Morphological Expression of the Renal Artery. A Direct Anatomical Study in a Colombian Half-caste Population

Expresión Morfológica de la Arteria Renal. Un Estudio Anatómico Directo en Población Mestiza Colombiana

Bladimir Saldarriaga*; Sergio A. Pinto** & Luis E. Ballesteros***

SALDARRIAGA, B.; PINTO, S. A. & BALLESTEROS, L. E. Morphological expression of the renal artery. A direct anatomical study in a Colombian half-caste population *Int. J. Morphol.*, 26(1):31-38, 2008.

SUMMARY: Irrigation of the kidneys is usually provided by a single renal artery; however, variations on this pattern have frequently been reported. This study was aimed at establishing the renal arteries' frequency and morphological characteristics in cadaverous material taken from a half-caste population from Bucaramanga (Colombia). The sample included 195 renal blocks corresponding to 57 (14.6%) kidneys from females and 333 (85.4%) from males. The renal arteries were injected with synthetic resin (palatal GP41L); following the resin's polymerization, the renal blocks were placed in KOH solution for corrosion the renal parenchyma. The individuals from whom the renal blocks, 74.9% of the kidneys presented renal arteries single and 25.1% had additional renal arteries. Average right and left renal artery length was 34.6 mm and 28.6 respectively ($p < 0.001$). Renal artery diameter was 4.87 mm. Main renal artery diameter in kidneys presenting additional renal arteries was less than that of those having a single renal artery, this being a significant difference ($p = 0.0000$). The renal arteries more frequently (85%) originated from the anterolateral part of the aorta. The right renal artery emerged rostrally in 49.2%, whilst both arteries were located at the same level in 34.4%. The renal poles received a greater contribution from frontal division branches, the upper pole 46.4% and the lower pole 55.9%. No significant differences were presented in the characteristics studied here regarding gender. The renal arteries presented great variability in morphological expression regarding their emergence and ramification level.

KEY WORDS: Renal artery; Anatomical variations; Kidney.

INTRODUCTION

Great technological advances due to modern diagnostic imaging techniques, particularly in the field of urology, in non-interventionist radiological procedures and in the area of surgery, have emphasized having better morphological referents for the renal vascularization pattern. Even though imaging techniques have good resolution, direct anatomical studies lead to recognizing anatomical vascularization patterns in greater detail, offering a referent having great usefulness for interpreting, managing, surgical approaches and diagnosing functional alterations (Longia *et al.*, 1984).

Renal irrigation is characterized by presenting great variability, the presence of a single bilateral or unilateral renal artery significantly predominating in most studies. Such variability is influenced by ethnic factors, and less so by gender (Ajmani & Ajmani 1983).

The renal artery emerges from the lateral surface of the aorta in most cases (Garcier *et al.*, 2001; Ozan *et al.*, 1997) It emerges from the posterolateral, anterolateral and posterior surfaces with less frequency. Other sites of origin have been described, such as the celiac trunk, common iliac and inferior phrenic artery (Garti *et al.*, 1986).

The distance from the renal arteries origin to the superior mesenteric (Garcier *et al.*,) and celiac trunk (Ajmani & Ajmani) have been taken as reference in determining the level of emergence. The renal arteries may emerge at the same level, or at different levels, the right renal artery may be found proximal or caudal to the left (Odman & Ranniger, 1968).

The renal arteries present a diameter of around 5mm. The right renal artery is longer than the left due to the aorta's location to the left of the middle plane of the abdominal cavity.

* Biol., MSc. Associate Professor, School of Medicine, Universidad Autónoma de Bucaramanga, Colombia.

** Medical student, School of Medicine, Universidad Autónoma de Bucaramanga, Colombia.

***MD, MSc. Associate professor, School of Medicine, Universidad Industrial de Santander and Universidad Autónoma de Bucaramanga, Colombia.

Based on the level of the renal artery ramification, it is known as the hilar renal artery when it divides at renal hilum level and extrahilar when the artery emits a segmentary branch entering the kidney's upper or lower poles before entering the hilum (Sampaio & Passos 1992).

This study was aimed at establishing the frequency of renal arteries and their morphological expression in cadaverous material taken from a half-caste population from Bucaramanga (Colombia), to enrich knowledge concerning renal vascularization, thereby serving as referent in teaching and clinical practice.

