

Standardization of the nomenclature of anatomical variants of the renal arteries – a conciliatory proposal

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ABSTRACT

Introduction: Commonly, the kidney is supplied by a single renal artery (RA). However, anatomical variants exist in more than 40% of the population. The nomenclatures used in literature to describe these variations are not comprehensive. We compare the different nomenclatures among the literature with the aim to mark their concordances and discrepancies, as well as to highlight and recommend descriptors to facilitate the understanding and communication regarding this subject. **Material and Methods:** Searches on the CAPES, Bireme and Pubmed databases for articles (published between 1992 and 2013) with the descriptors "Kidney", "Vessels", "Variations" and "Anatomy" were performed. Original works were included with samples of at least 50 kidneys. Articles regarding only parenchymal or collection system variations were excluded. **Results:** 17 articles were selected in total. The nomenclature for the renal vascular arterial anatomy presents various terms such as "Main", "Multiple", "Accessory", "aberrant". Due to the differences between the nomenclatures, there was difficulty to group and compare the results of the various studies of prevalence. Many nomenclatures differ among each other to name a vessel of the same variant, while others are insufficient to describe them with clarity and specificity and, sometimes, they ultimately diverge even in the same study. We propose the use of a standardized universal and systematized new nomenclature from an adaption of the nomenclature proposed by Sampaio and Passos. **Conclusion:** The main aspect of this terminology proposed herein consists in the designation of the renal vessels according to their origin and destiny. As such, this terminology is succinct, self-sufficient and specific for everyday use by professionals and researchers.

Keywords: anatomical variant, nomenclature, renal artery, standardization

INTRODUCTION

The kidney may receive blood supply from more than one renal artery (RA), which can originate from the abdominal aorta, iliac arteries and, more rarely, from the mesenteric artery or from the thoracic portion of the aorta. Regularly, the kidney is supplied by a single RA which emerges from the

abdominal aorta between L1 and L2, below the origin of the superior mesenteric artery and runs towards the renal pelvis [1].

After emerging from the aorta, both renal arteries (RAs) run towards the kidneys in a slightly posterior direction, due to the kidneys' anatomical orientation. The right renal artery (RRA) originates from the anterolateral portion of the aorta; as for the

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left renal artery (LRA) it originates from a more lateral position. The RRA characteristically courses in a descendent manner behind the inferior vena cava, while the LRA courses more horizontally [2].

The classical description defines that each RA divides itself only when entering the renal hilum, into anterior and posterior branches (called pre-segmental arteries). Variations of this pattern may include ramifications which occur before the hilum (called the extra-hilar or pre-hilar division) and also the pre-segmental ramifications [3].

The pre-segmental arteries of the classical pattern are subdivided in segmental arteries, which supply each renal segment (apical, superior, medial, inferior and posterior). Independent from the arterial pattern of the RA subdivisions, each branch is clinically and surgically important, as there is no collateral circulation between these segments, in a way that they are solely irrigated by their respective arteries [4].

Anatomical variations in renal vessels are not uncommon, occurring in average in more than 40% of the population [5], with some authors reporting them in up to 61.5% of the analyzed pedicles [1, 6-11]. According to Ugurel et al. (2010) [11], variations in RAs are the result of the changes in the organ's blood supply throughout the intrauterine development and also suffer influence of the gender and race.

They also may consist of alterations in the place of number, place of origin and level of emergency; may also vary in diameter, length and number. Probably in function of the large quantity of types of variations in RAs, various authors generated different nomenclatures. Terms such as accessory renal arteries, aberrant, anomalous, supernumerary and supplementary have already been used to describe the various types of RAs variants [1, 10].

The use of standardized nomenclatures improves the understanding and communication of a topic. The diversity of the possible types of RAs variants emphasizes even more this importance. In the practical assistance, it implies in the reduction in the risk of diagnostic or therapeutic confusion, which may generate errors and damage to the patient. In the academic scope, contributes to a comparison

and/or unification of the data of various sources of literature [1, 9, 10].

Such benefits will be reflected in the knowledge and execution of medical-surgical procedures such as kidney transplant, urological access, angioplasty of the RA, or even the study of pathologies such as renal vascular hypertension, Takayasu's disease and of the renal trauma [10].

Initially, the authors of this present work carried out a bibliographical research about studies concerning the prevalence of anatomical variations of the RAs, with the objective of summarizing them in a meta-analysis. As they came across the difficulty of joining the data of various original works, due to the use of terms that were divergent from one another, came to light the need of proposing a standardization of the nomenclature and the initial aim was abandoned.

