

Dolicho-arteriopathies (Kinking, Coiling, and Tortuosity) of the Carotid Arteries: A Study by Magnetic Resonance Angiography

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ABSTRACT

Aims and objectives: The aims and objectives of the present study were to document the dolicho-arteriopathies (DAs) of the common carotid artery (CCA) and internal carotid artery (ICA) and to estimate the external diameter of the segments of the ICA and CCA.

Materials and methods: Patients were divided into three groups according to contrast-enhanced magnetic resonance angiography (CEMRA) appearance of the CA: group I, normal; group II, the CCA with CA; and group III, the ICA with CA. The external diameters of CCA and ICA with or without DA were measured at the tree different parts, and mean diameters value were calculated.

Results: The most common DAs were tortuosity (75.5%), followed by kinking (17.1%) and coiling (7.4%). Dolicho-arteriopathies were found in 134 (40.3%) subjects, 89 (66.4%) in females and 45 (33.6%) in males older than 60 years ($p < 0.001$). Total 64 (47.8%) subjects presented CCA with DA. Total 33 (24.6%) presented the monolateral DA of CCA. Total 31 (23%) subjects presented the bilateral DA of the CCA. Total 70 (52.2%) subjects presented the ICA with DA. Total 29 (21.6%) presented the monolateral DA of ICA. Total 41 (30.5%) subjects presented the bilateral DA of ICA. The external diameters of CAA and ICA with DA were larger than without DA ($p < 0.005$).

Conclusion: Monolateral and bilateral DA of the CA have been frequently observed in females and over the age of 60 years. The external diameters of the CAA and ICA with DA were larger than without DA.

Keywords: Carotid artery, Coiling, Kinking, Tortuosity.

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INTRODUCTION

Dolicho-arteriopathies (DAs) (kinking, coiling, tortuosity) of the carotid arteries (CAs) have been a matter of debate because of up to date the natural history of such anomalies is not well known; furthermore, some authors consider these conditions due to a benign angiopathy,¹ while others suppose that they are burdened with disabling, even fatal neurological complications.²

Abnormalities in course and geometry of the internal carotid artery (ICA) are commonly identified in ultrasound³⁻⁵ and contrast-enhanced magnetic resonance angiography (CEMRA),⁶ and their classification as tortuosity, kinking, and coiling was first introduced in 1965 by Weibel and Fields.⁷ The clinical significance of the DA of the CA, their prognosis, and etiopathogenesis have not yet been clearly defined.^{8,9}

Clinical studies have shown that ICA tortuosity may lead to symptoms including dizziness, vertigo, syncopes, blackout, or persistent tinnitus (ringing in the ears).¹⁰ Severe tortuosity may lead to arterial kinking (acute angulation), which causes artery occlusion and is associated with severe symptoms including transient ischemic attack, stroke,^{3,11} hemiplegia, and other cerebrovascular deficiencies.^{5,12,13}

MATERIALS AND METHODS

The CEMRAs of 332 consecutive patients with no connective tissue disorders referred to the outpatient clinic were evaluated retrospectively. Abnormalities in direction and course of the ICA and common carotid artery (CCA) were classified according to the criteria of Weibel-Fields and Metz modified by the authors (29). Patients were divided into three groups according to CEMRA

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appearance: group I, normal; group II, the CCA with DA; and group III, the ICA with DA (Figs 1 to 4).

Bilateral and monolateral DAs of the CCA and ICA were investigated to compare each other according to age, right and left side, and diameter. The diameters of CAs with or without DA were measured at the tree different parts, and mean diameter values were calculated.

We used the Chi-square test. Differences were considered statistically significant at a p value of less than 0.05.

RESULTS

Of the 332 subjects examined, 198 (59.6%) presented normal CEMRA: 109 males (55%) and 89 females (45%) with a male/female ratio of 1:0.81. The right external diameters of both the CCA and ICA were found larger than the left side for male ($p < 0.05$), the left external diameters of both the CCA and ICA were found larger than the right side for female ($p < 0.05$), and the mean age was 56.6 years (Table 1).

