Clinical characteristics and outcomes of left ventricular pseudoaneurysm
A retrospective study in a single-center of China

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Abstract

Left ventricular (LV) pseudoaneurysm is a fatal and rare condition with a high risk of rupture. The symptoms are nonspecific and diagnosis is often delayed. The purpose of this study is to analyze a series of cases in our institution.

Between March 2009 and April 2016, 10 patients (5 males and 5 females) with LV pseudoaneurysm were retrospectively enrolled.

Clinical information, diagnostic imaging modalities, treatment, and outcomes were evaluated.

The mean age was 58.2 ± 11.0 years (28–71 years). The common symptoms were chest pain (3 cases), dyspnea (3 cases), and syncope (2 cases). All patients had nonspecific abnormalities on the electrocardiogram, and 7 patients had chest X-ray abnormalities. Three etiologies including myocardial infarction (6 cases), mitral valve replacement (3 cases), and suspected endocarditis (1 case) were identified. LV pseudoaneurysm was diagnosed in 8 patients by transthoracic echocardiography, and the other 2 patients were diagnosed by computed tomography angiogram. Posterior (4 cases) and lateral (4 cases) of the left ventricle were the most common positions of the rupture oriﬁce. Eight patients accepted surgery repair and 2 patients were treated conservatively. In 2 patients, residual apical aneurysm was found, 1 patient was detected with a residual LV pseudoaneurysm, and 1 patient had myocardial infarction at 61 months' follow-up.

Myocardial infarction was the most common etiology of patients with LV pseudoaneurysm. The most frequently ruptured oriﬁces were lateral and posterior walls of the left ventricle. Surgery is recommended as the ﬁrst option, and conservative therapy can be considered for appropriate patients.

Abbreviations: CABG = coronary artery bypass grafting, CMR = cardiac magnetic resonance, CTA = computed tomography angiogram, ECG = electrocardiogram, LAD = left anterior descend artery, LCX = left circumﬂex artery, LIMA = left internal mammmary artery, LV = left ventricular, MI = myocardial infarction, OM = obtus marginal branch, RCA = right coronary artery, RVOT = right ventricle outﬂow tract, SVG = saphenous vein graft, TEE = transesophageal echocardiography, TTE = transthoracic echocardiography.

Keywords: conservative therapy, diagnosis, left ventricle, pseudoaneurysm, surgery

1. Introduction

Left ventricular (LV) pseudoaneurysm is a contained cardiac rupture which is encircled by adherent pericardium or scar tissue, with no myocardial tissue. It often occurs after myocardial infarction (MI), cardiac surgery and interventions, endocarditis, or chest trauma. In general, clinical manifestations are always nonspecific, including congestive heart failure, chest pain or dyspnea, and arrhythmias, which make it rarely suspected and diagnosed delay. Pseudoaneurysms have a strong tendency to grow rapidly, which increases the risk of its rupture and consequent fatal acute pericardial tamponade. A timely diagnosis and early surgical or other helpful treatments are recommended in the management.

Since 1998, Frances et al evaluated the characteristics of 290 patients with LV pseudoaneurysm, and more than 300 case reports have been published with different kinds of etiologies, presentations, treatments, and prognosis. Diagnosis is the key point. Echocardiography, computed tomography angiogram (CTA), and cardiac magnetic resonance (CMR) are considered as good noninvasive imaging modalities for the diagnosis of pseudoaneurysm. Surgery was recommended in cases with symptomatic status, giant aneurysm size, and an impending rupture. Conservative therapy can be considered in asymptomatic cases, those with small aneurysms (<3 cm) and those
with a stable dimension during regular follow-up. What is more, percutaneous device closure also provides a new approach to treatment in some cases.\textsuperscript{15–8} The purpose of this study is to analysis a series of cases in our institution.

2. Materials and methods

2.1. Study design

This is a retrospective study of patients with LV pseudoaneurysm diagnosed at Fuwai Hospital (Beijing, China) between March 2009 and April 2016. All patients with discharge diagnosis of “left ventricular pseudoaneurysm” were found through electronic medical records system of Fuwai Hospital. The study was approved by the Ethics Committee of Fuwai Hospital.

