# Dolichoarteriopathies (Kinking, Looping, Tortuosity) of the Vertebral and Basiler Arteries

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## Abstract

The aim of this study is to document dolichoarteriopathies (kinking, looping, tortuosity) of the vertebral artery and basilar artery and to measure the external diametrs of the vertebral artery and basilar arteries with DA using CE-MRA.-Subjects were divided into six groups according to with or without DA of the VA and BA seen on the contrast enhancement magnetic resonance angiography (CE-MRA).-The external diameters of the vertebral artery (VA)and basilar arteries (BA) with and without dolichoarteriopathies (DA) were measured and compared with each other.–The most common DAs of the VA were tortuosity (40.7%), followed by looping (6.5%) and kinking (2.6%). Tortuosity and kinking of the BA were seen 7.6% and 0.5%, respectively.-The prevalence of the V1, V2, V3 and V4 segments with DA were seen 22.3 %, 12.5%, 8.7%, and 9.5% respectively.-The present study demonstrated the external diameters of the BA and VA with DA were larger than the ones without DA.–The most common DAs of the VA were tortuosity, looping and kinking, respectively. The incidences of DA according to the segments of the vertebral arteries were V1, V2, V3 and V4, respectively. The most common DAs of the BA were tortuosity and kinking, respectively.-VA and BA with DA have larger external diameter than without DA.

**Keywords:** Vertebral artery, basilar artery , dolichoarteriopathies.

## Introduction

The clinical significance of DA (kinking, coiling, tortuosity) and their prognosis have not been clearly defined yet (Caplan,2004; Han, 2012).

Tortuosity is an S- or C-shaped elongation or undulation in the course of the VA and BA (Veeramani, 2014). Tortuous vessels are often seen in the enhancement magnetic resonance angiography (CE-MRA) (Schep, 2001; Trucco, 2010).

Curving, angulation, twisting, looping and kinking of the VA, BA and carotid arteries were reported in clinical investigations (Hong-tao, 2014; Pancera, 2000; Pauliukas, 1990). The etiology and pathogenesis of torturous vessels are not well known (Caplan, 1986; Han, 2012).

## Materials and Methods

368 consecutive outpatients underwent CE-MRA were evaluated retrospectively. Subjects with vertebral artery hypoplasia and congenital variations of the vertebrobasiler system on CE-MRA were excluded in this study.

The study was approved by the local ethical committee (78025658-99). The written informed consent was obtained from all the patients before the commencement of the study.

CE-MRA [Gadolinium-BOPTA (MultiHance) 0.1 mmol/kg bodyweight] for detection of the anomalies of the vertebrobasilar system was taken. CE-MRA was performed on 1.5 Tesla units, since 2010 a Siemens Magnetom Aera has been used for imaging.

The limitation of our study was the lack of digital subtraction angiography (DSA). Due to technical inadequacy in our hospital, we didn't perform DSA examination in our patients.

VAs and BAs with DA were classified as tortuosity, loop and mild–moderate kinking.

The vertebral artery is divided into 4 segments: V1 (preforaminal), V2 (foraminal), V3 (atlantic, extradural or extraspinal) and V4 (intradural or intracranial) (Buckenham,2004).

Subjects were divided into six groups. Group 1 (control group) was included the subjects who have VA and BA without DA, Group 2 was included the subjects who have V1 segment with DA and, Group 3; subjects who have V2 segment with DA , Group 4; subjects who have V3 segment with DA , Group 5; subjects who have V4 segment with DA and, Group 6; subjects who have BA with DA (Figure 1-2).

The external diameters of the segments of the VA and BA with and without DA were measured at the two different parts of the same artery segment on the CE-MRA, and the mean diameter value was calculated.

We used chi-square test and multiple logistic regression analysis to determine the association of VA and BA with DA with age, sex, vascular risk factors. Differences were considered statistically significant at a p value of less than 0.05. Student t tests were used to compare these parameters between the groups. Bonferroni correction was used to determine significant p values.

**Figure 1:** CE-MRA showing loop formation of the (black arrow) V1 segment of the left VA and kink formation of the V1 segment of the left VA (white arrow), loop formation of the V4 segment of the left VA (black arrowhead) and tortuosity of the BA (white arrow head).

