

Endomyocardial biopsy guided by cross-sectional echocardiography

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SUMMARY The usefulness of cross-sectional echocardiography during endomyocardial biopsy was examined in 10 consecutive patients with myocardial disease of undetermined origin. Twenty-eight endomyocardial biopsies were obtained from the left ventricle and 34 from the right ventricle. Echocardiography was performed simultaneously with monitoring of the biopsy procedure by means of fluoroscopy, pressure measurement, and electrocardiographic recording from the biop-
tome.

Echocardiographic visualisation of the biopsy procedure was feasible in 100% of left and in 18% of right ventricular biopsies. Conventional positioning of the biop-
tome was corrected in a total of five cases because of inappropriate localisation as apparent from cross-sectional echocardiography. In the left ventricle the site of biopsy could be defined more precisely by echocardiography than by fluoroscopy. At the present stage of technical development the most important potential of ultrasonically guided endomyocardial biopsy seems to be the feasibility of obtaining selective biopsies from well defined areas of the left ventricle when serial analysis from a reproducible area is necessary.

Endomyocardial biopsy technique with employment of recently introduced types of biop-
tomes is associated with a minimal overall incidence of adverse effects,¹ but major complications such as haemopericardium have not been eliminated entirely.² Another limitation of the present endomyocardial biopsy procedure is the low feasibility of performing visually guided precision biopsies for serial analysis. Furthermore, undesired sampling from thin walled scar tissue or regions with mural thrombi cannot be avoided by means of fluoroscopy. Cross-sectional echocardiography has the potential of visualising both the localisation of the biop-
tome in the heart and areas suspected to entail increased risk of complications during the biopsy procedure. The aim of the present study was therefore to examine the contribution of ultrasound to endomyocardial biopsy technique.

Patients and methods

Ten consecutive patients referred for haemodynamic investigation and endomyocardial biopsy were included in the study, consisting of eight men and two women with a mean age of 37.5 years (range 19 to 59

years). On a clinical and echocardiographic basis, all patients were suspected of suffering from myocardial disease. The patients were in NYHA functional classes II to IV, except for case 7 who was in class I.

Endomyocardial biopsy was carried out immediately after heart catheterisation which was performed from the groin using conventional techniques.³ The venous or arterial catheter was replaced by a sheath with a length of 96 cm* which was guided during fluoroscopy to the right or left ventricle, respectively, by means of a 7.5 F pigtail catheter introduced through the sheath. The proximal end of the sheath was closed with a membrane† and pressure recording was obtained through the sheath. The tip of the sheath was positioned during fluoroscopy and, if necessary, the position was corrected after hand injection of contrast medium (Urografin[®] 76%). With a stable position of the sheath, the pigtail catheter was subsequently replaced by King's biop-
tome (KeyMed[®]).^{4 5}

Using anteroposterior fluoroscopy, the following positions of the sheath and biop-
tome were selected. In the left ventricle it was intended to obtain a 120° curve of the sheath and biop-
tome in the inferolateral direc-

*Cook.

†Cordis valve.

tion from the ascending aorta towards the apex of the heart. The tip of the sheath was positioned as apically as possible, but at least 2 cm from the border of the fluoroscopic silhouette of the heart. In the right ventricle, the sheath and bioptome were positioned with a 60° inferolateral angle from the inferior vena cava towards the inferior part of the ventricle and with the tip localised to the left of the border of the spine. Apposition to the interventricular septum was attempted by means of palpation with the catheter. In equivocal cases correct positioning was facilitated by rotating the x-ray equipment 90° to the lateral position.

During fluoroscopy the bioptome was advanced through the sheath, and the jaws of the bioptome were opened immediately after leaving the sheath. Palpation by the bioptome, ventricular extrasystoles, and abnormal pattern in the intracardiac electrocardiogram recorded from the tip of the bioptome⁴ were used as indicators of wall contact with the bioptome. The jaws of the bioptome were subsequently closed for sampling and the bioptome was rapidly withdrawn.

