ONLINE FIRST

ISSN: 0015-5659

e-ISSN: 1644-3284

A case of novel combined variations of the renal and testicular vessels

Authors: Tetsuhito Kigata, Yasushi Kobayashi

DOI: 10.5603/fm.96833

Article type: Case report

Submitted: 2023-08-17

Accepted: 2023-10-25

Published online: 2023-11-21

A case of novel combined variations of the renal and testicular vessels

Tetsuhito Kigata, Yasushi Kobayashi, Combined variation in urogenital vessels

Tetsuhito Kigata, Yasushi Kobayashi

Department of Anatomy and Neurobiology, National Defense Medical College, Namiki, Tokorozawa, Saitama, Japan

Address for correspondence: Yasushi Kobayashi, Department of Anatomy and Neurobiology, National Defense Medical College, Namiki, Tokorozawa, Saitama 359-8513, Japan, tel/fax: 04-2995-1478/04-2996-5186, e-mail: yasushi@ndmc.ac.jp

ABSTRACT

Variations in the pattern of urogenital vessels can arise as a single occurrence or as a combination, which may increase the risk of unexpected injury during surgical procedures. Multiple variations in the renal and testicular vessels, in a novel combination, were observed during dissection of an 87-year-old Japanese male cadaver. In the present case, the patient had two renal arteries on each side. On the right side, the superior and inferior renal arteries emerged from the abdominal aorta at the L1 and L4 vertebrae levels, respectively. On the left side, the superior renal artery originated from the abdominal aorta at the level of the L1/L2 intervertebral disc, whereas the inferior renal artery arose at L4. The right testicular artery emerged from the abdominal aorta at the level of the L2 vertebra and crossed the inferior vena cava posteriorly. The venous system also exhibited some variations. The left renal vein passed posteriorly to the

abdominal aorta and opened into the inferior vena cava at the level of the L2 vertebra. On the course to the inferior vena cava, the left renal vein was connected only to the first lumbar, azygos, and hemiazygos veins; blood was not collected from the left testicular and suprarenal veins, which usually open to the left renal vein. The patient had two right testicular veins. The lateral one opened into the angle between the right renal vein and the inferior vena cava at the level of the L2 vertebra, and the medial one drained into the inferior vena cava at a level slightly lower than the lateral one. Knowledge of the possible anatomical variations may be beneficial for performing safe retroperitoneal surgery and understanding the development of these vessels.
Keywords: anatomical variation, renal artery, renal vein, testicular artery, testicular vein

INTRODUCTION

Variations in the ramification patterns of renal and testicular vessels have been reported in detail, particularly with respect to their possible number, origin, course, and termination [8, 20, 23, 25, 27]. However, such mutations sometimes occur simultaneously and in various combinations, and may be accompanied by malformation in the kidney and urinary tract [1, 2, 9, 11, 13, 18, 21, 26, 28]. Compared to a single variation, the presence of multiple variations increases the risk of unexpected injury to the urogenital vessels during surgical procedures; therefore, a detailed description of combined variations is helpful to ensure safe surgery. Additionally, detailing possible variations in the urogenital vessels may facilitate to the understanding of their developmental processes. Hence, we herein report a case of bilateral supernumerary

renal arteries, retrocaval right testicular artery, retroaortic left renal vein, and duplicated right testicular veins and briefly reference their developmental process; to the best of our knowledge, this is the first report of such combined variation.

CASE REPORT

We encountered combined variations in the renal and testicular vessels (Fig. 1) in an 87-year-old Japanese male cadaver (No. 1117) during routine educational gross dissection at the National Defense Medical College.

Two renal arteries were present on each side. The right superior and inferior renal arteries originated from the abdominal aorta at the levels of the L1 and L4 vertebrae, respectively (RRA1 and RRA2 in Fig. 1); the superior one entered the hilus of the right kidney, while the inferior one entered the inferior pole of the right kidney. On the left side, the superior and inferior renal arteries arose from the abdominal aorta at the level of the L1/L2 intervertebral disc and L4 vertebra, respectively, and entered the left kidney through the hilus (LRA1 and LRA2 in Fig. 1).

