Associations between coronary artery stenosis detected by coronary computed tomography angiography and the characteristics of health checkup examinees in the Republic of Korea

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A B S T R A C T

Introduction: This study was conducted on healthy adults without a diagnosis related to cardiovascular disease to investigate the associations between asymptomatic coronary artery stenosis and the characteristics of health checkup examinees.

Methods: This study was performed on 601 people (320 males and 281 females), who underwent coronary computed tomography angiography (CCTA), among health checkup examinees from January 2, 2015 to December 31, 2016. Those with any prior history of cardiovascular diseases, underwent coronary artery bypass grafting or coronary artery stenting in the past, those with atrial fibrillation, those suspected of contrast agent side effects, and those whose creatinine levels deviated from the normal range were excluded.

Results: The mean age was 58.7 ± 8.0 years. Coronary artery stenosis was detected in 173 people (28.8%), and the mean coronary artery stenosis rate was 25.8 ± 12.8%. Regression analysis showed that coronary artery stenosis was influenced significantly by age, gender, glycated hemoglobin (HbA1c), past smoking duration, current smoking duration, and number of glasses of alcohol consumed (p < 0.05). In terms of the relationship between the presence of coronary artery stenosis and lifestyle habits, amount of alcohol consumed per day (p = 0.03), and patients with a longer period of past (p < 0.001) and current smoking duration (p = 0.01) had a significant effect on coronary artery stenosis.

Conclusion: These results suggest that men aged 60 years or older, who have consumed large amounts of alcohol and cigarettes for a long time, require continuous management through tests such as a health checkup, because of the high probability of coronary artery stenosis, even in those without specific symptoms.

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Introduction

According to the annual report on the cause of death statistics by provinces released by the National Statistical Office (NSO), cardiovascular disease mortality rose by 6.1% compared to the previous year in the order of malignant neoplasm (cancer), cardiovascular diseases, and cerebrovascular diseases. This has resulted in increased interest in coronary artery disease. Most patients who suffer from myocardial infarction or sudden cardiac death, resulting from such coronary artery disease, had mild chest pain or were asymptomatic. As they were asymptomatic, it was difficult for them to be diagnosed early. This is despite the fact that early diagnosis is very important because of the poor prognosis. Although coronary angiography using fluoroscopy is the most accurate method for coronary artery stenosis, invasive treatment, time burden due to hospitalization, and cost are recognized as problems. Multidetector computed tomography (MDCT) can now successfully acquire 3D images of the coronary arteries by tracking the movement of the heart. This technique is considerably less invasive compared to a catheter-based coronary angiograph. Therefore, it can be used extensively to detect diseases, such as coronary artery stenosis. CCTA has been used to determine coronary artery stenosis with high sensitivity, specificity, and accuracy.
Many studies have examined patients with cardiovascular disease symptoms. This study, however, was conducted on healthy adults without a diagnosis related to cardiovascular disease to examine the associations between asymptomatic coronary artery stenosis and the characteristics of health checkup examinees. Therefore, this study examined the association of factors, such as the life habits of health checkup examinees, such as smoking and alcohol consumption, and their physical characteristics, with coronary artery stenosis.

**Materials and methods**

**Subjects**

This study was performed on 601 people (320 males and 281 females), who underwent CCTA, among health checkup examinees from January 2, 2015 to December 31, 2016 in Incheon, Korea. Those with any prior history of cardiovascular diseases, underwent coronary artery bypass grafting or coronary artery stenting in the past, those with atrial fibrillation, those suspected of contrast agent side effects, those with a contraindication to beta-blockers, those who were taking sildenafil or tadalafl, and those whose creatinine (0.6–1.2 mg/dl) levels deviated from the normal range were excluded. This study was approved by the Research Ethics Review Committee of the Health Promotion Research Institute of Korea Association of Health Promotion (NO 130750-201703-HR-003).

**Data collection**

Body mass index (BMI) was classified as underweight (less than 18.5 kg/m²), normal (18.5–24.9 kg/m²), overweight (25–29.9 kg/m²), and obese (more than 30 kg/m²). Blood was taken eight hours after fasting, and the glycated hemoglobin (HbA1c), total cholesterol, and LDL-cholesterol levels were measured using an automatic biochemistry analyzer (HITACHI 7600-110, Japan).

