Journal of Internal Medicine 1990; **228**: 183–192

Non-invasive assessment of left ventricular diastolic function in patients with systemic sclerosis

E. KAZZAM, A. WALDENSTRÖM, J. LANDELIUS*, R. HÄLLGREN, A. ARVIDSSON‡ & K. CAIDAHL†

*From the Department of Internal Medicine and the *Department of Clinical Physiology, University Hospital, Uppsala, and the †Department of Clinical Physiology and the ‡Department of Clinical Data Processing, Sahlgren's Hospital, Gothenburg, Sweden*

Abstract. Kazzam E, Waldenström A, Landelius J, Hällgren R, Arvidsson A, Caidahl K (Department of Internal Medicine and Department of Clinical Physiology, University Hospital, Uppsala, and Department of Clinical Physiology and Department of Clinical Data Processing, Sahlgren's Hospital, Gothenburg, Sweden). Non-invasive assessment of left ventricular diastolic function in patients with systemic sclerosis. *Journal of Internal Medicine* 1990; **228**; 183–192.

To evaluate the extent of left ventricular (LV) diastolic impairment in systemic sclerosis, we examined 30 consecutive patients (15 men and 15 women) with this condition, and compared the findings with the data for 48 age- and sex-matched randomly sampled controls. All patients were investigated by phonocardiography, pulse curve recording, and M-mode echocardiography. Twenty-three of 30 (77%) patients had LV hypertrophy and/or diastolic impairment. Interventricular septum ($P = 0.0001$), LV posterior wall ($P < 0.05$), and the wall thickness to cavity dimension ratio ($P < 0.001$) were increased in patients compared to controls, as was LV mass index ($P < 0.002$). Five patients had asymmetric septal hypertrophy. LV end-diastolic dimension did not differ between groups. LV distensibility was impaired, as judged from apexcardiographic a/H ratio ($P < 0.05$) and from an increased left atrial index ($P < 0.005$). LV early filling was impaired, with a reduced left atrial emptying index ($P = 0.0001$), and a reduced rate of dimension increase in digitized M-mode ($P < 0.02$). We found no evidence of impaired LV relaxation. Blood pressure did not differ between patients and controls. With longer duration of the disease, left atrial dimension appeared to increase ($r = 0.42$, $P < 0.05$), while other variables were not related to disease duration. The impaired LV filling was not secondary to systolic dysfunction. We conclude that systemic sclerosis patients have an increased LV wall thickness, with impaired early filling properties and LV distensibility.

Keywords: apexcardiogram, diastolic function, echocardiography, left ventricle, systemic sclerosis.

Introduction

The characteristic manifestation of cardiac involvement in systemic sclerosis is myocardial fibrosis [1, 2]. The pathogenetic mechanisms of the scleroderma lesions in the heart and other affected organs are poorly understood [2]. Histopathological examinations show fibroblast proliferation and collagen accumulation. It has been proposed that a vasoabnormality. The extent to which immunological spastic component is also important for the cardiac mechanisms are involved in the sclerotic process is not well understood. The clinical signs and symptoms of heart disease in systemic sclerosis include congestive heart failure, arrhythmias and sudden death [3–5]. It is therefore important to be able to elucidate early cardiac involvement in this disease. Diastolic functional abnormalities are early signs of myocardial involvement, e.g. in hypertension and coronary disease [6, 7], and much attention has recently been focused on the importance of diastolic cardiac impairment as a cause of symptomatic heart failure

Presented in part at the XIth Congress of the European Society of Cardiology, Nice, France, 10–14 September 1989.

Abbreviations: ECG = electrocardiogram, LV = left ventricular.

[8–10]. In systemic sclerosis, diastolic dysfunction has been reported even when systolic abnormalities were absent [11–13]. However, two of these studies used the mitral valve closing velocity as an isolated measure of the diastolic function [11, 12], and the third study showed abnormal response to exercise only [13]. Another investigation revealed decreased coronary reserve but normal diastolic function in a group of seven patients [14]. Therefore, in order to determine the extent of diastolic dysfunction in systemic sclerosis, further studies have been deemed necessary [2].

The aim of this study was to evaluate the prevalence of LV hypertrophy and diastolic abnormalities in a consecutive series of scleroderma patients. The results were compared with those for a random sample of matched control subjects selected from the general population.

