Factors in the Etiology of Constrictive Pericarditis

By Ralph A. Deterling, Jr., M.D. and George H. Humphreys, II, M.D.

Because of uncertainty existing in respect to the etiologic factors in certain cases of constrictive pericarditis, an analysis of 25 proven cases and of additional series from the literature was conducted. It was evident that a fairly consistent clinical syndrome developed, but the factor of myocardial insufficiency deserves as much consideration as actual constriction by the pericardium. The survey supports the belief that the clinical picture of chronic constrictive pericarditis may result from tuberculosis in most cases, at times only by implication. In addition, cases can result from trauma to the chest, rheumatic heart disease and purulent pericarditis.

Despite the success of surgical treatment of constrictive pericarditis, its etiology remains obscure in many cases. Although tuberculosis is frequently cited, in many reported cases a meticulous search has failed to reveal any evidence of this disease in the clinical course, at operation, or at autopsy. Recently attention has been directed to a possible relationship to chest trauma, and the possibility that chronic constriction may result from pericarditis associated with rheumatic heart disease has been suggested.

In order to explore these and other factors which may produce constriction, the records of all patients with a diagnosis of pericarditis treated at the Presbyterian Hospital in New York between the years 1930 and 1954 were reviewed.

I. Analysis of All Cases with Pericarditis

A. Definition

Regardless of etiology, there are varying phases of pericarditis. Acute pericarditis of short duration, such as that associated with uremia, often has no serious sequelae. Once this phase has passed, it is difficult to diagnose chronic pericarditis unless physical signs or electrocardiographic changes persist or calcification appears. There may be no accompanying cardiac dysfunction. Qualifying terms such as purulent, traumatic, fibrinous or adherent make precise classification difficult. Accordingly more than 600 records were reviewed from which a group of 416 cases with definite evidence of pericarditis were obtained for analysis.

B. Etiology

1. Cardiac Disease. One hundred fifty four cases (37 per cent) were associated with cardiac disease, of which 139 were rheumatic in origin. Most of these revealed an adherent pericardium at autopsy, and in one the terminal clinical picture and the heavy investment of the heart by a thick fibrous pericardium were characteristic of constrictive pericarditis. In three others the clinical syndrome was suggestive of constriction, but since the patients were living, it was difficult to be certain whether myocardial disease or cardiac restriction played the major role.

In addition to rheumatic heart disease, various other cardiovascular diseases were associated with pericarditis. The most important of these was myocardial infarction. Although the specific diagnosis was made in comparatively few, it seems probable that many other patients with coronary occlusion suffered some degree of subsequent pericarditis.

2. Infection. There were 127 patients in whom pericarditis was related to infection. The largest number, 59, or 46.5 per cent were the result of pyogenic bacterial activity. In 21 patients the organism was a pneumococcus. A
wide variety of unidentified organisms were responsible in 31 others, including one case due to Friedländer bacillus. In seven, the organism was not identified. In two patients a staphylococcic infection was associated with an empyema of the left chest. Although suppurrative pericarditis has been cited as a cause of subsequent cardiac constriction, none of these patients developed evidence of constrictive pericarditis. One of these has been observed for 20 years following drainage and irrigation of the pericardial space with Dakin’s solution.42

Tuberculosis, either suspected or proven, was considered to be the cause in 53 patients, or 41.5 per cent. Of 41 of these patients reviewed by Wood71 in 1951, six had developed constrictive pericarditis. In subsequent years, there were 12 additional patients with tuberculous pericarditis, and two more had developed constrictive pericarditis. When these eight cases were separated into probable and proven tuberculosis etiology, it was found that there were four in each category. A positive history and proof of active tuberculosis elsewhere in the body was considered valid evidence that the etiology of the constrictive pericarditis was probably tuberculosis. The difficulty in assigning tuberculosis as the cause is exemplified by at least two recorded cases in which a specimen at the time of surgery revealed tubercles, but later at autopsy, no evidence of tuberculosis could be found in the pericardium.49

A nonsuppurrative form of pericarditis, unassociated with tuberculosis, was encountered in 14 patients, or 11 per cent. In most instances, the physician noted an association with a respiratory tract infection, and considered the pericarditis to be the result of a virus infection. If some of these patients later develop a constrictive syndrome, it is quite evident that proof of etiology would be most difficult in such patients.

Syphilis was stated to be the cause in one additional patient having a pericarditis. An apparent complete recovery followed adequate therapy of the syphilis and no evidence of constriction occurred subsequently.