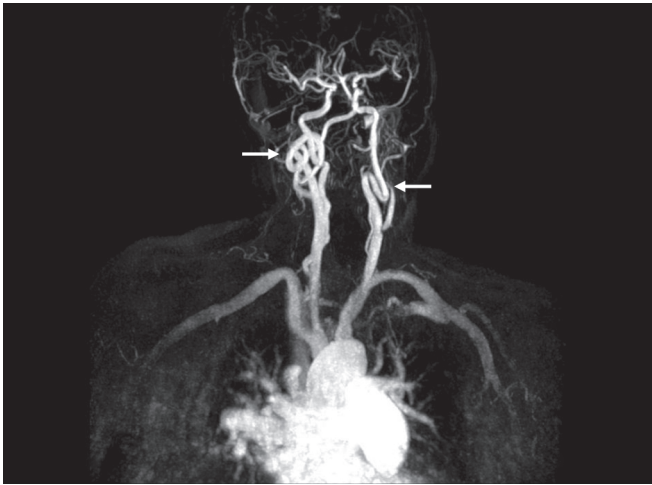


Fig. 1: Contrast-enhanced magnetic resonance angiography showing coiling of the right ICA and kinking of the left Q4 internal carotid artery (white arrows)

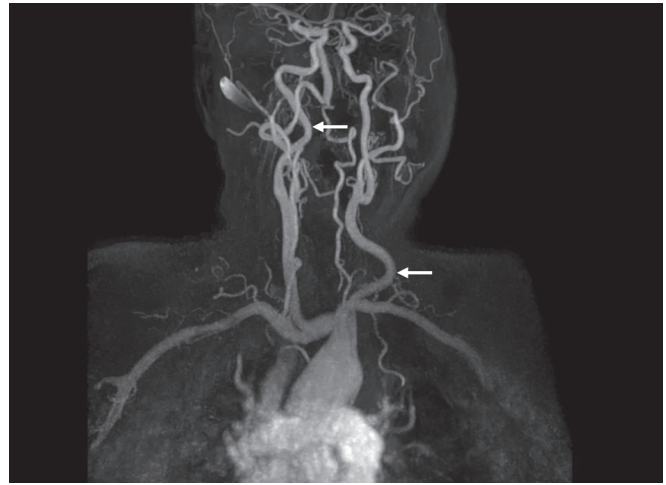


Fig. 2: Contrast-enhanced magnetic resonance angiography showing left common carotid artery "C" shaped elongation (white arrow) and "S" shaped elongation of internal carotid artery (white arrows)



Fig. 3: Contrast-enhanced magnetic resonance angiography showing left common carotid artery (CCA) "C" shaped elongation (white arrow), right kinking of the right CCA (white arrow) and bilateral "S" shaped elongation of the internal carotid artery (white arrows)



Fig. 4: Contrast-enhanced magnetic resonance angiography showing bilateral "S" shaped elongation of the internal carotid artery (white arrows)

Table 1: External diameters of the CCA and ICA without DA

Sex	Number	External diameter of the left CCA	External diameter of the right CCA	External diameter of the left ICA	External diameter of the right ICA	Age
Male	109	5.54 mm (3–9)	5.8 mm (3.1–9.8)	3.9 mm (1.8–4.5)	4.3 mm (2–5.7)	60.3 (17–84)
Female	89	5.3 mm (3.1–5.6)	5.3 mm (3.5–7.3)	3.5 mm (2.5–4.9)	3.61 mm (2.1–4.9)	52.8 (17–81)
Average		5.42 (± 0.12) mm	5.5 (± 0.25) mm	3.7 (± 0.2) mm	3.95 (± 0.34) mm	56.5 (± 3.8)

CCA, common carotid artery; DA, dolicho-arteriopathies; ICA, internal carotid artery

Of the 332 subjects examined, 134 (40.3%) presented DA: 45 males (33.6%) and 89 females (66.4%) with a male/female ratio of 1:2. The most common DA was tortuosity (75.5%), followed by kinking (17.1%) and coiling (7.4%).

Of the 134 subject examined with DA, 64 (47.8%) presented CCA with DA: 20 males (31%) and 44 females (69%) with a male/female ratio of 1:2.2 (Table 2). Right diameters of the CCA with CA were found larger than the left side for male ($p < 0.05$), but left diameters of the CCA with DA were found larger than the right side for female ($p < 0.05$); the age of these patients ranged from 37 to 90 years, and the mean age was 67.8 years (Table 2).

Of the 64 subjects with DA subjects examined, 31 (23%) subjects presented bilateral DA of the CCA, 18 males (58%) and 13 females (42%) with a male/female ratio of 1:1.38, and 33 (24.6%) subjects presented monolateral DA of the CCA: 9 males (27.2%) and 24 females (72.8%) with a male/female ratio of 1:2.66.

