Morphological Variations of Superior Segmental Artery of the Single Renal Artery

Study on corrosion casts

CRISTIAN ANDREI SARAU[1#], DANIEL FLORIN LIGHEZAN[1#], SILVIU LATCU[2], IOAN SAS[3], CODRUT IVAN[4], MARIOARA BOIA[5*], CRISTIAN DRAGOS BANCIU[1]

[1]"Victor Babes" University of Medicine and Pharmacy Timisoara, Department of Internal Medicine I, 2 Eftimie Murgu Sq, 300041, Timisoara, Romania

[2]"Pius Brînzeu" Emergency County Hospital Timisoara, 10 Iosif Bulbuca Bd, 300736, Timisoara, Romania

[3] "Victor Babes" University of Medicine and Pharmacy Timisoara, Department of Obstetrics and Gynecology, 2 Eftimie Murgu Sq, 300041, Timisoara, Romania

[4]"Victor Babes" University of Medicine and Pharmacy Timisoara, Department of Surgery II, First Surgical Clinic, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

[5]"Victor Babes" University of Medicine and Pharmacy Timisoara, Department of Neonatology, 2 Eftimie Murgu Sq., 300041, Timisoara, Romania

On a total of 150 renal corrosion casts with a single renal artery, the artery of superior segment was examined. Three morphological types have been highlighted: Type I, in which the superior segmental artery originating directly in the trunk of the renal artery (8.67% of cases); Type II, in which the superior segmental artery arises from the anterior branch of the renal artery (81.33% of cases); Type III, in which the superior segmental artery arises from the posterior branch of the renal artery (10% of cases). In 78% of cases, the superior segmental artery arises independently from the trunk or renal artery branches (anterior or posterior). In 22% of cases, the superior segmental artery realizes a common trunk with one or more other segmental arteries. Knowledge of these aspects is important both to investigate morphological imaging and performing partial resection of the renal parenchyma.

Keywords: kidney; corrosion casts; superior segmental artery; variations.

Medico-surgical literature reviews on morphological variability of impair [1-6] and pair [7-10] collateral branches of the abdominal aorta, highlights the importance of knowledge of these issues in current medical practice. The major morphological variations of abdominal aortic branches are usually classified into: variations of origin [1, 2, 5, 8, 9], variations in number [4, 8, 9] variations of trajectory [3, 4, 10, 11] and variations of distribution [12]. For the renal artery, the most common variations are those of number [2, 3, 9-11] with the presence of accessory or additional renal arteries. In the case of the single renal artery, the most important anatomical variations are the variation of origin and intraparenchymatous distribution. According to Terminologia Anatomica [13], the intraparenchymatous distribution of the renal artery branches has segmental distribution.

Terminologia Anatomica [13] homologates kidney with one renal artery. In accordance with this aspect, the renal artery gives rise to an anterior branch and posterior branch. The anterior branch gives rise to four segmental arteries: superior, anterior-superior, anterior-inferior and inferior. The posterior branch gives rise to only one branch: the posterior segmental artery [14]. In the present study, we analyzed the morphological variability of the superior segmental artery origin and association in case of the single renal artery presence. The appearance of variability at this level is represented by the different origin (from the trunk artery or its branches - anterior and posterior) of the segmental arteries [14].

The arteries of the superior renal segment show a large degree of morphologic variability regarding their origin and number and also their supplied renal territory [7]. This aspect is very important for the successful of minimally invasive surgery on renal parenchyma.