Thus, the present study aimed to elaborate and propose a standardization of the nomenclature of the anatomical variations of the RAs and for this, our team revised various studies of prevalence, comparing the nomenclatures applied by them, highlighting concordances and discrepancies among them, and finally recommending the descriptors which, for aspects such as specificity and clarity, had a higher potential to facilitate the understanding and the communication of the topic.

MATERIAL AND METHODS

Articles were retrieved from searches carried out in the CAPES, Bireme and Pubmed databases. Articles published between 1992 and 2013 were included. The descriptors used were: "Kidney", "Vessels", "Variations", and "Anatomy". Original works were included and articles with a sample of 50 kidneys or more were included. Articles published in Portuguese or English were also included. Articles which only reported anatomical variations of the parenchyma or collection system were not included.

The article published by Hazirolan et al. (2011) [2] was included posteriorly, due to its comprehensiveness and synthesis in the clarification of the divergence, and had its data treated aside from the original works initially selected.

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Only the variations of the RA from its origin up to the hilum were considered. The pre-segmental and segmental variations are not the focus of this study.

RESULTS

Seventeen articles were included in total. The Table 1 shows these articles divided according to their methods, of which 10 were performed in image studies, 06 were performed through autopsies, and 1 paper used the two combined aforementioned methods. The terminology used by the various authors can be found in Table 2.

The prevalence of the renal arterial pattern according to the nomenclature used by the main authors can be found in Table 3. All the terms used by the various authors are displayed on the first line. Cells in which the terms were absent in a study were filled with the letter "X". Thus, the quantity of "X" in Table 3 displays the discrepancies between nomenclatures and shows how the comparison between different studies is confusing.

Another difficulty was that some papers displayed the prevalence in individuals, while others showed the prevalence of variations in a number of renal pedicles ("kidneys" – two in each individual), what can cause difficulty during comparison; since the variations can be bilateral in a number of individuals (see the second and third columns of Table 1).

The data of Sampaio and Passos (1992) [9] study are presented separately in Table 4, in order to highlight their findings and emphasize the reference whose nomenclature seems to better attend to the premises adopted by the authors of the present work

DISCUSSION

Among the terms listed in Table, some of them, used by different authors, are apparently interchangeable. For example "accessory RA" and "Extra RA" designates supernumerary arteries which are not dominant. The authors use the terms "renal arteries" [6, 8, 9], "dominant renal artery" or " main renal artery" [1], that, despite being different, seem to designate the same type of structure: the more

calibrous branch which exits the aorta and enters the renal hilum.

Table 1: Methodologies used according to the references.

Type of Methodology	Articles
Autopsy	Daescu et al. (2012) [12], Hlaing et al. (2010) [7], Khamanarong et al. (2004) [8], Saldarriaga et al. (2008) [13], Sampaio and Passos (1992) [9], Weld et al. (2005) [3].
Imaging studies	Chai et al. (2008) [6], Guan et al. (2013) [14], Gumus et al. (2012) [15], Hazirolan et al. (2011) [2], Kawamoto et al. (2004) [16], Palmieri et al. (2011) [1], Perez et al. (2013) [4], Tombul et al. (2007) [17], Ugurel et al. (2010) [11], Yeh et al. (2004) [5].
Autopsy, imaging and surgery	Satyapal et al. (2001) [10].

Nevertheless, for the reasons already exposed, it is desirable that only one term would be chosen, accepted and used in a uniform manner by all. Furthermore, the denominations "dominant" or "main", when used in an isolated manner, do not make it clear the place of emergence and termination of such vessel, encompassing the idea that it was an important vessel and because of this are not complete in itself.

Still referring to the Table 2, the terms "multiple" or "accessory" [2, 5, 6, 11, 14, 15, 17], "extra" [15] and "supernumerary" [6, 7] seem all to be used to designate the existence of more than one artery irrigating the renal parenchyma, and for the same reason, are not specific enough to designate them morphologically.

For instance, an "accessory" renal artery may represent both an artery which originates in the aorta and leads directly to the superior kidney pole, and a double hilar artery (two arteries which emerge from the aorta and enter the hilum).

Table 2: Nomenclatures adopted to describe the variant renal arteries.

