Clinical, Microbiologic and Therapeutic Aspects of Purulent Pericarditis

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Twenty-six patients with purulent pericarditis were seen at the Massachusetts General Hospital between 1960 and 1974. The diagnosis was made in 16 of them during life, but only 6 survived, with an over-all mortality rate of 77 per cent. In eight patients, purulent pericarditis developed in the early postoperative period after thoracic surgery. In seven, purulent pericarditis was the result of contiguous spread of infection from a pleural, mediastinal or pulmonary focus in nonsurgical patients. In five patients, it was the result of direct spread to the pericardium from an intracardiac infection. In the remaining six patients, purulent pericarditis developed as the result of a systemic bacteremia. Immunosuppressive therapy, extensive thermal burns, lymphoproliferative disease and other systemic processes affecting host resistance were present in at least half the patients. Staphylococcus aureus was the etiologic agent in the largest number of patients (6 of 26 in this report). However, in contrast to previous studies, in a significant number of the patients (five), purulent pericarditis was the result of fungal infection (in three patients subjected to thoracic surgery and in two immunosuppressed patients).

This report confirms that purulent pericarditis is an acute disease with a fulminant course. The diagnosis is easily missed since classic signs of pericarditis (including chest pain, friction rub and diagnostic electrocardiographic abnormalities) may be absent. The echocardiogram shows considerable promise in allowing earlier diagnosis of the pericardial effusion which accompanies purulent pericarditis. Optimal therapy consists of prolonged antibiotic therapy and aggressive drainage of the pericardium. In this series, there were 6 survivors among the 11 patients (55 per cent) who received appropriate therapy.

Although purulent pericarditis has been recognized since Galen's day [1], the nature of the disease has changed—changed even from that described in Boyle, Pearce and Guze's classic review in 1961 [2]. These investigators documented the overwhelming importance of pleuropulmonary disease and uncontrolled gram-positive cocci infection—that due to Staphylococcus aureus, Streptococcus pneumoniae and Streptococcus pyogenes—in the pathogenesis of suppurative infection of the pericardium in the preantibiotic and early antibiotic eras. Even in their series, however, several trends were noted: a marked decrease in the incidence of concomitant pleuropulmonary infection; a fall-off in the occurrence of...
pneumococcal disease; an increase in the incidence of hospital-acquired, antibiotic-resistant infection; and an increase in the number of cases in elderly patients and in patients with complicating systemic illnesses. In the years since then, these trends have continued, and today purulent pericarditis is more commonly a disease of the debilitated patient with impaired host defenses; of the patient who has undergone extensive thoracic and/or cardiac surgery; of the patient with preexisting, nonpyogenic inflammatory disease of the pericardium; and of the patient with uncontrolled myocardial and/or endocardial infection. In addition, more traditional forms of the disease still occur. Two aspects of purulent pericarditis that have not changed since Galen's day are the insidiously subtle presentation it may have, and the large per cent of cases that go undiagnosed until postmortem examination.

Our purpose is to review the experience with this disease at the Massachusetts General Hospital during the period 1960 to 1974, emphasizing the following points: the clinical and epidemiologic settings within which purulent pericarditis now occurs, the microbiologic culprits of the disease today, the pathogenetic mechanisms by which the disease is produced, and modern methods of diagnosis and therapy. It is hoped that such information will provide a basis for a more effective attack on this ancient problem.

MATERIALS AND METHODS

The records of all patients with purulent infection of the pericardium seen at the Massachusetts General Hospital from July 1, 1960, to June 30, 1974, were reviewed, and form the basis for this study. Four of the patients have been the subjects of separate reports [3–6]. All patients included in this study fulfilled at least two of the three following criteria: (1) The demonstration of gross or microscopic evidence of an acute pericarditis with a predominance of polymorphonuclear leukocytes in the inflammatory infiltrate in material obtained at autopsy or surgery; or the demonstration of purulent fluid (more than 30,000 white blood cells/mm³ with more than 90 per cent polymorphonuclear leukocytes) at pericardiocentesis. (2) The demonstration of bacteria or fungi on gram stain of pericardial fluid. (3) The isolation of a bacterium (other than Mycobacterium tuberculosis) or fungus from cultures of pericardial tissue or fluid, or from cultures of immediately contiguous structures and/or blood.

