The incidence and natural history of pericardial effusion after cardiac surgery — an echocardiographic study

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ABSTRACT One hundred twenty-two consecutive patients (104 men; 18 women) were studied to determine the incidence and natural history of pericardial effusion occurring 2, 5, 10, and 20 to 50 days after cardiac surgery. Three patients had pericardial effusions before and 103 patients (91 men; three women) had effusions after surgery. Effusions were first recorded on the second postoperative day in 72 patients, on the fifth postoperative day in 29 patients, and on the tenth postoperative day in two patients. In 96 of these patients, effusions reached their maximum size by postoperative day 10. Of the 103 patients with effusions, 66 (64%) were followed to complete resolution. A specific pattern was observed in most resolving effusions. The echo-free space diagnostic of pericardial effusion became progressively more echo-dense as the effusion diminished in size. As the effusion became echo-dense, the posterior pericardium, which had been motionless, resumed its normal systolic anterior motion.

Pericardial effusion occurs frequently after cardiac surgery, but that associated complications are rare.


ECHOCARDIOGRAPHY is the technique of choice for the diagnosis of pericardial effusion. In 1974, Horowitz et al. correlated the size of pericardial effusions with the degree of separation between epicardium and pericardium. They were able to accurately detect as little as 15 to 20 ml of pericardial fluid. Martin et al. also showed that accurate quantification of pericardial effusion could be derived from M mode echocardiograms. The correlation for moderate-sized effusions was best, while that for small or large effusions was less accurate. Feigenbaum emphasized that lack of side effects and reproducibility of results make echocardiography ideally suited for serial studies. Also, with the development of portable equipment, the bedside evaluation of critically ill patients became possible.

Pericardial effusion is very common after cardiac surgery. Despite the high incidence of effusion, the clinical approach to this problem remains controversial. Prospective studies defining the course and outcome of postoperative pericardial effusion have not been done. Once pericardial effusion is documented, serial echocardiographic studies are frequently performed, at considerable expense. Since the significance of pericardial effusion and, therefore, the frequency and need for repeat studies, has not yet been demonstrated, we have designed a prospective study to investigate the natural history of postoperative pericardial effusion.

Methods

One hundred twenty-two consecutive patients who underwent cardiac surgery at New York University Medical Center during January and February 1983 were studied. There were 104 (85%) men and 18 (15%) women, ranging in age from 20 to 86 years (mean 59 ± 10.3). Operations performed were coronary artery bypass in 98 patients, aortic valve replacement in 13, coronary artery bypass with aortic valve replacement in six, aortic and mitral valve replacement in three, and coronary artery bypass with mitral valve replacement, coronary artery bypass with septal myectomy, Fontan anastomosis, and repair of an atrial septal defect in one each.

M mode echocardiograms were obtained in all patients before surgery, as well as on the second and fifth postoperative days. Studies were performed on postoperative day 10 in 109 patients (88%). Outpatient follow-up studies were performed 20 to 50 days after surgery in 112 patients (90%). A Picker Echoview System 80-C was used for all. All echocardiograms were recorded by two experienced echocardiographers who used standard techniques. On serial studies, an attempt was made to keep patient position and transducer orientation constant to minimize positional variation in effusion size.
Anterior and posterior effusions were measured as the maximal diastolic separation between pericardium and epicardium recorded at the level of the tip of the mitral valve (figure 1). Total effusion (sum of the anterior and posterior) was categorized as small (1 to 9 mm), moderate (10 to 19 mm), or large (20 mm or more). Although the echocardiograms were available to the patients’ physicians, no attempt was made to influence postoperative management.

Results

A total of 601 echocardiograms (122 preoperative and 479 postoperative) were recorded. The recordings were adequate to define the echocardiographic presence or absence of pericardial effusion in all of the preoperative and 98% (468/479) of the postoperative studies. Of the 11 echocardiograms of uninterpretable quality, 10 were recorded on the second postoperative day, and one was recorded on the tenth postoperative day.

