Clinical Significance of Low Voltage in Asymptomatic Patients With Pericardial Effusion Free of Heart Disease*

Yoshihiro Kudo, MD; Fumiyasu Yamasaki, MD; Tadafumi Doi, MT; Yoshinori Doi, MD; and Tetsuro Sugiura, MD, FCCP

**Study objective:** The purpose of this study was to evaluate the diagnostic value of low voltage with PR-segment and ST-T wave changes in determining the amount of clinically silent pericardial effusion detected in a routine echocardiography.

**Design:** Consecutive case series analysis.

**Setting:** Noninvasive cardiology department of a university hospital.

**Patients:** Among 8,041 consecutive patients referred to our echocardiography laboratory, 121 asymptomatic patients with pericardial effusion free of heart disease were studied.

**Interventions:** Echocardiography and ECG.

**Measurements and results:** The amount (small or moderate/large) of pericardial effusion was correlated with ECG. Among 121 patients with pericardial effusion, low voltage was detected in 32 patients (26%), while widespread PR-segment depression was observed in 32 patients (26%) and widespread ST-segment elevation in 8 patients (7%). Although there was a significantly higher incidence of low voltage in patients with moderate/large pericardial effusion compared to that of small pericardial effusion, 13 of 32 patients (41%) with low voltage had a small pericardial effusion. In patients with a small pericardial effusion, 7 of 13 patients (54%) with low voltage had PR-segment depression, while 15 of 85 patients (18%) without low voltage had PR-segment depression; the difference was significant (p = 0.011). In patients with moderate/large pericardial effusions, there was no significant difference in the incidence of PR-segment depression between patients with and without low voltage (47% vs 25%, respectively; p = 0.791).

**Conclusions:** In the presence of PR-segment depression, even a small pericardial effusion may cause low voltage in the surface ECG.

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**Key words:** ECG; echocardiography; pericardial effusion

Low voltage is one of the ECG manifestations of pericardial effusion, but it is not specific or sensitive enough to diagnose the presence of pericardial effusion.1–5 ST-segment elevation and PR-segment depression are two sensitive and, with an appropriate distribution, quasispecific ECG signs of acute pericarditis that may occur in patients with inflammatory pericardial effusion.1,6–8 Although echocardiography is the procedure of choice for the detection of pericardial effusion, it does not clearly demonstrate the two major pathophysiologic bases causing excessive pericardial fluid: fluid exudation due to pericardial inflammation or to fluid retention in the presence of hemodynamic abnormalities (hydropericardium).1 Therefore, it is important to consider the ECG changes associated with the occurrence of pericardial effusion. Accordingly, we designed a study to determine the diagnostic value of low voltage with PR-segment and ST-segment changes in evaluating the amount of pericardial effusions in normal hearts.

**Materials and Methods**

**Patients**

Among 8,041 consecutive patients who were referred to our echocardiography laboratory between January 15, 1996, and July...
12, 2002, we investigated 121 clinically stable asymptomatic patients (aged 19 to 98 years) with pericardial effusion in sinus rhythm, and no ECG and echocardiographic evidence of heart disease. Patients with sinus tachycardia (> 120 beats/min) were not included in this study. Informed consent was obtained from all the patients before the study procedure.

Electrocardiography

M-mode and two-dimensional echocardiography were performed with a Toshiba SSH 160A phased-array sector scanner (Toshiba; Tokyo, Japan) using 3.75-mHz or 2.5-mHz transducers by an experienced echocardiographer. Echocardiography was obtained with the patients in the 45° left lateral decubitus position, and all classic views were recorded on videotape for subsequent analysis by observers who were unaware of the ECG data. Anterior and posterior pericardial effusions were measured as the maximal diastolic epicardial-pericardial separation recorded at the level of the tip of the mitral valve; however, anterior separation was considered significant for effusion only in the presence of a posterior echo-free space. Pericardial effusion was classified as a small (pattern C with > 0.5 mm), moderate (pattern D with 0.5 to 20 mm), and large effusion (pattern D with > 20 mm) described by Horowitz et al. and Weitzenz et al. Detailed chart review was performed to assess the most likely causes for pericardial effusion in each patient. Pericardial effusion secondary to malignant disease, connective tissue disease, hypothyroidism, and renal disease was diagnosed when these conditions were present in the absence of other possible causes of effusion.