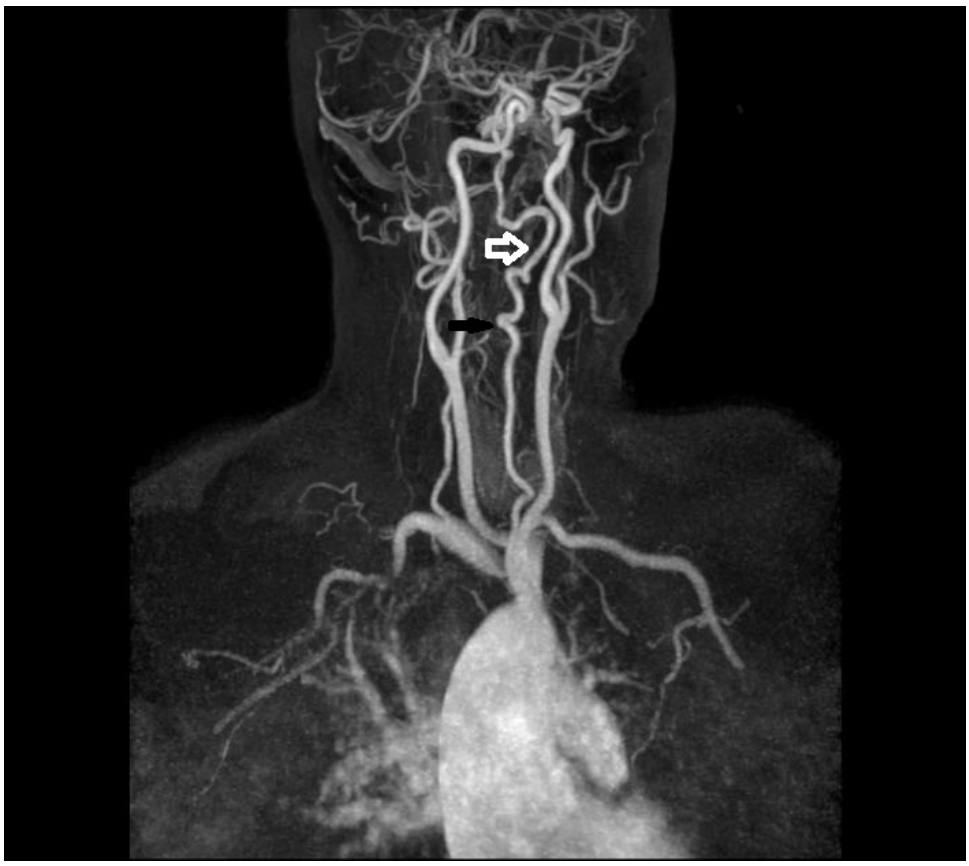

**Figure 2:** CE-MRA showing loop formatin of the V2 segment of the left vertebral artery (black arrow) and loop formation of the V3 segment of the left VA (white arrow).

## Results

Of the 368 subjects, 143 ( 38,8 %) exhibited BAs and VAs without DA on CE-MRA. 94 (65.7%) of 143 subjects was male and 62 was females (34.3%). Male/female ratio was 143/62. We found that the right external diameters of the VA without DA larger than left side for male and female ($p<0,05$), the mean external diameters of the BAs without DA for males were found larger than the females ($p<0,05$) and the mean age was 52±17,8 , 53.5±18.8 for males and 50,5±16,8 for females (Table 1). The mean external diameters of the segments of the VA without DA were larger on the right side than left side ($p < 0.05$ ) (Table 1).

225 (61.2 %) of the 368 subjects were defined VA and BA with DA on CE-MRA .108 (61.2%) of 225 subjects were male and 117 subjects were female (52%). Male/female ratio was 225/117.

195 (52.9 %) subjects had the VA with DA. 92 (47.1%) of 195 subjects were male and 103 (52.9%) were female. Male/female ratio was 92/103.

The present study demonstrated that the external diameters of the BA and VA with DA had larger than without DA (Table 1, 2).

82 (22.3%) subjects exhibited the V1 segment with DA, 44 (53.6%) of 82 subjects were males and 38 subjects were females (46.4%) A male/female ratio was 44/38 (Table 2). The mean age was 65.4±8,7 for females and 70.7±9 for males.

25 (6.8 %) subjects exhibited the V1 segments with bilateral DA.10 (2.7 %) of 25 subjects were male and 15 were females (4.1%). Male/female ratio was 10/15.

Tortuosity of the V1 segment was defined as 17.6% in this study. Looping and kinking of the V1 segment were defined 4.3% and 0.5%, respectively.

The prevalence of the bilateral tortuosity of the V1 segment was 6.8%.

The V1 segments with bilateral tortuosity frequently defined males than females and over 75 ages ($p< 0.01$) in this study.