3. Inflammatory Origin. In 10 cases inflam-
malignancy involving the chest wall or lung was there a diagnosis of pericarditis. None of these patients had signs of pericardial constriction. However, two patients, not included in this series, died of acute cardiac tamponade due to a rapidly forming pericardial effusion secondary to involvement of the parietal pericardium by a malignant tumor. As is thought to be the case with myocardial infarction, there must have been many more such cases with pericardial involvement. In such instances, the diagnosis of pericarditis is usually not made because the effusion is not of inflammatory origin.

5. Metabolic Factor. For want of a better classification, 63 cases have been listed in this category. None of the patients had the constrictive syndrome. The largest group, 57 patients or about 90 per cent, had uremic pericarditis. In three others, myxedema was present. Scleroderma, hypoprotenemia, and hyperthyroidism were present, each in one patient.

6. Trauma. Six patients had suffered a serious crushing injury to the chest, with death occurring in two within a short time. The remaining four survived and developed constrictive pericarditis.

7. Idiopathic Etiology. In 48 patients, pericarditis had been diagnosed, but no cause could be determined. In 12 of these, the clinical course and findings at autopsy were compatible with this diagnosis. Without a history of tuberculosis, contact with the disease, or evidence at autopsy, a tuberculous origin could not be assumed. In some, the skin test for the diagnosis of tuberculosis was negative.

II. Analysis of Cases with Proven Chronic Constrictive Pericarditis

Of 30 patients with the signs and symptoms of chronic constrictive pericarditis, 25 were confirmed by operation or autopsy, and cultures, as well as gross and microscopic examination of the pericardium were performed.

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* Alive. † Expired. ‡ Biopsy positive for tuberculosis.
S systolic R right TB tuberculosis
D diastolic L left RHD rheumatic heart disease
AF auricular fibrillation I idiopathic TR trauma
LBBB left bundle branch block
(Table 2). These 25 patients will be used for the analysis.

A. Clinical Aspects

1. Sex and age. There were 9 female patients and 16 males in the series. The age varied between 10 and 63 years, the average being 35.44 years. There were three patients, all male, who were less than 20 years of age; being 12, 12 and 10, respectively.

2. Signs and symptoms, and their duration (Table 3). Among the 25 cases, an elevation in venous pressure as measured in an antecubital vein was observed in all. In 20 cases in which specific venous pressures were recorded, the range was from 170 to 350 mm. H2O. It was below 200 in only one patient and the average was slightly above 200 for the group. Following operation, there was a marked fall in all but one case. The pressure then ranged between 65 and 170 mm. H2O, with an average of about 120. Ascites was noted clinically in all but one patient, and actually may have been present. Edema of the lower extremities, associated at times with presacral edema, was recorded in 19 cases. Contrary to what was expected an enlargement of the heart was noted 11 times by physical examination, and subsequent radiographic study revealed enlargement in two additional cases. Cardiac murmurs were heard in nine cases, there being a systolic murmur in all of these, and a diastolic murmur in two. Pleural effusion was present in nine cases, and was bilateral in two-thirds of them. A friction rub was noted in three patients, and mild cyanosis in two.

There were 23 patients in whom radiographic studies were reported. These included standard roentgenograms of the chest, and in some instances fluoroscopy, kymography, and angiocardiography. In the two meter frontal roentgenogram, an increase in the transverse diameter of the heart was noted in 13 patients. Diminished heart action was noted by kymography or fluoroscopy in 18 cases (fig. 1). Calcification of the pericardium was recorded in 11 cases (fig. 2). In a few patients, tomography demonstrated calcification of the pericardium when it was not evident in a standard frontal film (fig. 3). It is of interest that the pulse pressure varied between 18 and 60 mm. Hg, and in many it was over 30. There was no correlation of calcification to degree of heart activity or level of the pulse pressure.

In 22 cases, additional observations were recorded. The electrocardiogram revealed some abnormality of the T wave in all instances, with inversion in 17 and flattening in 5. Low voltage was noted 21 times. Auricular fibrillation was present in seven cases and bundle branch block in one. A heart rate above 85 beats per minute was present in nine patients. Axis deviation occurred in five cases, being to the right in four.

There was a systolic arterial pressure above 115 mm. Hg in eight patients, but in no case was there hypertension. In 14 patients, the diastolic pressure was below 80 mm. Hg. The pulse pressure ranged from 15 to 50 mm. Hg, averaging about 35 mm. Hg.