The right and left testicular arteries emerged from the abdominal aorta at the levels of the L2 and L3 vertebrae, respectively (RTA and LTA in Fig. 1). The right one advanced posteriorly to the inferior vena cava, proceeding towards the deep inguinal ring. Both testicular arteries crossed anteriorly to the ipsilateral inferior renal artery (Fig. 1).

The right renal vein drained into the inferior vena cava at the level of the L2 vertebra without any tributaries (not shown in Fig. 1). The left renal vein ran posteriorly to the abdominal aorta and opened into the inferior vena cava at the level of the L2 vertebra (LRV in Fig. 1); on the way to the inferior vena cava, the left renal vein was

anastomosed with the bilateral first lumbar veins as well as the azygos and hemiazygos veins (AnB in Fig. 1B). The left testicular vein and suprarenal veins, which received the inferior phrenic vein (LTV, SRV in Fig. 1), joined and proceeded anteriorly to the abdominal aorta, below the origin of the superior mesenteric artery, opening into the inferior vena cava at the level of the L1/L2 intervertebral disc (Fig. 1) without any communication with the retroaortic renal vein.

The right testicular vein was duplicated (RTV1 and RTV2; Fig. 1). The lateral vein ascended along the right testicular artery and opened into the inferior vena cava at the angle between the right renal vein and inferior vena cava at the level of the L2 vertebra (RTV1 in Fig. 1). The medial vein ascended parallel to the lateral vein and opened into the inferior vena cava, slightly below the opening of the lateral testicular vein (RTV2 in Fig. 1).

DISCUSSION

The present case exhibited multiple vessel variations, including bilateral supernumerary renal arteries, a retrocaval right testicular artery, a retroaortic left renal vein, and duplicated right testicular veins. The combined variations identified in this study are herein reported for the first time.

The primitive kidney receives the mesonephric arteries, which are several pairs of lateral branches that emerge from the thoracic to lumbar region of the aorta (MeA in Fig. 2A) [4]. During development, the kidney ascends from the pelvic cavity to the upper abdomen; accordingly, the upper mesonephric arteries supply blood to the kidney instead of the lower mesonephric arteries [4]. Subsequently, the lower mesonephric arteries usually regress; however, some of them occasionally persist and may become an

additional renal artery arising at a lower level than the orthotopic renal artery, as was observed in the present case (RA2 in Fig. 2D) [4].

Normally, the testicular artery is derived from the lower mesonephric arteries as well (MeA in Fig. 2A) [4], and according to Terayama et al. [29], the course of the definitive right testicular artery changes according to the positional relationship between the mesonephric arteries and the inferior vena cava during their development (Fig. 2). The inferior vena cava is formed by the cranial portion of the right subcardinal vein, the right sub-supracardinal anastomosis, and the caudal portion of the right supracardinal vein (Fig. 2) [3, 7, 12, 19]. The right mesonephric arteries run dorsal to the right subcardinal vein (Fig. 2A) [29]. Thus, in the case of a right testicular artery derived from the mesonephric arteries passing cranially to the sub-supracardinal anastomosis, the right testicular artery possesses a retrocaval course, as in the present case (TA in Fig. 2D).