Experimental part

In the present study, one used 150 human renal corrosion casts achieved in the Department of Anatomy of the "Victor Babes" University of Medicine and Pharmacy, Timisoara. The corrosion pieces were prepared in the 2000-2012 period. Renal pieces were harvested from human cadavers who had no history of renal disease. According with the technique used in the Anatomical Laboratory, the injection of the renal vasculo-ductal systems was performed with Ago II plastic compound (product based on nitrocellulose E950), using the technique described by Nanu, Corondan and Bejan [15], taken and improved later by Matusz [16] and by Zahoi [17]. After injection, the renal pieces were left for 24 h at room temperature for mass polymerization. After 24 h, the renal parenchyma was corroded with technical hydrochloric acid. All procedures for renal corrosion casts were approved by the Ethics Committee of the "Victor Babes" University of Medicine and Pharmacy, Timisoara. Of the 167 pieces of corrosion casts with a single renal artery, were kept only 150 pieces of corrosion casts, who presented the segmentation of the renal parenchyma in accordance with the renal segmentation homologated by Terminologia Anatomica [13]. The renal corrosion casts were photographed (Nikon D3, Tokyo, Japan, AF-S Nikkor Lens f/1.4G) and classified according to the present type of major arterial anatomic variation, in particular the origin and distribution of the superior segmental artery.

* *email marianaboia@yahoo.com; Tel.:* 0740137597 *# Authors with equal contributions*

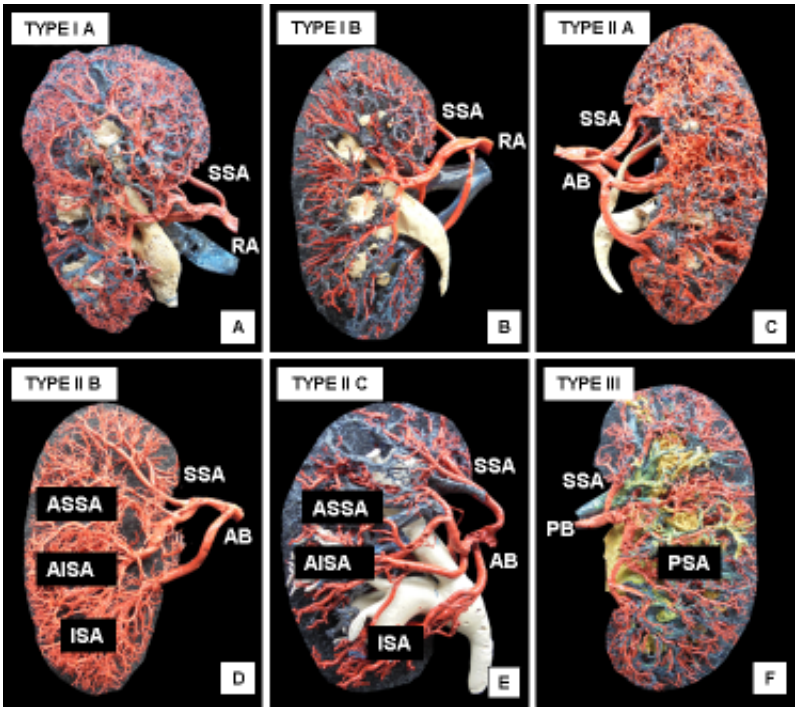

Fig.1. Renal corrosion casts highlighting the morphological types of the superior segmental artery origin. A, C-E - anterior view; B,F - posterior view. RA - renal artery; AB - anterior branch; PB - posterior branch; SSA - superior segmental artery; ASSA - anterior-superior segmental artery; AISA - anterior-inferior segmental artery; PSA - posterior segmental artery; ISA - inferior segmental artery. (Color figure can be viewed in the online issue, which is available at www.revmaterialeplastice.ro)

Results and discussions

Depending on the origin of the superior segmental artery, the studied material represented by the 150 pieces of corrosion casts, were classified into three morphological types:

- type I, in which the superior segmental artery originating directly in the trunk of the renal artery (13/150 cases - 8.67% of cases), with two subtypes: (ia) in which the superior segmental artery is the first branch that arises from the trunk of the renal artery (9/150 cases - 6% of cases); (ib) in which the superior segmental artery arises at the same level with other branches of the renal artery (4/150 cases - 2.67% of cases);

- type II, in which the superior segmental artery arises from the anterior branch of the renal artery (122/150 cases - 81.33% of cases), with three subtypes: (iia) the superior segmental artery, originated independently from anterior branch (93/150 cases - 62% of cases); (IIb) the superior segmental artery originated from a common trunk of anterior-superior and anterior-inferior segmental arteries (12/150 cases - 8% of cases, and (IIc) the superior segmental artery originated from a common trunk with anterior-superior and anterior-inferior and inferior segmental arteries (17/150 cases - 13.33% of cases);

- type III, in which the superior segmental artery arises from the posterior branch of the renal artery (15/150 cases - 10% of cases).

