Radiologic anatomy

Origin and initial course of the renal arteries a radiological study

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Abstract

The aim of this study was to determine the topography of the origin, implantation angle and initial course of the renal arteries in the transverse and frontal planes, from a prospective analysis of angiograms and helical CT-scans of 40 patients. In the frontal plane, the implantation angles of the right and left renal arteries were 73.8 ± 17˚ and 65.6 ± 16˚ respectively 17.9% of the right renal arteries were straight compared with only 5% of the left ones. The first sinuosity was observed to be at a distance greater than the aortic diameter for 43.6% of right renal arteries and at a distance less than the aortic diameter for 62.5% for the left renal a. In the transverse plane, the right renal a. had an implantation angle of 65.6 ± 15.7˚ compared with 95.7 ± 16.85% for the left renal a. The artery was rectilinear in 2.6% of the cases on the right side, and in 2.5% of the cases on the left. The first sinuosity occurred before the lateral margin of the spine was reached in 60.5% of right renal arteries and after the margin of psoas major muscle for 55% of left renal arteries. A knowledge of the anatomy of the origin and initial course of the renal arteries is important when considering vessel dilatation and the implantation of stents in the renal arteries. No correlation was observed between the origin, sinuosity or angulation of the renal arteries which could aid interventional procedures.

The aim of this study was to describe the topography of the origin and initial course of the renal aa. in the frontal and transverse planes to aid selective percutaneous endovascular catheterization, such catheterization being the starting point of balloon angioplasty, either with or without a stent, currently considered to be the initial treatment for renal a. stenosis.

Patients and methods

Forty patients (33 men, 7 women) aged 68 ± 8.8 years (range 37 to 84 years) were prospectively included in the study. All patients had some form of vascular pathology abdominal aortic aneurysm, high arterial blood pressure, a limp of the lower limb. To explore the renal aa., a CT-scan and an angiogram were acquired during the subsequent check-up the delay between the two explorations was between 2 and 10 days (mean 5.15 standard deviation SD 2.25). No scoliotic deformation was noted in any patient.

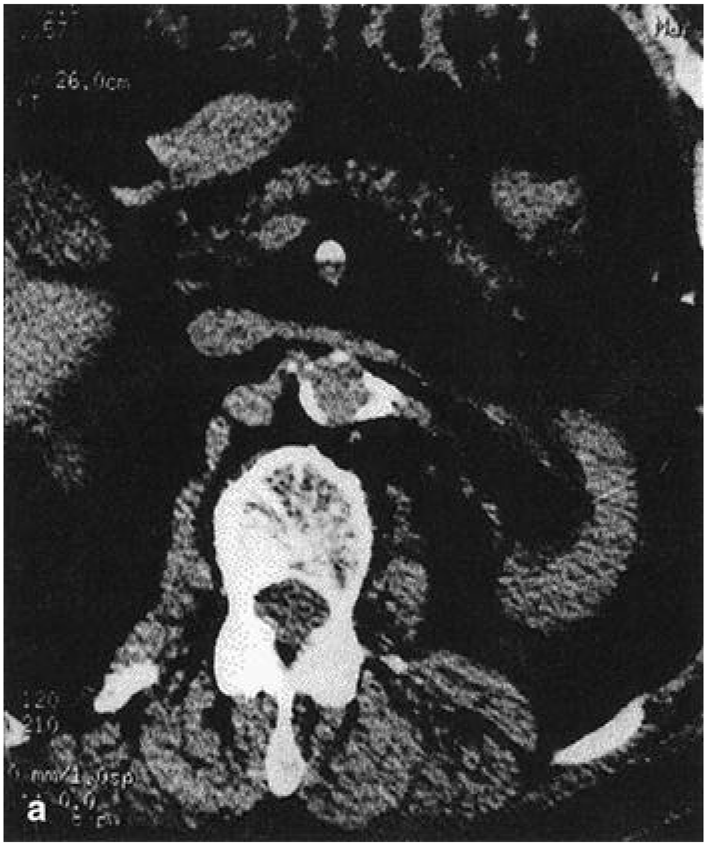
CT-scans were obtained using a HiSpeed Advantage scanner (General Electric, Milwaukee, USA), with a helical acquisition, using a 3 mm collimation, a 1/1 pitch and a "soft" reconstruction algorithm. Data acquisition was performed with and without intravenous injection of a bolus of contrast medium 150 ml iodine-containing contrast medium of low osmolality with a volume flow of 3 ml per second. The reconstructions were performed in 3/3 mm.