2.2. Diagnostic imaging modalities

Diagnosis of LV pseudoaneurysm depend on finding the discontinuity of the cavity-surrounding myocardium through imaging or interventional methods.\textsuperscript{11} The diagnostic imaging modalities included transthoracic echocardiography (TTE), transesophageal echocardiography (TEE), CTA, and CMR. Echocardiography proves to be valuable in this differential diagnosis and is recommended as the first option. The echocardiographic features typical of pseudoaneurysms include sharp discontinuity of the endocardial image at the site of communication of the pseudoaneurysm with the LV cavity and an orifice that is relatively narrow with comparison with the diameter of the pseudoaneurysm.\textsuperscript{18} A neck smaller than the aneurysmal cavity is a strong suggestive of a pseudoaneurysm, especially in cases in which color Doppler shows a “to and fro” flow at the neck. CTA can delineate the extent of pseudoaneurysms and the involvement of adjacent cardiac and noncardiac structures. CMR, with its higher spatial resolution, is more sensitive and specific for the diagnosis of a pseudoaneurysm than TTE. CMR shows the low signal of the pericardium which constitutes the only wall of the pseudoaneurysm.\textsuperscript{19} The absence of delayed enhancement findings of myocardial elements within the sac of the aneurysm on CMR, and the presence of delayed enhancement of the pericardium, is highly suggestive of a pseudoaneurysm. LV angiography was not performed in most cases for 2 reasons: LV pseudoaneurysm may be filled with some amounts of thrombus, there was a potential risk of systemic embolism; these patients had different extent of LV dysfunction, even a small ventricular pressure increase may lead to fatal cardiovascular events. As all patients were suspected of or diagnosed with LV pseudoaneurysm by TTE, following CTA or CMR was used in all patients in our center.

2.3. Clinical data and treatment

We used electronic medical records system of Fuwai Hospital to identify all patients discharged with a diagnosis of LV pseudoaneurysm. Clinical information including age, sex, symptoms, history of present illness, cardiovascular risk factors, etiologies of pseudoaneurysms, electrocardiogram (EGG), TTE, CTA, and CMR findings (the size and location of the orifice, with or without mitral valve involved or thrombus formation, any cardiac structures involved), treatments, and outcomes were recorded.

Treatments included cardiac surgery and conservative therapy. Surgical treatment is the first option in our hospital for all patients diagnosed with LV pseudoaneurysm, especially for patients with symptoms, aneurysm size ≥3cm, and an impending rupture. Conservative therapy can be considered in asymptomatic cases, those with small aneurysms (<3cm)\textsuperscript{16} and those with a stable dimension during regular follow-up. When surgery repair was performed, surgical records were reviewed to confirm the diagnosis. Two patients were treated with conservative therapy, a small pseudoaneurysm (20mm) was found in 1 patient, and the other patient was an old woman who had accepted coronary artery bypass grafting (CABG) and was a high-risk surgical candidate. TTE were advised every 6 months or if any patient had symptoms. CTA, as another choice, was also recommended if necessary.

2.4. Follow-up

The same person followed up all patients at an outpatient clinic, by telephone, or by post every 6 months. Patients can also visit outpatient clinic at anytime when they feel uncomfortable. All-cause mortality, cardio-cerebral vascular events including cardiac death, MI sudden cardiac death, revascularization, arrhythmia, residual aneurysm, cardiac rupture, and stroke were recorded during the follow-up.

2.5. Statistical analysis

All analyses were performed using SPSS version 19.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean with standard deviations and range. Categorical variables are presented as a number and/or frequency.

3. Results

3.1. Demographics features and manifestations of subjects

Between March 2009 and April 2016, 14 patients were suspected with ventricular pseudoaneurysm, given the background of medical history, clinical manifestation, and imaging features at Fuwai Hospital. One patient was diagnosed with pseudoaneurysm of the right ventricle outflow tract (RVOT) caused by endocarditis; this patient received RVOT reconstruction when he was 3 years old because of tetralogy of Fallot. Three patients were confirmed true aneurysm during cardiac surgery. Finally, 10 patients were enrolled in this study.

