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CLINICAL STUDY

Carotid arteries and vertebrobasilary system intracranial stenosis correlates with multi vessel coronary artery disease

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ABSTRACT

BACKGROUND: The goal of this study was to show the importance of the identifying potential carotid and vertebrobasilar stenosis with Computed Tomography Angiography (CTA) in severe coronary artery disease.

METHODS: In 109 patients, CTA of the carotid and the vertebrobasilar system were taken in the six months following the Coronary Angiography (CA). Coronary arteries and carotid vertebrobasilar system stenosis were considered significant at more than ≥ 50 %.

RESULTS: A significant statistical relationship was found between a coronary artery group of three-vessel disease (3-VD) and stenosis of the cervical segments of the right ($p = 0.022$) and left internal carotid artery (ICA) ($p = 0.001$); intracranial segments of the right ($p = 0.007$) and left ICA ($p = 0.020$), and the right vertebral artery (VA) ($p = 0.008$). There was a significant statistical relationship between Gensini score and stenosis of both the right ($p = 0.030$) and the left ICA cervical segments ($p = 0.003$).

CONCLUSION: In patients with severe coronary artery disease especially in 3-VD, CTA scan may be useful diagnostic tool for identifying stenosis of the carotid arteries, particularly in the intracranial segments of the ICA and in the preforaminal (V1) segment of the VA *(Tab. 4, Fig. 3, Ref. 22)*. Text in PDF *www.elis.sk.*

KEY WORDS: computed tomography angiography, carotid stenosis, vertebral artery stenosis, coronary artery stenosis.

Introduction

Atherosclerosis is a systemic condition that affects all vessels of the body. Atherosclerotic plaque tends to build in regions of reduced wall shear stress and low flow velocity, such as near branch ostia, bifurcations, and bends (1) .Recent studies have shown a correlation between atherosclerotic development in the coronary arteries and in the arteries of the carotid system (2). There is a strong correlation between acute coronary syndromes and stroke (3). Within the carotid arterial system, atherosclerotic plaque most commonly occurs at the bifurcation of the common carotid artery (CCA) and the internal carotid bulbus. Most of the studies have focused on the correlation between the thickness of the carotid intima-media and plaque formation in the coronary arteries (4, 5).

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The majority of studies reported in the literature have used gray scale and Doppler ultrasound imaging, which are easy to perform and do not involve the side effects of ionized radiation. However, ultrasonic waves achieve only limited intracranial penetration. Consequently, ultrasound evaluation of the intracranial segments of the internal carotid artery (ICA) and the vertebrobasilar system is not effective (6). Furthermore, imaging of the ostium of the vertebral artery (VA) and the subclavian artery is more difficult with ultrasound compared to Computed Tomography angiography (CTA) and magnetic resonance angiography (MRA) (7) . Prospective studies using CTA and MRA have investigated both intracranial and extracranial carotid segments (8, 9). CTA has become the most commonly used modality for assessing atherothrombotic cerebrovascular diseases in polyclinics. It is often used to evaluate anterior and posterior circulation of both the extracranial and intracranial arterial structures.

In this study , we investigated whether there was a possible excistance of relationship between the coronary artery stenosis, the Gensini scores that were measured with the initial coronary angiography (CA) and stenosis of the CCA, the ICA cervical and intracranial segments, the bilateral VA, and the basilar artery that was measured with the CTA scan. This study particularly focused on whether CTA should be used in patients with coronary artery disease (CAD) instead of Doppler ultrasound imaging in patients with vertebrobasilar symptoms and potential stenosis of the intracranial ICA .

Matherials and methods

This study was approved by local ethics committee. A retrospective evaluation was conducted of 11.630 patients with CAD who had undergone CA in the cardiology angiography unit between April 2014 and October 2017. Patients under 40 years of age, patients with chronic renal insufficiency, contrast medium hypersensitivity and thyroid dysfunction were excluded from the study. CTA scans of the carotid arteries and the vertebrobasilar system which were taken more than six months following the CA. Using the information systems of the hospital outpatient clinic and the clinical joint patient follow-up program, patients who had undergone intracranial and extracranial CTA examination in the six months following a CA were evaluated. After the exclusion criteria were applied, 109 patients were selected for the study.