During development, a pair of subcardinal and supracardinal veins and the anastomotic branches between them surround the aorta (Fig. 2A) [3, 6, 7, 14]. The course and tributaries of the definitive left renal vein are determined based on the remaining obliteration patterns of the venous ring [3, 6, 7, 14]. Typically, the left renal vein is derived from the inter-subcardinal and sub-supracardinal anastomoses and receives blood from the left subcardinal vein, which forms the testicular and suprarenal veins (Fig. 2B). However, the retroaortic left renal vein is derived from the inter-supracardinal and left sub-supracardinal anastomoses (Fig. 2C) [3, 7, 12, 16]. According to previous reports, the retro-aortic left renal vein typically receives blood from the left testicular and suprarenal veins (Fig. 2C) [15, 17, 24]. Thus, the anastomosis between the primitive left renal vein and the left testicular and suprarenal veins remains similar to a

normal pattern, even in the abnormal development of the left renal vein. However, in the present case, the retro-aortic left renal vein did not receive blood from the left testicular or suprarenal veins (Figs. 1 and 2D). Thus, the development in the present case may have differed from that reported previously. The primitive left renal vein and the left testicular and suprarenal veins were connected through the left sub-supracardinal anastomosis, and the localized regression of this anastomosis may have caused the rare drainage pattern found in this case (Figs. 1 and 2D). The regression pattern of the sub-supracardinal anastomosis plays a key role in determining the course of the left renal vein [16]. Considering the present case, the regression pattern of the sub-supracardinal anastomosis may have additionally changed the drainage pattern of the left testicular and suprarenal veins.

The right testicular vein was formed by the right subcardinal vein located caudally to the sub-supracardinal anastomosis. Duplication of the right testicular vein, which was detected in the present case, may have been caused by duplication [22, 23] or dysplasia of the subcardinal vein [5, 30].

CONCLUSIONS

Here, we reported a case with multiple variations in the renal and testicular vessels. The urogenital vessels are closely related to each other during development, which may partially contribute to the occurrence of combined variations, as in the present case. Detailed descriptions of possible combined variations are beneficial for performing safe renal and gonadal surgical procedures and for facilitating the understanding of their developmental processes.

Acknowledgements

The authors sincerely thank those who donated their bodies to the anatomical research field. The results of this research will potentially increase humankind's overall knowledge, which can improve patient care. Therefore, the donor and his family deserve the highest gratitude [8].