Ten patients including 5 males and 5 females were enrolled in this analysis. The mean age was 58.2 ± 11.0 years (28–71 years). The common symptoms were chest pain, dyspnea, and syncope. Epigastric pain and arrhythmia were also presented in other cases. Three patients had history of hypertension, 1 patient had diabetes, 2 patients had hyperlipidemia, and 3 patients had history of smoke.

3.2. Diagnostic imaging features of subjects

All patients had abnormalities on the ECG. Nonspecific ST changes and T-wave changes were found in 6 patients, abnormal Q wave was noted in 2 patients, and atrial arrhythmias were detected in 2 patients who had received mitral valve replacement. Seven patients had chest X-ray abnormalities, 2 patients had observable mass on chest X-ray, and the other 5 patients showed left heart enlargement. Three kinds of etiologies were considered in these patients, including 6 cases of MI (inferior,
interoposterior, or posteriolarateral MI), 3 cases of mitral valve replacement, and 1 case of unknown etiology who was suspected of endocarditis (Table 1).

Two-dimensional TTE was the most helpful basic examination, and all these patients were showed positive examination results and diagnosed or suspected of LV pseudoaneurysms. CTA was the most frequently used after imaging modality, and all patients were diagnosed with LV pseudoaneurysm. Three patients also underwent CMR. The mean diameters of left atria and left ventricles were 39.5 ± 8.7 mm (23–56 mm) and 51.4 ± 8.6 mm (36–60 mm), respectively. The mean LV ejection fraction was 53.2 ± 8.9% (35–65%). LV apical aneurysm accompanying pseudoaneurysm was found in 2 patients. Severe mitral valve regurgitation was detected in patient no. 2. Thrombus formation in pseudoaneurysm was confirmed in 5 patients, and extensive calcification of aneurysmal wall was also found in patient no. 2.

The most common position of the orifice of pseudoaneurysms was posterior (4 cases) and lateral (4 cases), and others were apical (2 cases). The mean rupture orifice diameter was 19.3 ± 12.9 mm (3.3–42 mm), and the size of LV pseudoaneurysm is shown in Table 2, which was difficult to determine because of irregular profile. Compression of pseudoaneurysm to adjacent structures was found in 4 patients: LV in patient no. 3, coronary sinus in patient no. 4, left atria and LV in patient no. 5, and left atria in patient no. 7.

3.3. Treatments and follow-ups

Eight patients accepted myocardial revascularization and 2 patients received only conservative therapy. The mean follow-up time was 34 months (1–78 months). residual apical aneurysm by TTE was found in patient no. 1 and patient no. 7, and residual left pseudoaneurysm was still detected in patient o. 2 (52 mm × 78 mm), with a 3-mm orifice connected to LV. Patient no. 4 accepted radiofrequency ablation of atrial flutter at 46 months follow-up with no other complications, and patient no. 9 patient had MI at 61 months follow-up.

3.4. Case reports

Patient no. 6 (Fig. 1) was a 57-year-old man who was referred to our hospital for chest pain on exertion for 2 months. One year before, he was diagnosed with interoposterior MI in other hospital and received conservative therapy. More than 1 month ago, coronary artery CTA showed mild stenosis in the proximal of left anterior descend artery (LAD), severe stenosis in the proximal of left circumflex artery (LCX), and multiple severe stenosis in the middle portion of right coronary artery (RCA), which was in accordance with coronary artery angiography. Pseudoaneurysm with thrombus formation in the lateral part of the left ventricle was also detected. CMR showed enlarged left ventricle, filling defect (thrombus) in the aneurysm, and transmural delayed enhancement in the lateral part. The patient received CABG and resection of ventricular aneurysm. After 28 months’ follow-up, the patient showed no discomfort and subsequent complications.

