Online Journal of Health and Allied Sciences
Peer Reviewed, Open Access, Free Online Journal
Published Quarterly : Mangalore, South India : ISSN 0972-5997
Volume 17, Issue 2; Apr-Jun 2018

Original Article:

Renal Arteries: A Morphological and Angiographic Assessment

Authors:
Serghei Covantev,
Natalia Mazuruc, Student,
Olga Belic, Associate Professor,
Department of Anatomy, State University of Medicine and Pharmacy «Nicolae Testemitanu», 165, Stefan cel Mare si Sfant, Bd. MD-2004, Chişinau, Republic of Moldova.

Address for Correspondence
Serghei Covantev,
165, Stefan cel Mare si Sfant,
Bd. MD-2004, Chişinau,
Republic of Moldova.
E-mail: Kovantsev.s.d@gmail.com.

Citation
Covantev S, Mazuruc N, Belic O. Renal Arteries: A Morphological and Angiographic Assessment. *Online J Health Allied Scs.* 2018;17(2):9. Available at URL: https://www.ojhas.org/issue66/2018-2-9.html

Submitted: May 7, 2018; Accepted: Jul 7, 2018; Published: July 25, 2018

Abstract: In comparison with other organs, variants of blood supply to the kidneys were always at special attention. In many respects, the relevance of the topic can be explained by the presence of a large number of surgical and non-surgical procedures performed on this organ, the number of which continues to grow. We therefore analyzed renal artery variations by the method of macroscopic anatomical dissection on 56 kidneys and retrospectively analyzed the data of 93 aortography performed using the Seldinger technique. In our study, one renal artery was encountered in 45 cases (80.34%) based on dissection method and in 156 cases (83.87%) based on angiography. Two renal arteries were found in 11 cases (19.64%) according to the dissection method and in 30 cases (16.13%) according to the data of the aortography. Bifurcation of the renal artery occurred in 5 cases (8.93%) and trifurcation – 2 cases (3.57%). Based on the angiography data bifurcation was detected in 16 cases (8.60%) and in trifurcation in 3 case (1.61%). Extrarenal division occurred in 10 cases (17.86%). Based on dissection method the superior polar arteries were recorded in 12 cases (21.43%). On angiographies, the superior polar arteries were encountered in 10 cases (5.38%) and inferior polar arteries – in 2 cases (1.08%). The data provided in the article can be used by specialists in urology, nephrology, vascular surgery, as well as in other therapeutic and surgical specialties.

Key Words: Renal arteries, Accessory renal artery, Extrarenal division, Polar artery, Angiography.

Introduction:

In comparison with other organs, variants of blood supply to the kidneys were always at special attention. In many respects, the relevance of the topic can be explained by the presence of a large number of surgical and non-surgical procedures performed on this organ, the number of which continues to grow.

The anatomy of the renal vessels is of particular importance in the case of kidney transplantation, reconstruction of its vessels, nephrogenic hypertension, and for kidney resection. In all these cases, it is necessary to take into account the variants of the development of renal vessels, which can occur in 4%-61.5% of cases and be the cause of intraoperative and postoperative complications.(1-3) In recent years, it has been shown that accessory kidney vessels can cause nephrogenic hypertension and their presence should be considered when performing ablation of renal vessels.(4) In addition, there is a tendency for the increase in the number of kidney transplants with accessory arteries, which can complicate the surgical procedure.(5)

Variants of blood supply to the kidneys are of great importance not only in the fundamental aspect, but also in clinical practice. Data provided in the article are useful in urology, nephrology, vascular surgery, as well as in other therapeutic and surgical specialties.

Materials and Methods

Variant anatomy of the blood supply of kidneys was studied by the method of macroscopic anatomical dissection. The study was performed on 28 organ complexes (56 kidneys) donated to the department of human anatomy, obtained from patients of different sex and age, who died of causes not related to renal pathology. The organs were fixed in a 10% formalin solution. We also retrospectively analyzed the data of 93 (186 kidneys) aortography performed using the Seldinger *technique* with the study of variants of development of the arterial supply of the kidneys. The obtained data were analyzed using descriptive statistics.