In 78% of cases, the superior segmental artery arises independently from the trunk or renal artery branches (anterior or posterior). In 22% of cases, the superior segmental artery realizes a common trunk with one or more other segmental arteries.

After the descriptions of Graves in 1954 [18], the arterial segmentation of the kidney parenchyma (with five segments) was accepted at the International Anatomical Congress at Wiesbaden in 1965 and included in Nomina Anatomica [19] and after in Terminologia Anatomica [13]. Knowledge of the morphological variability of the superior segmental artery is particularly important in achieving successful the partial nephrectomy of the upper pole [20, 21].

In morphological literature, there are few studies which analyze clearly the superior segmental artery origin [7, 22, 23]. On the studied material (150 kidney corrosion casts), the superior segmental artery arises directly from the renal artery trunk in 8.67% of cases, from the anterior branch in 81.33% of cases, and from posterior branch in 10% of cases.

The superior segmental artery arises most commonly from the anterior branch of the renal artery (Type II), the incidence being 81.33% of the cases, among the 150 corrosion casts from the present study (with higher percentages than in previous reports). The study of Singh et al. [24] reported same segmental artery in 70% of cases, Kher [25] reported in 45.28%, Chandragirish et al. [23] reported in 42.20% of cases, and Verma [26] in only 20.45% of cases. The superior segmental artery arises from the renal artery trunk (Type I) in 8.67% of cases, in the present study (in margin of variation values reported in previous studies). Verma [26] reported the origin of this artery from the junction of the anterior and posterior branches of the renal artery in 16.30% of cases, Chandragirish et al. [23] in 14% of cases, and Kher [25] reported in 5.66% of cases. The superior segmental artery arises from the posterior branch of the renal artery (Type III) in 10% of cases, in the present study (with lower percentages than in previous reports). Kher [25] reported the origin of this artery from the posterior branch of the renal artery in 29.70% of cases, and Chandragirish et al. [23] in 23% of cases.

Using anatomical data is particularly useful in supporting numerous surgical diagnoses, and supporting etiology pathogenesis and specific treatment in many diseases [27-29]. Numerous imaging methods among which highlights MDCT angiography and MR angiography [1-6, 8-11] clearly show anatomical structures, with the possibility of three-dimensional analysis. Making preparations of plastination [30, 31] and computer aided three-dimensional reconstruction and modeling of anatomical images [32], enable three-dimensional analysis and accurate morphometric analysis. Injection of plastics mass in vascular-ductal systems, followed by corrosion of the parenchymal tissues, gives rise to corrosion casts allowing for quality three-dimensional analysis. The viability of these preparations is very high and they can be successfully used in training students and residents in medicine [33, 34].

Conclusions

Analysis of the corrosion renal vascular-ductal systems allows the study of three-dimensional distribution of intraparenchymatous elements. This study showed the origin of the superior segmental artery at three distinct levels: renal artery trunk, anterior branch and posterior branch. Most commonly, the superior segmental artery arises from the anterior branch of the renal artery (81.33%), with three subtypes: arising independently from anterior branch, from a common trunk with anterior-superior and anterior-inferior segmental arteries, and from a common trunk with anterior-superior and anterior-inferior and inferior segmental arteries. Knowledge of these aspects is important both to investigate morphological imaging and performing partial resection of the upper renal parenchyma.

Acknowledgements: The authors are grateful to the Department of Anatomy, "Victor Babes" University of Medicine and Pharmacy Timisoara, for the opportunity to examine the renal corrosion casts.

