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Angiographic morphometry of internal carotid, external carotid and common carotid artery in Turkish adult

Işık Tuncer
Assiscout Professor, Department of Anatomy, Meram Faculty of Medicine, Necmettin Erbakan University, Meram, KONYA, Turkey

Abstract
Objective: Carotid anthropometry is an important asset in planning Neuroendovascular intervention, especially in cases of placement of stents, flow diverters and Stentrievers. The data on angiographic normative values of carotid circulation in the adult age group is not satisfying enough. The dimensions of ICA (Internal Carotid Artery), ECA (External Carotid Artery) and CCA (Common Carotid Artery) circulation on digital subtraction angiograms of adult patients are the goal of this study.
Material and Methods: The length of ICA, ECA, diameters of CCA in transverse and its length have been measured with CT angiogram. The study group consisted of 49 patients (mean age 49.63± 13.26). Height and weight of patients were measured and their BMI values were calculated. The distribution demonstrated by age-lateralization was imaged depending on strata and location in the carotid system.
Results: SD and mean which have been found in statistical analyses were 49.63 ±13.26 for age, 166.55 ± 6.71 for height, 71.82 ± 7.80 for weight, 26.02 ± 2.70 for BMI, 6.54 ± 0.70 for cctrg (Common Carotid Artery, transvers diameter, right), 6.58 ± 0.77 for cctl (Common Carotid Artery, transvers diameter, left), 7.96 ± 1.27 for cclr (Common Carotid Artery, length right), 8.10 ± 1.23 for ccll (Common Carotid Artery length, left), 6.64 ± 0.95 for iclr (Internal Carotid Artery, length, right), 67.2 ± 0.95 for icll (Internal Carotid Artery, length, left), 4.98 ± 0.83 for eclr (External Carotid Artery, length, right), 5.11 ± 0.88 ecll (External Carotid Artery, length, left). According to lateralization (right-left) all values were higher in left side (p<0.05).
Conclusion: In the light of these findings, by thinking three dimensional damage to internal, external and common carotid artery might be prevented.

Keywords: Internal, external and common carotid artery, morphometry, adult

Introduction

Knowledge of carotid dimensions is important for the performance of neurovascular procedures [1, 2]. Diameter values of cerebral arteries in adult is measured in detail in the literature [3, 4, 5, 6]. Stents for examples are being made according to these dimensional values. But the normal values and growth values of these vessels are not known enough in adult groups.

Increased intima-media thickness (IMT) of carotid arteries may imply expression of carotid vessel and coronary atherosclerosis [7, 8, 9, 10]. While Atherosclerosis-IMT relation is not accepted conclusively, increased IMT and hypercholesterolemia are one of atherosclerosis risk factors [11, 12, 13]. And IMT is related to age, blood pressure, diabetes, years of cigarette usage [12, 14]. According to a study, mean values of carotid IMT in Finnish male-population increased 0.12mm [15].

These risk factors mentioned above might have an effect on progression of atherosclerosis [15-16]. Myointimal hyperplasia or hypertrophy anomalies might increase pathological states related to IMT [17-21]. And surgical injuries related myointimal hyperplasia may be account for IMT increase [22].

To define states of atherosclerosis clinical tests with pharmacological and dietary are been done. Near and far wall B-mode ultrasound imaging of three certain segments of both extra-cranial carotid arteries have been shown in those studies. These segments visualized include proximal segment of internal carotid artery, carotid bifurcation and the last distal centimeter of common carotid artery [23, 24]. The importance of analyzing all visible tracts of the common carotid arteries other than the bifurcation is clearly evident according to several studies that show a relation between common carotid IMT (CC-IMT) and atherosclerosis risk factors [13-20].

In the common carotid arteries the absence of certain anatomic reference points like that exists in the carotid bifurcation and methodological errors of estimation might be limit of the sensitivity for the approach, and so masking or underscoring either spontaneous evolution or changes caused by treatment.

The aim of this study is the morphometric analysis of the internal, external and common carotid artery in an anatomically normal population. And the analysis was performed according to age groups and lateralization. We believe that this analysis will have a significant impact on planning surgical interventions.