Results

In all 56 cases (100%), the renal arteries originated from the aorta. The same results were obtained from the data of 93 aortographies. Normally, the kidney is supplied by one renal artery. This variant was found in 45 cases (80.34%) during the dissection and in 156 (83.87%) cases according to aortography. Often, the kidney can be supplied by two renal arteries. In such a case, one renal artery is the main one, and the other is an accessory one. Based on the dissection results two renal arteries were found in 11 cases (19.64%) (Figure 1) and in 30 cases (16.13%) according to aortographies (Figure 1.1). We have not detected cases of three or more renal vessels in our study groups.

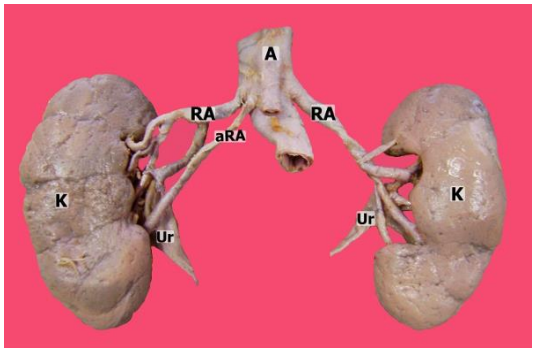

Fig. 1: Accessory renal artery (frontal view). Macrospecimen (woman, 79 years old). K – kidney; A – abdominal part of the aorta; RA –main renal artery; aRA – accessory renal artery; Ur – ureter.

Fig. 1.1: Accessory renal artery (aortography) A – abdominal part of the aorta; RA –main renal artery; aRA – accessory renal artery.

The renal artery can branch early into two or more vessels (bifurcation or a trifurcation) In case of a bifurcation the artery can also be called a «fork-like artery». During the dissection, this type was found in 5 cases (8.93%). In addition, 16 cases (8.60%) of the bifurcation were detected on angiography (Figure 2.1). This developmental variation can be uni- or bilateral (Figure 2). In rare cases, the artery can be divided into three branches (trifurcation) and this variant was found during dissection in 2 cases - 3.57% (Figure 3) and in 3 cases (1.61%) – on angiography (Figure 3.1).

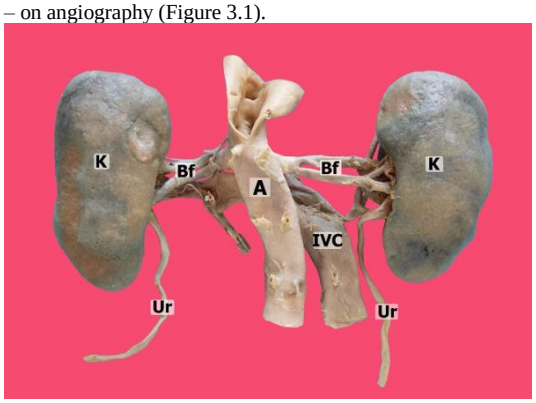

Fig. 2: Bilateral «fork-like» renal artery (posterior view). Macrospecimen (man, 64 years old). K – kidney; IVC – inferior vena cava; A – abdominal part of the aorta; Bf – renal artery bifurcation; Ur – ureter.

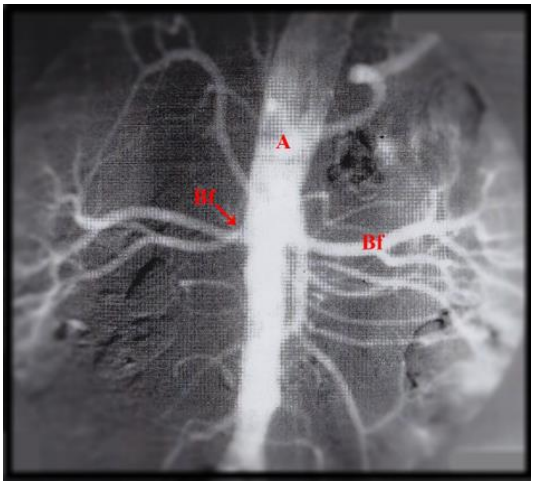

Fig. 2.1: Bifurcation of the renal artery (aortography). A – abdominal part of the aorta; Bf – renal artery bifurcation.

