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Sequential Study of Echocardiographic Changes in Purulent Pericarditis

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SUMMARY. **Serial echocardiographic studies were performed in a child with purulent pericarditis. Besides demonstrating the pericardial effusion, echocardiography was used to assess cardiac function. Computer analysis of changes in left ventricular dimension showed impaired diastolic filling, persisting after pericardiocentesis but normalizing after pericardiectomy.**

KEY WORDS: **Echocardiography — Pericarditis — Cardiac tamponade — Cardiac function in tamponade**

Several studies have confirmed the sensitivity of echocardiography in the diagnosis of pericardial effusion [7, 10, 21]. Particularly in younger children, early diagnosis and medical or surgical treatment of septic pericarditis are often life-saving [4, 16, 17].

We here report the echocardiographic findings in a boy with purulent pericarditis. Special attention is paid to left ventricular performance.

Methods

The echocardiograms were obtained with an Echocardiovisor Ultrasonoscope (Organon-Teknika) and a fiberoptic recorder using a 4.5-MHz unfocused transducer for M-mode registrations. Standard techniques were used for the echocardiographic examinations [7, 14]. Left ventricular function was assessed using both left ventricular dimension changes, systolic time intervals, and computer analysis of the echocardiographic registrations, as previously reported [2]. The left ventricular internal diameters (LVID) were measured in diastole and systole and the percentage change with systole (ΔLVID) was calculated [2]. Left ventricular preejection period (LPEP) and left ventricular ejection time (LVET) were measured from high-speed echocardiograms of the aortic leaflets and LVET was corrected for heart rate and expressed as a percentage of normal, LVET% [2].

High-speed left ventricular echocardiograms (paper speed 100 mm/s) were computer-analyzed as previously described [2], using the method first reported by Gibson and Brown [8]. The computer output was displayed on an *x-y* plotter (Fig. 1).

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Instantaneous left ventricular dimension and instantaneous mitral leaflet velocity can be derived from the output curves. The computer also calculates the rate of change of left ventricular dimension (dDim/dt), which is divided by the instantaneous dimension at which it occurs, giving a normalized lengthening rate with the dimensions s^{-1}. The peak lengthening rate and the peak shortening rate were measured.

Case Report

A five-year-old boy was admitted to the hospital because of high fever and severe dyspnea. On admission, he had pronounced tachycardia and tachypnea. Blood pressure was 120/80 and temperature 39.6°C. No pericardial friction rub was present and a paradoxical pulse was not noted. The ECG showed sporadic extrasystoles and ST-segment elevation in I, aVL, V_2–V_6. Chest X-ray showed an enlarged heart and signs of right pleural effusion. The initial echocardiographic study showed that there was a large pericardial effusion. About 150 ml of thick, purulent fluid was removed by pericardiocentesis. *Hemophilus influenzae* was cultured from pericardial fluid and blood. A second and third pericardiocentesis were performed during the following days. Because of lack of clinical and echocardiographic improvement, an anterior pericardiectomy was performed after one week of medical therapy. At surgery, a thickened pericardium was found, and when it was opened, fibrinous masses up to 2 cm thick were exposed. The postoperative course was uneventful. At discharge 3 weeks later, there were normal physical and echocardiographic findings.

Echocardiographic Findings

All preoperative echocardiographic examinations showed an echo-free space anteriorly and posteriorly (Fig. 2). Left ventricular function parameters at the initial examination gave normal ΔLVID and normal LPEP/LVET while LVET% was decreased to 70 (normal range 92–108). Subsequent serial examinations

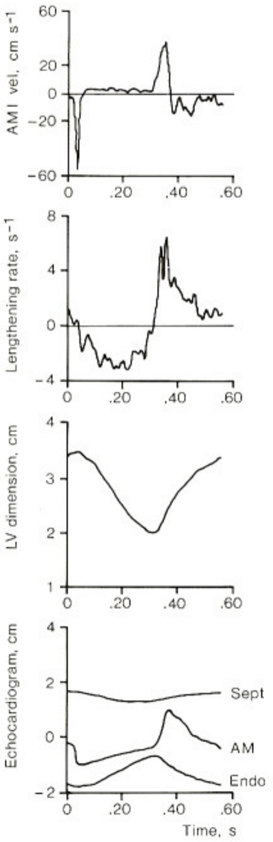

Fig. 1. Computer output of digitized echocardiogram from a healthy child showing, from below, direct printout of echoes, left ventricular *(LV)* instantaneous dimension, normalized lengthening rate, and anterior mitral leaflet instantaneous *(AM I)* velocity (see text).

