CARDIOVASCULAR MEDICINE

Echocardiographic features and brain natriuretic peptides in patients presenting with heart failure and preserved systolic function

M D Thomas, K F Fox, D A Wood, J S R Gibbs, A J S Coats, M Y Henein, P A Poole-Wilson, G C Sutton

Heart 2006;**92**:603–608. doi: 10.1136/hrt.2005.063768

See end of article for authors' affiliations

Correspondence to: Dr Martin D Thomas, Cardiovascular Medicine, National Heart and Lung Institute, Imperial College, 5th Floor, Lab Block, Charing Cross Hospital, Fulham Palace Road, London W6 8RF, UK; thomasmd@globalnet.co.uk

Accepted 18 August 2005
Published Online First 13 September 2005

Objective: To characterise patients who appear to fulfil the diagnosis of heart failure with preserved systolic function clinically, echocardiographically, and by concentrations of brain-type natriuretic peptide (BNP).

Methods: 102 new cases of heart failure were identified over 24 months in 213 patients referred to a rapid access heart failure clinic. Patients with heart failure and preserved systolic function with contemporary markers of diastolic function were assessed to evaluate their cardiac status further.

Results: Forty patients (39%) had an ejection fraction (EF) $< 45\%$ and 62 (61%) had an EF $\geqslant 45\%$. Of these 62 patients, 30 (48%) fulfilled the case definition of diastolic heart failure. The remaining 32 (52%) had neither an EF $< 45\%$ nor abnormalities of diastolic function. Dobutamine stress echocardiography was performed on 26 (42%) patients with EF $\geqslant 45\%$, which provided an alternative explanation for symptoms in 15 (58%) patients. Concentrations of BNP were higher in patients with diastolic abnormalities (mean (SEM) 101.4 (32.5) pg/ml *v* 58.4 (6.78) pg/ml, $p = 0.042$) and with no diastolic abnormalities (199 (37.9) pg/ml *v* 58.4 (6.78) pg/ml, $p < 0.0001$) than in patients with no heart failure.

Conclusion: Among ambulatory patients presenting with suspected heart failure in the community 19% have systolic dysfunction, 14% have diastolic dysfunction, and 15% seemingly have heart failure with neither systolic nor diastolic dysfunction. A new understanding, including alternative parameters of diastolic function, seems to be necessary to classify patients with heart failure and preserved systolic function.

The clinical syndrome of heart failure is traditionally associated with impaired left ventricular systolic function. The concept that heart failure can arise in the setting of preserved systolic function was first recognised in the early 1970s.[1] By the 1980s the syndrome was well documented. Epidemiological data show a wide variation in the prevalence of heart failure with preserved systolic function of 13–74%.[2] This broad range may be due to the different populations studied, the case finding methods employed, and the definitions used for the diagnosis of heart failure. Patients fulfilling criteria for the diagnosis of heart failure are often deemed to have diastolic heart failure if left ventricular systolic function is normal at rest, often with no direct assessment of diastolic function.

Some investigators have argued that many patients with heart failure and preserved left ventricular systolic function have an alternative explanation for their symptoms. Caruana *et al*[3] found that the majority of patients with suspected heart failure in the absence of left ventricular systolic dysfunction had other diagnoses to account for their breathlessness or ankle oedema.

Confusion in identifying patients with heart failure and preserved systolic function makes establishing the clinical course of this entity problematic and the design and interpretation of trials to develop treatments for affected patients equally difficult. There is an urgent need to be able to quantify this condition and to identify sufferers as a prelude to establishing effective treatments.

We have previously developed epidemiological methods to study the incidence, aetiology, and prognosis of heart failure in the community. Validated case finding methods of hospital surveillance and the establishment of rapid access heart failure clinics (RAHFCs) are used to identify patients with new cases of heart failure not requiring admission.[4 5] In these studies patients were defined on the basis of symptoms and signs of heart failure and the presence of a cardiac abnormality without distinguishing between systolic and diastolic dysfunction. A retrospective analysis of data from the Bromley heart failure study showed that 17% of patients with heart failure had preserved systolic function.[6] A majority of the patients within this cohort had pulmonary congestion, however, and it is possible that patients with preserved systolic function, who may have less frequent pulmonary congestion, were underrepresented.

We report a study investigating the clinical problem of patients who appear to fulfil the diagnosis of heart failure but have preserved systolic function. By characterising these patients clinically, echocardiographically, and by quantification of brain-type natriuretic peptide (BNP) we sought to describe this elusive condition in more detail.

METHODS

We assessed consecutive patients referred to an RAHFC by their general practitioner with a suspected diagnosis of heart failure. Those patients found to have preserved systolic function were characterised by clinical presentation, echocardiographic features at rest and at stress, and measurement of BNP.