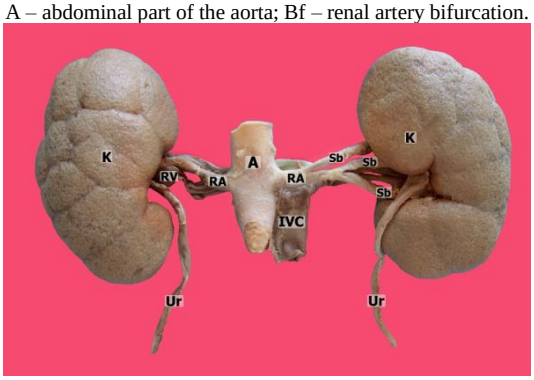

Fig. 3: Trifurcation of the renal artery (posterior view). Macrospecimen (woman, 72 years old). K – kidney; IVC - inferior vena cava; A – abdominal part of the aorta; RA – renal artery; Sb – a presegmentary branch of the renal artery; Ur – ureter.

Fig. 3.1: Trifurcation of the renal artery (aortography). A – abdominal part of the aorta; RA – renal artery; Trf – trifurcation of the renal artery.

Extrarenal division can be proximal or distal and was encountered in 10 cases (17.86%) during dissection (Figure 4). It represents the division of renal artery in segmental branches before its entrance into the renal parenchyma.

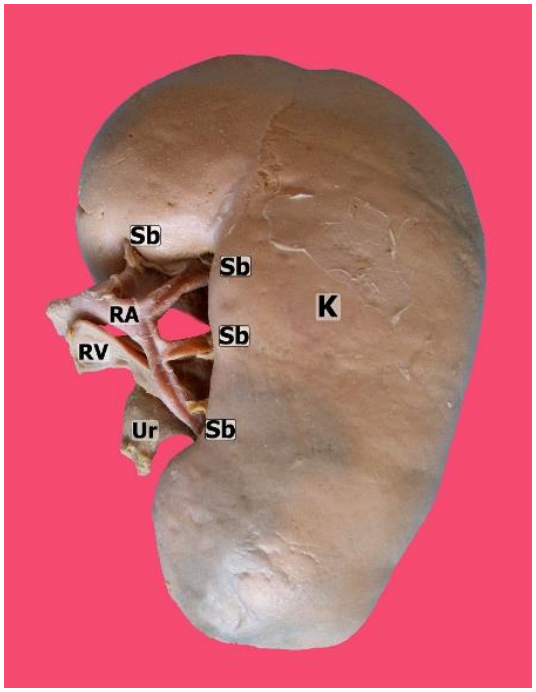

Fig. 4: Extrarenal division of the renal artery (anterior view).
Macrospecimen (woman, 21 years old). K – kidney; RA – renal artery; RV – renal vein; Sb – presegmentary branch of the renal artery; Ur – ureter.

Another type of developmental variations of the renal vascular supply are perforating arteries. A classic example of such type are the polar arteries, which were recorded in 12 cases (21.43%) based on the data from dissection (Figure 5) and can be superior, inferior or bipolar. On angiography, the superior polar artery was encountered in 10 cases (5.38%) and the inferior polar artery – in two cases (1.61%) (Figure 5.1).

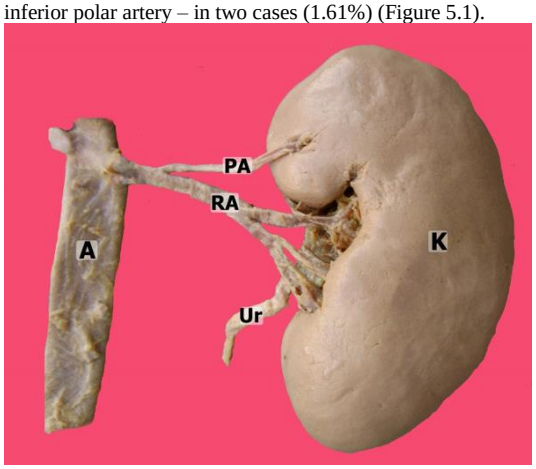

Fig. 5. Superior polar artery (anterior view).
Macrospecimen (woman, 55 years old). K – kidney; A – abdominal part of the aorta; RA – renal artery; PA – superior polar artery; Ur – ureter.