### Table 3. Symptoms and Signs Associated with Constrictive Pericarditis

<table>
<thead>
<tr>
<th>Symptoms (25 cases)</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dyspnea</td>
<td>22</td>
<td>88</td>
</tr>
<tr>
<td>Orthopnea</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Fever</td>
<td>14</td>
<td>56</td>
</tr>
<tr>
<td>Cough</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Precordinal pain</td>
<td>6</td>
<td>24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Signs (25 cases)</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevated ven. press</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Ascites</td>
<td>24</td>
<td>96</td>
</tr>
<tr>
<td>Edema</td>
<td>19</td>
<td>76</td>
</tr>
<tr>
<td>Enlarged heart</td>
<td>11</td>
<td>46</td>
</tr>
<tr>
<td>Pleural eff.</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>Cardiac murmur</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>Auric. fib.</td>
<td>7</td>
<td>28</td>
</tr>
<tr>
<td>Friction rub.</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Cyanosis</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Roentgen. findings (23 cases)</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diminished activity</td>
<td>18</td>
<td>78</td>
</tr>
<tr>
<td>Enlarged heart</td>
<td>13</td>
<td>58.5</td>
</tr>
<tr>
<td>Calcification</td>
<td>13</td>
<td>56.5</td>
</tr>
</tbody>
</table>

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<tr>
<th>ECG findings (22 cases)</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low voltage</td>
<td>21</td>
<td>95.5</td>
</tr>
<tr>
<td>Inverted T waves</td>
<td>17</td>
<td>77.5</td>
</tr>
<tr>
<td>Pulse rate above 85</td>
<td>9</td>
<td>41</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>8</td>
<td>36.5</td>
</tr>
<tr>
<td>Axis deviation</td>
<td>5</td>
<td>22.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vital signs (22 cases)</th>
<th>Cases</th>
<th>Per Cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulse pressure &lt;35 mm. Hg</td>
<td>14</td>
<td>63.5</td>
</tr>
<tr>
<td>Respirations &gt;22</td>
<td>10</td>
<td>46.5</td>
</tr>
</tbody>
</table>
tions of more than 22 per minute were present in 10 cases.

The symptoms in all 25 patients varied somewhat, but dyspnea was present in all but two. Orthopnea was noted in 14 cases, and fever had been observed at some time in 14. However, recorded elevation in body temperature was noted in only four cases during hospitalization. Cough was present in seven cases, and precordial pain in six. The duration of symptoms and signs varied greatly, from a few weeks to as long as 25 years. In many cases, the presumptive etiological mechanism preceded evidence of constrictive pericarditis.

Fig. 1. Kymograms obtained in a patient with idiopathic constrictive pericarditis (case 10). A. Before operation there was a small globular heart with definitely diminished pulsations. B. Following pericardectomy there was an increase in heart size and pulsations.

Fig. 2. Roentgenogram in frontal and left lateral projection of a patient with idiopathic constrictive pericarditis, (case 22). Note the calcified pericardium.
by many years, especially in the case of tuberculosis. In general, medical aid was sought within three months of the onset of dyspnea or cough. Ascites of several years' duration was not uncommon. Two patients were actually treated surgically for Laennec's cirrhosis of the liver, with no recognition of constrictive pericarditis for some time subsequently. The cirrhosis was mild by liver biopsy and function tests, yet the clinical course was very poor. The clinicians were puzzled by the progressive clinical deterioration and marked ascites, of a degree much greater than that expected from the cirrhosis. Autopsy revealed chronic constrictive pericarditis, and cardiac as well as portal cirrhosis of the liver in both cases. Tuberculosis was the etiologic factor in one, whereas the other remained idiopathic. In two additional cases of idiopathic constrictive pericarditis, portal cirrhosis was found at autopsy. This is of special interest, since Pick's original paper discussed the differential diagnosis of the two conditions when associated with ascites.50

Other laboratory data proved to be of little value. The blood picture was nonspecific. There was anemia in two patients. The white count was elevated in two cases, and depressed in two others. Urinalysis revealed albuminuria in six patients, being severe in only two. The erythrocyte sedimentation rate in 13 cases ranged between 2 and 48 mm. in 1 hour. The average was about 22 mm. in 1 hour.

The serum protein varied between 3.8 and 8.8 Gm. per 100 cu. ml. of blood. There was an average value of 6.64 Gm. in a group of 15 cases. The albumin ranged from 2.1 to 5.5 Gm. and the globulin from 1.6 to 3.8 Gm. In one patient, the globulin equalled the albumin, and in a few others, the normal albumin–globulin ratio was lowered. A nonprotein nitrogen of over 45 mg. per 100 cc. or a serum urea nitrogen of over 30 mg. per 100 cc. was observed in 5 of 17 cases in which this study was performed. The alkaline phosphatase was abnormally high in 7 of 10 cases, but the cephalin flocculation test was positive in only 2 of 11 cases. The circulation time was noted also in 11 patients, varying between 10 and 88 seconds. The average was 28 seconds, but six patients had values of 19 seconds or less. A tuberculin skin test was recorded in only five cases, and was positive in one. This patient had a definite tuberculous constrictive pericarditis, proved at operation and autopsy.