Article	Nomenclature
Chai et al. (2008) [6]	Main, accessory, supernumerary RA
Daescu et al. (2012) [12]	Main, extra-hilar, hilar, intra-sinusal RA
Guan et al. (2013) [14]	Dominant, multiple, accessory/hilar, polar/aberrant, superior polar accessory, inferior polar accessory RA
Gumus et al. (2012) [15]	Main, extra, superior polar extra, inferior polar extra, accessory RA
Hazirolan et al. (2011) [2]	Hilar, accessory, aberrant, polar RA
Hlaing et al. (2010) [7]	Accessory, superior accessory, inferior accessory, supernumerary, abnormal/aberrant, polar, multiple RA
Kawamoto et al. (2004) [16]	Main, accessory, polar RA, pre-hilar branch
Khamanarong et al. (2004) [8]	Main, hilar, superior polar, inferior polar RA
Palmieri et al. (2011) [1]	Main, multiple, superior polar, inferior polar RA
Perez et al. (2013) [4]	Main, pre-segmental branch, segmental branch, accessory, supernumerary, polar, extra-hilar, early ramification
Saldarriaga et al. (2008) [13]	Main, additional, hilar, superior polar, inferior polar RA
Sampaio and Passos (1992) [9]	Hilar, superior polar, inferior polar, superior extra-hilar polar branch, inferior extra-hilar polar branch, early bifurcation
Satyapal et al. (2001) [10]	Main, additional RA
Tombul et al. (2007) [17]	Main, accessory, multiple RA
Ugurel et al. (2010) [11]	Hilar, accessory RA.
Weld et al. (2005) [3]	Main, pre-segmental branch, segmental branch, accessory polar
Yeh et al. (2004) [5]	Dominant, accessory RA

Legend: RA = renal artery.

Table 3: Prevalence of the renal artery pattern.

Article	N	Side	Single RA (dominant/main)	Hilar RA	Multiple RA	Accessory RA	Extra RA	Polar RA		Total
								Superior Hilar	Inferior Hilar	
Chai et al. (2008) [6]	153 Kidneys (145L, 8R)	R	75% (6/8)	X	25% (2/8)	X	X	X	X	100%
		L	68.9% (100/145)	X	31.1% (45/145)	X	X	X	X	
		BI	X	X	X	X	X	X	X	
Ugurel et al. (2010) [11]	100 pat	R	58% (58/100)	X	X	18% (18/100)	X	X	X	100%
		L		X	X	17% (17/100)	X	X	X	
		BI	X	X	X	7% (7/100)	X	X	X	
Palmieri et al. (2011) [1]	200 pedic (100R, 100L)	R	X	X	56% (56/100)	X	X	X	X	100%
		L	X	X	67% (67/100)	X	X	X	X	
		BI	X	X	41% (82/200)	X	X	X	X	
Gümüş et al. (2012) [15]	820 pat	R	84% (684/820)	X	X	11% (90/820)	15.5% (127/820)	5.2% (43/820)		100%
		L	83% (681/820)	X	X	12.8% (105/820)	16.5% (134/820)	3.9% (32/820)		
		BI	X	X	X	X	4.6% (38/820)	X		
Khamanarong et al. (2004) [8]	534 kidneys	R	X	38.95% (208/534)	X	X	X	4.32% (23/534)	1.87% (10/534)	100%
		L	X	42.69% (228/534)	X	X	X	3% (16/534)	1.69% (9/534)	
		BI	X	X	X	X	X	X	X	

Legend: R = right; L = left; BI = bilateral; N = sample number; RA = renal artery; Pat = patients; Pedic = pedicles.

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For Sampaio and Passos (1992) [9], variant arteries, independently of their diameter, are generally indispensable to the kidney, once that they are segmental vessels destitute of sufficient anastomosis to impede ischemia of the parenchyma supplied by them in case of lesions. For this, in surgical practice, the differentiation of the origin and destiny of the variant vessel is fundamental for the tactic planning and for the choice of the technique to be used in particular patient.

Table 4: Prevalence and nomenclature of the renal artery pattern according to Sampaio and Passos (1992) [9].

Type	Prevalence
1 hilar RA	55.3%
2 hilar RA	7.9%
3 hilar RA	1.9%
1 Hilar RA + 1 superior extra-hilar polar branch	14.3%
1 hilar RA + 1 superior polar RA	6.8%
1 hilar RA + inferior polar RA	5.3%
Other variations	8.5%
Total	100%

N = 266 kidneys. Legend: RA = renal artery.

