

## Q: Should we still use electrocardiography to diagnose pericardial disease?

**M. CHADI ALRAIES, MD, FACP**

Department of Hospital Medicine, Medicine Institute, Cleveland Clinic

**ALLAN L. KLEIN, MD, FRCP(C), FACC, FAHA, FASE\***

Department of Cardiovascular Imaging, Cardiovascular Institute, Cleveland Clinic

**A:** YES. ACUTE PERICARDITIS has a unique clinical presentation, physical findings, and electrocardiographic (ECG) changes. ECG is always ordered to look for ischemic changes in patients with chest pain. Acute pericarditis develops in stages, which makes it easy to differentiate from early repolarization and, more significantly, myocardial infarction. The ECG changes, along with the clinical presentation and physical findings, can make the diagnosis of pericarditis.

In atypical and complicated cases, advanced imaging studies (ie, echocardiography and cardiac magnetic resonance imaging) have been used to confirm the diagnosis and to follow the course of the disease. However, ECG remains a useful, cost-effective test.

### ■ PERICARDIAL DISEASE IS DIVERSE

The pericardium is a thin layer that covers the heart and separates it from other structures in the mediastinum.

Pericardial syndromes include acute, recurrent, constrictive, and effusive-constrictive pericarditis, as well as pericardial effusion with or without tamponade. Causes include viral or bacterial infection, postpericardiotomy syndrome (Dressler syndrome), postmyocardial infarction, primary and metastatic tumors, trauma, uremia, radiation, and autoimmune disease, but pericardial syndromes can also be idiopathic.<sup>1</sup>

\*Dr. Klein has disclosed that he has served on a steering committee for clinical trials for Bayer.

doi:10.3949/ccjm.80a.11144

Acute pericarditis is the most common pericardial syndrome and occurs in all age groups. Once diagnosed, it can easily be treated with anti-inflammatory drugs. However, recurrent pericarditis, reported in 30% of patients experiencing a first attack of pericarditis, can be difficult to manage, can have a significant impact on the patient's health, and can be life-threatening.<sup>2</sup>

### ■ CHANGES OF ACUTE PERICARDITIS DEVELOP IN STAGES

Pericarditis can be diagnosed on the basis of ECG changes, clinical signs and symptoms, and laboratory and imaging findings.<sup>3</sup> ECG criteria of acute pericarditis have been published.<sup>4,5</sup>

The characteristic chest pain in acute pericarditis is usually sudden in onset and sharp and occurs over the anterior chest wall. The pain is exacerbated by inspiration and decreases when the patient sits up and leans forward.<sup>4</sup>

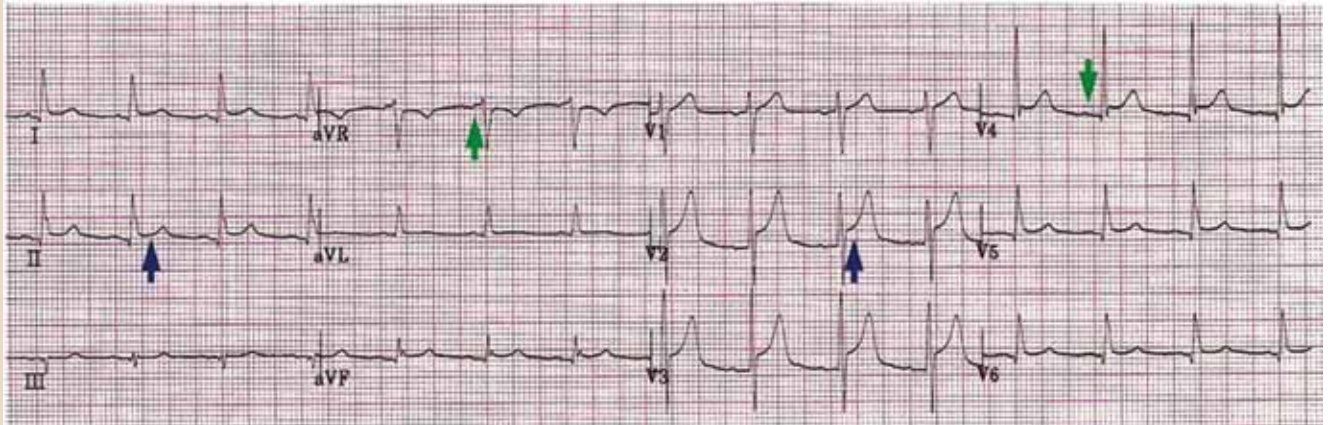
ECG classically shows a widespread saddle-shaped (upward concave) ST-segment elevation in the precordial and limb leads, reflecting subepicardial inflammation. PR-segment depression (with PR-segment elevation in lead aVR) can accompany or precede the ST changes and is known as the “discordant ST-PR segment sign” (FIGURES 1 AND 2). These changes are seen in 60% of patients.

