Topography of arterial and venous blood vessels in the kidneys of English Thoroughbred Horses

Topografia dos vasos sanguíneos arteriais e venosos nos rins de Cavalos Puro Sangue Inglês

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Abstract

In equines, kidney diseases are typically associated with respiratory and digestive problems, but surgical intervention is not common. The study of kidney blood vessels of domestic and wild animals are of fundamental importance for understanding many aspects of their physiology and nutrition. The current study used 30 pairs of kidneys from English Thoroughbred horses being 15 males and 15 females of different ages. The organs were donated by the Jockey Club of Sao Paulo. During the animal necropsies, the kidneys and their arteries and veins were removed together. The organs were fixed in formalin 10% for about 48 hours, for dissection and individualization of the components of the renal pedicle. After dissecting the material, the components of the renal pedicle were individualised. To analyse the results, the cranioventral, craniodorsal, caudoventral and caudodorsal quadrants were defined using two lines: craniocaudal and dorsoventral. Overall, the following results were obtained: in the hilar region, two arterial branches occurred in the right kidney in 50% of cases and two in the left kidney (33.3%); in the juxtahilar region, the number of arterial branches ranged from four to five in the right kidney in 20% of cases, whereas six occurred in the left kidney (16.7%); and regarding the extrahilar region, three branches occurred in the right kidney (26.7%) and three in the left kidney (20.0%).

Keywords: Equine. English Thoroughbred. Kidneys. Renal artery. Renal vein.

Resumo

As doenças renais em equinos, geralmente estão associadas a problemas respiratórios e digestórios, entretanto não são frequentes as intervenções cirúrgicas neste órgão para estes animais. O estudo dos vasos sanguíneos relativos aos rins nos animais domésticos e selvagens é de fundamental importância para o entendimento de diversos aspectos de sua fisiologia e nutrição. Neste trabalho, foram utilizados 30 pares de rins de equinos Puro Sangue Inglês, dos quais 15 machos e 15 fêmeas, de diferentes faixas etárias, provenientes de doação do Jockey Club de São Paulo. Durante a necropsia dos animais, os rins unidos por meio de suas artérias e veias renais foram retirados em bloco. Em seguida, foram fixados em solução de formol a 10%, por aproximadamente 48h, para a dissecação e individualização dos componentes dos pedículos renais. Para a análise dos resultados foram demarcados os quadrantes cranioventral, craniodorsal, caudoventral e caudodorsal, com duas linhas uma craniocaudal e a outra dorsoventral. Os resultados obtidos revelaram que: os ramos arteriais da região hilar são observados no rim direito em número de dois em 50%, no esquerdo em número de dois (33,3%), os ramos arteriais na região justahilar são computados no rim direito em número de quatro a cinco em 20% e no rim esquerdo em número de seis (16,7%), e nos ramos dispostos na região extrahilar são registrados no rim direito em número de três (26,7%) e no esquerdo em número de três (20%).

Palavras-chave: Equino. Puro Sangue Inglês. Rins. Artérias renais. Veias renais.

Introduction

The kidneys are vital organs in blood clearance during circulation and excretion of products resulting from the metabolism of food substances that must be eliminated in the form of urine. It is also noteworthy that in horses, kidney disease is typically associated

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with digestive and respiratory problems and may also be related to the nephrotoxicity of some medications administered at length (BAYLY; PARADIS; REED, 1980; DIVERS et al., 1987; 1992; CUNILLERAS; HINCHCLIFF, 1999; BAYLY, 2000).

Tabet et al. (2005) reported that renal biopsy is a technique used to identify the injury, evolution and severity of renal diseases but may cause complications, such as subcapsular and retroperitoneal hematomas, renal lacerations and bleeding in the renal arteries and veins. Although renal vascularization is important for illness and surgical and diagnostic procedures, available information regarding vascular patterns in equines is limited.

The thoroughbred horse has great economic importance and has attracted the attention of researchers who have developed studies to better understand this animal and promote improvements in its performance.