Cross-sectional echocardiography was carried out with the patient in a supine position on the catheterisation table, using an Aloka SSD 110 S-E mechanical sector scanner. Standardised parasternal, apical, and subcostal views were used in all patients for visualisation of the sheath and the bioptome. Furthermore, parasternal transducer positions between the left sternal border and the apex beat were used, with the scanning plane determined by the direction of the sheath and bioptome from the aorta towards the biopsy site (oblique views). After positioning the sheath by means of fluoroscopy an attempt was made to identify the tip by cross-sectional echocardiography. In equivocal cases the visualisation was improved by the injection of 5 to 10 ml isotonic sodium chloride through the sheath (Fig. 1). For the left ventricular biopsies the level of the tip was classified as either apical (beyond the papillary muscles), at the level of the papillary muscles, or posterior to the papillary muscles. In the right ventricular biopsies, the level of the tip was also classified in relation to the left ventricular papillary muscles, since no appropriate reference point in the right ventricle could be visualised in the patients of

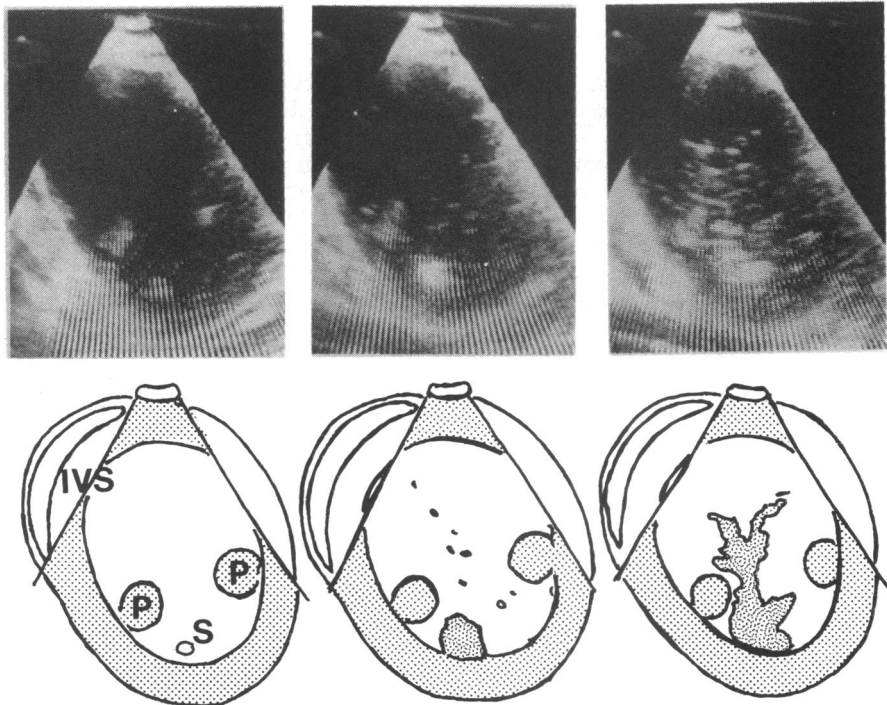


Fig. 1 Short axis view recorded by cross-sectional echocardiography during localisation of the tip of the sheath in the left ventricle. The tip is positioned at approximately 180° at the interpapillary muscle area and is identified by injection of saline (middle and right panels). IVS, interventricular septum; P, papillary muscles; S, sheath.

the present series. In both right and left ventricular biopsies the position of the tip of the sheath in the short axis view was recorded by dividing the short axis view of the left ventricle into 360° with 0° and 360° at the top and the anterolateral papillary muscle approximately at 90° (Fig. 1). After introduction of the biop-
tome, echocardiography was repeated for control of the position. During sample recording the echocardiographer wore a lead glove because of the fluoroscopy which was being done simultaneously.

In cases 6 to 10 the localisation of the biopsy sites as determined by combined fluoroscopy and catheter palpation was compared with the position as defined by cross-sectional echocardiography. The position of the biop-
tome using the two different methods was recorded independently by the person using the catheter and by the echocardiographer, each examiner being unaware of the results of the other.

An M-mode scan was obtained in all patients for measuring right and left ventricular dimensions at end-diastole.⁶

Results

Clinical diagnoses, number of biopsies, and echocardiographic data are listed in Table 1. In all patients, parasternal short axis views combined with oblique views determined by the course of the sheath and biop-
tome were superior to other projections for localising the biopsy site (Fig. 1 and 2). Visualisation of the biopsies using cross-sectional echocardiography was feasible in all 28 biopsies obtained from the left ventricle, that is, a success rate of 100% (88 to 100% with 95% confidence limits), whereas only six of 34 right ventricular biopsies were visualised, that is, 18% (7 to 35%). In approximately one-third of right ven-

tricular biopsies cross-sectional echocardiography could not be used during the sampling because the transducer concealed the pertinent area on the fluoro-
scope. Even before sampling, however, the tip of the biop-
tome could be visualised in only 18% of the cases.

