The Effect of Meals on the Electrocardiogram and the Ballistocardiogram in Patients with Angina Pectoris

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The effect of meals on the electrocardiogram and the ballistocardiogram was studied in 59 patients with angina of effort. Approximately one-fourth of the group showed a 0.5 to 1.0 mm. depression of the S-T segment, while the normal controls did not show this change. Premature ventricular contractions and inversion of the T wave were found more frequently in patients with angina following meals than in normal individuals. The patients with angina were unable to increase the cardiac output significantly following meals as compared to normal individuals. It is suggested that these findings may prove to be of value in evaluating cardiac function in patients with angina.

It has been shown that changes appear in the electrocardiogram of normal individuals following the ingestion of moderate meals. The most important effect of the meals was on the T wave, systole, decreased Q-T interval, and an increased QRS amplitude.

Electrocardiographic tracings of thirty-two patients with angina of effort, from the Outpatient Department of the Cincinnati General Hospital, made thirty minutes following meals showed a 0.5 to 0.75 mm. depression of the RS-T segment, and the development of, or an increase in, the existing concavity of the RS-T segment as compared with tracings made before ingestion of meals.

These findings may well be in accord with those of Moia and others.
Fig. 1.—(Normal subject) Electrocardiograms, made before and thirty minutes following a meal, of a normal 58 year old woman, a hospital attendant. The most important effect is a decrease in the voltage of the T waves.

Fig. 2.—(Patient with angina) Lead I of electrocardiogram, made before and thirty minutes following a meal, showing the development of bigeminal rhythm. All leads showed this change. The patient, G. B., was a 60 year old white man with severe angina.
Battle, who reported alterations characteristic of myocardial ischemia in the electrocardiograms made after meals in 27.2 per cent of the patients suffering with angina, although the criteria used in diagnosing myocardial ischemia were not stated.

In order to study the effect of a standard meal on both the electrocardiogram and cardiac output in patients with angina, ballistocardiograms were also made following meals.

Method

Fifty-nine patients suffering with angina of effort, fifty of whom were patients of the Out-Patient Department and the Medical Service of the Cincinnati General Hospital, were fed ninety-one standard mixed meals, consisting of 90 grams carbohydrate, 40 grams protein, and 40 grams fat. Warm drinks were given with each meal. Twenty normal controls in the same age group, consisting mainly of employees at the Cincinnati General Hospital, and ranging in age from 50 to 70 years, were given similar meals. Electrocardiograms and ballistocardiograms were made in both groups before meals and thirty minutes following the meals; the subjects rested fifteen minutes before ballistocardiograms were made. The electrocardiograms included limb leads, six standard unipolar chest leads, and augmented unipolar extremity leads. Only patients who gave a typical history of precordial pain on exertion, relieved by rest or nitroglycerin, were included in this study. Fifty-seven patients had coronary arteriosclerosis, and a large number of these had evidence of previous myocardial infarctions. One patient had rheumatic heart disease, and one patient had syphilitic heart disease. Their ages ranged from 43 to 70 years.

Electrocardiographic Results

Table 1 shows the average difference in electrocardiographic findings in the patients with angina and the control subjects, before meals and thirty minutes following meals.

Approximately 25 per cent of the patients with angina showed a 0.5- to 1.0-mm. depression of the RS-T segment, and the development of, or increase in, existing concavity of the RS-T segment. In some of the patients the segment shift occurred in one or more of the limb leads, while in others the change was apparent only in one or more of the V leads. No member of the control group showed a shift of the RS-T segment. In 10 patients extrasystoles occurred, while this change was not noted in the controls. In 20 per cent of the patients with angina, inversion of the T wave appeared following meals in one or more of the leads. One of the members of the control group showed T-wave inversion following the meal. This change was found in Lead III.

In 2 patients with angina, amplitude of the
Fig. 4.—(Patient with angina) Electrocardiograms made while the subject was fasting and thirty minutes, sixty minutes, and ninety minutes following a meal. This patient was a 50 year old Negro woman with hypertensive, arteriosclerotic heart disease, and angina. The electrocardiogram did not demonstrate return to the fasting state until sixty to ninety minutes after the meal.
Fig. 5.—Electrocardiograms, made before and after a meal on patient with angina, showing depression of the RS-T segments in Leads I and II and in the V leads, with increase in the pre-existing concavity of the RS-T segment. The patient was receiving digitalis therapy.

Fig. 6.—Electrocardiograms of a patient with angina made before and following a meal. Lead II shows the depression of the RS-T segment following the meal.
T wave increased following the meal. Both of the patients showing increased voltage of T waves following meals had severe angina, and one patient died while asleep. Five of the patients with angina complained of chest pain following the meal, and these patients showed no distinct alterations in the electrocardiogram as compared to other members of the group.

