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ORIGINAL ARTICLE

In determining cut-off values for increased carotid intima-media thickness age should be considered

Artmış karotid intima-media kalınlığı için sınır değerleri belirlemede yaş göz önünde bulundurulmalıdır

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ABSTRACT

Objective: Regardless of age and gender, the guidelines are considered to be >0.9 mm as the cut-off value for increased carotid intima-media thickness (C-IMT). In our study, we planned to investigate the effects of age and gender on C-IMT and cut-off values for C-IMT in different age groups.

Methods: 644 patients with a C-IMT measurement of at least 1 cardiovascular risk factor between 20-90 years of age were included. Common and internal C-IMT (CC-IMT and IC-IMT) measurements were obtained from carotid ultrasonography (USG). Patients, included in the study were divided into 5 groups as Group-I (20-40), Group-II (41-50), Group-III (51-60), Group-IV (61-70) and Group-V (>70).

Results: CC-IMT and IC-IMT values significantly increased from Group-I to Group-V. Group I-II-II-IV-V showed median CC-IMT values of 0.70-0.70-0.75-0.75-0.85mm, respectively. IC-IMT median value was 0.60-0.65-0.70-0.70-0.80 mm, respectively. In all groups, the median CC-IMT value was found to be 50µm higher than the median IC-IMT value. Only CC-IMT values were significantly different in males (0.80±0.20 mm vs. 0.76±0.19 mm, p=0.020). Increased age, hypertension (HT), smoking, hyperlipidemia, systolic-diastolic blood pressures and body mass index were found to be associated with increased C-IMT. Increased C-IMT was independently associated with age and HT presence. It was found that age increases every-1 decade and the presence of HT determines the presence of increased C-IMT by 44% and 53%, respectively.

Conclusion: C-IMT significantly increases with age. For this reason, new age-appropriate cut-off values are needed for C-IMT. In addition, CC-IMT values are approximately 50µm higher than IC-IMT measurements in all age groups and CC-IMT should be reported in USG reports.

ÖZET

Amaç: Yaş ve cinsiyetten bağımsız olarak kılavuzlarda artmış karotid intima-media kalınlığı (C-IMT) için sınır değer olarak >0.9 mm kabul edilmektedir. Çalışmamızda, yaş ve cinsiyetin C-IMT üzerine olan etkisini ve değişik yaş gruplarında C-IMT sınır değerlerini araştırmayı planladık.

Yöntemler: Bu retrospektif çalışmaya 20–90 yaş aralığında en az 1 kardiyovasküler risk faktörü olan C-IMT ölçümü yapılmış 644 hasta alındı. Karotid ultrasonografisinde (USG) ana ve internal C-IMT (CC-IMT ve IC-IMT) ölçümleri elde edildi. Hastaların klinik ve demografik parametreleri belirlendi. Çalışmaya dahil edilen hastalar; Grup-I (20-40), Grup-II (41-50), Grup-III (51-60), Grup-IV (61-70) ve Grup-V (>70) olarak 5 gruba ayrıldı.

Bulgular: CC-IMT ve IC-IMT değerleri Grup-I den Grup-V doğru anlamlı olarak artmaktaydı (p<0.05 her biri). Grup I-II-II-IV-V elde edilen ortanca CC-IMT değeri sırası ile 0.70-0.70-0.75-0.75-0.85 mm olduğu bulundu. IC-IMT ortanca değeri ise sırası ile 0.60-0.65-0.70-0.70-0.80 mm idi. Tüm yaş gruplarında, ortanca CC-IMT değerinin IC-IMT değerine göre 50 μm daha yüksek olduğu bulundu. Sadece, CC-IMT değerinin erkeklerde anlamlı olarak farklı olduğu sapandı (0.80±0.20 mm vs. 0.76±0.19 mm ve p=0.020). Yaş ile birlikte, hipertansiyon (HT), sigara içiciliği ve hiperlipidemi varlığı, sistolik-diyastolik kan basınıcı ve vücut kitle indeksi yüksekliği artmış C-IMT ile ilişkili olduğu bulundu. Regresyon analizinde, sadece yaş ve HT varlığı ile artmış C-IMT bağımsız olarak ilişkiliydi. Yaşın her 1-dekat artışı ve HT varlığının sırası ile %44 ve %53 oranında artmış C-IMT varlığını belirlediği tespit edildi.

Sonuç: C-IMT yaş ile beraber anlamlı olarak artar. Bu nedenle, C-IMT için yaşa uygun yeni sınır değerlere ihtiyaç vardır. Ayrıca CC-IMT değerleri tüm yaş gruplarında, IC-IMT ölçümüne göre yaklaşık 50 μm daha yüksektir ve USG raporlarında CC-IMT kullanılmalıdır.