46 (12.5%) subjects exhibited the V2 segment with tortuosity.12 subjects (26%) of 46 were male and 34 subjects were females (74%). Male/female ratio was 12/34. The mean age was 65.2±1.3 for female and 68,7±1.for male (Table 2). 16 (4.34% ) subjects exhibited the V2 segments with bilateral DA. 5 (1.3%) of 16 subjects were male and 11 were females ( 3% ) . Male/female ratio of was 5/11.

We observed that V2 segments with bilateral DA frequently were exhibited in females and over 65 ages ($p<0.01$).

The prevalence of tortuosity, looping and kinking of the V2 segment in this study were 6,8%, 1.36 % and 0.54%, respectively.

32 ( 8.7 %) subjects exhibited the V3 segment with DA. 17 (51,1%) of 32 subjects were male and 15 (48.9%) were female. Male/female ratio was 17/15. The mean age was 59.6±1,7 for female and 68±0,4 for male (Table2).

10 (2.7%) subjects exhibited the V3 segments with bilateral DA. 6 (60%) of 10 subjects were male and 4 females (40%) were female. Male/female ratio was 6/4.

The V3 segments with bilateral DA frequently were exhibited males than female and over 70 ages ($p<0.01$).

The prevalence of looping and kinking of the V3 segment in this study were 1,1% and 0,5%, respectively.

35 (9.5%) subjects exhibited the V4 segment with DA on CE-MRA.19 (5.1%) of 35 subjects were male and 16 females (4.4%). Male/female ratio was 19/16. The mean age was 65.4±8.7 for female and 68.5±0.9 for male (Table 2).

7 ( 1.9 %) subjects exhibited the V4 segment with DA, 3 (42.8 %) of 7 subjects were male and 4 (57.2%) were female. Male/female ratio was 3/4. The V4 segments with bilateral DA frequently were exhibited to males than female and over 70 ages ($p<0.01$).

The mean right and left external diameters of the V1, V2, V3 and V4 segments with DA were larger than the ones without DA ($p<0.005$) (Table 1 and 2).

30 (8.15%) of 368 subjects exibited the BA with DA on CE-MRA in this study. 16 (53%) of the 368 subjects were males (53%) and 14 (47%) were female. Male/female ratio was 16/14 (Table2).The prevalence of tortuosity and mild kinking of the BA defined on CE-MRA were 28 (7.6%) and 2 (0.5%), respectively. The external diameter of the BA with DA for male was found larger than for female (Table 2). The external diameter of the BA with tortuosity was larger than the ones without tortuosity ($p<0.005$) (Table1 and 2).

The most common DA of the VA were tortuosity (150 arteries, 40.7%), followed by looping (24 arteries,6.5%) and kinking (10 arteries, 2.1%). Of the 10 subjects with kinking VA, 8 (2.1%) presented mild kinking and 2 (0.5%) presented medium kinking of the VA (Table3). The most common DA of the BA were tortuosity (28 arteries,7.6%), followed by kinking (2 arteries, 0.54%).

The VA with DA was found frequently on the left side than the right side.

The male/female ratio was found to be equal in the cases of the VA and BA with DA in our study.

The prevalence V1, V2, V3, V4 segments and BA with DA were found to be 26.3%, 12%, 8.7%, 9.5% and 8.1% respectively.

The prevalence V1, V2, V3 and V4 segments with bilateral DA were found to be 6.9% , 4.3%, 2.7 % and 1.9% , respectively.

Unilateral DA of the VA was seen more frequently than bilateral DA.

The VA and BA with DA were equally present in males and females.

**Table 1:** The external diameters of the VA and BA without dolichoarteriopathies (Control group)

| | Left* | | Right* | |
|---|---|---|---|---|
| | M | F | M | F |
| V1 | 2,48±0,94 mm | 2,20±0,62 mm | 2,56±0,94 mm | 2,23±0,64 mm |
| V2 | 2,28±1,1 mm | 2,5±0,98 mm | 3,05±0,7 mm | 2,58±0,77 mm |
| V3 | 2,15±0,63 mm | 1,06±0,83 mm | 2,35±0,49 mm | 1,95±0,53 mm |
| V4 | 2,25±0,4 mm | 2,0 mm | 2,46±0,55 mm | 1,73±1 |
| BA | 2,66±0,82 | 2,35±0,69 | | |

M: male, F:Female ,*: millimeters.