The objective of this study was to determine the number and location of arterial branches and venous roots because available studies only indicated the number of renal arterial branches (ELLENBERGER; BAUM, 1932; BRUNI; ZIMMERL, 1947; KOCH, 1963; 1965; SCHWARZE; SCHRODER, 1972; GETTY, 1986).

Material and Methods

Thirty pairs of kidneys from thoroughbred horses of different ages 15 male and 15 female were used. The organs were obtained in the Jockey Club of Sao Paulo, Brazil.

During the necropsies, the kidneys and their attached arteries and veins were joined and removed together. Subsequently, this material was fixed in 10% formaldehyde solution for at least 48 hours, and thereafter, the material was dissected to characterize the components of the renal pedicle (Figure 1).

For a better description of the results, the cranioventralis, craniodorsalis, caudoventralis and caudodorsalis quadrants were defined using two lines: one longitudinal line drawn from cranial of the kidney caudal pole representing the craniocaudalis diameter and another equivalent to the dorsoventralis diameter and perpendicular to the first one, intercepting it in the the ureter center. After defining these four quadrants, the hilar, juxtahilar and extrahilar regions were

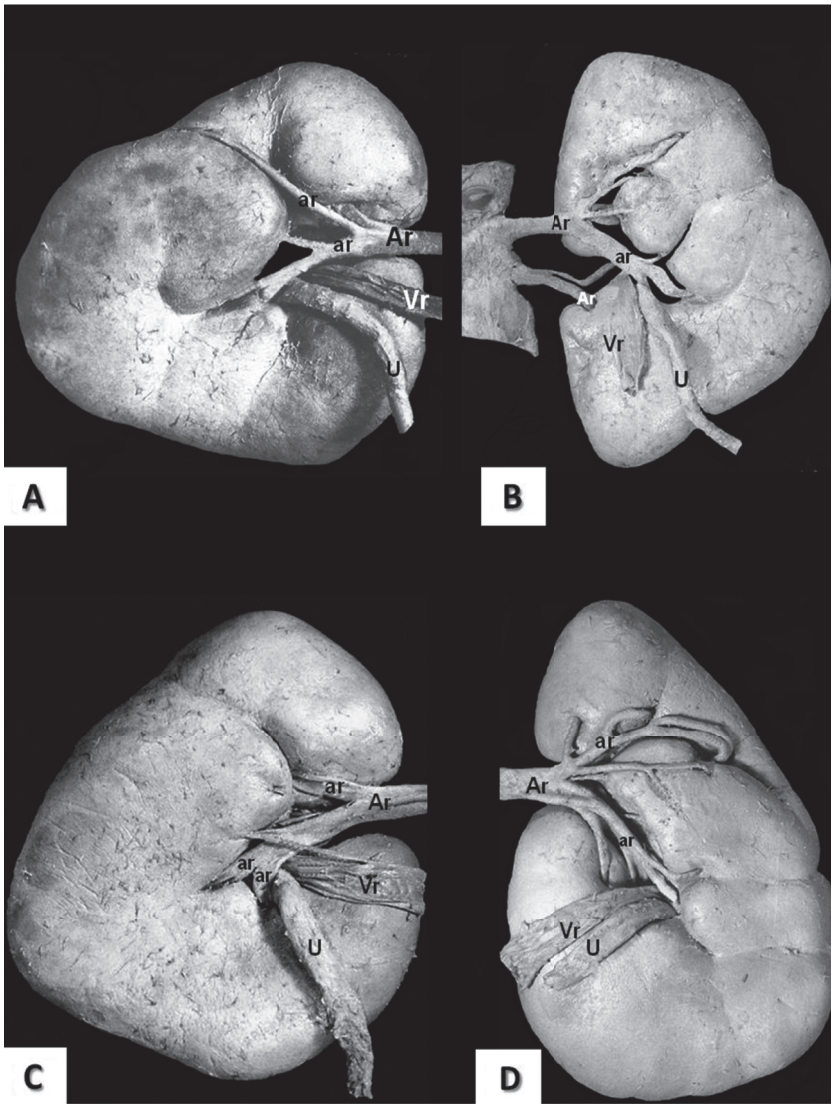

Figure 1 – (A-D) – Photography of the right kidney (A and C) and left (B and D), observed on the frontal side of English Thoroughbred horse. Observe the renal artery (Ar), the renal artery branches (ar); the renal vein (Vr) in relation to the ureter (U)
Source: (BARROS, 1980)

determined using four concentric circles, where the smallest circle represented the ureter. After delimiting the four territories, it was observed the number and locations of entrance and exit of vessels in the renal hilum (OLIVEIRA et al., 2011).