3. Course and treatment. The clinical course

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**Fig. 3. A.** Frontal roentgenogram of case 11 with traumatic constrictive pericarditis which failed to reveal calcium in the pericardium but which is well shown in tomogram, **B.**
ETIOLOGY OF CONstrictive PERICARDITIS

Table 4.—A Comparison of Clinical Features in Several Series of Cases

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<tr>
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</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>28</td>
<td>24</td>
<td>11</td>
<td>25</td>
<td>53</td>
<td>61</td>
<td>25</td>
</tr>
<tr>
<td>Male patients (%)</td>
<td>86</td>
<td>75</td>
<td>55</td>
<td>72</td>
<td>67.9</td>
<td>78.7</td>
<td>64</td>
</tr>
<tr>
<td>Age range (yrs.)</td>
<td>14-77</td>
<td>18-63</td>
<td></td>
<td></td>
<td></td>
<td>6-54</td>
<td>10-63</td>
</tr>
<tr>
<td>Dyspnea (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>92</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Ascites (%)</td>
<td>89</td>
<td>79</td>
<td>64</td>
<td>80</td>
<td>60</td>
<td>85.3</td>
<td>96</td>
</tr>
<tr>
<td>Edema (%)</td>
<td>96</td>
<td>64</td>
<td>55</td>
<td>76</td>
<td>64</td>
<td>67.2</td>
<td>76</td>
</tr>
<tr>
<td>Pleural effusion (%)</td>
<td>86</td>
<td>29</td>
<td>45</td>
<td>56</td>
<td>52.8</td>
<td>—</td>
<td>36</td>
</tr>
<tr>
<td>Cyanosis (%)</td>
<td>—</td>
<td>12.5</td>
<td>—</td>
<td>72</td>
<td>30</td>
<td>39.3</td>
<td>8</td>
</tr>
<tr>
<td>Albuminuria (%)</td>
<td>24.5</td>
<td>—</td>
<td>—</td>
<td>16</td>
<td>—</td>
<td>—</td>
<td>24</td>
</tr>
<tr>
<td>Enlarged heart (%) T.D.</td>
<td>—</td>
<td>25</td>
<td>60</td>
<td>23</td>
<td>54.8</td>
<td>54</td>
<td>56.5</td>
</tr>
<tr>
<td>Calcification (%)</td>
<td>—</td>
<td>—</td>
<td>73</td>
<td>48</td>
<td>55</td>
<td>52</td>
<td>48</td>
</tr>
</tbody>
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T.D. refers to transverse diameter of the heart as measured on a frontal two meter roentgenogram of the chest.

of patients with constrictive pericarditis was similar to that of patients with cardiac failure and medical treatment was relatively ineffective as time passed. Most of the cases received digitalis and some diuretic medication. Quinidine was administered to a few, mainly because of auricular fibrillation. As ascites and dyspnea became more of a problem, the clinical condition gradually deteriorated. Prior to 1935, cardiolyis51, was performed in three cases. One patient with tuberculous pericarditis died at operation, and another with an idiopathic form died on the fifth day following operation. Autopsy of the latter patient revealed pneumonia and portal cirrhosis, in addition to a constrictive, calcified pericardium. The remaining case regained a degree of good health on continued cardiac regimen, and died 12 years later. The cause of her pericarditis remained unknown.

Between 1938 and 1954, pericardietomy17 was performed on 18 patients. There were five deaths within a month of operation, and three subsequent deaths between 6 and 18 months from the date of operation. The remaining 10 patients survive, with follow-up as long as 13 years.

4. Pathology. Although adherent pericardium does not imply constriction, it was present in all cases of constrictive pericarditis. The pericardium was thickened but generally in an uneven distribution. Often there were fibrous trabeculations into the epicardium and myocardium, and the latter was pale and at times atrophied. The pericardium in some cases measured 5 to 8 mm. in thickness at points of maximal thickness. In some, there was spotty calcification and in others, almost a solid plaque of calcium. In over half the cases, calcium was not noted. A few cases had a cartilaginous-like thickening, with small cystic areas of degeneration. In only four patients was a positive culture for tuberculosis obtained from the specimen, or tubercles found microscopically.

In only a few instances did the pericardium appear as a cast completely encircling the heart. This suggests that with lesser degrees of restriction to heart action, myocardial insufficiency was an additional factor of importance. Indeed, varying degrees of atrophy and muscle damage were noted. In none was there any selective constriction of the cavae or pulmonary veins.