CA was performed by an experienced cardiologist. A coronary artery group number was assessed based on the number of major epicardial vessels that were narrowed. ≤50 % coronary artery stenosis was accepted as significant stenosis. Patients were categorized as zero-vessel disease (0-VD) if significant stenosis was not detected in any of the coronary arteries, one-vessel disease (1-VD) if there was significant stenosis in one coronary vessel, two-vessel disease (2-VD) if there was significant stenosis in two coronary vessels, and three-vessel disease (3-VD) if there was significant stenosis in three coronary vessels, respectively. The same cardiologist calculated the Gensini scoring as described in the literature (10).

CTA scans were performed with Toshiba™ Aquillon™ Prime 80 (Toshiba Medical Systems Corporation, Tokyo Japan). The CTA parameters were kV: 120, maS: 80, collimation: 1.25 × 1.25 mm, pitch: 1, FOV: 20 × 30 cm, matrix: 512 × 512, and slice thickness: 0.625 mm. Iohexol (Omnipaque 350/100) was used as an intravenous contrast agent at a rate of 4–6 ml/sec. Raw data was processed by an experienced neuroradiologist in the Sectra PacS system, and multiplanar reconstruction (MPR) images were obtained. The above-mentioned protocol, which was the standard used in our clinic for CTA, was scored by the same neuroradiologist .

The following were evaluated by separate MPR images: both of the CCAs, the ICA cervical and segments, the ICA petrocavernous and supraclinoid segments, the preforaminal (V1), foraminal (V2), atlantic (V3), and intradural (V4) segments of the VA, and the basilar arterial traces. Atherosclerotic plaques were noted as calcific, fibrocalcified, and fibrofatty. Stenosis rates were evaluated using Sectra Pacs vascular analysis software. Vascular stenosis was determined according to the North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria. Arterial stenosis was calculated as follows: $[(Dn–Ds)/Dn] \times 100$, where Dn is a normal distal diameter and Ds is a stenosed diameter (11). Stenosis in the both of the CCAs, the ICA cervical and intracranial segments, the VAs, and the basilar artery were considered significant if arterial stenosis was greater than 50 %.

Statistical analyses were performed with SPSS (Statistical Package for the Social Sciences, Version 17.0.0, SPSS Inc., Chicago, IL, USA). Relationships between related to the data collected for the CCAs, the ICA cervical and intracranial segments, the VAs, and the basilar artery and the coronary artery grouping scores were assessed by chi-squared analysis. Relationships between and the Gensini scoring and carotis and vertebrobasillary system stenosis were assessed by the Mann–Whitney U test. A p value of < 0.05 was accepted as statistically significant.

Results

The mean age of the patients in the study was 65.5 ± 9.2. The maximum age was 85 years, and the minimum age was 42 years (range: 43). Within the study group, 26 of the patients were female, and 83 were male.

The number of patients classified as 0-VD, 1-VD, 2-VD, and 3-VD was 30 (27.5 %), 28 (25.6 %), 24 (22.0 %) and 27 (24.7 %), respectively. The mean value of the Gensini score was 35.0 ± 33.8. The incidence of total oclusion in the left anterior descending (LAD), circumflex (Cx), and right coronary artery (RCA) was 14 (12.8 %), 9 (8.0 %) and 12 (11.0 %), respectively. The descriptive characteristics of the study population are summarized in Tables 1 and 2.

There was no statistically significant difference between stenosis of the CCAs and any of the coronary artery groups. No sta-

Tab. 1. Baseline characteristics of the study population (n=109). Values are presented as n (%) or mean±standard deviation.