Global angiograms were obtained following femoral catheterization using the Seldinger technique injection of 30 ml of a low osmolality contrast medium at the level of the suprarenal aorta with a flow of 20 ml per second, using a 5F calibre "pig tail" catheter. Data acquisition was performed by numerical subtraction using a GE-CGR DG 300.

During each examination the patient laid supine such that the pedicles of the vertebrae were projected at the same distance from the spinous processes.

Only the main renal aa. were evaluated, any accessory polar aa. were not considered in the analysis. Thus the variability of the blood supply to the kidneys was not investigated.

From the CT-scans the angle of origin of each renal a. in the transverse plane was determined with respect to the median sagittal plane, which was defined as a line passing between the apex of the spinous process and the anterior junction of the two laminae (Fig. 1). A line perpendicular to the median sagittal plane was drawn at the greatest diameter of the aorta. At the level of the ostium of the renal a., a line from its centre to the middle of the aorta was drawn the angle made by this line with the sagittal plane measured from 0˚ (anterior) to 180˚ (posterior).



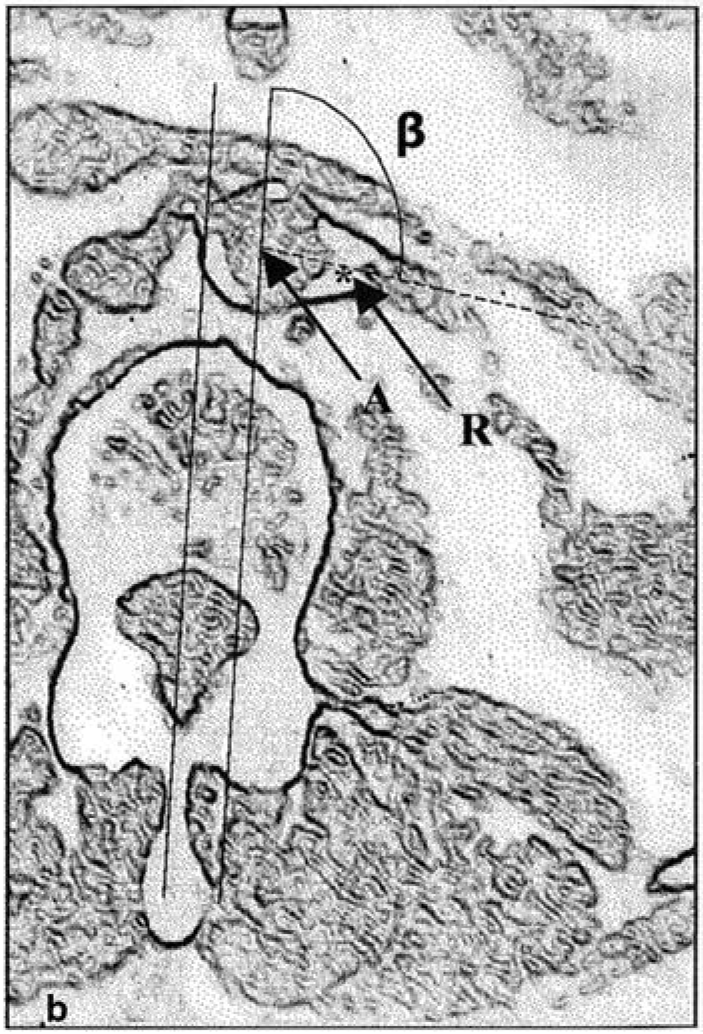


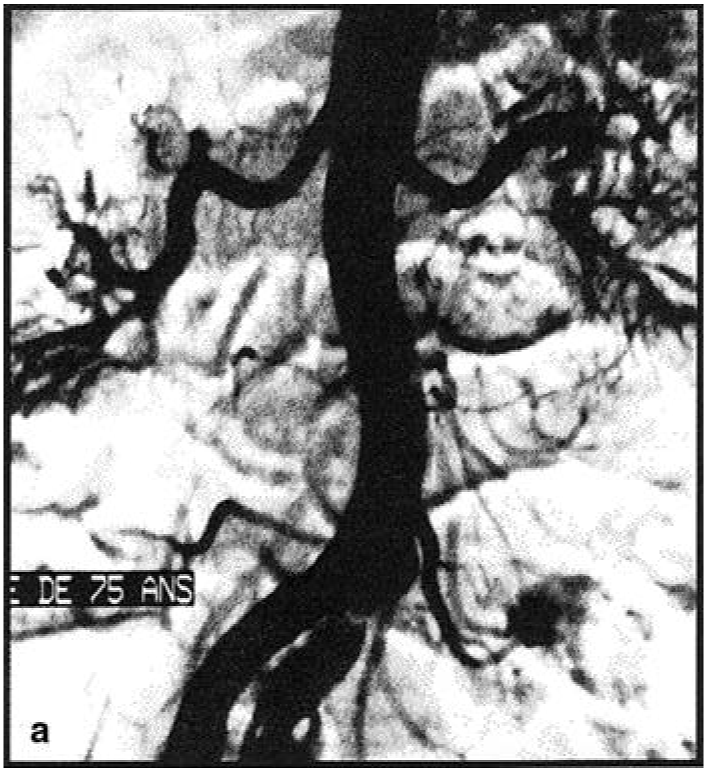
Fig. 1 Transverse CT section at the level of the origin of the renal aa. Left side, normal windowing right side, edge enhancement. The sagittal plane is represented by a line passing through the apex of the spinous process and anterior junction of the laminae. *R* is the centre of the renal a. and *A* the centre of the abdominal aorta. The angle ß between the sagittal plane and line A -R is 0˚ anteriorly and 180˚ posteriorly