B. Etiology (Table 2)

There were 12 patients in whom no specific etiologic factor could be assigned. Special effort was made to uncover a possible contact or hidden focus of tuberculosis. A negative history and examination was supplemented in four cases by a negative autopsy. In three cases, no autopsy was performed, but there were negative cultures and pericardial specimen
from operation. In one of these there was a negative tuberculin test, as well. Five living patients had negative histories and operative specimens. Two of these also had negative tuberculin tests. With the evidence available, it was difficult to believe the constrictive pericarditis resulted from tuberculosis in seven of the cases, and impossible to prove it so in the others.

Tuberculosis was definitely proved in four cases. In three patients, biopsy and culture were obtained at operation and were positive in only two. Final proof was forthcoming at autopsy in the one case with negative biopsy and in one case not subjected to operation. In an additional four patients, the diagnosis of tuberculous constrictive pericarditis was probable. One patient had a negative specimen at operation, but subsequent autopsy revealed active tuberculosis in mesenteric nodes. Three living patients also had negative operative specimens, but had a past history of proved tuberculosis.

Rheumatic fever had been present 10 years previously in one patient. Her background had been negative for tuberculosis. The clinical picture of constrictive pericarditis developed but operation was not performed. Autopsy revealed no evidence of tuberculosis and minimal valvular damage in the heart. There was significant myocardial damage and a thickened, fibrosed adherent pericardium. It was felt that the pericardial restriction played a definite role in the clinical picture.

Chest trauma was believed to be the underlying cause of constrictive pericarditis in four patients. In three, there had been a steering-post injury at the time of an automobile accident. The fourth patient sustained a football injury. All were males. The clinical picture had developed over a few years in three, but in only eight months in one case. In one case with both epicardial and pericardial calcification a large collection of thick semifluid brownish material, presumably old blood, was present in the pericardial cavity under considerable tension. Two others showed evidence of old blood in the adherent areas. None showed any evidence of tuberculosis in the pericardium removed at operation, and subsequent autopsy in two had failed to reveal any evidence of tuberculosis in the patient. In none was there a history or clinical evidence of tuberculosis.

Discussion

This review of 25 cases of chronic constrictive pericarditis has revealed some features of the disease which apparently differ from the classical concept. These differences may be resolved if we accept the clinical picture of chronic constrictive pericarditis to be a resultant balance between the mechanical restriction of an adherent, unyielding pericardium and the functional inefficiency of a damaged myocardium. It has been shown by Cournand and his group,25 Moschowitz,41 and others that all the salient features of constrictive pericarditis may exist without the "small, quiet heart" described so well by Beck.7 Certainly, if the pericardial sac thickens throughout and calcifies into a constricting husk within which the heart attempts to function, the classical triad associated with chronic cardiac compression will result.32 However, with significant myocardial dysfunction, less constriction may suffice to produce the same clinical result. Thus might be explained the observation that the heart may be enlarged.14, 23, 25, 29, 32, 43, 44, 49, 61 In our own series, this was so in about half the patients. A normal heart action, recorded in about 25 per cent of the group studied by fluoroscopy, and a pulse pressure in excess of 30 mm. Hg, which was observed in many of the patients, strongly suggest that mechanical constriction was not the sole factor in some of the cases. A narrowed pulse pressure (less than 30 mm. Hg) was noted in only 45 per cent of the cases analyzed by Paul and coworkers.49 Nevertheless, the clinical course and consistent occurrence of elevated venous pressure, ascites, edema and dyspnea, despite careful medical management, suggested that the thickened, adherent pericardium did play a role in addition to myocardial disease. Such a balance might well explain why some patients with tuberculous pericarditis develop the constriction syndrome whereas others do not. It is clear from the literature that only a rare patient has constrictive signs and symptoms
Etiology of Constrictive Pericarditis

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after suppurative or rheumatic pericarditis. It is of further interest that only an occasional case of chest injury later developed the syndrome of constrictive pericarditis.

In view of the fact that our series contained four patients in whom trauma was apparently the etiologic factor, reports of patients who had suffered acute heart injuries were reviewed. It became evident from the reports of Beck, Elkin, Maguire and Griswold, Naclerio and associates, Ramsdell, Singleton and Warburg that emphasis was usually placed on technical considerations in management and immediate survival rather than on long-term follow-up. Naclerio and coworkers suggested that failure to perform open exploration of the pericardial space following a penetrating wound might allow pocketing of blood in the posterior-inferior pouches of the space and subsequently produce constrictive pericarditis. Since he and his associates practiced open exploration, they had naturally not encountered any such late sequel. The only traumatic constrictive pericarditis known to him was in a man who sustained a crushing injury to the chest in an automobile accident.

