Distinguishing Left Ventricular Aneurysm From Pseudoaneurysm*
A Review of the Literature

Steven L. Brown, MD, PhD; Robert J. Gropler, MD; and Kevin M. Harris, MD

A postmyocardial infarction left ventricular pseudoaneurysm occurs when a rupture of the ventricular free wall is contained by overlying, adherent pericardium. A postinfarction aneurysm, in contrast, is caused by scar formation resulting in thinning of the myocardium. Although the usual treatment for patients with pseudoaneurysm is urgent surgical repair, the imaging characteristics of pseudoaneurysm and aneurysm, for which treatment is more conservative, are quite similar. The literature on the natural history and imaging characteristics of the two entities is reviewed, and an approach to distinguishing between the two entities is proposed.

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Key words: aneurysm; echocardiography; myocardial infarction; pseudoaneurysm

Abbreviations: TEE = transesophageal echocardiogram; TTE = transthoracic echocardiogram

Rupture of the free wall of the left ventricle is a catastrophic complication of myocardial infarction, occurring in approximately 4% of patients with infarcts and about 23% of those suffering fatal infarcts.1 Rarely, free wall rupture is contained by overlying, adherent pericardium, producing what has been termed a pseudoaneurysm of the left ventricle. Pseudoaneurysms are often detected incidentally by echocardiography or other imaging modalities. Because of their propensity to rupture, it has been recommended that they be repaired surgically. They may also give rise to congestive heart failure2 since the cavity is noncontractile, or to embolic events, because of the stagnant flow of blood leading to thrombosis.3 True aneurysms of the left ventricle that develop after infarction, in contrast, are thinned areas of scarred myocardium that move dyskinetically. Like pseudoaneurysms, they may lead to congestive heart failure or embolic events, and may also give rise to ventricular arrhythmias because of the effects of ventricular scarring on conduction. While pseudoaneurysms require urgent surgical resection because of the likelihood of rupture, true aneurysms can often be managed medically. This difference makes an accurate diagnosis imperative.

Unfortunately, the characteristics of the two entities as recorded with various imaging modalities are quite similar. Contrast ventriculography, radionuclide ventriculography, MRI, transthoracic echocardiography, and transesophageal echocardiography have all been studied as approaches to distinguishing between the two. The epidemiologic, anatomic, pathophysiologic, and imaging features of the two entities are reviewed, and an approach to diagnosis is proposed.

DEMONSTRATIVE CASE

A 69-year-old patient with a history of coronary artery disease presented with symptoms of progressive chest pain. He had presented 10 years prior with angina and had undergone coronary artery bypass grafting with a left internal mammary artery to the left anterior descending coronary artery. ECG revealed high lateral ST elevation with small lateral Q waves. He underwent a coronary angiographic examination that revealed a patent left internal mammary artery graft to the left anterior descending coronary artery and an occluded first diagonal artery about 1 cm after its origin. There was <30% residual stenosis after primary angioplasty of this vessel. A myocardial infarction was diagnosed by a peak total creatine kinase level of 389 IU/L with an MB level of 44 ng/mL. A transthoracic echocardiogram (TTE) showed mildly decreased overall left ventricular function with lateral akinesis.

The patient was believed to be in mild congestive...

*From the Cardiovascular Division, Washington University School of Medicine, St. Louis.
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Reprint requests: Dr. Kevin Harris, Cardiovascular Division, Washington University School of Medicine, 660 South Euclid Avenue, Box 8086, St. Louis, MO 63110
heart failure, and a radionuclide ventriculogram was obtained as an alternative measure of left ventricular function. The radionuclide ventriculogram revealed evidence of a lateral aneurysm vs pseudoaneurysm. Contrast ventriculography was performed to better evaluate the lateral wall which had not been seen well by TTE. This study revealed a large, dyskinetic cavity connected to the anterolateral left ventricle, with sluggish flow of contrast within the cavity (Fig 1). A transesophageal echocardiogram (TEE) was requested to better visualize this region. On TEE, the cavity appeared to be entirely surrounded by myocardium, with a broad connection to the remainder of the left ventricle (Fig 2). Because this finding was consistent with a true aneurysm, the patient was initially given an afterload-reducing drug and a mild diuretic. Owing to the discrepant results noted on the previous tests, a repeated radionuclide ventriculogram was performed 1 week later and suggested that the cavity had enlarged. A second contrast ventriculogram was then performed which also showed cavity enlargement and features suggestive of pseudoaneurysm. Thus, although the diagnosis of pseudoaneurysm was suggested by contrast and radionuclide ventriculography, TEE suggested a true aneurysm. Therefore, the patient was referred for surgery because of continued symptoms and a preoperative diagnosis of either an enlarging aneurysm or pseudoaneurysm. At the time of surgery, a true aneurysm was found.