Abbreviations: BNP, brain-type natriuretic peptide; EF, ejection fraction; ESC, European Society of Cardiology; RAHFC, rapid access heart failure clinic

Case identification and assessment

The RAHFC was sited within the Department of Cardiology at Charing Cross Hospital, the southern of two secondary care providers for the borough of Hammersmith and Fulham in West London, UK, with a population of 236 000.

The RAHFC ran alongside other established open access rapid cardiology services for chest pain and arrhythmias. These services provide a one stop assessment of patients referred by primary care physicians (general practitioners) for symptoms that may be a first indication of cardiac disease. Any patient with suspected heart failure would be identified irrespective of which rapid clinic they had been referred to thereby ensuring that no cases were lost. No appointments were needed and there were no age or other restrictions with the services running every working day. Patients simply attended with a note making the process of primary to secondary care referral as straightforward as possible. All primary care physicians within our catchment area were encouraged to refer any patient with suspected heart failure to the RAHFC. Frequent communication with them throughout the study resulted in a low threshold for referral. We have previously shown that such recruitment methods result in high ascertainment rates for new cases of heart failure.[5]

Over a six month pilot phase 30 new cases of heart failure were identified from surveillance of the inpatient population. In each case this was due to impaired systolic left ventricular function. This is in accordance with the previous study by Shiels *et al*.[7] Since the study goals were to investigate the entity of heart failure with preserved systolic function, only patients referred to the RAHFC were subsequently recruited and form the basis of this report.

All patients gave a full standardised medical history and underwent physical examination. A standard 12 lead ECG, chest radiograph, and serum biochemistry, including non-fasting plasma glucose and random cholesterol and triglycerides, haematology, and thyroid function tests were performed. BNP was measured by a certified quality assured point of care immunoassay (Biosite Diagnostics, La Jolla, California, USA).[8] BNP of all patients was measured within 15 minutes of venesection. All patients underwent transthoracic echocardiography according to a standard protocol by one trained operator (MT). Two dimensional, M mode, Doppler, and colour flow images were recorded on videotape in accordance with published criteria.[9] Left ventricular systolic function was quantitatively assessed by calculation of ejection fraction (EF) from left ventricular parasternal long axis M mode measurements by the modified method of Quinones *et al*.[10] If regional wall abnormalities made this inapplicable then the biplane method of discs was used.[11]

At the time of study design the most authoritative guidelines for the diagnosis of diastolic heart failure were those of the European Society of Cardiology (ESC).[12] Although these guidelines were not universally accepted, they formed a structure to take forward the assessment of heart failure with preserved systolic function.

Diastolic function was assessed by measurement of the E:A ratio (ratio of peak early transmitral Doppler diastolic inflow velocity to peak late diastolic inflow velocity), E wave deceleration time, and isovolumic relaxation time. The sample volume was paced between the tip of the mitral valve leaflets and an average of five consecutive cardiac cycles was measured to provide the final value. The E:A ratio was considered to be reduced in those under 50 years old when < 1 and in those above 50 years old when < 0.5. Similarly, E wave deceleration time was considered increased in those under 50 when > 220 ms and in those above 50 years old when > 280 ms. Isovolumic relaxation time was considered prolonged in those under 30 years old when > 92 ms, in those between 30 and 50 years old when > 100 ms, and in those above 50 years old when > 105 ms.

Stress echocardiography was performed on patients with an EF $\geqslant 45\%$ by applying a conventional protocol with dobutamine infusion at a starting dose of 5 μgm/kg/min with incremental increases to a peak of 40 μgm/kg/min. We aimed at 85% of the patient's age predicted maximum heart rate with atropine augmentation if required.

Case definition

No single definition of heart failure is entirely satisfactory and diagnostic criteria used in previous studies vary widely. We applied criteria recommended by the ESC.[13] To meet the case definition of heart failure, patients needed to have appropriate symptoms (shortness of breath, fatigue, fluid retention, or any combination of these symptoms) or clinical signs of fluid retention (pulmonary or peripheral) in the presence of an underlying abnormality of cardiac structure and function. Within the ESC guidelines, and hence in this study, echocardiography is recommended as the most practical tool to detect cardiac dysfunction, although no specific abnormalities are listed.

Continuing to follow the definition of diastolic heart failure proposed by the ESC,[12] in this study the diagnosis of diastolic heart failure required three obligatory conditions to be simultaneously satisfied: firstly, the presence of signs or symptoms of congestive heart failure (exertional dyspnoea, orthopnoea, gallop sounds, lung crepitations, pulmonary oedema); secondly, the presence of normal or only mildly abnormal left ventricular systolic function (left ventricular EF $\geqslant 45\%$); and lastly, evidence of abnormal left ventricular relaxation, filling, diastolic distensibility, or diastolic stiffness.