Incidence. Pericardial effusions were noted before surgery in four patients (3%) and after surgery in 103 patients (85%). Effusions were present in 91 of 104 men (88%) and 12 of 18 women (67%). The incidence of effusion was unrelated to the type of surgery the patient had undergone or to the operating surgeon.

Pericardial effusion was first recorded on the second postoperative day in 72 patients, on the fifth postoperative day in 29 patients, and on the tenth postoperative day in two patients (table 1). In no case was the effusion first noted after the tenth postoperative day. Table 1 also lists the postoperative days when effusions reached their largest sizes. This occurred on postoperative day 2 in 19%, on postoperative day 5 in 47%, and on postoperative day 10 in 27%. Thus, 93% of effusions peaked by the tenth postoperative day. Only 7% of effusions peaked in size after day 10. The average time from appearance to largest effusion was 5 days.

On postoperative day 2, 97 of 112 echocardiograms (87%) showed a small or no effusion, and no patient had a large effusion (table 2). Of the 40 patients without effusions on postoperative day 2, 24 later developed them. The clinical course in patients developing effusions on postoperative day 5 did not differ from those who developed effusions on day 2.

Sixty-six patients (64% of patients with pericardial effusion) were followed until complete resolution of their effusions. In 36 patients the effusions remained unresolved at the time of their last echocardiograms. Table 3 shows the size of effusions on the day of the last study in these 36 patients. There were small effusions in 20 and moderate effusions in 10 patients. None of these were increasing in size (i.e., larger than on their previous echocardiograms). Six patients had

![FIGURE 1. Method of calculating pericardial effusion. The total effusion is the sum of anterior (ANT. E.) and posterior (POST. E.) effusion. In this example, ANT. E. is 6 mm and POST. E. is 11 mm. The total effusion is 17 mm, which is considered moderate by our criteria.](http://circ.ahajournals.org/)

### TABLE 1

| Postoperative day of appearance and day of largest effusion (n = 103) |
|------------------------|--------|--------|--------|--------|--------|
|                        | Day 2  | Day 5  | Day 10 | Day 20 | Day 30+ |
| Appearance             | 72     | 29     | 2      | 0      | 0      |
| Largest                | 20     | 48     | 28     | 7      | 0      |

*Postoperative day 30 to 50.

### TABLE 2

<table>
<thead>
<tr>
<th>Size of pericardial effusions in 122 patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE size</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>No PE</td>
</tr>
<tr>
<td>Small</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>Large</td>
</tr>
</tbody>
</table>

PE = pericardial effusion.

These results are for all echocardiograms recorded for the study. Not listed are results from 10 studies on postoperative day 2 and from one on postoperative day 10 that were uninterpretable.
Large effusions at the time of the last study (one on day 10; five on day 20) and four of these were still increasing in size. These six patients were not available for further study, but were alive and well when contacted 2 months after surgery.

**Mode of resolution.** When first observed 77/103 (75%) of effusions had the appearance of an echo-free space. The areas of the remaining 26 (25%) were more echo-dense than the left ventricular blood pool, but often less dense than the left ventricular posterior wall. On subsequent studies an additional 45 effusions became echo-dense. The echo-dense quality first appeared in 21 patients on postoperative day 2, in 26 on postoperative day 5, in 12 on postoperative day 10, in seven on postoperative day 20, and in five on postoperative day 30. Care was taken to maintain constant echogenicity of the left ventricular posterior wall on serial studies. Therefore, comparison between its echogenicity and that of the pericardial effusion (both in absolute and relative terms) was accurate. To avoid creating echodensity artificially, gain control settings were similar on sequential studies.

Of the 71 effusions that became echo-dense, 42 were completely resolved by the time of the last echocardiogram, and 29 were diminishing (i.e., smaller than on previous study). Twenty-four effusions resolved without a demonstrated echo-dense transition. Seven effusions were still echo-free on the last echocardiogram.

In all patients with echo-free effusions, the posterior pericardium was motionless. With the development of echo density, the posterior pericardium resumed its normal systolic anterior motion (figure 2).

