RESEARCH

The prevalence and correlation of carotid artery calcification on panoramic radiographs and peripheral arterial disease in a population from the Republic of Korea: the Dong-gu study

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Objectives: The aim of this study was to determine the prevalence of carotid artery calcification (CAC) detected on panoramic radiographs and peripheral arterial disease (PAD), and to evaluate the difference in the prevalence of PAD between patients with CAC and patients without CAC detectable by panoramic radiograph.

Methods: The surveyed population consisted of 4078 subjects aged 50 years and older (1410 males and 2668 females) who underwent medical and dental examination in Gwangju city, South Korea. Two oral and maxillofacial radiologists interpreted the panoramic radiographs for the presence of carotid artery calcification. A trained research technician measured the ankle-brachial index (ABI). An ABI <0.9 in either leg was considered evidence of PAD.

Results: The prevalence of CAC on panoramic radiographs was 6.2% and that of PAD was 2.6%. Subjects with CAC had a significantly higher prevalence of PAD than those without CAC (5.5% vs 2.4%, respectively). The presence of CAC on panoramic radiographs was associated with PAD (odds ratio 1.84; 95% confidence interval 1.01–3.36) after adjusting for potential confounders.

Conclusion: CACs detected on panoramic radiographs were positively associated with PAD in middle-aged and older Korean adults.

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Keywords: carotid artery; panoramic radiography; peripheral arterial disease; ankle-brachial index

Introduction

Atherosclerotic occlusive disease is a diffuse process involving arterial blood vessels leading to ischaemic

vascular events, including peripheral arterial disease (PAD), coronary artery disease and cerebrovascular disease.¹ Cerebrovascular accident or stroke is the second most common cause of death in the Republic of Korea. As the Republic of Korea is one of the countries with a rapidly ageing population, enormous public health issues and socioeconomic burden are caused by stroke and they will grow rapidly in the future.² Several studies have examined the association between vascular risk factors and the presence of

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carotid artery calcification (CAC) on the panoramic radiographs.³⁻⁷

PAD refers to occlusive atherosclerotic disease of the abdominal aorta and the lower extremities.⁸ The prevalence of PAD is largely age related, increasing to more than 10% after the sixth and seventh decades of life. With the general ageing of the population, it seems likely that PAD will become increasingly common in the future.⁹

However, PAD may be underdiagnosed in primary care practice.¹⁰ The ankle-brachial blood pressure index (ABI) is an established clinical test for the assessment of peripheral arterial disease PAD.^{11,12}

In Western countries, the prevalence of a low ABI varied from 3.0% in the Atherosclerosis Risk in Communities (ARIC) study (subjects aged between 45 years and 64 years) to 19.1% in a study in Rotterdam (subjects aged 55 years and more).^{13,14} To the best of our knowledge, there are few epidemiological data for the Korean population. Some clinical studies of PAD were restricted to subjects with Type-2 diabetes mellitus.^{15,16} Therefore, we investigated the prevalence of CAC detected on panoramic radiographs, the distribution of PAD, and its association with CAC detected by panoramic radiographs in a population from the Republic of Korea.

Materials and methods

Study subjects

Data were drawn from the Dong-gu study. The Dong-gu study is an ongoing prospective study that was designed to investigate the prevalence, incidence and risk factors for chronic disease in the urban population. From 2007 to 2010, 34 040 eligible subjects aged 50 years or more residing in the Dong-gu district of Gwangju City in the Republic of Korea were invited to participate through a telephone call. A total of 9260 subjects were enrolled (response rate, 27.2%; 3713 males and 5547 females). Periodontal examination was carried out in 5621 subjects of the 7577 subjects who attended the study between 2008 and 2010. Of these, 5321 subjects received a dental panoramic radiographic examination. Radiographs of 4163 subjects who underwent panoramic radiography had a good image quality and showed an area of interest. 85 subjects were excluded from the study (30 subjects did not have ABI data, 10 subjects did not have lipid data, 10 subjects did not have abdominal circumference data and 35 subjects did not have lifestyle and medical history data). Finally, 4078 subjects (1410 males and 2668 females) were included in the current study.

