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Role of Doppler Ultrasound in Carotid Kinking and Coiling: A Pictorial Essay and Brief Review

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ABSTRACT

Doppler ultrasound is the initial non-invasive study for the evaluation of the carotid vasculature, it will help us to establish the presence of tortuous paths, the presentation variable, the flow velocities, and if there is a hemodynamic repercussion. In this pictorial review article, the different presentations of carotid tortuosities will be discussed, as well as the correct evaluation of color and spectral Doppler.

KEYWORDS: Doppler ultrasound, Kinking, Coiling

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INTRODUCTION

Carotid artery dolichoarteriopathies were defined as the presence of shape deformations including coils and kinks is a rare morphologic entity that is most frequently described in the extracranial internal carotid arteries (Fig 1). (1)(2) The etiology of carotid abnormalities is more congenial than acquired from vascular remodeling due to atherosclerosis, which can lead to hemodynamic and neurological abnormalities. (3) Clinical relevance of these alterations as well as their long-term prognosis has not been described by literature yet. (4)

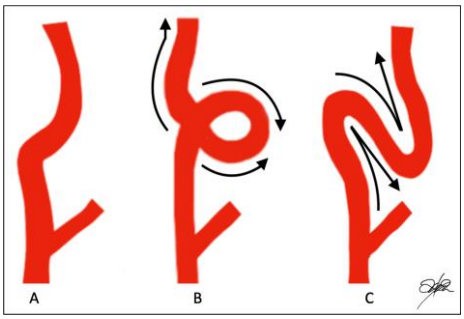

Figure 1. Internal carotid artery diagram. Normal carotid artery (A), Coiling carotid (B), and Kinking artery (C).

Classification

Carotid dolichoarteriopathies can be classified into 3 different types. Type 1: tortuosity a nonrectilinear stretch of an artery with an angulation >90; type 2: loop a 360º angulation of an artery on its transverse axis (‘‘coil’’ configuration); type 3: kinking the inflection of 2 or more segments of an artery with an internal angle of 90. Dolichoarteriopathies of carotid arteries are frequent, ranging between 10% and 45%. For type 3, a prevalence of 5% to 25% has been described. (5)

Technique

Doppler ultrasound is the gold standard for the evaluation of extracranial circulation. It allows for the evaluation of stenotic pathology as well as anatomic variants. A device that has a linear transducer with frequencies higher than 7Mhz,

color, and power Doppler with capacity for velocity measurement is necessary. Must have the B mode angulation function and color box. (6) The patient may lay down in the supine position with the head slightly hyperextended and rotated 45º away from the side being examined (Fig 2). (7)

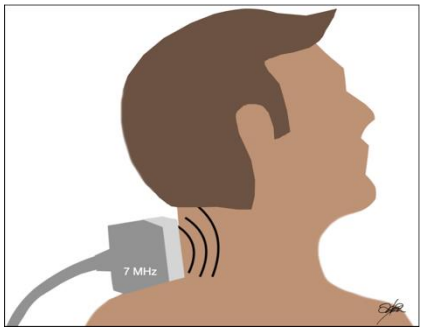

Figure 2. Diagram representing patient examination with neck tilt at 45 degrees using a 7 MHz linear transducer.

An axial and longitudinal study is performed from the origin of the common carotid artery to the most visible distal internal carotid artery. The color Doppler allows to detect the flow, determine its direction, as well as the presence of tortuosities, curls, or coiling, among others. Areas with the flow are represented as colored areas on a gray-scale baseline image. Spectral or pulsed Doppler is a quantitative representation of the velocities and directions of flow within the Doppler sample volume. Flow velocity and spectrum morphology should be assessed by recording peak systolic velocities, end-diastolic velocity, and resistance index in the common carotid artery, proximal internal carotid artery, and also the proximal external carotid artery. (6)

The ultrasound study includes a visual inspection in grayscale, color Doppler and spectral analysis of velocities with power Doppler (Fig 3). By carrying out a morphological analysis of the longitudinal and transverse directions, it is possible to achieve a "mental" 3D reconstruction of the carotid structures and orientation under evaluation, which is the most important objective of the study. The carotid arteries can be visualized from three approaches. One anterior to the sternocleidomastoid muscle, another lateral, and another from the posterior portion of it. (8)

