Constrictive pericarditis following cardiac surgery—Cleveland Clinic experience: report of 12 cases and review[1]

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From January 1972 to June 1983, 12 cases of confirmed constrictive pericarditis were found at the Cleveland Clinic, occurring as a long-term complication of cardiac surgery. These patients had had valve replacement, coronary artery bypass surgery, or other surgical procedures. Average time interval from initial cardiac surgery to definitive diagnosis was 12.6 months (range, 5 weeks to 34 months). Two patients were treated medically and 10 were treated surgically. Pathogenesis of pericardial constriction following cardiac surgery is unknown. Possible factors are mesothelial injury, bleeding, postpericardiotomy syndrome, and povidone-iodine irrigation. Constrictive pericarditis should be considered in the differential diagnosis of patients with right-sided heart failure after cardiac surgery.

Index terms: Heart failure • Heart surgery • Pericarditis, constrictive

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Constrictive pericarditis following cardiac surgery has been thought to be rare. A review of the cases with confirmed constrictive pericarditis at the Cleveland Clinic from January 1972 to June 1983 revealed 12 cases occurring as a long-term complication of cardiac surgery. This paper reports our experience and reviews the cases reported in the English literature.

Methods

A computer search was made of all the cases of constrictive pericarditis diagnosed at the Cleveland Clinic from January 1972 to June 1983. Only cases in which diagnosis

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had been confirmed by cardiac catheterization and in which there had been a prior history of cardiac surgery were included. The hemodynamic criteria used were as follows: elevated right atrial pressures with almost equal A and V wave and rapid X and Y descents; near equalization of diastolic pressures in the right atrium, right ventricle, pulmonary artery wedge, pulmonary artery diastolic and left ventricular diastolic pressures; and the "square root sign" or early dip and plateau in the right and left ventricular tracing.

With the above hemodynamic criteria, 12 cases of constrictive pericarditis following cardiac surgery were identified. Ten of these patients subsequently underwent operation, and diagnosis of constrictive pericarditis was confirmed in all 10. It is possible that some patients who had mild constrictive pericarditis were not recognized clinically or were not referred for cardiac catheterization.

Results

There were a total of 12 patients (10 men and 2 women) who had constrictive pericarditis as a long-term complication of cardiac surgery. The mean age was 55.3 years (range, 42 to 66 years). The patient profile, type of surgical procedures performed at the initial operation, and the time interval from initial surgery to diagnosis of constrictive pericarditis by cardiac catheterization are shown in *Tables 1 and 2.* Ten of the 12 patients had had their first cardiac operation at the Cleveland Clinic and 2 at other hospitals (patients 5 and 11). Povidone-iodine solution was not used for pericardial irrigation in our 10 patients. The pericardium was left open in all patients at the time of initial cardiac operation except for patient 11; in one patient who was operated on elsewhere, it was not known whether the pericardium was closed or left open at the time of first cardiac surgery (patient 5).

In 4 of the 12 patients (patients 2, 3, 5, 12), atrial fibrillation developed postoperatively and 2 patients required cardioversion. In one patient (patient 4), supraventricular tachycardia developed, which was converted to sinus rhythm with medications. Patient 7 required intra-aortic balloon pump for two days postoperatively. One patient required chest tube insertion for right pneumothorax. In 4 patients, problems such as fever, pericardial pain, pericardial rub, ST-T wave changes in electrocardiogram, and polyserositis compatible with postpericardiotomy syndrome developed within six weeks of the first cardiac operation and required treatment with steroids and anti-inflammatory agents.

Table 1. Type of cardiac disease

Pt no.	Initial diagnosis
1	1. ASHD
	2. Anterolateral MI
2	1. Rheumatic heart disease
	2. Chronic atrial fibrillation
3	1. Rheumatic heart disease
	AS, AR, MS, MR
4	1. ASHD
	2. Diabetes mellitus
	3. Hypertension
5	1. ASHD
	2. Hypertension
6	1. Calcific AS, mild MR
	2. Mild ASHD
7	1. ASHD
	2. Diabetes mellitus
8	1. ASHD
	2. Diabetes mellitus
9	1. ASHD
	2. Myocardial infarction
	3. Permanent pacemaker implanted 1978 for 3° AVB
10	1. Anteroseptal MI
	2. Diabetes mellitus
	3. Congenital aortic stenosis (severe)
11	1. ASHD
	2. Inferior MI
12	1. Bland-Garland-White syndrome
	2. Mitral regurgitation

Abbreviations: ASHD = atherosclerotic heart disease; MI = myocardial infarct; AS = aortic stenosis; AR = aortic regurgitation; MS = mitral stenosis; MR = mitral regurgitation; AVB = atrioventricular block.

Clinical presentation

The most common symptom at presentation in these patients was dyspnea: 11/12 (92%). Ten patients had exertional dyspnea, 5 had orthopnea, and 3 had paroxysmal nocturnal dyspnea. Eleven had peripheral edema. Gastrointestinal symptoms of abdominal pain, distension, nausea, vomiting, and anorexia were present in 9/12 patients (75%). Chest pain was present in 6/12. Six of 12 complained of fatigability, and one had syncope (8%).