Following the methods used in our previous epidemiological studies[4 5] we presented all cases to a panel of three cardiologists (DW, AC, and GS), who determined whether the case definition of heart failure had been met. The reproducibility of panel decisions for case definition, checked by re-presentation of a random sample of 10% of cases, was excellent (Cohen's $\kappa = 0.75$). In addition, one cardiologist specialising in echocardiography (MH) subsequently reviewed the echocardiograms, who evaluated each case to determine whether the case definition of diastolic heart failure had been met. The panel was blinded to BNP test results.

Statistical analysis

Data were initially entered on to a case record form and then double entered on to a computerised database. Proportions were compared by a χ^2 test. Differences between groups were assessed with an unpaired two tailed t test. All data were expressed as mean (SEM). A value of $p < 0.05$ was considered significant.

Ethics approval

The study complied with the Declaration of Helsinki. Ethical approval was granted by the local health authority ethics committee. Each participant gave written informed consent.

RESULTS

Two hundred and thirteen patients were referred to the RAHFC with suspected heart failure between February 2000 and January 2002 (24 months). The median age was 71 years (range 31–90 years) and 51% were women. One hundred and two patients (48%) fulfilled the ESC definition of heart failure as assessed by the panel of cardiologists. From these 102 patients 40 (39%) had an EF $< 45\%$ (systolic heart failure) and the remaining 62 (61%) had heart failure with preserved systolic function with an EF $\geqslant 45\%$.

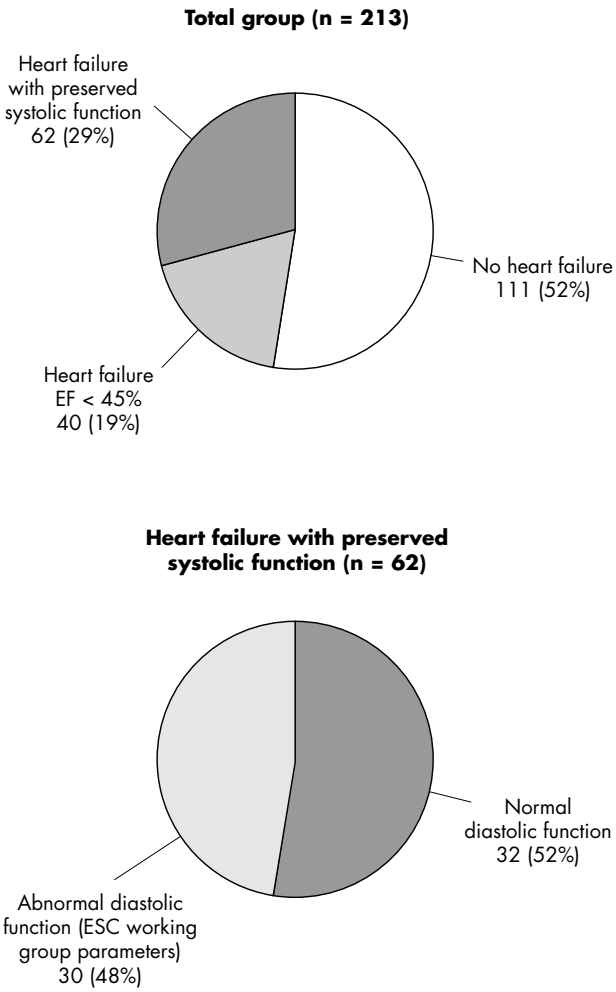


Figure 1 Panel assessment of patients seen by applying the European Society of Cardiology (ESC) definition of heart failure according to echocardiographic criteria. EF, ejection fraction.

Of the 62 patients with heart failure with preserved systolic function 30 (48%) fulfilled the ESC working group definition of diastolic heart failure. The remaining 32 (52%) fulfilled the case definition of heart failure but had neither an EF < 45% nor abnormalities of diastolic function as described in the ESC working group guidelines (fig 1).

Three patients fulfilling the ESC working group definition of diastolic heart failure had significant valve disease as an alternative cardiovascular explanation for their symptoms with 27 having isolated diastolic abnormalities. In patients with no abnormalities of diastolic dysfunction the underlying cardiac abnormality was identified as hypertrophic obstructive cardiomyopathy in one, pulmonary hypertension in two, cor pulmonale in three, ECG abnormalities in seven, and valve disease in six; the remaining 13 patients had evidence of left ventricular hypertrophy. No alternative diagnoses were apparent in either group to explain their symptoms after panel presentation.

The sex distribution of the two groups did not differ significantly but patients with diastolic abnormalities tended to be older than those with no diastolic abnormalities (applying age based parameters). A history of hypertension was not seen more often in either group, but both systolic and diastolic blood pressures were higher in the diastolic abnormality group as was a faster resting heart rate. Patients with diastolic abnormalities were more likely to present in New York Heart Association functional class II. Cardiothoracic ratio on chest radiography did not help to differentiate between the groups (table 1).

