International Journal of Cardiology 168 (2013) 3665–3670

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

Left ventricular apical aneurysm associated with normal coronary arteries following cardiac surgery: Echocardiographic features and differential diagnosis

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ARTICLE INFO

Article history:
Received 4 June 2013
Accepted 4 June 2013
Available online 2 July 2013

Keywords:
Echocardiography
Ventricular aneurysm
Cardiac surgery
Left ventricular apical aneurysm
Takotsubo cardiomyopathy
Transcatheter aortic valve implantation

ABSTRACT

Left ventricular aneurysms mainly occur in patients with transmural myocardial infarction caused by left anterior descending coronary artery occlusion. Left ventricular apical aneurysm is rarely found in patients with normal coronary arteriograms, and even rarer in these patients following cardiac operations. We analyzed 37 patients with postoperative left ventricular apical aneurysm, including 1 case from our hospital and 36 cases from the literature; 23 cases (62%) had left ventricular apical true aneurysms and 14 cases (38%) had left ventricular apical pseudoaneurysms, all confirmed at surgery and/or angiography. All cases, with the exception of one, had previously undergone cardiac surgery under cardiopulmonary bypass with apical venting. Although left ventriculography is generally regarded as the gold standard for diagnosis of ventricular aneurysm, echocardiography is an accurate and sensitive method in the evaluation of left ventricular apical aneurysm. Differential diagnosis of left ventricular apical aneurysm includes takotsubo cardiomyopathy, post transapical approach for transcatheter aortic valve implantation, and left ventricular diverticulum.

1. Introduction

Left ventricular apical aneurysm may result from transmural myocardial infarction caused by left anterior descending coronary artery occlusion. Ventricular apical aneurysm is rarely found in patients with normal coronary arteriograms, and even rarer in these patients following cardiac surgery. We reviewed 37 patients with postoperative left ventricular apical aneurysm, including 1 case from our hospital and 36 cases from the literature, and hereby discuss their anatomical characteristics, incidence, etiology, clinical presentations, complications, echocardiographic features, prognosis, treatment and differential diagnosis.

2. Anatomical characteristics of left ventricular apex

Baptista et al [1] divided the left ventricular apex into three types. Type I was defined as the anatomical apex, with its base established at the incisura apicis cordis. Type II was defined as the amplified anatomical apex, with its volume twice that of the anatomical apex. Type III was defined as the geometric apex, which represents the distal third of the ventricles. The number of the branches of the coronary arteries gradually decreases from the geometric (the largest type) to the anatomical apex (the smallest): 27 on the surface of the geometric apex, 14 on the surface of the amplified anatomical apex, and 7 on the surface of the anatomical apex. Thus the myocardial blood supply becomes less abundant as the cardiac muscles approach the anatomical apex, which consequently is more prone to be affected by interruption of coronary blood supply resulting in myocardial infarction and subsequent formation of ventricular aneurysm [2].

3. Incidence of left ventricular apical aneurysm

Left ventricular apical aneurysm is mainly caused by transmural myocardial infarction following left anterior descending coronary artery occlusion, although it has also been reported following various types of cardiac surgery [3]. In one reported series with a four-year follow-up in 50 postoperative children with congenital heart disease [4], there were 16 cases (32%) with left ventricular apical aneurysm confirmed by left ventricular angiography; the types of congenital heart disease were as follows: 6 cases of ventricular septal defect, 5 cases of tetralogy of Fallot, 2 cases of aortic stenosis, and 3 cases of miscellaneous malformations. All of the 50 cases were operated under cardiopulmonary bypass with apical venting. Other cardiac surgical procedures resulting in left ventricular aneurysm formation included double artificial mechanical valve implantation [5], congenital supravalvular aortic stenosis repair [6], and transcatheter closure of ventricular septal defect [7]. Among the aforementioned 3 cases, 2 [5,6] with apical aneurysm were

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0167-5273/$ – see front matter
http://dx.doi.org/10.1016/j.ijcard.2013.06.001

confirmed by both left ventricular angiography and normal coronary arteries on coronary angiography, and 1 [7] of apical aneurysm confirmed by ultrasound examination in a 12-month follow-up. In our hospital we had 1 case of left ventricular apical aneurysm following patent ductus arteriosus ligation 14 years earlier in a 41-year-old man, confirmed by echocardiography (Fig. 1), coronary angiography and left ventriculography (Fig. 2) and coronary computed tomography angiography (Fig. 3). His 24-hour ambulatory electrocardiograms showed various types of ventricular arrhythmias (Fig. 4).

Left ventricular aneurysm can be true or false, the latter being usually called pseudoaneurysm. Left ventricular pseudoaneurysms form when cardiac rupture is contained by adherent pericardium or scar tissue [8]. Although left ventricular pseudoaneurysms are not common, the diagnosis is important because they are prone to rupture and cause sudden death. One third of left ventricular pseudoaneurysms were caused by cardiac surgery [8]. Next to myocardial infarction, cardiac surgery ranks the second commonest cause of left ventricular pseudoaneurysm [8]. A retrospective study of 143 patients with transapical transcatheter aortic valve implantation [9] showed that 18/54 (33%) had an apical hypo- or akinesia at 6-month follow-up echocardiographic examination, 10 (7%) had severe apical bleeding complication, and 2 (2%) developed an apical pseudoaneurysm. Other reported cardiac surgical procedures resulting in left ventricular pseudoaneurysm were as follows: aortic valve commissurotomy [10], myomectomy in idiopathic subaortic muscular stenosis [11], closure of atrial septal defect and repair of partial anomalous pulmonary venous drainage [12], mitral valve replacement [13], Marfan syndrome surgery [14], aortic valve surgery [15–17], coronary artery bypass grafting [18], aortic dissection repair [19] and transapical transcatheter aortic valve implantation [20]. All of these cases were operated under cardiopulmonary bypass with apical venting. Apical pseudoaneurysm has high risk of rupture [8] and low probability of spontaneous closure [21], although spontaneous closure has been reported [22,23]. In our review of the literature, 36 patients with postoperative left ventricular apical aneurysm included 22 (61%) with left ventricular apical true aneurysm and 14 (39%) with left ventricular apical pseudoaneurysm.

