Determinants of Carotid Atherosclerosis in the General Mongolian Population

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Objective: Atherosclerotic risk factors contribute to carotid atherosclerosis. Carotid intima-media thickness (IMT), as assessed using a non-invasive high-resolution ultrasound, can predict cardiovascular disease (CVD). Whereas the control of CVD is crucial for the Mongolian people, the studies on carotid atherosclerosis are lacking. The present population-based survey was a cross-sectional investigation of the determinants of carotid IMT in the general Mongolian population.

Methods: A total of 344 Mongolian volunteers, aged 18 to 69 years, without CVD and on no medication, were recruited from a health screening setting. The current smoking habits, body mass index, mean blood pressure (MBP), blood total cholesterol (TC), glucose, insulin and carotid IMT (maximum level) were measured.

Results: Mongolian males had a significantly higher prevalence of current smoking and a higher level of IMT than females (average= .58 mm in males vs .46 in females). Both a single and multiple regression analysis adjusted for all the measures revealed that IMT was significantly and positively correlated with age, male sex, MBP, TC and glucose among all of the participants. IMT was significantly and positively correlated with age, followed by MBP, TC and glucose among males, while among females, IMT was significantly and positively correlated with age, followed by MBP and TC.

Conclusions: Age was the strongest determinant of carotid atherosclerosis, and the increases in blood pressure and cholesterol levels were also important measures in both sexes as well as glucose levels in males in particular, thus suggesting a preventive strategy for CVD in the general Mongolian population. (*Ethn Dis*. 2010;20:257–260)

Key Words: Age, Blood Pressure, Cholesterol, Glucose, Sex Difference

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Introduction

Atherosclerotic risk factors including age, male sex, smoking, obesity, diabetes mellitus, hypertension and hypercholesterolemia contribute to cardiovascular disease (CVD).[1–4] Carotid atherosclerosis, an increased level in carotid intima-media thickness (IMT), is the surrogate marker for CVD, which is widely useful in clinical practice and preventive cardiological fields with a non-invasive high resolution B-mode.[5–8]

Nationwide statistical data show that the Mongolian people are at a high risk of CVD; one in every five people have ≥3 atherosclerotic risk factors.[9] Since 1991, the mortality rates of CVD have been increasing, and CVD is listed as one of the primary causes of death and an important issue in Mongolian health.[10] Recently, our studies have also demonstrated that the Mongolian people have a high risk of CVD burden; for example, higher levels of body mass index (BMI) and blood pressure than the Japanese people.[11,12] Furthermore, the level of the cardio-ankle vascular index (CAVI), a new marker of arterial stiffness for predicting future CVD, is higher in the Mongolian people.[11,12] In addition, the Mongolian people show more vascular aging, in spite of lower levels of blood total cholesterol (TC) and glucose in comparison to a similar generation of Japanese people.[11] Therefore, based on this unique characteristic of Mongolian people, research on vascular medicine is necessary for this population in particular. The environmental factors (ie, high altitude) and genetic components may be related to their CVD risks.[13–15] However, there has been no investigation concerning the determinants of carotid atherosclerosis.

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Our study examined the relationship between atherosclerotic risk parameters and carotid IMT in the Mongolian population.

Methods

A cross-sectional population-based survey was conducted in Ulaanbaatar city, Mongolia, from 2006 to 2007. A total of 344 Mongolian volunteers (males/females: 131/213), aged 18 to 69 years (mean age: 43.2 years), without CVD and any medication were recruited from the health screening setting. This study was approved by the Ethical Committee of Ministry Health of Mongolia and each volunteer gave their informed consent.

Inclusion criteria for the general population included systolic blood pressure (SBP) of <180 mm Hg, diastolic blood pressure (DBP) of <110 mm Hg, BMI of <35 kg/m^2, TC of <300 mg/dL and glucose of <150 mg/dL. Current smoking was self-reported by a questionnaire. The BMI was calculated as the weight divided by the square of height measured in light indoor clothing without shoes. SBP and DBP were measured

after the patient had at least 5 minutes of rest. Mean blood pressure (MBP) was then estimated as the equation of DBP+([SBP – DBP]/3).[16] A 12-hour overnight fasting serum/plasma specimen was collected by venipuncture, and these samples were stored at −80°C until laboratory assayed. The concentrations of serum TC and plasma glucose were measured enzymatically and insulin was measured by a sandwich enzyme immunoassay (TOSOH Co. Ltd., Tokyo, Japan).