ECG

A 12-lead ECG was performed within 24 h of echocardiography. Low voltage in the limb leads was defined as a QRS amplitude of < 5 mm in all limb leads, and low voltage in the precordial leads was defined as a QRS amplitude of < 10 mm in all precordial leads.4 In this study, we chose to define low voltage as patients who had low voltage in limb leads alone or those who had it in both limb and precordial leads. PR segment was assessed by using a magnifying glass and at least 0.5 mm of PR-segment depression from the TP segment in both limb leads (more than two leads in leads I, II, aVL, and aVF) and precordial leads (more than two leads in V5 through V6) were considered diagnostic of PR-segment depression. ST-segment elevation was defined as ≥ 0.5 mm from the TP segment in both limb leads and precordial leads except in aVR and V1. Low voltage, and PR-segment and ST-segment deviations were considered present only after being diagnosed by two cardiologists who had no knowledge of the clinical findings. In case of disagreement, consensus was established with a third observer.

Statistical Analysis

Results are reported as mean ± SD. Statistical analysis between the two groups was performed by Student t test for continuous variables and Fisher exact probability test for discrete variables; p < 0.05 was considered significant.

RESULTS

Clinical Characteristics

Sixty-nine patients had malignant disease, 24 patients had connective tissue disease, 17 patients had hypothyroidism, and 11 patients had renal disease (chronic renal failure or nephrotic syndrome) [Table 1]. Ninety-eight patients had small pericardial effusions, and 23 patients had moderate or large pericardial effusions. No patient had clinical or echocardiographic evidence of cardiac tamponade.

Low Voltage

Among 121 patients with pericardial effusion, low voltage was detected in 32 patients (26%). There were no significant differences in age, sex distribution, and heart rate between patients with and without low voltage (Table 2). Although there was a significantly higher incidence of low voltage in patients with moderate or large pericardial effusion compared to that of small pericardial effusion (p < 0.001), 13 of 32 patients (41%) with low voltage had a small pericardial effusion. Thirty-two of 121 patients (26%) with pericardial effusion had PR-segment depression, and 8 patients (7%) had ST-segment elevation in the leads of epicardial derivation. There were significantly higher incidences of PR-segment depression and ST-segment elevation in patients with low voltage compared to those without low voltage (p = 0.001 and p < 0.001, respectively).

PR-Segment Depression

None of the patients with hypothyroidism or renal disease had widespread PR-segment depression and ST-segment elevation (Table 3). In contrast, 36% with malignant disease and 29% with connective tissue disease had PR-segment depression, while 9% with malignant disease and 8% with connective tissue disease had ST-segment elevation.

Eight of 32 patients with PR-segment depression had ST-segment elevation, but none of the patients with isoelectric PR segment had ST-segment elevation.

Table 1—Etiology of Pericardial Effusion

<table>
<thead>
<tr>
<th>Diseases</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignant</td>
<td>10</td>
</tr>
<tr>
<td>Lung cancer</td>
<td>10</td>
</tr>
<tr>
<td>Breast</td>
<td>4</td>
</tr>
<tr>
<td>GI cancer</td>
<td>10</td>
</tr>
<tr>
<td>Other cancers</td>
<td>32</td>
</tr>
<tr>
<td>Leukemia</td>
<td>13</td>
</tr>
<tr>
<td>Connective tissue</td>
<td></td>
</tr>
<tr>
<td>Systemic lupus erythematosus</td>
<td>10</td>
</tr>
<tr>
<td>Dermatomyositis</td>
<td>2</td>
</tr>
<tr>
<td>Progressive systemic sclerosis</td>
<td>3</td>
</tr>
<tr>
<td>Rheumatoid arthritis</td>
<td>9</td>
</tr>
<tr>
<td>Hypothyroidism</td>
<td>17</td>
</tr>
<tr>
<td>Renal disease</td>
<td></td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>7</td>
</tr>
<tr>
<td>Nephrotic syndrome</td>
<td>4</td>
</tr>
</tbody>
</table>

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pericardial effusion. Among clinically stable patients between ECG abnormalities and the amount of should be considered when evaluating the relation the accumulation of excessive pericardial fluid however, two major pathophysiologic bases causing pressure of fluid or superficial myocarditis1

or injury of the underlying myocardium by the effusion can be attributed to the presence of effusion

18%, respectively; p 0.011). In contrast, in patients with moderate or large pericardial effusions, there was no significant difference in the incidence of PR-segment depression between patients with and without low voltage (47% vs 25%, respectively; p 0.791). Among the patients with isoelectric PR segment, low voltage was present in 8% with a small pericardial effusion, whereas 77% of patients with a moderate or large pericardial effusion had low voltage; the difference was significant (p < 0.001).

