Computed tomography in patients with hypertrophic cardiomyopathy

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SUMMARY Computed tomography was undertaken in nine patients (age range 33-69 (mean 48.7) years) with hypertrophic cardiomyopathy. The ventricular septum was demonstrated in each patient and shown to be thickened (mean 25 mm at maximum width). The results agreed with those obtained by echocardiography, except in two patients in whom computed tomography showed preferential thickening of the mid-portion of the ventricular septum. The ventricular free wall was not clearly seen.

Computed tomography may prove a valuable technique in the assessment of patients with hypertrophic cardiomyopathy.

Computed tomography has proved to be a valuable technique in the diagnosis of aortic dissection,¹⁻³ pericardial disorders,^{4,5} and cardiac tumours.⁶ It may identify patent coronary artery bypass grafts⁷ and left ventricular thrombus.⁸ We report its use in patients with hypertrophic cardiomyopathy diagnosed by echocardiography or at cardiac catheterisation.

Patients and methods

Nine patients were studied (eight men, one woman). Their ages ranged from 33-69 (mean of 48.7) years. The Table shows the clinical data. In all the patients the diagnosis had been made on clinical criteria and confirmed by M mode echocardiography and in five cases by cardiac catheterisation.

All the investigations were carried out on a Siemens Somaton 2 CT scanner. This is a rotate-rotate computed tomographic system capable of rapid sequence scans. For the studies in this report, the scan time used was 5 s and the slice thickness 8 mm, and all images were obtained at full inspiration. The patient was initially positioned within the gantry and 3-4 pre-contrast images were obtained at differing anatomical levels. These were used to estimate the position of the ventricular septum before the contrast study. Fifty

millilitres of contrast medium (Conray 420) were then injected into a large peripheral arm vein, 30 ml as a bolus and the remaining 20 ml more slowly during the next 20 s. The first scan was obtained immediately after the bolus, again at full inspiration. Five further contrast enhanced images were then obtained as rapidly as possible during the next minute. Our machine has a 5 s interscan time thus allowing normal respiration between scans. The six postcontrast images were obtained at 5 mm anatomical increments so that there was every chance of getting at least two satisfactory images of the septum. In some patients an attempt was made to align the plane of the scan to the long axis of the heart by gantry angulation after an initial lateral scanogram.

Measurements of septal thickness were subsequently made with electronic calipers on the evaluation console. A standard window width (256 Hounsfield Units) was used for viewing. The level was then adjusted until the contrast medium in the chambers was in the middle of the grey scale (often around +100 HU).

Results

The Table and Figs. 1-5 show the results. In four patients, the septum was appreciably thickened (Figs. 1-4). In case 7, the septum had a "diamond" configuration measuring 28 mm at its maximum (Fig. 1). In all patients the septum was thickest in its mid-portion, and the values shown in the Table are the maximum widths of the septum. In case 2 there was

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Table Clinical data and results of echocardiography and computed tomography in nine patients with hypertrophic cardiomyopathy

Case No	Age (yr)	Sex	Symptoms	Signs	Cardiac diameter (cm)*	ECG	M mode echocardiography	Rest pressure gradient (mm Hg)	PESP (mm Hg)	Coronary artery disease	LV angiogram	Computed tomography (septal size)
1	48	M	Palpitation	Ejection murmur	—	LA +, LVH	Septum 22 mm	110	170	LAD, RCA	HCM	23 mm
2	62	M	Dyspnoea, angina	Pansystolic murmur	14.5	LA +, LVH	Septum not defined, calcium in valve ring	80	—	RCA	HCM	25 mm, calcium present
3	42	M	Dyspnoea, chest pain	Ejection murmur	12.5	Left axis deviation, septal Q waves	Septum 20 mm, SAM, aortic valve closure	—	—	—	—	33 mm, diamond configuration
4	69	M	Dyspnoea, angina, syncope	Pansystolic murmur	14	Normal	Small LV, septum	10	105	Minor	HCM	17 mm
5	49	M	Tiredness	Ejection murmur, jerky carotid pulse	16.5	LVH	Septum 30 mm	—	—	—	—	36 mm (inter-atrial septum enlarged)
6	34	M	Congestive failure	Ejection murmur	18	LVH	Septum 27 mm	85	106	None	HCM, MR	26 mm
7	33	F	Congestive failure, dyspnoea	Ejection murmur, LV + and jerky carotid pulse	15	LVH, left axis deviation	Septum 18 mm, SAM, small LV	100	150	None	HCM	28 mm, diamond configuration
8	50	M	Dyspnoea, palpitation, atypical chest pain	Ejection murmur	15	LVH	Septum 20 mm	—	—	—	—	19 mm
9	51	M	Syncope	Systolic murmur, LV +	17	LVH	Septum 20 mm	—	—	—	—	19 mm

*Radiographic.