One patient developed cardiac tamponade (postoperative day 3) that was relieved surgically. Her echocardiogram from day 2 showed a 12 mm (moderate) effusion. One patient died of refractory congestive heart failure on the sixth postoperative day.

**Treatment.** As mentioned before, we made no attempt to influence the postoperative management of these patients. The attending surgeons made the therapeutic decisions based on their own clinical judgment. Nonetheless, we recorded the use of all medications that may have affected the size of pericardial effusion. These included aspirin and nonsteroidal anti-inflammatory drugs and steroids, either alone or in combination. It should be noted that some of these medications were given for reasons other than for the treatment of pericardial effusion. For instance, aspirin was routinely administered to most patients who underwent aortic valve replacement. Of the 103 patients with pericardial effusion, 46 received one of the aforementioned drugs. The duration of administration var-

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**TABLE 3 Patients with unresolved effusions**

<table>
<thead>
<tr>
<th>PE size</th>
<th>Postop. day 10</th>
<th>Day 20</th>
<th>Day 30 + ^</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>1</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Moderate</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Large</td>
<td>1</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

Patients whose effusions were still present on their last study are grouped by effusion size.

PE = pericardial effusion.

^Postoperative day 30 to 50.
TABLE 4
Effects of drug treatment

<table>
<thead>
<tr>
<th>Drug</th>
<th>Total No. of patients</th>
<th>Rx started before PE peaked</th>
<th>Rx started at peak PE</th>
<th>Rx started after PE peaked</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspirin</td>
<td>17</td>
<td>3</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Nonsteroid anti-inflammatory</td>
<td>17</td>
<td>4</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>(Indocin, Motrin)</td>
<td>10</td>
<td>1</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Prednisone</td>
<td>6</td>
<td>0</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Aspirin/nonsteroid anti-inflammatory</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

All values indicate number of patients.
PE = pericardial effusion; RX = drug therapy.

Discussion

M mode echocardiography is accepted as a highly sensitive and specific technique for the detection of pericardial effusion. As pointed out by Feigenbaum,4 proper technique is essential to avoid false-negative and false-positive results. For instance, excessive gain may result in echoes filling in the pericardial space and thus obscuring pericardial fluid. Isolated echo-free anterior spaces may be due to epicardial fat pads rather than effusions. This echocardiographic finding was noted in only one of our patients. Since this finding was not present on the preoperative study, and the size of the echo-free space changed with serial studies, pericardial effusion rather than a false-positive result seemed likely. Other structures, such as the descending aorta and coronary sinus, may also have an appearance on M mode echocardiograms similar to that of a pericardial effusion. Again, with the absence of an echo-free space in the preoperative echocardiogram, and with careful attention to consistency in transducer position and orientation on serial studies, this source of a false-positive result can be confidently disregarded. Barring technical errors, false-positive results are exceptional, as in the unusual case of tumor encasement of the heart.5 Similarly, false-negative results are rare, although M mode echocardiograms may fail to detect localized effusions. Our laboratory recently reported three cases of cardiac tamponade resulting from localized effusion.6 The effusions were seen on two-dimensional but not on M mode recordings. Although the use of two-dimensional echocardiography in this study would have allowed for better visualization of pericardial effusions, we believe that the possible failure to detect a rare case of loculated effusion does not materially affect our results.

A limitation of echocardiography has been the occasional inability to obtain a recording of diagnostic quality. Of the 601 echocardiograms recorded, 11 (2%) were technically inadequate. Almost all were obtained on postoperative day 2, when subcutaneous emphysema, hyperinflation of the chest, and pneumomediastinum presented obstacles to the transmission of sound that is necessary for echocardiograms of diagnostic quality.

Pericardial effusion is common after cardiac surgery. In a study of 40 randomly selected pediatric patients, Clapp et al.7 found a 53% incidence of postoperative pericardial effusion. Nineteen of 21 effusions occurred by day 5. Studies beyond day 10 were not reported; all patients showed resolving effusions on the last day of study.

