Effect of Non-nicotine Cigarettes and Carbon Monoxide on Angina

WILBERT S. ARONOW, M.D.

SUMMARY The effect of smoking five non-nicotine cigarettes and of breathing carbon monoxide on exercise-induced angina was evaluated in 12 patients with angina. Smoking increased venous carboxyhemoglobin from 1.71 to 5.35%, decreased exercise duration until angina 45%, increased ischemic ST-segment depression at angina from 1.33 to 1.52 mm, and decreased systolic blood pressure times heart rate at angina. Breathing carbon monoxide increased venous carboxyhemoglobin from 1.73 to 5.37%, decreased exercise duration until angina 35%, increased ischemic ST-segment depression at angina from 1.31 to 1.50 mm, and decreased systolic blood pressure times heart rate at angina. Greater decreases in exercise duration until angina and in systolic blood pressure times heart rate at angina (p < 0.001) were observed after smoking than after breathing carbon monoxide. Tobacco components other than nicotine or carbon monoxide are responsible for a small decrease in exercise performance until angina.

PATIENTS WITH ANGINA PECTORIS develop anginal pain sooner after exercise following cigarette smoking for at least two reasons: 1) nicotine increases the myocardial oxygen demand and 2) carboxyhemoglobin decreases oxygen delivery to the myocardium. Smoking high-nicotine cigarettes aggravates exercise-induced angina pectoris more than smoking low-nicotine cigarettes. Smoking low-nicotine cigarettes aggravates exercise-induced angina pectoris more than smoking non-nicotine cigarettes.

Tobacco smoke contains more than 4000 known compounds. In addition to carbon monoxide and nicotine, tobacco smoke contains oxides of nitrogen, hydrogen cyanide and carbon disulfide that may play a role in aggravating cardiovascular disease. Therefore, I investigated the effect of smoking five non-nicotine cigarettes and of breathing enough carbon monoxide to produce a carboxyhemoglobin level similar to that after smoking on the duration of exercise until the onset of angina pectoris. The data from this study are reported below.

Materials and Methods

Twelve men, mean age 52.1 ± 5.1 years (± SD), all of whom smoked one package of cigarettes daily, were subjects. Each subject had classic stable exertional angina pectoris and angiographic evidence of coronary artery disease with > 75% narrowing of at least one major coronary vessel. After careful explanation of the risks involved, written informed consent was obtained from all 12 men.

The 12 subjects were familiarized with the equipment and the procedures and practiced exercising upright on a Collins (Warren E. Collins, Inc., Braintree, Massachusetts) constant-load bicycle ergometer before the study began. The study was performed on two consecutive mornings. Smoking was not permitted for at least 12 hours before the study each morning and was not permitted during the study periods except by protocol. The subjects remained in the same area during the study periods and were carefully observed to ensure adherence to the protocol.

On two successive study mornings, at 8 o’clock, with the subject in the fasting state, venous blood was drawn and analyzed for carboxyhemoglobin and hemoglobin levels with a 282 Co-Oximeter (Instrumentation Laboratory, Inc., Lexington, Massachusetts). Then, leads 2 and V5 were simultaneously recorded with an electrocardiograph with the patient sitting on the bicycle ergometer. The resting heart rate was obtained from this ECG. The resting blood pressure was then measured with a mercury sphygmomanometer.

Each subject then exercised upright on the bicycle ergometer with a progressive work load until the onset of anginal discomfort, and the duration of exercise was recorded with a stopwatch. The work load was increased 25 watts every 3 minutes. The initial work load was chosen so that angina pectoris would develop 180–360 seconds after exercise in the control periods. The patient was monitored by telemetry with leads 2 and V5 throughout exercise. An ECG with leads 2 and V5 was simultaneously recorded at the onset of angina pectoris. The heart rate was obtained from this ECG. The blood pressure was recorded at the onset of angina pectoris, with the patient continuing to exercise until the blood pressure was recorded.