Conflict of interest: None declared

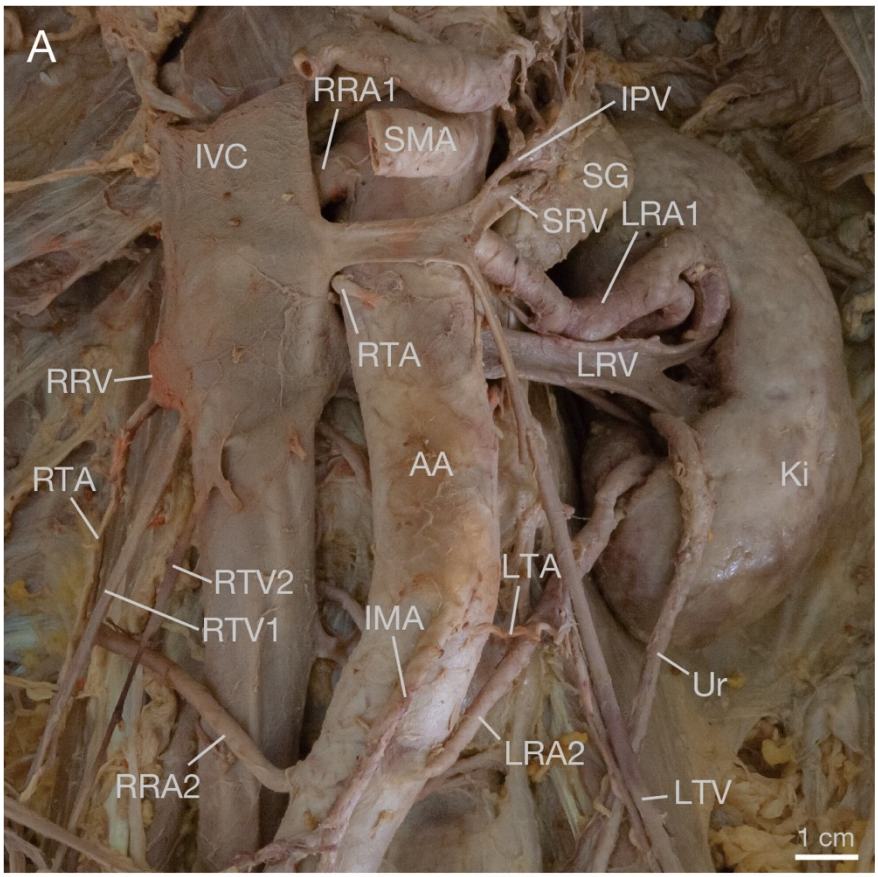
REFERENCES

1. Ahuja S, Maglasang N, Tan Y, et al. A unique case of extrarenal calyces and associated vascular variations in an adult female cadaver. Folia Morphol. 2022; 81(4):1072-1078. doi:10.5603/FM.a2021.0099
2. Arathala R, Deshmukh VR, Nagaraj S, et al. A rare combination of genitourinary vascular anomaly. J Clin Diagn Res. 2018; 12(10):AD01-AD03. doi:10.7860/JCDR/2018/36655.12133.
3. Bass JE, Redwine MD, Kramer LA, et al. Spectrum of congenital anomalies of the inferior vena cava: cross-sectional imaging findings. Radiographics. 2000; 20(3):639-652. doi:10.1148/radiographics.20.3.g00ma09639.
4. Felix W. The development of the urogenital organs. In: Keibel F, Mall FP (ed.). Manual of Human Embryology. Philadelphia, J. B. Lippincott Company 1912: 752-880.
5. Fernandes JR, Strufaldi MB, Machado BS, et al. Bilateral duplication of gonadal veins: a case report. Int J Morphol. 2012; 30(4):1487-1489. doi:10.4067/S0717-95022012000400035.
6. Gupta R, Gupta A, Aggarwal N. Variations of gonadal veins: embryological prospective and clinical significance. J Clin Diagn Res. 2015; 9(2):AC08-AC10.

doi:10.7860/JCDR/2015/9493.5578.
7. Hoeltl W, Hruby W, Aharinejad S. Renal vein anatomy and its implications for retroperitoneal surgery. J Urol, 1990; 143(6):1108-1114. doi:10.1016/s0022-5347(17)40199-6.
8. Hostiuc S, Rusu MC, Negoi I, et al. Anatomical variants of renal veins: a meta-analysis of prevalence. Sci Rep. 2019; 9(1):10802. doi:10.1038/s41598-019-47280-8.
9. Ichikawa T, Ono S, Nagafuji Y, et al. Congenital venous anomalies associated with retrocaval ureter: evaluation using computed tomography. Folia Morphol. 2023; 82(2):300-306. doi:10.5603/FM.a2022.0036.
10. Iwanaga J, Singh V, Ohtsuka A, et al. Acknowledging the use of human cadaveric tissues in research papers: Recommendations from anatomical journal editors. Clin Anat. 2021; 34(1): 2-4. doi:10.1002/ca.23671.
11. Jetti R, Jevoor P, Vollala VR, et al. Multiple variations of the urogenital vascular system in a single cadaver: a case report. Cases J. 2008; 1(1):344. doi:10.1186/1757-1626-1-344.
12. Kitamura S, Sakai A, Yoshioka T, et al. [A rare case of the retroaortic renal vein.] Kaibogaku Zasshi. 1979; 54(4):129-135.
13. Kosuri KC, KS S, Nelluri V. Anomalous renal vasculature existing with congenital anomalies of kidneys, ureters and suprarenal glands: a cadaveric study. Ital J Anat Embryol. 2020; 124(3):517-526. doi:10.13128/ijae-11680.
14. Kumar S, Neyaz Z, Gupta A. The utility of 64 channel multidetector CT angiography for evaluating the renal vascular anatomy and possible variations: a pictorial essay. Korean J Radiol. 2010; 11(3):346-354. doi:10.3348/kjr.2010.11.3.346.
15. Kyung DS, Lee JH, Shin DY, et al. The double retro-aortic left renal vein. Anat Cell Biol. 2012; 45(4):282-284. doi:10.5115/acb.2012.45.4.282.