Table 1 Characteristics of patients with heart failure with preserved systolic function and with or without diastolic abnormalities

Variable	Diastolic abnormalities (n = 30)	No diastolic abnormalities (n = 32)	p Value
Age (years)	75.2 (1.69)	68.9 (2.52)	0.09
Men/women	12/18	13/19	0.96
History of hypertension	16 (53.3%)	14 (43.7%)	0.45
NYHA class			
I	6 (20%)	11 (34%)	0.32
II	22 (74%)	12 (38%)	0.01
III	1 (3%)	8 (25%)	0.04
IV	1 (3%)	1 (3%)	0.94
Heart rate (beats/min)	85.0 (3.55)	72.2 (2.30)	0.04
Systolic BP (mm Hg)	162.0 (3.94)	145.3 (4.77)	0.009
Diastolic BP (mm Hg)	88.9 (2.50)	77.8 (2.89)	0.005
Cardiothoracic ratio	0.56 (0.01)	0.56 (0.01)	0.83

Data are mean (SEM).
BP, blood pressure; NYHA, New York Heart Association.

As expected the concentrations of BNP of patients without heart failure were within normal limits at 58.4 (6.78) pg/ml. Patients with systolic heart failure had significantly higher concentrations of BNP (539.9 (89.7) pg/ml, p = 0.0001). Higher concentrations of BNP were seen in patients with heart failure and diastolic abnormalities (101.4 (32.5) pg/ml, p = 0.042) and in those with no diastolic abnormalities (199 (37.9) pg/ml, p < 0.0001) than in patients with no heart failure.

Twenty six (42%) patients with EF ⩾ 45% underwent dobutamine stress echocardiography (11 with diastolic abnormalities and 15 with no diastolic abnormalities) with the remaining 36 patients declining consent for further investigations. An alternative explanation, not identified by resting transthoracic echocardiography, for the symptoms was found in 15 (58%) patients: left ventricular outflow tract obstruction, development of restrictive filling pattern at stress, chronotropic incompetence, and underlying ischaemic heart disease (fig 2).

DISCUSSION

One hundred and two patients (48%) referred to an RAHFC with suspected first presentation of heart failure fulfilled the ESC criteria for the diagnosis of heart failure. Of all patients with heart failure 62 (61%) had an EF ⩾ 45% with 30 (29%) fulfilling the criteria for diastolic heart failure.

This study was designed to investigate heart failure with preserved systolic function in the population. We have previously conducted epidemiological studies in heart failure and have established methods for capturing all patients presenting with heart failure in a circumscribed population. Pilot data showed that cases of heart failure with preserved systolic function were concentrated in ambulatory patients referred to an RAHFC. Hence, this report describes only these patients. The RAHFC was one of three rapid access clinics for specialist assessment, without delay or appointments, of suspected new presentations of cardiac disease to primary care. This service was unique to Charing Cross Hospital and therefore encouraged local general practitioners to refer their patients to this service. In a large urban area with overlapping secondary care providers it cannot be guaranteed that all patients with suspected heart failure were referred, but it is highly likely that the patients assessed in the RAHFC were representative of the population presentation of heart failure even if not all incident cases were seen.