Satyapal et al. (2001) [10] proposed a unification of the nomenclature, however the authors did not denominate the arteries according to their place of emergence or with the place of the renal parenchyma in which it enters, generalizing all the variants under the label "additional arteries".

Analyzing the descriptors shown in Table 2, it can be observed that this is not an isolated deficiency of this author. From the analyzed articles, Guan et al. (2013) [14] uses the most conflicting nomenclature, for instance, in the case of a single renal artery, the author calls it dominant or principal. To denominate the variant of more than one renal artery, the author also uses the term "multiple", "hilar" and "polar", depending on the place to where the artery is destined, but, in some sentences they appear to be synonyms, as

they name the hilar artery "accessory" and the polar artery "aberrant". The author sometimes uses the term "accessory polar" artery, not making it clear in which situation a polar artery would be aberrant and when it would be accessory.

Hlaing et al. (2010) [7] uses the terms "supernumerary", "accessories" and "additional" as synonyms and, even though they also use the nomenclature of superior and inferior polar artery, the authors collectively calls them aberrant/abnormal, terms which, according to Sampaio and Passos (1992) [9] must be avoided, as these arteries are important vessels.

Sampaio and Passos (1992) [9], proposed a nomenclature which incorporates this precept, defining the vessel primarily by the region to which it is directed. Furthermore, the authors agree that among the revised nomenclatures, theirs was the most complete and specific.

The terms used by them were: (1) hilar artery – branch of the aorta which penetrates the kidney in the hilum and only in there or at the renal sinus offer per-segmental/segmental branches; (2) superior/inferior extra-hilar polar branch – branch originated from the hilar artery, before it enters the hilum and penetrates the renal parenchyma outside the hilum (at the superior or inferior pole); (3) superior polar artery – a branch of the aorta which penetrates the kidney at the superior pole; inferior polar artery – a branch of the aorta or the common iliac artery which penetrates the kidney by the inferior pole; (4) early bifurcation – renal artery where the main trunk has less than 1 cm of length, after the origin of the aorta, branching pre-segmental/segmental vessels.

The terms "dominant" and "accessory" may be adequately used, for instance, when there are more than one hilar artery (homonymous), in order to show which of them irrigates a larger portion of the kidney's parenchyma. The terms superior, inferior or middle should be used to determine the position of said branch. In cases where there is more than one hilar artery of similar caliber, they should be denominated "codominant" hilar arteries. A practical example of these aspects would be: double hilar artery, superior dominant and inferior accessory".

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For these reasons, there is a necessity of elaborating a new nomenclature in order to standardize the literature and to help the communication between anatomists and surgeons.

In order to be self-understood and sufficiently specific to discard additional explanations, each variant must carry in itself the origin (from the aorta, from the hilar artery, from the iliac artery) and destiny of the vessel (to the hilum or pole). If there are vessels from the same origin and destiny, the terms superior, middle or inferior should be added, as well as a reference to the biggest or smallest caliber ("dominant" or "accessory").

With individualized data in a table (Table 4), the nomenclature proposed by Sampaio and Passos (1992) [9] seems to be the best reference towards the construction of a consensus and as result, the new nomenclature proposed herein (listed below) preserves a good part of their main concepts, albeit with a few adjustments where it seems to be more deficient (e. g. when referring the origin of the variant vessels).

Single hilar artery: a branch of the aorta, which penetrates the kidney in the hilum region and, only in the hilum or renal sinus, offers pre-segmental branches. It is assumed that the origin is always from the aorta. When the origin is diverse, add a reference to the origin to the term, for example: "single hilar artery of common iliac artery origin".

Double or multiple hilar arteries: two or more branches which emerge from the aorta and penetrate the kidney in the hilum region. The caliber of these arteries will provide the term "dominant", while the smaller arteries should be labeled as "accessory". When designating its topography, for instance, one can use the following nomenclature: double hilar artery; superior dominant; inferior accessory. When caliber differences are not evident, they should be called codominant. If it is possible to identify a predominance of segmental branching of one or more of these arteries to the posterior or anterior surfaces of the kidney, even more specific terms may be applied, such as "superoposterior

accessory hilar artery". The aortic origin is implicit in all the cases. When different, should be referred, for example, as "superior accessory hilar artery of superior mesenteric artery origin".