Figure 1 shows electrocardiograms of a normal subject made before and thirty minutes following a meal. Figures 2 to 7 show electrocardiograms of patients with angina made before and after meals.

**Ballistocardiographic Results**

In 23 patients, ballistocardiographs were made before and following meals. Five patients with angina, not in congestive failure, in whom the tracing conformed to a normal pattern, showed the ballistocardiographic changes following meals which are summarized in table 2.

In 18 patients with angina, the ballistocardiograms were distinctly abnormal in pattern, and since the formulas for abnormal patterns have not been derived the cardiac output could not be calculated. Of these 18 patients, however, only 4 showed a slight increase in amplitude following meals, while 3 patients had decreased amplitude in the ballistocardiogram. Eleven patients with angina showed no apparent change in amplitude following meals.

![Electrocardiograms before and after meal](image)

**Figure 7.**—Electrocardiograms of a patient with angina made before and thirty minutes following a meal. The T wave in Lead II has become diphasic.

**Table 2.**—Ballistocardiographic Changes before and following Meals in Patients with Angina, not in Congestive Failure, and in Control Subjects.

<table>
<thead>
<tr>
<th>Before Meals (Liters/Min) Angina (not in congestive failure)</th>
<th>30 Minutes Following Meals (Liters/Min.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.4</td>
<td>8.2</td>
</tr>
<tr>
<td>5.7</td>
<td>5.1</td>
</tr>
<tr>
<td>5.2</td>
<td>4.8</td>
</tr>
<tr>
<td>6.9</td>
<td>7.0</td>
</tr>
<tr>
<td>6.7</td>
<td>6.5</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>32.9</td>
<td>31.6 (-14%)</td>
</tr>
</tbody>
</table>

**Controls**

| 5.8                                                          | 6.6                                      |
| 4.1                                                          | 7.7                                      |
| 7.1                                                          | 6.5                                      |
| 5.8                                                          | 6.1                                      |
| 6.0                                                          | 8.4                                      |
| 4.8                                                          | 6.6                                      |

|                                                          |                                          |
| 34.6                                                         | 42.9 (+24%)                              |

Ballistocardiograms, made before and thirty minutes following a meal, of a normal individual and a patient with severe angina are shown in figures 8 and 9 respectively.
Fig. 8.—(Normal subject) Ballistocardiograms, made before and thirty minutes following a meal, showing normal response to meal with increase in cardiac output. The patient, C. G., was a nurse 52 years of age. She had no organic heart disease.

Fig. 9.—(Patient with angina) Ballistocardiograms, made before and thirty minutes following a meal, showing decrease in cardiac output. The patient was a 53 year old white machinist with severe angina. He died while asleep.
Discussion

It is of interest that no member of the control group showed an RS-T shift following the meals, in contrast to the appearance of depressed RS-T segments in 25 per cent of the patients with angina. The greater frequency of premature ventricular contractions and T-wave inversions in the group with angina, as compared to the control group, may be significant.

In normal individuals it has been pointed out that the ingestion of food results in an increased cardiac output, varying from 0.5 to 2.0 liters in different individuals, depending upon such factors as size and composition of the meals. In our series the average cardiac output following meals increased 1.4 liters (24 per cent) in the control group, while the patients with angina, not in congestive failure, failed to show a significant change. The inability of the patients with angina to increase the cardiac output significantly following meals seems striking enough to suggest that this finding may be utilized in attempting to evaluate cardiac status in patients with angina. In general, the ballistocardiographic results were more informative than the electrocardiographic findings.

Many authors have pointed out the extra-cardiac influences exerted on the coronary arteries, and von Bergman and Gilbert and associates have shown that coronary flow may be reduced by distention of the stomach or abdominal cavity. Gilbert, Fenn, and Le Roy also have shown that atropine is able to improve the after-meal tolerance for 10 per cent oxygen in patients with angina. Studies are now in progress to determine the influence of atropine on the after-meal electrocardiogram and ballistocardiogram in patients with angina. Preliminary work tends to substantiate Gilbert's view that increased incidence of anginal pain following meals need not be explained solely by increased cardiac work, but may well be explained in part by reflex coronary vasoconstriction as a result of gastric or abdominal distention.

Summary

1. In 59 patients with angina of effort, 25 per cent showed a 0.5- to 1.0-mm. depression of the RS-T segment, and the development of, or an increase in, the existing concavity of the RS-T segment, following meals. Normal controls did not show this change.

2. Premature ventricular contractions and inversion of the T wave were found more frequently in patients with angina following meals than in normal individuals. This finding may be significant.

3. The patients with angina were unable to increase the cardiac output significantly following meals as compared to normal individuals. It is suggested that this finding may prove to be of value in evaluating cardiac function in patients with angina.

REFERENCES


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