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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 analysis 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 pseudoanerysm 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 mammary 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.[1] It often occurs after myocardial infarction (MI), cardiac surgery and interventions, endocarditis, or chest trauma.[2,3] 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[1] 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.[3] Surgery was recommended in cases with symptomatic status, giant aneurysm size, and an impending rupture.[3] Conservative therapy can be considered in asymptomatic cases, those with small aneurysms (<3 cm)[4] and those

Editor: Danny Chu.

Funding: This work was supported by grants from National Key Research and Development Plan of China (2016YFC1300100) and National Science Foundation of China (81541010).

All other authors declare that they have no conflicts of interest.

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Medicine (2017) 96:18(e6793)

Received: 27 January 2017 / Received in final form: 6 April 2017 / Accepted: 7 April 2017

http://dx.doi.org/10.1097/MD.0000000000006793

with a stable dimension during regular follow-up. What is more, percutaneous device closure also provides a new approach to treatment in some cases.[5–8] 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.[1] 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 in comparison with the diameter of the pseudoaneurysm.[9] 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.[9] 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 (ECG), 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 $\geq$3 cm, and an impending rupture. Conservative therapy can be considered in asymptomatic cases, those with small aneurysms (<3 cm)[4] 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 (20 mm) 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,

Table 1

Clinical characteristics and etiology of patients with left ventricular pseudoaneurysms.

No.	Age	Sex	Symptoms	Etiology	ECG	Chest X-ray
1	70	F	Arrhythmia	MV replacement CABG	Atrial flutter	Enlarged heart
2	28	F	Dyspnea	Unknown	Nonspecific ST changes	Mass
3	57	M	Syncope	AV replacement, inferior MI	Abnormal Q wave	Mass
4	60	F	Dyspnea	MV replacement	Nonspecific ST changes	Normal
5	53	M	Chest pain	Posterior MI	T wave changes	Enlarged heart
6	57	M	Chest pain	Inferoposterior MI	Abnormal Q wave	Normal
7	66	F	Cough, syncope	MV replacement	Atrial fibrillation	Enlarged heart
8	71	F	Epigastric pain	CABG, inferoposterior MI	T wave changes	Normal
9	58	M	Chest pain	Inferoposterior MI	T wave changes	Enlarged heart
10	59	M	Dyspnea, cough	Posteriolateral MI	T wave changes	Mass

AV = aortic valve, CABG = coronary artery bypass grafting, ECG = electrocardiogram, F = female, M = male, MI = myocardial infarction, MV = mitral valve.

inferoposterior, or posteriorlateral 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 $53.2 \pm 8.9\%$ (35–65%). LV apical aneurysm accompanying pseudoanerysm was found in 2 patients. Severe mitral valve regurgitation was detected in patient no. 2. Thrombus formation in pseudoanerysm 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 (5.3–42 mm), and the size of LV pseudoaneurysm is shown in Table 2, which was difficult to determine because of irregular profile. Compression of pseudoanerysm 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 5-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 inferoposterior 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 transmyocardial delayed enhancement in the lateral part. The patient received CABG and resection of ventricular aneurysm. After 28 months' follow-up, the patients 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

Table 2

Location, size, imaging modalities and treatment of left ventricular pseudoaneurysms.

No.	Orifice location	Orifice diameter, mm	PA diameter, mm × mm	TTE	CT/MRI	Treatment
1	Apical	7.8	30 × 50	Diagnostic	CT	Surgery
2	Posterior	4.5, 5	66 × 80	Diagnostic	CT	Surgery
3	Lateral	21	121 × 57	Helpful	CT	Surgery
4	Posterior	17	32 × 29	Helpful	CT	Surgery
5	Lateral	13	131 × 37	Diagnostic	CT/MRI	Surgery
6	Posterior	42	40 × 41	Diagnostic	CT/MRI	Surgery
7	Apical	10	122 × 87	Diagnostic	CT	Surgery
8	Lateral	30, 7 to RV	Huge	Diagnostic	CT	Conservative
9	Posterior	5.3	20 × 20	Diagnostic	CT	Conservative
10	Lateral	30	105 × 95	Diagnostic	MRI	Surgery

No. 8 patient had 2 rupture orifices, one communicated with LV which was 30 mm, the other connected to right ventricle which was 7 mm.
CT = computed tomography, MRI = magnetic resonance imaging, PA = pseudoaneurysm, RV = right ventricle, TTE = transthoracic echocardiography.