In addition, from the CT-scans, the course of the renal a. was classed as being one of two types rectilinear or sinuous. Of the latter three sub-groups could be identified on the right side (x, y and z), and two on the left side (x and y), depending on the topography of the first sinuosity (Table 1) with regard to the spine and the ipsilateral psoas major m.

	Right	Left
x	before the right lateral margin of the vertebra	before the lateral margin of the left ps major m.
y	between the right lateral margin of the vertebra and the lateral margin of the right psoas major m.	after the lateral margin of the left psoa major m.
z	after the lateral margin of the right psoas major m.	

Table 1. The sinuous renal a. subgroups determined from CT-scans

From the angiograms (Fig. 2) the implantation angle of each renal a. was determined as previously described [5], using the following radiological landmarks 1) the aortic axis a line joining the midpoints of the aortic margins at the levels of the celiac trunk and the renal aa. 2) the renal a. axis a line joining the centre of the ostium and the midpoint between the renal a. margins before any change of course. The implantation angle of each renal a. was taken as the angle between the aortic and renal a. axes. The course of the renal aa. was also described as being one of two types rectilinear or sinuous. Of the latter two sub-groups could be identified group A, in which the first sinuosity appeared after a distance greater than the aortic diameter, and group B, in which the first sinuosity occurred within a distance less than the diameter of the aorta.