Material and Methods

The study was conducted in 2015 – 2016 in Department of Anatomy in Meram Faculty of Medicine, Necmettin Erbakan University with 49 patients, scanned with CT. totally 98 internal carotid, external carotid and common carotid arteries, being 49 right and 49 left, have been examined. Ethical approval for the study was obtained from the ethics committee

of Meram Faculty of Medicine, Necmettin Erbakan University.

Information of age, sex and personal data have been noted on forms. For height measurement from ground to vertex height was assumed. Values were in cm. For weight measurement bascule was used. Afterwards it was time for CT scans. Measurements were performed by contrast agent in supine position.

Patients joined for computed tomography (CT) angiography examination in May, June and July 2016 by the Necmettin Erbakan University Meram Faculty of Medicine, Radiology Department. The 49 patients who scanned with CT angiography were between 19-75 years old. However; 49 patients were included except for 18 patients were not included in the study because of presence of the stents, stenosis, occlusion, plaques or technical reasons.

CT of the patients were performed using dual CT, which consists of double tube system and 64 sections (Somatom Definition; Siemens Erlangen, Germany). The details are as follows; section thickness was 1 mm, NEX1, matrix 256x256, TR-10 msec, TE-4.2 msec, T1-450, FA-15, sequence 3D T1 FSPGR.

Statistical analysis:

The obtained data were analyzed statistically with the help of the SPSS 17 software. The correlations between the different groups were determined with the "Pearson analysis test". Beforehand the usage of paired sample t test"; a normality was assessed for the statistically analysis. In all the statistical analyses; $p<0.05$ was considered statistically significant.

Results

With the two sided measurements on total 49 patients (49 right and 49 left) (age 19-75) 98 carotid systems have been examined. Data obtained by length and diameter measurements have been evaluated statistically. Mean ± SS, t and p values of these parameters according to lateralization (right-left) have been obtained and regulated in a table (Table 1). A significant difference was observed in terms of lateralization ($p<0.05$). All findings were of a greater value in the left side.

Table 1: Comparison of the parameters measured in carotid system according to Lateralization (right, left) (mean ± SD, n= 49 right, n= 49 left) (cm)

	Right mean ± SD	Left mean ± SD	T	DF	P
CCT	6.54 ± 0.70	6.58 ± 0.77	-0.87	49	0.386
CCL	7.96 ± 1.27	8.10 ± 1.23	-2.47	49	0.017
ICL	6.64 ± 0.95	6.72 ± 0.95	-1.8	49	0.77
ECL	4.98 ± 0.83	5.11 ± 0.88	-2.22	49	0.031

The statistical correlations between the studied parameters are given in Table 2-3. Correlation between BMI and parameters of right carotid system excluding CCT was not regarded as significant ($p>0.05$). Correlation of other parameters with each other, excluding CCL-ICL, was regarded as significant ($p<0.05$) (Table 2). Correlation between BMI and parameters in left carotid system was not regarded as significant ($p>0.05$). Correlations of parameters with each other was regarded as significant ($P<.0.05$) (Table 3).

Table 2: Correlation of parameters in right carotid system (CC, IC, EC) (n=49)

	BMI	CCT	CCL	ICL	ECL
CCT	0.084				
CCL	- 0.198	0.409*			
ICL	- 0.028	0.367*	0.509*		
ECL	0.520*	0.613*	0.339*	0.637*	

Table 3: Correlation of parameters in left CC, IC and EC (n=49)

	BMI	CCT	CCL	ICL	ECL
CCT	0.020				
CCL	- 0.121	0.400*			
ICL	- 0.023	0.407*	0.545*		
ECL	- 0.037	0.638*	0.314*	0.629*	

Discussion

Being aware of vascular morphology is important for planning the treatment and for assessment of device performance for endovascular interventions [25]. Mean value of internal diameter of arteries and vascular geometry are important in diagnosis and management of cerebral aneurysms, strokes and ischemia [26].

Of all the intracranial aneurysms (up to 6.8 %) are seen in pediatric age group [27]. And embolic strokes in children and endovascular treatment of them have been reported recently [28-29]. A group of children with aneurysms and embolic stroke might require endovascular management with stents or similar devices that require accurate vascular morphometric measurements for the operation. And data about the morphometry of internal carotid circulation in pediatric age group is insufficient. The data consist of CT and MR angiograms and the most accurate imaging measurements done with the digital subtraction angiograms [30]. Studies on cadavers have some limitations about external diameters of the vessels [25].