In an effort to determine whether penetrating wound follow-up studies would reveal any instances of chronic constrictive pericarditis, a personal questionnaire was sent to a group of surgeons who have handled many heart wounds. The replies indicated that the follow-up often was very incomplete or uncertain. In one case, localized injury from a penetrating wound and the associated hemopericardium was followed some time later by a constrictive pericarditis. A similar wound in another series produced a tuberculous pericarditis, since the knife passed through a tuberculous area. In 1944 Straus reported the occurrence of constrictive pericarditis in a 46 year old man who had part of a needle left in the heart wall and pericardium at the time of an injection of epinephrine for cardiac resuscitation. No massage was performed. The clinical syndrome developed six years later and was confirmed as constrictive pericarditis by operation. Tuttle has seen two soldiers develop constrictive pericarditis following bullet wounds of the chest, and Mortensen and Warburg reported a case associated with a gunshot wound. Harken, who had extracted many missiles from the region of the heart, had not known of subsequent constrictive pericarditis. Beck, Bigger and Blalock have not observed constrictive pericarditis following penetrating wounds of the heart.

White and other authorities have thought that hemopericardium alone might produce constriction. However, several experimental studies in dogs have failed to support this theory. Fehn in 1913, Beck and Moore in 1925 and Ehrenhaft and Taber in 1952 reported their experiments in which instillation of autologous blood within the pericardial cavity of dogs had produced minimal or no adherence and no constrictive signs or symptoms. Ehrenhaft and Taber also injected the lipid fraction of pooled dog blood into the pericardial space of other dogs and typical constrictive syndrome developed at seven weeks in only one animal.

Still, there are many reports of crushing or nonpenetrating chest injury which was followed by constrictive pericarditis. In 1940, Glenn reported the development of constriction three years following a steering-post injury to the chest of a 46 year old man. An autopsy failed to reveal any other possible cause. White and Glendy referred to a patient who developed constrictive pericarditis some time following a chest injury. Dejou in 1946 reported the case of a 19 year old French soldier who had constrictive signs after a nonpenetrating chest injury. In 1948, Mortensen and Warburg in their review made reference to a case of constrictive pericarditis resulting from a crushing injury. Barker and Johnston in 1950, described three cases with constrictive pericarditis, one of whom required pericardiectomy three years following chest trauma. One patient in Blalock's group of cases of constrictive pericarditis had a previous severe crushing injury to the chest. Overholt and associates, in 1952, described constrictive pericarditis occurring in a 50 year old man five years following a nonpenetrating chest injury. No evidence of tuberculosis was noted at operation. Pericardiectomy has also been performed in patients with late traumatic hemo-
pericardium, but without constrictive pericarditis.\textsuperscript{1, 20, 37} Harrington\textsuperscript{26} and Holman\textsuperscript{32} have not observed constrictive pericarditis associated with chest injury.

The possibility that tuberculosis might be the real etiologic agent in some patients with incidental chest injury was raised by Ravitch.\textsuperscript{53} He had seen a Negro patient at the time of a penetrating wound of the heart. The patient was treated by repeated pericardial aspiration, which later revealed bloody fluid but not blood. The man had an active apical tuberculosis. It was thought that the woundsing instrument went through the focus of infection or nodes. In our series, there was a 10 year old Negro boy who had had chest trauma but in whom the pericardial specimen obtained at the time of pericardectomy showed tuberculosis. He died at operation, and autopsy further confirmed the diagnosis of tuberculous pericarditis. It is only reasonable that such cases should impress one with the possibility of tuberculosis being the real cause, despite a history of trauma or rheumatic fever. This is especially so, since it is very difficult to demonstrate tuberculosis in the pericardium of patients who very likely have had a tuberculous pericarditis.\textsuperscript{13, 66}