Excluded from the series were patients who had a variety of infections and evidence of pericardial effusions by either echocardiogram, roentgenogram, radioisotope scan or electrocardiogram, but who recovered without precise definition of the pericardial process.

Specimens for culture were inoculated on Brucella agar plates containing 5 per cent horse blood, McConkey agar and thioglycollate broth, and were incubated at 37°C in air enriched with 5 per cent carbon dioxide. During the last 5 years covered by this report, primary anaerobic cultures were usually performed as well. In selected patients, Sabouraud's medium was used for fungal isolation.

The patients with purulent pericarditis have been grouped according to the portal of infection and whether the disease occurred as a result of a surgically-induced infection or was acquired de novo as part of a "medical" illness. Group I: Patients with contiguous spread from a postoperative infection. Group II: Nonsurgical patients with contiguous spread from a pleural, mediastinal or pulmonary focus. Group III: Nonsurgical patients with contiguous spread from intracardiac infections. Group IV: Nonsurgical patients with noncontiguous spread during systemic bacteremia.

RESULTS

Twenty-six patients with purulent pericarditis were identified during the 14 years of this study. Twenty of these patients died, for an over-all mortality of 77 per cent. The diagnosis of purulent pericarditis was made during life in 18 of the 26 (69 per cent) and at autopsy in the remainder. No particular age group had a preponderance of cases (Figure 1). Fifteen of the 26 patients were male.

Predisposing Conditions. Table I delineates the clinical settings in which purulent pericarditis occurred. In eight patients (group I), the disease developed in the early postoperative period (1 to 3 weeks after thoracic surgery). In two, transthoracic esophageal surgery was associated with esophageal perforation and contiguous spread of infection from the mediastinum to the pericardium; in the remaining six, open heart surgery was complicated by extensive sternal wound infection, sternal osteomyelitis, mediastinitis and, again, contiguous spread to the pericardium. In seven patients (group II), the disease developed in association with primary pleural, mediastinal and/or pulmonary infection. Four of these patients had left-sided pneumonia and empyema (two of these had bilateral pneumonias and empyemas); two had pneumonia in the lower lobe of the left lung without accompanying pleural space involvement. The pulmonary infection was believed to be the primary event in these six patients, with contiguous spread occurring to the adjacent pleural and/or pericardial spaces. In the remaining patient, a patient with 50 per cent third degree total body burns and persistent Salmonella bacteremia, purulent pericarditis was secondary to contiguous spread from a mediastinal abscess that had developed. In five patients (group III), it was a complication of intracardiac infection; as a result of contiguous spread from infected heart valves (two aortic and one mitral) in three and as a result of contiguous spread from a myocardial abscess in two. Six patients (group IV) had purulent pericarditis as a result of a systemic bacteremia.
Two of the six patients with pleuropulmonary infection (group II) and four of the six with bacteremia (group IV) survived. None of the patients in groups I (postsurgical) and III (intracardiac infection) survived; the development of purulent pericarditis represented the final coup-de-grace in a desperately ill group of patients.

Associated systemic diseases that may have impaired host resistance were present in 12 patients (hepatic failure in 2, uremia in 1, diabetes mellitus in 3, leukopenia in 1, extensive third degree burns in 2, acute lymphoblastic leukemia in 1 and large dose corticosteroid and azathioprine therapy in 2). Two patients with preexisting nonsuppurative pericarditis had a secondary infection from a transient bacteremia originating from an extrathoracic site. One of these patients had bacteremia due to Klebsiella pneumoniae from a site of acute pyelonephritis, with the development of a Klebsiella pericarditis superimposed on preexisting uremic pericarditis. The other patient had idiopathic (presumably viral) pericarditis for 3 weeks [4] with partial recovery before the development of an acute decompensation due to Bacteroides species superinfection of the pericardial space.

**Microbiology.** A wide variety of organisms caused purulent pericarditis in these patients (Table II). The most common were Staph. aureus (eight patients); fungi (five patients; due to Candida species infection in three, to Aspergillus species in one, and to both Aspergillus and Candida species in one); Strep. pneumoniae (two patients) and H. influenzae (two patients). Purulent pericarditis due to staphylococci occurred after cardiac surgery in three patients (group I), after intracardiac infection in three patients (group III) (resulting from acute bacterial endocarditis of the aortic valve in two and from a myocardial abscess in one patient with staphylococcal bacteremia), was secondary to pneumonia in one (group II) and due to bacteremia in one. Purulent pericarditis due to fungi occurred postoperatively in three patients (after cardiac surgery in two and after esophageal surgery in one), and after pulmonary infection in two immunosuppressed patients (one had leukemia and one was receiving large doses of corticosteroid). Both patients with purulent pericarditis due to pneumococci had pneumonia and empyema. Meningitis with septicemia preceded the onset of pericarditis in both cases due to H. influenzae.