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Abbreviations:

BMI	*Body mass index*
C-IMT	*Carotid IMT*
CAD	*Coronary artery disease*
CC	*Common carotid*
CC-IMT	*Common C-IMT*
CV	*Cardiovascular*
DBP	*Diastolic blood pressure*
DM	*Diabetes mellitus*
HL	*Hyperlipidemia*
HR	*Heart rate*
HT	*Hypertension*
IC	*Internal carotid*
IC-IMT	*Internal C-IMT*
IMT	*Intima-media thickness*
SBP	*Systolic blood pressure*
USG	*Ultrasonography*

Atherosclerosis begins in the tunica intima and media layers of the vessel wall, and changes that occur here causes early increase in intima-media thickness (IMT). In adult patients, IMT evaluation is performed from the common carotid (CC) or internal carotid (IC) arteries by ultrasonography (USG). Carotid IMT (C-IMT) increases in those with cardiovascular (CV) diseases or CV risk factors. Hypertension (HT) due to increased blood pressure, diabetes mellitus (DM) due to glucose intolerance, hyperlipidemia (HL), cigarette causing endothelial dysfunction, coronary artery disease (CAD)-myocardial infarction-stroke presence due to similar risk factors are independent determinants of measurement IMT.[1–14] Therefore, in diseases such as HT and DM, the subclinical target organ involvement or asymptomatic atherosclerosis is diagnosed early with IMT measurement and IMT measurement is recommended by the guidelines.[1,2] In daily practice, IMT evaluation is frequently used and carotid arteries are used most often for this evaluation. The most important reasons for carotid IMT being target IMT according to other regions is that it is superficially localized, easily visualized and most importantly it is due to the fact that there is lots of C-IMT data is in the literature.

In the literature, there are conflicting conclusions about the common C-IMT (CC-IMT) and internal C-IMT (IC-IMT) of the C-IMT measurement site in patients with CV risk factors. In some of these studies CC-IMT increase was assessed. In another part, IC-IMT or bifurcation measurement has been evaluated.[1,3,15–25] All HT, DM, HL and CV protection guidelines are evaluated and there is no clear data with C-IMT measurement site and cut-off values.[1–4] In fact, the CV protection guideline suggests that routine C-IMT measurements should not be performed in subclinical atherosclerosis screening because the cut-off values are unclear.[3] We speculated that the IMT values obtained in CC or IC artery might be different, especially when we observed that the CC-IMT measurement values were higher than the IC-IMT during routine USG. We have not yet found a clear and important data when we look at the literature, including guidelines in this regard. Age and male sex are a risk factor for CV diseases and are associated with C-IMT increase.[9–12] Independent of age and gender, guidelines for increased C-IMT are considered to be >0.9 mm.[1–4] However, and we believe that patients with CV risk factors according to current evidence and clinical experience should have different IMT threshold values in different age groups.

For this reason, we planned to investigate the effect of age and gender on both CC-IMT and IC-IMT and C-IMT cut-off values in different age groups.

METHODS

Study population

This retrospective study included 644 patients (314 males, 330 females and mean age 54.6±14.7 years) who were successfully enrolled in the C-IMT measurement and recorded for C-IMT measurement due to CV risk factors in our Hospital Radiology Clinic between August 2017 and September 2018. All patients included in the study have at least one major CV risk factor. A total of 880 individuals were screened for this study. One-hundred and fifty-six subjects with exclusion criteria were excluded, and 80 subjects (11.1% of the remaining patients) were excluded due to presence of calcific plaques and/or carotid artery stenosis. Patients enrolled for the study were divided into 5 groups as age; Group I= between 20–40 age, Group II= between 41–50 age, Group III= between 51–60 age, Group IV= between 61–70 age, Group V= Age group over 70. Known secondary or malignant HT, carotid artery stenosis, calcific plaques or C-IMT ≥1.5 mm, aortic dissection, congestive heart failure, cerebrovascular disease, severe heart valve disease, inflammatory diseases, hematologic diseases, cancer, pregnancy, active thyroid disorder, renal and liver failure were also excluded from both groups. The Local Ethics Committee approved the study protocol and each participant gave written informed consent.

After a detailed medical history and a complete physical examination, basic characteristics of patients such as age, gender, presence of HT, DM, HL, current smoking status, obesity, body mass index (BMI), heart rate (HR), systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded.