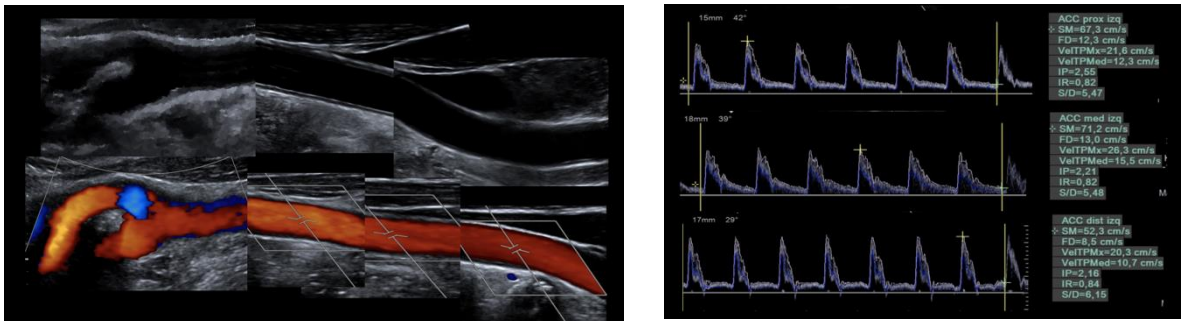

Figure 3. 47-year-old woman with a normal carotid artery. A carotid artery from the proximal third to the bifurcation in B-mode, Carotid artery from the proximal third to the bifurcation in color Doppler mode. Spectra and results after evaluation in spectral Doppler mode of the common carotid artery (CCA). Evaluation of three portions of the CCA is observed, with spectra tending to triphasic morphology, rhythmic, with maximum picosistolic velocities (PS) of 71.2 cm / s, normal findings.

Kinking

The best-understood definition is the one described by Metz, who states that the bend of the ICA is due to an elongation of the vessel and is defined as the abrupt angulation of the vessel axis from 90° or less (Fig. 4), and in turn classified into three grades: grade 1: bending of 90-60°; grade 2: 60 to 30°; grade 3: <30° (Fig. 5-9). (9)(10)

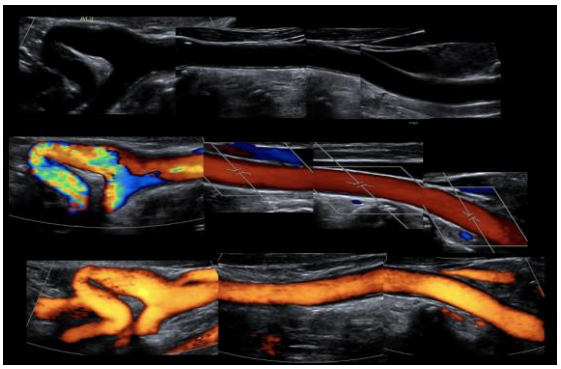

Figure 4. Carotid artery. B Mode, Color Doppler and Power Doppler. After the bifurcation, an internal carotid artery (ICA) with two angulations is observed, the first of 30º (Kinking) and the second of 45º. In the first portion, there is a slight decrease in the caliber of the vessel.

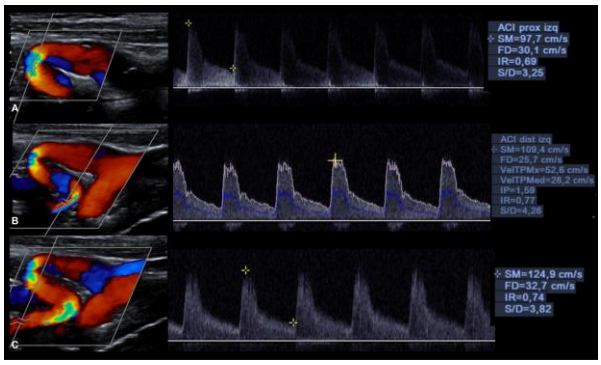

Figure 5. 45-years old men with cephalea. ICA with color and pulsed Doppler application. Assessment of the ICA before angulation (A), After the first angulation (B), and after the second angulation (C). A progressive increase in speed is identified up to maximum velocities of 124.9 cm / s, reaching upper limits within normality.

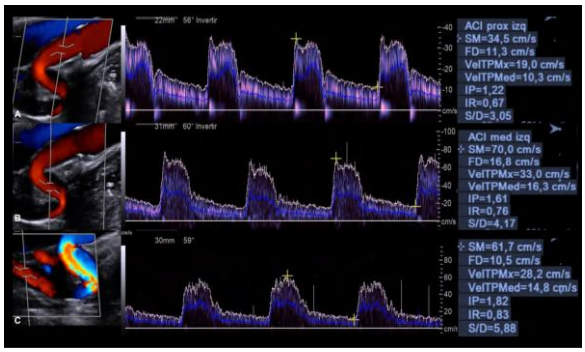

Figure 6. 52-years old women with tinnitus. ICA with color and pulsed Doppler application. Evaluation of the ICA before the first angulation with a PS velocity of 34.5 cm / s, After the first angulation with a PS velocity of 70 cm / s. After second angulation with a PS velocity of 61.7 cm / s. After the first angulation, a doubling of the initial velocity is observed, from 34.5 cm / s to 70cm / s, still within normal parameters.