16. Macchi V, Parenti A, De Caro R. Pivotal role of the sub-supracardinal anastomosis in the development and course of the left renal vein. Clin Anat. 2003; 16(4):358-361. doi:10.1002/ca.10151.
17. Martinez-Almagro A, Almenar Garcia V, Martinez Sanjuan V, et al. Retroaortic left renal vein: a report of six cases. Surg Radiol Anat. 1992; 14(4):361-366. doi:10.1007/BF01794764.
18. Mazengenya P. Multiple variations of the renal and testicular vessels: possible embryological basis and clinical importance. Surg Radiol Anat. 2016; 38(6):729-733. doi:10.1007/s00276-015-1584-7.
19. McClure CFW, Butler EG. The development of the vena cava inferior in man. Am J Anat. 1925; 35:331-383. doi:10.1002/aja.1000350302.
20. Nallikuzhy TJ, Rajasekhar SSSN, Malik S, et al. Variations of the testicular artery and vein: A meta-analysis with proposed classification. Clin Anat. 2018; 31(6):854-869. doi:10.1002/ca.23204.
21. Nayak SB, Sirasanagandla SR, Shetty SD, et al. Multiple vascular variations at the vicinity of the left kidney. Anat Sci Int. 2013; 88(4):230-233. doi:10.1007/s12565-013-0177-y.
22. Nayak SB, Vasudeva SK. Triple right testicular veins and their variant termination and communications. Heliyon. 2020; 6(9):e05014. doi:10.1016/j.heliyon.2020.e05014.
23. Nidhi G, Amod D, Suniti P. Variations in testicular veins: An anatomico-clinical review. Gal Int J Health Sci Res. 2020; 5(2):56-68.
24. Okamoto K. The posterior renal vein (new definition), together with its morphological significance. Okajimas Folia Anat Jpn. 1990; 67(2-3):203-217. doi:10.2535/ofaj1936.67.2-3_203.
25. Recto C, Pilia AM, Campi R, et al. Renal artery variations: a 20.782 kidneys review. Ital J Anat Embryol. 2019; 124(2):153-163. doi:10.13128/ijae-10776.

26. Salimy MS, Luiselli GA, Yuen M, et al. A case of solitary kidney with duplex collecting systems and renal vascular variants in an adult male cadaver. Folia Morphol. 2021; 80(3);722-725. doi: 10.5603/FM.a2020.0082
27. Satyapal K. The renal veins: a review. Eur J Anat. 2003; 7(S1):43-52.
28. Stojadinovic D, Zivanovic-Macuzic I, Sazdanovic P, et al. Concomitant multiple anomalies of renal vessels and collecting system. Folia Morphol. 2020; 79(3):627-633. doi:10.5603/FM.a2019.0108.
29. Terayama H, Yi SQ, Naito M, et al. Right gonadal arteries passing dorsally to the inferior vena cava: embryological hypotheses. Surg Radiol Anat. 2008; 30(8): 657-661. doi:10.1007/s00276-008-0378-6.
30. Yang CY, Xue HG, Tanuma K, et al. Variations of the bilateral testicular veins: embryological and clinical considerations. Surg Radiol Anat. 2008; 30(1):53-55. doi:10.1007/s00276-007-0285-2.