Finally, the number and the entrance and exit locations of the arterial branches and venous roots were recorded on schematic drawings representing the kidney pairs rotated 90° toward the midventral direction, thus accounting for not only the different quadrants but also the regions indicated in the quadrants (Figure 2).

The terminology adopted in this work is the one recommended by the Nomina Anatomica Veterinaria (2012).The results and sample description were photo documented.

Results

In the current investigation, the number and location of the arterial branches and venous roots of the renal arteries and veins were recorded. The vessels observed in the different quadrants of the hilar, juxtahilar and extrahilar regions were analyzed separately.

The number of arterial branches located in the hilar region of the right kidney were two (50.0%), three (26.70%), one (13.30%) and four (3.30%), whereas the left kidney contained two (33.30%), three (23.30%), one (20.0%) and four (10.0%).

The number of arterial branches observed in the right kidneys in the juxtahilar region were four (20.0%), five (20.0%), six (16.70%), seven (16.70%), two (10.0%), three (10.0%), one (3.30%) and nine (3.30%), whereas the left kidney contained six (16.70%), four (13.30%), five (13.30%), seven (13.30%), two (10.0%), three (10.0%), one (6.70%), 11 (6.70%), nine (3.30%) and ten (3.30%).

The number of arterial branches based in the right kidney in the extrahilar region were three (26.70%), two (16.70%), four (13.30%), five (10.0%), six (10.0%), 11 (6.70%), one(3.30%), seven (3.30%) and 25 (3.30%), whereas the left kidney it was observed three (20.0%), one (13.30%), two (10.0%), five (6.70%), six