MATERIAL AND METHOD

One hundred and ninety-five renal blocks were studied in this non-probabilistic, cross-sectional, descriptive study; they were extracted from individuals, who had necropsy performed on them at the Instituto de Medicina Legal, Bucaramanga (Colombia).

The sample included 57 (14.6%) kidneys from females and 333 (85.4%) from males.

A convenience sample was obtained complying with the following inclusion criteria: kidneys from half-caste male and female subjects (half-castes were considered to be individuals presenting a phenotypical mixture of Caucasoid, Negro and Mongoloid racial groups), having no signs of retroperitoneal pathology or trauma. The renal arteries were injected with synthetic resin (80% palatal GP41L and 20% styrene) at 120 mm mercury pressure. Perfused renal blocks were subjected to polymerization (24 hours) and corrosion (8 hours) with 20% KOH.

An electronic calibrator was used for taking measurements. The different findings from patterns of renal irrigation were reported considering the specimens' gender, number of renal arteries, side on which presented, length, diameter, emergent surface from the aorta, ramification level and distance to the superior mesenteric. Photographic records were made of each piece evaluated.

The continuous variables were described with their means and standard deviations while nominal variables were described in terms of percentages; Chi(X²) square and Student T-test statistical tests were made, accepting an alpha error of up to 5%. Epiinfo 2002 was used for creating the database and STATA 8.0 for making the statistical analysis.

RESULTS

The individuals from whom the renal blocks were extracted had an mean age of 33.8 (15.6 SD), ages ranging from 12 to 86. mean male and female age (34.1±15.2 and 30.9±17.0 years old, respectively) was similar ($p = 0.122$).

Two hundred and ninety-two kidneys (74.9%) presented single renal arteries and 98 (25.1%) additional renal. Single renal artery presentation frequency was great on the right-hand side (151, 77.8%) than the left-hand side (141, 72.7%), no significant differences being presented regarding the number of renal arteries according to side ($p = 0.140$).

The length of the right-hand renal artery (34.6 mm) was significantly greater ($p < 0.001$) than the left-hand one (28.6 mm). Most specimens presented renal artery lengths ranging from 31 to 45 mm on the right-hand side and 16 to 30 mm on the left-hand side (Table I; Figs. 1 and 2). Short-length arteries, determined by early ramification of the main renal artery (arteries having a length less than 15 mm), were observed on the right-hand side in 7.3% of cases and in 9.4% on the contralateral side (Table II; Figs. 3 and 4).

Left-hand side renal artery diameter in cases of single renal artery had an average 4.93 mm diameter and 4.8mm on the right-hand side. No significant differences were found regarding gender (Table I). The main renal artery presented a 3.98 mm diameter (0.86 SD) in kidneys presenting additional renal arteries on the right-hand side and 4.28 mm (0.92 SD) on the left-hand side. These diameters were significantly less than those for kidneys presenting a single renal artery ($p = 0.0000$).

Regarding renal artery's diameter, this was greater in taller individuals, correlation not being significant between these two parameters (Spearman's rho)= 0.1641 and 0.1876 for the right- and left-hand sides, respectively). Taking the distance from the renal artery's emergence to the origin of the superior mesenteric artery as reference, it was observed that the right renal artery was proximal related to the left-hand one, this difference not being significant in relation to gender (Table III). The right-hand renal artery emerged proximally in 60 (49.2%) of the 122 renal blocks having a single bilateral artery; the left was proximal in 20 of them (16.4%) and both arteries emerged at the same level in the remaining 42 specimens (34.4%). The distance in the aorta vertical axis separating the origin of the right renal artery from the left-hand one was 2.9 mm on average.

Table 1. Average measures (length, diameter, distance) between the superior mesenteric artery and the singles renal arteries.

	Male	Female	p value
Length of the right-hand renal artery	34.38 ± 11.58	35.98 ± 9.51	0.2566
Length of the left-hand renal artery	28.68 ± 10.30	28.20 ± 6.56	0.8141
Diameter of the right-hand renal artery	4.84 ± 0.90	4.57 ± 0.63	0.1550
Diameter of the left-hand renal artery	4.97 ± 0.73	4.71 ± 0.96	0.1841
DSMR	10.36 ± 6.29	9.36 ± 4.78	0.52
DSML	11.23 ± 5.95	11.07 ± 4.62	0.91

DSMR= Distance of the right renal artery to the superior mesenteric artery. DSML= Distance of the left renal artery to the superior mesenteric artery.