Pre-segmental extra-hilar artery: branch of the hilar artery which emerges from this vessel before it enters the hilum and terminates. The same precepts are applied to the terms superior/inferior. When more than one is present for the same renal segment, designate them as a dominant and the others accessory. When a preferential distribution in the anteroposterior direction is evident, one should add after the terms superior/inferior, the terms anterior/posterior.

Extra-hilar polar branch: a branch which originates from the hilar artery, before it enters the hilum. This vessel penetrates the renal parenchyma outside the hilum (at the renal pole). The same precepts are applied to the terms superior/inferior. When more than one is present for the same segment, designate one as dominant and the others as accessory and, when possible, add anterior/posterior after the terms superior/inferior.

Polar artery: a branch of the aorta which penetrates the kidney by the pole. In this variant the terms superior/inferior applies, and, when able, one should include the terms dominant/accessory and anterior/posterior. It is assumed that the origin is always aortic, unless it is specified, for example: "superior polar artery of adrenal artery origin".

Hilar artery with early bifurcation: a single branch of the aorta with less than 1cm of length which offers pre-segmental or segmental branches, which in turn will penetrate the renal sinus.

Special attention must be given to the presence of artery originating from the superior/inferior mesenteric artery, common iliac artery or any other arteries besides the ones described in the article. In these rare cases, the first name designates the renal region which the artery will supply and the second name the origin of the

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vessel. For example, "superior/inferior polar artery of superior mesenteric artery origin" should be used. In cases where the artery goes to the renal hilum, one must be attentive to the caliber of the vessel and describe it as accessory or dominant (e. g. "dominant hilar artery of common iliac artery origin" and/or "superior/ inferior accessory hilar artery of superior mesenteric artery origin").

The right and left sides must always be added to the descriptors. Terms such as "aberrant", "multiple", "extra", "main" should be avoided, so as not to cause confusion with the others, even if some appear as clear synonyms of dominant or accessory.

CONCLUSION

The arterial supply of the kidneys is often subject to variation, as such, there is a need to a standardized and universally accepted nomenclature. Furthermore, those existent are in some degree inefficient, confusing, contradictory or incomplete, which leads to difficulty in surgical and purely anatomical communication.

The standardization of the nomenclature of the renal arteries anatomical variations here proposed seeks to be specific and self-explanatory in its terms, sufficiently succinct and pragmatic. As such it can be adopted in the everyday practice by professionals and researchers. It is based in the adaptation of an anterior classification proposed by Sampaio and Passos (1992), and its main characteristic consists in the designation of the vessel according to its origin/destiny.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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RESUMO

*Padronização da nomenclatura das variações anatômicas das artérias renais -
uma proposta conciliatória*

Introdução: Comumente, o rim é suprido por uma única artéria renal (AR). No entanto, existem variações anatômicas em mais de 40% da população. As nomenclaturas utilizadas na literatura para descrevê-las não são padronizadas. O objetivo desse trabalho foi comparar as nomenclaturas usadas por diferentes autores, marcar as concordâncias e discrepâncias, além de destacar e recomendar descritores para facilitar o entendimento e a comunicação sobre o assunto. **Material e Métodos:** Foram realizadas buscas de artigos publicados nas bases de dados CAPES, Bireme e Pubmed (foram incluídos artigos publicados desde 1992 até 2013) com os descritores "Rim", "Vasos", "Variações" e "Anatomia". Trabalhos originais que tinham amostra de pelo menos 50 rins foram incluídos. Artigos referentes somente às variações do parênquima ou do sistema de coleta foram excluídos. **Resultados:** 17 artigos foram selecionados no total. A nomenclatura da anatomia vascular renal apresenta vários termos como "Principal", "Múltiplo", "Acessório", "aberrante". Devido às diferenças entre as nomenclaturas, destacou-se uma dificuldade para agrupar e comparar os resultados dos diversos estudos de prevalência. Muitas nomenclaturas diferem entre si para nomear uma da mesma variante, outras são insuficientes para descrevê-las com clareza e especificidade e, por vezes, divergem mesmo dentro de um mesmo estudo. A partir de uma modificação da nomenclatura de Sampaio e Passos, propomos a utilização de uma nova nomenclatura padronizada universal e sistematizada. **Conclusão:** A principal característica da classificação proposta neste trabalho é a denominação do vaso renal de acordo com a sua origem e seu destino. Portanto, essa classificação é autossuficiente, sucinta e específica para uso cotidiano por profissionais e pesquisadores da área.

Palavras-chave: variação anatômica, nomenclatura, artéria renal, padronização