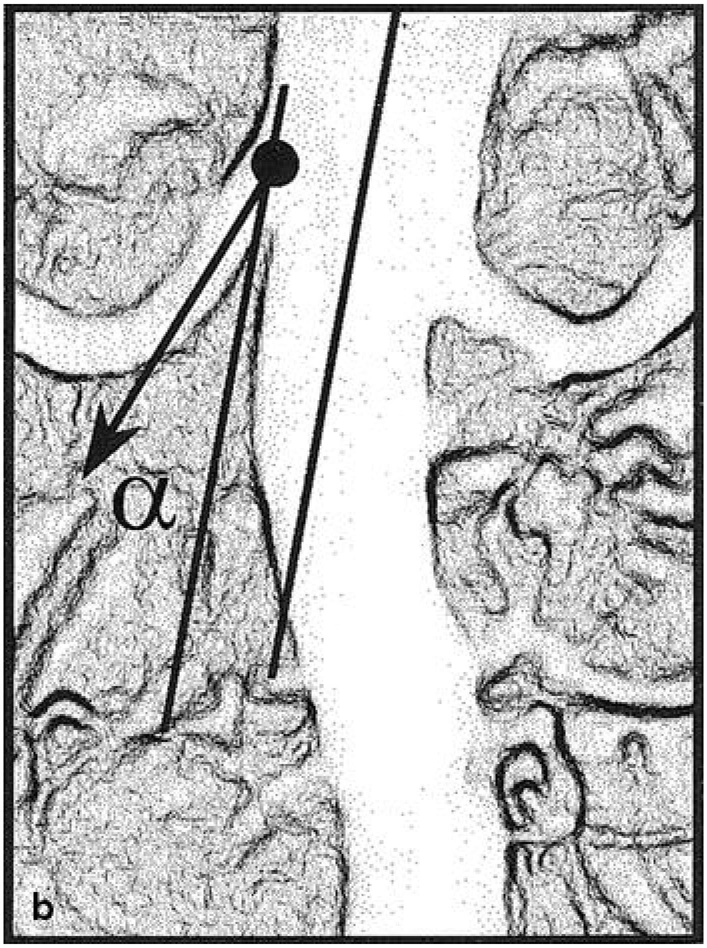


Fig. 2 Measurement of implantation angle of the renal a. angle in the frontal plane from angiograms. Left side, native image right side, the same image with edge enhancement. The aortic axis is a line passing along the aorta equidistant from the aortic margins the renal a. axis is a line passing from the centre of the ostium to the midpoint of the renal a. before it becomes sinuous alpha is the angle of implantation in the frontal plane

From the angiograms the topography of the renal aa. fell into one of three groups 1) both arteries were at the same level 2) the right renal a. arose more proximally than the left one 3) the right renal a. arose more distally than the left.

The implantation angle measured from the angiograms in the frontal plane corresponded to a projected angle, the value of which depended on the orientation of the renal a. in the horizontal plane. For each patient the measurements obtained from the angiogram were corrected by the corresponding values taken from the CT. The formula that gave the value of the real angle theta (i.e. the angle between the aortic and renal a. axes in the plane going through the two vessels) was

tan alpha

tan theta ***CARACTERE-NON-TRANSCODE***=

cos ß

where alpha is the angle measured in the frontal plane and ß is the orientation of the renal a. in the horizontal plane.

Student's t-test was used to compare the data obtained from the CT-scans and the angiograms, the threshold for significance being 5%. Comparison of the data with respect to the sinuosity of the right and left renal aa. in the frontal and transverse planes was performed using analysis of variance (ANOVA).

Results

The mean implantation angles of the renal aa. are presented in Table 2 for both the transverse and frontal planes, while figures 3 and 4 show the calculated and measured implantation angles in the frontal plane for the right and left renal aa. respectively. The right and left implantation angles in the transverse plane are shown in figure 5. The mean angle between the two renal aa. in the horizontal plane was 158.03 ± 25.71˚ (range 79 -211˚).