Patient no. 7 (Fig. 2) was a 66-year-old woman, who was transferred to our hospital because of ruptured LV pseudoaneurysm penetrating into the left pleural cavity. When she was 59 years old, she accepted mitral valve replacement because of rheumatic
mitral stenosis. Two months ago, she developed chest pain, dyspnea after coughing, and then syncope occurred. She came back to consciousness several minutes later and was sent to local hospital. Chest CT showed massive pleural effusion in the left side, and about 3000mL blood pleural effusion was drained out. TTE showed that the LV ruptured into pericardium. CTA showed normal coronary artery and a huge LV pseudoaneurysm. The location of the orifice was at the apical of left ventricle and as large as 10mm. The etiology may be also due to MI (coronary spasm or thrombus). This patient received simply repair of pseudoaneurysm and showed no discomfort after 27 months’ follow-up.

Patient no. 8 (Fig. 3) was a 71-year-old woman who was referred to our hospital because of epigastric pain. She had history of angina for 2 years. Seventeen months before, coronary artery angiography in other hospital showed 90% and 60% stenosis in the proximal of LAD and LCX, respectively, and multiple severe stenosis (70%–90%) in the RCA. She received CABG (left internal mammary artery [LIMA]-LAD, saphenous

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**Figure 1.** Patient no. 6. (A) Coronary angiography (CAG) shows severe stenosis of the proximal and middle portion of LCX. (B) CAG shows multiple severe stenosis in the middle portion of RCA. (C) CT reveals a pseudoaneurysm with a wide neck. (D) CMR shows a thin wall with full-thickness delayed enhancement and thrombus formation in the pseudoaneurysm. CMR = cardiac magnetic resonance, CT = computed tomography, LCX = left circumflex artery, PA = pseudoaneurysm.

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**Figure 2.** Patient no. 7. (A) Chest X-ray shows an enlarged heart and encapsulated effusion in the right lung. (B) CTA reveals a narrow neck and a giant pseudoaneurysm. (C) CT reconstruction shows an optimal visualization of pseudoaneurysm. CTA = computed tomography angiogram, PA = pseudoaneurysm.
cardiac surgery if possible. The patient had chest tightness occasionally and was recommended to consider high-risk surgery. At 6 months postinfarction ventricular septal defect; LV dysfunction may occur because of persistent left-to-right shunts.\[13,14\]

Though nonspecific, LV pseudoaneurysm usually present with some symptoms, for example, congestive heart failure and chest discomfort (chest pain or dyspnea). Syncope (2 cases in our study) can be the first presentation induced by inadequate cardiac output, ventricular tachyarrhythmia, or rupture of aneurysms. Cough can also be a nonspecific symptom which may present of heart failure or pleura involved with a risk of rupture. Because of aspecific and various symptoms, diagnosis of LV pseudoaneurysm is always made tardily, and is reported 4 months after infarction.\[11\]

Finding the discontinuity of the cavity-surrounding myocardium is key evidence verifying the existence of a pseudoaneurysm, which is highly dependent on the auxiliary examinations, especially the imaging methods. ECG and chest X-ray may provide some clues for a LV pseudoaneurysm; however, those 2 examinations in patients were nonspecific, similar to clinical symptoms. In 2 patients, chest X-ray showed a mass on the left heart border that gave us a hint to consider this condition, but is easily to blur with lung mass.\[16\] TTE was reported to be the most common helpful imaging modality for diagnosis of LV pseudoaneurysm. It can be diagnostic in most cases (8/10), but the relation of pseudoaneurysm to the adjacent vessels could not be clearly identified. CTA and CMR can delineate the extent of pseudoaneurysms and differentiate the involvement of adjacent cardiac and noncardiac structures. In some cases, an enhancing pericardium containing a pseudoaneurysm can mimic an infarcted myocardium. Then surgical assessment and pathological evaluation is occasionally imperative to make a definitive diagnosis.\[17\] A narrow aneurysm entrance followed by a large dilation of the aneurysm sac may strongly indicate this diagnosis, and the wide entrance was not typical of a false aneurysm. In patient no. 6, it seemed to be a true aneurysm because of a wide neck, whereas CAG showed LCX had no branch in this region and CMR confirmed an arch full-thickness delayed enhancement which was discontinued with