The ECG changes develop in stages, making them easy to differentiate from early repolarization and, more significantly, from myocardial infarction. Four stages are apparent<sup>1,4,6-9</sup>:

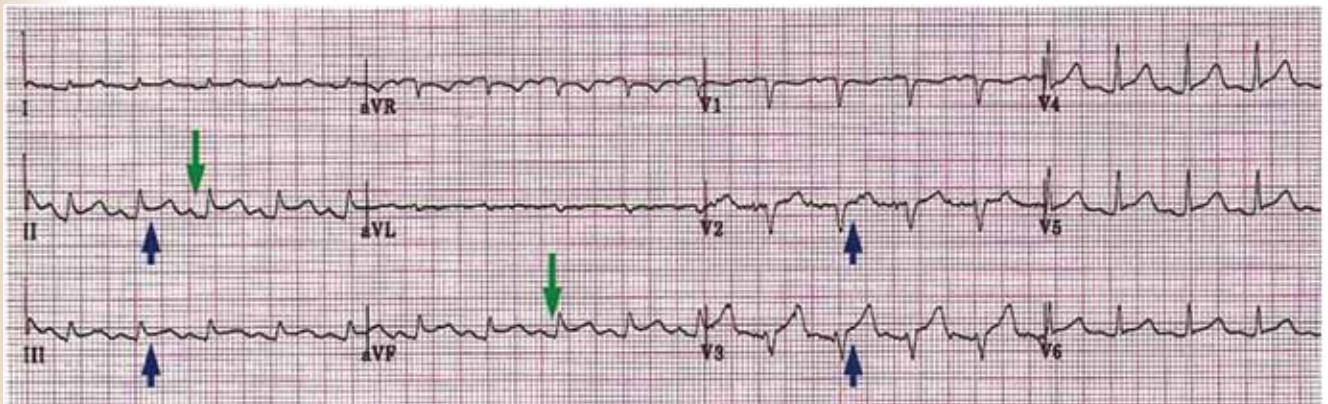
- **Stage I** occurs in a few hours to days, with diffuse, up-sloping ST-segment elevation and upright T waves, the result of an alteration in ventricular repolarization caused by pericardial inflammation. Because of al-

**Acute pericarditis classically causes widespread upward concave ST-segment elevation**

Postpericardiotomy syndrome (Dressler syndrome)



**FIGURE 1.** Electrocardiogram of a 63-year-old man who presented with chest pain, fever, and a friction rub 4 weeks after cardiac bypass surgery. Note the diffuse up-sloping ST-segment elevations (blue arrows), best seen in II, III, and V<sub>2</sub> to V<sub>6</sub>. Subtle PR-segment deviation (positive in aVR and negative in most other leads) is also present (green arrows). Postpericardiotomy syndrome (Dressler syndrome) is acute pericarditis that occurs 4 to 6 weeks after pericardiotomy.



**FIGURE 2.** Electrocardiogram of a 19-year-old man who developed flu-like symptoms 2 weeks earlier. On the morning of this tracing he had fever, chest pain that worsened with deep breathing, and a pericardial friction rub. Note the diffuse up-sloping ST-segment elevations (blue arrows) and PR-segment depression in leads II and aVF (green arrows). Also note the low QRS amplitude, which suggests pericardial effusion.

teration in repolarization of the atrium secondary to inflammation, the PR segment is elevated in aVR and depressed in the rest of the limb and chest leads.