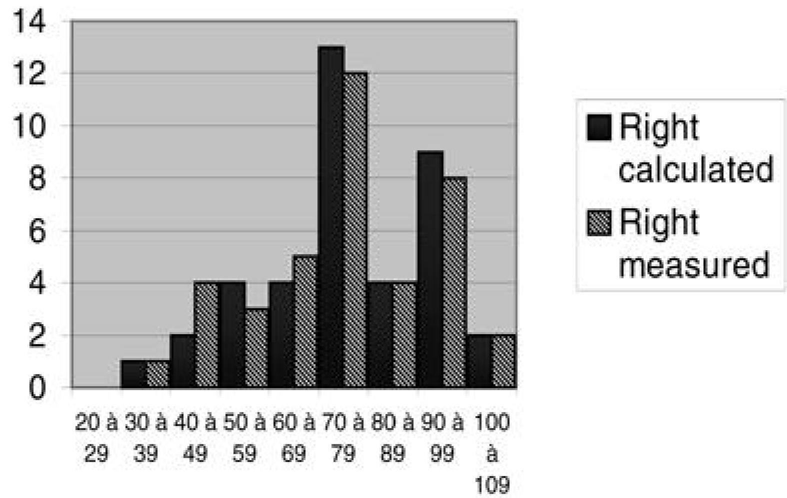


Fig. 3 The implantation angles of the right renal a. in the frontal plane

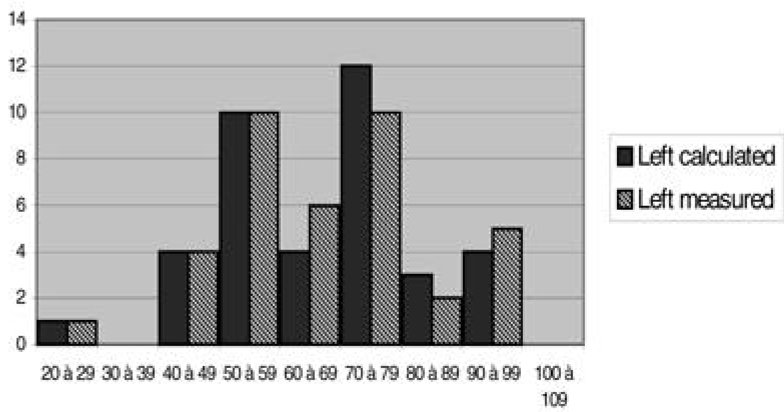


Fig. 4 The implantation angles of the left renal a. in the frontal plane

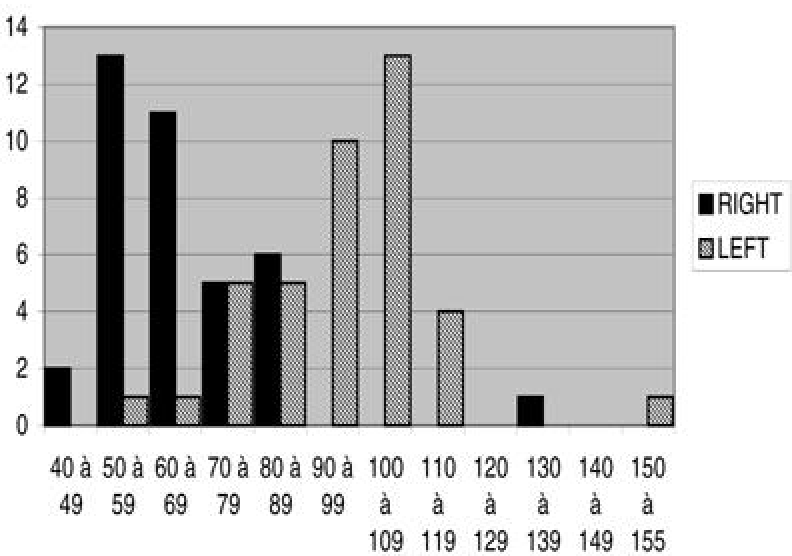


Fig. 5 Implantation angle of the right and left renal aa. in the transverse plane

Implantation angle	Right	Left
Transverse plane	N = 38 65.63 ± 15.68 (44-134)	N = 40 95.68 ± 16.85 (59-155)
Frontal plane (measured)	N = 39 73.79 ± 16.96 (37-110)	N = 40 65.34 ± 16.04 (39.3-105)
Frontal plane (calculated)	N = 38 75.86 ± 15.36 (28-95)	N = 40 66.06 ± 15.51 (28.7-94)

Table 2. Mean implantation angle (˚) of the right and left renal aa. in the transverse and frontal planes

The height of renal a. implantation on the aorta could only be determined in 38 cases. Of these 18 right renal aa. (47.4%) were more proximal than the left ones, 17 (44.7%) were at the same level as the left ones, and the remaining 3 (7.8%) were more distal than the left ones.

Details of the sinuosity of both renal aa. are presented in Table 3 . For the right renal a. sinuosity classification could only be made in 39 cases, while in the axial plane it could only be classified in 38 cases.

	Frontal plane			Transverse plane			
	Rectilinear n (%)	A n (%)	B n (%)	Rectilinear n (%)	x n (%)	y n (%)	z n
Right	7 (17.94)	17 (43.58)	15 (38.46)	1 (2.63)	23 (60.52)	13 (34.21)	1 (2
Left	2 (5)	13 (32.5)	25 (62.5)	1 (2.5)	17 (42.5)	22 (55)	

Table 3. Position of the first sinuosity of the right and left renal aa. in the frontal and transverse planes

Discussion

This anatomic radiological study has enabled the orientation of the renal aa. with respect to the long axis of the aorta to be determined in both the frontal and transverse planes, as well as their initial course. The results presented differ from those of previous investigators, who were generally more interested in analysing the number of renal aa. rather than their angles of origin [6, 7, 9]. The limited number of patients investigated in the current study is due to it being prospective, as well as the need for as short a delay as possible between the two types of examinations (angiography and CT-scan) to facilitate comparison of the data.