This study was conducted in accordance with the Declaration of Helsinki guidelines. The study protocol was approved by the institutional review board (I-2008-05-056) of Chonnam National University Hospital, and informed consent was obtained from each subject.

Medical examinations

Information on the demographic characteristics, lifestyle, medical history and hypertension or diabetes mellitus medication use of each subject was assessed with a standardized questionnaire administered by trained staff. Smoking status was classified as never smokers (smoked fewer than 100 cigarettes in their lifetime and were not currently smoking), former smokers (smoked 100 or more cigarettes in their lifetime but currently did not smoke) and current smokers (smoked 100 or more cigarettes in their lifetime and currently smoke). Weight was measured to the nearest 0.1 kg while the subjects were dressed in light clothing. Height was measured to the nearest 0.1 cm with the subject in stocking feet. Body mass index (BMI, kg m^{-2}) was calculated by dividing the body weight (kg) by square of height (m^2). Abdominal circumference was measured with the subject standing, at the level midway between the lower rib margin and the iliac crest. Blood pressure was measured after at least 5 min of rest in the sitting position using a mercury sphygmomanometer. The average of three consecutive readings of systolic blood pressure and diastolic blood pressure taken at 1 min intervals was used in the analysis.

Venous blood samples were collected from subjects following an overnight fast. Serum was separated and stored on site at -70°C until required. Total cholesterol (TC), high-density lipoprotein (HDL) cholesterol and triglyceride (TG) concentrations were examined using a Model 7600 automatic analyzer (Hitachi, Tokyo, Japan).

Panoramic radiographs

All panoramic radiographs were taken using Proline XC (Planmeca Oy, Helsinki, Finland) with a digital sensor. The radiographs were examined by two oral and maxillofacial radiologists for the presence of carotid artery calcifications appearing as heterogeneous radio-opacities in a verticolinear orientation adjacent to the hyoid bone, epiglottis and cervical vertebrae either at, above or below the intervertebral space between C3 and C4 (Figure 1).

Two oral and maxillofacial radiologists interpreted all the panoramic radiographs. Each observer interpreted each panoramic radiograph individually, followed by

Figure 1 Panoramic radiograph shows the radio-opacities in bilateral carotid vasculature area. White arrows indicate carotid artery calcification

a discussion of each film between the two observers. The diagnosis was made when the two observers agreed.

ABI measurement

After having taken at least 5 min of rest in the supine position, the cuffs were attached around both the arms and ankles of the subjects. The BP cuff was used to measure systolic blood pressure of the brachial artery in both the arms and of the left and right posterior tibial arteries and dorsalis pedis arteries in the ankle by using an oscillometric method with the VP-1000 system (Colin Co., Komaki, Japan) (Figure 2). ABI was measured as the ratio of the ankle systolic blood pressure to the arm systolic blood pressure. If ABI of either leg was less than 0.9, the patient was defined as having PAD.

Statistical analyses

Data are presented as mean $\pm$ standard deviation (SD) or as a percentage for categorical variables.

Multivariate logistic regression was used to evaluate the association between CAC and PAD. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated in the unadjusted, age- and sex-adjusted, and multivariate-adjusted models after adjusting for sex, age, BMI, abdominal circumference, smoking, antihypertensive medication, antidiabetic medication, high-density lipoprotein (HDL), triglyceride logarithm, total cholesterol, glucose, systolic blood pressure and diastolic blood pressure. Statistical analyses were performed using SPSS® v. 15.0 software (SPSS, Chicago, IL).

Results

The subjects consisted of 1410 (34.6%) males and 2668 (65.4%) females. The prevalence of CAC and PAD by age group and sex is shown in Figure 3.

General and biochemical characteristics according to the presence or absence of carotid artery calcification are presented in Table 1. The prevalence of CAC on panoramic radiographs was 6.2%. Subjects with CAC were older and had higher BMI, abdominal circumference, triglycerides, total cholesterol, diastolic blood pressure, and antihypertensive and antidiabetic medication use than subjects without CAC ($p < 0.05$). However, HDL cholesterol, fasting glucose and systolic blood pressure were not significantly different between subjects with CAC and subjects without CAC.