**Table 2:** The external diameters of the segments of the VA and BA with dolichoarteriopathies.

| | Left | | Right | |
|---|---|---|---|---|
| | M | F | M | F |
| V1 | 3,09±0,94mm | 2,71±0,74mm | 2,61±0,6 mm | 2,64±0,8mm |
| V2 | 3,0±0,7 mm | 2,58±0,76mm | 3,18±1,0 mm | 2,6±0,75mm |
| V3 | 2,25±0,63mm | 2,23±0,5 mm | 2,5±0,57 mm | 2,5±0,9 mm |
| V4 | 2,48±0,74mm | 2,43±0,67mm | 2,54±0,6 mm | 2,2±0,8 mm |
| BA | 2,81±0,8 mm | 2,37±0,7 mm | | |

**Table 3:** Distribution of dolicoarteriopathy according to segments of vertebral and basilar arteries

| Tortuosity | | | Loop | | Kink (Mild) | | Kink (Moderate) | |
|---|---|---|---|---|---|---|---|---|
| | R | L | R | L | R | L | R | L |
| V1 | 30 | 35 | 6 | 10 | 1 | 1 | | |
| V2 | 10 | 15 | 2 | 1 | 2 | 2 | 1 | 1 |
| V3 | 12 | 13 | 2 | 3 | 1 | 1 | | |
| V4 | 15 | 20 | - | - | | | | |
| Total (V) 67 | | 83 | 10 | 14 | 4 | 4 | 1 | 1 |
| BA | 28 | | | | 2 | | | |

## Discussion

VA and BA with tortuosity, looping, and kinking are seen frequently in clinical practice. The external diameters of the BA and VA with DA had larger than the ones without DA

The prevalence of VA and BA with DA in this study was 61.1%. A high incidence of VA and BA with DA was reported by Savitz et al. (Savitz, 2005). But the true incidence of VA and BA with tortuosity are unknown. We observed that the right VA was dominant in 50% of the subjects. The left VA was dominant in 25% of the subjects, but there is not any dominance in 25% of the subjects. Dodevski et al., reported that the left VA was dominant in 50% of the population, the right in 25% (Dodevski, 2011). The VA and BA with DA were seen equally in both sexes in these studies.

Hassler O et al. reported that VA and BA with DA were less common in people under 60 years of age and was more common in patients over 70 year of age (Hassler, 1967). Matskevichus Z K et al. and Ulusoy OL et al. reported that kinks of these arteries result from changes associated with age, osteochondrotic shortening of the cervical vertebral column and arterial hypertension (Matskevichus, 1990; Ulusoy, 2016) . Beigelman R et al. reported that most of the loops of VAs were congenital (Beigelman, 2004).

DA of the V1 segment was common. Some authors reported that the prevalence of the V1 segment with DA varied from 2.7 % to 55% (Matula,1997; Veeramani, 2014 ). We defined 17.6% prevalence of the V1 segment with tortuosity in this study.

The prevalence of the bilateral tortuosity of the V1 segment was 6.9%. Males frequently had V1 segment with tortuosity than females. But Veeramani R. et al. reported that no significant differences between sexes were found (Veeramani, 2014). The prevalance of the V1 segment with loop formation (LF) was 2.98% in this study. Paksoy et al. reported a 7.51% incidence of LF of V1 segment ( Paksoy, 1976).

Han HC. et al and Pancera P. et al. reported that elongation of the artery was a result of arterial hypertension and loss of elasticity of the arterial wall in the elderly subjects (Han, 2012; Pancera, 2000) . But Beigelman R. et al. reported that some of them were congenital (Beigelman, 2010).

The prevalence of the V2 segment with tortuosity was 12.5 % in this study. Fan BH et al. reported a same prevalence for V2 segment with tortuosity (Fan, 2015).

The prevalence of the bilateral tortuosity of the V2 segment for consecutive 368 subjects was 6.9 %. The prevalence of V2 segments with looping, kinking in the present study were 0.81%, 1.62% and 4.8%, respectively. But Doweidar A. et al. and Kim HS. et al. reported that kinks and loops were rare in V2 segment (Doweidar, 2014; Kim, 2010). V 2 segment with tortuosity was frequently seen in female than male in this study. This study demonstrated that the left external diameter of the V2 segment with tortuosity was larger than the right side for male and female. But Veeramani R. et al. reported that there was no significant differences between diameters of the right and the left side of V2 segment for both sexes (Veeramani, 2014). Pauliukas PA. et al. reported that kinking of the V2 segment was mostly due to the compression of the VA by osteophyte or deformation of the vertebral column in cervical osteochondrosis (Pauliukas, 1990). There is not any cervical osteochondrosis subject in this study.

