SUMMARY Two hundred and twenty patients were selected for testing with the patient-activated Pocket Electrocardiograph (PECG) because angina pectoris and similar diagnoses could not be excluded. They were selected during a 30-month period from the population of approximately 12,000 new patients visiting a general medical clinic at Nippon Medical School Hospital. The test confirmed the preliminary diagnosis in 79.1%: 9.6% were not confirmed and 11.3% did not have an attack during the PEGC examination. The PEGC examination is useful in the differential diagnosis of angina pectoris, cardiac neurosis, phantom arrhythmia, and arrhythmia when the routine ECG examinations are essentially negative.

THE DIAGNOSIS OF ANGINA PECTORIS is frequently complicated by the absence of positive ECG findings. To diagnose these patients it is useful to have an ECG taken during the attack. With the conventional ECG equipment such a recording is almost impossible if the attacks are infrequent and last for short periods of time. In view of the potentially dire consequence of misdiagnosing angina pectoris, many expensive, invasive, and potentially hazardous diagnostic tests have been devised to assist in its diagnosis. The Holter equipment that records the patient's ECG for 24 hours and is similar to the Pocket Electrocardiograph (PECG) has proved useful.1,2,3

To make accurate diagnosis of the cases in which there are episodes of palpitation, chest pain, or other varieties of cardiac attacks, the obtaining of an electrocardiogram during the episodes is indispensable.

With this in mind, we have developed a pocket electrocardiographic recorder1 which can be activated by the patient. The system best suited to this purpose involves the recording of the electrocardiogram with a magnetic tape cassette and its later reproduction for diagnostic examination.

In the present study, we postulate that various kinds of cardiac attacks are accurately diagnosed by an ECG record taken during an attack. It should be recognized, however, that because the PEGC uses a single modified V1 lead, up to 10% of the true ischemic responses which could be detected by additional bipolar leads or a true X, Y, and Z axis system may be missed.4

**Design of the PEGC System**

The PEGC system is designed to be light, compact, easy to operate, shock-resistant, comparatively free of waveform distortion, and inexpensive.1

The Zuiko Pearlcorder (Olympus Optical Co. Ltd.), the portable recording unit carried by the patient, uses two mercury batteries providing eight hours of continuous operation. An automatic INST (instant-acting) circuit in the CR coupling stage assures that recording can begin within one second after the unit is switched on.

The ECG amplifier of the recorder features a differential input with input impedance of 5 megohms, time constant of 1.5 seconds, frequency response characteristic of 0.1 to 100 Hz, -3 db at 100 Hz, and input levels of 4mV and 8mV for maximum modulation (fig. 1).

The magnetic recording equipment uses a pulse-width modulation system with a carrier frequency of 400 Hz, minimizing wow and flutter normally resulting from low tape speed.

The demodulator uses a frequency discriminator, eliminating malfunctions due to amplitude-modulation noise. Demodulator output is fed to 1) an oscilloscope for display on a cathode ray tube, or 2) a regular heated-stylus recorder for registration on a chart (fig. 2).

The system uses a bipolar chest lead, with disposable electrodes attached to the patient’s chest with paste at C5 (different electrode) and C5R or C6R (indifferent electrode). The electrodes are connected to the portable recording unit by wire leads. The patient is instructed in the operation of the recorder and told to turn it on in the event of a cardiac attack. He returns the recorded tape for reproduction and evaluation every two to three days.

**Method**

In January 1975 the authors reviewed all patients who had been tested with the PEGC in the general medical clinic during the previous 30 months including 100 who participated in the initial study.1 They reviewed the diagnosis of each patient at the time of first examination, following PEGC testing, and the diagnosis as of January, 1975. It was the practice of the clinic to select for testing with PEGC all patients suspected of having angina pectoris who had a negative resting ECG and a negative exercise ECG.

The patients attending the clinic were reviewed. The population characteristics of the patients tested using the PEGC were studied. Maintenance and repair requirements of the equipment were examined. Patients with a preliminary diagnosis of angina pectoris have been followed up to reconfirm diagnosis made by PEGC examination.

**Population Studied**

Out of 100,000 patients who visited the general medical clinic during the 30-month study period starting in April of
1972, there were approximately 12,000 new patients. Of some 3,000 new patients who were referred for cardiovascular disease evaluation, 220 with negative ECG were selected for testing using the pocket electrocardiograph (PECG). These patients consisted of 142 males and 78 females, ages ranging from 11 to 78, whose chief complaints were chest pain, precordial oppression, discomfort, palpitation, and arrhythmic attacks.

Table 1 shows the preliminary diagnosis distribution by age and sex of the 220 patients. In the group of angina pectoris, 45 were male and 7 female, a ratio of 6:1. The high incidence with respect to age is from 50 years to 69 years. In the other groups there are more males than females. The distribution by age displayed no constant trend.