Nearly all patients had a normal right ventricular end-diastolic diameter, whereas the left ventricular end-diastolic diameter varied from normal to severe dilatation (Table 1). The sites of the biopsies as defined by cross-sectional echocardiography are given in Table 2. Most of the left ventricular biopsies were sampled from the relatively small interpapillary muscle area of the inferoposterior wall. According to a necropsy analysis this interpapillary muscle area ranges from approximately 4 cm² in the normal heart to approximately 15 cm² in hearts with myocardial disease and weights exceeding 550 g (U Baandrup, personal communication 1982).

In cases 6 to 10 where the left ventricular biopsy site was recorded independently by the echocardiographer and the operator doing the biopsy, there was only one discrepancy regarding the left ventricular level of the biopsy (Table 2). The difference between the methods in localisation of the biop-
tome in the short axis view varied from 0° to 90°, with a mean difference of 32°. In case 6 the position of the sheath and biop-
tome as confirmed by anteroposterior and lateral fluoroscopy seemed inappropriate according to the cross-sectional echocardiogram in one of the biopsies from the right ventricle. Echocardiography showed that the biop-
tome pointed towards the anterior wall instead of towards the interventricular septum as intended. None the less the biopsy was carried out, but a cine film recorded in the lateral view showed that the sampling had unfortunately taken place tangentially from the anterior wall of the right ventricle (Fig. 3). In two similar, but subsequent

Table 1 Clinical and echocardiographic data in 10 patients subjected to endomyocardial biopsy

Case No.	Age (years) and sex	Clinical diagnosis	Biopsies performed		Biopsies visualised		End-diastolic diameters (cm/m ²)	
			Right ventricle	Left ventricle	Right ventricle	Left ventricle	Right ventricle	Left ventricle
1	59 F	Adriamycin cardiotoxicity (breast cancer)	3	4	0	4	1.4	3.2
2	53 F	Adriamycin cardiotoxicity (lung cancer)	0	4	—	4	—	—
3	36 M	Congestive cardiomyopathy	4	4	1	4	1.7	3.1
4	41 M	Amyloidosis	5	0	1	—	1.3	2.4
5	40 M	Congestive cardiomyopathy	4	4	0	4	1.3	2.9
6	19 M	Myocarditis	4	0	1	—	1.2	3.2
7	21 M	Myocarditis	3	4	2	4	1.3	2.6
8	32 M	Congestive cardiomyopathy	3	4	1	4	0.9	4.2
9	31 M	Congestive cardiomyopathy	4	0	0	—	1.0	3.5
10	43 M	Congestive cardiomyopathy	4	4	0	4	0.8	3.1
Total			34	28	6	28		