Subjects and methods

Subjects

Thirty consecutive patients (15 men and 15 women; age range 25–77 years), with systemic sclerosis according to the American Rheumatism Association (ARA) criteria [15], were studied (Table 1). The patients were referred to Uppsala University Hospital from the Uppsala region between December 1986 and March 1988. Their disease had been recognized for 5.6 years (range 0.5–23 years). One patient had right bundle branch block, and none had left bundle branch block.

For comparative purposes, age- and sex-matched control subjects were selected from the general population of Uppsala. A sample of 90 age- and sex-matched subjects (three to each patient) was drawn from the population register kept by the County Census Bureau. All controls were informed about the investigation protocol, and 55 individuals consented to participate in the study. Controls were excluded if they were being treated for hypertension, if they had coronary or rheumatic heart disease according to clinical history or electrocardiogram (ECG), or if they had known renal or pulmonary disease. Controls were not excluded on the basis of blood pressure level, and none had bundle branch block. Of the 55 subjects willing to participate, two were excluded because of previous antihypertensive treatment, one because an ECG indicated coronary heart disease, one because clinical history suggested ischaemic heart disease, two because of a history of rheumatic heart disease, and one subject was excluded due to inadequate recordings. The remaining 48 subjects (26 men and 22 women, age range 25–77 years) constituted a healthy control group.

Methods

A 12-lead ECG was performed, and blood pressure was measured in the supine position after 15–30 min of rest. Carotid pulse tracings and apexcardiograms were recorded and interpreted as described previously [6]. In brief, a carotid pulse curve or an apexcardiogram, ECG (standard lead-II), and a phonocardiogram from the third left parasternal intercostal space were recorded simultaneously at 100 mm s^{-1}, using a direct writing ink-jet 7-channel Mingograph (Siemens Elema).

M-mode echocardiograms were obtained (Honeywell 8100, dry silver paper recorder, 50 mm s^{-1}), guided by the two-dimensional short-axis view (Hewlett Packard ultrasound imaging system model 77020A), with subjects in the left lateral position.

Measurements

All measuring points were agreed upon by two observers (EK and KC). One investigator (EK) was responsible for interpreting all the data after the recordings had been coded and mixed by KC. Only beats with acceptable or good quality were used for measurements. With the exception of the atrial emptying index, all measurements were performed by means of a digitizer-computer system (Summagraphics digitizer connected to a PDP 11/34 or Professional-350 computer, Digital Equipment) [16]. Five beats were measured from pulse curves and Doppler recordings. From echocardiographic tracings three beats (peak rates of dimension change, two beats) were evaluated. The mean values were used for subsequent calculations.

The pre-ejection period/LV ejection time ratio was obtained from the carotid pulse tracing. The apexcardiographic A-wave, adjusted for the total amplitude (a/H ratio), and the time interval between the initial high frequency components of the aortic component of the second heart sound and the O-point of the apexcardiogram (A2-O interval), were measured. The A2-O interval was calculated as a percentage (A2-O%) of the A2-O interval predicted from the heart rate, according to the relationship in the control group.

Table 1. General characteristics (mean values ± SE) of patients and controls

	Controls ($n = 48$)	Patients ($n = 30$)	P-value
Age (years)	54.6 ± 2.1	54.5 ± 2.4	0.9766
Sex (female/male)	22/26	15/15	0.5253
Height (cm)	172.7 ± 1.1	170.9 ± 1.9	0.3846
Weight (kg)	72.6 ± 1.7	65.1 ± 2.0	0.0074
Body surface area (m^2)	1.9 ± 0.03	1.7 ± 0.04	0.0184
Body mass index ($kg\ m^{-2}$)	39.0 ± 0.5	37.5 ± 0.9	0.0084
Heart rate ($beats\ min^{-1}$)	62.1 ± 1.3	68.3 ± 1.8	0.0058
Systolic blood pressure (mmHg)	134.9 ± 2.6	132.9 ± 3.5	0.6533
Diastolic blood pressure (mmHg)	81.4 ± 1.4	78.7 ± 2.1	0.2577
Mean arterial blood pressure (mmHg)	99.2 ± 1.6	96.8 ± 2.1	0.3435

Cardiac dimensions were measured from M-mode echocardiographic recordings according to the recommendations of the American Society of Echocardiography [17]. LV internal diameter, interventricular septal thickness, and posterior wall thickness were measured at the electrocardiographic P- and Q-waves. LV dimension was measured also at end-systole (the shortest distance between the septum and the posterior wall). The cube formula was used to calculate the ejection fraction. The LV mass was calculated as described previously [16], assuming a LV muscle shell with the thickness of the mean of the septum and the posterior wall. The LV mass was adjusted for body surface area. The correlation between measurements at the electrocardiographic P- and Q- waves was good ($r = 0.96$), and only values from measurements at the Q-wave are given. The left atrial diameter was measured at the aortic valve closure, and adjusted for body surface area.