B-mode ultrasonography evaluation for intima-media thickness

The left and right CC and IC arteries were examined with a high-resolution ultrasound system (Philips EPIQ 7) equipped with a 12-5 MHz high resolution linear converter (Philips Health Care, Bothell, WA, USA. All arteries were examined both longitudinally and transversely. All arteries were scanned longitudinally to visualize the IMT on the posterior or distal wall of the artery. All measurements were made on frozen images. Two images of the best quality were selected for analysis on each study. IMT was defined as the distance from the anterior margin of the first echogenic line to the anterior margin of the second line. The first line represents the intima-lumen interface and the second line represents the collagen-containing top layer of adventitia. All IMT values were calculated as averages of six measurements. The patients were examined in the supine position. Patients rotated their heads by 45° from where they were scanned for the examination of the carotid arteries. CC-IMT and IC-IMT were accepted as IMTs measured from 10-20 mm proximal before bifurcation (for the CC artery) and at the distal segment of the right and left main carotid artery in the distal segment after bifurcation (for the IC artery) respectively. (Fig. 1a-d). All USG examination time was approximately 20-30 minutes. Subjects were evaluated by a 1 well experienced radiology specialist for conventional and Doppler USG examinations. Specialist had more than 12 years of experience in USG studies and at least 1000 carotid artery Doppler USG procedures in a year. In our study, as an increased C-IMT with the suggestions in guidelines; CC-IMT or IC-IMT was considered to be more than 0.9 mm.[1–3,26]

Statistical analysis

All analyses were made by using SPSS 22,0 (Chicago, IL, USA) statistical software. The distribution of continuous variables was evaluated and tested for being norm by Kolmogorov Smirnov test. Continuous variables in group data were referred as mean±standard deviation. Categorical variables were referred as number and percentiles. Student t test or One way ANOVA were used to compare continuous variables in groups.

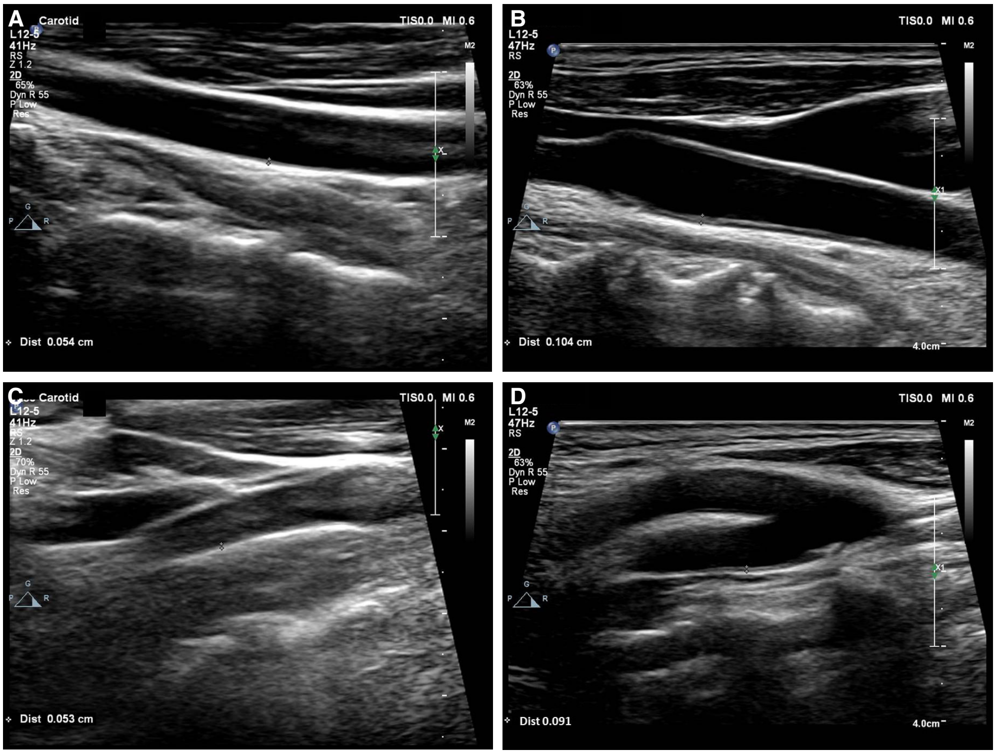

Figure 1. Common and internal carotid intima-media thickness (CC-IMT and IC-IMT) measurement by B-mode ultrasound **(A)** normal CC-IMT measurement as 0.54 mm in Group I; **(B)** increased CC-IMT measurement as 1.04 mm in Group V; **(C)** normal IC-IMT measurement as 0.53 mm in Group II; **(D)** increased IC-IMT measurement as 0.91 mm in Group IV.

While Mann-Whitney U test or Kruskal-Wallis 1-way ANOVA test were used for not normally distributed samples. For normally distributed data, Scheffe and Games-Howell tests were used for multiple comparisons of groups with respect to homogeneity of variances. For non-normally distributed data, Bonferroni adjusted Mann Whitney U test was used for multiple comparisons of groups. Parameters associated with C-IMT were determined with univariate Pearson's and Spearman's correlation analyses. Statistically significant parameters were included in a linear regression analysis, and the parameters having the closest association with the C-IMT were identified. A logistic regression analysis was performed to determine the independent markers among patients with C-IMT over 0.9 mm. The chi-square (χ^2) test was used to compare categorical variables. It was determined as statistically significant if $p<0.05$.