Monolateral and bilateral DA of the CCA have been frequently observed in females and over age of 60 years ($p < 0.01$).

Of the 134 subject examined, 70 (52.2%) presented DA of the ICA: 25 males (35.7%) and 45 females (64.3%) with a male/female ratio of 1:1.8 (Table 3). The external right diameters of the ICA with DA were found smaller than the left side for male ($p < 0.05$), but left

Table 2: External diameters of the CCAs with DA

Sex	External diameters of the left CCA with DA	External diameters of the right CCA with DA	Age	Number
Female	5.7 mm (3–8.3)	5.5 mm (3–8.2)	65 (37–90)	44
Male	6.4 mm (5.3–7.7)	6.81 mm (3.7–8.9)	70.75 (44–90)	20
Average	6.0 (± 0.35) mm	6.15 (± 0.66) mm	67.8 (± 2.8)	

CCA, common carotid artery; DA, dolicho-arteriopathies

Table 3: External diameters of the ICAs with DA

Sex	External diameter of the left ICA with DA	External diameter of the right ICA with DA	Age	Number
Female	3.84 mm (2.5–6.5)	3.84 mm (2.5–5.7)	66.1 (37–88)	45
Male	4.4 mm (3.1–6.7)	4.34 mm (2.1–6.4)	60.6 (37–60)	25
Average	4.03 (± 0.37) mm	4.09 (± 0.25) mm	63.3 (± 2.7)	

ICA, internal carotid artery; DA, dolicho-arteriopathies

and right external diameters of the ICA with DA were found equal for female, the ages of these patients ranged from 37 to 88 years, and the mean age was 63.3 years (Table 3).

Our study reported that the external diameters of the CCA and ICA were larger in patients with DA than in those without DA ($p < 0.05$).

Total 29 (8.73%) subjects presented monolateral DA of the ICA: 12 males (41.3%) and 17 females (58.7%) with a male/female ratio of 1:1.4.

Total 41 (12.3%) subjects presented bilateral DA of the ICA: 13 males (31.7%) and 28 females (68.3%) with a male/female ratio of 1:3.6. Bilateral DA of the ICA were observed more frequently than monolateral DA of the ICA over the age of 60 years ($p < 0.05$).

Total 14 (4.2%) subjects presented bilateral DA of the ICA and CCA: 4 males (28.5%) and 10 females (71.5%) with a male/female ratio of 1:2.5.

Eight (5.9%) subjects presented monolateral DA of the ICA with bilateral DA of the CCA: 4 males (50%) and 4 females (50%) with a male/female ratio of 1:1.

Seven (2.4%) subjects presented monolateral DA of the CCA with bilateral DA of the ICA: seven females (100%) with a male/female ratio of 1:0.

Four (1.2%) subjects presented monolateral DA of the ICA with monolateral DA of the CCA: one male (25%) and three females (75%) with a male/female ratio of 1:3.

DISCUSSION

The occurrence of DA, based on the anatomical, ultrasound, and angiography studies, is reported to be seen in a wide range of frequency between 10 and 43% of the population with no history of atherosclerotic disease, diabetes, or hypertension.^{3,7} According to the studies performed with carotid duplex ultrasound, the prevalence of DA ranged from 28 to 56%.^{4,13–16} Our study showed

that 40.3% of the patients referred for CEMRA of the CA had DA. A similar prevalence of DA of the CA (58%) was reported by Del Corso,¹⁴ while Pellegrino reported a less frequency (25.6%) in their study population.⁴ The wide range of prevalence of DA of the CA can be explained by the use of different methods and diagnostic tools, and the selection of different study groups.

We observed a frequent presence of DA of the ICA (52%) and predominance for the left in females, but predominance for the right in males, with monolateral DA, which was compatible with the previous studies,^{4,13} but some authors reported a frequent presence of bilateral DA and predominance for the left in cases with unilateral DA.¹⁷

We observed a frequent presence of bilateral DA of the ICA (30.5%) and predominance for the left in females, but predominance for the right in males, with monolateral DA of the ICA (21.6%), which was compatible with the previous studies,¹⁷ but some authors reported a frequent presence of bilateral DA and predominance for the left in cases with monolateral DA.^{4,13} The right external diameters of the ICA with CA were found smaller than the left side for males ($p < 0.05$), but the left and right external diameters of the arteries were found equal for females.