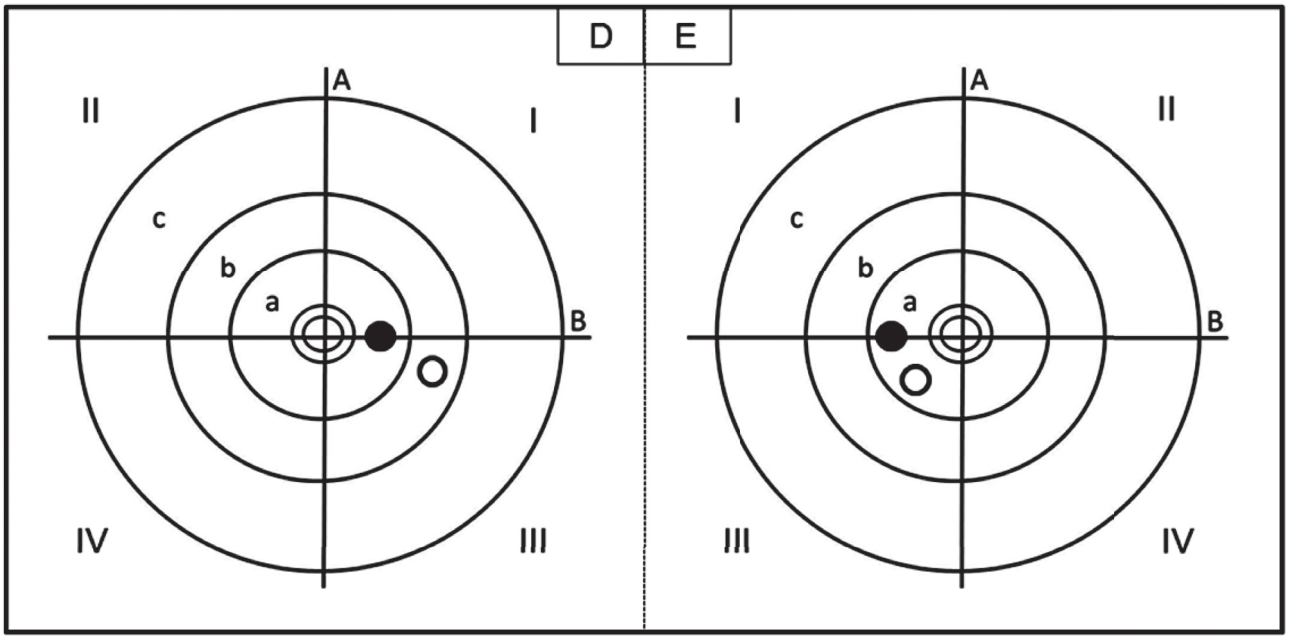

Figure 2 – A schematic representation of the arterial branches and venous branches roots in the hilar region (a), juxtahilar (b) and extrahilar (c), craniocaudalis line (A), dorsoventralis line (B), craniodorsalis quadrant I, cranioventralis quadrant II, caudodorsalis quadrant III, caudoventralis quadrant IV, ◎ ureter, ○ arterial branch, ● vein root in the right kidney (D) and left kidney (E)
Source: (BARROS, 1980)

(6.7%), seven (6.70%), nine (6.70%), 11 (6.70%), four (3.30%), eight (3.30%), ten (3.30%) and 19 (3.30%).

Many arterial branches in both right and left kidneys were located in the cranioventralis quadrant followed by the craniodorsalis, caudoventralis and caudodorsalis quadrants.

Regarding the different quadrants, the following results were observed: the arterial branches in the right and left kidneys were predominantly ventral in 27 cases (90.0%), lower numbers were observed in the ventral quadrants of both kidneys twice (6.70%), an identical distribution in the ventral and dorsal quadrants was only observed once (3.30%) in the right kidney, an exclusively ventral location was only observed once (3.30%) in the left kidney, a predominantly cranial location was observed in 28 animals (93.30%) in the right kidney and 27 cases (90.0%) in the left, an identical distribution in the cranial and caudal quadrants was observed once (3.30%) in the left kidney, greater numbers were observed in the caudal quadrants once (3.30%) and an exclusively cranial location was observed once (3.30%) in the right kidney and twice (6.70%) in the left.

In the hilar region, renal arterial branches with similar central and peripheral locations were observed seven cases (23.3%) in the right kidney and eight (26.70%) in the left, an exclusively peripheral location was observed nine times (30.0%) in the right kidney and five (16.70%) in the left, a predominantly central location was observed six times (20.0%) in the right kidney and four (13.30%) in the left, an exclusively central location was observed four times (13.30%) in the right kidney and fivefold (16.70%) in the left and greater numbers were located twice (6.70%) in the periphery of the right kidney and four times (13.30%) in the left.

In the extrahilar region, renal arterial branches were in a predominantly peripheral location eight times (26.70%) in the right kidney and 13 times (43.30%) in the left, exclusive peripheral locations were observed six times (20.0%) in the right kidney and five (16.70%) in the left, a greater number of branches located in the centre was observed five times (16.70%) in the right kidney and four (13.30%) in the left, an exclusively central location was observed four times (13.30%) in the right and left kidneys and an identical number located in the centre and periphery was observed five times (16.70%) in the right kidney and twice (6.70%) in the left.

The venous roots were located on the dorsoventralis line between the cranio and caudodorsalis quadrants 25 times (83.30%) in the right kidney and 26 times (86.70%) in the left, between the cranio and caudoventralis quadrants four times (13.30%) in the right kidney and once (3.30%) in the left, in the craniodorsalis quadrant once (3.30%) in the right kidney and four times (13.3%) in the left and in the cranioventralis quadrant once (3.30%) in the right kidney.