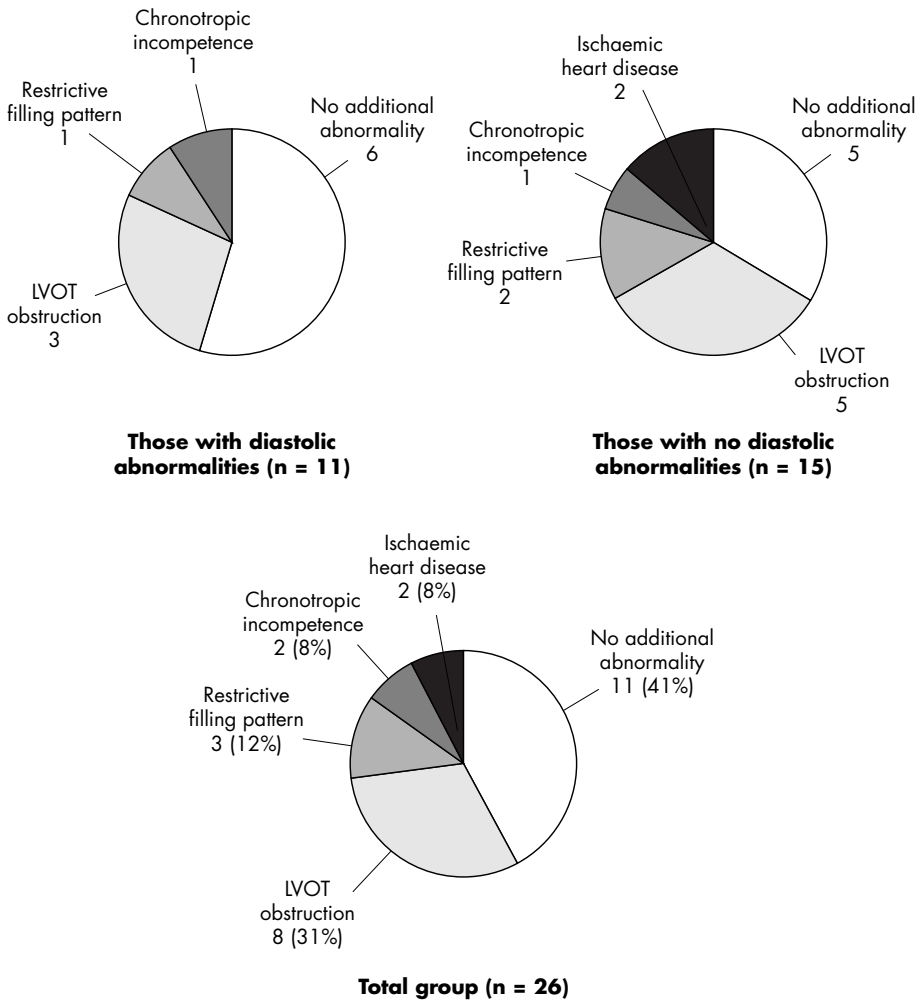


Figure 2 Dobutamine stress echocardiographic findings in patients with preserved systolic function. LVOT, left ventricular outflow tract.

Clinical assessment was standardised and all cases were presented to a panel of cardiologists who reviewed the recorded clinical findings and investigations to apply the ESC definition of heart failure. The use of such a panel has been previously applied. Since echocardiographic features were central to this study each case was further assessed by a cardiologist with a special interest in systolic and diastolic function. The key findings were that of those patients who fulfilled the ESC case definition for heart failure 61% had no significant systolic dysfunction and 31% neither had systolic dysfunction nor fulfilled the separate criteria for diastolic heart failure published by the ESC working group.

Some other studies have looked at the problem of heart failure with preserved systolic function. Eight studies have directly assessed diastolic function in the setting of normal systolic function.[14–21] Only one group has used the ESC guidelines on the diagnosis of diastolic heart failure. Badano *et al*[20] identified 143 consecutive patients with heart failure. Seventy (49%) had preserved systolic function with a left ventricular EF $>$ 45% but only nine (6%) fulfilled the ESC criteria for diastolic heart failure. Alternative clinical diagnoses were available for the remaining 61 patients to explain their presentation, which included obesity and pulmonary disease.

Studies have shown the high positive and negative predictive value of plasma BNP in the diagnosis of heart failure. Maisel *et al*[22] assessed the value of rapid bedside measurement of plasma BNP for distinguishing between heart failure and a pulmonary cause of dyspnoea in a seven centre, multinational study of 1586 patients presenting with acute dyspnoea. A plasma BNP $>$ 100 pg /ml diagnosed heart failure with a sensitivity, specificity, and predictive accuracy of 90%, 76%, and 83%, respectively. Raised plasma BNP can also establish the presence of heart failure due to diastolic dysfunction with similar accuracy to that of systolic dysfunction.[23–25]

We have shown a significant rise in plasma BNP concentrations in patients with heart failure with systolic dysfunction and diastolic dysfunction, and in those with neither systolic nor diastolic abnormalities. BNP concentrations were higher in patients with neither systolic nor diastolic abnormalities than in patients with no heart failure (58.4 (6.78) pg/ml *v* 199 (37.9) pg/ml, $p < 0.0001$ compared with 58.4 (6.78) pg/ml *v* 101.4 (32.5) pg/ml, $p = 0.042$).

In patients with an EF $\geqslant$ 45% who underwent dobutamine stress echocardiography, an alternative explanation, not identified by resting transthoracic echocardiography, for the patients' symptoms was found in 58%. Despite the small numbers, an alternative explanation to symptoms was more likely to be found for patients with neither systolic nor diastolic abnormalities, which appears to be supported by the finding of higher BNP concentrations in this group.

The application of the diastolic function parameters suggested by the ESC working group does not seem to provide a cardiac abnormality to explain the cause of breathlessness in a substantial group of patients fulfilling a

widely used definition of heart failure, but with preserved systolic function, as these patients do not have the required diastolic abnormalities. The limitations of the methods used to define diastolic function may explain some of the cases of heart failure with normal systolic and diastolic function such as patients with left ventricular hypertrophy, where diastolic function would be unlikely to be truly normal.

Breathless patients with systolic dysfunction seem to form a coherent group who have other abnormal physiological parameters (exercise capacity, natriuretic peptides), have an adverse outcome, and respond favourably to therapeutic interventions. They have the properties of a group of patients with a common disease. Breathless patients without systolic dysfunction do not seem to form such a neat entity. It seems unlikely that simply altering the boundaries for normal ranges of the current recommended diastolic parameters or other combinations of diastolic parameters would solve the problem. New echocardiographic techniques, including tissue Doppler imaging, or detailed assessment of long axis systolic function may identify other echocardiographic abnormalities in these patients but, unless clinicians can be convinced that these ''abnormalities'' are causally related to the patients' symptoms and identify a cohort of patients with a distinctive clinical course, these techniques will still not resolve the clinical problem of patients with suspected cardiac breathlessness.

