, the inferior renal polar arteries usually arise from the aorta or the renal artery, and much less frequently from a suprarenal, common iliac, or superior mesenteric artery [1]. The incidence of inferior renal polar arteries at an extrahilar level originating in the abdominal aorta varies between 0.6% (71/1237) [1] and 9.7% (24/250) [19]. Because the metanephros receives more new cranial branches from vessels close to it during ascent while the former lower branches are degenerated [7], incomplete degeneration of the former lower branches leads to the presence of the inferior renal polar artery below the renal artery. Therefore, the inferior renal polar arteries showing upward course have been implicated as an etiological factor in a form of hydronephrosis surgically correctable [1].

The inferior renal polar arteries with a high origin from the abdominal aorta may cross the lower renal arteries to supply the inferior pole of the kidney, which has rarely been reported to date [2, 13, 16]. Herein, we presented a case of bilateral inferior renal polar arteries originating from a high aortic position and discussed its embryological significance.

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Table 1. Morphologic parameters of the bilateral multiple renal arteries. Renal segments classified into superior, anterior superior, anterior inferior, inferior, and posterior according to a previous report [19]

Variables	Distance from the bifurcation of the abdominal aorta [mm]	Vertebrae level at origin	External diameter [mm]	Segmental distribution
Right				
R1	95	Intervertebral space between LV 1–2	3	Inferior
R2 (main)	91	Upper half of LV 2 body	7	Apical; anterior superior; anterior inferior; posterior
Left				
L1	101	Intervertebral space between LV 1–2	4	Apical; anterior inferior; inferior
L2	97	Intervertebral space between LV 1–2	3	Anterior superior; anterior inferior
L3 (main)	89	Upper half of LV 2 body	5	Apical; posterior

LV — lumbar vertebrae

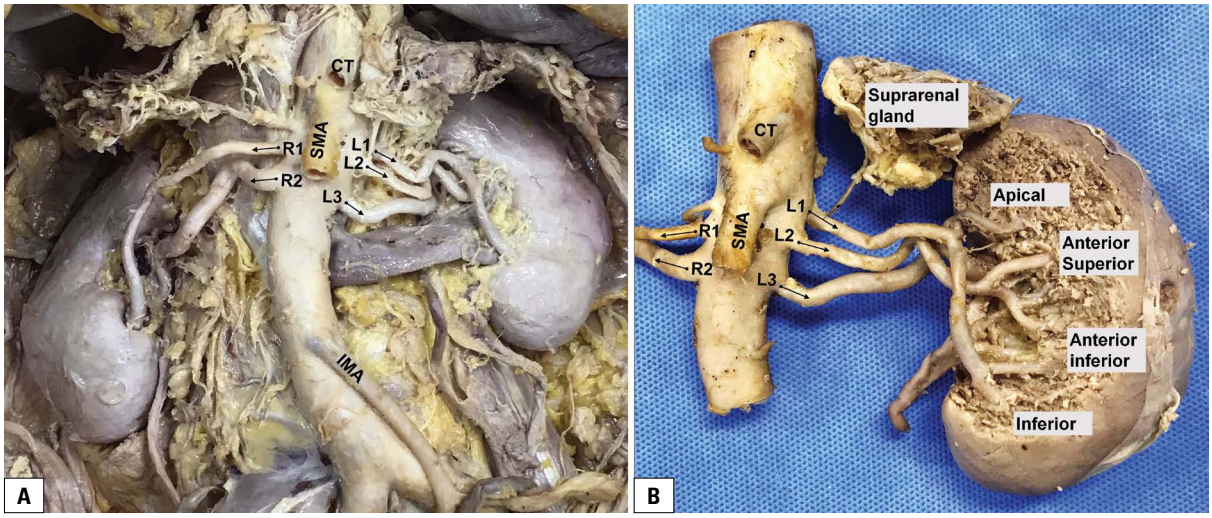

Figure 1. Photographs of bilateral inferior renal polar arteries before (**A**) and after (**B**) dissection to clarify the segmental distribution. The multiple renal arteries were designated R1 to R2 from the highest to the lowest on the right side and, similarly, L1 to L3 on the left side. The highest artery (R1 and L1) arose from above the main renal artery (R2 and L3), crossed it, and entered the inferior pole of the kidneys, respectively. Dashed arrow — left suprarenal artery; CT — coeliac trunk; IMA — inferior mesenteric artery; SMA — superior mesenteric artery.

CASE REPORT

During routine educational dissection, we found a rare variation of bilateral inferior renal polar arteries (Fig. 1) in an 84-year-old Korean female cadaver, whose cause of death was 'cerebral infarction'.

The renal arteries were designated R1 to R2 from the highest to the lowest on the right side and, similarly, L1 to L3 on the left side, in which the lowest was the main renal artery bilaterally. We analysed the distance from the bifurcation of the abdominal aorta, the vertebral level at the origin, the external diameter, the segmental distribution, and other characteristics of each renal artery (Table 1).