4. Etiology of left ventricular apical aneurysm

Corrective surgery for congenital heart defect is usually performed under cardioplegic arrest and cardiopulmonary bypass. However, cardioplegic arrest may lead to transient hypoperfusion for myocardial cells, myocardial ischemia-reperfusion injury [24], and myocardial stunning or necrosis [25]. Myocardial stunning is a common complication after cardiac surgery, characterized by the decline of myocardial contractile function [25]. As mentioned earlier, left ventricular apex is very sensitive to myocardial contractility changes. With the increase of postoperative myocardial oxygen consumption, decrease of coronary blood flow and the decline of cardiac ejection fraction [24], the apical myocardium may gradually develop a state of ischemia which may cause ventricular dysfunction or failure [5] and eventually may lead to aneurysmal formation [26].

To vent through the left ventricular apex is a very crucial step in open heart surgery; it provides a clear and dry surgical field for the surgeon and ensures a smooth operation. In addition, apical venting under systemic low-temperature environment could be helpful in preventing left ventricular distention during the critical period of rewarming and reperfusion [27]. However, left ventricular apical venting is the main cause for apical pseudoaneurysm after cardiac surgery [14,16,18,19,23,28], the location of the apical pseudoaneurysm being usually the site for apical venting [19,28]. True apical aneurysm may also be caused by apical venting [4]; the cause is myocardial focal infarction from suturing or suture breakage [29–31]. Improvement of the techniques in repairing the apical vent and choosing other sites for left ventricular venting may prevent the occurrence of these complications [28].

5. Clinical presentations and complications of left ventricular apical aneurysm

The majority of patients with left ventricular apical aneurysm after cardiac surgery have few clinical symptoms, although some may have palpitation and dizziness due to ventricular tachyarrhythmias [31]. Of the 16 cases with postoperative left ventricular apical aneurysm among 50 children with congenital heart disease reported by Weesner and associates [4], all were asymptomatic. However, these aneurysms are anticipated to represent a potential source of cardiovascular complications later in life. The potential complications include arrhythmias, endocarditis, thromboembolism, and aneurysm rupture [32–35].

6. Echocardiographic features of left ventricular apical aneurysm

Echocardiography is the preferred diagnostic method for left ventricular aneurysm, especially in differentiating true aneurysm from pseudoaneurysm [36], although left ventricular angiography is

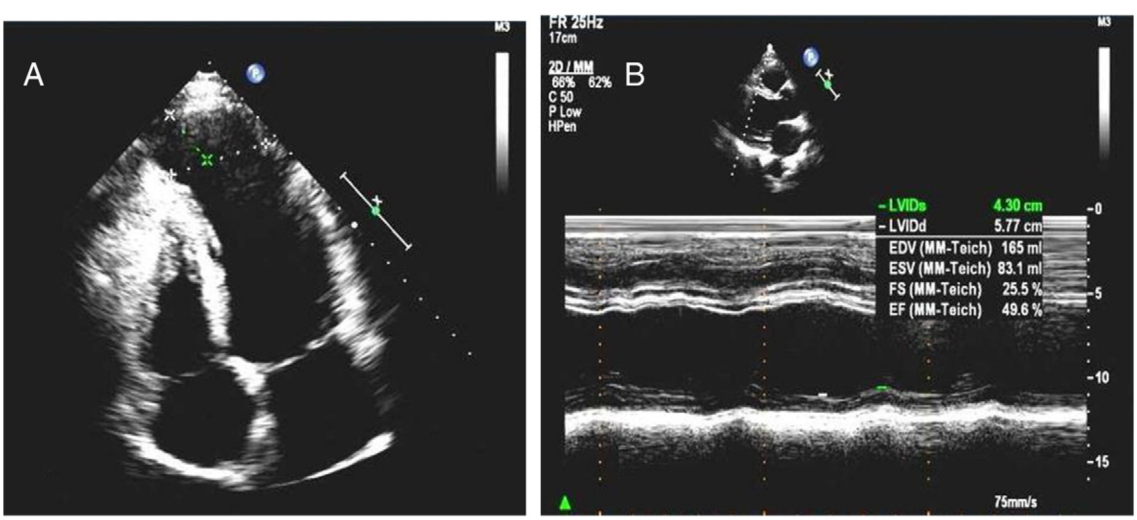

Fig. 1. The echocardiograms of left ventricular apical true aneurysm in a 41-year-old man following patent ductus arteriosus ligation 14 years earlier: (A) The apical four-chamber view showing the thinning and aneurysmal bulge of the left ventricular apex with paradoxical motion. The basal width of the aneurysm = 42 mm and its depth = 24 mm. (B) Parasternal left ventricular long axis view on M-mode of mitral valve at the chordae level showing a left ventricular end-diastolic anteroposterior diameter of 57 mm and LVEF of 50%.