In our group of 122 patients, 85% developed effusion. We realize that the size of effusion may have no bearing on the clinical course in these patients. A small effusion may cause tamponade and a moderate or large effusion may produce no symptoms and therefore may not be suspected. In fact, many of our patients with significant effusions were discharged 8 to 10 days after surgery. These patients did as well as those without effusions at discharge.

We found that virtually all effusions were present by the fifth postoperative day. Therefore, in a patient without an effusion by day 5, further echocardiograms seem unnecessary unless a new effusion was strongly suspected on clinical grounds.
In patients who did have effusions, the time of resolution varied considerably. Some effusions were present for less than 3 days, and many took a month or more to resolve. Since all but one of these resolved uneventfully, frequent follow-up echocardiograms or extended hospital observation seems unwarranted.

A specific pattern was observed in the resolving effusions. An early effusion was typically echo-free. At about the time the effusion peaked in size, it developed some degree of echo density. As the effusion diminished, it became more echo-dense, and the posterior pericardium resumed its normal systolic anterior motion. This pattern was present in the majority (69%) of patients. Twenty-four effusions resolved without showing this progression, but this may have occurred in the interval between studies. Clearly, alterations in gain control or reject can affect the density of pericardial effusions on echocardiograms. Every effort was made to keep gain control consistent and reject at a minimum. We also compared the density of effusion to those of both the left ventricular posterior wall and the left ventricular blood pool in an attempt to avoid error in differentiating echo-free from echo-dense areas.

Echo density in this setting may well represent organizing tissue or clotted blood. In 1961, Edler first showed that thrombus in vessels and cardiac chambers reflect ultrasonic waves. More recently, Kerber and Payvandi showed that clotted blood in the pericardial space of dogs was echo-reflective as compared with saline or unclootened blood. He postulated that the homogeneous nature of thrombus due to fibrin-liquid interfaces produced the echo-reflective quality. Allen et al., also in 1977, noted in animals the appearance of more intense echoes as pericardial blood clotted.

Recently, Mikell et al. showed that in a ventricular aneurysm or during experimental asystole stagnant blood is more echo-reflective than flowing blood, but less reflective than thrombus. Earlier, Sigel et al. had postulated that physical layering of static blood was responsible for its increased echo density.

Echo-dense effusions have been reported in humans. In a patient with chronic renal failure, D'Cruz et al. noted both echo-dense and echo-free areas on the same M mode sweep. In a study of children, Clapp et al. found that 90% of postoperative effusions became echo-dense. Woolf and Gerwitz reported an echo-dense separation between thickened parietal and visceral pericardium in four patients with purulent pericarditis. At surgery, “fibrous peel and adherent exudative debris” was found. Horowitz et al., in patients with effusive-constrictive pericardial disease, showed echo-dense pericardial spaces that proved to contain coagulated exudate adherent to pericardium.

In our study patients it is unknown whether the dense intrapericardial echoes represented fibrous organization or clotted blood. We have seen two other postoperative patients with similar echocardiographic findings who had pericardial clots at autopsy. They died 7 and 14 days after surgery.

Only one of our study patients developed cardiac tamponade (day 3). There were no instances of late (greater than 7 days) tamponade. Others have reported a 0.1% to 6% incidence of late cardiac tamponade. Of note is that their patients routinely received anticoagulants.

This study did not attempt to define the efficacy of treatment for postoperative pericardial effusion. Although we noted no difference in treated versus untreated patients, this problem was not approached systematically. Different drugs were used for varying periods, and were used to treat different clinical problems. Before the exact effect with the various drugs can be established, a detailed, prospective, randomized study needs to be undertaken.

In summary, we have found that pericardial effusion after cardiac surgery is extremely common, but that associated complications are rare. By 30 days after surgery, most effusions are nearly or completely resolved. We conclude that prolonged hospital stays or the performance of serial echocardiograms for clinically uncomplicated pericardial effusion is both costly and unnecessary and should be avoided.

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