Fig. 1. Kidney arteries with simetrical emergence (Posterior view). AA. Abdominal Aorta; IC. Inferior vena cava; L. Left renal artery; R. Right renal artery; U. Ureter.

Fig. 2. Kidney arteries with asimetical emergence (Posterior view). AA. Abdominal aorta; IC. Inferior vena cava; L. Left renal artery R. Right renal artery; U. Ureter.

The renal artery emerged with greater frequency (84.8% of the pieces evaluated) from the anterolateral part of the aorta on both the right- and left-hand sides, no significant differences being presented between males and females ($p = 0.28$ on the right-hand side and $p = 0.392$ on the left). The renal artery emerged from the posterolateral surface of the aorta in very few cases (Table IV).

The renal pole's blood supply was presented with greater frequency from the anterior division's branches, 46.4% corresponding to the superior pole and 55.9% to the inferior one. Irrigation provided by a branch originating directly from the renal artery (superior renal polar branch) was observed on the right-hand side in 26 kidneys (17.2%) and in 19 on the left-hand side

Fig. 3. Kidney arteries with early ramification of the left kidney artery. (Posterior view). AA. Abdominal aorta; IC. Inferior vena cava; L. Left renal artery; R. Right renal artery; U. Ureter. * Left inferior renal polar artery.

Fig. 4. Kidney arteries with presence of a left superior polar kidney artery and early ramification of the main renal artery. AA. Abdominal aorta; IC. Inferior vena cava; L. Left renal artery; R. Right renal artery; U. Ureter. * Superior renal polar artery.

Table. II. Range of the lengths between the left and right single renal arteries.

Length	Right renal artery		Left renal artery	
	n	%	n	%
4 - 15	11	7.3	13	9.4
16 - 30	44	29.3	81	58.3
31 - 45	75	50.0	38	27.3
46 - 60	20	13.3	7	5
Total	150	100.0	139	100.0

* In the right side register was not obtained in one artery and in the left side in two arteries.

(13.5%). The superior renal polar artery was observed on the right-hand side with greater frequency in females, such difference not being statistically significant ($p = 0.053$); presentation of this branch being very similar on the left-hand side ($p = 0.575$).

The right-hand inferior renal polar branch was observed in 5 specimens (3.3%) and 5 on the left-hand side (3.5%), no significant differences being presented regarding gender ($p = 0.505$ for the right-hand side and $p = 0.909$ from the left).

DISCUSSION

Renal irrigation is assumed to be provided by a single renal artery in descriptions given by texts dealing with anatomy (Testut & Jacob 1979; Williams *et al.*, 2001); however, considerable variations on this pattern have been reported in the literature specializing in the topic (Anson *et al.*, 1936; Bordei *et al.*, 2004; Cicekcibasi *et al.*, 2005; Harrison *et al.*, 1978; Ronstrom, 1947). Renal irrigation provided by a single renal artery had 75.1% frequency in the present study, agreeing with that reported by Cicekcibasi *et al.*; Merklin & Michels, 1958 and Harrinson *et al.* Other authors have reported high frequency ranging from 82% to 87% (Reis & Esenther, 1959; Ronstrom; Wozniak *et al.*, 1972; Engelbrecht *et al.*, 1969). Differing from the previously-mentioned results, Coen & Raftery (1992) reported remarkably lower single renal artery incidence (50.9%) in the population being studied.

Table III. Distance between the superior mesenteric artery and the right and left renal arteries.

Distance SMA(mm)	Right renal artery		Left renal artery	
	n	%	n	%
0 - 5	19	18.1	13	12.6
5.1 - 10	33	31.4	31	30.1
10.1 - 15	35	33.3	35	34.0
15.1 - 20	12	11.4	16	15.5
> 20.1	6	5.7	8	7.8

SMA. Superior mesenteric artery.

Table IV. Emergence of the renal artery from the surface of the aorta in relation to gender.