Eleven of the 12 patients had elevated jugular venous pressure and hepatomegaly, of whom one had jaundice. All 11 patients had accompanying peripheral edema. Ascites was present in 9/12. Seven had an early diastolic sound. Pericardial rub was heard in 2 patients. In 2 patients, Kussmaul's sign was recorded.

Table 2. Initial surgery and time interval from surgery to diagnosis of constrictive pericarditis

Pt no.	Sex	Age	Operation	Time of operation	Time interval from operation
1	M	66	SVG, LAD, Dg, Cx	1979	5 wk
2	M	44	MVR (porcine Hancock)	1981	7 wk
3	M	45	AVR (Starr-Edwards), MVR (Starr-Edwards)	1976	4 mo
4	M	51	SVG, LAD, Dg, Cx, RCA	1980	7 mo
5	M	62	SVG, LAD	1977	12 mo
6	M	66	AVR, (Bjork-Shiley)	1980	13 mo
7	M	51	SVG, LAD, Dg, Cx	1973	13 mo
8	M	64	SVG, LAD, Cx	1979	21 mo
9	F	62	SVG, LAD, Dg, ventricular aneurysmectomy	1979	30 mo
10	M	62	SVG, LAD, AVR (Starr-Edwards)	1975	34 mo
11	M	48	SVG, LAD, Dg, SVG, Cx, Cx, RCA	1981	12 mo
12	F	42	SVG, LAD, Cx, MVR (Carpentier-Edwards)	1968 1983	10 wk

Abbreviations: SVG = saphenous vein graft, LAD = left anterior descending, Dg = diagonal, Cx = circumflex, MVR = mitral valve replacement, AVR = aortic valve replacement, RCA = right coronary artery.

Normal sinus rhythm was present in 8 patients. Three patients were in atrial fibrillation and one had atrial flutter. One patient had a broad and notched P-wave exceeding 200 msec. The QRS complex was low in voltage in 2 patients. Prior anterior myocardial infarction was present in 4 patients. The most common electrocardiographic findings were nonspecific T-wave and ST changes. Six patients had normal heart size. Cardiomegaly defined as cardiothorax ratio exceeding 0.5 was present in 6 patients, 4 of whom showed slight cardiomegaly. The right atrium was prominent in one patient. Right pleural effusion was present in 3 patients. None showed evidence of pericardial calcification. Echocardiography was done in 11 patients, and demonstrated small posterior pericardial effusion in 6. Two had moderate-size posterior pericardial effusion. Thickened pericardium was seen in 3. Paradoxical septal motion was present in 3. Left atrial enlargement was present in 2.

Hemodynamic data

All 12 patients had hemodynamic characteristics of constrictive pericarditis (*Tables 3 and 4*). The right atrial pressures were elevated with almost equal A and V waves (in patients with sinus rhythm) and rapid X and Y descent, giving rise to the characteristic M or W pattern of right atrial pressures. The early diastolic dip and plateau or "square root sign" was present in the right ventricular pressure tracing of all patients. The "square root sign" was present in the left ventricular pressure tracings in the 10 patients in whom left ventricular pressure tracings were obtained. There was near equalization of diastolic pressures

Table 3. Hemodynamic data

Pt. no.	Right atrium (mm Hg)	Right ventricle (mm Hg)	Pulmonary artery (mm Hg)	Pulmonary artery wedge (mm Hg)	Left ventricle (mm Hg)
1	a = 18 v = 16	24/16	24/16 m = 18	a = 18 v = 16 m = 14	120/22
2	v = 32 y = 15 m = 28	48/30	48/30 m = 38	v = 32 m = 30	...
3	a = 18 v = 18 m = 18	45/18	45/20 m = 20	a = 18 v = 20 m = 18	100/18
4	m = 24	40/26	40/26	a = 28 v = 26 m = 24	120/26
5	a = 14 v = 14 m = 12	28/14	28/16 m = 22	a = 12 v = 22 m = 16	100/14
6	a = 24 v = 24 m = 22	40/22	40/24 m = 28	a = 28 v = 26 m = 26	...
7	a = 24 v = 20	42/20	42/22 m = 30	m = 24 LA m = 28	124/30
8	a = 16 v = 18 m = 15	40/22	40/22	a = 20 v = 20 m = 20	120/24
9	a = 28 v = 26 m = 25	50/25	50/25 m = 40	a = 30 v = 50 m = 35	120/25
10	a = 16 v = 16 m = 14	38/14	38/14 m = 20	a = 20 v = 20 m = 14	124/35
11	m = 25	45/25	35/25	LA m = 25	128/25
12	v = 15 m = 13	42/14	40/14	m = 16	110/17

Table 4. Hemodynamic data

Pressure	mm Hg
Mean RA	= 19.5
Mean PAW	= 22.2
Mean PA diastolic	= 21.3
Mean RV end diastolic	= 20.5
Mean LV end diastolic	= 21.9