Variables	Values
Mean Age, years	65.5±9.2
Gender	83 (76.1) male
Hypertension	74 (67.9)
Diabetes	62 (56.9)
Hyperlipidemia	49 (45.0)
Smoking	38 (34.9)
Hct %	39.36±5.47
Hgb g/dl	12.99±1.93
WBCx10³/uL	7.79±2.51
Plateletx10³/uL	243.81±67.78
Creatinine mg/dl	0.93±0.27
Urine mg/dl	34.75±10.36
Mean Gensini Score	35.0±33.8
0-VD, 1-VD, 2-VD, 3-VD CAS	30 (27.5), 28 (25.6), 24 (22.0) and 27 (24.7)
Total occlusion LAD, Cx, RCA	14 (12.8), 9 (8) and 12 (11)

Hct – Hematocrit, Hg – Hemoglobine, WBC – White Blood Cell, VD – Vessel Disease, CAS – Coronary Artery Stenosis, LAD – Left Anterior Descending, Cx – Circumflex, RCA:Right Coronary Artery

Tab. 2. Severity and prevelance of carotis and vertebrobasillary system stenosis.

	normal	<50%	≥50%	occluded
Right CCA	81 (74%)	25 (22%)	0 (%)	3 (2%)
Left CCA	70 (64%)	38 (34%)	1 (0.09%)	0 (0%)
Right ICA cervical	40 (36%)	29 (%26)	23 (21%)	7 (6%)
Left ICA cervical	41 (37%)	31 (28%)	18 (15%)	9 (8%)
Right ICA intracranial	65 (59%)	33 (30%)	8 (7%)	3 (2%)
Left ICA intracranial	65 (59%)	27 (24%)	11 (10%)	6 (5%)
Right VA	72 (66%)	11 (10%)	17 (15%)	9 (8%)
Left VA	74 (67%)	15 (13%)	16 (14%)	4 (3%)
BA	104 (95%)	2 (%1)	3 (%2)	0 (%0)

CCA – Common Carotid Artery, ICA – Internal Carotid Artery, VA – Vertebral artery, BA – Basillary artery

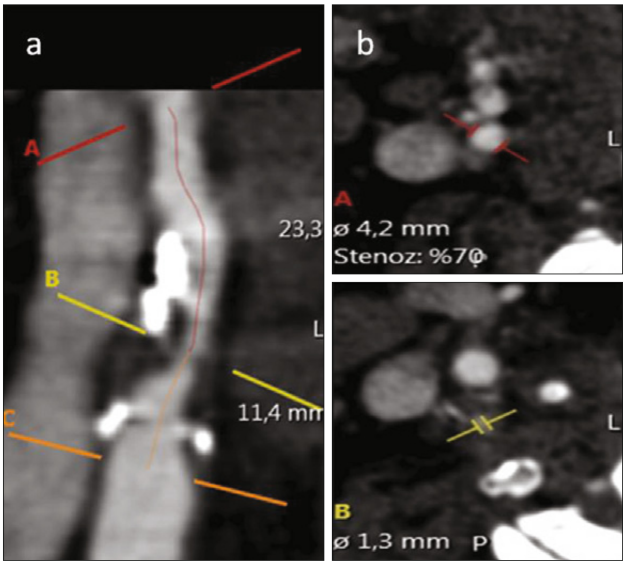

Fig. 1. a) In the MPR vessel analysis, CTA clearly depics the right ICA cervical stenosis at level B, b) according to stenosis analysis axial sections show that stenosis rate was calculated 70 % compared to distal normal ICA segment (level A).

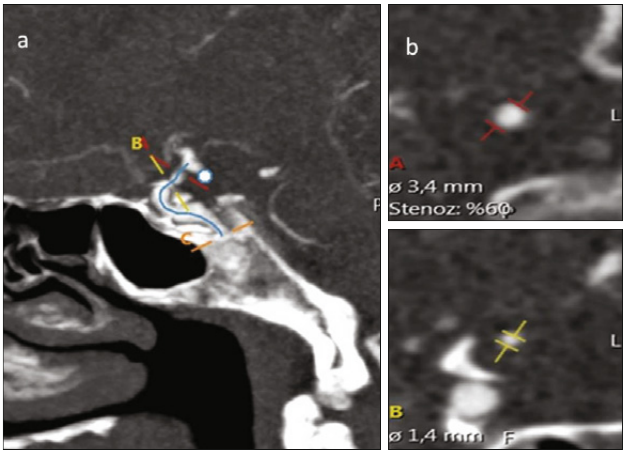

Fig. 2. a) CTA shows the stenosis of the supraclinoid (ophtalmic) segment of right ICA, b) significant stenosis can be clearly seen at level B.