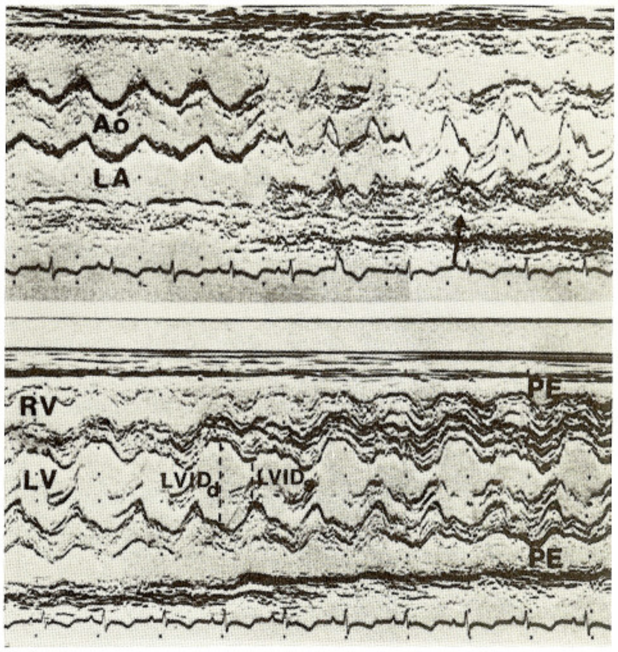

Fig. 2. Echocardiogram, showing a sweep from the aortic root *(Ao)* to the left ventricle *(LV)*. There is anterior and posterior pericardial effusion *(PE)*, and the posterior echo-free space can be seen to end at the level of the left atrium *(LA)*. Measuring sites for left ventricular internal dimensions in systole and diastole *($LVID_s$, $LVID_d$)* are indicated. *RV*, right ventricle.

demonstrated significant changes of LVET% while LPEP/LVET and ΔLVID remained normal.

During the whole preoperative period, excluding the examinations during artificial ventilation, there were marked changes in right ventricular diastolic dimension (RVD) and left ventricular diastolic dimension ($LVID_d$) during inspiration and expiration. RVD increased as much as 8 mm while $LVID_d$ decreased as much as 9 mm on inspiration. These differences were not found when the patient was on artificial ventilation and also disappeared after pericardiectomy (Fig. 3).

Serial values of LVET% and $LVID_d$ are plotted in Fig. 4, with $LVID_d$ measured at expiration. During the first 4 days, the lowest values of LVET% were recorded with the highest amount of pericardial fluid, and both LVET% and $LVID_d$ increased slightly after the first and third pericardiocentesis (the second pericardiocentesis yielded only a small amount of fluid).

Computer analysis of the echocardiograms showed normal peak lengthening and shortening rates for the instantaneous left ventricular dimension and normal early diastolic closure rate of the anterior mitral leaflet both pre- and postoperatively. The computed curve for the left ventricular instantaneous dimension was, however, abnormal, showing a plateau pattern in late diastole instead of the normal slope. This pattern remained after pericardiocentesis but became normal after pericardiectomy (Fig. 5).

Discussion

Echocardiography is an established noninvasive method for detecting pericardial effusion [7, 10]. It has been suggested that echocardiography may provide clues to the presence or absence of tamponade [1, 18, 21], in addition to providing an estimate of the quantity of fluid in the pericardial sac [3].

We found it valuable to study left ventricle function serially by echocardiography, including computer analysis of the echocardiograms. It must be emphasized that the term left ventricular function is used in a broad sense, since the various measurements are influenced by changes in myocardial contractility, preload, and afterload. It has been shown that systolic time intervals are sensitive measurements of left ventricular function [11, 13]: they can be reliably measured by echocardiography from the aortic leaflet echoes [9].