A
RRA1
IPV
IVC
SMA
SG
SRV
LRA1
RTA
LRV
RRV
AA
Ki
RTA
LTA
RTV2
RTV1
IMA
Ur
LRA2
RRA2
LTV
1 cm

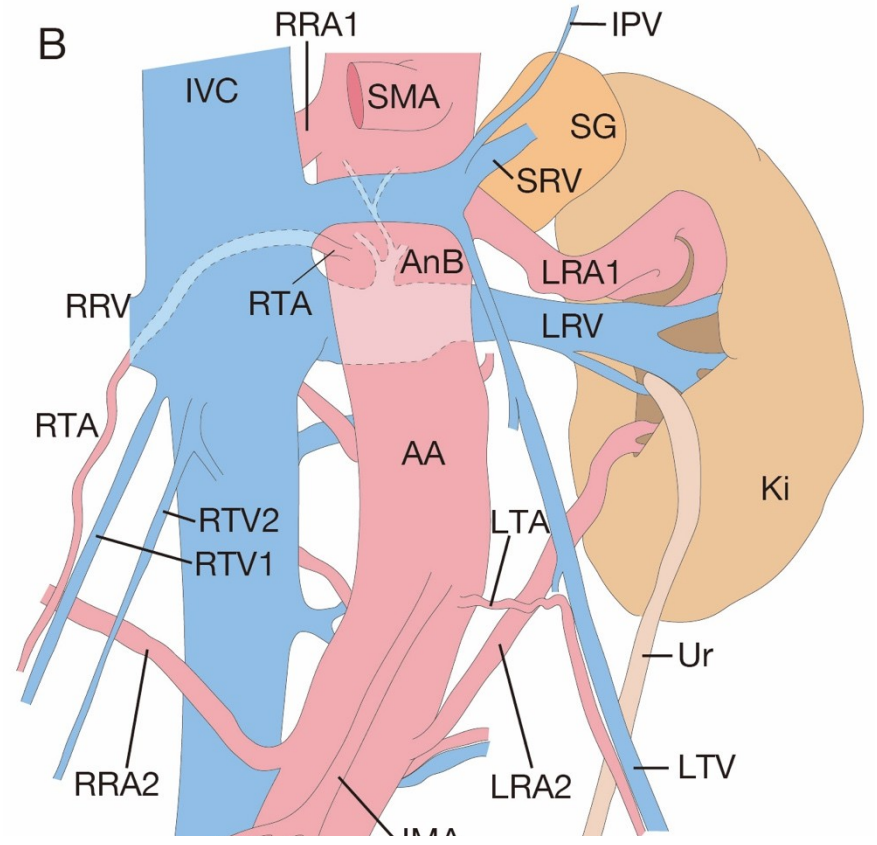

B
RRA1
IPV
IVC
SMA
SG
SRV
AnB
LRA1
RRV
RTA
LRV
RTA
AA
Ki
RTV2
LTA
RTV1
Ur
RRA2
LRA2
LTV

Figure 1. A. Photograph in a ventral view showing the bilateral supernumerary renal artery, retrocaval right testicular artery, retroaortic left renal vein and duplicated right testicular vein. The right kidney is removed so that the retrocaval course of the right testicular artery is clearly shown; **B.** Schematic drawing of A. AA — abdominal aorta; AnB — anastomotic branch between the left renal vein and the lumbar, azygos, and hemiazygos veins; IMA — inferior mesenteric artery; IPV — inferior phrenic vein; IVC — inferior vena cava; Ki — kidney; LRA — left renal artery; LRV — left renal vein; LTA — left testicular artery; LTV — left testicular vein; RRA — right renal artery; RRV — right renal vein; RTA — right testicular artery; RTV — right testicular vein; SG — suprarenal gland; SMA — superior mesenteric artery; and SRV — suprarenal vein.