Relatively unusual organisms causing single cases of purulent pericarditis included the following: Salmonella typhimurium in the previously described burn patient with mediastinal infection and persistent bac-

**TABLE I** Classification of the 26 Patients with Purulent Pericarditis According to Route of Infection, Clinical Setting and Outcome

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
<th>No. of Patients</th>
<th>Survived</th>
<th>Died</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Patients with contiguous spread from a postsurgical infection</td>
<td></td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>II</td>
<td>Nonsurgical patients with contiguous spread from a pleural, mediastinal or pulmonary focus</td>
<td></td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>III</td>
<td>Nonsurgical patients with contiguous spread from intracardiac infections</td>
<td></td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>IV</td>
<td>Nonsurgical patients with noncontiguous spread to the pericardium during systemic bacteremia</td>
<td></td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>
TABLE III Clinical Manifestations in 26 Patients with Purulent Pericarditis

<table>
<thead>
<tr>
<th>Manifestations</th>
<th>Per cent of Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symptoms</td>
<td></td>
</tr>
<tr>
<td>Fever</td>
<td>100</td>
</tr>
<tr>
<td>Chills</td>
<td>62</td>
</tr>
<tr>
<td>Night sweats</td>
<td>62</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>54</td>
</tr>
<tr>
<td>Cough</td>
<td>42</td>
</tr>
<tr>
<td>Chest pain*</td>
<td>27</td>
</tr>
<tr>
<td>Signs</td>
<td></td>
</tr>
<tr>
<td>Tachycardia</td>
<td>100</td>
</tr>
<tr>
<td>(pulse rate greater than 100/ min)</td>
<td></td>
</tr>
<tr>
<td>Friction rubs†</td>
<td>46</td>
</tr>
<tr>
<td>Hypotension and/or pulse pressure less than 25 mm Hg</td>
<td>42</td>
</tr>
<tr>
<td>Pulsus paradoxus more than 10 mm Hg</td>
<td>38</td>
</tr>
<tr>
<td>Elevated central venous pressure (more than 10 cm H₂O)</td>
<td>31</td>
</tr>
<tr>
<td>Hepatomegaly</td>
<td>15</td>
</tr>
</tbody>
</table>

*Seven patients had chest pain; it was pleuritic in four, precordial and nonpleuritic in two and both pleuritic and precordial in one.
†Twelve patients had a friction rub; it was pericardial in origin in nine, pleural in two, both pericardial and pleural in one.
tery compromise did not develop had only minimal, microscopic changes at autopsy, and the pericarditis was not an important part of the clinical course.

In group III patients (intracardiac infection) the major manifestations were those of the underlying infections, acute bacterial endocarditis in three patients and myocardial abscess secondary to a bacteremia in two. However, the sudden circulatory decompensation that led to death in all five of these patients included spread of infection into the pericardium with resulting hemodynamic embarrassment. All patients were receiving appropriate antimicrobial therapy for their infections, and none would surgery have been likely to alter the outcome; in all instances, spread of infection within the myocardium, as well as within the pericardium, would have made those patients inoparable.

In group IV patients (systemic bacteremia) fever, chills and tachycardia of sudden onset with subsequent development of hemodynamic embarrassment was the typical presentation. The duration of illness from onset to either death or recognition and therapy was less than 5 days in all cases. Five of these six patients had evidence of impaired venous return; four of them manifested significant pulsus paradoxus. The one patient without circulatory manifestations, and the only one in this group who died before a diagnosis was made, was a 17 year old boy with acute meningococcemia of less than 16 hours duration who only had microscopic evidence of disease (plus positive cultures) at postmortem. Despite the predominance of cardiac findings in these patients, friction rubs were present in only one of the group IV patients, being found predominantly in group I and group II patients.