Our case underscores the difficulty in differentiating between an aneurysm and a pseudoaneurysm preoperatively. Despite multiple imaging tests, the diagnosis could not be established definitively preoperatively in our patient. Radionuclide and contrast ventriculography showed the appearance of a narrow neck which is suggestive of a pseudoaneurysm. The stagnant flow within the cavity and rapid increase in size added support to this diagnosis. In contrast, echocardiography did not reveal a clear myocardial discontinuity and the orifice to the cavity ratio was consistent with a true aneurysm.

**Clinical Characteristics**

**Natural History of Patients With a Pseudoaneurysm**

In 1967, Roberts and Morrow reported the case of a patient with and reviewed the literature on postinfarction ventricular pseudoaneurysm. They noted six prior reports, the earliest by Corvisart in 1797. The patient described by Roberts and Morrow had a large aneurysmal cavity that produced both New York Heart Association class IV heart failure and embolic events, resulting in a decision to resect. A pseudoaneurysm was found at the time of surgery which was repaired, although the patient died in the operating room of refractory arrhythmias. In 1975, Gueron et al reviewed the cases of 23 patients with postinfarction ventricular pseudoaneurysms, including two of their own. In the series of six patients whose courses after surgical resections had

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21747/ on 03/31/2017)

**Figure 1.** Left ventriculogram in right anterior oblique projection showing large cavity (arrow) arising from left ventricle. In real time, the cavity appeared to communicate to the left ventricle by an orifice with a narrow neck.

![Figure 2](http://journal.publications.chestnet.org/pdfaccess.ashx?url=/data/journals/chest/21747/ on 03/31/2017)

**Figure 2.** TEE transgastric projection of left ventricle. Arrow points to cavity. There does not appear to be myocardial discontinuity.
neurysms, including the risk of rupture or other complications, such as congestive heart failure, embolic events, or arrhythmias, is not known. Of the 12 patients in the report of Gueron et al.2 who did not undergo surgery, eight did not suffer rupture. On review of the primary reports, we found that of the six patients who died, two died of congestive heart failure, two died of documented arrhythmias, and two died suddenly without cardiac monitoring. All of these deaths may have been attributable to pseudoaneurysm. Since this is an autopsy series, it is possible that the risk of an adverse outcome is overestimated.

In 1975, Vlodaver et al.17 reported on two patients who died suddenly and whose autopsies revealed rupture of a small, chronic pseudoaneurysm at the site of an old myocardial infarction. In each case, the original infarct had not been diagnosed clinically. The authors concluded that unlike true aneurysms, which are likely to rupture only in the peri-infarct period, pseudoaneurysms may rupture even later after infarction. This contention is supported by other reported findings, as reviewed by Gueron et al.2 They noted that rupture could occur any time from the immediate peri-infarct period to 6 years later. Vlodaver and colleagues also point out that without autopsy, these deaths would have been ascribed to sudden cardiac death from an arrhythmic event, suggesting that the true incidence of death from rupture of a pseudoaneurysm is higher than that documented. The fact that the pseudoaneurysms were small in these two patients may suggest that the small size of a pseudoaneurysm does not predict a good outcome.

Aneurysm

In their review of data on the natural history of patients with true aneurysm, Mills et al.18 suggested that the traditional indications for aneurysmectomy be liberalized in this group because of their poor prognosis. They noted 27% 3-year survival in an autopsy series10 and 70% survival in medically treated patients with aneurysms in the Coronary Artery Surgery Study.20 The Coronary Artery Surgery Study analysis, however, showed that when corrected for age, left ventricular dysfunction, and clinical severity of heart failure, the presence of aneurysm was not an independent predictor of death. Therefore, any significant improvement in survival after surgery is likely to be related to the beneficial effects of aneurysmectomy on left ventricular function.