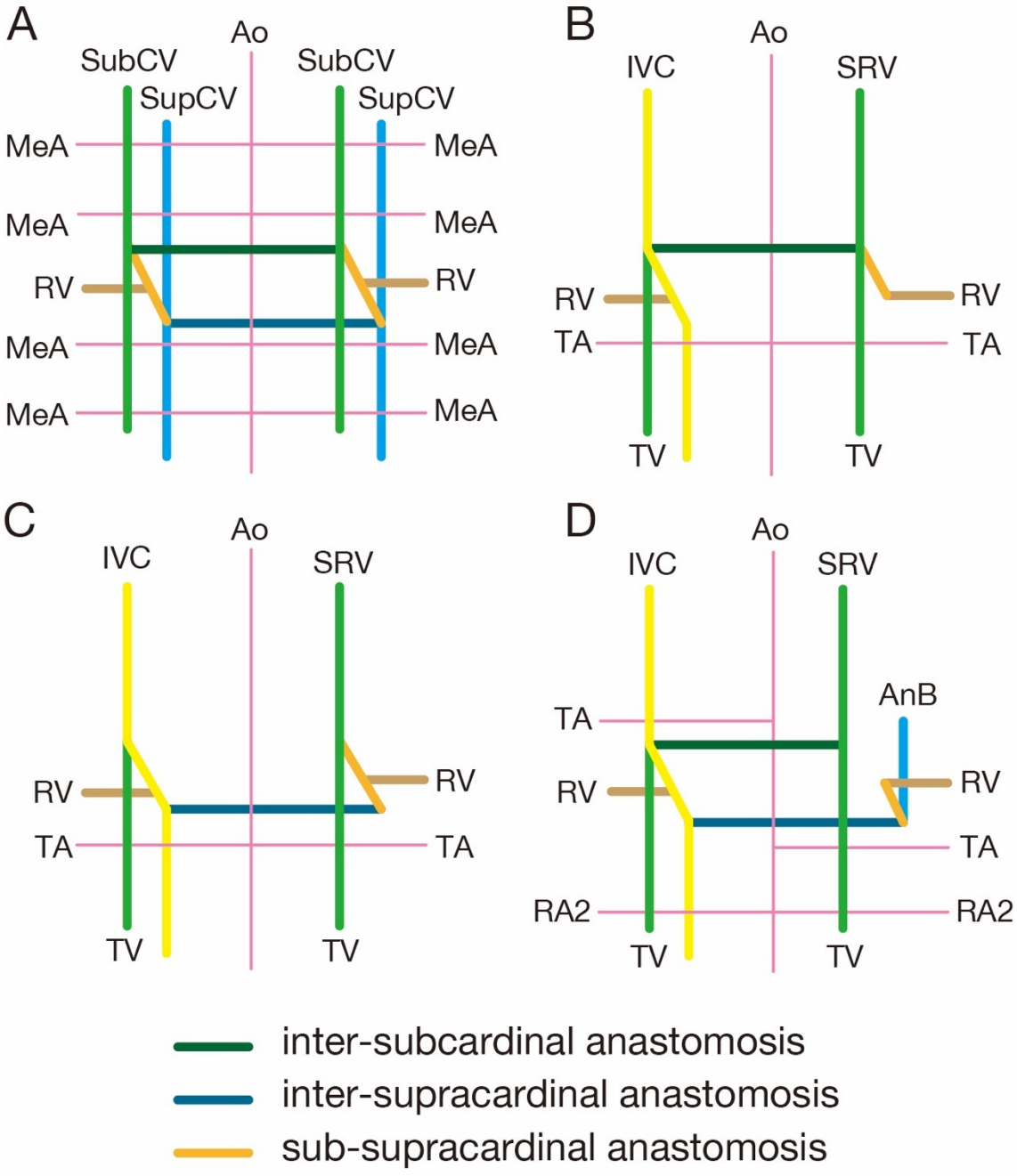


Figure 2. Schematic drawings of the possible development of the abnormal ramification patterns of the urogenital vessels of the present case; **A.** All the primitive urogenital vessels which may exist during development are shown; **B.** The typical development pattern is shown; **C, D.** The conceivable persistent and regression pattern forming the retroaortic left renal vein is shown in prior studies and the present case, respectively. Ao

— aorta; AnB — anastomotic branch with the first lumbar, azygos and hemiazygos veins; IVC — inferior vena cava; MeA — mesonephric artery; RA2 — inferior one of duplicated renal arteries; RV — renal vein; SubCV — subcardinal vein; SupCV — supracardinal vein; TA — testicular artery; TV — testicular vein.