After 5 minutes of rest in the supine position, the IMT on the far wall of common carotid arteries was measured by a high-resolution ultrasound (EH54-9DR system; DIASUS, Scotland, UK) equipped with the linear transducer 10-MHz in B-mode. The highest level of the IMT (referred to as the maximum IMT)[8] in the common carotid arteries were used in the present analyses.

Statistical Analyses

The data are presented as the mean and standard deviation (SD). The data on non-parametric parameters are presented as the median and interquartile range. The non-parametric parameters were used after the log-transformation. Comparisons between the sexes were performed using unpaired *t*-tests (for continuous variables) and the χ^2-test (for categorical variables). The single and multiple linear regression analyses were used for the correlations between IMT and atherosclerotic parameters. In the multiple correlation analyses, age was not included into the models in the respective subgroup analyses if the coefficient was $\geq$0.6 in the single regression analysis for IMT (because it may not appropriately guarantee the linear regression model). All statistical analyses were performed with the Statistical Package for Social Science (SPSS) version 16.0 for Windows (SPSS Inc., Chicago, USA). A $P<.05$ was considered to be statistically significant.

Table 1. Clinical data including carotid intima-media thickness (IMT) in the study population

	All (*n*=344)	Males (*n*=131)	Females (*n*=213)
Age, years	43.2 ± 16.1	42.6 ± 17.0	43.5 ± 15.6
Smoking, % (*n*)	22.4 (77)	39.7 (52)	11.7 (25)*
BMI, kg/m^2	25.9 ± 4.8	25.7 ± 4.8	26.0 ± 4.8
SBP, mm Hg	131.5 ± 21.7	132.5 ± 20.0	130.9 ± 22.7
DBP, mm Hg	82.9 ± 13.5	83.9 ± 13.4	82.2 ± 13.5
MBP, mm Hg	99.1 ± 15.6	100.1 ± 15.0	98.5 ± 16.0
TC, mg/dL	177.1 ± 36.9	173.8 ± 36.3	192.4 ± 38.2
Glucose, mg/dL	95.2 ± 41.1	99.6 ± 45.1	79.2 ± 37.2
Insulin, μU/mL	8.1 [5.2–13.3]	8.6 [5.2–14.5]	7.8 [5.3–11.7]
IMT, mm	.63 [.49–.86]	.70 [.51–1.18]	.61 [.49–.75]*

BMI: body mass index, SBP: systolic blood pressure, DBP: diastolic blood pressure, MBP: mean blood pressure, TC: total cholesterol.
Data are presented as the mean ± standard deviation.
Insulin and IMT only were presented as the median [interquartile range].
Statistical significance between the male and female groups: *$P<.01$.

RESULTS

The prevalence of current smoking and the level of IMT were significantly higher in males than females in this population (Table 1). The IMT was significantly and positively correlated with age, male sex, BMI, MBP, TC and glucose in the single correlation analyses of all subjects (Table 2). The IMT remained significantly correlated with male sex, MBP, TC and glucose in the multiple correlation analyses.

By sex, the IMT was significantly and positively correlated with age, BMI, MBP, TC and glucose among males in the single correlation analyses, and the IMT was confirmed to be independently, significantly and positively correlated with MBP, TC and glucose in the multiple correlation analyses (age could not be entered into the model). The IMT in females was significantly and positively correlated with age, BMI, MBP, TC, glucose and insulin in the single correlation analyses, and the IMT was confirmed to be independently, significantly and positively correlated with MBP and TC in the multiple correlation analyses (age could not be entered into the model).

DISCUSSION

Generally, comparative studies have shown that age and blood pressure is commonly associated with the carotid IMT levels in Asians and Americans.[14,15,17] In addition, BMI and low-density lipoprotein cholesterol are reportedly associated with the IMT in Korean males, and BMI, TC, and glucose in Japanese males.[17] Age and TC, not blood pressure, are associated with the IMT in Chinese people.[15] There have been few studies evaluating the determinants of carotid IMT in different Asian populations in general, and the Mongolian population in particular, who may be at risk for CVD. Our findings, therefore, are likely valuable as basic information to understand the development of CVD in Mongolia.