- **Stage II**—the ST and PR segments normalize.
  - **Stage III**—widespread T-wave inversion.
  - **Stage IV**—normalization of the T waves.
- There is no pathologic Q-wave formation or loss of R-wave progression in acute pericarditis.

The ECG changes of pericarditis vary widely from one patient to another, depending on the extent and severity of pericardial inflammation and the timing of the patient’s presentation.

Changes vary in duration. In some cases, ST elevation returns to baseline within a few days without T-wave inversions; in other cases, T-wave inversions can persist for weeks to months. Sometimes the abnormalities resolve by the time symptoms develop.

■ ASSOCIATED CONDITIONS

**Myocardial involvement**

In acute myocarditis, findings on ECG can be normal unless the pericardium is involved. Changes that can be seen in myocarditis and that indicate a deeper involvement of inflam-

mation include ST-segment abnormalities, arrhythmias (eg, premature ventricular or atrial contractions), pathologic Q waves, intraventricular conduction delay, and right or left bundle branch block.<sup>1,10-12</sup>

Elevated troponin and new focal or global left ventricular dysfunction on cardiac imaging indicates myocarditis, especially in a patient with a normal coronary angiogram.<sup>10-13</sup>

### Pericardial effusion: Tachycardia and low QRS voltage

Pericardial effusion is often a complication of pericarditis, but it can also develop from other conditions, such as myxedema, uremia, malignancy, connective tissue disease, aortic dissection, and postpericardiotomy syndrome, and it can also be iatrogenic.

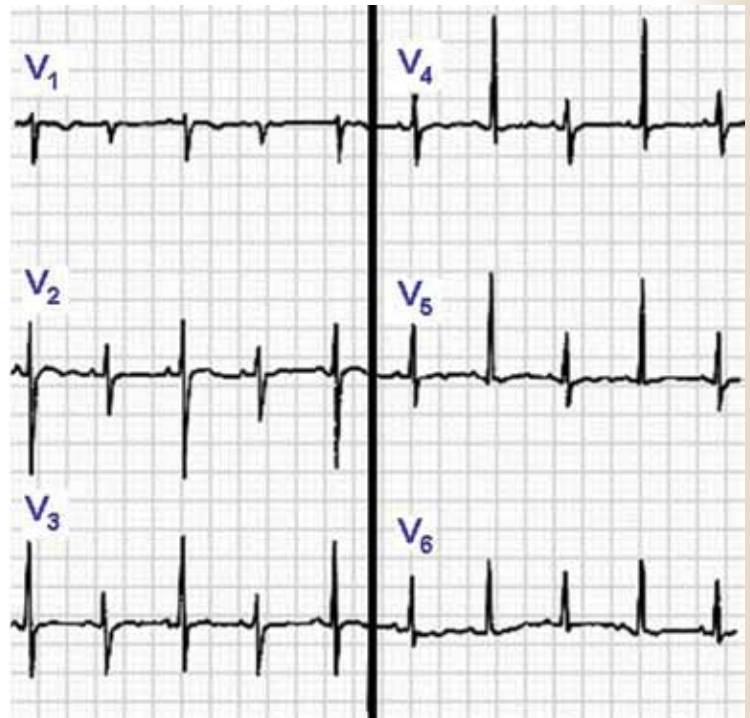
The most common ECG sign of pericardial effusion is tachycardia and low voltage of the QRS complexes. Low voltage is defined as a total amplitude of the QRS complexes in each of the six limb leads less than or equal to 5 mm, and less than or equal to 10 mm in V<sub>1</sub> through V<sub>6</sub>. However, low voltage is not always present in the chest leads.