RESULTS

Patients were divided into 5 groups as Group I, II, III, IV and V patients. There were 111 (17%), 147 (23%), 153 (24%), 134 (21%) and 99 (15%) patients in Groups I, II, III, IV and V respectively. Patients were categorized into two main groups: patient with increased CC-IM T (>0.9 mm) or normal CC-IMT (≤ 0.9mm). It was found that 162 patients (25%) had increased C-IMT. Cohen kappa values that evaluate intraobserver variability were over 90% for all C-IMT measurements. All clinical and demographic parameters were compared in both groups (age and C-IMT) (Table 1 and 2).

When clinical and demographic findings were compared among the study groups, presence of HT, DM, smoking and HL were significantly higher in Group V than other groups (Table 1). HR was highest

Table 1. **Clinic and demographic findings according to age groups**

Variable	Group I (n=111)	Group II (n=147)	Group III (n=153)	Group IV (n=134)	Group V (n=99)	*p*
Age (year)	33.9±4.7	44.5±5.4	55.8±2.9	64.6±2.4	77.4±6.0	<0.001
Sex (male/female)	49/62	81/66	80/73	59/75	45/54	0.475
Hypertension, n (%)	43 (39)	81 (55)	67 (44)	72 (54)	59 (60)	0.015
Diabetes mellitus, n (%)	12 (11)	34 (23)	36 (24)	38 (28)	46 (47)	<0.001
Current smoker, n (%)	19 (17)	46 (31)	49 (32)	40 (30)	34 (34)	0.033
Hyperlipidemia, n (%)	15 (14)	31 (21)	40 (26)	47 (35)	47 (48)	<0.001
Obesity, n (%)	12 (11)	37 (25)	33 (22)	26 (19)	16 (16)	0.766
Systolic blood pressure (mm Hg)	127±17$^{\alpha}$	132±14	132±12	133±13	135±14	0.033
Diastolic blood pressure (mm Hg)	79±11	81±11	81±12	80±8	80±8	0.064
Heart rate (bpm)	74±10$^{\alpha,*}$	78±12$^{\mu}$	81±14^{b}	79±15^{d}	87±16	<0.001
Body mass index (kg/m^2)	26.2±2.5	27.4±3.8$^{\mu}$	26.9±3.4	26.1±3.9	25.5±4.3	<0.001
Mean CC-IMT (mm)	0.71±0.17$^{\alpha,\beta,*}$	0.73±0.17$^{\mu,}$⁑	0.78±0.18^{b}	0.82±0.21^{d}	0.87±0.20	<0.001
Median CC-IMT (mm)	0.70	0.70	0.75	0.75	0.85	
Mean IC-IMT (mm)	0.64±0.16$^{\alpha,\beta,*}$	0.69±0.18$^{\mu,}$⁑	0.72±0.17^{b}	0.74±0.22^{d}	0.84±0.20	<0.001
Median CC-IMT (mm)	0.60	0.65	0.70	0.70	0.80	
CC-IMT or IC-IMT >0.9 mm, n (%)	17 (15)	25 (17)	32 (21)	46 (34)	42 (42)	<0.001
Absolute-ΔC-IMT	0.06±0.04	0.05±0.04	0.06±0.05	0.07±0.06	0.04±0.07	0.065

The values were shown as mean±standard deviation or n (%), BMI: Body mass index; CC-IMT: Common carotid intima-media thickness; IC-IMT: Internal carotid intima-media thickness; Absolute-ΔC-IMT: Difference between CC-IMT and IC-IMT (CC-IMT-IC-IMT).
Group I= between 20–40 age, Group II= between 41–50 age, Group III= between 51–60 age, Group IV= between 61–70 age, Group V= Age group over 70.
α: The significant association between the group I and group V ($p<0.05$); β: The significant association between the group I and group IV ($p<0.05$); *: The significant association between the group I and group III ($p<0.05$); ¥: The significant association between the group I and group II ($p<0.05$); *μ*: The significant association between the group II and group V ($p<0.05$)
⁑: The significant association between the group II and group IV ($p<0.05$); a: The significant association between the group II and group III ($p<0.05$); b: The significant association between the group III and group V ($p<0.05$); c: The significant association between the group III and group IV ($p<0.05$); d: The significant association between the group IV and group V ($p<0.05$).