**Laboratory Findings.** The presence of significant acute inflammation was reflected in the white blood cell counts of virtually all the patients, white blood cell counts of more than 12,000/mm³ (with 20 of the 26 patients having white blood cell counts of more than 17,000/mm³) and marked shifts to the left in the polymorphonuclear leukocyte population being present in all but 3 patients. The three exceptions included one patient with leukemia, one renal transplant patient who was receiving large doses of corticosteroids and azathioprine, and one patient with underlying neutropenia of unknown etiology—all adequate reasons for lack of a leukocytosis. Moderate anemia (hematocrit values between 30 and 35 per cent) was present in 15 of the patients (58 per cent), but other blood tests were less helpful, with only minimal abnormalities of liver function and cardiac muscle enzymes being noted.

Chest roentgenograms were performed in 25 of the 26 patients. Twenty-four of these showed abnormalities (increased heart size in 19 (76 per cent), pneumonia in 12 (48 per cent), pleural effusion in 8 (32 per cent) and mediastinal widening in 3 (12 per cent). In the majority of instances, the roentgenogram suggested the pathologic process (such as pneumonia, empyema or mediastinitis) accompanying the purulent pericarditis without giving clear-cut evidence of pericardial disease. In 11 instances, the finding of progressive enlargement of the cardiac silhouette with a "waterbottle-like" configuration in the absence of pulmonary vascular congestion was highly suggestive of significant pericardial fluid accumulation. Three echocardiograms were carried out, and all three were positive, including two in patients in whom neither the chest roentgenogram nor electrocardiogram was particularly helpful. A right heart catheterization was carried out in one patient, revealing the elevated central venous pressure, poor cardiac pulsations, typical pressure tracing and increased thickness between right atrial endocardium and pericardial border that are characteristically found in patients with cardiac tamponade.

Electrocardiograms were obtained in 23 patients. The tracings were normal or showed no changes from a previous electrocardiogram in eight patients, and were abnormal in 15. Nonspecific S-T and T wave changes were noted in seven patients and were the most common findings. More classic abnormalities associated with pericarditis, including diffuse S-T wave elevation (five patients) and diffuse T wave inversion (three patients, one of whom also demonstrated low QRS voltage and electrical alternans), were seen in the other eight patients. Arrhythmias that could be ascribed to the pericarditis and not to digitalis, electrolyte disturbances, hypoxia, acid-base disturbances, myocardial abscesses and the like were distinctly unusual.

Detailed analyses were carried out on pericardial fluid obtained from five patients. The white blood cell counts of the fluid ranged from 6,100 to 241,000/mm³, being greater than 50,000/mm³ in four of the five. Differential counts revealed more than 90 per cent polymorphonuclear leukocytes in all instances. Sugar levels were less than 35 mg/100 ml in all but one patient, and the protein level ranged from 3.3 to 6.2 g/100 ml (mean 4.7 g/100 ml). In one patient, a patient with pleuropulmonary disease, fluid was relatively clear, the white blood cell count was only 6,100/mm³ (94 per cent polymorphonuclear leukocytes), the sugar level was 79 mg/100 ml and the protein level was 4.2 g/100 ml, but gram-positive cocci were seen on gram stain and Staph. aureus grew on culture. All the other patients had low sugar levels and higher white blood cell counts. Pericardial fluid lactic dehydrogenase values were determined in two patients and were 4,800 and 6,700 units/ml, respectively (normal values are 60 to 120 units/ml).
Therapy and Complications. Eleven patients received treatment consisting of more than 2 days of appropriate antibiotics and at least one pericardiocentesis. Six of these survived, for a mortality rate of 44 per cent in those in whom adequate therapy was instituted. Two of the survivors were treated only with pericardiocentesis plus antibiotics. The four others required thoracotomy and at least partial pericardietomy in addition to this. In two of these, the indication for surgery was repeated reaccumulation of fluid: in two, acute pericardial constriction developed 1 and 3 weeks, respectively, after therapy had been instituted. In one of these, a large epicardial abscess was found and drained at the time of surgery. Antimicrobial therapy was continued for 4 to 6 weeks in all survivors.

Of the remaining 15 patients, the correct diagnosis was made during life in 7 and at autopsy in 8. The seven diagnosed but inadequately treated patients included two from group I (postsurgical) and five from group III (intracardiac infection). All of these, in addition to six of the eight in whom the diagnosis was made at autopsy, had received at least 10 days of appropriate antibiotic therapy without pericardial drainage before they died.