The time interval between aortic valve closure and mitral valve opening was measured as isovolumic relaxation time. The peak rate of change of LV dimension before atrial contraction, and the peak rate of posterior wall thinning during the same period, were calculated. The time from minimum LV dimension to peak LV filling, and the time interval between the most anterior excursion of the posterior LV wall and posterior wall peak thinning were measured. The left atrial emptying index was obtained from the posterior aortic wall motion [18], as an estimate of early LV filling properties [8, 16]. Since atrial emptying index was related to heart rate within the control group ($r = -0.51$, $n = 47$, $P < 0.0002$; with an expected atrial emptying index of $1.14 - 0.004 \times$ heart rate), we calculated the atrial emptying index as a percentage of the expected atrial emptying index (AEI%).

Statistical analyses

The data are presented as mean values ± standard error (SE) of the mean. An unpaired two-sided t-test was used to compare differences between patients and controls. P values < 0.05 were considered to be statistically significant. For selected variables, abnormal values were defined by two standard deviation (SD's) of the control group. Multiple regression analysis was used to determine whether diastolic abnormalities were secondary to systolic dysfunction.

Results

Body composition and blood pressure

Despite their similarity in height, patients weighed less and had a lower body mass index than controls (Table 1), which may indicate a subnormal amount of body fat. Heart rate, recorded together with M-mode echocardiography, was higher in patients, while the blood pressure level was similar in the two groups.

LV dimension, wall thickness and mass

LV dimension was not increased in scleroderma patients as a group (Table 2), and only two patients showed an increased LV diastolic dimension. Septal and posterior wall thicknesses were significantly higher in the patient group. Furthermore, the LV wall thickness to dimension ratio and the LV mass index were increased.

Indices of LV distensibility

The apexcardiographic a/H ratio was significantly

Table 2. Left ventricular dimensions (mean values ± SE)

	Controls ($n = 48$)	Patients ($n = 30$)	*P*-value
Left ventricular dimension (mm)	49.6 ± 0.8	48.5 ± 1.4	0.4410
Septal thickness (mm)	9.9 ± 0.3	12.2 ± 0.5	0.0001
Posterior wall thickness (mm)	9.1 ± 0.3	10.1 ± 0.4	0.0357
Septum + posterior wall (mm)	19.1 ± 0.5	22.3 ± 0.8	0.0003
Wall thickness/cavity ratio	0.47 ± 0.02	0.56 ± 0.03	0.0002
Left ventricular mass (g)	175.7 ± 7.4	199.6 ± 11.8	0.0739
Left ventricular mass index ($g\ m^{-2}$)	94.8 ± 3.2	115.6 ± 6.5	0.0016

Table 3. Diastolic left ventricular function (mean values ± SE)

	Controls ($n = 48$)	Patients ($n = 30$)	*P*-value
Measures of left ventricular distensibility			
Apexcardiographic a/H-ratio (%)	9.6 ± 0.6	11.9 ± 0.9	0.0288
Left atrial dimension (mm)	35.9 ± 0.9	37.4 ± 1.3	0.1885
Left atrial index ($mm\ m^{-2}$)	19.3 ± 0.4	21.9 ± 1.0	0.0046
Left ventricular relaxation and early filling properties			
Ac-Mo (ms)	72.6 ± 6.1	77.3 ± 7.7	0.6267
Ac-Mo%	100.0 ± 8.4	106.2 ± 10.5	0.6447
A2-O (ms)	143.8 ± 3.2	151.4 ± 3.9	0.1361
A2-O%	100.1 ± 2.2	107.1 ± 2.9	0.0588
Left ventricular peak dD/dt ($cm\ s^{-1}$)	14.3 ± 0.5	12.3 ± 0.6	0.0162
Time to peak dD/dt (ms)*	149.2 ± 9.2	137.7 ± 10.0	0.4158
Posterior wall peak −dD/dt ($cm\ s^{-1}$)	−9.8 ± 0.5	−8.7 ± 0.6	0.1407
Time to peak −dD/dt (ms)†	150.6 ± 5.1	136.9 ± 9.1	0.1621
Atrial emptying index	0.87 ± 0.01	0.63 ± 0.03	0.0001
AEI%	97.6 ± 1.1	72.6 ± 3.4	0.0001

