

# Characteristics, echocardiographic findings, and clinical implications of myocardial ischemia

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**Condition:** **Acute ischemia,**

**Definition:** Acute ischemia, Myocardial ischemia, or cardiac ischemia, is a condition that reduces the heart muscle's ability to pump blood. A sudden, severe blockage of one of the heart's artery can lead to a heart attack. Myocardial ischemia might also cause serious abnormal heart rhythms.

**Resting coronary flow:** Reduced;

**Regional wall motion:** Hypokinesia,

**Response to inotropes:** Worsens,

**Contractile recovery after revascularization:** Full,

**Perioperative implications:** Urgent pharmacologic or interventional treatment indicated. Infarction if ongoing.

**Condition:** **Stunned myocardium,**

**Definition:** Post reperfusion contractile dysfunction;

**Resting coronary flow:** Normal;

**Regional wall motion:** Hypokinesia,

**Response to inotropes:** Biphasic,

**Contractile recovery after revascularization:** Full to partial,

**Perioperative implications:** Urgent pharmacologic or interventional treatment indicated. Infarction if ongoing.

**Condition:** **Hibernating myocardium**,

**Definition:** Acute ischemia;

**Resting coronary flow:** Reduced;

**Regional wall motion:** Hypokinesia,

**Response to inotropes:** Worsens,

**Contractile recovery after revascularization:** Full,

**Perioperative implications:** Urgent pharmacologic or interventional treatment indicated. Infarction if ongoing.

**Condition:** **Infarction**,

**Definition:** Permanent ischemia with myocyte damage;

**Resting coronary flow:** Severely reduced;

**Regional wall motion:** Akinesia-dyskinesia,

**Response to inotropes:** No change,

**Contractile recovery after revascularization:** None,

**Perioperative implications:** Revascularization not indicated.

### **Physiologic basis for the detection of ischemia**

Segmental endocardial motion and myocardial thickening are the foundations for echocardiographic detection of myocardial ischemia. The phenomena was observed by Robert Tennant and Carl J Wiggers in 1937 (**Robert Tennant, and Carl J. Wiggers The effect of coronary occlusion on myocardial contraction 31 may 1935 <https://doi.org/10.1152/ajplegacy.1935.112.2.351>**), occlusion of a coronary artery results in severe regional wall motion abnormality (RWMA) in the corresponding myocardium.

Decades later, Pandian et al. established the value of echocardiography for detecting ischemic RWWAs. (**Pandian NG, Kreis A, Weintraub A, et al. Real-time intravascular ultrasound imaging in humans. Am J Cardiol. 1990; 65:1392-6. doi: 10.1016/0002-9149(90)91334-3**) (**Pandian NG, Kreis A, Weintraub A, et al. Real-time intravascular ultrasound imaging in humans. Am J Cardiol. 1990;65:1392-6. doi: 10.1016/0002-9149(90)91334-3**)

Since then, multiple human studies have shown that RWCA (i.e., reductions in systolic wall motion and/or thickening) detected by

echocardiography are an earlier and more sensitive indicator of ischemia than electrocardiography (**Alexander Bracey, Harvey P. Meyers, and Stephen Smith. Prevalence of regional wall motion abnormality is similar between patients with STEMI (+) and STEMI (-) occlusion myocardial infarction J Am Coll Cardiol. 2021 May, 77 (18\_Supplement\_1) 214).**

The progression in wall dysfunction from hypokinesia to dyskinesia correlates to the progression in degree of perfusion abnormalities which has been established in dog studies.

Reductions in systolic wall thickening reflect subendocardial ischemia, while akinesia reflects ischemia sparing the subepicardial myocardial layer only, and dyskinesia plus acute wall thinning are seen in the setting of transmural ischemia (**Nielsen M, Andersson C, Gerds TA, et al. Familial clustering of myocardial infarction in first-degree relatives: a nationwide study. Eur Heart J. 2013;34:1198-203. doi: 10.1093/eurheartj/ehs475).**

An echocardiographic dog study has found that segmental contraction abnormalities are induced only when myocardial perfusion is less than 25% of control. Although human data on the possible quantitative relationship between myocardial perfusion and segmental wall contraction are missing, from a clinical point of view acute changes in segmental function are highly indicative of acute ischemia.

Prolonged reduction or cessation of coronary flow leads to infarction.

By echocardiography, acutely infarcted myocardium may look similar to acutely ischemic myocardium. In contrast, scar tissue presents echocardiographically as a thin, dense, and permanently akinetic or dyskinetic wall.

Although reduced or absent wall thickening may be the most sensitive indicator of ischemia, reduced endocardial motion may be the more conspicuous echocardiographic sign of severe ischemia.

However, adjacent nonischemic regions may pull the endocardium of an ischemic area inward; this points out the importance of also considering wall thickening that will still indicate ischemia.

Quite typically, unaffected, nonischemic regions develop exaggerated inward movement (termed *compensatory hyperkinesis*) that partially

offsets the adverse effects of akinesis or dyskinesis in other regions on cardiac stroke volume.

This is the principal reason why hemodynamic instability is a late and ominous sign of ischemia and usually only occurs with very severe regional or global ischemia.