Apical ballooning of the left ventricle: first series in white patients

W J R Desmet, B F M Adriaenssens, J A Y Dens

Background: A cardiac syndrome of "apical ballooning" was recently described, consisting of an acute onset of transient extensive akinesia of the apical and mid portions of the left ventricle, without significant stenosis on the coronary angiogram, accompanied by chest symptoms, ECG changes, and a limited release of cardiac markers disproportionate to the extent of akinesia. Until now, this syndrome has been reported only in Japanese patients.

Objective: To describe 13 white patients who presented with this syndrome over the previous four years.

Results: All but one of the patients were women with a mean age of 62 years. Eight of them presented with chest pain, of whom six had cardiogenic shock. In nine patients a triggering factor was identified: emotional stress in three, trauma in one, pneumonia in one, asthma crisis in one, exercise in two, and cerebrovascular accident in one. In all patients left ventriculography showed very extensive apical akinesia ("apical ballooning") in the absence of a significant coronary artery stenosis, not corresponding with the perfusion territory of a single epicardial coronary artery. Mean maximal creatine kinase MB and troponin rise were 27.4 µg/l (range 5.2–115.7 µg/l, median 16.6 µg/l) and 18.7 µg/l (range 2.0–97.6 µg/l, median 14.5 µg/l), respectively. Six patients were treated with intra-aortic balloon counterpulsation. One patient died of multiple organ failure. On necropsy, no myocardial infarction was found. In the 12 survivors, left ventricular systolic function recovered completely within three weeks.

Conclusions: This is the first series of "apical ballooning" to be reported in white patients. Despite dramatic initial presentation, left ventricle function recovered completely within three weeks in the survivors.

METHODS

We describe 13 white patients who presented with this novel heart syndrome at our institution over the past four years: one in 1998, four in 2001, and eight in 2002. The following parameters were evaluated: sex, age, presenting symptoms and duration of symptoms before admission, serial ECGs, QT interval, cardiac enzymes, cardiac imaging, invasive pressures, cardiac index and wedge pressure, the use of intra-aortic balloon counterpulsation, pathological findings, and parameters of recuperation.

RESULTS

Case reports

Case 1 (patient 5)

A 48 year old woman with a history of haemochromatosis presented to the emergency department with a four hour history of chest discomfort, dyspnoea, and palpitations. The ECG on admission showed slow R progression in the precordial leads. Subsequently she developed negative T waves in the anterolateral leads.

The troponin I, creatine kinase (CK), and CK MB concentrations were slightly increased (table 1).

Over the following hours she developed haemodynamic instability with evolution to cardiogenic shock. An emergency echocardiography showed anterolapal akinesia. Left ventriculography confirmed the presence of a large anterolapal akinetik zone with a severe decrease of left ventricular ejection fraction (30%). No intraventricular pressure gradient was observed. Coronary angiography showed normal coronary arteries. Intra-aortic balloon counterpulsation was initiated and intransparent inotropic drugs were administered.

On endomyocardial biopsies, there was no evidence of haemochromatosis, sarcoidosis, myocarditis, or vasculitis.

After 12 days the patient made a complete functional recovery, with normalisation of the wall motion and global left ventricular systolic function on echocardiographic evaluation.

Case 2 (patient 2)

A 78 year old woman with restrictive lung disease caused by a congenital diaphragmatic hernia with superimposing corticoid dependent obstructive lung disease was admitted after a fall with two rib fractures. She was transferred to the coronary care unit because of ST elevations seen on monitoring. Twelve lead ECG had clearly changed and showed ST elevation of 7 mm in leads V2 and V3 and of 2 mm in V4, as well as discrete ST segment elevations in leads I and aVL. The patient had no thoracic pain but was receiving an infusion of tramadol for pain caused by her rib fractures. She complained only of increasing dyspnoea.