* Time from minimum left ventricular dimension.
† Time from most anterior systolic position of posterior wall endocardium.
Ac-Mo = time from aortic valve closure to mitral valve opening; Ac-Mo% = Ac-Mo as percentage of expected value; A2-O = time from A2 to apexcardiographic O-point; A2-O% = A2-O as percentage of expected value; AEI% = atrial emptying index as a percentage of expected value; dD/dt = rate of change of dimension (during left ventricular filling period).

higher in patients than in controls, indicating reduced LV distensibility (Table 3). The left atrial index was increased, although this was not the case for the left atrial dimension.

Indices of LV relaxation and early filling properties

The LV isovolumic relaxation time, i.e. the time interval between aortic valve closure and mitral opening, was not prolonged, while the A2 to apexcardiographic O-point interval tended to be prolonged after correction for heart rate. The early filling period was associated with a reduced rate of LV early dimension increase, as measured by digitized M-mode. In addition, the rate of posterior wall thinning tended to be lower among patients (NS). The time periods from minimum LV dimension and from the most anterior systolic position of the posterior wall endocardium to the peak rates of LV dimension increase and posterior wall thinning, respectively, did not differ. There was a pronounced reduction of the left atrial emptying index among patients, a discrepancy which remained when accounting for heart rate.

Individual data

The number of patients with either a low or a high value for selected variables is shown in Table 4, when the patient and control groups differed significantly with regard to ventricular wall thickness (Table 2) and LV diastolic function (Table 3). The number of patients with a value outside two SD's of that for the control group is shown in relation to the total number of patients with an acceptable recording.

Table 4. Number of patients with either a low or high value of selected variables* according to the reference limits†, in relation to the total number of acceptable recordings

	Reference limits	Number of patients below lower limit	Number of patients above upper limit
Septal thickness (mm)	6.6–13.4	0/28	9/28 (31%)
Posterior wall (mm)	5.2–13.0	0/29	3/29 (10%)
Septum + posterior wall (mm)	12.7–25.5	0/28	7/28 (25%)
Wall thickness/cavity ratio	0.22–0.56	0/28	7/28 (25%)
Left ventricular mass index ($g\ m^{-2}$)	50–139	0/28	7/28 (25%)
Left atrial index ($mm\ m^{-2}$)	14.3–24.3	0/28	8/28 (29%)
Apexcardiographic a/H ratio (%)	3.0–16.2	0/29	5/29 (17%)
Atrial emptying index	0.71–1.03	17/28 (60%)	0/28
AEI%	82.5–112.6	17/28 (60%)	0/28

* Only the variables in Tables 2 and 3 that differed significantly between patients and controls are shown.
† Reference limits are mean ± 2SD's of the control group.
AEI% = atrial emptying index as a percentage of expected value.

One-third of the patients had a thick interventricular septum, while three patients had a thick posterior LV wall (Table 4). Wall thickness and its ratio to cavity dimension were abnormal in 25% of patients, as was LV mass index. Five patients, but none of the controls, had asymmetric septal hypertrophy, defined as septal thickness above the reference range, together with a septal to posterior wall ratio >1.3.

In total, 13 patients (43%) had LV hypertrophy, ten of whom showed an increased septal thickness. Ten of the 13 patients with hypertrophy also exhibited abnormal diastolic function, while three did not. Of the 10 patients, five had combined reduction of distensibility and filling properties, four showed impaired LV early filling, and one had reduced distensibility alone.

Among all the patients, signs of reduced LV distensibility were found in 10 subjects, with either an increased a/H ratio or an increased left atrial index, or a combination of both. Four of these 10 patients did not exhibit LV hypertrophy, although two of the four patients also showed disturbed early filling.

Isolated reduction of early filling was observed in six patients. Of these, one showed a reduced rate of dimension change as well as a low AEI%, while five had a low AEI% alone.

Thus 13 patients exhibited LV hypertrophy, four had reduced distensibility without hypertrophy, and six showed isolated early filling abnormalities. Examination of the remaining seven patients revealed no pathological values when considering the variables listed in Table 4.