Blalock and Burwell,\textsuperscript{13} Burwell and Ayer,\textsuperscript{15} D’Abreu,\textsuperscript{18} Holman,\textsuperscript{30, 31} Parsons-Smith and associates,\textsuperscript{46} Sellers,\textsuperscript{57} Stewart,\textsuperscript{61} and others have favored infection (among which tuberculosis ranks first) as the cause of most, if not all cases, of constrictive pericarditis. Many of these authors have rejected the possibility that rheumatic fever could be a competent cause for constrictive pericarditis. Chambliss and coworkers\textsuperscript{46} collected 61 cases of constrictive pericarditis among which 10 patients had a previous history of rheumatic fever and no evidence of tuberculosis. They admitted that one of these patients may have developed his constriction as a result of the rheumatic process. Kaltman and colleagues\textsuperscript{49} in 1953 reported 18 patients with proved constrictive pericarditis among whom five were believed to have the rheumatic pericarditis as the sole cause. All were males with large hearts. Complete autopsy performed in three failed to suggest other etiology. Calcification of the pericardium was present in only one case. Moschcowitz\textsuperscript{41} reported a 25 year old woman believed to have developed constrictive pericarditis on a rheumatic basis. There was a much enlarged heart encased in a very thick, calcified pericardium found at autopsy. Partial pericardectomy had been performed on two occasions with definite relief each time. Among our cases of proved constrictive pericarditis, there was a 42 year old Negro woman with a course suggestive of this syndrome, in whom there was a rheumatic heart disease. At autopsy, there was an enlarged heart encased in a thickened, adherent pericardium and no evidence of tuberculosis. In addition, there were minimal valvular abnormalities. In our group of five unproved cases there were three patients with only a rheumatic background as a possible cause.

It would be well to reiterate that adherent pericardium should not infer constriction. A review at Massachusetts General Hospital in 1932\textsuperscript{40} revealed 43 patients with adherent pericardium among 1900 autopsies or 2.3 per cent. Twenty-two were on a rheumatic basis. There were no constrictive cases among the entire 43 cases. A previous collection of 62 additional cases of adherent pericardium from 3053 autopsies had revealed three cases with true constrictive pericarditis. They were all of proved tuberculous origin. Moschcowitz\textsuperscript{41} found 130 cases of adherent pericardium from 9618 autopsies, or 1.4 per cent. Rheumatic pericarditis was the cause for 46.2 per cent of cases with complete or partial adherence. We found 49 cases with adherent pericardium, and rheumatic pericarditis was considered as the cause in 24 instances, or 49.5 per cent. Only one of these 24 patients had constrictive signs and symptoms. In only one case was myocardial infarction thought to be the cause of a constrictive pericarditis.\textsuperscript{43}

Polyserositis with indeterminate or atypical endocarditis\textsuperscript{88} was claimed by Moschcowitz\textsuperscript{41} to be the cause of one proved case of constrictive pericarditis examined at autopsy. Polyserositis as a cause has been listed by other authors, but usually in association with rheumatic heart disease, tuberculosis or pneumonia.
Wood and Krumbhaar do not believe that polyserositis alone leads to constriction.

Suppurative pericarditis can produce a constrictive pericarditis but does so infrequently. The reports of Blalock and Burwell, Harrison and White, Johnston and Mangiardi, Shipley and Winslow, and others indicate that the pneumococcus or staphylococcus is the usual organism. We found no constrictive pericarditis developing among our 59 cases of suppurative or pyogenic pericarditis, in 21 of which a pneumococcus was recovered. It is of special interest that the case of streptococacic pericarditis treated by irrigation with fresh Dakin’s solution did not develop constrictive pericarditis. Beck reported constrictive pericarditis as a complication of the use of Dakin’s solution inside the pericardial cavity.

Since all authors readily accept tuberculosis as a proved cause for chronic constrictive pericarditis, we shall only re-emphasize the fact that it is very difficult to prove the diagnosis in many cases in which presumptive evidence exists. White and Churchill proved tuberculosis to be the agent in only 5 of 37 cases, whereas Blalock and Burwell found 21 tuberculous cases among 28. Harrington reviewed 24 cases and proved tuberculosis in only 5. Sellors, on the other hand, claimed 16 of 20 cases to be tuberculous. Holman reported four proved cases among nine; and McKusick considered 8 of 20 cases to be proved or probable. Stewart proved tuberculous cases among 25. Almost without exception, there are “idiopathic” cases in all series, and it is certain that additional cases of tuberculous pericarditis will be recognized among these when autopsy is performed. It is impossible to implicate virus infection in some of these patients with any assurance, but in the future, more careful study and documentation may produce evidence for or against such an etiologic agent. Harrington, Paul and co-workers, and others cite operated cases in which the only positive finding was the history of a previous attack of influenza or atypical pneumonia. In our series, similar cases are classified as idiopathic.

There is a remarkable agreement in the clinical syndrome when our findings are compared with those of several other authors who have carried out detailed analyses (table 4). The high percentage of patients with enlarged heart was quite interesting. Blalock and Burwell indicated that they had encountered no marked cardiac enlargement, but no mention was made of slight increases in transverse diameter. While some of the enlargement observed in certain patients may be the result of the shadow caused by a thickened pericardium, there are many cases in which this is not the sole factor.