We observed a frequent presence of DA of the CCA (47.8%) and predominance for the left in females. The right external diameters of the CCA with DA were found larger than the left side for males, but left external diameters of CCA with DA were found larger than the right side for females.

We observed a frequent presence of bilateral DA than monolateral DA of the ICA, but observed a frequent presence of unilateral DA than bilateral DA of the CCA. In this study, elderly women (>60 years) were more frequently affected by DA, but both sexes were equally affected among the patients under the age of 60. Our results do not agree with the studies showing a greater prevalence of DA in men.^{7,14–16} In opposite to our results showing that DA was related to advanced age in women, some authors showed decreasing frequency of DA in women after the age of 70.⁴ Other authors reported a higher frequency of DA in women independent of the age.^{13,14}

Monolateral and bilateral DA of the CA have been frequently observed to females and over the age of 60 years. Because of the anatomical position of the CA with DA, there is a potential risk of devastating complications in head and neck surgery.

Tortuosity may be caused by multiple factors: genetic factors, degenerative vascular diseases, and an alteration in blood flow and pressure.¹⁸ Some authors consider these alterations a consequence of atherosclerotic vessel remodeling, while others ascribe them to anatomical variations of the embryological origin.¹⁹ Dolicho-arteriopathies are a result of alterations in embryological development rather than vascular remodeling secondary to aging and/or atherosclerosis.¹⁹

The aging seemed more important than atherosclerosis.^{14,20} Our results do agree with the studies showing a greater prevalence of DA in aging.

It is still controversial whether DAs are related to vascular risk factors, such as hypertension, hyperlipidemia and diabetes, atherosclerotic diseases, and ischemic stroke. Some of the previous studies showed an association between DA and vascular risk factors or carotid atherosclerosis,¹⁴ while most of them did not show.^{4,9,20}

Some authors reported that hypertensive pressure, reduced axial tension, and weakened wall stiffness may play an important role in the development of artery tortuosity.^{16,18} On the other

hand, tortuosity increases the resistance to blood flow and severe tortuosity can obstruct or even occlude blood flow.^{21,22} Our study suggested that the external diameters of both the CCA and ICA were larger in patients with DA than in those without DA. Togay et al. reported that the lumen diameter at the origin of the ICA was larger in patients with DA than those without DA and lumen diameter at the level of CCA was inversely correlated to the severity of DA.¹⁷ But some authors reported that reduced wall thickness or lumen diameter is associated with a higher prevalence of tortuosity,¹⁸ although there is discrepancy among the clinical reports on the correlation between atherosclerosis and artery tortuosity.^{17,23} Some authors suggested a possible relationship between kinking of the CA and hypertension¹⁶ or trans ischemic attack (TIA).^{9,16} Arterial degenerative disease is often concomitant with ICA tortuosity but is not always associated with it.^{7,24,25} On the other hand, kinks without atheromatous plaques, though rather frequent, are usually not considered as a cause of stroke.^{9,15,26,27}

Some correlations among the lumen diameter, atherosclerosis, and kinkings were demonstrated previously.¹³ Some authors reported that larger lumen diameters at the origin of the ICA was obtained in cases with DA in their study,^{5,17} plaque severity was less prominent in their cases.¹⁷ Lack of correlation between the lumen diameter and carotid plaques favors the embryogenic hypothesis in the pathogenesis of DA.¹⁹

Frequently in clinical practice, DAs have no clear importance as a risk factor of ischemic stroke or a marker of carotid or systemic atherosclerosis. However, as previously mentioned, some authors using Doppler echography demonstrated that they are not a mechanism of acute cerebral ischemia and therefore are unlikely to be a cause of neurological events or symptoms.²⁸ It appears that DAs identified on CEMRA are more of a curiosity than a clinically significant finding. Because the external diameters of the CCA and ICA were larger in patients with DA than in those without DA, DA may even prevent moderate to severe plaque formation in the CAs.¹⁷ The hypothesis that DA may also prevent ischemic stroke should be assessed in a larger patient population prospectively, but because of the anatomical position of the CA with DA there is a potential risk of complications in head and neck surgery.

Because of the anatomical position of the CCA and ICA with DA, there is a potential risk of complications in angiography and head and neck surgery. For this reason, the presence of DA should be excluded preoperatively by means of diagnostic imaging, such as afforded by CEMRA.

CONCLUSION

Monolateral and bilateral DA of the CA have been frequently observed in females and over the age of 60 years. The external diameters of the CAA and ICA with DA were larger than without DA.

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