Correlations between LV hypertrophy and reduced diastolic function

The interventricular septum was the measure of LV hypertrophy that differed most significantly between patients and controls. We therefore evaluated the relationship between septal thickness and measures of diastolic function in the entire study sample (both patients and controls). There was a reduction in distensibility with increasing septal thickness that was significantly correlated with a/H ratio and left atrial index ($r = 0.36$, $P < 0.01$, $n = 63$; and $r = 0.24$, $P < 0.05$, $n = 72$). LV relaxation and early filling properties were also impaired relative to LV hypertrophy. Thus septal thickness correlated with the A2-O interval and with the A2-O% ($r = 0.36$, $P < 0.01$, $n = 64$; and $r = 0.42$, $P < 0.001$, $n = 64$), with the LV filling rate ($r = 0.28$, $P < 0.05$, $n = 66$), and, most closely of all, with the atrial emptying index and with AEI% ($r = 0.50$, $P < 0.001$, $n = 72$; and $r = 0.51$, $P < 0.001$, $n = 72$, respectively). The relationships between septal thickness and some of the variables mentioned (a/H ratio, A2-O%, and AEI%) are shown in Fig. 1. Septal thickness identified 12 subjects (10 patients, two controls) as having LV hypertrophy (when applying the reference values in Table 4). As shown in Fig. 1, a/H ratio and A2-O% did not contribute to discrimination between patients and controls with similar septal thickness. However, AEI% identified a further 10 cases as pathological, and a low value of AEI% was only found in one control.