Emergence	Right		Left	
	Male (%)	Female (%)	Male (%)	Female (%)
Lateral	19 (15.5)	2 (7.4)	18 (16.5)	2 (7.1)
Anterolateral	102 (83.6)	24 (88.9)	90 (82.6)	26 (92.9)
Posterolateral	1 (0.9)	1 (3.7)	1 (0.9)	0
p value	0.28		0.392	

The presence of bilateral single renal arteries had 62.9% frequency, similar to that reported by Odman & Ranniger; other studies have reported 69% (Coen & Raftery), 75.1% (Geyer & Poutasse, 1962) and 35% (Anson *et al.*).

A discrepancy was presented regarding the most frequent side for presenting a single renal artery; greater predominance of the right-hand side was found in our study, agreeing with Bordei *et al.*; Satyapal *et al.*, 2001; Vilhova *et al.*, 2001. Other work has pointed out that this anatomical expression is more frequent on the left-hand side (Khamanarong *et al.*, 2004; Cicekcibasi *et al.*). Such differences could be explained by the number of renal specimens evaluated and by the techniques or study methods used.

The lengths of the right- and left-hand renal arteries (34.6 and 28.6 mm) observed in the present work agreed with that reported by Dhar & Lal (2005). Greater length right renal arteries (44 to 111 mm) were described by Janschek *et al.*, 2004; such discordance could have been due to the greater number of specimen having late ramification of the right renal artery observed in the reference work.

The short-length renal artery frequency (early ramification) observed in our study (8.3%) was less than that reported by Holden *et al.*, 2005 (12%); Patil *et al.*, 2001, Sasaki *et al.*, 2000 (10%); Kapoor *et al.*, 2004 (11.8%). Kawamoto *et al.*, 2003 reported a considerably greater frequency to the foregoing (19%). The low frequency (2.6%) reported by Sampaio & Passos can be highlighted. It is important that this characteristic be born in mind, as these branches may be erroneously interpreted as being additional arteries in diagnostic imaging studies. Surgical complications may also be determined in renal transplants since the first 15 mm of the renal artery may be used for anastomosis with the receptor iliac artery. Early ramification of the main renal artery in renal laparoscopic surgery is considered to be exclusion criteria. In surgical terms, early or precocious division of the renal artery is considered to be equivalent to arterial supply by multiple arteries, such morphological characteristic being important to consider when performing a transplant (Sampaio & Passos,).

There is little information about these arterie's diameter in current morphometric studies of renal arteries.

Diagnostic imaging reports have been mainly

focused on managing pathological cases, especially those characterized by renovascular hypertension-associated stenosis. Data from diagnostic imaging studies varies, depending on the technique used. Renal artery diameter found in our study (4.87 mm) was slightly less than the 5.9 mm reported in angiographic studies (Aytac *et al.*, 2003; Behar *et al.*, 2002) and that reported by Testut & Jacob.

The difference in single renal artery diameter (4.87 mm) was evident in relation to that of the main renal artery when additional arteries were presented (4.15 mm). This characteristic is very important for predicting the presence of accessory renal arteries. The presence of additional renal arteries is very probable (98.8% specificity) when the main renal artery has a diameter of less than 4.15 mm. Kidneys presenting a main renal artery greater than 5.5 mm very probably do not present additional renal arteries (Aytac *et al.*).

The emergence of single renal arteries from the anterolateral surface of the aorta (84.8%) agreed with reports by Beregi *et al.*, 1999 and Verschuyt *et al.*, 1997. This percentage was greater than that reported by Ozan *et al.* and Kosinski, 1994. This finding was less than that reported for the right-hand renal artery (95%) by Garcier *et al.* Contrasting with the foregoing results, Cicekcibasi *et al.* described remarkable lesser frequency (26.9%) of the ostium on the anterolateral surface of the aortic wall. An occasional finding related to the presence of the ostium of the renal artery in the posterolateral part of the aorta (1%), agreeing with that reported by Ozan *et al.*

Discrepancies in results regarding the location of the ostium of the renal arteries arose from the criteria used for demarking the surface of the aorta; this meant that the differences could have been just a few millimeters in defining the site of emergence. The advanced age of the individuals providing most cadavers hampered determining the ostium by direct dissection (the aorta was sinuous). Such situation can be avoided in diagnostic imaging studies and corrosion injection, since it allows suitable visualization and demarcation of the aortic surface.