One venous root was observed in all animals (100.0%) in the hilar region of the right and left kidneys and always predominantly occupied the central position. Many venous roots were observed once (3.30%) in the juxtahilar region in the right and left kidneys. In the right and left kidney pairs, equivalent numbers of venous roots occurred frequently, 28 times (93.30%), which was only observed six times (20.0%) for arterial branches.

The arteries were equally distributed in both the right and left kidneys in the hilar region, observed eight times (26.70%), in which, a predominantly central location was observed three times (10.0%), identical numbers located in the periphery and centre were observed three times (10.0%), an exclusively peripheral location was observed once (3.30%) and an exclusively central location was observed once (3.30%). Regarding the extrahilar region, arteries were observed in seven cases (23.30%): a predominantly peripheral location was observed four times (13.30%), an exclusively peripheral location was observed once (3.30%), a predominantly central location was observed once (3.30%) and an exclusively central location was observed once (3.30%).

There was a statistically significant difference at the 5% level for gender, but only when the numbers of arterial branches in the right hilar region were compared.

A statistical comparison of the English Thoroughbred horse results obtained in the current study were performed with those reported for mongrel horses, Creole horses and mules regarding the number of arterial branches analyzed separately for males and females. There were significant regional differences at the 5% significance level: the hilar region of both the right and left kidneys in all cases, the juxtahilar region of both the right and left kidneys in all cases except the left kidney of female Creole horses and the extrahilar region in the left kidney of male mongrel horses and right kidney of male Creole horses.

Discussion

The origin of the renal arteries from the abdominal aorta in English Thoroughbred horse occurred as always unique in both antimeres. This pattern will occur in other animal species such as rat (GREENE, 1963), rabbit (BARONE, 1997; MOURA; SANTOS, 2006), and rats of the species *Rattus norvegicus* (FERNANDES et al., 1981) and for the golden hamster (VILARTA et al., 1982a), mouse (VILARTA et al., 1982b), capybara (SOUZA et al., 1996) and agouti (CARVALHO et al., 2008) and cavies (OLIVEIRA et al., 2011).

The pattern of renal arteries was also observed in domestic animals such as sheep (PEDUTI NETO, 1976), goats (ALBUQUERQUE, 1979), pigs (FAGUNDES; BORELLI; FERREIRA, 1988) and wild boar (CARVALHO et al., 2006), renal artery shows only the two antimeres. In relation to the findings in dogs by Maala and Coloma (1993) results are similar to results of English Thoroughbred horse where the left renal artery may be duplicated.

The number of renal arterial branches ranged from four to 24 with a high frequency of nine (30.0%) in the right kidney and 11 (36.70%) in the left kidney, differing significantly at the 5% level with respect to gender and only in the right hilar region. It must be emphasized that there are few comparisons for these results even with those available in the textbook of veterinary anatomy because these sources mainly present generic and incomplete information, as was previously mentioned.

Thus, specifically for equines, Bossi, Caradonnna and Spampani (1909) and Silva Neto and Peduti Neto (1996), mentioned the presence of two or three branches arising from the renal artery, which was never observed by our group for thoroughbred horses. Silva Neto and Peduti Neto (1996) indicated four to six arterial branches, whereas Schwärze and Schröder (1972) and Getty (1986) suggested five to eight and Bradley (1922) recorded six to eight. These results are partially consistent with our results for thoroughbred horses with four vessels only observed once (3.30%) in the left kidney, five vessels only once (3.30%) in the right and left kidneys, six vessels only once (3.30%) in the left kidney, seven arteries four times (13.30%) in the right and three frequency (10.0%) in the left and only once (3.30%) in the right and left. Lesbre (1923); Schmaltz (1928); Zimmerl (1949); Massui (1960); González Y Garcia and González Alvarez (1961); Dobberstein and Hoffmann (1963; 1964); Koch (1963; 1965) and Schummer and Nickel (1979) present more general data on the renal vessels, which do not compare with the results described in the current study.

According to Schwarze and Schroder (1972); Getty (1986) and Silva Neto and Peduti Neto (1996) the arterial branches penetrated only through the ventral surface of the kidney, whereas in our study, notably, the penetration of these vessels also occurred through the dorsal surface.