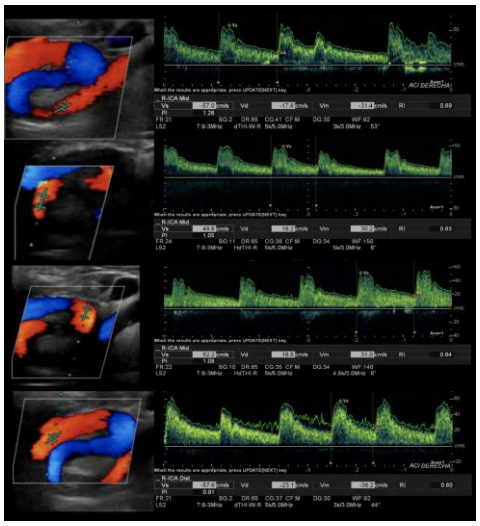

Figure 7. 71-years old women with a history of syncope under study. CA with color and pulsed Doppler application. Evaluation in 4 segments of the ICA where PS velocities not greater than 57.6 cm / s are observed, with variability not greater than 8 cm / s.

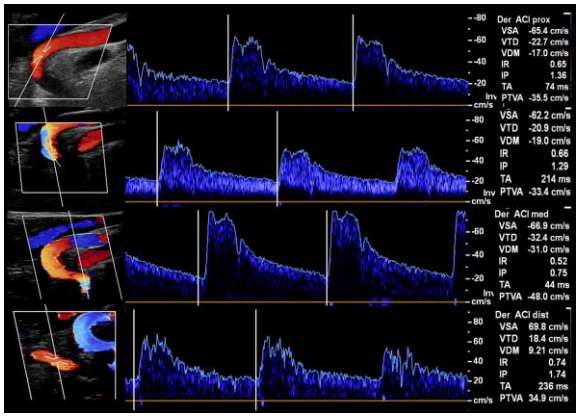

Figure 8. 80-years old men with a history of transient cerebral ischemia. ICA with color and pulsed Doppler application. Evaluation in 4 segments of the ICA where PS velocities not greater than 69.8 cm / s are observed, with variability not greater than 7.6 cm / s. As in the previous example, there are certain cases in which, despite the angled segments, no significant variability is observed in the velocities of the assessed paths.

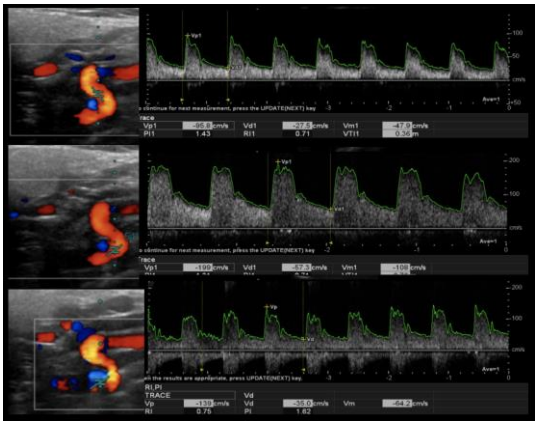

Figure 9. 67-years old women with a history of recurrent migraine attacks. ICA with the application of color and pulsed Doppler, evaluation in 3 segments of ICA. Post-first angulation assessment where a PS velocity of 95.8 cm / s is identified (A). Assessment at the level of the second angulation showed an increase in PS velocity of up to 199 cm / s and after the second angulation, decreasing to 139 cm / s. In this examination, an almost double increase in the PS velocity is again observed, showing values that generate hemodynamic repercussions.

Clinical presentation of kinks, in general, is the same as regular carotid stenosis (11). It is generally accepted that the carotid kinking may be either the source of cerebral emboli or the vessel may be temporarily occluded by head/neck

rotation thus causing symptoms of cerebral ischemia. In both instances the resulting clinical presentation may be transient ischemic attacks and/or complete stroke, usually a minor one (12)(13), probably due to the hemodynamic changes.