Current definitions of heart failure may need to be revised. The prevalence of breathlessness in the community is high.[26] Perhaps patients with normal systolic and diastolic parameters have a non-cardiac cause of breathlessness and any additional underlying cardiac abnormality, such as valve abnormalities, left ventricular hypertrophy, or rhythm disturbances, may be coincidental and not responsible for their symptoms. If those with neither systolic nor diastolic abnormalities do not have heart failure then many of these patients with apparent diastolic heart failure may also not have heart failure. The inclusion of patients without heart failure in studies of heart failure with preserved systolic function would explain their lower readmission rates and good prognosis.[27 28] Alternatively, all of these patients may have heart failure with cardiac abnormalities we are not currently identifying. So what is wrong with these 33% of patients with heart failure fulfilling the ESC criteria for heart failure but with neither systolic nor diastolic abnormalities? Further resting echocardiographic parameters may help but for patients with exertional dyspnoea, exercise or stress echocardiography may be needed.

The ESC definition of heart failure, however, may yet suggest a way forward. Echocardiography is not the only way to identify an abnormality of cardiac function. Whereas it is effectively used to identify circumferential systolic dysfunction it appears less able to resolve other cases. Using alternative parameters of cardiac function—for example, through cardiac magnetic resonance imaging, or basing definitions on the physiological and biochemical consequences of cardiac dysfunction such as impaired maximum oxygen uptake and raised natriuretic peptides—may help distinguish patients with heart failure from the normal population.

In conclusion we have shown that in a detailed and assiduous study of ambulatory patients presenting with suspected heart failure in the community, 19% have systolic dysfunction, 14% have diastolic heart failure, and 15% seemingly have heart failure with neither systolic nor diastolic dysfunction according to contemporary definitions. Whether this latter group constitute a new category of heart failure, have non-cardiac breathlessness, or present a challenge to the validity of the definition of diastolic heart failure we applied is unclear. But until we can identify, among patients with suspected heart failure with preserved systolic function, those with heart failure and the nature of their cardiac dysfunction, attempts to find treatments will be severely hampered. This study suggests that revised methods of assessment and particularly new echocardiographic parameters are required if the spectrum of cardiac abnormalities in patients with heart failure is to be understood.

Authors' affiliations

M D Thomas, K F Fox, D A Wood, J S R Gibbs, A J S Coats, M Y Henein, P A Poole-Wilson, G C Sutton, Cardiovascular Medicine, National Heart and Lung Institute, Imperial College, London, UK