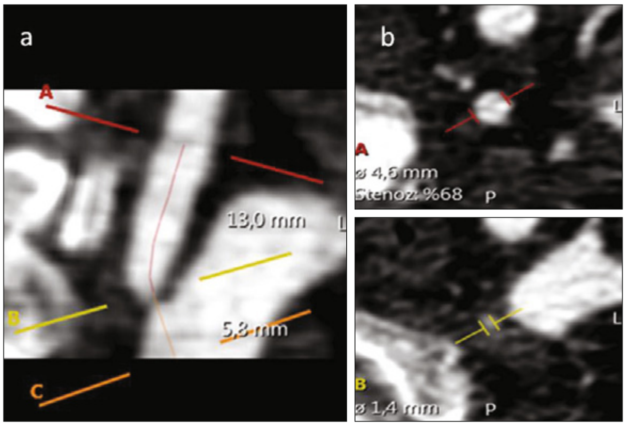

Fig. 3. a) At the level of left Vertebral Artery (VA) preforaminal segment ostium, CTA shows the significant stenosis at level B, b) the stenosis rate was calculated 68 % compared with normal VA lumen at level A.

tistically significant relationship was also determined between stenosis of the right and left ICA cervical segments and coronary artery groups of 0-VD, 1-VD, and 2-VD; whereas those segments did have statistical significance with 3-VD (p = 0.022 for the right ICA cervical segment and p = 0.001 for the left ICA cervical segment) (Figs 1a, b).

The petrocavernous segment was the most frequently involved intracranial segment of both ICAs detected by CTA (n = 11 for the right ICA and n = 17 for the left ICA). There was no significant relationship between the right ICA intracranial segment and coronary artery groups ,of 0-VD and 1-VD, but there was a significant relationship with 2-VD and 3-VD (p = 0.007) (Figs 2 a,b). Although there was no statistically significant relationship between the left ICA intracranial segments and coronary artery groups of 0-VD, 1-VD, or 2-VD, there was a statistically significant relationship with 3-VD (p = 0.02). In both VAs, stenosis was mostly observed in the V1 segment, especially at the ostium (n = 26 for the right VA and n = 23 for left VA). While there was no correlation between stenosis of the right VA and coronary artery groups of 0-VD, 1-VD, or 2-VD, a significant statistical relationship was observed with 3-VD (p = 0.008) (Figs 3 a,b). Left VA and basilar artery stenosis did not show a statistical relationship with coronary vascular disease (p = 0.119 for the left VA and p = 0.17 for the basilar artery). The relationship between carotid-vertebral artery stenosis and coronary artery groups is summarized in Table 3.

In our study, for patients with a coronary artery groups of 3-VD, CTA clearly depicted significant stenosis in 55 % of the right ICA cervical segments, 48 % of the left ICA cervical segments, 22 % of the right ICA intracranial segments, and 37 % of the left ICA intracranial segments. In the posterior circulation, patients with a coronary group of 3-VD also showed narrowing in 40 % of the right VA, 25 % of the left VA, and 7 % of the basilar artery. This demonstrates that in cases of patients with a coronary group of 3-VD, CTA may play an important role in determining the atherothrombotic conditions and treatment options of the carotid and vertebrobasilar systems.

Gensini scoring is an important descriptive method that calculates and summarizes the stenosis in coronary arteries. We also investigated the relationship between stenosis of the carotid and vertebrobasilar system and Gensini scoring. No statistical significance was found between stenosis of the CCAs and Gensini score (p = 0.882 for the right CCA, p = 0.110 for the left CCA). There was a statistically significant relationship between stenosis of both ICA cervical segments and Gensini scoring (p = 0.030 for the right ICA, p = 0.003 for the left ICA). A low statistical significance was found between the stenosis in the right ICA intra-

Tab. 3. Relationship between coronary artery group and carotis-vertebrobasillary system stenosis.