The prevalence of the V3 segment with tortuosity for consecutive 368 subjects was 8.7% . Fan BH. et al. reported that the prevalence rate of V3 segment with tortuosity was 9.7% (Fan, 2015). The prevalence rate of bilateral tortuosity of the V3 segment for consecutive 368 subjects was 0.27%. The prevalence of V3 segment with looping was 0.27%, V3 segment with mild kinking was %1, and segment with moderate kinking was 0. 6% in this study. Looping in this segment was very rare. Doweidar A. et al. and Kim HS. et al. reported that they were congenital. V3 segment with tortuosity was seen frequently males than females in this study (Doweidar, 2014; Kim, 2014).

The prevalence of V4 segment with tortuosity was 6.7% in this study. Fan BH. et al. reported a greater prevalence of V4 segment with tortuosity (Fan, 2015). The prevalence of the bilateral tortuosity of the V4 segment for consecutive 368 subjects was 1.9%. Males had frequently V4 segment with DA than females.

The prevalence of BA with tortuosity was 8.15% in this study . Tortuosity and kinking of the BA in this study were seen 7.6% and 0.5% , respectively. Rusu MC. et al. reported that BA with tortuosity had high incidence in their study (Rusu, 2011). Jeng JS. et al. reported that the BA may be angulated anteriorly and laterally due to the effects of blood inflowing from the vertebral arteries (Jeng, 2004). The BA shows gross anatomic changes, including a more acute angle at the angulation point with advancing age (Jeong, 2015). Lee SH. et al. reported that vascular risk factors had variable effects on these arterial remodeling processes ( Lee, 2012).

The present study demonstrated that external diameters of the BA with tortuosity for males were larger than females.

The present study demonstrated that the external diameters of the BA and VA with DA had larger than the ones without DA. But Rusu MC. et al. reported that there were no significant differences between them (Rusu, 2011).

Oliviero U. et al. and Togay-Isikay C. et al reported that there was discrepancy among the clinical reports on the correlation between atherosclerosis and artery tortuosity (Oliviero, 2003; Togay, 2005). Stehbens W. E. et al. reported that VA with tortuosity did not have any haemodynamic consequences but the VA with loop segments caused radicular symptoms by nerve root compressions (Stehbens, 1985). The most important mechanism of blood flow impairment is also the kinking of the artery. Cosar M. et al. reported that hemodynamic abnormalities caused by vascular tortuosity were different from those induced by atherosclerotic stenosis (Cosar, 2008).

VA and BA with tortuosity were related with hypertension in advanced age in both sexes in this study. This study was in accordance with the studies conducted by Lee SH. et al., Oliviero U. et al. and Togay-Isikay C. et al. (Lee, 2012; Oliviero, 2003; Togay, 2005).

The most common DAs of the VA were tortuosity (40.7%), followed by looping (6.5%) and kinking (2.6%).

The tortuosity and mild kinking of the BA were seen 7.6% and 0.5% , respectively. Savitz SI. et al. reported that VA and BA with tortuosity had high prevalence in their study (Savitz, 2005). Jeong SK. et al. reported that the BA shows gross anatomic changes with advancing age, including a more acute angle at the angulation point (Jeong, 2015).

The prevalence of the V1, V2, V3, V4 segments and BA were seen 26.3%, 12%, 8.7%, 9.5%, respectively The prevalence rate of the BA was 8.1%.

Our study demonstrated that arteries with DA had larger external diameter than without DA. Our results do not agree with the studies conducted by Han HC. et al. showing reduced lumen diameter is associated with a higher prevalence of tortuosity (Han, 2012).

Dodevski A. et al. reported that severe tortuosity could result in poor blood supply to the brain, leading to clinical symptoms of transient ischemic attack (Dodevski, 2014).

This study suggests that although VA and BA with tortuosity, looping, and kinking are seen frequently in clinical practice and have clear importance in surgery, angiography and ininvasive procedures. It is of great importance to know the exact details of the course of the segments of the VA and BA to prevent catastrophic laceration of the VA and BA during the surgical procedures.

## Conclusion

The most common DAs of the VA were tortuosity, looping and kinking, respectively. The prevalence of DAs according to the segments of the vertebral arteries was V1, V2, V3 and V4, respectively. The most common DAs of the BA were tortuosity and kinking, respectively.

VAs and BA with DA have larger external diameter than without DA.

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