Table 2. The parameters associated with C-IMT and linear regression analysis for parameters significantly correlated with C-IMT

	Univariate analyze		Multivariate analyze	
	p	r	*p*	β
For common carotid intima-media thickness				
Age (years)	<0.001	0.307	<0.001	0.373
Systolic blood pressure (mm Hg)	<0.001	0.257	<0.001	0.191
Diastolic blood pressure (mm Hg)	0.004	0.117	0.939	0.004
Body mass index (kg/m²)	0.010	0.102	0.338	0.047
For internal carotid intima-media thickness				
Age (years)	<0.001	0.325	<0.001	0.369
Systolic blood pressure (mm Hg)	<0.001	0.262	<0.001	0.160
Diastolic blood pressure (mm Hg)	0.001	0.131	0.617	0.024
Heart rate (bpm)	0.022	0.092	0.933	0.004
Body mass index (kg/m²)	0.002	0.121	0.070	0.098

*$R^2_{Adjusted}$=0.183 and 0.195, respectively.

Table 3. Demographic and clinical findings of the subjects with normal and increased carotid intima-media thickness

Variable	Normal C-IMT (n=482)			Increased C-IMT (n=162)			*p*
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			52.7±14.4			60.3±14.4	<0.001
Sex							
Male	226			88			0.061
Female	256			74			
Hypertension	218	45		104	64		<0.001
Diabetes mellitus	116	24		50	31		0.101
Current smoker	130	27		58	36		0.023
Hyperlipidemia	122	25		58	36		0.010
Obesity	87	18		37	23		0.112
Systolic blood pressure (mm Hg)			129±15			135±13	0.001
Diastolic blood pressure (mm Hg)			79±10			81±10	0.010
Heart rate (bpm)			79±14			80±14	0.677
Body mass index (kg/m²)			26.3±3.7			27.2±3.5	0.009

CC-IMT: Common carotid intima-media thickness, IC-IMT: Internal carotid intima-media thickness; SD: Standard deviation.

in Group V and statistical significance was found between Group V and other four groups (Table 1). SBP was significantly higher Group V than Group I. BMI was highest in Group II and statistical significance was found only between Group II and Group V (Table 1).

When the patients are grouped by gender; CC-IMT value was found to be significantly higher in males (0.80±0.20 mm vs 0.76±0.19 mm and p=0.020), similarly, IC-IMT was significantly higher in males than in females, but this difference was not statistically significant (0.73±0.19 mm vs 0.71±0.19 mm and p=0.196).

When carotid USG findings were compared between groups, CC-IMT and IC-IMT values increased significantly from Group I to Group IV (Fig. 2a-d). It was determined that CC-IMT and IC-IMT levels sta-