References

1. MATUSZ P, MICLAUS GD, PLES H, TUBBS RS, LOUKAS M. Absence of the celiac trunk: case report using MDCT angiography. Surg Radiol Anat., 2012, 34(10):959-963.
2. MATUSZ P, IACOB N, MICLAUS GD, PURECA A, PLES H, LOUKAS M, TUBBS RS. An unusual origin of the celiac trunk and the superior mesenteric artery in the thorax. Clin Anat., 2013, 26(8):975-979.
3. MATUSZ P, LOUKAS M, IACOB N, PLES H. Common stem origin of left gastric, right and left inferior phrenic arteries, in association with a hepatosplenomesenteric trunk, independently arising from the abdominal aorta: Case report using MDCT angiography . Clin Anat., 2013, 26(8):980-983.
4. IACOB N, MICLAUS GD, MATUSZ P. About the common trunk of the inferior phrenic arteries. JASI, 2013, 62(2):184-185.
5. IACOB N, SAS I, JOSEPH SC, PLEŞ H, MICLAUS GD, MATUSZ P, TUBBS RS, LOUKAS M. Anomalous pattern of origin of the left gastric, splenic, and common hepatic arteries arising independently from the abdominal aorta. Rom J Morphol Embryol., 2014, 55(4):1449-1453.
6. IACOB N, PURECA A, BELIC O, MATUSZ P. A hepatomesenteric trunk, in association with left gastric and splenic arteries arising independently from the abdominal aorta: A case report using MDCT angiography. JASI, 2014, 63(2):179-182.
7. BORDEI P, ŞAPTE E, ILIESCU D, BRÂNZANIUC K, BAZ R, MATUSZ P, DINA C. Morphological assessments on the arteries of the superior renal segment. Surg Radiol Anat. 2012, 34(2):137-144.
8. MICLAUS GD, MATUSZ P. Bilateral quadruple renal arteries. Clin Anat., 2012, 25(8):973-976.
9. MICLAUS GD, SAS I, JOSEPH SC, MATUSZ P, PLES H, TUBBS RS, LOUKAS M. Seven renal arteries: A case report using MDCT angiography. Rom J Morphol Embryol., 2014, 55(3 Suppl):1181-1184.
10. PUPCA G, MICLAUS GD, BUCURAS V, IACOB N, SAS I, MATUSZ P, TUBBS RS, LOUKAS M. Left crossed fused renal ectopia L-shaped kidney type, with double nutcracker syndrome (anterior and posterior) . Rom J Morphol Embryol., 2014, 55(3 Suppl): 1237-1241
11. MATUSZ P, MICLĂUŞ GD, GABRIEL A, CATERENIUC I, OLARIU S, TUBBS RS, LOUKAS M. Single ectopic thoracic renal artery associated with a normal kidney position and renal artery stenosis: a case report and review of literature. Rom J Morphol Embryol. 2015;56(2):557-562.
12. NATSIS K, PARASKEVAS G, PANAGOULI E, TSARAKLIS A, LOLIS E, PIAGKOU M, VENIERATOS D. A morphometric study of multiple renal arteries in Greek population and a systematic review. Rom J Morphol Embryol., 2014, 55(3 Suppl):1111-1122.
13. *** FICAT. Terminologia Anatomica. International anatomical terminology. Thieme Stuttgart, New York, 1998.
14. SARAU CA, LATCU S, BUZAS A, SAS I, IVAN C, BOIA M, IOANOVICIU SD, LIGHEZAN DF. Morphological Variations of Inferior Segmental Artery of the Single Renal Artery. Study on Corrosion Casts. Mat. Plast., **52**, no. 3, 2015, p. 330
15. NANU I, CORONDAN G, BEJAN L. Despre masele plastice de nitroceluloză în pregătirea preparatelor anatomice de coroziune. Morfologia normală şi patologică. 1958, 2:115-118.
16. MATUSZ P. Tipologii de desfăşurare spaţială şi interrelaţii morfologice privind elementele de angio- şi bilioarhitectură hepatică, Teză de doctorat, UMF Timişoara, 1994.