Coiling

Defined as the elongation or redundancy of the ICA with a circular configuration of 360° (Fig. 10), involving the origin of the carotid arteries. It is generally believed that coiling as well as kinking are associated with atherosclerosis or fibromuscular dysplasia. (14)

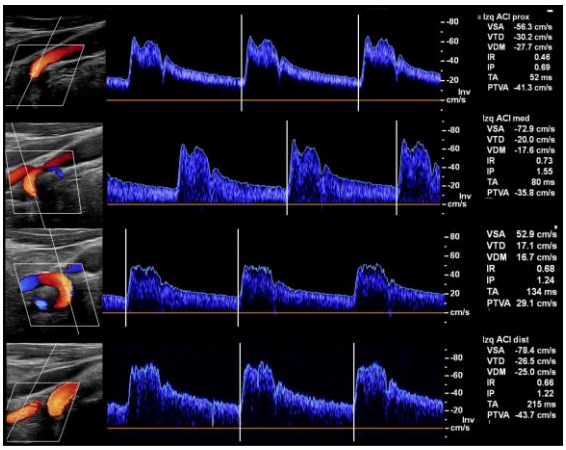

Figure 10. 66-years old woman with a history of syncope. ICA in color and pulsed Doppler mode, observing that despite this morphology, all the segments maintain normal speeds, reaching maximum values of 78.4 cm/s, with a variability no greater than 25.5 cm/s.

Other studies

Cerebral angiotomography has been a valuable tool in these patients, it must be obtained with four intracranial vessel projections, it is important to assess the kink from different angles, currently, with 3D reconstruction angiography, the degree of the kink can be accurately measured (Fig. 11). (15)

Other studies used are angiography (Fig 12), which shows us the tortuosity and has great sensitivity to detect it.

Figure 11. Computed tomography angiography in the 3D reconstruction of carotid arteries where the presence of bilateral tortuosity is identifie

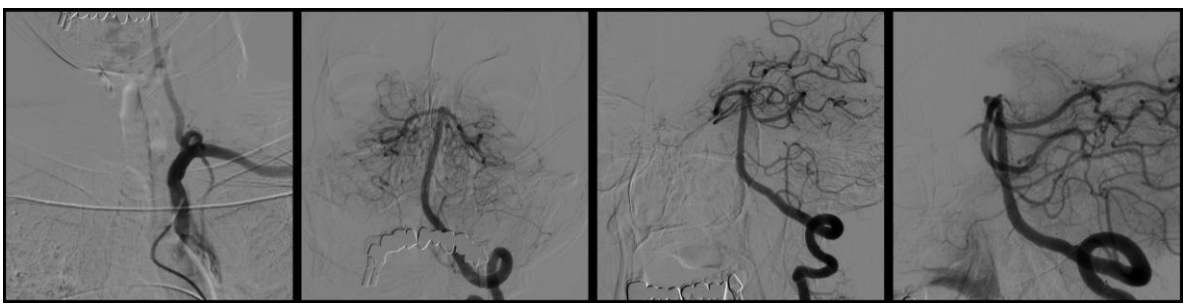

Figure 12. ICA angiography where the presence of a coil is identified.

Treatment

1) Arterial transposition, criticized for not removing arterial elongation.
2) Adhesions lysis.
3) Vascular procedures such as segmental resection and end to end anastomosis.

4) Endarterectomy technique with eversion, which allows correction of severe elongation and kinking of the ICA. (16)

DISCUSSION

The tortuosity of the carotid arteries includes the presentation in curl and angulation, of the latter we can subdivide them according to their degree of angulation (1-2). The etiology can be congenital or acquired, with the atheromatous disease being an important cause (3). The prognosis of these patients is still not clear, since there is not much literature on the matter, however it has been found that patients with this condition may present with neurological symptoms of some kind (4). Doppler ultrasound is an inexpensive, non-invasive tool that, in expert hands, can provide an excellent diagnosis of this pathology (6). Among the main findings to be evaluated in the ultrasound examination, they include the type of tortuosity that the vessels have and the hemodynamic repercussion that determines said morphology, as we have seen in this case-based work, on some occasions, there is tortuosity but not frank hemodynamic repercussion; however, in some cases, an abrupt increase in picosystolic velocities has been observed, a hemodynamic condition generated by a very pronounced angulation, which reminds us of a “stenotic” type effect; or being the counterpart, low velocities associated with tortuosities that remind us of "low output data" in heart patients. In the study of tortuosities, we can include some studies that provide us with a vision with greater structural definition, such as computed tomography angiography with 3D reconstruction and digital subtraction angiography (11).

CONCLUSIONS

Kinking and Coiling can be an uncommon findings, it is necessary to know the main findings during the Doppler ultrasound examination, as well as their adequate characterization to determine if there is hemodynamic repercussion or attributable clinical deterioration. In expert hands, it represents a non-invasive, low cost, and a great diagnostic value study.

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