LVH, left ventricular hypertrophy; SAM, systolic anterior motion of the mitral valve; LA+, left atrial hypertrophy; LV+, clinical left ventricular enlargement; LAD, left anterior descending; RCA, right coronary artery; HCM, hypertrophic cardiomyopathy; MR, mitral regurgitation; PESP, postextrasystolic pressure gradient.

pronounced intracardiac calcification, which produced linear artefacts (Fig. 2). The thick septum is, however, clearly seen. In case 5 there was some thickening of the interatrial septum as well as gross thickening of the interventricular septum (Fig. 3). This was not so prominent in any of the other patients. In case 3 there was once again a diamond configuration

with an appreciably thickened septum and a poorly defined left ventricular free wall (Fig. 4). The septum measured 33 mm at its maximum thickness.

The Table shows the results of M mode echocar-

Fig. 1 Case 7 (33 year old woman): computed tomogram showing the interventricular septum (S) most thickened (28 mm) in its mid-portion so forming a "diamond" configuration. R, right ventricle; L, left ventricle.

Fig. 2 Case 2 (62 year old man): computed tomogram showing linear artefacts from mitral ring calcification (C), which degrade the image; nevertheless, the septum (S) is well seen (25 mm maximum). R, right ventricle; L, left ventricle.

Fig. 3 Case 5 (47 year old man): computed tomogram showing that the interventricular septum (S) becomes progressively thicker towards the apex (reaching 36 mm). Posteriorly the ventricular septum merges with quite a thick interatrial septum. R, right ventricle; L, left ventricle.

Fig. 4 Case 3 (42 year old man): computed tomogram showing a diamond shape to the septum (S). R, right ventricle; L, left ventricle.

diography as well as computed tomography. In all nine patients the septum was clearly seen on computed tomography, and in eight of the nine patients M mode echocardiography identified the septum. The presence of other echocardiographic abnormalities such as systolic anterior motion of the mitral valve or early closure of the mitral valve is evident, but they do not bear any fixed relation to septal thickness. There

Fig. 5 Normal subject: computed tomogram clearly showing the septum (S) (measured at 11 mm) between the right (RV) and left (LV) ventricles.

is agreement between the two methods except in cases 3 and 7. Although both these had abnormally thickened septa on M mode echocardiography with systolic anterior motion of the mitral valve, the values obtained by computed tomography for septal thickness were greater. In both cases a diamond configuration was seen on computed tomography. For comparison, Fig. 5 shows a cardiac computed tomogram from a normal subject. The septum is clearly defined and measures 11 mm at its maximum thickness.

Discussion

The computed tomographic findings in these patients with hypertrophic cardiomyopathy diagnosed by clinical criteria, cardiac catheter, or echocardiography show that excellent tomographic images of the heart may be obtained which provide adequate definition of the interventricular septum. In our studies the scan time was 5 s, which is of course extremely long for cardiac imaging. Despite this, the pictures are of adequate quality to allow measurement of the septum, and comparison with real time echocardiography shows remarkably good agreement. The normal (mean (SD)) septal width has been previously reported as 0.8 (0.6) cm, and in all our cases the septum was appreciably thickened.⁹ The technique was able to demonstrate the septum far more clearly than the free wall. A possible explanation for this may be that the movement of the septum is less than the free wall, and therefore it is more clearly seen despite the long data acquisition time. Certainly in patients with left ventricular aneurysms the free wall of the aneurysm is clearly seen, presumably because it is relatively immobile.

It must not be forgotten that the information obtained is anatomical, and the technique is therefore limited in its application to such a dynamic organ as the heart. The use of stop action or electrocardiogram gated tomography^{10 11} has been described for cardiac computed tomography. These techniques, however, increase the overall scan time substantially and also do not eliminate motion artefacts due to respiration.

The two cases in which the computed tomographic measurements exceeded those of M mode echocardiography are of interest. In both, a diamond septal configuration was seen on computed tomography. The variability in septal thickness has been reported previously by angiographic techniques in hypertrophic obstructive cardiomyopathy,¹² a possible reason being that the echocardiographic beam did not transverse the thickest part of the septum and therefore the value obtained was less than that for computed tomography.