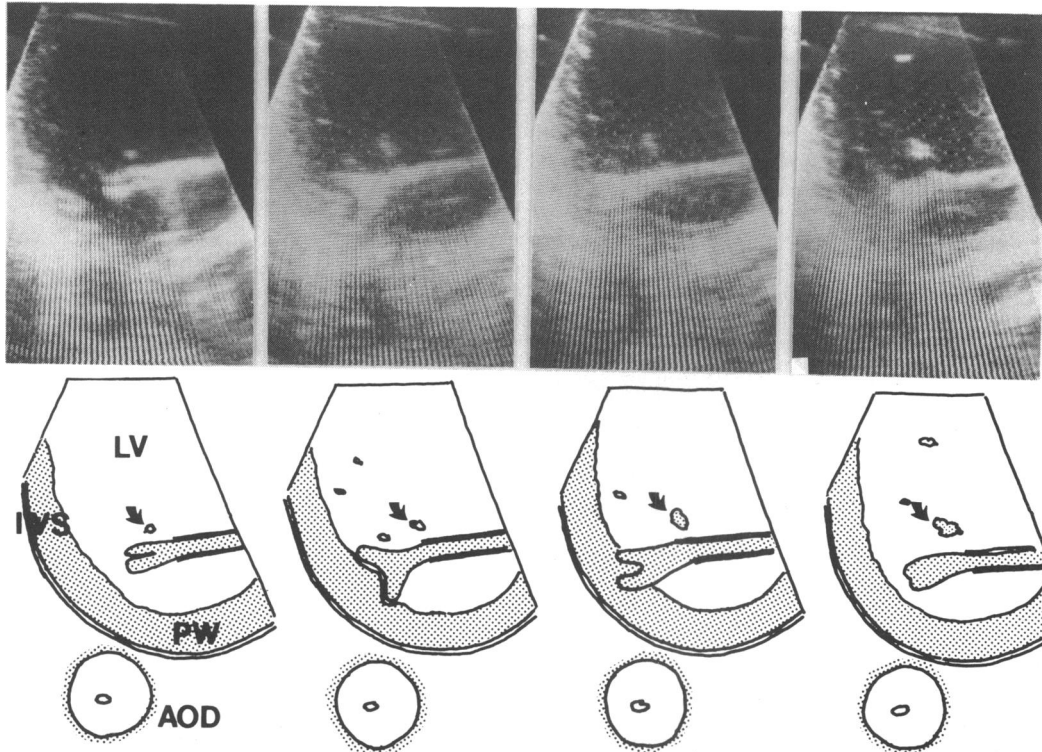


Fig. 2 Endomyocardial biopsy monitored by cross-sectional echocardiography. An oblique view determined by the course of the biptome was used. Arrows indicate saline oozing out from the sheath during the introduction of the biptome. AOD, descending aorta; IVS, interventricular septum; LV, left ventricular cavity; PW, posterior wall.

Table 2 Sublocalisation of biopsy site defined by cross-sectional echocardiography ($n = 34$)

	Level in relation to left ventricular papillary muscles			Localisation in short axis view (0° and 360° at top)
	Posteriorly	Papillary muscle level	Apically	
Left ventricle	{	1	1	120°
		4		150°
		12		180°
		10		210°
Total	0	27	1	
Right ventricle	{	1	0	270°
		4		300°
		1		330°
Total	0	6	0	

cases of right ventricular biopsy, the position of the sheath was corrected according to cross-sectional echocardiography before introducing the biptome.

The position of the biptome selected by fluoroscopy appeared too close to the mitral apparatus as assessed by cross-sectional echocardiography in two cases of left ventricular biopsy, and the position of the instrument was corrected accordingly. In case 9 an

unsuspected large floating thrombus originating from the left ventricular apex was shown by cross-sectional echocardiography after the performance of right and left heart catheterisation, left ventricular angiography, and subsequent introduction of the sheath into the left ventricle. The sheath was gently withdrawn without complications, and only right ventricular biopsies were subsequently carried out.

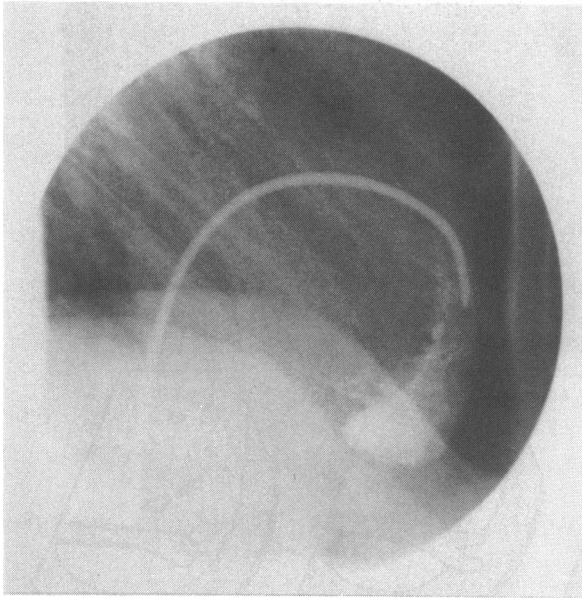


Fig. 3 Sheath position in the right ventricle in the lateral view. Cine-film with injection of contrast medium shows close position of the sheath to the anterior free wall as predicted by cross-sectional echocardiogram.

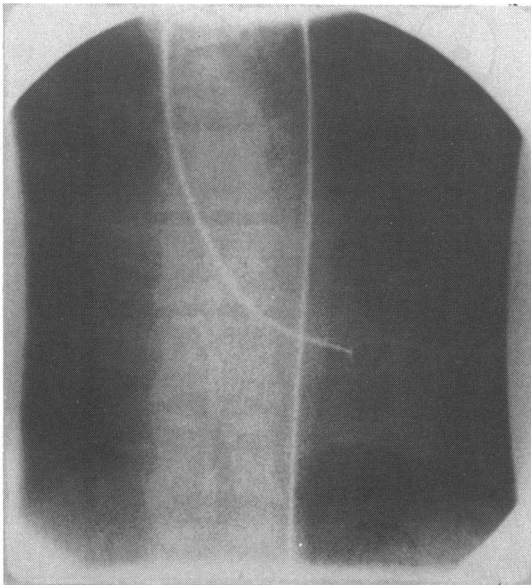


Fig. 4 Left ventricular biopsy. Sheath and King's biptome in open position.