Even if indications for aneurysmectomy are broadened, however, the urgency of repair is obviously quite different than for pseudoaneurysm.2 There-
fore, distinguishing between the two entities is of great practical importance. Various clinical and imaging characteristics of the two have been examined retrospectively in an attempt to identify features distinguishing the two, but to our knowledge, no approach has been tested prospectively.

**Surgical Treatment**

The risks attending surgery are difficult to estimate because of the rarity of the entity, but they are likely considerably less now than in the past because of improvements in surgical techniques. Mills et al. reviewed the experience at one center in the repair of true aneurysms and found an in-hospital mortality of 3.3% among 61 patients treated between 1987 and 1991. The surgical management of pseudoaneurysms is simpler because myocardium does not need to be excised or excluded. Although the risks of pseudoaneurysm repair have not been quantified, it is generally accepted that they are less than those of unrepaired pseudoaneurysm.

**Symptoms and Examination Findings**

Pseudoaneurysms are often asymptomatic and incidentally discovered on imaging tests. Symptoms include recurrent chest pain which may be associated with symptoms of hypotension. Signs of a pseudoaneurysm include decreased heart sounds, a pericardial friction rub, elevation of both left- and right-sided filling pressures, and sinus bradycardia or junctional rhythm. When the pseudoaneurysm is large, it may produce an apical impulse. The mechanical interference of the mass on ventricular filling may result in a third heart sound. A pansystolic or to-and-fro murmur may be produced by flow across the mouth of the pseudoaneurysm. The ECG often shows persistent ST segment elevation in the area of the infarct. Unfortunately, all of these signs and symptoms are also characteristic of true aneurysms.

**Location**

One of the most easily documented potential features proposed for distinguishing true aneurysms from pseudoaneurysms is location. Plain chest radiography often reveals pseudoaneurysm, particularly when there is a discrete bulge in the cardiac shadow in an atypical location for ordinary cardiomegaly, such as posteriorly. It has been suggested that an inferior or posterior location is suggestive of pseudoaneurysm rather than a true aneurysm, and this seems consistent with data from clinical series. In the review by Gueron et al., for example, in patients in whom the location was noted, about half of the pseudoaneurysms were posterior or inferior, while half were anterior, apical, or lateral. In a series of patients with true aneurysms diagnosed before their deaths, reported by Loop et al., only 3% were posterior.

In autopsy series, in contrast, location has not been useful in distinguishing an aneurysm from a pseudoaneurysm. For example, in a consecutive series of 65 true aneurysms diagnosed at autopsy, 23 did not involve the anterior wall, and 15 involved only the posterior wall. Loop et al. suggest that the difference between the prevalence of posterior aneurysms at autopsy (ranging from 15 to 36%) and in clinical reports (3% in their series) is due to the extensive posterior infarction necessary for aneurysm formation. Extensive infarction in this region involves the posterior papillary muscle which usually results in severe mitral regurgitation and death, and thus these patients never go on to develop aneurysms.

Stated differently, their assertion is that extensive infero-posterior myocardial infarctions are more often fatal than extensive anterior infarctions, so that patients with extensive inferoposterior myocardial infarctions die rather than develop aneurysms.

One alternative explanation for the clinical preponderance of anterior wall true aneurysms is that true aneurysms in the posterior wall are more difficult to detect by usual imaging methods, resulting in a discovery bias in favor of anteroapical aneurysms. Another possible explanation for the greater prevalence of posterior pseudoaneurysms is that the rupture of the anterior wall usually results in immediate death, only rarely being contained by adherent pericardium. Perhaps, in contrast, posterior rupture is more often contained by pericardium, allowing pseudoaneurysm formation. In any case, since true aneurysms in any location are much more common than pseudoaneurysms, the location of an abnormality in an individual patient is not an adequate criterion for clinical decision making.