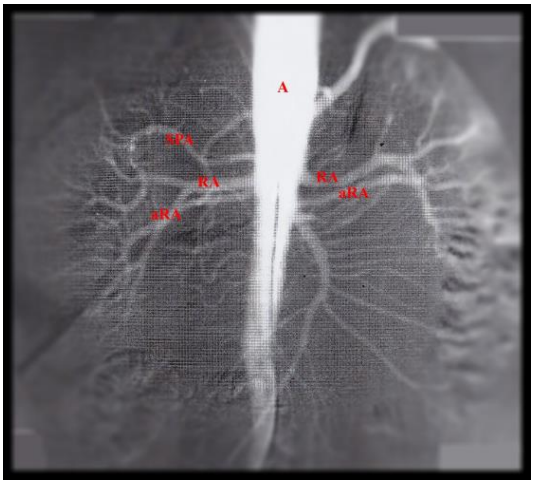

Fig. 5.1. Superior polar artery.
A – abdominal part of the aorta; RA – renal artery; SPA – superior polar artery; aRA – accessory renal artery.

Based on the data obtained during dissection and angiography, it can be noted that the accessory renal arteries, as well as early bifurcation and trifurcation of the artery are more often found on the right (Table 1).

Table 1: The incidence of developmental variations of renal vessels

		Dissection	Aortography
One artery		45 (80.34%)	156 (83.87%)
Two arteries	Left	3 (5.36%)	11 (5.91%)
	Right	6 (10.71%)	19 (10.22%)
	Bilateral	1 (1.79%)	-
	Total	11 (19.64%)	30 (16.13%)
Superior polar artery	Left	8 (14.29%)	3 (1.61%)
	Right	2 (3.57%)	5 (2.69%)
	Bilateral	1 (1.79%)	1 (0.54%)
	Total	12 (21.43%)	10 (5.38%)
Inferior polar artery	Left	-	-
	Right	-	-
	Bilateral	-	1 (0.54%)
	Total	-	2 (1.08%)
Bifurcation of the artery	Left	-	3 (1.61%)
	Right	3 (5.36%)	7 (3.76%)
	Bilateral	1 (1.79%)	3 (1.61%)
	Total	5 (8.93%)	16 (8.60%)
Trifurcation of the artery	Left	-	-
	Right	2 (3.57%)	1 (0.54%)
	Bilateral	-	1 (0.54%)
	Total	2 (3.57%)	3 (1.61%)

Discussion

In the majority of cases (99.1%) the renal arteries originate from the abdominal aorta.(1)

Nowadays, there is no common opinion on the cause of the emergence of accessory renal arteries. Felix described that in a 18 mm fetus the developing mesonephros, metanephros and the suprarenal glands are vascularized by nine pairs of arteries that take origin from the dorsal aorta and can be divided into cranial (1st и 2nd), middle (3rd-5th) and caudal (6th-9th). Thus failure to reduce the number of arteries results in accessory renal vessels.(6)

The incidence of accessory arteries is uneven and depends not only on the study method. Depending on the population,

accessory renal arteries occur from 4% (Malaysia) to 61.5% (Brazil).(1,2) The incidence also can be very variable in countries with ethnical heterogeneity.(7) The Republic of Moldova is a multinational country, which means that the frequency of occurrence of the accessory arteries can vary in wide ranges depending on the nation. In countries that are geographically close to the Republic of Moldova - Ukraine and Romania, the incidence of accessory renal arteries is 31.8% and 19.9%, respectively.(8,9)

Based on the data from the literature more than one accessory renal artery is a rare finding (according to Jamkar and co-workers in 3.77% of specimens on the left side and 4.71% on the right side this variant was found).(10) Several authors consider that accessory renal arteries are more frequent from the right then from the left ($p = 0.01$).(11) Usually the diameter of the main renal artery in this case is smaller.(12) It should be noted, that variants of development of the renal artery (in particular, accessory arteries) are often associated with other developmental variations of vascular supply. In particular, of the celiac trunk, blood supply to the liver, testicles or adrenal glands.(13-15)

Information on the presence of the accessory renal arteries may be useful for the early diagnosis of certain diseases. For example, there is an opinion that existence of the accessory renal arteries can lead to hypertension. In patients with hypertension, accessory renal arteries are detected more often (59% compared with 32%, $p = 0.004$). The operation for renal denervation in such patients is also less likely to succeed, or the result is less prominent.(16,17)

Despite the fact that at present accessory renal arteries, as a rule, do not increase the risk of internal and postoperative complications, they nevertheless increase the duration of surgery (245 vs. 221 min, $p = 0.023$) and slightly increase the blood loss (225 vs. 220 ml, $p = 0.029$).(18)