On the right side (Fig. 1A), two renal arteries arose from the anterolateral aspect of the abdominal aorta. The superior additional artery (R1) arose from above the main renal artery (R2) and crossed the main renal artery anteriorly into the inferior pole of the right kidney.

On the left side (Fig. 1A), three renal arteries arose from the abdominal aorta. The superior additional artery (L1) arose from the posterolateral aspect of the abdominal aorta just below the superior mesenteric artery, and ran forward the main renal artery (L3), then divided and entered the superior and inferior pole of the left kidney, respectively. The left suprarenal

artery arose from L1 (Fig. 1B). The middle additional artery (L2) arose from the anterolateral aspect of the abdominal aorta just below the L1, ran forward the main renal artery, and entered the kidney through the hilum below the main renal artery.

DISCUSSION

The inferior segmental artery variations of the kidney are subdivided into four types based on their origin: I — from the anterior division of the renal artery; II — from the posterior division of the renal artery, III — from the renal artery directly, and IV — from the aorta. The incidence of the inferior segmental branch arising from the aorta was approximately 2.2% (10/459) [3], in which most of the inferior segmental branches arose below the renal artery from the aorta. Meanwhile, the incidence of the inferior segmental branches detached from the superior renal artery was 1.6% (4/250) [19]. However, the authors did not mention whether the superior renal artery directly originated from the aorta or not. Only a few reports have been published on the inferior renal polar arteries with a high origin from the abdominal aorta [2, 13, 16]. The reported inferior renal polar arteries with a high origin from the abdominal aorta were right-sided, arose above the main renal artery from the aorta, and entered just below the renal hilum, but clear explanations were lacking. The present case, the bilateral inferior segmental branch from the inferior renal polar arteries with a high origin from the abdominal aorta, might be the first report. A very similar case was reported in bilateral ectopic kidney in the pelvic cavity [7].

Nine pairs of arteries, the cranial (the 1st and the 2nd pair), middle (the 3rd to the 5th pair), and the caudal (the 6th to the 9th pair), form a vascular network from the lateral aorta, the so-called rete arteriosum urogenitale between 6th cervical and 3rd lumbar vertebrae, and supply the mesonephros, metanephros, gonads, and the suprarenal glands [5]. The differing origins and/or additional numbers of renal arteries around the renal hilum are usually explained by this 'ladder theory'. Insufficient degeneration of mesonephric arteries leads to the presence of more than one renal artery, with or without different origins. We agree with the previous report on the bilateral multiple renal arteries, and attempted to suggest a feasible explanation for the present case since the reason why the inferior renal polar arteries develop with a high origin from the abdominal aorta is not known. The existence of the inferior renal polar arteries with a high origin from the abdominal aorta could be explained by the persistence of a mesonephric artery from the cranial part with a longer oblique course to reach the lower pole of the kidneys as suggested in the case of high-positioned gonadal artery [4]. As in the high-positioned gonadal artery, an extremely high-positioned inferior renal polar artery was also reported with a thoracic origin at the lower thoracic vertebrae [6, 15]. Compared to normal renal arteries, the ectopic renal arteries arose more posteriorly or posterolaterally in origin from the aorta [7]. In the present case, L1 arose from the posterolateral aspect of the aorta and supplied the left kidney as the apical, anterior inferior and inferior segments, which might reinforce the previous hypotheses [4, 7].

Due to the very complex embryogenesis of the kidneys [8, 9], renal vascularisation variants are not uncommon, which is primarily important in surgery, nephrology, and radiology. In any surgical and interventional procedures, including renal transplants, aneursymorraphy, and other vascular reconstructions, unawareness of the presence of multiple renal arteries may result in a fatal outcome. The inferior renal polar artery with a high origin from the abdominal aorta showed a narrow calibre which has suggested as an etiological factor of renovascular hypertension [2]. Although the mean renal artery diameter found in cadavers casted with synthetic resin (4.87 mm) was slightly less than that reported in angiographic studies (5.9 mm) [17], the dimeter of multiple renal arteries was significantly smaller than when a single renal artery was present [11] and the presence of a supernumerary renal artery should be predicted when the main renal artery has a luminal diameter less than 4.15 mm in a cadaveric study [17]. Recently, the sum of the luminal areas of smaller, additional renal vessels needs to be equal to or a little higher than that of a single renal artery to compensate for based on the renal-aortic ratio [12]. In the present case, the right main renal artery was thicker than the left one, and more additional arteries on left side were expected, as suggested.

CONCLUSIONS

Taken together, we clearly showed bilateral inferior renal polar arteries with a high origin from the abdominal aorta for the first time based on embryological explanation. The renal artery presents a variety of spectra in morphological representations of num-

bers, length, diameter, and branching level, which is extremely important as it enables efficient clinical interventions and reduces the risk of complications. Because the renal artery is an end artery, a deeper understanding on the renovascular development is important to clinicians as well as anatomists.

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