**Imaging Characteristics**

**Contrast Ventriculography**

The first report (to our knowledge) of the successful surgical repair of pseudoaneurysms was published in 1957 by Smith et al. In their patients, the diagnosis was made by a technique called direct cardioangiography, which required a needle to be placed in the left atrium percutaneously so that contrast could be injected manually. To our knowledge, there has been no prospective trial of the use of modern ventriculography in distinguishing aneurysms from pseudoaneurysms. There have been two case series, both published in 1978 and 1979.
of Higgins et al.\textsuperscript{25} the infarct-related artery was the left anterior descending in three patients and the right coronary artery in eight. The characteristic features of the pseudoaneurysms were a narrow neck connecting the ventricle to the pseudoaneurysm cavity, which was equal to or larger than the true left ventricle in about half of the cases. The contrast medium tended to remain in the pseudoaneurysmal cavity for several beats after injection, consistent with the stagnant flow of blood in the sac. In comparison to pseudoaneurysms, these authors revealed that true aneurysms were much more often apical or anterolateral (96\% vs 27\% of pseudoaneurysms), and that a correspondingly greater preponderance of patients with true aneurysms had a left anterior descending infarct-related artery (96\% vs 27\%).\textsuperscript{25}

Spindola-Franco and Kronacher\textsuperscript{26} made the observation that coronary arteriography was helpful in identifying the true location of the epicardium. This information can be used to distinguish pseudoaneurysm from true aneurysm because the cavity of a true aneurysm, since it is bounded by epicardium, will not extend beyond the coronary arteries, whereas a pseudoaneurysm will lie outside the epicardium. The coronary arteries, therefore, do not “drape over” the paraventricular chamber of a pseudoaneurysm.\textsuperscript{26}

**Radionuclide Ventriculography**

Although the first report of identification of a left ventricular pseudoaneurysm by radionuclide ventriculography was reported more than 20 years ago, the experience with this method is fairly limited.\textsuperscript{27,28} Both equilibrium and first-pass radionuclide ventriculography have been used for this purpose. The characteristic finding is that of a discrete neck connecting to a paraventricular chamber.\textsuperscript{29,30} Moreover, the paraventricular chamber should not be pulsatile and in general should show persistent radionuclide activity throughout the cardiac cycle.\textsuperscript{31} When first-pass radionuclide ventriculography is performed, the paraventricular chamber will exhibit delayed filling relative to the true left ventricular cavity. However, because of the relative limited resolution of radionuclide ventriculography and the varied appearance of left ventricular pseudoaneurysms, the usefulness of this method is limited.

**Magnetic Resonance Imaging**

There have been several reports describing the utility of MRI in identifying left ventricular pseudoaneurysm.\textsuperscript{32-35} Advantages of MRI are its high spatial resolution and ability to image the entire heart. Thus, it is highly accurate in determining the size and location of the pseudoaneurysm.\textsuperscript{34} Additional advantages include the capability to distinguish between pericardium, thrombus, and myocardium and the potential to visualize disruption of the epicardial fat layer by the pseudoaneurysm.\textsuperscript{35} Indeed, numerous individual case reports have described instances in which MRI provided useful information with respect to differentiating left ventricular aneurysm from pseudoaneurysm when compared with other imaging methods.\textsuperscript{35} However, the primary limitation of MRI is its lack of portability.

**Echocardiography**

TTE is the modality most studied with respect to distinguishing between ventricular aneurysms and pseudoaneurysms. In 1975, Roelandt et al.\textsuperscript{36} used M-mode echocardiography to diagnose a pseudoaneurysm by the recognition of an echo-free space posterior to the ventricle. In 1980, Catherwood et al.\textsuperscript{37} using two-dimensional TTE, compared findings in five patients with pseudoaneurysm to a control group with true aneurysm. TTE demonstrated a globular pseudoaneurysmal cavity in four of the five patients, with clot within the cavity in three of these four. In all four, the orifice of the pseudoaneurysmal cavity could be seen as a distinct discontinuity in the ventricular wall. In each case, the orifice diameter, the largest internal end-systolic diameter of the cavity, and the length of the largest end-systolic perimeter of the cavity were measured by echocardiography and ventriculography. There was excellent correlation between echocardiographic and angiographic results. Based on echocardiographic results, the mean ratio of orifice to cavity diameter was 0.37 for pseudoaneurysms and 1.0 for true aneurysms, and the ratio of orifice to cavity perimeter was 0.17 for pseudoaneurysms and 0.48 for true aneurysms. In another echocardiographic series, Gatewood and Nanda\textsuperscript{38} showed that the ratio of the maximum diameter of the orifice to the maximum internal diameter of the cavity had a ratio of 0.25 to 0.50 for pseudoaneurysms, while the range was 0.90 to 1.0 ratios for true aneurysms.

