Role of transoesophageal echocardiography in the diagnosis and management of aortic root abscess

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Abstract

Objective—To assess and compare the roles of transthoracic and transoesophageal echocardiography in the diagnosis and management of an aortic root abscess.

Design—To select patients with echocardiographic diagnosis of aortic valve endocarditis with and without an aortic root abscess and correlate this with a retrospective review of surgical and necropsy data.

Setting—Tertiary referral centre at a university teaching hospital.

Patients and methods—34 patients with confirmed aortic valve endocarditis were treated over a four and a half year period. All patients underwent both transthoracic and transoesophageal echocardiography with 17 patients having biplane or multiplane imaging.

Result—11 patients (32%) had an aortic root abscess. Transthoracic echocardiography identified four cases of aortic root abscess whereas transoesophageal echocardiography correctly detected all 11 cases and also detected complications including mitral aortic intervalvar fibrosa fistula in two patients and right atrial involvement in another two patients. Only biplane imaging was able to show an anterior aortic root abscess in one patient and the circumferential involvement of the aortic annulus in another two patients. All patients with an aortic root abscess were treated surgically after transoesophageal echocardiographic diagnosis. After operation, prosthetic aortic regurgitation was present in seven patients and a repeat operation was performed in three patients. Only transoesophageal echocardiography detected a postoperative aorto-right atrial fistula in two patients and recurrence of the root abscess in another. There were five deaths in hospital (45%).

Conclusions—Compared with transthoracic echocardiography, transoesophageal echocardiography was more sensitive and more specific for the early diagnosis of aortic root abscess and its complications and facilitated both the preoperative and postoperative management of these patients. Biplane and multiplane imaging provide additional diagnostic information. All patients with suspected aortic valve endocarditis

should have an early transoesophageal echocardiographic study.

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Transthoracic echocardiography has traditionally been the investigation of choice for the detection of valvar vegetations, the assessment of associated valvar dysfunction, and other complications in patients with infective endocarditis.¹⁻³ Its reduced diagnostic sensitivity and inadequate image quality in some patients, however, especially those with prosthetic valves, remain important limitations.

Infection of the aortic valve may extend into the annulus and the mitral aortic intervalvar fibrosa resulting in the formation of an aortic root abscess. These structures are relatively avascular and offer little resistance to infection. In necropsy and surgical series, this serious complication has been reported in up to 40% of patients with native aortic valve endocarditis and the incidence is higher in patients with prosthetic aortic valve endocarditis.⁴⁻⁶ As the presence of an aortic root abscess is usually an indication for urgent surgery, its prompt and accurate diagnosis is essential if perioperative morbidity and mortality are to be reduced and surgical repair facilitated. Aortic root abscess has often been difficult to diagnose preoperatively by transthoracic echocardiography. Transoesophageal echocardiography, with its better image quality due to the close proximity to cardiac structures and the use of a higher frequency transducer, has been shown to be better than transthoracic echocardiography in the detection of valvar vegetations⁷ and the assessment of associated dysfunction of the prosthetic valve.⁸

There is little information available on the role of transoesophageal echocardiography in the detection and management of aortic root abscess and its complications.^{9,10} Therefore, the aim of our study was to assess the role of transoesophageal echocardiography in the diagnosis and management of an aortic root abscess both before and after surgical intervention.

Patients and methods

PATIENTS

Between January 1989 and May 1993, a total of 234 patients with suspected infective endocarditis were referred to our echocardiography

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laboratory for transoesophageal echocardiography. Thirty four consecutive patients with proved aortic valve endocarditis were identified and this group formed our study population.

ECHOCARDIOGRAPHY

All patients had both transthoracic and transoesophageal echocardiography. Transthoracic echocardiography was performed with 2.5 MHz and 3.5 MHz phased array transducers with a Hewlett Packard Sonos 1000 system (Hewlett Packard, Andover, Massachusetts). Systematic examinations were performed from all the standard echocardiographic windows. Transoesophageal echocardiography was performed immediately after the transthoracic study with a 5 MHz transducer mounted at the tip of a modified gastroscope according to standard protocols.¹¹ Monoplane imaging was performed in 17 patients, biplane in 14, and multiplane in three. All patients gave written informed consent. All patients fasted for at least four hours before the examination and were sedated with intravenous fentanyl and midazolam. The oropharynx was anaesthetised with 10% xylocaine spray. There were no complications.