COMMENTS

The microbiologic, clinical and therapeutic features of purulent pericarditis have changed dramatically over the past decade. Previously, it was a disease of children and young adults [2]; today, it is found equally in all age groups. Previously pleuropulmonary disease was the cause of approximately 50 per cent of the cases [2]; today, less than 25 per cent occur in this setting. Once Staph. aureus and Strep. pneumoniae accounted for at least half of all cases [2]; today, fungi, gram-negative bacilli and associated unusual pathogens are the cause of many cases. Once primary infection in healthy patients was the rule: today, major thoracic and cardiac surgery, immunosuppressive therapy, extensive thermal burns, lymphoproliferative diseases and other systemic processes are the substrata within which this disease occurs. The major area in which there has been no change, however, is in the unacceptably high mortality rate. In view of this a reexamination of the pathogenesis, clinical presentations, etiologies, and the diagnostic and therapeutic approaches available appears to be in order.

Pathogenesis. The pathogenesis of purulent pericarditis has been best worked out in those cases accompanying intrathoracic disease and occurring by contiguous spread of infection. The first lesion observed is a local area of acute inflammation of the parietal pericardium adjacent to the site of contiguous infection. Next there is an accumulation of fluid, which is at first clear, then contains organisms. has fibrin deposition and only later becomes grossly purulent [2,7]. In this series, four of the five patients who underwent detailed pericardial fluid examination had the "late picture" of gross purulence, high white blood cell count and low sugar content. However, in one patient with purulent pericarditis accompanying Staph. aureus bronchopneumonia, there was a relatively low white blood cell count in the pericardial fluid and a normal sugar content. When comparing this last patient with the other four, it is apparent that this patient had had an acute staphylococcal infection for less than 36 hours, whereas the others had been sick for more than 4 days. It is believed that these findings correspond to a very early stage in the pathogenetic series of events.

Direct extension from the pleural space or lung accounts for the majority of cases of pericarditis accompanying thoracic infections, but the observation that right-sided pneumonia or empyema may accompany purulent pericarditis has suggested that other mechanisms may be at work [2,7–13]. Although systemic bacteremia may well be the final common denominator, Hahn et al. [11] and others [12] have suggested that microscopic septic emboli from a pulmonary focus of suppuration may go directly to the pericardium, myocardium or mediastinum via the bronchial arteries, without involving the rest of the systemic circulation.

Clinical Setting and Presentation. Purulent pericarditis is a disease that almost always occurs as a complication of another illness [2,14,15], be it surgical wound infection, intrathoracic infection or bacteremia. In all instances that we have observed, it is an acute progressive, septic process of less than 6 days' duration that requires prompt and aggressive attention. Early recognition and effective therapy of pericardial disease is impossible unless the physician is alert to the disease settings in which spread of the infection to the pericardium may take place.

Pericardial disease occurring in the postoperative patient (group I) in this series did not ever present as an isolated phenomenon, but rather as part of gross intrathoracic infection in patients with sternal wound infection or mediastinal abscess. Aggressive surgical drainage plus prolonged antibiotic therapy may be successful even in this group of desperately ill patients [16]. In patients who have undergone esophageal surgery, recognition that pericardial involvement can occur via esophageal perforation and mediastinal contamination should prompt the attending physician to look closely for the clinical and laboratory correlates of pericardial disease, particularly in the presence of circulatory compromise and a febrile postoperative course.