Results

Table 2 shows the results of a comparison of the preliminary diagnosis and the diagnosis following PECG test in the 220 cases. Of 52 patients with a preliminary diagnosis of angina pectoris based upon history and physical examination, 43 (84.2%) were diagnosed as true angina pectoris following PECG test. The PECG findings of these cases showed either ST-segment depression or elevation of 0.1 mV during attacks. Seven of the remaining nine patients with preliminary diagnosis of angina pectoris were diagnosed as arrhythmias following PECG and in two cases no attacks occurred during PECG test. Patients with arrhythmia were presumed to have phantom arrhythmia as described by Coraday et al.8 There were five cases of ventricular bigeminy and two cases of transient atrial fibrillation — these had no change of ST segment. The PECG tests proved useful in establishing diagnosis or discriminating so-called phantom arrhythmia in cases in which ECG could not be recorded during the attack although there was a suspicion of angina pectoris.

There were 16 cases with preliminary diagnosis of chest pain where the diagnosis of angina pectoris could not be excluded. Twelve (75.0%) claimed they had an attack, but showed no abnormal findings during PECG test. One case proved to be transient right bundle branch block (RBBB) on PECG. Cine-coronary angiography was performed in this case and the patient was found to have normal coronary arteries.

Three patients had no attacks during PECG test.

There were 69 patients who were given a preliminary diagnosis of arrhythmia but the diagnosis of angina pectoris could not be excluded. They included patients with irregular pulse, palpitation, precordial discomfort, and dizziness. In fifty-four (78.3%) cases the diagnosis was confirmed following PECG as arrhythmia. The cases which were confirmed as arrhythmic attack by PECG are classified as follows: 37 cases of atrial and ventricular premature contraction, six cases of atrial fibrillation, three cases of atrial flutter, six cases of paroxysmal tachycardia, one case of complete A-V block, and one case of sick sinus syndrome. The PECG permitted a more specific diagnosis than could be made at the time of preliminary diagnosis.

There were four cases confirmed as arrhythmia in which dizziness was included in the preliminary complaints. One was recognized as complete A-V block by PECG and a pacemaker was implanted. Two cases were transient atrial fibrillation. One case was sick sinus syndrome.

Of the remaining 15 cases with a preliminary diagnosis of arrhythmia, six patients showed no abnormalities on the PECG during attack. In the remaining nine cases there was

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**Table 1. Distribution of the 220 Cases by Age, Sex, and Preliminary Diagnosis**

<table>
<thead>
<tr>
<th>Age</th>
<th>M</th>
<th>F</th>
<th>M</th>
<th>F</th>
<th>M</th>
<th>F</th>
<th>M</th>
<th>F</th>
<th>Total</th>
</tr>
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<td>0</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
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<td>3</td>
<td>6</td>
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<td>20-29</td>
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<td>0</td>
<td>0</td>
<td>3</td>
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<td>10</td>
<td>5</td>
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</tr>
<tr>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>4</td>
<td>10</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>40-49</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>11</td>
<td>11</td>
<td>11</td>
<td>29</td>
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<td>50-59</td>
<td>20</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>7</td>
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<td>60-69</td>
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<td>4</td>
<td>2</td>
<td>3</td>
<td>13</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>22</td>
</tr>
<tr>
<td>70-79</td>
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<td>1</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
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<td>9</td>
<td>7</td>
<td>41</td>
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<td>69</td>
<td>83</td>
<td>220</td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
no attack recognized by the patient during the PECG test, so the preliminary diagnosis of arrhythmia could not be confirmed.

There were 83 cases with a preliminary diagnosis of cardiac neurosis. These patients complained of various kinds of symptoms: palpitation, breathlessness, oppressive sensation, inframammary pain around the left chest wall.

In 65 cases (78.3%) the PECG test permitted the patient's physician to be more confident of his clinical impression that the patient's complaints did not result from arrhythmias or myocardial ischemia. In some of these patients the PECG showed an increase in the heart rate or sinus tachycardia, ST-segment changes, or ectopic cardiac rhythms falling within the normal range. In some of the patients, heart rates during the attack were less than when the patient's original resting ECG was taken. Of the remaining 18 cases, six were found to have arrhythmias and one demonstrated ST-segment abnormalities which led to a diagnosis of true angina pectoris. The remaining 11 patients had no symptomatic attacks during PECG testing and thus no useful information was obtained.

There were 174 confirmed diagnoses following PECG out of 220 patients tested (79.1%). Preliminary diagnosis of angina pectoris showed the highest confirmation percentage (84.2%), although at time of preliminary diagnosis these patients had negative ECG tests.

In 21 cases (9.6%) the diagnosis was not confirmed following PECG test (Table 3).