The right-hand renal artery had a cranial origin in relation to the left in a greater number of specimens (49.1%), agreeing with that reported by Ozan *et al.*; Keen, 1981; Kosinski; Merklin & Michels; Cicekcibasi *et al.*; Pick & Anson, 1940. A greater frequency (65%) of cranial origin of the right-hand renal artery has been reported by Garcier *et al.* The symmetrical emergence of the renal arteries observed in the present study (34.4%) agreed with that observed by Merklin & Michels;

Cicekcibasi *et al.* and Pick & Anson, and was considerably greater than that found by Ozan *et al.*; Keen, who reported such morphological expression ranging from 10% to 16%. Beregi *et al.* have described a higher frequency for the symmetrical emergence of the renal arteries (50%). This parameter is relevant in angiographic studies Behar *et al.* and in invasive management of atherosclerotic stenosis of the renal arteries.

The incidence of renal superior polar artery in the present study (15.4%) agreed with that reported by Sampaio & Passos, and other studies referred to by Eisendrath (1920) and Ronstrom. These authors reported 16.6% frequency for this artery in Caucasians (whites) and 11.9% in Negros. There were no marked differences between the findings observed in different racial groups.

The inferior polar renal artery was found less frequently than the superior polar renal artery. Our findings (3.4%) had an intermediate range between the percentages reported by Sampaio & Passos, Eisendrath and Longia *et al.* The presence of these arteries was observed as a characteristic of early ramification of the renal artery; such morphological expression is clinically important, especially when emergency surgery is involved.

This study, carried out on a half-caste Colombian population, showed that six out of each ten individuals present single bilateral renal arteries, rostral emergence from the surface of the right renal artery's aorta predominating. The renal artery's diameter is a factor which should be considered as predicting the presence of additional renal arteries. The renal arteries present a broad spectrum of variability in their morphological expression respecting their length, level of ramification, diameter and emergence. Such aspects are important when considering a surgical approach, trauma, interpreting diagnostic images and teaching renal vascularization.

ACKNOWLEDGEMENTS. This work was carried out with funding from Colciencias, the Universidad Autónoma de Bucaramanga and the Universidad Industrial de Santander. We would especially like to recognize the Instituto de Medicina Legal y Ciencias Forenses, Northeastern Colombian region, for supplying the anatomical pieces used in this study.

We would also like to thank Carlos Bermúdez Barajas, Lab Technician, María Eugenia Niño Associate Professor, School of Medicine, Universidad Autónoma de Bucaramanga for statistical analysis and Jason Garry for translating the manuscript.

SALDARRIAGA, B.; PINTO, S. A. & BALLESTEROS, L. E. Expresión morfológica de la arteria renal. Un estudio anatómico directo en la población mestiza colombiana *Int. J. Morphol.*, 26(1):31-38, 2008.

RESUMEN: La irrigación de los riñones es proporcionada usualmente por una arteria renal única; sin embargo, variaciones en este patrón han sido frecuentemente reportadas. El objetivo de este estudio fue establecer las características morfológicas y frecuencia de las arterias renales en material cadavérico de una población mestiza de Bucaramanga (Colombia). La muestra incluyó 195 riñones, correspondiendo 57 (14,6%) y 333 (85,4%) a cadáveres femeninos y masculinos respectivamente. Las arterias renales fueron inyectadas con resina sintética (palatal GP41L), luego de la polimerización de la resina, fueron sumergidos en solución de KOH, para la corrosión del parénquima renal. Los bloques renales presentaron una arteria renal única en un 74,9%, y arterias renales adicionales en un 25,1%. El largo promedio de las arterias renales derechas e izquierdas fue 34,6 mm y 28,6 mm respectivamente ($p < 0,001$). El diámetro renal fue de 4,87 mm. El diámetro mayor de las arterias renales adicionales fue menor que el de la arteria renal única, con una diferencia significativa ($p = 0,0000$). Las arterias renales se originaron con mayor frecuencia (85%) de la parte anterolateral de la aorta. La arteria renal emergió por anterior en un 49,2%, aunque ambas arterias estaban localizadas al mismo nivel en un 34,4%. Los polos renales recibieron su irrigación de las ramas de la división anterior en un 46,4% y 55,9%, en el polo superior e inferior respectivamente. No existieron diferencias significativas en las características con respecto al sexo. Las arterias renales presentan gran variabilidad en su expresión morfológica con respecto a su emergencia y nivel de ramificación.