Purulent pericarditis secondary to intracardiac in-
fection (group III) is likewise difficult to treat. Ideal therapy is eradication of cardiac infection before spread to the pericardium rather than after. Evidence of pericarditis has been noted in 13.2 per cent of patients with bacterial endocarditis examined at necropsy [17]. Myocardial abscesses have been found at autopsy in about 20 per cent of patients with endocarditis, and in a small percentage of patients with bacteremia [18,19]. The risk of development of both myocardial abscesses and purulent pericarditis appears to be especially high in patients with endocarditis due to Staph. aureus. In one recent report [20] of autopsies, in 39 patients who died with Staph. au-
reus endocarditis, 36 per cent had myocardial ab-
scesses and 10 per cent had purulent pericarditis. In bacterial endocarditis, myocardial abscesses may develop as localized lesions secondary to the sys-
temic bacteremia or from direct extension from the infected valvular vegetation [19,21,22]. They are difficult to detect clinically. Their presence should be sus-
pected under the following circumstances: continuing evidence of infection in patients with bacterial endocarditis receiving effective antibiotic chemother-
apy [18,19], particular electocardiographic abnor-
malities [18,23] and circulatory compromise not ex-
plainable by valvular dysfunction alone. Infection spreading from aortic valve vegetations into the ad-
joining high septal tissue may be associated with the following electocardiographic findings: a prolonged P-R interval, atrioventricular dissociation, left bundle branch block and multifocal ventricular ectopic beats [23]. In mitral valve infection, accelerated junctional rhythms and Wenckebach type block may occur because of the close relation of the mitral valve and junctional tissue. Unfortunately, isolated, scattered myocardial abscesses are often silent until after irre-
versible spread to adjoining tissues has occurred. Several workers [24,25] have stressed the impor-
tance of erosion of the aortic valve annulus due to in-
fected bacteremia [26,27]. This possibility was first suggested by Solomon et al. [35], who cul-
tured streptococci at postmortem examination from the pericardium of four patients with uremic pericarditis, pointing out that this is relatively common in patients with Staph. aureus infection but quite rare in those with Strep. viridans infection.

Group II (pleuropulmonary) and group IV (bactero-
mic) patients are worthy of the most attention since they are the most likely to survive. In this series, 6 of the 12 patients in these two groups survived (mortal-
ity 50 per cent). It is in these patients that circulatory measurements and close observation for evidence of cardiac tamponade can be most helpful. Ten of these 12 patients manifested such abnormalities. On the other hand, chest pain and pericardial friction rubs were seen only infrequently in this group. The lack of chest pain is not surprising since the visceral and inner surface of the parietal pericardium are insensitive to pain [26]. Accordingly, ancillary diag-
nostic clues must be sought. These include the fol-
lowing: (1) Echocardiography may be the most help-
ful noninvasive technic available. It provides a very sensitive indicator of a pericardial fluid collection and distinguishes clearly pericardial fluid from enlarge-
ment of the cardiac silhouette due to tumor or cham-
ber dilatation [27-32]. (2) Electrocardiographic ab-
normalities, especially in patients without known coro-
mary artery disease, can be useful. However, a di-
agnostic pattern [33] is relatively uncommon and was present in only 8 of 23 patients in this series. (3) Enlargement or change in configuration of the car-
diac silhouette in the absence of pulmonary vascular engorgement on chest roentgenogram may provide evidence of pericardial effusion, although this is rela-
tively nonspecific. (4) Cardiac catheterization is the traditional definitive but highly invasive technic that can be used in making the diagnosis prior to surgical intervention.

In this series, associated systemic diseases that interfered with host defense against infection were present in at least 50 per cent of the patients. Of particular interest were two patients with extensive third degree burns who died with purulent pericarditis: one of contiguous spread from a mediastinal site in the setting of a persistont gram negativo bacteremias, and one from bacteremic spread to the myocardium and pericardium. A recent review from the U.S. Army Institute of Surgical Research has documented the importance of suppurative infections of the heart in burn victims, reporting 64 cases over a 17 year peri-

Two of the patients in this series had preceding nonsuppurative pericardial disease. This possibil-
ity was first suggested by Solomon et al. [35], who cul-
tured streptococci at postmortem examination from the pericardium of four patients with uremic pericarditis. Others [36-38], reviewing the data in patients with uremic and viral pericarditis, were unable to confirm this association. However, two of our pa-
tients, in whom bacterial pericarditis appeared to have complicated preexisting nonsuppurative pericarditis, reopen this question. At the least, the diag-

nosis of bacterial superinfection should be consid-
ered and pursued aggressively in any patients with preceding nonsuppurative pericardial disease who suddenly show signs of unexplained infection, espe-
cially when there is evidence of circulatory impair-
ment [4].

A variety of unusual conditions have been reported to lead to purulent pericarditis, although they were not seen in this series; bacteremic seeding of a site of myocardial infarction with subsequent spread to
the adjacent pericardium [39–41], contiguous spread through the diaphragm due to a congenital abnormality or catastrophic rupture through the diaphragm (perforated ulcer [42], infected choledochal cyst [43], a pericardioperitoneal communication in a patient with peritonitis [44], subphrenic abscess [45], etc.), contiguous spread from a retropharyngeal abscess to the mediastinum and pericardium [8] and, finally, penetrating wounds [42,46]. Fortunately, these are rare occurrences.