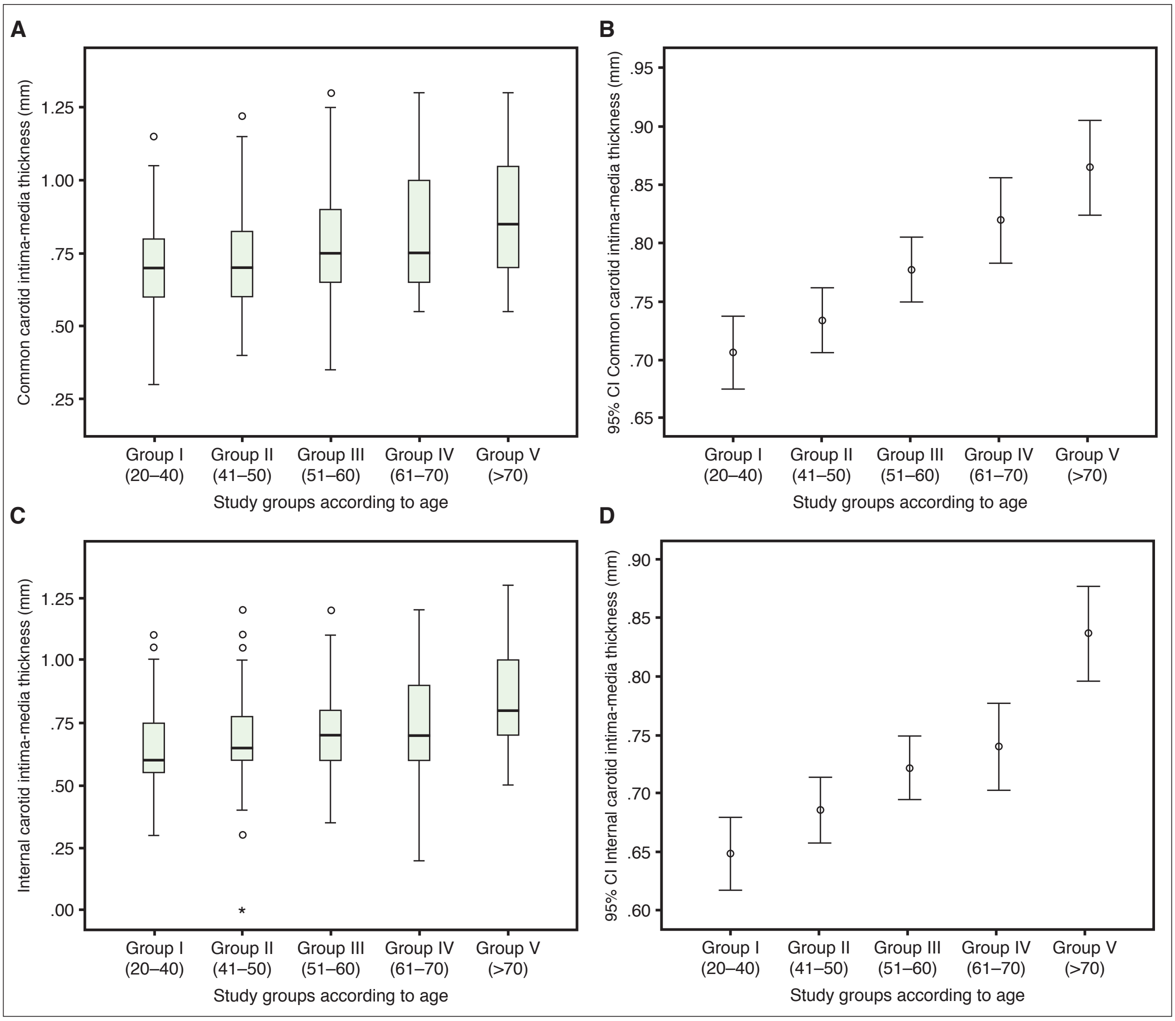

Figure 2. Common and internal carotid intima-media thickness (CC-IMT and IC-IMT) measurement; **(A)** CC-IMT values according to study groups; **(B)** Similar finding with simple error bar (95% Confident Interval for mean value of CC-IMT); **(C)** IC-IMT values according to study groups; **(D)** Similar finding with simple error bar (95% Confident Interval for mean value of IC-IMT).

tistically different between all study groups (Table 1). Presence of increased C-IMT was significantly higher in Group V than other groups (Table 1). Absolute difference between CC-IMT and IC-IMT (Absolute-ΔC-IMT) was similar between all groups.

There was a positive correlation between IC-IMT and age, SBP, DBP, HR and BMI. In these parameters, age and SBP were independent determinants of IC-IMT in linear regression analysis (Table 2, Fig. 3a). Except DBP, similar findings were found for CC-IMT (Table 2 and Fig. 3b).

Age, presence of HT, smoking and HL, SBP, DBP and BMI were significantly higher in the increased C-IMT group, whereas no significant difference was observed for the sex, presence of DM and obesity and HR between two groups (Table 3). The variables that were significantly associated with increased C-IMT in the univariate analysis were entered into logistic regression analyses to predict increased C-IMT. Age and presence of HT were found to be independently

Table 4. Independent parameters for occurrence of increased carotid intima-media thickness

	Odds ratio	95% Confidence interval	*p*
Age (each 1 year)	1.440	1.266–1.639	<0.001
Hypertension (presence)	0.534	0.340–0.840	0.007

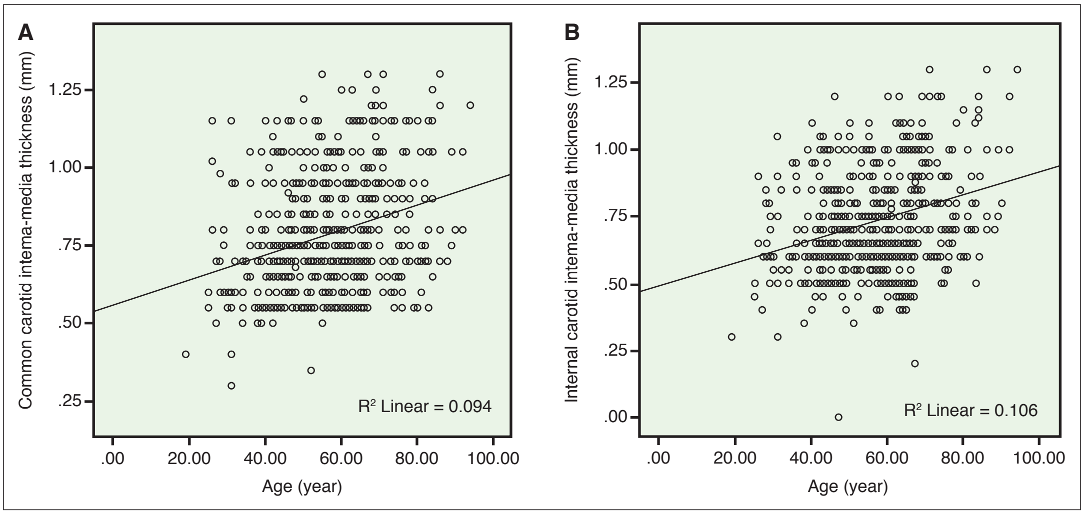

Figure 3. There is significant correlation between age and **(A)** common carotid intima-media thickness (IMT), **(B)** internal carotid IMT.