In 25 cases (11.8%) there was no attack during the PECG test. In the cases with a preliminary diagnosis of angina pectoris there were only two patients with no attack, much less than other preliminary diagnostic groups. Diagnoses of patients with preliminary diagnosis of anginal pain were confirmed most frequently by PECG test.

The PECG System performed with a minimum amount of maintenance and repairs during the study period. Availability of equipment, rather than technical performance or diagnostic requirements, was the primary factor influencing how often the PECG was used.

Comparison of Holter Instrument with PECG

The purpose of this study is to observe the clinical and mechanical performance of the PECG. The more difficult and expensive task of making a clinical comparison with the Holter instrument was not addressed. However, a brief comparison of the physical characteristics should be helpful.

Holter's portable ECG recording instrument is also used in this clinic. It records continually for 24 hours. PECG can record for 60 minutes. The patient activates the PECG at time of attack, shortly after the attack begins.

Four patients whose preliminary diagnosis was arrhythmia apparently experienced attacks of such short duration that they were unable to activate the PECG to record evidence of abnormal cardiac activity. Detailed questioning of these patients revealed that the attacks may have been caused by premature contractions. The physicians might have gained more information if these patients had been recorded by Holter's instrument.

For the remaining 191 patients who experienced attacks, abnormal findings were recorded and diagnoses were established. Presumably little additional information would have been obtained using the Holter's instrument.

Table 4 shows a comparison of the features of the PECG and Holter's System. PECG weighs 410 g (Holter's ECG 1,600 g) and measures 85 mm x 22 mm x 150 mm (Holter's ECG 120 mm x 45 mm x 240 mm).

Because the PECG taping process is activated only at the onset of an attack, time required for analysis is minimal.

Table 3. Diagnosis of 21 Cases in which PECG Test Did Not Confirm Preliminary Diagnosis

<table>
<thead>
<tr>
<th>Preliminary diagnosis</th>
<th>Angina pectoris</th>
<th>Other chest pain</th>
<th>Arrhythmia</th>
<th>Cardiac neurosis</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis following use of PECG</td>
<td>7</td>
<td>*</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other chest</td>
<td>1</td>
<td>0</td>
<td>*</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>*</td>
<td>2</td>
</tr>
<tr>
<td>Cardiac neurosis</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>6</td>
<td>*</td>
</tr>
<tr>
<td>Total</td>
<td>21</td>
<td>1</td>
<td>0</td>
<td>13</td>
<td>2</td>
</tr>
</tbody>
</table>
Conversely, the Holter system records for up to 24 hours and requires expensive equipment and a technician to select abnormal portions of a lengthy recording for review by the physician.

The Holter system also records during asymptomatic periods and during onset of attacks. The diagnostic value of this additional information would require further study.

**Discussion**

Some of the reasons for a negative exercise ECG at the time of preliminary examination are: 1) The attacks occurred infrequently and when the patient was at rest and were therefore not precipitated by physical stress. 2) The attacks were angina pectoris of effort, but only occurred when associated with cold weather or when walking followed eating. 3) Some of the handicapped and the old patients did not exert enough physical effort. 4) There were infrequent arrhythmic attacks not stimulated by exercise.

The PECG is useful in differentiating anginal attacks from arrhythmic attacks as noted in the report of results.

For effective therapy of the arrhythmic patient it is essential to determine the etiology of the arrhythmia. This is done best by taking an ECG at the time of attack. Hence PECG is useful for this type of patient.

Physicians are reluctant to make the diagnosis of cardiac neurosis without extensive diagnostic testing, which may be very hazardous or expensive for the patient. When the physician finds a negative ECG recorded when the patient says he is having an attack, this helps justify a diagnosis of cardiac neurosis and may preclude the need for further diagnostic work.

Shumack et al., Semler et al., and Water et al. reported cases of secondary transient cerebral ischemic attacks due to arrhythmic attacks. The above statements suggest that PECG tests are effective as diagnostic tests to discriminate transient dizziness or syncope due to heart disease from other causes. There are some cases in which PECG was useful in diagnosing patients who because of age, handicaps, or old myocardial infarction, were reluctant to perform the exercise test. Diagnosis of these patients using the PECG results in rehabilitation of increased numbers of myocardial and stroke patients.

More experience may identify new technical problems in the use of the PECG, and where and when it can be of greatest diagnostic assistance. It appears that the PECG equipment may be of greater assistance to physicians who have had limited experience in diagnosing cardiovascular disease. The simplicity of the equipment permits physician use with essentially no additional technical training or assistance.

**Acknowledgment**

The authors are grateful to Fred Frazier and Elise Overholser of the Missouri Regional Medical Program for their assistance in the preparation of this manuscript.

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Circulation. 1976;53:939-942
doi: 10.1161/01.CIR.53.6.939

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0009-7322. Online ISSN: 1524-4539

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