Lesbre (1923); Schwarze and Schroder (1972); Schummer and Nickel (1979) and Silva Neto and Peduti Neto (1996) indicated unique values for the renal veins, which was consistent with many of the thoroughbred kidneys examined in the current study, i.e., 28 times (93.30%) for both the right and left

kidneys. In the current study, two venous roots were observed only twice (6.70%), once in each kidney, which indicates that our results are not consistent with the data from Caradonna and Zimmerl (1930) who described the presence of four or five and five or six venous branches, respectively. Other results related to the number of venous roots provided by González Y Garcia and González Alvarez (1961) and Getty (1986) were not comparable with the current study because they are inaccurate.

Pereira (1974) observed the following results for renal arterial branches in the hilar region of mongrel horses: five (26.70%), four (23.30%), three (13.30%), nine (10.0%), ten (10.0%), six (6.70%), seven (6.70%) and eight (3.30%) vessels in the right kidney and five (40.0%), four (20.0%), three (16.70%), six (13.30%), seven (3.30%), nine (3.30%) and 11 (3.30%) vessels in the left kidney. The following results were observed in the juxtahilar region: two (36.60%), three (23.3%), one (13.3%), four (10.0%), five (6.70%) and six (6.70%) vessels in the right kidney and two (26.70%), four (26.70%), three (23.30%), one (13.30%), five (6.70%) and six (3.30%) vessels in the left, whereas in the extrahilar region, five (16.70%), two (13.30%), one (10.0%), three (10.0%), 13 (10.0%), four (6.70%), six (6.70%), eight (6.70%), nine (6.70%), seven (3.30%), 10 (3.30%), 12 (3.30%) and fifteen (3.30%) vessels in the right kidney and three (13.30%), five (13.30%), six (13.30%), seven (10.0%), one (6.70%), two (6.70%), four (6.70%), 10 (6.70%), eight (3.30%), nine (3.30%), 11 (3.30%), 12 (3.30%), 13 (3.30%), 14 (3.30%) and 18 (3.30%) vessels in the left kidney were observed. A comparison of these values with those observed in the current study from thoroughbred horses presents a significant difference at the 5% level for the number of arterial vessels observed in the hilar and juxtahilar regions of both the right and left kidneys, and in the extrahilar region, only in the left kidney for males. Independently considering the results obtained for males and females, the identical results were observed in donkeys (SOUZA; PEREIRA, 1987).

Albuquerque (1976) observed a significant difference at the 5% level in mules regarding gender for the number of arterial vessels observed in the right hilar region. This author observed the following results in this region: six (30.0%), three (20.0%), four (16.70%), five (13.30%), two (10.0%) and seven (10.0%) vessels in the right kidney and four (30.0%), five (30.0%), three (13.30%), six (10.0%), two (6.70%) and eight (3.30%) vessels in the left. In the juxtahilar region, one (30.0%), three (26.70%), four (10.0%), two (6.70%) and five (6.70%) vessels were observed in the right kidney, and two (26.70%), three (26.70%), one (23.30%), four (6.70%), five (6.70%) and seven (3.30%) vessels were observed in the left. In the extrahilar region, three (16.70%), five (16.70%), seven (16.70%), two (13.30%), six (13.30%), one (6.70%), four (6.70%) and eight (3.30%) vessels were observed in the right kidney, and four (20.0%), three (16.70%), five (16.70%), two (10.0%), seven (10.0%), one (6.70%), eight (6.70%) and 11 (3.30%) vessels were observed in the left. A statistical comparison of these results with those obtained in the current study in thoroughbred horses showed a significant difference at the 5% level for the number of arterial branches observed in the hilar and juxtahilar regions of both the right and left kidneys, considering the results obtained for males and females independently. This was not the case with the number of arterial branches of the Creole breed by Guarenti (1979).