In the frontal plane the present study showed that the mean angle made by the right renal a. with the aorta was 73˚, whereas the values reported in previous anatomic studies [3, 14] were 60˚. For the left renal a. the mean angle was 65˚ in this series compared with 70˚ in other studies [3, 14]. Early anatomical studies [1, 10, 16, 18] gave an initial horizontal orientation of the renal aa. without giving angular values, however in a radio-anatomic study, Guntz [8] stated that 24% of the arteries were ascendant, 42% horizontal and 34% descendent. The high proportion of ascendant arteries was more prevalent for the left renal a.

These somewhat contradictory findings can be explained in two ways. Firstly, in angiograms the pictures are theoretically acquired when a deep inspiration is taken. Secondly, because of the oblique entry of the renal a. into the aorta, the measurements taken in the frontal plane may be false as the renal a. is hidden by the contrast medium in the aorta. This superimposition is not taken into account when determining the axis of the artery, an important point since the renal aa. can rapidly become sinuous. In the present study such superposition of vessels was systematically looked for and, by rapid data acquisition, each renal a. was visualised if necessary, the numerical subtraction was varied. It is not clear whether superimposition of vessels was taken into account in earlier studies since in many cases the methodology was not clear.

The relationship between renal a. angulation with the aorta and the course of the renal a. was studied by Verschuyl [19], who found that the initial course of the renal aa. was rectilinear in only 20% of right renal aa. and 5% on left. The present study showed that the first sinuosity of the right renal a. was at a variable distance from its ostium, however it was very close to the ostium (less than the aortic diameter) in 62.5% of left renal aa. In the frontal plane no significant difference was observed in the frequency of right and left sinuosities.

The relative topography of the origins of the renal aa. from the aorta was found to be variable, thus confirming earlier observations from angiographic studies in which the right renal a. arose more proximally in 65% of cases [2, 4, 11, 12, 15, 17]. This data contradicts the classical works of Paturet [14], Poirier [16] and Johnston [10], in which the left renal a. is said to arise more proximally than the right. Nevertheless, the difference in the level of origin varied by only a few millimetres from the data obtained from anatomical dissection, which is in general undertaken on the elderly in whom the abdominal aorta is probably more sinuous therefore making the relative location of the renal aa. less easy to determine. A recent anatomical study [12], using the superior mesenteric a. (SMA) ostium as a landmark, has shown that the origin of the right renal a. was closer to the SMA than the left one in 53.3% of cases and at the same level in 10%. This confirms the role of this landmark in determining the reliability of the ostia of the renal aa. on the aorta.

When viewed in the transverse plane, in 95% of cases the right renal a. arose from the aorta ventrolaterally (45˚-90˚) thus confirming other recent observations [2, 19, 20]. However, this is in contrast to the classical anatomical studies [1, 3, 13, 18], which state that the renal aa. have a dorsolateral origin. In 97% of cases in the present study, the origin of the left renal a. was lateral or dorsolateral (45˚-135˚). The angles measured in our series are similar to those reported in the literature [2]. Without quantifying this angulation, Ozan [12] have shown a lateral or anterolateral origin of the renal aa. in 30 cadavers. The difference between these results of on anatomical study and those of the radio-anatomical analyses is probably due to an analysis of the ostia on isolated aortae, without taking into account their real position in the retroperitoneal region.0

In the horizontal plane the angle between the right and left renal aa. measured on average 158˚, being similar to the value of 161˚ reported by Verschuyl [19]. As the number of cases in the current series was small, no comparison between the sexes has been undertaken however, the angle between the two renal aa. has been reported to be closer to 180˚ in females [19]. Because the small number of our series, we did not compare the measures between genders the angle between both renal aa. has been reported as more often near 180˚ in females than in males [19] it allows the simultaneous study of both renal aa. if an opacification in an oblique plane allows the location of both ostia.

Only 3% of the arteries in the current series were rectilinear in the horizontal plane. For the right renal a. the first sinuosity appeared before the opposite lateral margin of the lumbar vertebra this may be associated with its ventrolateral origin from the aorta. The difference in the distribution of the left and right sinuosities was not statistically significant. There appear to be no studies which have systematically analyzed the sinuosity of the renal aa.

The association of the sinuous course of the renal aa. in the transverse and frontal planes, principally on the left side, may be an important feature in the interpretation of the results presented in this study, especially in the calculation of the real implantation angle. The calculation did not take into account a possible proximal sinuosity hidden by the contrast medium in the aorta. However, this may be an insignificant factor since the arterial segment that may be hidden will be short.