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Conclusions: This is the first series of "apical ballooning" to be reported in white patients. Despite dramatic initial presentation, left ventricle function recovered completely within three weeks in the survivors.
Table 1 Findings in 13 white patients with “apical ballooning”

<table>
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<th>Patient number</th>
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<td>CVA, fall</td>
<td>Dyspnoea, cough</td>
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<td>Emotional stress</td>
<td>Unknown</td>
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<td>V1–V4</td>
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<td>Slow R progression anterior, ST ↑</td>
<td>V1–V6</td>
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<td>Negative T</td>
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<td>ECG on day 1</td>
<td>15 min later, broad QRS after resuscitation</td>
<td>12 h later, negative T</td>
<td>V1–V6, ST ↑</td>
<td>V2–V6</td>
<td>Negative T</td>
<td>V2–V6</td>
<td>Unchanged</td>
<td>8 h later, ST ↑ more pronounced</td>
<td>V4–V6, aVF</td>
<td>12 h later, ST ↑ more pronounced</td>
<td>V2–V6</td>
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<td>I, II, aVF, V3–V6</td>
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<td>ECG on day 2</td>
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<td>V3–V6</td>
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<td>V3–V6, II, III, aVF, ST ↑</td>
<td>V3–V5</td>
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<td>V2–V6, II, III, aVF, V3–V6</td>
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<td>V1–V3</td>
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<td>17.5</td>
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<td>1.7</td>
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<td>NYHA</td>
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<td>II</td>
<td>I</td>
<td>I</td>
<td>I</td>
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<td>II</td>
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CK, creatine kinase; CVA, cerebrovascular accident; F, female; IABP, intra-aortic balloon pump; IPG, intraventricular pressure gradient; LBBB, left bundle branch block; LVEDP, left ventricle end diastolic pressure; M, male; NA, not available; NYHA, New York Heart Association functional class at discharge; PCWP, pulmonary capillary wedge pressure; TTE, transthoracic echocardiography; VF, ventricular fibrillation.
An urgent coronary angiography was performed. Surprisingly this showed normal coronary arteries but a severely affected systolic function: only the basal parts of the heart had normal contractility, and a large apical portion was akinetic. End diastolic left ventricular pressure was 35 mm Hg. Ejection fraction was 36%. The same characteristics of normal basal contractility and severely reduced apical contractility were documented by magnetic resonance imaging afterwards. Biochemically there was a slight rise in cardiac markers: troponins rose to 17 µg/l (normal < 0.6 µg/l). Treatment was conservative with diuretics and oxygen. Treatment with an angiotensin converting enzyme inhibitor was initiated. In the following days, systolic function improved gradually. A control transthoracic echocardiography showed normalisation of the regional contractility on day 10.

Clinical findings
All but one of the patients were women, with a mean age of 62 years (table 1). Only one patient had a history of angina-like complaints. The clinical presentation in our series varied from mere ECG abnormalities to chest pain, dyspnoea, and even ventricular fibrillation or evolution to cardiogenic shock. Eight of the 13 patients presented with chest pain, of whom six had cardiogenic shock. In nine patients possible triggering by a major physical or emotional impact was identified: severe emotional stress in three, exercise in two, and trauma, an asthma crisis, pneumonia, and a cerebrovascular accident in one patient each.

The ECG on admission was normal in five patients. In another five patients slight to pronounced ST segment elevation was noted in multiple anterior leads. Two patients presented with negative T waves and one with a new left bundle branch block. In all patients negative T waves in the anterior leads developed over the following days. After a mean of three weeks, the ECG had normalised in four patients and in the others negative T waves persisted, up to one year in one patient.

In the acute phase, 12 of the 13 patients had a QTC interval of at least 400 ms (range 310–674 ms, mean 450 ms, median 436 ms).

Maximum troponin I concentrations ranged from 2.0 to 97.6 µg/l (mean 18.7 µg/l, median 14.5 µg/l). The MB fraction of CK rose moderately in all patients (range 5.2–115.7 µg/l, mean 27.4 µg/l, median 16.6 µg/l).

In all patients, echocardiography exhibited akinesia of the apical and mid portions of the left ventricle. The same pattern of contractility was observed on magnetic resonance imaging in three patients.