In these series there were patients treated for some time with a clinical diagnosis of portal cirrhosis, and the cases of Glenn and of Strauss are additional examples. In our series, there were four patients with constrictive pericarditis, in whom portal and cardiac cirrhosis was found at autopsy. Two of these patients had been treated vigorously for portal cirrhosis during several years and had had omentopexy or splenectomy. Liver biopsy had confirmed only moderate portal cirrhosis. However, the poor clinical course and excessive ascites, edema and dyspnea for the degree of liver dysfunction, led to the late suspicion that a cardiac element also existed. This was confirmed at autopsy. Our experience is interesting when one recalls the original paper by Pick describing pseudocirrhosis in three patients. Although Harrington noted some retention of bromsulfoxaline in all of his cases, the liver function tests are usually not seriously affected in chronic constrictive pericarditis. Therefore, one must consider possible pericardial disease in a patient with large liver, ascites and fairly good liver function. However, the possibility of both conditions coexisting in a patient cannot be excluded.

Ascites and pleural effusion appear to be the result of an inefficient right heart, as suggested by elevated venous pressure, edema, and occasional cyanosis. We believe this to be the sum of compression and myocardial ineffectiveness. A study of the heart muscle of patients with constrictive pericarditis has revealed actual atrophy of the fibers. When one adds varying degrees of actual myocardial damage from a circulatory or disease process, it may
not require a great amount of actual constric-

tion for the development of the constrictive

syndrome. Holman and Lambert have

considered constriction of the vena cava to

be of real importance in the development of

the syndrome. However, Sawyer and asso-
ciates, Sellors and others have questioned

this, and in none of our 11 patients having

complete autopsy was there evidence of sig-
nificant narrowing of the cavae. At least a 50

per cent reduction in cross sectional area of

the inferior vena cava is necessary for the

production of ascites. Harvey and cowork-
ers studied five patients by cardiac catheteri-
zation during various stages of the clinical course, and found that
calcification of the pericardium alone in no way implies constriction, and also that there may be significant myocardial damage in the patient with clinical constrictive pericarditis. In their opinion, this is at times a reversible factor. This analysis indicates that pericardial constriction may not be the sole or even major factor. That patients with significant myocardial damage and minimal pericardial re-

striction may be headed for fully developed constrictive pericarditis has been suggested in case reports by Lambert and by Moschocowitz.

In conclusion, from this analysis of 25 pa-
tients with proven constrictive pericarditis and comparison with cases reported by other authors, certain factors appear to be important in the development of the clinical syndrome of constrictive pericarditis: (1) Prolonged exposure of the pericardium to irritant or damaging agents; tuberculous infection, foreign bodies or partially organizing blood clot are examples. (2) Extensive pericardial involvement rather than discrete localization. (3) A varying degree of pericardial compression or constriction in association with myocardial damage by disease or injury.

**Summary**

An analysis of 416 cases of pericarditis treated at the Presbyterian Hospital in New York between the years 1930 and 1954 has been presented. From this group, there were five patients with the clinical but unproven diagnosis of chronic constrictive pericarditis, and 25 in whom the diagnosis was proved by operation or autopsy. The signs and symptoms presented by these patients are comparable with those reported by others. There was a high incidence of cardiac enlargement. In-

vestigation of etiologic basis for constrictive pericarditis in this group and in reports by other authors indicated that it is impossible to de-
termine a definite cause in many patients. Among proved causes, tuberculosis is the most frequent. Evidence is presented that injury, purulent infection of the pericardium, and rheumatic heart disease may produce the con-

strictive syndrome. The concept that this syndrome results from a myocardial factor as well as pericardial compression is emphasized.

**Summario in Interlingua**

Es presentate un analyse de 416 casos de pericarditis tractate al Hospital Presbyterian de New York inter le annos 1930 e 1954. Le grupo include le casos de 5 patientes con un non-confirmate diagnose clínice de pericarditis constrictive chronic e 25 casos con le mesma diagnose confirmate al operation o al autopsia. Le signos e symptomas presentate per iste patientes es comparable con illos reportate per altere autores. Nos trovava inter illos un alte frequentia de allargamento cardiac. Le investi-
gation del base etiologic de pericarditis constrictive—tanto in nostre serie como etiam in illos reportate per alteros—indica que il es frequentemente impossible determinar un causa specific. Inter le causas demonstrate, tuberculosis es le plus frequente. Nos presenta datos in supporto del concepcion que le syndrome constrictive pote esser producita per vulneres, infectiones purulente del pericardio, e morbo rheumatic del corde. Nos sublinea le concepcion que le syndrome pote resulbar ab factores myocardiales tanto ben como ab un compression pericardiac.

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