Gatewood and Nanda\textsuperscript{38} make several recommendations for the use of any imaging modality in patients suspected of having pseudoaneurysm. First, nonconventional views may be necessary to identify what may be a very small hole in the ventricular wall that lies between two large cavities: the pseudoaneurysm and the ventricle. Scanning in the wrong echocardiographic plane will identify only ventricle, myocardium, and an echo-free space outside the ventricle. Therefore, multiple planes, including planes oblique to conventional views, must be obtained. Similarly, as one of their cases illustrated, an angiographic view that is not orthogonal to the
ventricular wall interposed between the pseudoaneurysm and the ventricular cavity will show only a true aneurysm, since the narrow neck will not be seen. Second, the presence of thrombus within the pseudoaneurysmal cavity may result in an underestimation of the maximum cavity diameter. The index of Gatewood and Nanda reflects the diameter of the echo-free space, without respect to whether it appeared to be bounded by thrombus, endocardium, or pericardium. Nevertheless, this possible confounding factor must be borne in mind. Appropriate caution should be exercised in the use of diameter measurements obtained with techniques that rely on imaging the blood pool, such as angiography and blood pool scintigraphy. Similarly, echocardiographic data must be examined carefully to determine the level of confidence of identification of material comprising the wall of the cavity (ie, thrombus vs myocardium).

The nature of flow within a pseudoaneurysm has been used to distinguish it from true aneurysm based on results with echocardiographic Doppler techniques. The presence of turbulent flow by pulsed Doppler at the neck of a cavity or within the cavity itself suggests a pseudoaneurysm, but Roelandt et al described the presence of bidirectional color flow Doppler between an extracardiac echo-free space and the left ventricle that allowed distinction between a simple pericardial effusion and a left ventricular pseudoaneurysm. Sutherland et al reported a series of cases in which color Doppler imaging was superior to both pulsed and continuous-wave Doppler in detecting flow into a pseudoaneurysm. Together, these reports suggest that color flow imaging is useful for distinguishing pericardial effusion from pseudoaneurysm, and for sensitively detecting flow to direct pulsed-wave and continuous-wave Doppler interrogation of flow patterns. It seems likely that the turbulence and size of a jet in the presence of a pseudoaneurysm would be quite different from the flow seen with a true aneurysm, but this distinction has not been confirmed.

TEE is a safe, portable test that is ideal for use in the ICU in the evaluation of shock and the mechanical complications of myocardial infarction. A small number of cases have been described to date in which TEE provided more accurate information than TTE in the evaluation of posterior ventricular pseudoaneurysms.

Conclusions

At present and to our knowledge, there is no definitive noninvasive test to make the distinction between the two entities on gross inspection. However, the pathologic feature that distinguishes between the two is that a true aneurysm contains elements of myocardium, while a pseudoaneurysm does not. While the differentiation of myocardium vs thrombus lining a pseudoaneurysm cavity may be very difficult to discern with conventional imaging techniques, future advances in tissue characterization techniques with either MRI or echocardiography may ultimately improve our abilities to make the distinction. Similarly, three-dimensional reconstructive techniques may ultimately aid our abilities in understanding this complicated anatomy, without any of the assumptions inherent in two-dimensional visualization.

Based on the fundamental pathologic characteristics, we propose an approach to distinguish between the two with current modalities. Regardless of which imaging technique is used, the presence of myocardium surrounding the cavity suggests true aneurysm and myocardial discontinuity suggests pseudoaneurysm. If neither continuity nor discontinuity of myocardium can be demonstrated, surrogate markers such as the ratio of orifice to maximum diameter, the flow characteristics of the chamber, and/or the relationship of coronary arteries to the chamber must be used in identification of the entity.

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