PALABRAS CLAVE: Arteria renal; Variación anatómica; Riñón.

REFERENCES

- Ajmani, M. L. & Ajmani, K. To study the intrarenal vascular segments of human kidney by corrosion cast technique. *Anat Anz.*; 154(4):293-303, 1983.
- Anson, B. J.; Richardson, G. A. & Minear, W. L. Variations in the number and arrangement of the renal vessels. A study of the blood supply of four hundred kidneys. *J. Urol.*; 36:211-9, 1936.
- Augustyn, M. Supernumerary segmental branches of the renal artery. *Folia Morphol. Warsaw.*, 41:441-7, 1982.
- Aytac, S. K.; Yigit, H. & Sancak, T. Correlation between the diameter of the main renal artery and the presence of an accessory renal artery. *J. Ultrasound Med.*, 22:433-9, 2003.
- Behar, J.V.; Nelson, R. C.; Zidar, J. P.; DeLong, D. M. & Smith, T. P. Thin –Section Multidetector CT angiography of renal artery stents. *A. J. R.*, 178, 2002.
- Beregi, J. P.; Mauroy, B.; Willoteaux, S.; Mounier-Vehier, C. & Remy-Jardin, M. Anatomic variation in the origin of the main renal arteries: spiral CTA evaluation. *Eur. Radiol.*, 9(7):1330-4, 1999.
- Bordei, P.; Sapte, E. & Iliescu, D. Double renal arteries originating from the aorta. *Surg. Radiol. Anat.*, 26(6): 474-9, 2004.
- Cicekcibasi, A. E.; Ziyilan, T.; Salbacak, A.; Seker, M.; Buyukmumcum, M. & Tuncer, I. An investigation of the origin, localization and variations of the renal arteries in human fetuses and their clinical relevance. *Ann. Anat.*, 187(4): 421-7, 2005.
- Coen, L.D. & Raftery, A.T. Anatomical variation of renal arteries and renal transplantation. *Clin Anat.*, 5:425-32, 1992.
- De Beer, P. M. The renal arteries in the South African Bantu-Speaking Negro. *S. Afr. J. med. Sci.*, 31: 67-81, 1966.
- Dhar, P. & Lal, K. Main and accessory renal arteries--a morphological study. *Ital. J. Anat. Embryol.*, 110(2):101-10, 2005.
- Eisendrath, D. N. The relation of variation in the renal vessels to pielothomy and nephrectomy. *Ann. Surg.*, 71:726-43, 1920.
- Engelbrecht, H. E.; Keen, E. N.; Fine, H. & Bulcke, C. V. The radiological anatomy of the parenchymal distribution of the renal artery – a revised approach. *S. Afr. Med. J.*, 43:826-34, 1969.
- Garcier, J. M.; De Fraissinette, B.; Filaire, M.; Gayard, P.; Therre, T. & Ravel, A. Origin and initial course of the renal arteries: a radiological study. *Surg. Radiol. Anat.*, 23(1):51-5, 2001.
- Garti, I.; Nissenkorn, I. & Lerner M. Common origin of inferior mesenteric and main renal artery. *Eur. Urol.*, 12:215-6, 1986.
- Geyer, J. R. & Poutasse, E.F. Incidence of multiple renal arteries on aortography. Report of a series of 400 patients, 381 of