**DISCUSSION**

The ECG abnormalities produced by pericardial effusion can be attributed to the presence of effusion or injury of the underlying myocardium by the pressure of fluid or superficial myocarditis1–6,11; however, two major pathophysiologic bases causing the accumulation of excessive pericardial fluid should be considered when evaluating the relation between ECG abnormalities and the amount of pericardial effusion. Among clinically stable patients referred to our echocardiographic laboratory for cardiac assessment, low voltage was detected in 26%. In contrast to the low incidence of widespread ST-segment elevation (7%), we found that 26% of patients had widespread PR-segment depression. These data indicate that the incidence of low voltage and PR segment depression are not rare in patients with a clinically silent pericardial effusion.

ECG diagnosis of acute pericarditis requires widespread J-ST elevation (stage I ECG change), but stage I ECG changes are frequently not recorded in patients with acute pericarditis.5,12 Widespread PR-segment depression in limb and precordial leads is almost as characteristic of an ECG sign of pericardial inflammation as the classic ST-segment deviations.1,6–8 The diagnostic significance of PR-segment depression in patients with pericardial involvement is that PR-segment depression could be detected in patients with isoelectric ST segment (stage II ECG change of pericarditis) and diagnosed in patients having ST-segment changes due to bundle-branch block.9–8

Myocardial interstitial fluid is the source of pericardial fluid,13 and fluid flux at the level of the microvascular membrane is governed by hydrostatic and osmotic pressure generated in the microvessels and interstitium. The factors related to the occurrence of noninflammatory pericardial effusion are hemodynamic factors, increased capillary permeability, lymphatic obstruction, low colloid osmotic pressure, and/or sodium and water retention. In this study, all 28 patients with a diagnosis of hypothyroidism or renal disease had neither widespread PR-segment depression nor ST-segment elevation suggestive of subepicardial myocarditis. Pericardial effusion in hypothyroidism is a serous effusion related to a combination of sodium or water retention, slow lymph drainage and increased capillary perme-
ability with subsequent leakage of protein into the interstitial space. Volume overload and/or low plasma oncotic pressure have been reported to play a major role in the genesis of asymptomatic pericardial effusions in patients with renal disease. Interestingly, among the patients with isoelectric PR segment, low voltage was present in 8% with a small pericardial effusion, whereas 77% of patients with a moderate or large pericardial effusion had low voltage. These data indicate that in the absence of PR-segment and ST-segment changes, pericardial effusions have little effect on the ECG voltage unless moderate-to-larger amounts of fluid insulate the heart.

Neoplastic pericardial effusion is due to malignant pericardial involvement, but the presence of pericardial effusion may be due to nonmalignant causes such as previous radiation, chemotherapy, and infection. Pericardial effusion is also a common cardiovascular manifestation of autoimmune disease caused by pericarditis. In this study, PR-segment depression was observed in 36% of malignant disease and in 29% of connective tissue disease. As all the patients with PR-segment depression had malignant disease or connective tissue disease, widespread PR-segment depression in these patients reflects subepicardial atrial injury due to pericardial inflammation. Moreover, among the patients with a small pericardial effusion, in contrast to 18% incidence of PR-segment depression in patients free of low voltage, 54% of patients with low voltage had PR-segment depression. These data indicate that subepicardial myocardial involvement by the inflammatory process can cause low voltage despite a small pericardial effusion.

Limitations

The final diagnosis of the cause of pericardial effusion detected by echocardiography should be based on specific data obtained by invasive methods, but no new diagnosis was made during the follow-up in all patients. Nonetheless, the assessment of the PR segment with low voltage may help the initial assessment of a clinically silent pericardial effusion.

Conclusions

In the presence of PR-segment depression, even a small but inflammatory pericardial effusion may cause low voltage in the surface ECG.

References

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