The pediatric population merits special attention when considering purulent pericarditis, because suppurrative disease ranks second only to rheumatic fever among the causes of pericarditis in this age group [15,47]. In this subset of patients, bacteremia and pleuropulmonary infection are the major etiologic considerations, with Staph. aureus, Strep. pneumoniae, H. influenzae and N. meningitidis being the most common organisms [15,47–50]. The major diagnostic problem is to distinguish pericardial fluid collections from acute dilatation of the heart secondary to myocarditis and heart failure [3,48,49]. Friction rubs are present in only 15 per cent of pediatric patients with purulent pericarditis [15], electrocardiographic abnormalities seen with pericarditis are difficult to distinguish from those due to myocarditis [3,15,32,47], and, especially in infants with respiratory distress, measurements of pulsus paradoxus are often inaccurate [3]. The echocardiogram can be most useful here, and is perhaps the greatest single advance in the early diagnosis of purulent pericarditis in this age group [32].

Microbiology. Staph. aureus remains the most frequent cause of purulent pericarditis. In this series, infections in 8 of 26 patients were due to Staph. aureus. Three of these represented hospital-acquired infection, one a nosocomial pneumonia and two related to contaminated intravenous lines and bacteremia. Since 1935, at least 15 per cent of cases of staphylococcal pericarditis have been hospital-acquired [2]. Boyle’s report [2] and our experience would suggest that hospital-acquired disease is even more important today. Complications, particularly acute constriction [2,47,48,51–53], associated mycotic aneurysms of the proximal aorta [54] and systemic bacteremia with metastatic infection, are quite prevalent in staphylococcal pericardial disease. Because of the dangers of acute cardiac tamponade or constriction, circulatory status of patients with staphylococcal pericarditis should be closely monitored to assess the possible need for thoracotomy and pericardiectomy [2,47,48,51–53].

Kauffman et al. [10] recently described five patients with pneumococcal pericarditis, reminding us that this disease has not become extinct. These investigators made the following important clinical observations: (1) Pericardial friction rubs, pulsus paradoxus and an enlarged cardiac silhouette may be absent in this form of the disease despite circulatory embarrassment. (2) A preceding pneumonia was present in 93.1 per cent of 113 patients described in the medical literature, and in 66.6 per cent both pneumonia and empyema were present. (3) In most circumstances, pericardial involvement occurs as a late event in patients, such as alcoholics, in whom there is a long delay between onset of pneumonia and initiation of penicillin therapy. Among the cases recorded since 1945, this delay in obtaining therapy averaged 21 days [10,55–58]. Both of our patients with pneumococcal pericarditis had pneumonia and empyema, both had been ill and presumably had pneumonia for some days prior to their admission to the hospital (one was an alcoholic who had been on a binge and one was an elderly resident in a nursing home); both lacked friction rubs, although other evidence of pericardial disease was present.

In 1950, Zimmerman [59] predicted an increase in the incidence of infection due to fungi because of the wide use of antimicrobial and cytotoxic agents. At the time of Boyle’s review article [2] (all cases reported up through 1957), no case of Candida or Aspergillus infection had been described. Since then a variety of single case reports of Aspergillus pericarditis have appeared [60], but the finding in this series of five cases of fungal pericarditis is the first major confirmation of Zimmerman’s prediction as far as pericardial infection is concerned. In this series all the patients with fungal pericarditis had received broad-spectrum antimicrobial therapy. Three had underlying diseases or were receiving drugs that rendered them immunosuppressed, and two had recently undergone major surgical procedures. A closely related case was that due to Nocardia asteroids in a renal transplant patient who was receiving corticosteroids, azathioprine and broad-spectrum antibiotics. Other cases due to Nocardia have been reported [61,62] and, like the true fungal cases, carry a mortality rate approaching 100 per cent.