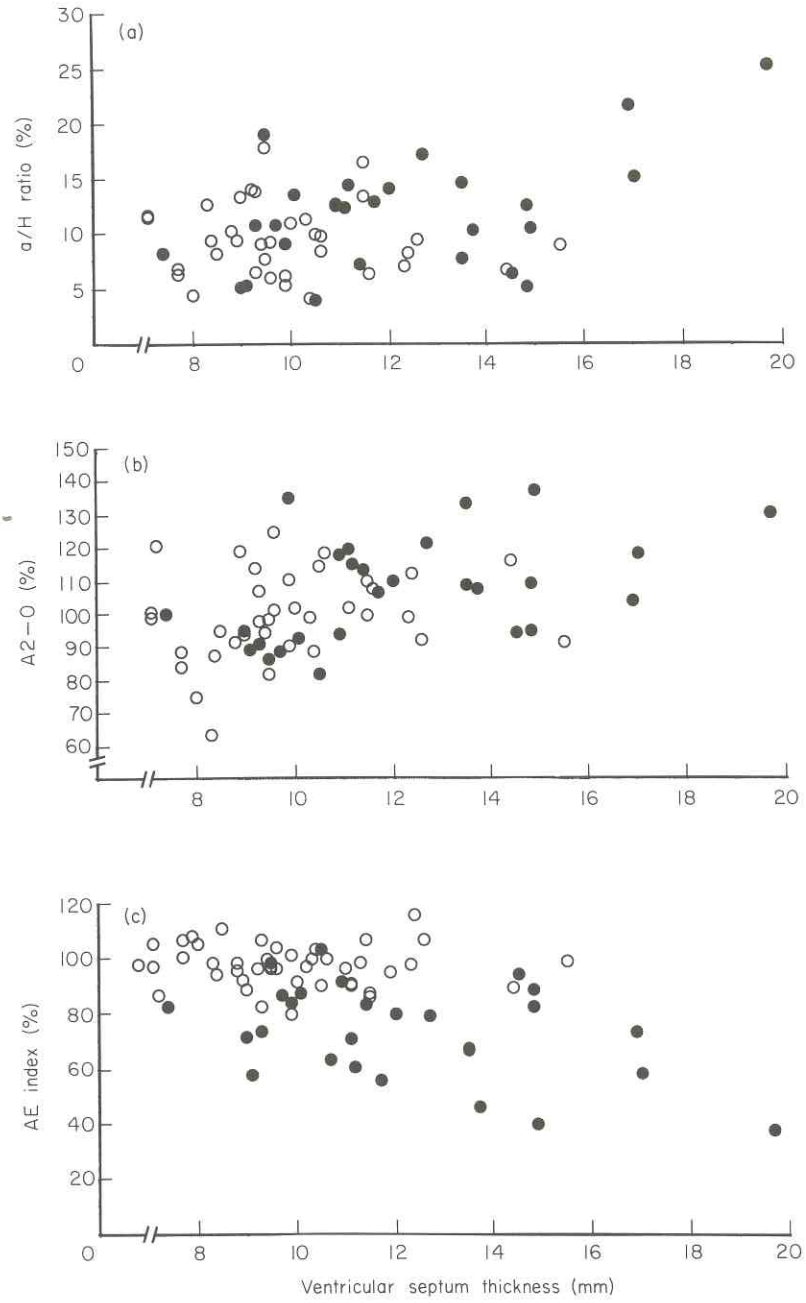

Fig. 1. Relationship between ventricular septal thickness and three parameters of diastolic function: (a) the apexcardiographic a/H ratio; (b) A2-O%, i.e. the time interval between A2 and apexcardiographic O-point as a percentage of the expected value; (c) AEI%, i.e. the atrial emptying index as a percentage of the expected value. (●) = patients, (○) = controls. For correlations see text.

Correlations between disease duration and cardiac abnormalities

Within the patient group, we evaluated a possible relationship between duration of the disease and LV hypertrophy, as well as diastolic impairment. Left atrial dimension ($r = 0.42$, $P < 0.05$, $n = 26$) and left atrial index ($r = 0.43$, $P < 0.05$, $n = 26$) were related to duration of the disease. The relationship between disease duration and left atrial dimension was not due to increase of the left atrium with age, since atrial dimension was not related to age, neither was disease duration. With the exception of left atrial dimension, the applied indices of LV structure and diastolic function were not related to disease duration.

Consideration of systolic LV function

Multivariate analysis was used to evaluate whether

Table 5. Multivariate analysis using atrial emptying index, systolic variables and heart rate to discriminate between patients and controls

	β coefficient	*t*-value	*P*-value
Atrial emptying index	−2.298	7.05	0.0001
Pre-ejection period/ left ventricular ejection time	1.341	2.55	0.0130
Ejection fraction	0.834	1.67	0.1008
Heart rate	−0.008	1.504	0.1375

the diastolic impairment was secondary to systolic LV dysfunction. Atrial emptying index was selected as an estimate of diastolic function. Heart rate was also accounted for in the analysis, as it may affect measurements of LV relaxation and filling. The relationship between atrial emptying index and group was not abolished when the pre-ejection period/LV ejection time ratio, ejection fraction, and heart rate were taken into account (Table 5). Thus diastolic abnormalities, indicated by a low atrial emptying index, were independent of systolic dysfunction in this patient group.

Discussion

The results of the present study demonstrate that LV hypertrophy and diastolic dysfunction are common in scleroderma. Age, which influences diastolic function, was identical in the two groups. The fact that diastolic dysfunction may be secondary to systolic impairment was taken into consideration, but it was found not to be essential in our patients.

These findings should be reliable, since we selected from the general population a control group matched to the patients. Furthermore, all controls and patients were evaluated by one and the same investigator. Great care was taken to ensure objective evaluation of data, and bias was avoided by blinding the interpreter to the identity of recordings.

LV hypertrophy

Both septal and LV posterior wall thicknesses were increased, although the increase in septal thickness was most significant. Thus five subjects were found to have asymmetric septal hypertrophy. This is in agreement with the findings of Ferri *et al.* [5], who observed asymmetric hypertrophy in 10 of 53 patients.

The increased wall thickness in the scleroderma group caused an increase in LV mass, which was significant when body surface area was taken into account. Our patients weighed less than the controls. Likewise, D'Angelo *et al.* [19] found an increased heart weight when correcting for body size. A slight increase of left and right ventricular mass appears to be common in systemic sclerosis [19–21], mainly because of increased wall thickness [11, 22].

LV distensibility, relaxation and early filling properties

Left atrial index was increased in patients. The left atrial dimension is an indirect measure of LV diastolic dysfunction, in the absence of mitral valve disease [16, 23]. None of our patients had mitral stenosis, and only two individuals had moderate mitral regurgitation as revealed by Doppler investigation [24]. In addition, the LV distensibility, or passive stiffness, was impaired as indicated by the apexcardiographic a/H ratio, which is a sensitive index of the diastolic function [25]. The time interval to peak early filling tended to be short, as observed previously in heart failure [16]. LV early filling velocity was reduced as judged by the digitized M-mode, and the atrial emptying index. The left atrial emptying index has proved useful in assessment of LV filling in hypertension [7], and in heart failure while systolic function is still intact [8]. This variable expressed most significantly the difference in diastolic properties between patients and controls. As is shown in Fig. 1, there was little overlap between the two groups.