Competing interests: None declared

REFERENCES

1 **Dodek A**, Kassebaum DG, Bristow JD. Pulmonary edema in coronary-artery disease without cardiomegaly: paradox of the stiff heart. *N Engl J Med* 1972;**286**:1347–50.
2 **Vasan RS**, Benjamin EJ, Levy D. Prevalence, clinical features and prognosis of diastolic heart failure: an epidemiologic perspective. *J Am Coll Cardiol* 1995;**26**:1565–74.
3 **Caruana L**, Petrie MC, Davie AP, *et al*. Do patients with suspected heart failure and preserved systolic function suffer from ''diastolic heart failure'' or from misdiagnosis? A prospective descriptive study. *BMJ* 2000;**321**:215–9.
4 **Cowie MR**, Wood DA, Coats AJ, *et al*. Incidence and aetiology of heart failure: a population-based study. *Eur Heart J* 1999;**20**:421–8.
5 **Fox K**, Cowie MR, Wood DA, *et al*. Coronary artery disease as the cause of incident heart failure in the population. *Eur Heart J* 2001;**22**:228–36.
6 **Fox KF**, Cowie MR, Wood DA, *et al*. Heart failure with normal systolic function: a population based study [abstract]. *Heart* 2000;**83**(suppl 1):P53.
7 **Shiels P**. Heart failure with normal systolic function. *Br J Cardiol* 1998;**5**:533–6.
8 **Dao Q**, Krishnaswamy P, Kazanegra R, *et al*. Utility of B-type natriuretic peptide in the diagnosis of congestive heart failure in an urgent-care setting. *J Am Coll Cardiol* 2001;**37**:379–85.
9 **Sahn DJ**, DeMaria A, Kislo J, *et al*. The committee on M-mode standardization of the American Society of Echocardiography. Recommendations regarding quantitation in M-mode echocardiographic measurements. *Circulation* 1978;**58**:1072–82.
10 **Quinones MA**, Waggoner AD, Reduto LA, *et al*. A new, simplified and accurate method for determining ejection fraction with two-dimensional echocardiography. *Circulation* 1981;**64**:744–53.
11 **Schiller NB**, Shah PM, Crawford M, *et al*. Recommendations for quantitation of the left ventricle by two-dimensional echocardiography. *J Am Soc Echocardiogr* 1989;**2**:358–67.
12 **European Study Group on Diastolic Heart Failure**. How to diagnose diastolic heart failure. European study group on diastolic heart failure. *Eur Heart J* 1998;**19**:990–1003.
13 **European Society of Cardiology**. Guidelines for the diagnosis and treatment of heart failure. Task force for the diagnosis and treatment of chronic heart failure, European Society of Cardiology. *Eur Heart J* 2001;**22**:1527–60.
14 **Stone GW**, Griffin B, Shah PK, *et al*. Prevalence of unsuspected mitral regurgitation and left ventricular diastolic dysfunction in patients with coronary artery disease and acute pulmonary edema associated with normal or depressed left ventricular systolic function. *Am J Cardiol* 1991;**67**:37–41.
15 **Aguirre FV**, Pearson AC, Lewen MK, *et al*. Usefulness of Doppler echocardiography in the diagnosis of congestive heart failure. *Am J Cardiol* 1989;**63**:1098–102.
16 **Soufer R**, Wohlgelernter D, Vita NA, *et al*. Intact systolic left ventricular function in clinical congestive heart failure. *Am J Cardiol* 1985;**55**:1032–6.
17 **Yip GW**, Ho PP, Woo KS, *et al*. Comparison of frequencies of left ventricular systolic and diastolic heart failure in Chinese living in Hong Kong. *Am J Cardiol* 1999;**84**:563–7.
18 **Shiels P**, MacDonald TM. Isolated diastolic heart failure: what is it? *Postgrad Med J* 1998;**74**:451–4.
19 **Kupari M**, Lindroos M, Livanainen AM, *et al*. Congestive heart failure in old age: prevalence, mechanisms and 4-year prognosis in the Helsinki ageing study. *J Intern Med* 1997;**241**:387–94.
20 **Badano L**, Albanese MC, Fresco C, *et al*. Prevalence of diastolic heart failure among patients admitted to hospital with congestive heart failure [abstract]. *Eur J Heart Fail* 2000;**2**(suppl 2):72.
21 **MacFadyen RJ**, MacLeod CM, Shiels P, *et al*. Isolated diastolic heart failure as a cause of breathlessness in the community: the Arbroath study. *Eur J Heart Fail* 2001;**3**:243–8.
22 **Maisel AS**, Krishnaswamy P, Nowak RM, *et al*. Rapid measurement of B-type natriuretic peptide in the emergency diagnosis of heart failure. *N Engl J Med* 2002;**347**:161–7.
23 **Maisel AS**, Koon J, Krishnaswamy P, *et al*. Utility of B-natriuretic peptide as a rapid, point-of-care test for screening patients undergoing echocardiography to determine left ventricular dysfunction. *Am Heart J* 2001;**141**:367–74.
24 **Krishnaswamy P**, Lubien E, Clopton P, *et al*. Utility of B-natriuretic peptide levels in identifying patients with left ventricular systolic or diastolic dysfunction. *Am J Med* 2001;**111**:274–9.

25 **Lubien E**, DeMaria A, Krishnaswamy P, *et al*. Utility of B-natriuretic peptide in detecting diastolic dysfunction: comparison with Doppler velocity recordings. *Circulation* 2002;**105**:595–601.
26 **Rogers A**, Addington-Hall JM, Abery AJ, *et al*. Knowledge and communication difficulties for patients with chronic heart failure: qualitative study. *BMJ* 2000;**321**:605–7.
27 **Pernenkil R**, Vinson JM, Shah AS, *et al*. Course and prognosis in patients ⩾70 years of age with congestive heart failure and normal versus abnormal left ventricular ejection fraction. *Am J Cardiol* 1997;**79**:216–9.
28 **McDermott MM**, Feinglass J, Lee PL, *et al*. Systolic function, readmission rates, and survival among consecutively hospitalised patients with congestive heart failure. *Am Heart J*, 1997;**134**:728–36.