Aortic valve endocarditis was considered to be proved when a new vegetation or root abscess was detected at the aortic valve together with either positive blood cultures or symptoms and signs of sepsis when blood culture was negative. An aortic root abscess was considered to be present when there were echolucent cavities in the perivalvar region or abnormal perivalvar echodensity identified in more than one tomographic plane when endocarditis was suspected.^{9 10 12} Complications of the aortic root abscess such as formation of an aneurysm or fistula were sought. The severity of aortic regurgitation was assessed semi-quantitatively by colour and pulsed wave Doppler and was graded as nil, trivial, mild, moderate, or severe according to the criteria of Perry *et al.*¹³

ANATOMICAL CORRELATION

Surgical records of all patients with infective endocarditis undergoing open heart surgery and necropsy studies of all patients who died of infective endocarditis during the same

period were reviewed. The presence, site, and extent of aortic root abscess were examined by direct inspection at surgery or necropsy and confirmed by histopathological examination as an area of necrosis with purulent material at or extending from the aortic valve annulus.

FOLLOW UP

All patients with an aortic root abscess who were discharged from hospital were followed up. Patients, their general practitioners, and attending physicians were contacted and events after discharge were recorded.

Results

There were 34 patients with proved aortic valve endocarditis. The mean age was 52, 24 were men, and 10 were women. *Staphylococcus aureus* was the most common causative organism (nine patients, 26%). Six patients (18%) had culture negative aortic valve endocarditis (previous antibiotic treatment in three). *Staphylococcus epidermidis* was the causative organism in four patients (12%), viridans type streptococci in five (15%), other non-viridans streptococci in five (15%), gram negative organisms in three (9%), *Candida albicans* in one patient, and clostridial species in another. The underlying aortic valve was native tricuspid aortic valve in 23 patients (65%), bicuspid aortic valve in three (6%), heterograft in five (18%), St Jude prosthesis in two (9%), and Starr-Edwards prosthesis in one. Twenty three patients were treated surgically and there were eight deaths in hospital (overall mortality rate 18%).

Aortic root abscess was confirmed either at surgery or necropsy in 11 patients (32%, table 1). Of these 11 patients, six were found to have vegetations on the aortic valve, the mean (range) age was 48 (16–79), and there were 10 men and one woman. The mean (range) duration of symptoms before diagnosis of aortic root abscess was 4.6 (1–12) weeks. *S aureus* was the causative organism in five of the 11 patients (45%). The underlying aortic valve was a porcine heterograft in four (36%), St Jude prosthesis in two (27%), bicuspid aortic valve in three (27%), and native tricuspid aortic valve in two (18%).

Table 1 Clinical findings and outcome of the 11 patients with aortic root abscess

Patient	Sex/age	Aortic valve	Organism	Duration (weeks)	Surgery	Follow up
1	F/68	Heterograft	<i>Candida</i>	4	Death on induction	Death in hospital
2	M/47	Heterograft	<i>Staph aureus</i>	3	AVR, root repair	Death in hospital
3	M/47	Bicuspid	<i>Staph aureus</i>	2	AVR, MVR, root repair	AR, abscess, Ao-LA fistula, reop, death in hospital
4	M/62	Native tricuspid	<i>Staph aureus</i>	1	AVR, root repair	AR, CHB, Ao-RA fistula, death in hospital
5	M/57	Native tricuspid	<i>Strep pneumoniae</i>	2	AVR, root repair	AR, CHB, Ao-RA fistula, death in hospital
6	M/59	St Jude's	<i>Staph epidermidis</i>	12	AVR, root repair	Discharged, AR
7	M/37	St Jude's	Culture negative	6	Homograft aortic root	Discharged
8	M/79	Heterograft	<i>Clostridia</i>	12	AVR, root repair	Discharged
9	M/16	Bicuspid	<i>Staph aureus</i>	2	AVR, root repair	Discharged, late reop for AR
10	M/24	Heterograft	<i>Staph aureus</i>	2	Homograft aortic root	Discharged, AR
11	M/30	Bicuspid	Viridans streptococci	6	AVR	Discharged, late reop for AR

Abscess, recurrence of aortic root abscess after surgery; Ao-LA fistula, aorto-left atrial fistula; Ao-RA fistula, aorto-right atrial fistula; AR, aortic regurgitation; AVR, aortic valve replacement; CHB, complete heart block; Duration, duration of symptoms before diagnosis of abscess; MVR, mitral valve replacement; Reop, reoperation; Root repair, repair of aortic root with bovine pericardium; *Staph*, *Staphylococcus*; *Strep*, *Streptococcus*.