Another type of anomalies of the kidney's blood supply are the polar arteries. They can be encountered in 3.56% – 22.6% of cases. The superior polar arteries are more frequent and can be seen in 7.32 – 22.6% of cases, while the inferior polar arteries – only in 3.56% – 5.3%.(3,19) Still, there are opinions that the incidence of inferior polar arteries is higher.(20) The presence of inferior polar arteries can be linked to a higher rate of ureteral complications compared to the patients who don't have inferior polar arteries (47% VS 14%, $p = 0.01$).(18) This can be explained by the fact that the vascularization of the ureter in this case depends on the inferior polar artery.(21) Besides that, the presence of the inferior polar artery can also cause ureteral compression and thus lead to hydronephrosis.(22)

The branching of the renal artery into segmental branches, can be before the sinus (81.67%), in the region of the sinus (10%) and inside the sinus (8.33%).(23) Thus, the early branching of the artery into segmental branches can be seen in 18.33%-21.36%. The number of the branches is also variable.(11,23) Fork-like arteries (bifurcation of the renal artery) are encountered in approximately 9.4%-16.5% of cases.(24,25).

Finally, accessory renal arteries, as well as early bifurcation and trifurcation of the artery are more often found on the right side. Furthermore arterial supply variations are more frequent than variations of venous drainage this can be explained by embryological and hemodynamical factors that contribute to a higher incidence of arterial variations.(26)

Conclusions

In our study, we identified the frequency of occurrence of various variants of kidney's blood supply based on the data of the macroscopic dissection data and angiographic examination. In our study, one renal artery was encountered in 45 cases (80.34%) based on dissection method and in 156 cases (83.87%) based on angiography. Two renal arteries were found in 11 cases (19.64%) according to the dissection method and in 30 cases (16.13%) according to the data of the aortography. Bifurcation of the renal artery occurred in 5 cases (8.93%) and trifurcation - 2 cases (3.57%). Based on the angiography data bifurcation was detected in 16 cases (8.60%) and in trifurcation in 3 cases (1.61%). Extrarenal division occurred in 10 cases (17.86%). Based on dissection method the superior polar arteries were recorded in 12 cases (21.43%). On angiography, the superior polar arteries were encountered in 10 cases (5.38%) and inferior polar arteries as well in 2 cases (1.08%). Data provided in the article can be used by specialists in urology, nephrology, vascular surgery, as well as in other therapeutic and surgical specialties.

References

1. Johnson PB, Cawich SO, Shah SD, Aiken W, McGregor RG, Brown H, et al. Accessory renal arteries in a Caribbean population: a computed tomography based study. *Springer Plus*. 2013;2:443.
2. Palmieri BJ, Petroianu A, Silva LC, Andrade LM, Alberti LR. Study of arterial pattern of 200 renal pedicle through angiotomography. *Revista do Colegio Brasileiro de Cirurgioes*. 2011 Mar-Apr;38(2):116-21.
3. Khamanarong K, Prachaney P, Utraravichien A, Tong-Un T, Sripaoraya K. Anatomy of renal arterial supply. *Clinical Anatomy*. 2004;17(4):334-6.
4. Mendelsohn FO. Does complete renal denervation translate into superior clinical outcomes? Lessons learned from denervation of accessory renal arteries. *Clinical Research in Cardiology*. 2014 Sep;103(9):681-3.
5. Troppmann C, Wiesmann K, McVicar JP, Wolfe BM, Perez RV. Increased transplantation of kidneys with multiple renal arteries in the laparoscopic live donor nephrectomy era: surgical technique and surgical and nonsurgical donor and recipient outcomes. *Archives of Surgery (Chicago, Ill: 1960)*. 2001 Aug;136(8):897-907.
6. Felix W. Mesonephric arteries (aa. mesonephrica). In Keibel F, Mall FP. (Eds.) Manual of Human Embryology. vol. 22, Lippincott, Philadelphia, Pa, USA, 1912. pp. 820–825.
7. Gulas E, Wysiadecki G, Cecot T et al. Accessory (multiple) renal arteries - Differences in frequency according to population, visualizing techniques and stage of morphological development. *Vascular*. 2016 Oct;24(5):531-7.
8. Vilhova I, Kryvko YY, Maciejewski R. The radioanatomical research of plural renal arteries. *Folia Morphologica*. 2001 Nov;60(4):337-41.
9. Bordei P, Sapte E, Iliescu D. Double renal arteries originating from the aorta. *Surgical and Radiologic Anatomy : SRA*. 2004 Dec;26(6):474-9.
10. Jamkar AA, Khan B, Joshi DS. Anatomical study of renal and accessory renal arteries. *Saudi Journal of Kidney Diseases and Transplantation*. 2017 Mar-Apr;28(2):292-7.
11. Tarzamni MK, Nezami N, Rashid RJ, Argani H, Hajealioghli P, Ghorashi S. Anatomical differences in the right and left renal arterial patterns. *Folia Morphologica*. 2008 May;67(2):104-10.
12. Ramadan SU, Yigit H, Gokharman D, Tuncbilek I, Dolgun NA, Kosar P, et al. Can renal dimensions and the main renal artery diameter indicate the presence of an accessory renal artery? A 64-slice CT study. *Diagnostic and Interventional Radiology (Ankara, Turkey)*. 2011 Sep;17(3):266-71.
13. Ugurel MS, Battal B, Bozlar U, Nural MS, Tasar M, Ors F, et al. Anatomical variations of hepatic arterial system, coeliac trunk and renal arteries: an analysis with multidetector CT angiography. *The British Journal of Radiology*. 2010 Aug;83(992):661-7.
14. Bergman RA, Cassell MD, Sahinoglu K, Heidger PM, Jr. Human doubled renal and testicular arteries. *Annals*