Figure 4 shows that LVET% was depressed in the presence of significant pericardial fluid. LPEP/LVET and ΔLVID remained normal during the study period. Similar findings have been described by Lewis and Gotsman in their study of left ventricular function in constrictive pericarditis [12]. They explained this by stating that LPEP/LVET (and in our study also ΔLVID) are measurements of

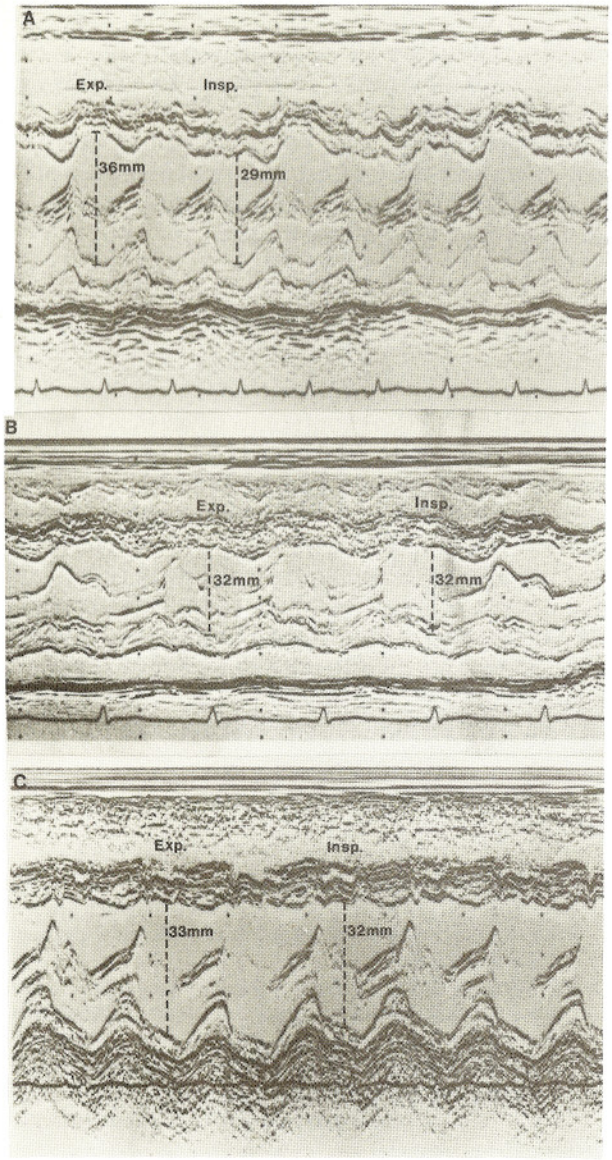

Fig. 3. Echocardiograms showing the left ventricle initially **(A)**, during artificial ventilation **(B)**, and after pericardiectomy **(C)**. In **A** there is marked decrease in left ventricular internal dimension with inspiration while the decrease with inspiration in **B** and **C** is very slight.

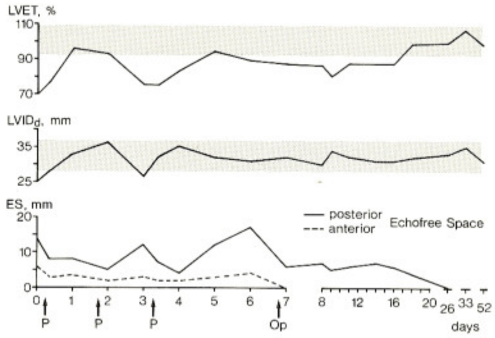

Fig. 4. Serial values of left ventricular ejection time *(LVET)*, left ventricular internal dimension in diastole *($LVID_d$)* and anterior and posterior echo-free space *(ES)*. The posterior *ES* decreases after the first and third pericardiocentesis *(P)* and *$LVID_d$* increases. The initially low *LVET* can also be seen to normalize slowly. *Op*, pericardiectomy.

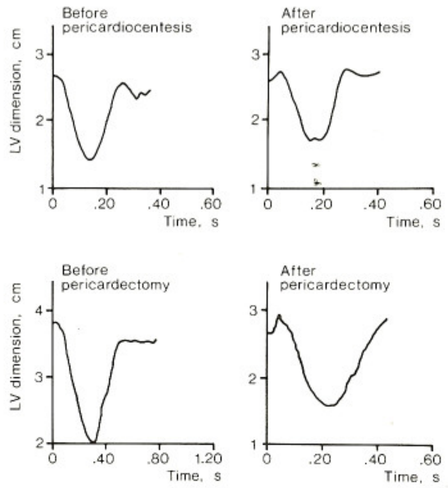

Fig. 5. Computer output of left ventricular instantaneous dimension. Both before and after pericardiocentesis there is an abnormal plateau pattern in late diastole. After pericardiectomy the pattern is normal.