Table 2 Comparison of preoperative transthoracic (TTE) and transoesophageal (TOE) echocardiographic findings of the 11 patients with aortic root abscess

Patient	TTE	TOE
1	Aortic root abscess, AV vegetation, no AR	Aortic root abscess, AV vegetation, no AR
2	Aortic root abscess, severe AR	Aortic root abscess, severe periprosthetic AR
3	AV vegetation, mild AR, thickening of base of AML	Aortic root abscess, AV vegetation, mild AR, MAIVF aneurysm, fistula
4	AV vegetation, mild AR	Aortic root abscess, AV vegetation, mild AR, RA wall vegetation
5	AV vegetation, severe AR	Aortic root abscess, AV vegetation, severe AR, RA wall vegetation
6	Moderate AR	Aortic root abscess, moderate periprosthetic AR
7	Trivial AR, thickening of base of AML	Aortic root abscess, trivial AR, MAIVF aneurysm, fistula
8	Mild AR	Aortic root abscess, mild periprosthetic AR
9	Aortic root abscess, mild AR	Aortic root abscess, AV vegetation, mild AR
10	Aortic root abscess, moderate AR	Aortic root abscess, moderate periprosthetic AR
11	Severe AR	Aortic root abscess, severe AR, AV vegetation

AML, anterior mitral leaflet; AV, aortic valve; AR, aortic regurgitation; MAIVF, mitral aortic intervalvular fibrosa; RA, right atrium.

Figure 1 Aortic root abscess (arrow) affecting the posterior region of the aortic annulus : transoesophageal echocardiography (horizontal plane). IVS, interventricular septum; LA, left atrium; LV, left ventricle; MV, mitral valve; RV, right ventricle.

Figure 2 Transoesophageal echocardiography (longitudinal plane) showing a diffusely thickened aortic annulus (arrows) consistent with circumferential involvement by the root abscess. AV, aortic valve (St Jude); LA, left atrium; RA, right atrium; RVOT, right ventricular outflow tract.

PREOPERATIVE ECHOCARDIOGRAPHIC FINDINGS Table 2 shows the results of the echocardiographic studies in the 11 patients with confirmed aortic root abscess. Of the six patients who had vegetations on the aortic valve at surgery or necropsy, the vegetations were seen by transthoracic echocardiography in four patients (sensitivity 66%) and in all six patients by transoesophageal echocardiography. Associated aortic regurgitation was trivial in two, mild in four, moderate in two, and severe in three.

Only four of the 11 cases of aortic root abscess were correctly identified by transthoracic echocardiography (sensitivity 36%). By contrast, transoesophageal echocardiography detected all 11 cases of aortic root abscess (sensitivity 100%). The most common site for an aortic root abscess was the posterior region of the aortic annulus (fig 1, n = 7). In two other patients the whole aortic annulus was involved resulting in aortoventricular discontinuity. The annulus in the region of the left coronary cusp was involved in one patient and the anterior half of the annulus in another. The echocardiographic appearances of aortic root abscess ranged from a diffusely thickened aortic root in early cases to multiple echolucent spaces near the aortic annulus in more advanced cases.

Four of the 11 patients with aortic root abscess had monoplane transoesophageal imaging and seven had biplane examination. The longitudinal plane image available in these seven patients provided considerable additional information. Biplane imaging was able to diagnose aortoventricular discontinuity in two patients by clearly showing the anterior extension of the aortic root abscess in the longitudinal plane (fig 2). In patient 5, the aortic root abscess was seen only in the longitudinal plane due to its anterior location (fig 3). In all four patients with prosthetic aortic regurgitation (patients 2, 6, 8, 10), the longitudinal plane showed the site of periprosthetic aortic regurgitation to be in the posterior aortic annulus.