Mechanisms proposed to explain low QRS voltage associated with pericardial effusion include internal short-circuiting of the electrical currents by accumulated fluids within the pericardial sac, greater distance of the heart from body surface electrodes, reduced cardiac size caused by effusion, and change in the generation and propagation of electrical current in the myocardium.<sup>14,15</sup>

### Cardiac tamponade: Tachycardia, electrical alternans, low QRS voltage

Sinus tachycardia and electrical alternans are specific but not sensitive signs of pericardial tamponade (FIGURE 3).<sup>16,17</sup> Electrical alternans is characterized by beat-to-beat alterations in the axis of QRS complexes in the limb and precordial leads as a result of the mechanical swinging of the heart in a large pericardial effusion.<sup>17</sup> There is evidence to suggest that low QRS voltage is more the result of the tamponade than the effusion.<sup>18</sup>

Treating tamponade with pericardiocentesis, surgical creation of a fistula (“window”) between the pericardial space and the pleural



**FIGURE 3.** Electrocardiogram of a 68-year-old man who developed shortness of breath 1 day after cardiac bypass surgery. Cardiomegaly was found on plain chest radiography. This tracing shows sinus tachycardia with electrical alternans: beat-to-beat alterations in the axis of the QRS complexes, suggesting a large pericardial effusion with tamponade.

cavity, or anti-inflammatory drugs can resolve low QRS voltage within 1 week.

### DIFFERENTIAL DIAGNOSIS OF ACUTE PERICARDITIS

#### Acute myocardial infarction

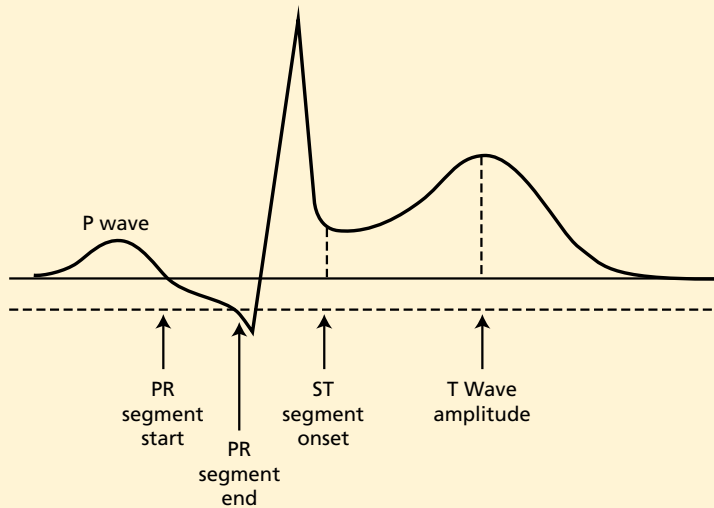
ECG changes in acute pericarditis differ from those in acute myocardial infarction in many ways.

ST-segment elevation in pericarditis rarely exceeds 5 mm, in contrast to acute myocardial infarction, in which ST elevation at the J point has to be more than 2 mm and in two anatomically contiguous leads.<sup>19</sup>

In pericarditis, the changes occur more slowly and in stages, reflecting the evolving inflammation of different areas of the pericardium.

The ST segment is elevated diffusely in the precordial and limb leads in pericarditis, indicating involvement of more than one coronary vascular territory, differentiating it from characteris-

Acute pericarditis



**FIGURE 4.** A distinctive feature of acute pericarditis is the ratio of ST elevation to T-wave amplitude in leads I,  $V_4$ ,  $V_5$ , and  $V_6$ . If the ratio exceeds 0.24, acute pericarditis is present. The end of the PR segment is used as the baseline for the ST-segment onset and T-wave maximal amplitude.

acute pericarditis, then PR elevation in aVR with PR depression in other leads may be seen.

Finally, pathologic Q waves or high-grade heart block reflects acute myocardial infarction.

**Early repolarization: Elevation of the J point**

Early repolarization is sometimes seen in healthy young people, especially in black men.

Early repolarization is characterized by elevation of the J point (ie, the junction between the end of the QRS complex and the beginning of the ST segment). Elevation of the J point causes elevation of the ST segment in the mid to lateral precordial leads ( $V_3$ – $V_6$ ) with an upright T wave.<sup>21</sup>

Acute pericarditis tends to cause ST-segment elevation in both the limb and precordial leads, whereas ST elevation in early repolarization mainly involves the lateral chest leads.

The PR segment is more prominent in acute pericarditis, especially in lead aVR.