		Coronary artery Groups (n)				Total	p
		0 -VD	1-VD	2- VD	3 -VD		
Right CCA	≤%49	29	27	23	27	106	0.623
	≥ %50	1	1	1	0	3	
Right ICA cervical	≤%49	25	21	17	15	78	0.022
	≥ %50	5	7	7	12	31	
Right ICA intracranial	≤%49	30	26	19	21	96	0.007
	≥ %50	0	2	5	6	13	
Left CCA	≤%49	29	28	24	27	108	0.447
	≥ %50	1	0	0	0	1	
Left ICA cervical	≤%49	28	21	19	14	82	0.001
	≥ %50	2	7	5	13	27	
Left ICA intracranial	≤%49	28	25	20	17	90	0.020
	≥ %50	2	3	14	10	19	
Right VA	≤%49	27	22	18	16	83	0.008
	≥ %50	3	6	6	11	26	
Left VA	≤%49	26	25	18	20	89	0.119
	≥ %50	4	3	6	7	20	
BA	≤%49	30	27	24	25	106	0.170
	≥ %50	0	1	0	2	3	

CCA – Common Carotid Artery, ICA – Internal Carotid Artery, VA – Vertebral artery, BA – Basillary artery

Tab. 4. Relationship between Gensini Scoring and carotis-vertebrobasillary stenosis.

Vessel	Stenosis	Gensini Mean	p
Right CCA	≤%49	35.23±34.21	0.882
	≥ %50	26.83±19.97	
Right ICA cervical segment	≤%49	31.03±34.21	0.030
	≥ %50	44.96±33.84	
Right ICA intracranial segments	≤%49	32.78±34.2	0.049
	≥ %50	51.38±3.22	
Left CCA	≤%49	35.32±33.86	0.110
	≥ %50	0	
Left ICA cervical segment	≤%49	29.61±32.08	0.003
	≥ %50	51.35±34.51	
Left ICA intracranial segments	≤%49	32.34±32.93	0.081
	≥ %50	47.57±36.34	
Right VA	≤%49	33.07±33.99	0.118
	≥ %50	41.13±33.3	
Left VA	≤%49	34.02±33.69	0.495
	≥%50	39.35±35.24	
BA	≤%49	34.14±33.37	0.177
	≥ %50	65.00±45.92	

CCA – Common Carotid Artery. ICA – Internal Carotid Artery. VA – Vertebral artery, BA – Basillary Artery

cranial segments and Gensini scoring ($p = 0.049$). No significant statistical relationship was found between stenoisis of the left ICA intracranial segment, both of the VAs, and the basilar artery and Gensini scoring (Tab. 4).

Discussion:

Our study showed the importance of CTA as a diagnostic tool for the carotid and vertebrobasilary system stenosis in the multi vessel CAD patients. Although the correlation between atherosclerotic changes in the coronary arteries and the arteries of the carotid system has been investigated with different diagnostic modalities, it has rarely been studied with CTA. Atherosclerosis commonly affects the bulb of the ICA cervical segment as well as the coronary arteries. In many studies, Doppler ultrasound imaging has revealed a relationship between stenosis of the cervical segments of carotid arteries and the coronary arteries (12, 13). CA is an invasive procedure for the evaluation of CAD. It is used in patients who have been identified as likely candidates for CAD based on clinical findings, detected myocardial ischaemia, semiology and other risk factors.

CTA plays an important role in diagnosis and evaluation of patients with a high risk of cerebrovascular disease and clinical semiologies. It is also useful in cases of patients with atherothrombotic risk factors. CTA provides high contrast and spatial resolution, as well as accurate differentiation of calcific and fibrofatty plaque compositions. CTA can establish plaque stenosis rates as accurately as conventional digital substraction angiography (DSA). CTA is generally preferred over DSA, because CTA is noninvasive and can depict vascular wall pathologies, plaque morphology, and extravascular tissues in addition to the vascular lumen (14, 15). CTA scans provide vital information to the clinician, as the rate of carotid stenosis and the nature of the atherothrombotic plaque play an important role in determining the course of treatment (15, 16). Atherothrombotic medical therapy, carotid stenting, and endovascular surgery can all be used to reduce the risk of stroke in the atherothrombotic occlusion of the carotid system. CTA also provides an advantage over MRA, in that CTA contrast resolution is higher and it can distinguish calcific-fibrofatty regions in atheromatous plaques (17, 18).