Figure 3. Patient no. 8. (A) Chest X-ray shows left ventricle amplification. (B) CTA shows a left ventricle pseudoaneurysm with a large orifice. (C) The black arrow shows the orifice communicating with the right ventricle. CTA=computed tomography angiogram, PA=pseudoaneurysm.
adjacent ventricular wall; what is more, adhesion between the epicardium and the pericardium in this position was found during the surgery, which is similar with cases reported by Mousavi et al.\textsuperscript{[6]} and Della Rocca et al.\textsuperscript{[7]}

Distinction of pseudoaneurysm from a true aneurysm can be difficult because most patients may be asymptomatic or have nonspecific symptoms.\textsuperscript{[8]} ECG and chest X-ray abnormalities are usually nonspecific, and the most common chest X-ray finding is an enlarged heart in our study. What is more, pseudoaneurysm and true aneurysm could coexist in the same patient, which was supposed a delayed rupture of a true aneurysm that was contained by the pericardium and gave rise to a pseudoaneurysm inside of a true aneurysm.\textsuperscript{[9]}

Concurrent LV apical true aneurysm and pseudoaneurysm was found in patient no. 1 and patient no. 7. They were patients who had mitral valve replacement. Patient no. 1 also had CABG (LIMA-LAD), so actually MI should be also considered in this patient. Both patients received cardiac surgery, but still had apical aneurysms during follow-up and were suggested to be managed medically.

Although mortality rates in patients who underwent surgery was approximately 23%, but untreated pseudoaneurysms had an approximately 30% to 45% risk of rupture,\textsuperscript{[10]} so surgical resection was considered the most appropriate way of LV pseudoaneurysm in our center. In this retrospective study, patient no. 4 received a coronary sinus approach to repair the pseudoaneurysm which had been reported by Guo et al.\textsuperscript{[11]}

Most patients (8/10) accepted surgery and had a good outcome in the mid-term follow-up. Although patients with LV pseudoaneurysm have high mortality rates regardless of treatment, prolonged survival has been observed even in a few patients who do not undergo surgery.\textsuperscript{[12]}

Conversely, a conservative approach can be considered in asymptomatic cases, especially those with small aneurysms of less than 3 cm dimension and those with a stable dimension during regular follow-up.\textsuperscript{[13,14]} What is more, percutaneous closure in small neck pseudo-aneurysm with coils or occluders is also described in recent years.\textsuperscript{[15,16]}

Although no death or rupture was observed in our study in both patients receiving surgical treatments and conservative approaches, the results must be interpreted with caution for relative short follow-up periods and small sample size, and the choice for surgery opportunity still need further researches.

There are several limitations that should be addressed. First, this study was a retrospective study and had a relative small sample size. Second, the accuracy of cardiac imaging modalities were not evaluated, especially CMR. What is more, treatments including surgery repair and conservative therapy in high-risk patients, and which is better may not be able to be assessed considering the high risk of potential rupture.

5. Conclusions

In conclusion, MI was the most common etiology of patients with LV pseudoaneurysm. Lateral and posterior walls of the left ventricle were the most frequently ruptured orifices. TTE was a preferred diagnostic tool followed by CTA and CMR. Surgery may be recommended as the first option, and conservative therapy can be considered for appropriate patients.