Because of the clinical presentation and the ECG changes, a severe ischaemic event was suspected and coronary angiography was performed in all patients between 2–72 hours after the onset of symptoms (mean 17 hours, median 12 hours). In patients who were not in cardiogenic shock, 100 µg glyceryl trinitrate intracoronarily was administered. Five patients had completely normal coronary arteries. In the others minor stenoses were seen, estimated to be < 25% diameter stenosis in all cases. A large apical portion of the left ventricle was akinetic or dyskinetic, whereas basal contractility was normal or even supernormal (fig 1) End diastolic pressures were increased (mean 27 mm Hg, minimum 18 mm Hg, maximum 42 mm Hg). In the six patients who received intra-aortic balloon counterpulsation, a Swan-Ganz catheter was inserted. The first measurement showed a low cardiac index (mean 1.8 l/m/minute). When compared with the left ventricular end diastolic pressure obtained during coronary angiography, the clearly lower wedge pressures reflect the unloading effect of the intra-aortic balloon pump.

In the 12 surviving patients a complete recovery of left ventricular systolic function after two weeks on average was documented by echocardiography. In two cases, a significant intraventricular pressure gradient was measured. At the time of contractile recovery the ECG normalised in four patients. In the remaining patients negative T waves persisted. One patient died of multiple organ failure. On necropsy, there were no macroscopic signs of recent myocardial infarction or scars. Microscopic examination showed normal myocardial tissue, except for some fatty infiltration of the left ventricular wall.

Possible recurrence?
Six years before the present admission, patient 6 had been hospitalised abroad for a similar clinical syndrome of cardiogenic shock with extensive anteroapical akinesia for which intra-aortic balloon counterpulsation was needed. Coronary angiography and left ventriculography four weeks after the acute episode were completely normal. Five months after her ventricular fibrillation with apical ballooning, patient 9 presented with vague chest complaints and deep negative T waves in the anterior leads. Coronary angiography was again normal, and the complaints did not recur in the following three months. We considered this episode to be “aborted” apical ballooning.

DISCUSSION
Apical ballooning: a distinct syndrome?
In 1990 and 1991 Satoh and colleagues’ and Dote and associates’ described a syndrome consisting of an acute onset of transient extensive akinesia of the apical and mid portions of the left ventricle without significant epicardial coronary artery stenosis, accompanied by chest symptoms, ECG changes, and minimal enzymatic release. They named this syndrome “Takotsubo” shaped cardiomyopathy because of the

**Figure 1** End diastolic (A) and end systolic (B) left ventriculograms of patient 9 show extensive akinesia of the apical and mid portions of the left ventricle, representative of all patients in the present series. On coronary angiography (C) no coronary artery stenoses were seen. The distal end of the left anterior descending artery does not reach the apex.
resemblance of the systolic left ventricular image to the Japa-
1030 Desmet, Adriaenssens, Dens
ese patients. Since it is now obvious that it also occurs in
Clinical implications
white patients, clinicians in the western world should also be
aware of the existence of this syndrome. This is important
because this syndrome mimicking acute myocardial infarction
may inadvertently expose patients to futile administration of
fibrinolytic agents. More important, we urgently need more
information on the pathophysiology and optimal treatment of
this syndrome. These are not necessarily the same for all
patients presenting with this syndrome, since various
pathophysiological mechanisms may underlie the final clini-
cal picture. Indeed, while some of these patients have been
successfully treated with β adrenoceptor blockade, α adreno-
ceptor agonism, and volume expansion, many others have
received positive inotropic agents and intra-aortic balloon
counterpulsation. Since the optimal treatment of some
patients presenting with this syndrome may thus be
detrimental to other patients, it is of vital importance that the
cardiological community gather this needed information. In
addition, since recurrence of this syndrome in some patients
seems possible, prompt recognition is needed.

In 1986, Scully and associates1 described a similar case of a
44 year old woman who was well until she was informed that
her 17 year old son had committed suicide by hanging. On
endomyocardial biopsy they found necrotic myocytes with
focal interstitial mononuclear cell infiltration, and antimyosin
antibody cardiac scintigraphy was strongly positive. They
treated the patient for myocarditis and she made an unevent-
ful recovery over the following months.

The only endomyocardial biopsy we performed was entirely
normal. Although this may well be caused by sampling error,
the clinical picture in this syndrome is not suggestive of myo-
carditis, and a close association between intense emotional
stress and sudden onset myocarditis seems most unlikely. In
addition, in the one patient who died, no signs of myocarditis
or myocardial necrosis were found on microscopic examina-
tion.