In case 2 the radiological orientation was severely impeded because of metastases in the lungs and anterior mediastinum. The position of the sheath and biptome in the left ventricle, however, was easily defined by cross-sectional echocardiography, whereas neither fluoroscopy nor cross-sectional echocardiography allowed safe biopsy from the right ventricle. A standard M-mode echocardiogram was unobtainable

in this patient (case 2). The individual biopsy procedures were generally prolonged by about one minute because of recording the cross-sectional echocardiogram, but in some of the first patients the delay was up to five minutes concerning the initial biopsy. Case 4 had a brief period of transient ventricular tachycardia during right heart catheterisation, but otherwise there were no complications related to the invasive procedures.

Discussion

Obviously, careful monitoring of the endomyocardial biopsy procedure is essential to minimise the rate of complications. To avoid myocardial perforation, the biptome must be advanced towards the myocardial wall in the open position, and the jaws must therefore be opened immediately after the biptome has left the sheath (PJ Richardson, personal communication 1980). At the present stage of technical development fluoroscopy seems superior to cross-sectional echocardiography for the visualisation of this moment (Fig. 2 and 4). In contrast, it is feasible to visualise the myocardial contact of the biptome by cross-sectional echocardiography but not by fluoroscopy. In order to see the myocardial contact on the echocardiogram, however, the ultrasonic transducer has to be in position on the thoracic wall before the tip of the biptome is advanced outside the sheath. This makes it essential for the echocardiographer to wear a lead glove, a prerequisite that renders the ultrasound examination extremely awkward. In all cases the site of the left ventricular biopsies was selected by fluoros-

copy alone but in two cases it was later corrected by cross-sectional echocardiography. Surprisingly, this showed that nearly all the sites chosen by means of fluoroscopy were localised between the two papillary muscles. The study documented the superiority of cross-sectional echocardiograms as compared with fluoroscopy in defining the site of biopsy in the left ventricle. Pathological anatomical studies have shown great topographic variation with respect to the structural composition of the myocardium within the same heart.⁷ Thus, accurate definition of the biopsy site in the left ventricle by cross-sectional echocardiography immediately before sampling is a great potential of the technique. It might well prove important in patients where serial myocardial biopsies are obtained to monitor the course of a disease or the effect of an intervention.⁸ Furthermore, cross-sectional echocardiography in endomyocardial biopsy from the left ventricle makes it possible to avoid sampling from areas with thinned myocardium caused by scar tissue and to avoid areas with thrombi, and the technique has the potential of obtaining selective biopsies from tumours. In addition cross-sectional echocardiograms can assist the radiological monitoring in special cases such as in case 2 with impeded fluoroscopy resulting from metastases in the lungs and mediastinum.

A considerably lower yield of cross-sectional echocardiograms was found in the right ventricular biopsies, since less than 20% of the biopsies were visualised. It appeared particularly difficult to demonstrate the tip of the sheath and bioptome when they were located in the inferior third of the ventricle as judged by fluoroscopy, and only biopsies from the middle third of the ventricle were visualised. Possibly some of the difficulties were the result of the circumstance that nearly all patients had right ventricles of normal size. A small semilunar ventricle in the short axis view may make it impossible to distinguish the tip of the sheath or bioptome from myocardial trabeculae. Saline injection through the sheath did not improve the identification significantly, possibly because the contrast effect was inhibited by the very limited space around the catheter. In spite of the difficulties in monitoring the right ventricular biopsies in the present study, it seems possible to obtain a sample from the right site of the middle part of the interventricular septum with the help of cross-sectional echocardiography.

In the present series, the biopsy site as confirmed by fluoroscopy was corrected in accordance with the cross-sectional echocardiographic findings in a total of five cases. Though suggestive, the present data do not, however, verify that cross-sectional echocardiograms can further reduce the risk of complications associated with endomyocardial biopsy.^{1,2}

In conclusion simultaneous cross-sectional echocardiography and fluoroscopy are inconvenient as

the technique requires the echocardiographer to wear a lead glove and the ultrasonic transducer may conceal some right ventricular biopsy sites on the x-ray monitor. Accordingly, alternating cross-sectional echocardiography and fluoroscopy during positioning of the bioptome are recommended, but at present it seems most appropriate to visualise the moment of sampling by means of fluoroscopy.

The contribution of cross-sectional echocardiography to endomyocardial biopsy appears to be particularly valuable in cases requiring selective biopsy from the left ventricle, for example when serial analysis from a reproducible localisation is required. For this purpose, well defined sublocalisations within the interpapillary muscle area appear to be an appropriate choice. In addition, the technique can doubtlessly improve positioning of the bioptome free of the mitral valve apparatus, possible mural thrombi, or thin walled scar tissue.

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