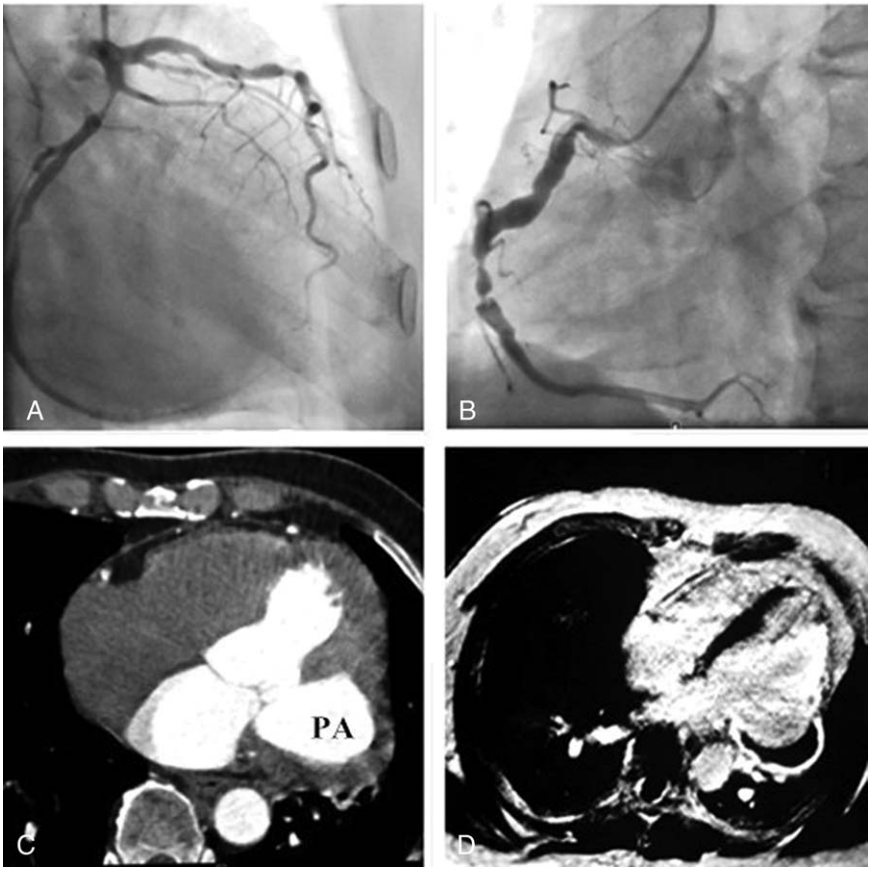

Figure 1. Patient no. 6. (A) Coronary angiography (CAG) shows severe stenosis of the proximal and middle portion of LCX. (B) CAG shows multiple severe stenosis in the middle portion of RCA. (C) CT reveals a pseudoaneurysm with a wide neck. (D) CMR shows a thin wall with full-thickness delayed enhancement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

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 3000 mL blood pleural effusion was drained out. TTE showed that the LV ruptured into pericardium. CTA showed normal coronary artery and a huge LV pseudoanerysm. The location of the orifice was at the apical of left ventricle and as large as 10 mm. The etiology may be also due to MI (coronary spasm or thrombus). This patient received simply repair of pseudoanerysm 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

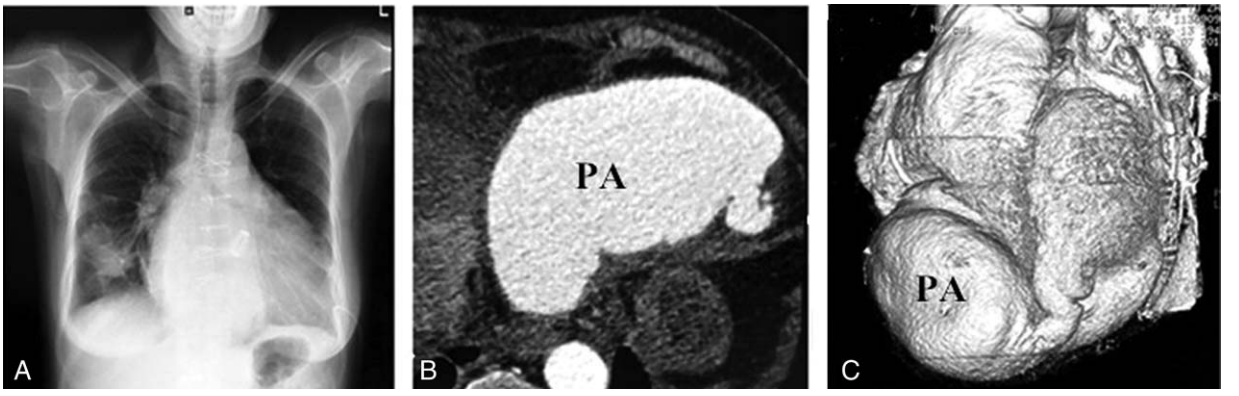

Figure 2. Patient no. 7. (A) Chest X-ray shows an enlarged heart and encapsulated effusion in the right lung. (B) CTA reveals a narrow neck and a giant pseudoaneurysm. (C) CT reconstruction shows an optimal visualization of pseudoaneurysm. CTA = computed tomography angiogram, PA = pseudoaneurysm.