Alkan et al. used DSA in a study of patients who had undergone coronary artery bypass grafting (CABG) due to occlusive CAD. They reported a statistically significant relationship between stenosis in the ICA cervical segment and in the coronary arteries.

They found no statistical significance between stenosis of the ICA intracranial segments, the vertebrobasilar system, and the coronary artery (11). Bae et al. showed similar findings in CABG patients who had been evaluated with MRA (19).

Our results aligned with the studies mentioned above. When the number of narrowed coronary arteries increased, the stenosis rates in the ICA cervical segments (most commonly at the ICA bulb) also rose. However, our study also revealed a significant statistical relationship between stenosis of the right ICA intracranial segments and coronary artery group rankings of 2-VD and 3-VD. A correlation was also identified between stenosis of the left ICA intracranial segments and 3-VD.

Gensini scoring reflects cumulative stenosis rates in coronary arteries. A study by Avci et. al showed a significant relationship between Gensini scoring and carotid stenosis. We discovered similar results, calculating a statistical significance between Gensini scoring and stenosis of both ICA cervical segments (20). Like Avci et al, we also demonstrated that Gensini scoring provides a stronger correlation with carotid stenosis of cervical segments than coronary artery group 3-VD. Our study revealed differences in the correlations between the right and left ICA intracranial segments and Gensini scoring of the coronary artery. A significant statistical relationship was not found between Gensini scoring and stenosis of the left ICA intracranial segments, but Gensini scoring had a low probability value when compared with stenosis of the right ICA intracranial segments. Our study shows that 3 VD coronary artery group may be a better predictor of ICA intracranial segment stenosis than Gensini scoring. According to our study, patients with high Gensini scoring must be evaluated with Doppler ultrasound for strong probability of cervical ICA stenosis.

Rozeman et al. showed that Doppler ultrasound imaging was not as effective as CTA in detecting stenosis of the V1 segment of the VA, particularly stenosis of the ostium (7). Pasaoglu also showed that CTA is useful for detecting the vertebrobasilar system in vertigo patients (21). In our study, the V1 segment of the VA was the most frequently narrowed segment of both the right VA (n = 26) and the left VA (n = 23). A significant statistical relationship was observed between stenosis of the right VA and a coronary artery group of 3-VD. However, this correlation was not seen for the left VA and the basilar artery. There was no significant statistical relationship between Gensini scoring and stenosis of the vertebrobasilar system vessels. According to our study and the related literature, coronary artery groups may be more valuable than Gensini scoring for evaluation of stenosis of the ICA intracranial segments (11, 19).

Although CTA has a number of benefits, its use includes the risks of radiation exposure and contrast agent side effects. The high level of ionizing radiation limits CTA's applicability to any patient. The iodinated contrast media used in CTA may cause hypersensitivity reactions, contrast media-induced nephropathy, or contrast media-induced thyroid dysfunction (22).

Small number of patients included in the study and retrospective design consist of the major limitation of the study . Another limitation was that the findings could not be confirmed with carotis vertebrobasillary DSA, because of the abcense of DSA of patients. Nevertheless, the findings are important. Clinicians should be aware that CAD and cerebrovascular disease share common risk factors, and they should not be deterred from exploring potential links. Although DSA is the gold standard for determining cerebral vascular stenosis rates, CTA provides a noninvasive option that is easy to perform.

Conclusion

CTA should be considered in patients with a coronary artery group of 3-VD, even if lesions in the ICA cervical segments have not been detected with Doppler ultrasound imaging. CTA may also be recommended in patients with suspected narrowing in the ICA intracranial segments. Finally, CTA may provide important information when evaluating the VA ostiums and intracranial segments of patients with a 3-VD , and vertebrobasilar symptoms. High Gensini scoring might be useful for detecting cervical ICA stenosis with Doppler ultrasound.

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