The statistical analysis used did not show a correlation between the level of origin of the renal aa., their sinuosity in the transverse or frontal planes and their implantation angles. An angiogram or a CT-scan is not sufficient by itself to enable a full evaluation of the morphological variations of the renal aa.

Conclusion

The data presented in the current study confirm that the angles of origin of the renal aa. are variable in the frontal, as well as in the horizontal plane. CT-scans and angiograms separately provide insufficient data concerning the orientation of the renal aa., therefore before inserting a percutaneous endoluminal catheter both investigations should be undertaken and used to aid catheter insertion. Angiography, which enables visualization of the vessel lumen (luminography), is always undertaken as it is the initial step of the endoluminal procedure. A preliminary CT-scan, although it does not provide good lumen visualization, reveals the iliac, aortic and renal vessel walls and, as such, potentially dangerous emboli, atheromatous plaques and calcifications. These latter features are important factors that need to be taken into account in endoprosthesis implantation, as well as in vessel dilatation with a balloon, especially when there is ostial stenosis of the renal a.

References

1. Adachi (1928) Das Arteriensystem der Japaner. vol 2, Maruzen, Kyoto, pp 74-87

2. Beregi JP, Mauroy B, Willoteaux S, Mounier-Vehier C, Remy-Jardin M, Francke JP (1998) Anatomic variation in the origin of the main renal arteries spiral CTA evaluation. Eur Radiol 9 1330-1334

3. Bouchet A, Cuilleret J (1991) Anatomie topographique, morphologique et fonctionnelle. Vol. IV, Abdomen, Rétropéritoine, Petit bassin et périnée. SIMEP, Villeurbanne, pp 2139-2141

4. Calas F, Martin R, Convert A (1963) Contribution à l'étude de la vascularisation du rein. C R Assoc Anat 117 408-421

5. Cormier JJ, Hernandez C, Kieny R, Natali J (1966) Aortographie abdominale (tronc et collatérales) Masson, Paris, pp 67-83

6. Dachman AH, Newmark, Mitchell MT, Woodle ES (1998) Helical CT examinations of potential kidney donors. Am J Roentgenol 171 193-200

7. Garcier JM, Macheda B, Therre T, Privat C, Perez N, Ravel A, Viallet JF, Vanneuville G, Boyer L (1999) Etude radio-anatomique de l'angle d'origine des artères rénales dysplasiques. J Radiol 80 927-931

8. Guntz M (1967) Radio-anatomie de l'artère rénale déductions chirurgicales. CR Assoc Anat 138 623-631

9. Johnston PT, Helper EJ, Cushy BS et al. (1999) Renal artery stenosis CT angiography - comparison of real time volume rendering and maximum intensity projection algorithms. Radiology 211 337-343

10. Johnston TB, Whillis J (1947) Gray's anatomy descriptive and applied. Longman Green and Co, London, p 785

11. Mercier R, Vanneuville G (1968) Anatomie radiologique de l'aorte abdominale et de ses branches collatérales et terminales. Expansion scientifique française, Paris, pp 49-65

12. Ozan H, Alemdaroglu A, Sinav A, Gumusalan Y (1997) Location of the ostia of the renal arteries in the aorta. Surg Radiol Anat 19 245-247

13. Patra P, Moussu M, Chaillou P, Noel SF (1993) Anatomie des artères rénales. In Kieffer E Chirurgie des artères rénales. Edition AERCV, Paris, pp 3-19

14. Paturet G (1958) Traité d'anatomie humaine tome III, appareil circulatoire. Masson, Paris, pp 511-527

15. Pinet A, Lyonnet D (1980) Artériographie rénale. In Traité de radiodiagnostic. Masson, Paris

16. Poirier P, Charpy A (1896) Traité d'anatomie humaine. Masson, Paris, pp 775-777

17. Sampaio FJ, Passos MA (1992) Renal arteries anatomic study for surgical and radiological practice. Surg Radiol Anat 14 3-117

18. Sappey Ph C (1869) Traité d'anatomie descriptive Tome II - myologie, angiologie. A. Delahaye, Paris

19. Verschuyl EJ, Kaatee R, Beek F et al. (1997) Renal artery origin location and distribution in the transverse plane at CT. Radiology 203 71-75

20. Verschuyl EJ, Kaatee R, Beek F et al. (1997) Renal artery origin best angiographic projection angles. Radiology 205 115-

Surg Radiol Anat 22: 51-55