Within 2 hours on the first morning, the subject smoked five non-nicotine Mint Bidis cigarettes purchased from a tobacco shop in Los Angeles. These cigarettes were made from Indian herbal leaves. Immediately after smoking the fifth cigarette, the patient sat on the bicycle ergometer and an ECG with leads 2 and V5 was simultaneously recorded. The heart rate was measured from this ECG. Then, the blood pressure was recorded with a mercury sphygmomanometer. Next, venous blood was drawn and...
analyzed for carboxyhemoglobin and hemoglobin levels.

Then, the patient exercised upright on the bicycle ergometer until the onset of angina pectoris, and the duration of exercise was recorded with a stopwatch. An ECG with leads 2 and V5 was simultaneously recorded at the onset of angina pectoris. The heart rate was recorded from this ECG. The blood pressure was recorded at the onset of angina pectoris, with the patient continuing to exercise until the blood pressure was obtained.

On the second morning, the subject breathed 100 ppm of carbon monoxide until the rise in venous carboxyhemoglobin level was identical to that after he had smoked five non-nicotine cigarettes. The patient then sat on the bicycle ergometer and an ECG with leads 2 and V5 was simultaneously recorded. The heart rate was measured from this ECG. The blood pressure was next recorded with a mercury sphygmomanometer. The patient then exercised upright on the bicycle ergometer until the onset of angina pectoris, and the duration of exercise was recorded with a stopwatch.

An ECG with leads 2 and V5 was simultaneously recorded at the onset of angina pectoris. The heart rate was obtained from this ECG. The blood pressure was recorded at the onset of angina pectoris, with the patient continuing to exercise until the blood pressure was obtained.

The ECGs were coded and analyzed in a blind manner after the study was completed. The data were analyzed using the t test for correlated means.

**Results**

Table 1 indicates the duration of exercise until the onset of angina pectoris for each patient and the mean exercise duration in the two control periods, after smoking five non-nicotine cigarettes and after breathing carbon monoxide. Table 1 also presents the statistical analysis of the differences shown. Table 1 shows a reduction in mean exercise duration until angina pectoris after smoking non-nicotine cigarettes and after breathing carbon monoxide (p < 0.001). The decrease in mean exercise duration until angina was greater after smoking non-nicotine cigarettes than after breathing carbon monoxide (p < 0.001).

Table 2 shows the resting heart rate, systolic and diastolic blood pressure, product of systolic blood pressure times heart rate/100, and venous carboxyhemoglobin level in the two control periods, after smoking five non-nicotine cigarettes and after breathing carbon monoxide. Table 2 also presents the statistical analysis of the differences shown. Table 2 indicates no change in mean resting heart rate, systolic or diastolic blood pressure or resting product of systolic blood pressure times heart rate/100 after smoking non-nicotine cigarettes or after breathing carbon monoxide. Table 2 also shows equivalent increases in mean venous carboxyhemoglobin level after smoking non-nicotine cigarettes and after breathing carbon monoxide (p < 0.001).

Table 3 indicates the mean heart rate, systolic and diastolic blood pressure, product of systolic blood pressure times heart rate/100 and the amount of exercise-induced ST-segment depression at the onset of angina pectoris in the two control periods, after smoking five non-nicotine cigarettes and after breathing carbon monoxide. Table 3 also presents the statistical analysis of the differences shown. All 12 pa-
TABLE 3. Mean Heart Rate, Systolic and Diastolic Blood Pressure, Product of Systolic Blood Pressure × Heart Rate/100, and Exercise-induced ST-segment Depression at Onset of Angina in the Control Periods, After Smoking, and After Breathing Carbon Monoxide