of Anatomy = Anatomischer Anzeiger. 1992 Aug;174(4):313-5.
15. Nayak BS. Multiple variations of the right renal vessels. *Singapore Medical Journal*. 2008 Jun;49(6):e153-5.
16. VonAchen P, Hamann J, Houghland T, Lesser JR, Wang Y, Caye D, et al. Accessory renal arteries: Prevalence in resistant hypertension and an important role in nonresponse to radiofrequency renal denervation. *Cardiovascular Revascularization Medicine :Including Molecular Interventions*. 2016 Oct - Nov;17(7):470-3.
17. Id D, Kaltenbach B, Bertog SC et al. Does the presence of accessory renal arteries affect the efficacy of renal denervation? *JACC Cardiovascular Interventions*. 2013 Oct;6(10):1085-91.
18. Kok NF, Dols LF, Hunink MG, Alwayn IP, Tran KT, Weimar W, et al. Complex vascular anatomy in live kidney donation: imaging and consequences for clinical outcome. *Transplantation*. 2008 Jun 27;85(12):1760-5.
19. Sampaio FJ, Passos MA. Renal arteries: anatomic study for surgical and radiological practice. *Surgical and Radiologic Anatomy : SRA.* 1992;14(2):113-7.
20. Guan WH, Han Y, Zhang X, Chen DS, Gao ZW, Feng XS. Multiple renal arteries with renal cell carcinoma: preoperative evaluation using computed tomography angiography prior to laparoscopic nephrectomy. *The Journal of International Medical Research*. 2013 Oct;41(5):1705-15.
21. Desgrandchamps F, Paulhac P, Fornairon S, De Kerviller E, Duboust A, Teillac P, et al. Artificial ureteral replacement for ureteral necrosis after renal transplantation: report of 3 cases. *The Journal of Urology*. 1998 Jun;159(6):1830-2.
22. Bush WH, Brannen GE, Lewis GP. Ureteropelvic junction obstruction: treatment with percutaneous endopyelotomy. *Radiology*. 1989 May;171(2):535-8.
23. Daescu E, Zahoi DE, Motoc A, Alexa A, Baderca F, Enache A. Morphological variability of the renal artery branching pattern: a brief review and an anatomical study. *Romanian Journal of Morphology and Embryology = Revue Roumaine de Morphologie et Embryologie.* 2012;53(2):287-91.
24. Budhiraja V, Rastogi R, Asthana AK. Variant origin of superior polar artery and unusual hilar branching pattern of renal artery with clinical correlation. *Folia Morphologica*. 2011 Feb;70(1):24-8.
25. Saldarriaga B, Perez AF, Ballesteros LE. A direct anatomical study of additional renal arteries in a Colombian mestizo population. *Folia Morphologica*. 2008 May;67(2):129-34.
26. Covantev S, Mazuruc N, Belic O. Renal Veins: Developmental Variations and Clinical Significance. *Online J Health Allied Scs.* 2017;16(4):12.