References

[1] Frances C, Romero A, Grady D. Left ventricular pseudoaneurysm. J Am Coll Cardiol 1998;32:557–61.
[2] Faustino M, Ranchordas S, Abecasis J, et al. Left ventricular pseudoaneurysm - a challenging diagnosis. Rev Port Cardiol 2016; 35:373; e371–6.
[3] Peetre R, Linka A, Jenni R, et al. Surgical treatment of acquired left ventricular pseudoaneurysms. Ann Thorac Surg 2000;70:533–7.
[4] Muñozovc E, Bergland J, Avdic S, et al. Surgical treatment of left ventricular pseudoaneurysm. Med Arch (Sarajevo, Bosnia and Herzegovina) 2014;68:215–7.
[5] Chiff P, Thorne S, de Giovanni J. Percutaneous device closure of a pseudoaneurysm of the left ventricular wall. Heart (British Cardiac Society) 2004;90:e62.
[6] Kar B, Ghohkar G, Gregoric ID, et al. Percutaneous closure of a left ventricular pseudoaneurysm in a high-risk surgical candidate. Texas Heart Inst J 2012;39:680–2.
[7] Bortnick AE, Gordon E, Gutsche J, et al. Percutaneous closure of a left ventricular pseudoaneurysm after Sapien XT transapical transcatheter aortic valve replacement. JACC Cardiovasc Intervent 2012;5:e37–8.
[8] Rahim SA, Greason KL, Bjarnason H, et al. Left ventricular pseudoaneurysm. J Am Coll Cardiol 2009;54:740.
[9] Kang LM, Zhang J, Fan CM, et al. Traumatic left ventricular pseudoaneurysm. Chin Med J 2009;122:758–60.
[10] Csapo K, Voith L, Szuk T, et al. Postinfarction left ventricular pseudoaneurysm. Clin Cardiol 1997;20:898–903.
[11] Yeo TC, Malouf JJ, Oh JK, et al. Clinical profile and outcome in 52 patients with cardiac pseudoaneurysm. Ann Intern Med 1998;128:299–305.
[12] Haramoto M, Ogiw N, Hanafusa Y, et al. Ruptured left ventricular pseudoaneurysm penetrating into the left pleural cavity. Japanese J Thorac Cardiovasc Surg 2003;49:581–3.
[13] Dogan A, Aksoy H. Giant pseudoaneurysm caused by left ventricle free-wall rupture leading left to right shunting: a rare case. Turk Kardiyoloji Dernegi arsivi 2013;41:1777.
[14] Inoue T, Hashimoto K, Band K, et al. Left ventricular pseudo-false aneurysm perforating into the right ventricle. Interact Cardiovasc Thorac Surg 2015;21:137–9.
[15] Brown SL, Gropler RJ, Harris KM. Distinguishing left ventricular aneurysm from pseudoaneurysm. A review of the literature. Chest 1997;111:1403–9.
[16] Yalince H, Demir S, Gocen U, et al. Left ventricular pseudoaneurysm perceived as a left lung mass. Kardiochir Torakochirurgia Pol 2016;13:157–8.
[17] Konen E, Merchant N, Gutierrez C, et al. True versus false left ventricular aneurysm: differentiation with MR imaging-initial experience. Radiology 2005;236:65–70.
[18] Mousavi N, Bukkas R, Walker JR, et al. Left ventricular pseudoaneurysm: the role of multimodality cardiac imaging. Can J Cardiol 2009;25: e389.
[19] Della Rocca DG, Forleo GB, Stazi CA, et al. Massive left ventricular pseudoaneurysm 20 years after acute myocardial infarction. J Am Coll Cardiol 2013;62:e523.
[20] Milner B, Dulgheru R, Nichini A, et al. Left ventricular aneurysm: true, false or both? Acta Cardiol 2016;71:616–7.
[21] Sousa P, Santos W, Cordeiro P, et al. Pseudoaneurysm inside of a true aneurysm. J Cardiothorac Surg 2013;8:97.
[22] Guo HW, Xu JP, Chang Y, et al. Coronary sinus approach to repair an intracardiac ventricular pseudoaneurysm. J Cardiac Surg 2012;27:692–5.
[23] Vajayvergiya R, Hasan A, Singhal M. Spontaneous closure of a large left ventricular pseudoaneurysm. Indian Heart J 2016;68(suppl 2): S81–2.
[24] Arslantas U, Kilicgedik A, Cersit S, et al. A fifteen years old left ventricular pseudoaneurysm. Int J Cardiol 2016;203:327–8.
[25] Rose-Castro VH, Molina-Bello E, Valenzuela-Suarez H, et al. Survival after left ventricular free wall rupture in an elderly woman with acute myocardial infarction treated only medically. Case Rep Vasc Med 2012;2012:728602.