Subjects with CAC had a significantly higher prevalence of PAD than those without CAC (5.5% vs 2.4%, respectively; $p < 0.05$).

Table 2 shows the association between CAC detected on panoramic radiographs and PAD. The crude OR showed that the presence of CAC on panoramic radiographs was associated with PAD (OR 2.35; 95% CI 1.32–4.19). When adjusted for sex, age, BMI, abdominal circumference, smoking, antihypertensive medication, antidiabetic medication, HDL, triglyceride logarithm, total cholesterol, glucose, systolic blood pressure and diastolic blood pressure, the strength of the association was attenuated but remained statistically significant (OR 1.84; 95% CI 1.01–3.36).

Discussion

Previous studies have reported the prevalence rate of CACs on panoramic radiographs in the dental patient population in Asia (2.5–4%).^{6,7} The prevalence of CAC in a Korean population was 6.2%. This higher prevalence of CAC might be related to lifestyle. Recent epidemiological studies show that Koreans are more obese and hypertensive than in the past, and that both BMI and diabetes mellitus have also increased.^{17,18}

a

b

Figure 2 Measurement of the ankle-brachial blood pressure index (ABI). BaPWV, brachial-ankle pulse wave velocity; DIA, diastolic blood pressure; haPWV, ascending aorta-ankle pulse wave velocity; L-Ank, left ankle; L-Bra, left brachial; MAP, value from the area of the wave form divided by the amplitude of the pulse (in percentage); PP, pulse pressure; R-Ank, right ankle; R-Bra, right brachial; SYS, systolic blood pressure

Figure 3 Prevalence (%) of carotid artery calcification and peripheral arterial disease by age group (years) and sex

Table 1 General and biochemical characteristics of the study sample

Variable	Total (n = 4078)	CAC (−) (n = 3825)	CAC (+) (n = 253)	p-value
Age (years)	64.5±7.8	64.3±7.7	67.4±7.9	<0.001 ^a
50-59	1257 (30.8%)	326 (23.1%)	931 (30.8%)	
60-69	1778 (43.6%)	624 (44.3%)	1154 (43.6%)	
70-79	940 (23.1%)	411 (29.1%)	529 (23.1%)	
≥80	103 (2.5%)	49 (3.5%)	54 (2.5%)	
Men, n (%)	1410 (34.6%)	1330 (34.8%)	80 (31.6%)	0.308 ^a
Body mass index (kg m ⁻²)	24.1±2.8	24.0±2.8	24.7±2.8	0.001 ^a
Abdominal circumference (cm)	86.4±8.2	86.3±8.1	87.4±8.6	0.012 ^a
Smoking status	2995 (72.5%)	2773 (72.5%)	182 (71.9%)	0.503 ^a
Never smokers				
Former smokers	753 (18.5%)	701 (18.3%)	52 (20.6%)	
Current smokers	370 (9.1%)	351 (9.2%)	19 (7.5%)	
Antihypertensive medication (%)	1404 (34.4%)	1297 (33.9%)	107 (42.3%)	0.007 ^a
Antidiabetic medication (%)	472 (11.6%)	432 (11.3%)	40 (15.8%)	0.030 ^a
Triglycerides, mg dl ⁻¹	138.2±91.7	137.4±90.4	155.8±108.5	0.002 ^a
Total cholesterol (mg dl ⁻¹)	201.7±39.3	201.2±39.1	209.1±41.3	0.002 ^a
HDL cholesterol (mg dl ⁻¹)	51.9±11.7	51.9±11.7	51.8±10.9	0.958 ^a
Glucose (mg dl ⁻¹)	108.5±24.5	108.3±24.4	111.2±25.3	0.068 ^a
Systolic blood pressure (mmHg)	123.2±16.9	123.1±16.9	124.3±17.4	0.305 ^a
Diastolic blood pressure (mmHg)	73.8±10.3	73.9±10.3	72.4±10.7	0.030 ^a
Peripheral arterial disease (%)	107 (2.6%)	93 (2.4%)	14 (5.5%)	0.003 ^a

CAC, carotid artery calcification; HDL, high-density lipoprotein.