- whom had arterial hypertension. *JAMA*, 182:118-25, 1962.
- Graves, F. T. The aberrant renal artery. *J. Anat.*, 90: 553-8, 1956.
- Harrison, L. H.; Flye, M.W. & Sleigler H. F. Incidence of anatomical variants in renal vasculature in the presence of normal renal function. *Ann Surg.*, 188:83-9, 1978.
- Holden, A.; Smith, A.; Dukes, P.; Pilmore. H. & Yasutomi, M. Assessment of 100 live potential renal donors for laparoscopic Nephrectomy with Multi-Detector row helical CT. *Radiology*, 237:973-80, 2005.
- Janschek, E. C.; Rothe, A. U.; Holzenbein, T. J.; Langer, F.; Brugger, P. C.; Pokorny, H. *et al.* Anatomic basis of right renal vein extension for cadaveric kidney transplantation. *Urology*, 63: 660-4, 2004.
- Kawamoto, S.; Montgomery, R. A.; Lawler, L. P.; Horton, K. M. & Fishman, E. K. Multidetector CT Angiography for Preoperative Evaluation of Living Laparoscopic Kidney Donors. *Am. J. Roentgenol.*, 180:1633, 2003.
- Kapoor, A.; Mahajan, G.; Singh, A. & Sarin, P. Multispiral CT angiography of renal arteries of live potencial renal donors . A review of 118 cases. *Transplantation*, 77(10): 1535- 9, 2004.
- Keen, E. N. Origin of renal arteries from the aorta. *Acta Anat., (Basel)*, 110(4):285-6, 1981.
- Khamanarong, K.; Prachaney, P.; Utraravichien, A.; Tong-Un, T. & Sripaoraya K. Anatomy of renal arterial supply. *Clin. Anat.*, 17:334-6, 2004.
- Kosinski, H. Variability of places of origin of the human renal arteries. *Folia Morphol (Warsz)*, 53(2):111-6, 1994.
- Longia, G.S.; Kumar, V. & Gupta C. D. Intrarenal arterial pattern of human kidney--corrosion cast study. *Anat Anz.*, 155(1-5):183-94, 1984.
- Merklin, R. J. & Michels, N. A. The variant renal and suprarenal blood supply with data on the inferior phrenic, ureteral and gonadal arteries. A statistical analysis based on 185 dissection and review of the literature. *J. Int. Col. Surg.*, 9:41-76, 1958.
- Odman, P. & Ranniger, K. The location of the renal arteries an angiography and postmortem study. *Am. J. Roentgenol.*, 104:283-8, 1968.
- Ozan, H.; Alemdaroglu, A.; Sinav, A. & Gumusalan, Y. Location of the ostia of the renal arteries in the aorta. *Surg. Radiol. Anat.*, 19(4):245-7, 1997.
- Patil, U. D.; Ragavan, A. & Nadaraj, T. Helical CT angiography in evaluation of live kidney donors. *Nephrol. Dial. Transplant.*, 16(9):1900-4, 2001.
- Pick, J. & Anson, B. J. The renal vascular pedicle: An anatomical study of 430 body halves. *J. Urol.*, 44: 411-34, 1940.
- Reis, R. H & Esenther, G. Variations in the pattern of renal vessels and their relation to the type of posterior vena cava in man. *Am. J. Anat.*, 104:295-318, 1959.
- Ronstrom, G.N. Incidence of single and multiple renal arteries in negroes. *Am. J. Phy. Anthropol.*, 5:485-90, 1947.
- Sampaio, F. J. & Passos, M. Renal arteries: anatomic study for surgical and radiological practice, *Surg. Radiol. Anat.*, 14:113-7, 1992.
- Sasaki, T. M; Finelli, F. & Burgarin, E. Is laparoscopic donor nephrectomy the new criterion standard? *Arch. Surg.*, 135:943-7, 2000.
- Satyapal, K. S.; Haffejee, A. A.; Singh, B.; Ramsaroop, L.; Robbs, J. V. & Kalideen, J. M. Additional renal arteries: incidence and morphometry. *Surg. Radiol. Anat.*, 23:33-8, 2001.
- Testut, L. & Jacob, O. *Anatomía topográfica con aplicaciones medicoquirúrgicas*. Salvat, Barcelona, 1979. Tomo II.
- Verschuyt, E. J.; Kaatee, R. & Beek, F. Renal arterie origin: best angiographic projection angles. *Radiology*, 205:115- 20, 1997.
- Vilhova, I.; Kruvko, Y. Y. & Maciejewski, R. The radioanatomical research of plural renal arteries. *Folia Morphol (Warsz)*, 60(4):337- 41, 2001.
- Williams, P. L.; Warwick, R.; Dyson, M. & Bannister L. H. *Gray's anatomy*. 38th. Ed. Edinburgh, Scotland, Churchill Livingstone, 2001.
- Wozniak, W.; Kiertz, A. & Warzniak, S. The question of the renal arterial segments. *Anat. Anz.*, 132:332-40, 1972.

Correspondence to:
 Bladimir Saldarriaga T.
 Calle 157 # 19-55
 Cañaveral Parque, Bucaramanga
 School of Medicine
 Universidad Autónoma de Bucaramanga
 COLOMBIA

Email: vsaldarr@unab.edu.co.

Received: 11-09-2007

Accepted: 12-11-2007