After performing CCTA using 128-slice MDCT (SIEMENS, SOMATOM Definition AS) equipment (Table 1), the images were reconstructed using a TeraRecon program (iNtuition Workflow). A radiologist evaluated the presence (stenosis group) or absence (normal group) of coronary artery stenosis according to the coronary artery stenosis rate (0, >1) in the left anterior descending artery (LADA), left circumflex artery (LCA), left main coronary artery (LMCA), and right coronary artery (RCA) (Fig. 1). When the stenosis rate was different per LADA, LCA, LMCA, and RCA, the heaviest area was used as the stenosis rate.

Statistical analysis was performed using SPSS 22.0 for Windows (NY, IBM Corporation, USA, Chicago). The significance of the factors affecting coronary artery stenosis was tested by examining the difference according to gender using a chi-square test, while the influences of glycated hemoglobin (HbA1c), total cholesterol, LDL-cholesterol, alcohol consumption, and smoking were assessed using a t-test. Logistic regression analysis was conducted to examine the influences of the physical and living characteristics of the health checkup examinees. P values of less than 0.05 were considered indicative of statistical significance.

**Results**

**General characteristics**

Among the 601 subjects, the mean age, BMI, glycated hemoglobin (HbA1c), total cholesterol, and LDL-cholesterol levels were 58.7 ± 8.0 years, 24.8 ± 2.9 kg/m², 5.9 ± 0.9%, 206.8 ± 40.8 mg/dl, and 123.6 ± 39.9 mg/dl. In terms of alcohol consumption, 309 (51.4%) and 292 (48.6%) subjects were included in the drinking and non-drinking group, respectively. The number of alcohol drinking days per week was 2.2 ± 1.6 days, and the amount of alcohol consumed during a single drinking session (number of glasses) was 6.3 ± 4.3 glasses. In terms of smoking, 319 (53.1%) and 282 (46.9%) subjects were non-smokers and smokers, respectively. 153 subjects (25.5%) were included in the past smoking group. The past smoking period was 21.1 ± 10.6 years, and the past smoking amount per day was 17.6 ± 10.3 cigarettes. The current smoking group included 129 subjects (21.5%) with a smoking duration of 28.3 ± 11.1 years, and the current smoking amount per day was 15.6 ± 7.7 cigarettes.

Based on the CCTA, coronary artery stenosis was detected in 173 patients (28.8%), and the mean coronary artery stenosis rate was 25.8 ± 12.8% (Table 2).
Table 2
General characteristics of the person (n = 601).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean (±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age(y)</td>
<td>58.7 ± 8.0</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>320 (53.2%)</td>
</tr>
<tr>
<td>Female</td>
<td>281 (46.8%)</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.8 ± 2.9</td>
</tr>
<tr>
<td>Glycated hemoglobin (%)</td>
<td>5.9 ± 0.9</td>
</tr>
<tr>
<td>Cholesterol (mg/dl)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>206.8 ± 40.8</td>
</tr>
<tr>
<td>LDL</td>
<td>123.6 ± 39.9</td>
</tr>
<tr>
<td>Alcohol drinking</td>
<td></td>
</tr>
<tr>
<td>Non drinking</td>
<td>309 (51.4%)</td>
</tr>
<tr>
<td>Drinking</td>
<td>292 (48.6%)</td>
</tr>
<tr>
<td>Drinking days/week</td>
<td>2.2 ± 1.6</td>
</tr>
<tr>
<td>Drinking amount/day (No. glasses)</td>
<td>6.3 ± 4.3</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
</tr>
<tr>
<td>Non smoking</td>
<td>319 (53.1%)</td>
</tr>
<tr>
<td>Smoking</td>
<td>282 (46.9%)</td>
</tr>
<tr>
<td>Past smoking</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>153 (25.5%)</td>
</tr>
<tr>
<td>Year of past smoking</td>
<td>21.1 ± 10.6</td>
</tr>
<tr>
<td>Smoking amount/d</td>
<td>17.6 ± 10.3</td>
</tr>
<tr>
<td>Current smoking</td>
<td></td>
</tr>
<tr>
<td>Smoking</td>
<td>129 (21.5%)</td>
</tr>
<tr>
<td>Year of current smoking</td>
<td>28.3 ± 11.1</td>
</tr>
<tr>
<td>Smoking amount/day</td>
<td>15.6 ± 7.7</td>
</tr>
<tr>
<td>Coronary artery stenosis</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>428 (71.2%)</td>
</tr>
<tr>
<td>Stenosis</td>
<td>173 (28.8%)</td>
</tr>
<tr>
<td>Stenosis rate (%)</td>
<td>25.8 ± 12.8</td>
</tr>
</tbody>
</table>