associated with increased C-IMT. In multivariate logistic analysis, Age (each 10-years) and presence of HT were found to augment the development of increased C-IMT by 44% and 53.4%, respectively (Table 4).

DISCUSSION

The main outcome of this study is the age of the patient, independently determines the C-IMT measurement. The median C-IMT value increases by about 50 μm for each decade after the age of 40 years. Another dramatic finding is that CC-IMT values are found to be 50 μm higher than IC-IMT values in all age groups. CC-IMT values are significantly higher in men like the previous data. Another finding is that, apart from age, among other major risk factors only HT presence is independently associated with increased C-IMT.

The most common causes of death worldwide is atherosclerotic vascular diseases and related CV events. Therefore, atherosclerosis should be detected in the course of subclinical or asymptomatic phase. It is important to diagnose subclinical or asymptomatic atherosclerosis with increasing IMT value. With new USG instruments, high-resolution probes and automated measurement methods, C-IMT can be measured clearer and objective imaging.[27,28] IMT measurements have been shown to be a better predictor of target organ involvement of CV risk factors such as HT, DM, HL, obesity and subclinical atherosclerosis in early stages of these patients without major CV events.[1–4]

The arterial disease and risk factors led us to the peripheral arteries to detect clinical signs and the carotid artery was the most studied area. IMT is not only a premature atherosclerotic zone, but also a smooth muscle hypertrophy/hyperplasia marker. Increased IMT causes increased CV risk regardless of traditional risk factors. With C-IMT, the presence and severity of CAD, MI and stroke are also closely related.[1,21,2,29–32] It has been clearly shown that especially hypertension and other major CV risk factors such as DM, hyperlipidemia, obesity, cigarette consumption, advanced age and male gender prevalence increase C-IMT. The detailed guidelines for diagnosis and treatment of these risk factors have clearly been implicated in the role of IMT measurement in determining target organ damage or subclinical atherosclerosis. C-IMT increase (C-IMT >0.9 mm) in HT patients, carotid wall thickening with other name is closely associated with subclinical or asymptomatic organ damage and atherosclerosis and C-IMT measurement was recommended as a routine examination. Although it is suggested that the C-IMT measurement is recommended in the guidelines for IMT measurement, it is not clear which of the common, internal or bifurcation regions of the carotid artery is important. It is stated in the last HT guideline that measurements in both the main carotid and bifurcation regions are similar without literature support, and are associated with vascular hypertrophy and atherosclerosis, respectively.[1] In the last HT guideline, >0.9 mm C-IMT cut-off value for asymptomatic organ damage was recommended.[1] But in two studies higher IMT values (1.06 mm and 1.16 mm) in elderly patients were reported to be useful in CV risk determination.[33,34] But still in the daily practice and guidelines >0.9 mm are used and these values apply in all age groups. As a matter of fact, this issue was included in the CV disease prevention guideline published in 2016, and the C-IMT screening determined by Carotid USG is not routinely recommended (Class III recommendation).In the same guideline, definition, measurement location and variability of IMT measurement, and the lack of standardization at different times and again in different people have been mentioned. However, with the information obtained from the study and literature review, we think that these problems can be solved with the automatic C-IMT measuring devices in the same patient by using the CC-IMT region only. Dyslipidemia is another major CV risk factor and increases IMT.[4] However, routine C-IMT measurement is not recommended in patients with dyslipidemia, for patients with elevated C-IMT only, appropriate treatment is recommended for the presence and treatment of HL, according to the lipid panel and conclusion.[4] In patients with familial HL, the situation is different, showing that C-IMT is elevated in these patients and is regressed by treatment.[4] For this reason, C-IMT measurement may be recommended following these patients. Consistent with previous studies in our study, there is an association between HL and increased C-IMT but this relationship was not independent in univariate analyzes. DM patients also experience increased oxidative stress and endothelial dysfunction with free oxygen radicals and subsequent IMT increase in vascular remodeling.[2] Increased IMT in DM patients is an important predictor of CV disease and its development.[35,36] C-IMT measurements are recommended for predicting the occurrence of subclinical atherosclerosis or CV disease and CV events such as HT in DM patients.[2,37] In our study, C-IMT increases are associated with DM presence. However, this relationship is not more important than HT.