In many of the morphometric studies artery measurements in the circle of willis were performed during autopsies [31-35]. In this current study data have been obtained in intraoperative field and by CT angiography, and compared with other data. Supraclinoid part of internal carotid artery begins in the part artery pass over anterior clinoid process to enter subarachnoid space and terminate at the ICA bifurcation, and its average length is 14.8±3.0 mm [32]. We stated the supraclinoid ICA as the distance from the ICA bifurcation to the point where the ICA view becomes obstructed by the ACP, as measured by pre-anterior clinoidectomy. According to cadaveric morphometric study of Evans *et al*. [32] left and right combined mean values of the ICA length removal of the ACP were lesser than the mean values (10.5 ± 2.4 mm) of the supraclinoid ICA in our intraoperative observations. Length values in posterior communicating artery (PCOM) aneurysms (9.7 + 2.8 mm) were significantly lesser than the ones in middle cerebral artery (MCA) bifurcation aneurysms (12.2 ± 1.9 mm) and in anterior communicating artery (COM) aneurysms (13.8 ± 2.2 mm). Marinkovic *et al*. [31] claimed that length values ranging between 8-18.5 mm (average 13.5 mm); this values were, being 16.3 – 3.6 mm, are lesser in our study. Tanriover *et al* [35] claimed that length values of M1 were ranging between 10.1-29.3 mm (average 17.8 mm), also lesser

in our study (20.1 ± 5.3 mm). Rhoton Jr., *et al*. [36] claimed the diameter of the supraclinoid ICA as ranging from 2.5-7.0 mm (average 4.3 mm), which is similar to those (4.2 ± 1.0 mm) in our study. Study of Farımaz *et al*. [37] in CT scan measurements, mean value of the nearest distance of medial walls of the carotid arteries coursing in the cavernous sinus was measured to be 15.8 ± 3.8 mm in females and 17.1 ± 4.7 mm in males. In surgical operations [37], the medial wall of the internal carotid artery will have to be penetrated before an injury could occur to the internal carotid artery coursing in the cavernous sinus. So if abundant venous bleeding is the case in transsphenoidal surgery it is likely to be secondary to the penetration of the cavernous sinus and surgeons must be aware of the course of the internal carotid artery, which is approximately 3 mm away. A negative correlation between age and mean distance between medial walls of internal carotid arteries has been observed.

Other than the intracranial arterial measurements using modern angiographic equipment, 10 adults for related measurements were included in the study. Our limited adult group showed measurements mostly similar to the published literature. This group was included for the purpose of comparison, because of the lack of normative data on carotid and cerebral artery diameters in Turkish population. ICA and cerebral artery diameters of adult were coherent with the values in the literature [38]. Wollschlaeger *et al*. [38] claimed angiographic measurements 2.03 mm for anterior cerebral artery (ACA), 2.87 mm for middle cerebral artery (MCA) and 3.7 mm for ICA. A cerebrovascular geometry study in anterior circulation showed a mean diameter of 5 ± 0.6 mm and 3.6 ± 0.4 mm for cavernous ICA and the ICA terminus measured with computed tomography angiography (39). And it was also reported that mean diameters of 3.1 ± 0.4 mm and 2.4 ± 0 mm at the MCA and M2 origins respectively. No difference were the case according to gender or side. Artery measurements in these studies are similar to magnetic resonance angiography findings of Krabbe-Hartkamp *et al*. [3], and our findings and the findings of Wollschlaeger *et al*. [38] in adults are on the selective angiography, more likely to show values accurately since it is the gold standard for vascular imaging.

As conclusion concerns about the abstinence from stenting in adult groups seems to be righteous for the peripheral circulation rather than the circulation and the current armamentarium of stents or stent-like devices is sufficient to cover the need in the adult population. Although the ability of current devices to cover the need in adults is an indication of such devices should rely on other data but not limited to long-term efficacy and patency rates as well and the need for associated antiplatelet medications. But those are not in the scope of this study.

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