Only transoesophageal echocardiography detected local complications of aortic root abscess in four patients. In two patients, the aortic root abscess resulted in an aneurysm of the mitral aortic intervalvular fibrosa that had ruptured into the left atrium leading to formation of a fistula (patient 3, 7, fig 4). In another two patients, the membranous ventricular septum was involved and an echodense mass was seen extending from the aortic annulus into the right atrial cavity (patients 4, 5). These findings were all subsequently confirmed at operation.

CLINICAL COURSE

All patients with an aortic root abscess were treated surgically. Two patients had homograft aortic root and valve replacement with reimplantation of the coronary arteries (patients 7, 10). Six patients had aortic valve replacement and reconstruction of the aortic root with bovine pericardium (patients 2,4,5,6,8,9). One patient had mitral and

Figure 3 Aortic root abscess (straight arrows) affecting the anterior half of the aortic annulus : transoesophageal echocardiography (longitudinal plane). Curved arrow: vegetation extending from the aortic annulus onto the right atrial wall. AV, native tricuspid aortic valve; other abbreviations as for fig 2.

aortic valve replacement with repair of the aortic root (patient 3). One patient had aortic valve replacement with debridement and closure of the abscess cavity (patient 11). St Jude's valve prostheses were used in all patients except the two who had homograft replacement.

There were five deaths in hospital in the aortic root abscess group (mortality 45%). Three patients died of uncontrolled sepsis with an intracardiac fistula (patients 3, 4, 5). One critically ill patient died during induction of anaesthesia (patient 1), and one patient died of postoperative low cardiac output syndrome on day 1 (patient 2).

Figure 4 Transoesophageal echocardiography (horizontal plane) showing a mitral aortic intervalvar fibrosa aneurysm (curved arrow) that has ruptured into the left atrium (LA) resulting in a fistula depicted by an abnormal jet (straight arrow) on colour Doppler map in systole. Abbreviations as for fig 1.

ROLE OF TRANSOESOPHAGEAL ECHOCARDIOGRAPHY IN PREOPERATIVE MANAGEMENT

The diagnosis of aortic root abscess was made by transoesophageal echocardiography within 24 hours of admission in eight patients. In the remaining three patients diagnosis was delayed because of delay in referral for transoesophageal echocardiography after initial negative transthoracic studies. All 11 patients were referred for consideration of surgery after the diagnosis of aortic root abscess was made by transoesophageal echocardiography. Surgery was recommended in five patients on the basis of transoesophageal echocardiographic finding of the presence of an aortic root abscess alone without significant aortic regurgitation. In the remaining six patients, surgery was undertaken based on the transoesophageal echocardiographic findings of both an aortic root abscess and important aortic regurgitation. Six patients had urgent surgery within 36 hours of the transoesophageal echocardiographic diagnosis. Surgery was delayed in five patients because of the need to refer the patients to another hospital for homograft aortic root replacement in two cases, the need for drainage of a complicating cerebral abscess in one case and low virulence of causative organism and the desire to establish antibiotic treatment in two cases.

POSTOPERATIVE ECHOCARDIOGRAPHIC FINDINGS

Transthoracic echocardiographic studies were performed in nine patients and transoesophageal studies in seven patients after operation. All postoperative studies were performed within two weeks of the operation except for the two patients who had homograft aortic root replacement at another hospi-

Figure 5
Transoesophageal echocardiography (longitudinal plane) showing an aorto-right atrial fistula (curved arrow) depicted by an abnormal colour jet (straight arrows) on colour Doppler map in systole. AV; aortic valve (St Jude); TV, tricuspid valve; other abbreviations as for figs 1 and 2.

tal. Transthoracic echocardiography detected moderate prosthetic aortic regurgitation in five patients but did not show mild prosthetic aortic regurgitation in another two patients. By contrast, transoesophageal echocardiography clearly showed the periprosthetic site of aortic regurgitation in all the patients with postoperative aortic regurgitation. Transoesophageal echocardiography correctly showed postoperative aorto-right atrial fistula in two patients (patients 4, 5, fig 5). Transthoracic echocardiography did not show the fistula in patient 4 and incorrectly diagnosed a ventricular septal defect in patient 5. Recurrence of the aortic root abscess with dehiscence of the aortic prosthesis was detected by transoesophageal echocardiography but not by transthoracic echocardiography in patient 3. A repeat operation was performed for recurrent aortic root abscess in this patient and for severe postoperative periprosthetic aortic regurgitation in two other patients (patients 9,11).