IMT measurement studies have shown that IMT is higher in male patients than in women.[9–12] However, with increasing age, this difference disappeared and there was no statistical significance in the postmenopausal period.[10] In our study, CC-IMT value in males was significantly higher than females, but this difference was not significant in multivariate analysis.CV risk factors increase with age, CV risk factors increases IMT. For this reason, it is normal to have C-IMT increase in male patients and with increasing age. According to our results, CC-IMT IC-IMT is thicker in all age groups. In our study; presence of HT disease or the presence of elevated SBP is also independently associated with and C-IMT thickness or increased C-IMT status, respectively. Target organ involvement in all age groups of CC-IMT was detected earlier than IC-IMT. In this case, it can be said that CC-IMT is the most prominent vascular localization with arterial stiffness. This finding was consistent with ESC 2013 HT guidelines.

There is still no global standard for carotid IMT measurement, but CV disease and CV are still being used to determine risk. Frequently CC-IMT or IC-IMT is measured in patients who are admitted to radiology clinics for IMT measurement by carotid USG examination. Occasionally carotid bifurcation and very rarely external C-IMT measurements are made. Mean or maximum IMT values from different carotid segments are reported in protocols that vary according to clinics. This difference is also apparent in the studies on C-IMT. In the studies performed, anatomically the average or maximum values of the CC-IMT, IC-IMT or bifurcation region, the right or left carotid artery, or their average or measured anatomical regions are indicated. For this reason, no standard place of measurement and definition can be made.[15–25] Several cohort studies have shown that IMT values measured from all carotid segments identify CV event development in a similar manner.[15,18–20,38,39] In a study conducted, increased IC-IMT value has been shown to better predict CV event development according to CC-IMT.[21] In two studies conducted by Polak et al.,[20,39] IC-IMT mean value and IC-IMT maximal value reported that IC-IMT was more significant while CV was closely associated with disease development.[39] In addition, IC-IMT has been found to better detect CV event development.[20] In an important study, it was reported that CC-IMT was significantly affected by factors such as age and BP, but IC-IMT was not affected by these factors, and it is indicated that IC-IMT is a better CV risk factor and atherosclerosis marker.[7] Our study was not study of CV disease or prognosis. However, in our study both CC-IMT and IC-IMT were associated with age and HT presence. This finding did not support the finding like previous study that IC-IMT did not relate to age and BP.

Study limitations

There are some important limitations in this study. Although the number of patients taken for the study is sufficient this is a retrospective study. Patients were not followed up and there was no efficient data in the effect of the treatment on the IMT. Apart from clinical and demographic data, many clinical and laboratory parameters directly related to IMT have not been evaluated. Among clinical data, the presence or absence of CAD was not shown. Because it is clear that the IMT value is increased by CAD. Among the biochemical parameters, especially hs-CRP, lipid panel and inflammatory markers are associated with increased IMT. These evaluations were not performed because our study was retrospective.[40,41] In addition, we did not evaluate the prognosis of the disease in our study. Although some studies have used carotid artery bifurcation for C-IMT measurement, we did not measure this area because of the anatomic structure of this region and inadequate literature data.[40] The C-IMT can be measured automatically and semi-automatically with new software programs, resulting in a lower average value than the manual measurement.[43,44] This automatic measurement especially removes operator dependence and is more useful for repetitive measurements. However, our high-resolution device did not have this software program so we could not make this evaluation. In our study, if IMT could be measured automatically or semi-automatically, more objective and meaningful results could be obtained.

Conclusion

According to our study and previous studies, IMT values are increasing with age and age is a very important risk factor associated with IMT. However, instead of giving a constant IMT value to determine an increased IMT, it would be better to give a certain cut-off value for the specific age. The median C-IMT value obtained in patients over 70 years of age is close to the guideline value. New border values are needed for patients over 70 years of age, especially if they can be diagnosed with elevated C-IMT. The question of whether IMT assessment should be done from CC or IC artery is still unclear. According to our study results, CC-IMT value is increased without significant increase in IC-IMT (<0.9 mm). CC-IMT is more useful than IC-IMT in showing vascular organ involvement in relatively early stages of CV diseases and risk factors. For this reason, CC-IMT values should be given in the carotid USG examinations required for patient follow-up for target organ involvement, and these values should be used in follow-up and repeat IMT measurement should be done in the same region. These findings according to our clinical knowledge and the vascular anatomy, should be supported by new studies. Guidelines should also be updated in this regard. For this reason, there is a need for new prospective and multicenter studies on this subject.

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Keywords: Advanced age; carotid intima-media thickness; cut-off values.

Anahtar sözcükler: İleri yaş; karotid intima-media kalınlığı; sınır değerler.