17. ZAHOI DE. Tipologii de distribuţie spaţială şi interrelaţii morfologice privind elementele vasculo-ductale ale rinichiului. Teză de Doctorat. UMF "Victor Babeş" Timişoara, 2001.
18. GRAVES FT. The anatomy of intrarenal arteries and its application to segmental resection of the kidneys. Brit J Surg., 1954, XLII: 605-616.
19.*** IANC. Nomina Anatomica, 6th edn. Churchill Livingstone, London, 1989.
20. KAPLAN JR, CHANG P, PERCY AG, WAGNER AA. Renal transposition during minimally: invasive partial nephrectomy a safe technique for excision of upper poletumors. J Endourol. 2013, 27(9):1096-100.
21. SHAO P, LI P, XU Y, CAO Q, JU X, QIN C, YIN C, TANG L. Application of combined computed tomography arteriography, venography, and urography in laparoscopic partial nephrectomy with segmental artery clamping. Urology. 2014, 84(6):1361-5.
22. BUDHIRAJA V, RASTOGI R, ASTHANA AK. Variant origin of superior polar artery and unusual hilar branching pattern of renal artery with clinical correlation. Folia Morphol (Warsz). 2011, 70(1):24-28.
23.CHANDRAGIRISH S, NANJAIAH CM, SHIRUR SY, SAHEB SH. Study on variations of superior segmental branch of renal artery. Int J Anat Res., 2014, 2(4):701-704.
24. Singh G. Kacker N, Bajpai RN.Vascular pattern of kidney. The Antiseptic. 1967, 64: 669-672
25. Kher GA, Bhargava I, Makhni FS. Internal branching of the renal artery. Ind J Surg., 1960, 22: 563-579.
26. VERMA M, CHATURVEDIN RP, PATHAK RK. Anatomy of the renal vascular segments. J Anat Soc., 1961, 10:12-14.
27. PETRIE A, TUBBS RS, MATUSZ P, SHAFFER K, LOUKAS M. Obturator hernia: anatomy, embryology, diagnosis, and treatment. Clin Anat., 2011, 24(5):562-569.
28. OSIRO S, TIWARI KJ, MATUSZ P, GIELECKI J, TUBBS RS, LOUKAS M. Grisel's syndrome: a comprehensive review with focus on pathogenesis, natural history, and current treatment options. Childs Nerv Syst., 2012, 28(6):821-825.
29. DEAN C, ETIENNE D, HINDSON D, MATUSZ P, TUBBS RS, LOUKAS M. Pectus excavatum (funnel chest): a historical and current prospective. Surg Radiol Anat., 2012, 34(7):573-579.
30. SORA MC, MATUSZ P. General Considerations Regarding the Thin Slice Plastination Technique. Clin Anat., 2010, 23(6):734-736.
31. WENGERT G, BARTL R, SCHUELLER-WEIDEKAMM C, GABRIEL A, MATUSZ P, SORA MC. The Posterior Aspect of the Shoulder An Anatomic Study Using Plastinated Cross-Sections. Mat Plast., **51**, no. 4, 2014, p. 452-
32.SORA MC, JILAVU R, MATUSZ P. Computer aided three-dimensional reconstruction and modelling of the pelvis, by usingplastinated cross sections, as a powerful tool for morphological investigations. Surg Radiol Anat., 2012, 34(8):731-736.
33. BEDREAG O, BUT AR, HOINOIU B, MICLAUS GD, URSONIU S, MATUSZ P, DOROS IC. Using Pig Tracheobronhial Corrosion Casts in Training of the Medical Students and Residents. Mat Plast., **51**, no.4, 2014, p. 444
34. MATUSZ P, LATCU S, SORA, MC, HOINOIU B, BEDREAG O, PIRTEA L, SAS I, IOANOVICIU SD. Achievement and Using Ex-situ Pig Renal Corrosion Casts in Training of the Medical Students and Residents. Mat. Plast., **52**, no. 2, 2015, p. 230

Manuscript received: 14.08.2015