We found that Mongolian males had a significantly higher IMT level than that of females. This suggests that the males may have a greater CVD risk, and in fact, this appeared to demonstrate more atherosclerotic manifestations in comparison to females. Sex hormones such as estrogen may be reportedly ascribed to the sex difference in the IMT levels.[18]

Our study also found that aging was the strongest parameter for an increase in IMT. The influence level of aging (observed as correlation coefficients) in the present population seemed to be greater than the other ethnic groups (ie,

Table 2. Correlation coefficients of atherosclerotic parameters to carotid intima-media thickness

	All (*n*=344)		Males (*n*=131)		Females (*n*=213)	
Regression model	**Single**	**Multiple**	**Single**	**Multiple**	**Single**	**Multiple**
Age, years	.66 (<.0001)†	ni	.75 (<.001) †	ni	.63 (<.001) †	ni
Sex, male	.19 (.001)*	.18 (<.001) †	ni	ni	ni	ni
Current smoking	.08 (.14)	.00 (.97)	.09 (.33)	.06 (.37)	−.06 (.41)	−.08 (.17)
BMI, kg/m^2	.29 (<.001) †	.03 (.65)	.33 (<.001) †	−.03 (.71)	.29 (<.001) †	.05 (.45)
MBP, mm Hg	.46 (<.001) †	.35 (<.001) †	.51 (<.001) †	.37 (<.001) †	.43 (<.001) †	.37 (<.001) †
TC, mg/dL	.33 (<.001) †	.21 (<.001) †	.47 (<.001) †	.31 (<.001) †	.28 (<.001) †	.14 (.03)*
Glucose, mg/dL	.28 (<.001) †	.11 (.02)*	.37 (<.001) †	.22 (.007)*	.19 (.006)*	.05 (.47)
Insulin, μU/mL	.15 (.006)*	.05 (.35)	.11 (.23)	−.14 (.86)	.17 (.01)*	.11 (.09)

BMI - body mass index; MBP - mean blood pressure; TC - total cholesterol.
P values in parentheses.
Multiple linear regression analyses are adjusted for all the listed parameters.
ni: the parameter is not included into the regression models.
Statistical significance: *$P<.05$, †$P<.01$.

the multiple regression coefficients of age to IMT; .3 in the Korean, .3 in the Japanese, .04 in the Chinese population),[14,17] even though we can not directly compare the data on the association of age to IMT between several studies. It is interesting to note that for the Mongolian people, age is a powerful determinant for the onset of carotid atherosclerosis.

Furthermore, in our study, the MBP and TC were significantly correlated with IMT. The contribution of blood pressure to the IMT is consistent with previous study results.[14,17,19,20] The influence of TC on the IMT is reportedly greater in Asians than in Caucasians.[21] This may partly account for the present study finding of a significant correlation between TC and IMT, while the study population had a relatively low level of TC. Humans experience hyperoxidative stress at high altitudes (eg, Mongolia).[22] Low serum concentrations of TC at high altitude with chronic hypoxia are reported to increase cholesterol infiltration in arterial walls.[23] It is hypothesized that even in a low level of TC, lipids including cholesterol may undergo oxidative modification, leading to the promotion of spontaneous atherosclerosis.[24]

We further showed the level of glucose to be positively correlated with the IMT in males, although, similarly to TC, the glucose level appeared to be relatively low in this study population. The endogenous sex hormones such as testosterone are atherogenic, and the inverse association between testosterone and blood glucose in males is reported.[25,26] This may, in part, have caused the sex difference in the glucose-IMT correlation.

There are some potential limitations to the present study. The cross-section design did not completely determine the causality of atherosclerotic risk factors to carotid atherosclerosis. The study volunteers were mainly from an urban area in Mongolia. The state of CVD development may differ in urban and rural areas in Mongolia. Therefore, a nationwide evaluation will be performed in the near future.

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In summary, our study suggests that age was the strongest determinant of carotid atherosclerosis. Blood pressure and cholesterol levels were also important determinants in both sexes, as were glucose levels for males in particular. Further studies are needed to clarify the mechanism of the roles of atherosclerotic risk factors on vascular health in the Mongolian people.

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