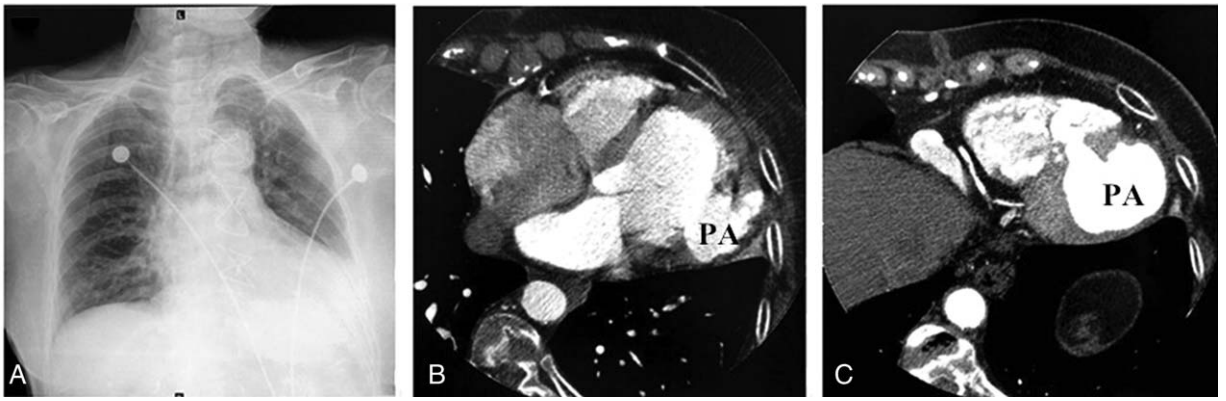

Figure 3. Patient no. 8. (A) Chest X-ray shows left ventricle amplification. (B) CTA shows a left ventricle pseudoaneurysm with a large orifice. (C) The black arrow shows the orifice communicating with the right ventricle. CTA = computed tomography angiogram, PA = pseudoaneurysm.

vein graft [SVG]-obtuse marginal branch [OM]). Fifteen months ago, she developed chest pain abruptly for nearly an hour. ECG showed ST-segment elevation in the lead of II, III, aVF, V7–9. She accepted thrombolytic therapy, but TTE confirmed ventricular septal rupture later and he received conservative therapy. CTA in our hospital showed normal LIMA-LAD, the occlusion of orifice of SVG and also a large LV pseudoanerysm at the lateral and bottom of left heart with 2 rupture orifices (one to LV and the other to right ventricle). This patient accepted medical therapy considering high risk of surgery. At 6 months' follow-up, the patient had chest tightness occasionally and was recommended to cardiac surgery if possible.

4. Discussions

Left ventricular pseudoaneurysm is a type of rare and lethal condition derived from rupture of the ventricular free wall, but enclosed by the adherent pericardium or scar tissue. The incidence of LV pseudoaneurysm was 0.23%, reported by Csapo et al.[10] For low incidence of LV pseudoaneurysm, only sporadic cases and a few cases series have been reported in the past, despite of high rupture and mortality risks in published researches.[1] This study retrospectively analyzed 10 patients with LV pseudoanerysm and showed 3 etiologies including MI, mitral valve replacement, and suspected endocarditis. In 2009, Kang et al[9] from our hospital also reported a case of traumatic LV pseudoaneurysm; a 35-year-old woman complained of chest pain and short of breath, and had a history of blunt chest trauma of falling from a tree, LV pseudoaneurysm (70 mm × 51 mm) in the apical of the left ventricle was found.

Transmural MI, which was regarded most frequent, and also surgery, trauma, and infection are common etiologies inducing LV pseudoaneurysm.[1,11] MI accounted for 6 cases of LV pseudoaneurysm followed by mitral valve replacement. Only 1 case was suspected of endocarditis, because of young age without any cardiovascular risk factors and having history of fever of unknown origin. Inferior and inferoposterior MI accounted for all cases with MI in our study. Two reasons were considered, one was that the posterior wall was relatively stationary and had a little space, and patients were usually in the recumbent position, so an inflammatory reaction of the posterior pericardium may result in pericardial adhesions.[1] The other was that anterior wall had great amplitude of movement and a big space, for which most patients may be more likely to die because of acute cardiac tamponade when rupture occurred. LV pseudoaneurysm had a tendency to rapid enlargement and rupture. Rupture of LV pseudoaneurysm can penetrate into the left pleural cavity, like in patient no. 7. It penetrated through the pericardium and the left mediastinal pleura into the left pleural cavity, which generated hemo-hydrothorax in pleural effusion associated with pericardial effusion.[12] Occasionally, LV pseudoaneurysm may perforate into the right ventricle, like in patient no. 8, and the hemodynamic presentation is similar to 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 sysmptoms, 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,[1,15] 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

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[18] and Della Rocca et al.[19]

Distinction of pseudoaneurysm from a true aneurysm can be difficult because most patients may be asymptomatic or have nonspecific symptoms.[20] 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, pseudoanerysm 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.[21] 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.

Though mortality rates in patients who underwent surgery was approximately 23%, but untreated pseudoaneurysms had an approximately 30% to 45% risk of rupture,[1] 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.[22] 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.[23] 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.[24,25] What is more, percutaneous closure in small neck pseudo-aneurysm with coils or occluders is also described in recent years.[5–8]

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.

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