Pathophysiology
The observation of a normal ECG in the beginning of the dis-
case and the development of the abnormalities described
above after 4–24 hours in five of the 13 patients argues against
a stenotic or a vasospastic event, in which we would expect
immediate ECG changes.

The severe myocardial hypocontractility with very limited
release of cardiac enzymes and complete recovery over a rela-
tively short period of time is reminiscent of myocardial stun-
ing. Also, the observed ECG abnormalities included sym-
metrical diffuse T wave inversion and QT prolongation, a
pattern that has been associated with left ventricular stunning
in unstable ischaemic syndromes. 1-4 By definition, stunned
myocardium results from prolonged postischaemic left ventri-
cle dysfunction after brief myocardial ischaemia. 1 However, in
none of the patients described by Tsuchihashi and colleagu-
ies10 in our series, had a significant intraventricular pressure gradient.

Patient 10 of our series needed mitral surgery seven months
after her acute episode because of complaints due to mitral
regurgitation and LVOT obstruction caused by systolic anterior
movement of the anterior mitral leaflet in the absence of sig-
ificant septal hypertrophy.

In the majority of cases described to date, triggering condi-
tions that precede onset were described, consisting of expo-
sure to internal (emotional) and external stresses (trauma, surgical procedure, exacerbation of a pre-existing
condition). This suggests that enhanced sympathetic activity
plays a major part in the origin of this syndrome. On the other
hand, Villareal and colleagues 9 observed left ventricular
outflow tract (LVOT) obstruction in three patients with a
similar syndrome. They hypothesised that patients with a
sigmoid interventricular septum, small LVOT, and reduced left
ventricular volumes (primarily women) and an abnormal or-
ientation of a slack mitral apparatus have a geometrical
predisposition to dynamic LVOT obstruction, which may
manifest in the setting of intense adrenergic stimulation or
hypovolaemia. 6 With LVOT obstruction, apical and anterior
wall stress and left ventricular filling pressures increase while
systemic blood pressure decreases. Increased oxygen demand
and reduced coronary perfusion pressure may combine to
produce myocardial ischaemia, stunning, regional wall motion
abnormalities, and associated T wave changes. This hypothesis
may explain the female predominance in the patients
presenting with this syndrome. On the other hand, only 12 of
72 patients in Tsuchihashi’s series and only 2 of 13 patients
in our series had a significant intraventricular pressure gradient.

The only endomyocardial biopsy we performed was entirely
normal. Although this may well be caused by sampling error,
the clinical picture in this syndrome is not suggestive of myo-
carditis, and a close association between intense emotional
stress and sudden onset myocarditis seems most unlikely. In
addition, in the one patient who died, no signs of myocarditis
or myocardial necrosis were found on microscopic examina-
tion.

Clinical implications
Until now, this novel clinical syndrome had, with the excep-
tion of a few isolated cases, been described only in Japa-
nese patients. Since it is now obvious that it also occurs in
white patients, clinicians in the western world should also be
aware of the existence of this syndrome. This is important
because this syndrome mimicking acute myocardial infarction
may inadvertently expose patients to futile administration of
fibrinolytic agents. More important, we urgently need more
information on the pathophysiology and optimal treatment of
this syndrome. These are not necessarily the same for all
patients presenting with this syndrome, since various
pathophysiological mechanisms may underlie the final clini-
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successfully treated with β adrenoceptor blockade, α adreno-
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received positive inotropic agents and intra-aortic balloon
counterpulsation. Since the optimal treatment of some
patients presenting with this syndrome may thus be
detrimental to other patients, it is of vital importance that the
cardiological community gather this needed information. In
addition, since recurrence of this syndrome in some patients
seems possible, prompt recognition is needed.
Conclusion

We report the first series of “apical ballooning” in white patients. This syndrome consists of an acute onset of transient extensive akinesia of the apical and mid portions of the left ventricle, without significant stenosis on the coronary angiogram, accompanied by chest symptoms, ECG changes, and a limited release of cardiac markers disproportionate to the extent of akinesia. Despite dramatic initial presentation, left ventricle function recovered completely within weeks in the survivors.

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