a Smoking in the past but no smoking now.
b Smoking from past to present.

Differences in the presence or absence of coronary artery stenosis

Among the 601 examinees, 173 subjects (28.8%) had coronary artery stenosis, of whom 118 (68.2%) were males and 55 (31.8%) were females. Males were 2.1 times more at risk than females and was statistically significant (p < 0.001) (Table 3).

The mean age in the coronary artery stenosis group was 61.6 ± 7.5 years, which was 4.1 years older than the 57.5 ± 7.9 years in the normal group (p < 0.001). The glycated hemoglobin (HbA1c) level in the coronary artery stenosis group was 6.01 ± 0.96%, which was significantly higher than the 5.9 ± 0.8% observed in the normal group (p = 0.05).

Number of alcohol drinking days was similar in the two groups: 2.3 ± 1.6 days in the coronary artery stenosis group and 2.4 ± 1.6 days in the normal group. The amount of alcohol consumed per day was 5.3 ± 4.4 glasses in the coronary artery stenosis group and 4.9 ± 3.8 glasses in the normal group. The incidence of coronary artery stenosis increased significantly with increasing amount of alcohol consumed per day (p = 0.03). In terms of the level of alcohol consumption, the percentage of non-drinking subjects, subjects who consumed seven glasses or less during a single drinking session, and subjects who drank eight glasses or more during single drinking session were 42.8%, 36.4%, and 20.8%, respectively, in the coronary artery stenosis group, whereas they were 54.9%, 33.4%, and 11.7%, respectively, in the normal group. Although the amount of alcohol consumed during a single drinking session was higher in the coronary artery stenosis group, the difference was not statistically significant.

Past-smoking duration was significantly higher in the coronary artery stenosis group (24.9 ± 10.6 years) than in the normal group (18.4 ± 9.8 years), showing an association of coronary artery stenosis with a longer past smoking duration (p < 0.001). Among the current smokers, the smoking duration was 31.7 ± 10.3 years in the coronary artery stenosis group and 26.5 ± 11.2 years in the normal group, indicating a significantly higher incidence of coronary artery stenosis with a longer smoking duration in the case of current smokers (p = 0.01). Regarding the amount smoked per day, there was no significant difference in coronary artery stenosis in both past- and current-smoking groups (Table 4). In terms of total smoking duration, the percentage of non-smokers, less than 10-year smokers, and more than 10-year smokers was 37.0%, 5.8%, and 57.2%, respectively, in the coronary artery stenosis group, whereas they were 59.6%, 6.1%, and 34.4%, respectively, in the normal group. The probability of coronary artery stenosis was significantly high in patients with a more than a 10-year smoking experience (p < 0.001).

In terms of the BMI, the ratios of normal, overweight, and obese were 53.2%, 41.0%, and 5.8%, respectively, in the coronary artery stenosis group, and 55.1%, 39.5%, and 5.4%, respectively, in the normal group. The obesity rate was higher in the coronary artery stenosis group, but the difference was not statistically significant.

In terms of LDL-cholesterol, the percentage of subjects with a normal LDL level of 129 or lower and with a high LDL level of 130 or more were 65.3% and 34.7%, respectively, in the coronary artery stenosis group, and 57.5% and 42.5%, respectively, in the normal group. Although the LDL-cholesterol level was higher in the normal group, the difference was not statistically significant.

In terms of the total cholesterol level, the percentage of subjects with a normal total cholesterol level of 99–199 and with a high total cholesterol level of 200 or more was 50.3% and 49.7%, respectively, in the coronary artery stenosis group, and 43.8% and 56.1%, respectively, in the normal group. Although the total cholesterol level was higher in the normal group, the difference was not statistically significant.