Regarding the number of venous roots, Pereira (1974) simply considered a renal vein located dorsally to the ureter, whereas Albuquerque (1976) observed a venous root (100%) in the left kidney in the hilar region, one (6.70%) in the right and one (13.3%) in the left kidney in the juxtahilar region, one (3.30%) in the right and one (13.3%) in the left kidney in the extrahilar region and one (3.30%) in the right and one (3.30%) in the left kidney between the hilar and juxtahilar regions. Guarenti (1979) observed one venous root (93.30%) and two (6.70%) in the right kidney and one (86.70%) and two (13.30%) in the left

kidney in the hilar region and two (3.3%) in the right and one (16.70%) in the left kidney in the juxtahilar region. A statistical analysis showed no significant differences at the 5% level between these results from these authors and those obtained here with English Thoroughbred horses.

Regarding the location of the arterial branches, it must be emphasized that in mongrel horses, the vessels observed in the hilar region were often predominantly located in the periphery in both right and left kidneys, whereas in Creole horses, the arterial branches were exclusively located in the periphery in the right kidney and predominantly located in the periphery in the left kidney. This latter data partially agree with the results observed for English Thoroughbred horses, in which the arterial branches in the right kidney were exclusively located in the periphery, whereas the arterial branches in the left kidney were similarly located in the center and periphery. Regarding the extrahilar region in mongrel horses, the arterial branches were more often predominantly located in a central position in both the right and left kidneys, whereas in Creole horses, the vessels were predominantly located in the periphery in the right kidney and similarly located in the centre and periphery in the left kidney. This observation also demonstrated that the results for this region obtained from English Thoroughbred horses were only consistent with those described for the right kidney of Creole horses because in English Thoroughbred horses, the vessels in this region were more frequently located in the periphery of both kidneys.

Because the identification of the overall behavior of these vessels was not possible for mules, as clarified by Albuquerque (1976), any comparison with the data obtained herein could not be performed, which also occurred in relation to the vessels in the juxtahilar region, which is a transitional region. It is understandable that the different regions are difficult to characterise, as was performed by Pereira (1974) and Guarenti (1979) in mongrel horses and Creoles horses, respectively.

The location of the arterial branches in the quadrants was not emphasized by Pereira (1974); Albuquerque (1976); Guarenti (1979) and Souza and Pereira (1987). According to the studies performed by these authors, who considered the hilar, juxtahilar and extrahilar regions together, the dorsal quadrant was more populated and the cranioventralis quadrant was more populated in both the right and left kidneys, which coincided with the results obtained in the current study of English Thoroughbred horses. The caudodorsalis quadrant more frequently contained a smaller number of vessels in both mongrel and Creole horses, which was also observed in English Thoroughbreds. This observation did not occur in mules, in which the caudoventralis quadrant in most cases contained a smaller number of vessels.

The venous roots of mules and Creole horses were often arranged and located on the dorsoventralis line between the craniodorsalis and caudodorsalis quadrants, i.e., 29 times (96.70%) in the right kidney and 25 times (83.30%) in the left for mules and 25 times (83.30%) in the right kidney and 26 times (86.70%) in the left for Creole horses. These results were close to those obtained in the current study with the English Thoroughbred horse, which indicated this arrangement 25 times (83.30%) in the right kidney and 26 times (86.70%) in the left.

For the number of arterial branches, it is notable that the identical incidence in both the right and left kidneys was observed in six cases (20.0%) in mongrel horses, four times (13.3%) in mules and eight times (26.7%) in Creole horses and for venous roots 25 times (83.3%) in mules and 21 times (70.0%) in Creole horses. These observations were similar to those observed for English Thoroughbred horses, in which matching kidneys with an identical number of arterial branches occurred in six cases (20.0%), and the identical number of venous roots occurred 28 times (93.3%).

Finally, it must be emphasized that in the present investigation it was not identified the vessels of intermediate position for either arterial branches or venous roots, as was described by Albuquerque (1976) for mules. Although the origin of these elements was not the purpose of this investigation, we recorded double renal arteries in three cases (10%) only in the left kidney, which was not considered by other authors, most likely because they only investigated the number and arrangement of these vessels, facts observed in cavies (OLIVEIRA et al., 2011).

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