Another finding that strongly favors acute pericarditis is the ratio of the height of the ST-segment junction to the height of the apex of the T wave of more than 0.25 in leads I,  $V_4$ ,  $V_5$ , and  $V_6$  (FIGURE 4).<sup>5,8,22</sup>

tic regional changes in myocardial infarction.<sup>19,20</sup>  
If concomitant atrial injury is present with

REFERENCES

- Imazio M, Trincherio R. Triage and management of acute pericarditis. *Int J Cardiol* 2007; 118:286–294.
- Little WC, Freeman GL. Pericardial disease. *Circulation* 2006; 113:1622–1632.
- Imazio M, Spodick DH, Brucato A, Trincherio R, Markel G, Adler Y. Diagnostic issues in the clinical management of pericarditis. *Int J Clin Pract* 2010; 64:1384–1392.
- Spodick DH. Acute pericarditis: current concepts and practice. *JAMA* 2003; 289:1150–1153.
- Troughton RW, Asher CR, Klein AL. Pericarditis. *Lancet* 2004; 363:717–727.
- Shabetai R. Acute pericarditis. *Cardiol Clin* 1990; 8:639–644.
- Baljepally R, Spodick DH. PR-segment deviation as the initial electrocardiographic response in acute pericarditis. *Am J Cardiol* 1998; 81:1505–1506.
- Spodick DH. Diagnostic electrocardiographic sequences in acute pericarditis. Significance of PR segment and PR vector changes. *Circulation* 1973; 48:575–580.
- Spodick D, editor. *The Pericardium: A Comprehensive Textbook*. New York, NY: Marcel Dekker; 1997:46–64.
- Smith SC, Ladenson JH, Mason JW, Jaffe AS. Elevations of cardiac troponin I associated with myocarditis. Experimental and clinical correlates. *Circulation* 1997; 95:163–168.
- Sarda L, Colin P, Boccaro F, et al. Myocarditis in patients with clinical presentation of myocardial infarction and normal coronary angiograms. *J Am Coll Cardiol* 2001; 37:786–792.
- Spodick DH. Arrhythmias during acute pericarditis. A prospective study of 100 consecutive cases. *JAMA* 1976; 235:39–41.
- Imazio M, Trincherio R. Myopericarditis: etiology, management, and prognosis. *Int J Cardiol* 2008; 127:17–26.
- Toney JC, Kolmen SN. Cardiac tamponade: fluid and pressure effects on electrocardiographic changes. *Proc Soc Exp Biol Med* 1966; 121:642–648.
- Karatay CM, Fruehan CT, Lighty GW Jr, Spear RM, Smulyan H. Acute pericardial distension in pigs: effect of fluid conductance on body surface electrocardiogram QRS size. *Cardiovasc Res* 1993; 27:1033–1038.
- Spodick DH. Acute cardiac tamponade. Pathologic physiology, diagnosis and management. *Prog Cardiovasc Dis* 1967; 10:64–96.
- Eisenberg MJ, de Romeral LM, Heidenreich PA, Schiller NB, Evans GT Jr. The diagnosis of pericardial effusion and cardiac tamponade by 12-lead ECG. A technology assessment. *Chest* 1996; 110:318–324.
- Bruch C, Schermund A, Dages N, et al. Changes in QRS voltage in cardiac tamponade and pericardial effusion: reversibility after pericardiocentesis and after anti-inflammatory drug treatment. *J Am Coll Cardiol* 2001; 38:219–226.
- Wang K, Asinger RW, Marriott HJ. ST-segment elevation in conditions other than acute myocardial infarction. *N Engl J Med* 2003; 349:2128–2135.
- Brady WJ, Perron A, Ullman E. Errors in emergency physician interpretation of ST-segment elevation in emergency department chest pain patients. *Acad Emerg Med* 2000; 7:1256–1260.
- Kambara H, Phillips J. Long-term evaluation of early repolarization syndrome (normal variant RS-T segment elevation). *Am J Cardiol* 1976; 38:157–166.
- Ginzton LE, Laks MM. The differential diagnosis of acute pericarditis from the normal variant: new electrocardiographic criteria. *Circulation* 1982; 65:1004–1009.

ADDRESS: M. Chadi Alraies, MD, FACP, Department of Hospital Medicine, A13, Cleveland Clinic, 9500 Euclid Avenue, Cleveland, OH 44195; e-mail [alraie@ccf.org](mailto:alraie@ccf.org).