H. influenzae infection was documented in two patients: one a 26 year old healthy adult with a probable H. influenzae infection of the upper respiratory tract complicated by bacteremia that infected the pericardium; and one a 14 month old child with bacteremia and meningitis. H. influenzae pericarditis has not been uncommon in the pediatric population, particularly in the age group under 5 [3,15,47–49]. Usually these patients had a history of acute respiratory disease (laryngitis or pneumonia); meningitis was frequently present; and in only one did pericarditis occur without evidence of infection elsewhere [63–66]. All but three of the previously described patients with H. influenzae pericarditis have been less than 12 years old.
of age [66,67]. Crossley et al. [66] surveyed this subject in detail and pointed out that there may be an increasing incidence of H. influenzae type b disease in adults, not only of the pericardium, but also of the lungs, epiglottis, joints and meninges. This perhaps reflects a decrease in the prevalence of bactericidal antibody against type b H. influenzae in the adult population [68-71].

There have been a large number of reports [72-88] of pericarditis associated with meningococcal disease, and there has been some confusion as to when in the course of meningococcal infection the pericardium becomes infected and whether or not immunologic mechanisms may play a role [87,88]. Our single case of meningococcal disease demonstrates that the pericardium may become infected very early in the bacteremic process. Others [83-86] have pointed out that meningococcal pericarditis may occur without evidence of meningococcal disease elsewhere, presumably due to a transient bacteremia that had no other clinical effects. In addition, in several recent reports [87,88], it has been suggested that late pericarditis may commonly occur in the convalescent stage of meningococcal disease. This seems to represent a hypersensitivity phenomenon, does not require antimicrobial therapy, and usually responds to salicylate and/or corticosteroid therapy.

A wide variety of miscellaneous causes of purulent pericarditis were noted in this series and others that have been reported in the literature: Clostridium species [89], Salmonella species [41,90-92], a variety of other gram-negative enteric bacilli [2], P. tularensis [2], H. pertussis [93], N. gonorrhoeae [2,94], mixed cases of granulomatous (either tuberculosis or actinomycotic) and pyogenic infection [2], Vibrio fetus [95], Listeria monocytogenes [96] and others [2]. One of the more interesting single cases in this series was that due to Strep. mitis. In this patient, Strep. mitis infection of the aortic valve spread to the aortic root and then to the pericardium. Strep. mitis is a "viridans" Streptococcus, usually causing a subacute form of disease [97]. In our patient, however, an acute bacterial endocarditis was caused, analogous to that usually associated with Staph. aureus infection. This is an example of the point emphasized by Weinstein et al. [18] in their recent review of bacterial endocarditis—the differentiation of acute and subacute disease is a clinical one based not on the organism, but rather on the pace of the infection and the virulence of the etiologic agent.

Since such a large variety of organisms can potentially cause purulent pericarditis, and since obtaining material for culture requires invasive technics, it is essential that appropriate culture media and methods be employed from the beginning. Pericardial fluid should routinely be cultured for aerobic and anaerobic bacterial pathogens, as well as for acid-fast bacilli and fungi.

**Treatment.** As with any localized form of infection, the therapy of purulent pericarditis requires adequate drainage and appropriate antimicrobial therapy. Some workers have advocated the use of repeated pericardiocenteses for drainage [98], and this was successful in two of our six patients who survived, in association with 4 to 6 weeks of antimicrobial therapy. However, recurrences of effusions are the rule and multiple pericardial aspirations may be hazardous [99], so we, and others [10,48,56] have quickly resorted to open drainage if one or two pericardiocenteses are not successful in controlling fluid accumulation. Acute pericardial constriction also demands prompt surgical intervention. Whether pericardiectomy or just a pericardial window will be necessary is dependent upon what is found at operation: adherent, thickened pericardium with or without thick pus requires pericardiectomy; whereas thinner fluid, with acutely rather than chronically inflamed pericardium, may be treated with a pericardial window. Both the transthoracic and the subxiphoid approach have been utilized for pericardial windows [100,101]. The latter has the advantage that it does not require violation of the pleural space.

Antimicrobial therapy is the basis of the medical management. A variety of reports of intrapericardial instillation of antibiotics in such patients have appeared [2,6,102,103], but a recent study by Tan et al. [104] showing excellent penetration of antimicrobial agents into pericardial fluid suggest that this is not necessary. In our limited experience, prompt drainage and adequate drug therapy prevented the occurrence of chronic constrictive pericarditis, a complication noted in the past in some patients with purulent pericarditis.

**REFERENCES**

7. Still GF: Observations on suppurative pericarditis in chil-