Values are mean ± standard deviation for continuous traits and percentages for binary traits.

^ap<0.05 between patients with carotid artery calcification and patients without carotid artery calcification.

Table 2 Logistic regression analysis for the associations between carotid artery calcification and peripheral arterial disease

	PAD (−)	PAD (+)	Crude OR	Model 1 ^a	Model 2 ^b
CAC (−)	3732 (94.0)	93 (86.9)	1	1	1
CAC (+)	239 (6.0)	14 (13.1)	2.35 (1.32–4.19)	1.92 (1.07–3.46)	1.84 (1.01–3.36)

CAC, carotid artery calcification; OR, odds ratio; PAD, peripheral arterial disease.

Values in the parenthesis indicate percentage or 95% confidence interval.

^aAdjusted for sex and age.

^bAdjusted for sex, age, body mass index, abdominal circumference, smoking, antihypertensive medication, antidiabetic medication, high-density lipoprotein cholesterol, triglyceride logarithm, total cholesterol, glucose, systolic blood pressure and diastolic blood pressure.

However, the result of the present study revealed that the prevalence of PAD (a low ABI, 2.6%) is lower than that reported previously in Western populations and Japanese men.^{13,14,19} The prevalence of PAD in females in our study was lower than that in males.

Despite the lower prevalence of PAD in the present study, patients with PAD are four times as likely to have a myocardial infarction, are two to three times more likely to have a stroke, and are at a three times higher risk of death than the general population.^{20–22}

Current guidelines of the American Heart Association recommend the ABI for screening of asymptomatic patients to identify and treat patients with an increased risk of coronary artery disease and stroke.²³ The ABI is an easy to use, inexpensive and reliable tool to identify patients with high atherosclerotic burden and thus at high cardiovascular risk. Among trained investigators, test–retest reliability of the ABI is excellent, and a series of large-scale epidemiological studies have shown a strong correlation between low ABI scores and cardiovascular mortality.²⁴

An ABI <0.9 in either leg is considered as evidence of PAD, and progressively lower ABI values indicate more severe obstruction.²⁵

PAD is a manifestation of systemic atherosclerosis that has developed over many years. The most common symptom of PAD is intermittent claudication (IC), which is defined as pain in the leg(s) upon walking and is relieved by rest. However, non-invasive measures such as the ABI have shown that asymptomatic PAD is several times more common in the population than IC.⁹ PAD is a chronic disease that is underdiagnosed and

undertreated compared with other cardiovascular diseases.¹⁰

The limitation of the present study is that panoramic radiography is not a reliable method for detecting CACs. However, a positive predictive value of 100% per patient and >80% for luminal stenosis in the subgroup of patients with confirmed carotid atherosclerotic occlusive disease indicates that this method may be highly useful for detecting the presence of CAC.²⁶ Also, 23% of patients with radiographically identified atheromas had haemodynamically significant stenotic disease that placed them at an increased risk of developing stroke.²⁷ Dental researchers demonstrated that the presence of CAC on panoramic radiographs often heralds a myocardial infarction.^{3,28} Patients with CAC detectable by panoramic radiography are more likely to have suffered cerebrovascular events.²⁹

In our study, a significant difference was found between CAC and factors including, age, obesity, antihypertensive medication, antidiabetic medication, triglycerides, total cholesterol and diastolic blood pressure.

This present study revealed that CACs detected on panoramic radiographs were positively associated with PAD in middle-aged and older Korean adults (OR 1.84; 95% CI 1.01–3.36).

In conclusion, patients with CAC on panoramic radiographs are more likely to have PAD. The detection of CAC may be a useful marker and predictor for PAD. Furthermore, the detection of CAC and peripheral arterial disease is an important step in the prevention of major life-threatening events such as ischaemic stroke and myocardial infarction.

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