A comparison of the relation of septal to free wall thickness, as has been reported for echocardiograms,^{13 14} could not be made because of the relatively poor definition of the free wall. A septal to free wall ratio $>1.3:1$ is, however, now not felt to be diagnostic of hypertrophic cardiomyopathy,^{15 16} and our findings would suggest that this may be due to the variable thickness of the septum in its different parts, as suggested by certain echocardiographic reports.^{17 18}

Intracardiac calcium, as seen in case 2, is not unusual in patients with hypertrophic cardiomyopathy, particularly if they are elderly.¹⁹ Calcification is readily detected by computed tomography, but Fig. 2 shows the linear artefacts that may arise and which may prove a limitation in patients with prosthetic valve rings or clips on vein grafts. Despite the artefacts we were able to define septal thickness in the patient in case 2, when the echocardiogram was unable to show the septum adequately.

In conclusion, this study has shown that computed tomography may define the interventricular septum in patients with hypertrophic cardiomyopathy. The information it provides is anatomical but may be valuable in patients with this condition especially if echocardiography is technically difficult or unexpectedly normal.

References

- Moncada R, Salinas M, Churchill R, *et al.* Diagnosis of dissecting aortic aneurysm by computed tomography. *Lancet* 1981; i: 238-41.
- Heiberg E, Wolverson M, Sundaram M, Connors J, Susman N. CT findings in thoracic aortic dissection. *AJR* 1981; 136: 13-7.
- Egan TJ, Neiman HL, Herman RJ, Malave SR, Sanders JH. Computed tomography in the diagnosis of aortic aneurysm dissection or traumatic injury. *Radiology* 1980; 136: 141-6.
- Tomoda H, Hoshiai M, Furuya H, *et al.* Evaluation of pericardial effusion with computed tomography. *Am Heart J* 1980; 99: 701-6.
- Houang MTX, Arozana X, Shaw DG. Demonstration of the pericardium and pericardial effusion by computed tomography. *J Comp Asst Tomogr* 1979; 3: 601-3.
- Godwin JD, Axel L, Adams JT, Schiller NB, Simpson PC Jr, Gertz EW. Computed tomography: a new method for diagnosing tumor of the heart. *Circulation* 1981; 63: 448-51.
- Kahl FR, Wolfman NT, Watts LE. Evaluation of aortocoronary bypass graft status by computed tomography. *Am J Cardiol* 1981; 48: 304-10.
- Nair CK, Sketch MH, Mahoney PD, Lynch JD, Mooss AN, Kenney NP. Detection of left ventricular thrombi by computerised tomography. *Br Heart J* 1981; 45: 535-41.
- Guthaner DF, Wexler L, Harell G. CT demonstration of cardiac structures. *AJR* 1979; 133: 75-81.
- Harell GS, Guthaner DF, Breiman RS, *et al.* Stop-action cardiac computed tomography. *Radiology* 1977; 123: 515-7.
- Sagel SS, Weiss ES, Gillard RG, *et al.* Gated computed tomography of the human heart. *Investigative Radiology* 1977; 12: 563-6.
- Redwood DR, Scherer JL, Epstein SE. Biventricular cineangiography in the evaluation of patients with asymmetric septal hypertrophy. *Circulation* 1974; 49: 1116-21.
- Henry WL, Clark CE, Epstein SE. Asymmetric septal hypertrophy. Echocardiographic identification of the pathognomonic anatomic abnormality of IHSS. *Circulation* 1973; 47: 225-33.
- Abbasi AS, MacAlpin RN, Eber LM, Pearce ML. Left ventricular hypertrophy diagnosed by echocardiography. *N Engl J Med* 1973; 289: 118-21.
- Feizi O, Emanuel R. Echocardiographic spectrum of hypertrophic cardiomyopathy. *Br Heart J* 1975; 37: 1286-302.
- Shah PM. Echocardiography in the diagnosis of hypertrophic obstructive cardiomyopathy. *Am J Med* 1977; 62: 830-5.
- Tajik AJ, Seward JB, Hagler DJ. Detailed analysis of hypertrophic obstructive cardiomyopathy by wide-angle two-dimensional sector echocardiography [Abstract]. *Am J Cardiol* 1979; 43: 348.
- Taylor RD, Child JS, Shah PM. Variations in septal hypertrophy in hypertrophic obstructive cardiomyopathy [Abstract]. *Am J Cardiol* 1979; 43: 348.
- Kronzon I, Glassman E. Mitral ring calcification in idiopathic hypertrophic subaortic stenosis. *Am J Cardiol* 1978; 42: 60-6.