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Smoking control</th>
<th>After smoking</th>
<th>Carbon monoxide</th>
<th>After carbon monoxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>129.1 ± 3.9</td>
<td>105.4* ± 6.0</td>
<td>129.3 ± 4.0</td>
<td>110.4* ± 5.5</td>
</tr>
<tr>
<td>SBP (mm Hg)</td>
<td>155.2 ± 10.2</td>
<td>146.6* ± 10.8</td>
<td>154.9 ± 0.7</td>
<td>148.0* ± 10.4</td>
</tr>
<tr>
<td>DBP (mm Hg)</td>
<td>81.7 ± 4.2</td>
<td>82.6 ± 4.0</td>
<td>81.0 ± 3.6</td>
<td>81.8 ± 4.4</td>
</tr>
<tr>
<td>Heart rate × DBP/100</td>
<td>200.4 ± 16.4</td>
<td>154.9* ± 18.4</td>
<td>200.5 ± 15.6</td>
<td>163.7* ± 17.4</td>
</tr>
<tr>
<td>ST-segment depression (mm)</td>
<td>1.33 ± 0.19</td>
<td>1.52± 0.31</td>
<td>1.31 ± 0.24</td>
<td>1.50± 0.35</td>
</tr>
</tbody>
</table>

Values are mean ± SD.
*p < 0.001 after smoking compared with respective control and after carbon monoxide compared with respective control.
†p < 0.005 after smoking minus respective control compared with after carbon monoxide minus respective control.
‡p < 0.005 after smoking minus respective control compared with after carbon monoxide minus respective control.
§p < 0.025 after smoking compared with respective control and after carbon monoxide compared with respective control.

Abbreviations: SBP = systolic blood pressure; DBP = diastolic blood pressure.

The data from this study show that smoking five non-nicotine cigarettes caused a rise in venous carboxyhemoglobin from 1.71 to 5.35%, and a 45% decrease in exercise duration until angina pectoris. After breathing sufficient carbon monoxide to raise the venous carboxyhemoglobin level from 1.73 to 5.37%, the exercise duration until angina decreased 35%. Therefore, the data show that carbon monoxide is the major component in non-nicotine cigarettes responsible for the decrease in exercise duration until angina pectoris. The greater decrease in exercise duration until angina pectoris after smoking the non-nicotine cigarettes than after breathing carbon monoxide (p < 0.001) is attributable to components of tobacco smoke other than nicotine or carbon monoxide.

Smoking non-nicotine cigarettes did not affect the resting product of systolic blood pressure times heart rate and, therefore, did not increase the myocardial oxygen demand. This observation is consistent with previous data.9, 10, 12

The product of systolic blood pressure times heart rate at the onset of angina is a good index of myocardial oxygen delivery.12, 18 I found a reduction in product of systolic blood pressure times heart rate at the onset of angina after smoking non-nicotine cigarettes and after breathing carbon monoxide, findings consistent with previous data.9, 10, 11 The greater reduction in product of systolic blood pressure times heart rate at angina after smoking non-nicotine cigarettes than after breathing carbon monoxide (p < 0.001) is attributable to components of tobacco smoke other than nicotine or carbon monoxide. The data also show that carbon monoxide is the major component in non-nicotine cigarettes responsible for the decrease in product of systolic blood pressure times heart rate at angina and, therefore, probable decrease in oxygen supply to the myocardium.

More ischemic ST-segment depression at the onset of angina occurred after smoking non-nicotine cigarettes and after breathing carbon monoxide than in the control periods. The increases in ischemic ST-segment depression at exercise-induced angina pectoris after smoking non-nicotine cigarettes and after breathing carbon monoxide were similar (p = NS).

Finally, although this study shows that tobacco components other than nicotine or carbon monoxide cause a small decrease in exercise performance until angina pectoris and a small probable decrease in oxygen supply to the myocardium, this study does not clarify which components of tobacco smoke are responsible. Further studies must be performed to investigate the effects of concentrations of oxides of nitrogen, hydrogen cyanide, carbon disulfide, and other components inhaled in tobacco smoke on the cardiovascular system.

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References


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