LONG TERM FOLLOW UP

The mean (range) duration of follow up was 21 (4–46) months for the six patients who were discharged from hospital. At the time of follow up, all six patients were in New York Heart Association functional class I with no evidence of recurrence of endocarditis. Moderate aortic regurgitation was present in two patients (patients 6,10).

Discussion

Aortic root abscess complicating aortic valve endocarditis is associated with high mortality and morbidity.^{14 15} Our study shows that transoesophageal echocardiographic imaging greatly facilitated the preoperative and post-

operative diagnosis and management of aortic root abscesses in our patients and that the availability of biplane imaging offered considerably more information compared with monoplane imaging. To the best of our knowledge, this is the largest reported series of patients in whom transoesophageal echocardiography was used for the detection of an aortic root abscess and in which most of the patients underwent biplane or multiplane examination.

INCIDENCE OF AORTIC ROOT ABSCESS

Arnetts and Roberts found an aortic valve ring abscess at necropsy in 21 of 52 patients (49%) with native aortic valve endocarditis, and in all 15 patients (100%) with prosthetic aortic valve endocarditis.⁴ In a later necropsy series of 59 patients with aortic valve endocarditis reported by the same workers, 24 patients (41%) had a root abscess.⁵ The overall incidence of aortic root abscess in aortic valve endocarditis in our series of patients was 32% with the incidence of this complication in the presence of an aortic prosthesis being 60%.

PREVIOUS ECHOCARDIOGRAPHIC STUDIES

Before the advent of transoesophageal echocardiography, transthoracic echocardiography had been reported to be useful in the detection of an aortic root abscess before operation^{12 16 17} with a reported sensitivity for the detection of an aortic root abscess ranging from 18% to 67%.^{10 18 19} Karalis *et al* reported the use of transoesophageal echocardiography in detecting subaortic complications of aortic valve endocarditis in 24 cases,⁹ but they did not specifically examine the role of transoesophageal echocardiography in the management of these patients. Moreover, the sensitivity of transoesophageal echocardiogra-

phy in diagnosing these complications could not be determined because only patients with subaortic complications documented on transoesophageal echocardiography were included in the study. In another series of patients described by Daniel *et al*, the overall sensitivity of transoesophageal echocardiography for diagnosing abscesses associated with endocarditis was 87% and the specificity was 94.6%.¹⁰ Transoesophageal echocardiography did not detect an aortic root abscess in four of the 26 patients with this complication (sensitivity 85%). The lower sensitivity in this series compared with ours may have been due to the use of only monoplane imaging in all cases.

ROLE OF TRANSOESOPHAGEAL ECHOCARDIOGRAPHY IN MANAGEMENT

Early preoperative diagnosis of aortic root abscess in our patients was made possible by transoesophageal echocardiography without which surgery might have been considerably delayed in many of our patients. Preoperative detection of the complications of an aortic root abscess with transoesophageal echocardiography was also helpful in planning the surgical approach.

Transthoracic echocardiography has important limitations after operation due to artefacts and masking of colour flow by prosthetic material and image degradation from mechanical ventilation. Transoesophageal echocardiography was able to overcome these difficulties, providing valuable information about the site of periprosthetic regurgitation, recurrence of the root abscess, or development of a fistula.

MONOPLANE V BIPLANE TRANSOESOPHAGEAL ECHOCARDIOGRAPHY

With the biplane probe, the aortic valve could be seen in both the short and the long axes in most patients in the longitudinal imaging plane when the probe tip was flexed laterally. Biplane imaging was especially important in detecting involvement of the anterior aortic root annulus by the abscess, which was poorly seen by conventional monoplane imaging. The longitudinal plane provided the only means of detecting the root abscess in one patient and accurately defined the involvement of the circumference of the annulus in two other patients.

LIMITATIONS OF OUR STUDY

The sensitivity and specificity of transoesophageal echocardiography in our study in diagnosing aortic root abscesses in patients with surgical or necropsy corroboration was 100%. Of the 34 patients with proved aortic valve endocarditis, 10 were managed medically and there was one death in hospital and one late death. Necropsy studies on these two patients did not show an aortic root abscess. Eight patients were managed medically and it was therefore possible that an aortic root abscess may have been missed by transoesophageal echocardiography in these patients. Their favourable clinical course with antibiotic treatment alone makes the presence

of an aortic root abscess very unlikely. The small number of patients with an aortic root abscess treated in a single referral centre, and the fact that a few early patients had monoplane transoesophageal echocardiography were other limitations of this study.