Thus we could not confirm the negative findings of Kahan *et al.* [14], who found no difference between controls and patients with regard to LV compliance measured by invasive technique. Possible explanations for the discrepancy in results could be different selection criteria for the control material, different techniques, or the fact that our patients had a more severe disease. Our findings of increased LV passive stiffness and reduced early filling are consistent with the earlier studies of Smith *et al.* [12] and Gottdiener *et al.* [11], and provide echocardiographic evidence of decreased ventricular compliance.

We used isovolumic relaxation time and the A2-O interval as measures of LV relaxation. The A2-O interval, which includes the isovolumic relaxation period as well as part of the early LV filling phase [26,

27], tended to be prolonged only when it was adjusted for heart rate and the isovolumic relaxation time was not reduced. The decrease in this time interval with very high filling pressures [16, 28], which may cause a non-linear (U-shaped) relationship between 'diastolic function' and isovolumic relaxation time, was not a plausible explanation for the observed lack of difference, since in only one patient was there dilated cardiomyopathy, and the ejection fraction was not reduced in the patient group [29]. Thus LV relaxation was apparently not impaired to the same extent as passive filling and distensibility.

Relationship between LV hypertrophy, diastolic function and blood pressure

Pathological LV hypertrophy may cause impairment of diastolic function [30, 31], while the hypertrophy observed in athletes is not associated with diastolic dysfunction [32, 33]. This is illustrated by Fig. 1, lower panel, in which control subjects exhibited a narrow AEI% range irrespective of septal thickness, while in patients with a thicker septum there was an obvious decrease in AEI%.

Several studies reported that LV wall thickness is abnormal only in scleroderma patients with systemic hypertension [2, 12, 20]. This was not the case in our study, as there was no significant difference in mean arterial blood pressure or in cavity dimension between the two groups, and there was no correlation between systolic blood pressure and LV mass. This also suggests that ventricular hypertrophy was not due to an increased afterload. To a greater extent it may be due to myocardial fibrosis [20], which is secondary to increased intrinsic collagen production [2].

Diastolic function as secondary phenomenon

Diastolic and systolic function of the heart are closely related, both at the atrial [34] and at the ventricular level [35]. They are often simultaneously abnormal [34], and both may increase filling pressures. We have previously shown systolic function to be impaired in the present study population [29]. Therefore it was necessary to evaluate whether the diastolic abnormalities were primary or secondary to the systolic dysfunction or the increased heart rate. However, when systolic function and heart rate were taken into consideration, atrial emptying index indicated independent impairment of LV filling properties.

Conclusions

This study shows that 17 of 28 patients (60%) had LV diastolic dysfunction, which is consistent with the occurrence of (clinically often unrecognized) myocardial fibrosis in 50–70% of scleroderma patients at autopsy [2], and also with our previous finding of cold-induced perfusion defects in 12 of 21 patients (57%) [36]. If signs of diastolic dysfunction are pooled with signs of LV hypertrophy, 77% of patients investigated show cardiac involvement. LV relaxation was found to be unimpaired, indicating a normal function of the sarcoplasmic reticulum involved in the active process of relaxation by reuptake of calcium ions. On the other hand, passive and active LV filling, which mirrors the elastic elements, was probably compromised as a result of collagen infiltration.

Cardiac involvement in systemic sclerosis sometimes precedes the appearance of skin symptoms, [37], causing a diagnostic dilemma. Furthermore, involvement of the heart has been found to be associated with a poor prognosis [38, 39]. Noninvasive techniques, particularly echocardiography, have been shown to be very useful during the early detection and follow-up of cardiac dysfunction in systemic sclerosis [39], including antemortem diagnosis of cardiac involvement [2, 40]. Thus we find the recommendation [11, 12] that echocardiography be used as a routine procedure in systemic sclerosis highly pertinent. The present data indicate that septal thickness and atrial emptying index are useful measures of LV involvement. Early detection of cardiac involvement allows specific therapy to be instituted, and the effects can then be adequately monitored. Such studies are currently in progress.

Acknowledgements

This study was supported by the Swedish Heart and Lung Foundation, Skandia Life Insurance Company, King Gustaf V's 80th Year Foundation, and Uppsala University.

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Received 19 December 1989, accepted 29 January 1990.

Correspondence: Kenneth Caidahl, MD, Department of Clinical Physiology, Sahlgren's Hospital, S-413 45 Gothenburg, Sweden.