Table 3
Differences in coronary artery stenosis according to gender.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Normal (n = 428)</th>
<th>Stenosis (n = 173)</th>
<th>X²(df) p</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>%</td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Male</td>
<td>202 (47.2%)</td>
<td>118 (68.2%)</td>
<td>21.75</td>
</tr>
<tr>
<td>Female</td>
<td>226 (52.8%)</td>
<td>55 (31.8%)</td>
<td>(1)</td>
</tr>
</tbody>
</table>

Discussion

Many countries have observed a rapid increase in coronary artery disease caused by dietary changes due to industrialization and urbanization. Ischemic heart disease has traditionally been investigated using invasive catheter-based coronary angiography, but complications can occur due to the high radiation doses and other procedure-related risks. In many instances, catheter-based angiography has been replaced with less invasive CCTA which is an alternative method for diagnosing coronary artery disease.

In general, the risk of cardiovascular disease increases with age due to the increased arterial stiffness caused by the structural and functional changes in the blood vessels. Even in the present study, the coronary artery stenosis group was 41 years older. Male subjects (118 people, 68.2%) were 2.1 times more likely to have coronary artery stenosis than female subjects (55 people, 31.8%), showing a similar result to those of other studies. Mikkola TS et al. also reported that the mortality rate due to heart disease was higher in males. The risk of developing coronary artery disease depending on glycated hemoglobin (HbA1c) was also consistent with previous reports. The mean glycated hemoglobin (HbA1c) was 6.0 ± 1.0% in the coronary artery stenosis group, which was higher than the normal level. Cholesterol was reported to be related to coronary artery stenosis; however, there was no significant association with coronary artery stenosis in the present study. This is because the mean total cholesterol level of the subjects was 206.8 mg/dl, which was higher than the normal level, even though the study subjects were general health checkup examinees.

In the present study, the amount of alcohol consumed during a single drinking session, rather than the number of alcohol drinking days per week, was found to be a major factor for developing...
coronary artery stenosis. This was in contrast to Lee et al. because the present study subjects had a larger number of alcohol drinking days per week and a larger amount of alcohol consumption than the subjects examined by Lee et al. The smoking duration also affected coronary artery stenosis. Subjects who had smoked for more than 10 years had a 2.5-fold higher risk of coronary artery stenosis than non-smokers. The smoking amount was more than 3 cigarettes higher in the coronary artery stenosis group than in the normal group, which was not significant. This result was similar to those of other studies. According to Kim et al., more than 90% of patients with confirmed coronary artery disease received a health warning for smoking from their doctors, but only 6% received a specific prescription for non-smoking. An active prescription from a doctor is deemed necessary because smoking is one of the greatest risk factors of coronary artery disease.

van de Wall did not recommend CCTA as a screening test in asymptomatic individuals without clinical suspicion of coronary artery disease. This study was conducted on those who wanted CCTA among health checkup examinees. The limitations of the study were the use of a single hospital dataset and the use of observations from a single radiologist. An analysis of more cases and several joint studies would be necessary to further validate the results of this study.

CCTA using 128 channel MDCT scanner, which is superior to the scanners used in most previous studies, produced accurate results with low radiation exposure to the patients, and the influences of gender, age, blood level, smoking, and alcohol drinking on coronary artery stenosis could be determined in health checkup examinees without specific symptoms.

Conclusion

In terms of the relationship between coronary artery stenosis and the life characteristics of the health checkup examinees (on healthy adults without a diagnosis related to cardiovascular disease), who underwent CCTA, the incidence of coronary artery stenosis was higher in male patients, older patients, patients with higher glycated hemoglobin (HbA1c) levels, patients with a larger amount of alcohol consumed per day, and patients with a longer past and current smoking duration. In addition, the incidence of coronary artery stenosis was greater in the more than 10-year smokers than the smokers with a shorter smoking duration. These results suggest that men aged 60 years or older, who have been drinking alcohol and smoking for a long time, require continuous monitoring, such as a health checkup, because of the high probability of coronary artery stenosis even in those without any specific symptoms.

Conflict of interest statement

The author(s) confirm that this article content has no conflict of interest.

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