IMAGES IN CARDIOLOGY

doi: 10.1136/hrt.2005.071985

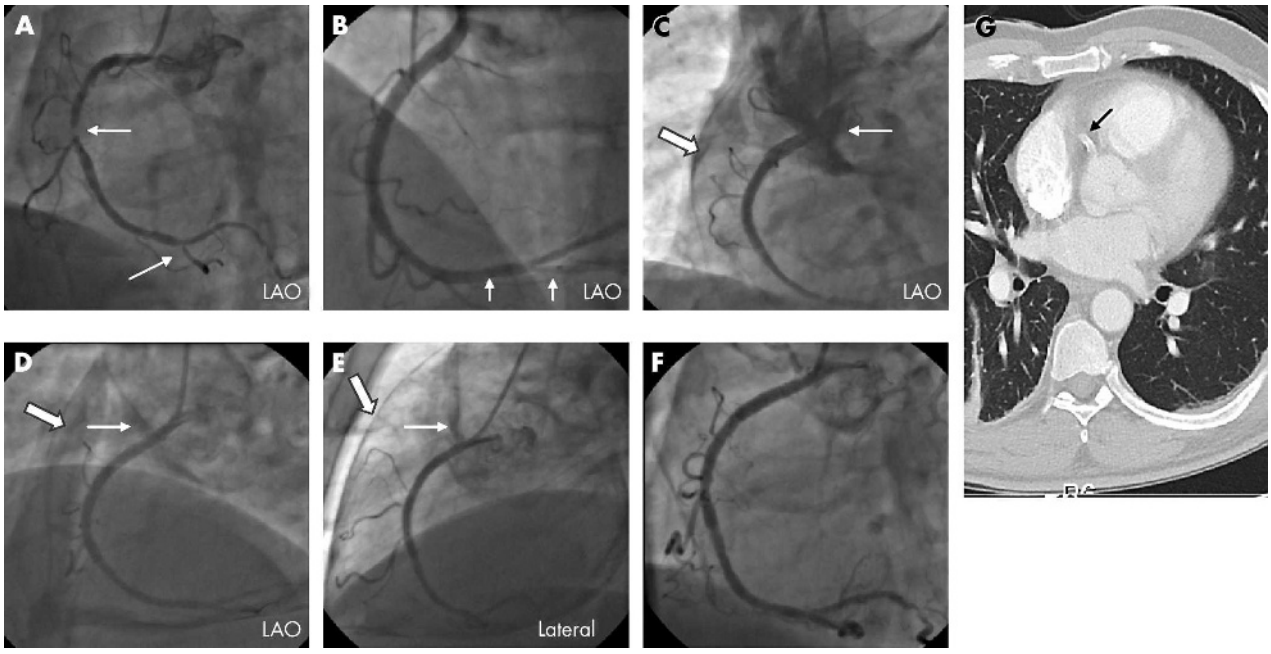
Covering your mistakes: PTFE covered stents in iatrogenic coronary dissection

A 46 year old man with type 2 diabetes mellitus and hypercholesterolaemia presented with an acute inferior ST elevation myocardial infarction, treated with streptokinase. He had persistent ST elevation and was transferred for emergency angiography which documented two severe right coronary artery (RCA) stenoses (panel A). Using a 6 French JR4 guide catheter, the proximal lesion was treated with a 3.5 × 32 mm BSC Liberte stent, post-dilated with a 4.0 × 20 mm balloon (panel B). Positioning of the second 2.75 × 12 mm stent at the crux required deep guide catheter engagement. Angiography following deployment demonstrated extensive retrograde dissection into the coronary sinus of Valsalva (CSV) and extravasation into the pericardial space (panel C). A 3.5 × 12 mm polytetrafluoroethylene (PTFE) covered stent (Abbott Vascular) was expeditiously deployed (18 atmospheres) at the ostium of the RCA, immediately arresting the flow of contrast. Another 3.5 × 12 mm PTFE covered stent was then deployed distal to the first, with overlap, sealing off the dissection (panels D and E). The patient remained haemodynamically stable throughout.

An echocardiogram during the procedure showed only a rind of fluid adjacent to the posterolateral aspect of the left ventricle. A subsequent computed tomographic (CT) scan of the chest showed no evidence of aortic dissection or significant pericardial effusion (panel G). Angiography at three months showed a satisfactory result (panel F).

Extensive coronary artery dissections with or without rupture occasionally occur during percutaneous interventions, but retrograde extension into the CSV is rare. It occurs more commonly with RCA than left coronary dissections, possibly because of differences in the histology of the proximal coronary arteries. Dissection is often guide catheter, guidewire or balloon inflation induced, and further propagated by contrast injection and/or coronary flow. Conservative treatment may be adequate for limited dissections. Extensive dissections with pericardial extravasation require immediate treatment; the use of covered stents obviates the need for high risk emergency surgery.

S S El-Jack
S Pornratanarangsi
M W I Webster
mwebster@adhb.govt.nz



(A) Baseline angiography of the right coronary artery (RCA). Stenotic lesions were identified in the mid RCA and at the crux (arrows). (B) A stent has been successfully deployed in the proximal lesion and another positioned across the distal lesion (arrows). (C) Proximal dissection extending into the coronary sinus of Valsalva (CSV) (thin arrow) with contrast extravasation into the pericardium (bold arrow). (D, E) PTFE covered stents have been deployed in the proximal vessel, sealing off the dissection. Contrast hold up remains in the aortic wall (thin arrow) and pericardium (bold arrow) but no active flow is observed. (F) Follow up angiography in three months showing patent stents and no evidence of dissection. (G) CT scan of the chest after initial percutaneous coronary intervention showing the PTFE covered stents in the proximal right coronary artery with no evidence of aortic dissection or significant pericardial effusion. LAO and lateral: left anterior oblique and lateral (LAO 90) angiographic views.