"relative" fiber shortening or lengthening and can be normal despite great reduction in ventricular volumes, while LVET is related to "absolute" fiber shortening and can be abnormal depending on the degree of constriction.

LPEP/LVET has been used to distinguish between restrictive cardiomyopathy and constrictive pericarditis. In constrictive pericarditis LPEP/LVET is normal, as in our patient, while in restrictive cardiomyopathy it is increased [11].

Others have shown that there can be marked respiratory variations in LVET in the presence of cardiac tamponade, presumably reflecting variations in stroke volume [13, 18]. We did not find significant respiratory variations in LVET% in our patient, but the low values recorded initially may indicate a low cardiac output, just as Lewis and Gotsman in their study found that patients with a small stroke index always had a shortened LVET [12].

Settle et al. have pointed out that in patients with cardiac tamponade there is a very marked increase of RVD and decrease of $LVID_d$ during inspiration [18]. This is probably due to the increased right ventricular filling during inspiration, leading to an increase in intrapericardial pressure which impairs left ventricular filling; right ventricular filling does not seem to be impaired by cardiac tamponade [18]. In our patient this pattern of respiratory ventricular dimension changes was very prominent before the pericardiectomy, except when he was studied during artificial ventilation, when RVD and $LVID_d$ remained almost constant during the respiratory cycle. This supports the theory that the changes are due to increased right ventricular filling during inspiration, with secondary impairment of left ventricular filling. When the patient is on artificial respiration the normal pressure changes in the thorax and thus the changes of right ventricular filling with respiration do not take place.

In our patient the variations in RVD and $LVID_d$ disappeared after pericardiectomy. It has been stated that respiratory changes in ventricular dimensions can be normal in children [18], and similar respiratory changes in left ventricular dimension have been found in a normal population between five and 47 years of age [3], the mean inspiratory decrease in $LVID_d$ being 2.9 ± 0.4 mm. The changes in our patient were, however, much more prominent; the disappearance of the pattern after pericardiectomy confirmed that this was indeed an abnormal pattern, indicating impairment of left ventricular filling.

It has been suggested that measurements of cardiac chamber sizes in cardiac tamponade may not be comparable from cycle to cycle if there is gross cardiac displacement within the pericardial sac during cardiac contraction [15]. In our patient, we found no evidence of significant cardiac displacement: the depth of the pericardial effusion behind the heart remained unchanged from beat to beat, indicating that the position of the heart in the pericardial sac did not change.

By computer analysis of echocardiograms, instantaneous velocities for wall and leaflet movements can be calculated and the movement pattern studied in detail. This can be helpful in various forms of heart disease [8]. Normal values for children have already been reported [2]. In our patient, we found normal values for peak normalized shortening and lengthening rate, and normal early diastolic closure rate of the anterior mitral leaflet. The computer analysis of left ventricular instantaneous dimension showed, however, an abnormal pattern, with all the dimension changes taking place during systole and the early part of diastole, while the dimension remained constant during the later part of diastole (Fig. 5). This indicates that left ventricular emptying was essentially normal, while left ventricular filling was normal during early diastole (normal lengthening rate, normal mitral velocity) but impaired during the later part of diastole. The late diastolic plateau pattern of the left ventricular instantaneous dimension curve can be compared with the left ventricular pressure curve in patients with constrictive pericarditis when the diastolic pressure increases to a plateau after the early diastolic dip, indicating restriction to ventricular filling during this period [12].

After pericardiectomy, the pattern of left ventricular dimension changes became normal immediately, as did LVET%, indicating that all the abnormalities have been due to constriction.

Conclusion

In both children [6, 20] and adults [5], purulent pericarditis has been reported to be associated with a high mortality rate. The clinical findings of impeding cardiac tamponade can be difficult to detect, particularly in children. Echocardiography offers a sensitive means of diagnosing pericarditis but is also valuable in following the patients during treatment. Signs of impaired filling of the left ventricle can be detected early. Since the interval between acute pericarditis and the development of constriction may be days, weeks, or even years [17, 19], all such patients should be followed carefully.

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