In conclusion, in patients with aortic valve endocarditis, transoesophageal echocardiography is highly sensitive and specific in detecting the presence, location, and extent of an aortic root abscess and in detecting complications of an aortic root abscess such as formation of a fistula. Biplane and multiplane imaging are better than monoplane imaging in showing the involvement of the anterior aortic root annulus. Thus transoesophageal echocardiography facilitates both the preoperative and postoperative management of these patients. Therefore, we strongly recommend that all patients with suspected aortic valve endocarditis should have transoesophageal echocardiographic examination early in the course of their illness especially in the presence of an aortic prosthesis. Transoesophageal echocardiography should also be performed early after operation to obtain baseline information and to detect complications.

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SHORT CASES IN CARDIOLOGY

Unsuspected coronary artery disease revealed by administration of nebulised salbutamol

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Electrocardiogram (A) during administration of salbutamol 2.5 mg by nebuliser and (B) an hour later.

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A 29 year old man presented with an acute attack of asthma. His regular medications included inhaled ipratropium bromide and salbutamol and he had been taking oral theophylline for three days before presentation. The peak expiratory flow rate was 160 l/min rising to 350 l/min after administration of 5 mg of nebulised salbutamol. Posteroanterior chest radiography, arterial blood gas analysis, and white cell count were unremarkable. There were no identifiable risk factors for coronary artery disease.

He was given a further three doses of 2.5 mg of nebulised salbutamol over the next 7 h and when the last dose was given he complained of mild chest discomfort. An electrocardiogram performed during the period of discomfort showed sinus tachycardia with upsloping ST segment depression in the septolateral leads. The pain ceased promptly when he stopped using the nebuliser, and the electrocardiogram reverted to normal (fig). Similar pains and electrocardiographic changes occurred after repeat nebuliser administration of salbutamol 12 h later. He reverted to aerosol delivery of salbutamol and did not experience further pain.

At the time of the first episode of pain serum creatine kinase was 303 IU/l (normal 30-250 IU/l) lactate dehydrogenase 342 IU/l (normal 100-200 IU/l), and the aspartate transaminase concentration was normal. Repeated estimations over the next 2 days were normal.

A week later a routine electrocardiogram remained normal and transthoracic echocardiography was normal. Treadmill exercise electrocardiography using the standard Bruce protocol showed 2 mm planar ST segment depression in leads V4-6, with a walking time of 12 minutes limited by fatigue. The maximal heart rate was 160 beats/min and no chest pain was reported. The same response was seen 1 h later after the administration of 2.5 mg salbutamol by nebuliser.

Ten days after admission, coronary angiography showed that the left anterior descending artery was occluded at its origin, filling retrogradely from the right coronary artery. Both the left circumflex and right coronary arteries were normal. Left ventricular end

diastolic pressure was 16 mm Hg, and the ventriculogram seemed normal with no significant impairment of anterior wall motion.

Comment

Inhaled β_2 agonists increase systolic blood pressure, reduce diastolic blood pressure, and are positive inotropes

The electrocardiogram may show reduced T wave amplitude and prolongation of the corrected QT interval (QTc).^{1,2} Positive chronotropic effects have been reported to hasten the onset of exercise-induced ischaemia in those with known occlusive coronary artery disease, an effect possibly heightened by steal from subendocardial to the subepicardial vessels.³ A 60 year old hypertensive smoker had a myocardial infarction while using a salbutamol nebuliser,⁴ and severe ischaemia was seen in three other patients with previously diagnosed ischaemic heart disease.

Our case is unusual because the patient's age, lack of risk factors, normal resting electrocardiogram and lack of prior symptoms meant that without the chance use of nebulised salbutamol coronary disease might never have been suspected. Furthermore, abnormal electrocardiographic changes occurred readily with inhaled salbutamol but only late and at much higher heart rates during exercise, suggesting a role for subendocardial steal.³ Patients in whom unusual electrocardiographic changes are seen during treatment with β_2 agonists should be closely examined even if the diagnosis of ischaemic heart disease seems unlikely.

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