Abbreviations: RA = right atrial, PAW = pulmonary artery wedge, PA = pulmonary artery, RV = right ventricular, LV = left ventricular.

in the right atrium, right ventricle, pulmonary artery wedge, and pulmonary artery diastolic and left ventricular pressures. The pulmonary artery systolic pressure in all patients was less than 50 mm Hg. Mean pulmonary artery diastolic pressure was 21.3 mm Hg. The mean pulmonary artery wedge pressure was 22.2 mm Hg. The mean right atrial pressure was 19.5 mm Hg. The mean left ventricular diastolic pressure was 21.9 mm Hg. The mean right ventricular diastolic filling pressure was 20.5 mm Hg. A right angiocardiogram was obtained in 3 patients. This showed thickening of the right atrial wall, straightening and immobility of the right atrial border, and enlargement of the right atrium. The coronary angiogram showed all grafts to be patent with the exception of that of patient 11. This patient had occlusion at the origin of the saphenous vein bridge graft, to the left anterior descending artery, and diagonal branch. Two patients were treated medically with aspirin, prednisolone, and furosemide (Lasix). Ten patients did not respond to medical therapy and underwent pericardiectomy.

Operative findings

At operation, constrictive pericarditis was confirmed in all 10 patients. Thickened and adherent pericardium was found in all patients. Constriction and calcification were found around the right atrium and systemic inflow to the heart in one patient. In one case (patient 4) a posterior clot was found. In another patient (patient 10), 100 ml of "wine-colored" blood was drained from the posterior diaphragmatic portion of both ventricles. Both ventricles were encased in very thick pericardium. Patient 12 had additional excision of periguard pericardium, which had been placed at the time of the second operation. It was felt by the surgeon that the scarring and fibrosis were a reaction to the bovine periguard pericardium. Histologic examination showed a foreign body reaction. Histology in all patients showed various degrees of chronic inflammation and fibrosis.

Discussion

Constrictive pericarditis has several causes. The clinical, hemodynamic, and angiographic features are well known.[1–4] Constrictive pericarditis as a long-term complication of cardiac surgery has been thought to be rare. A review of the literature revealed a total of 44 cases reported in the English literature to date.[5–12, 14–15] The largest series, from Emory University Affiliated Hospitals,[15] reported 19 cases. Our report adds to the literature 12 cases of constrictive pericarditis after cardiac surgery, making a total of 56 cases reported to date (*Table 5*).

Of the 56 cases, the type of cardiac surgery performed initially was known in 50 (*Table 6*). Twenty-seven patients had coronary artery bypass surgery alone consisting of single, double, triple, and quadruple bypasses. One patient had a left internal mammary artery graft to the left anterior descending artery in addition to one saphenous vein graft to the diagonal branch. One patient had saphenous vein bypass graft and ventricular aneurysmectomy. One patient had combined bypass graft and aortic valve replacement. Seventeen patients had valve replacement. Two patients had repair of atrial septal defect. One patient had two prior operations 15½ years apart; the first operation was a double coronary artery bypass graft for Bland-Garland-White syndrome and the second operation was mitral valve replacement and bovine pericardial graft.

Table 5. Constrictive pericarditis following cardiac surgery; review of literature

		No. of patients
Lange[14]	1967	5
Kendall et al[5]	1972	2
Simon and Pluth[6]		1
Brown and Older[7]	1977	1
Kilman et al[8]	1977	3
Cohen and Greenberg[9]	1978	3
Marsa et al[10]	1979	3
Rice et al[16]	1980	5
Rubio et al[11]	1980	1
Kanakis et al[12]	1981	1
Miller et al[15]	1982	19
Cleveland Clinic	1983	12
Total reported to date		56

Table 6. Type of cardiac surgery (review); known = 50/56

Type of surgery	Number of patients
I. Coronary artery bypass surgery	
a) LIMA—LAD and SVG	1
b) SVG only	27
c) SVG and ventricular aneurysmectomy	1
II. Valve replacement	18
III. CABG + valve replacement	1
IV. Repair of ASD	2
Total	50

Abbreviations: LIMA = left internal mammary artery, LAD = left anterior descending, SVG = saphenous vein graft, CABG = coronary artery bypass graft, ASD = atrial septal defect.

The interval from initial surgery to time of definitive diagnosis ranged from two weeks to five years and nine months. Constrictive pericarditis in the Miller et al[13] series presented at an average of about eight months after the initial surgery. In our series, the definitive diagnosis based on cardiac catheterization was made at an average interval of 12.6 months from the time of initial surgery.

The etiology of constrictive pericarditis following cardiac surgery is not well known. It is remarkable that it is not as common as one would expect from the number of cardiac operations that have been performed to date. Kutcher et al[13] reported an incidence of 0.2%; Miller et al[15] reported 0.3%. Milder cases of constrictive pericarditis may show normal hemodynamics unless intravenous saline loading is performed.[17]

Various pathogenetic mechanisms leading to constrictive pericarditis have been implicated. The etiological factors considered are the extent of serosal injury, degree of intraoperative and postoperative bleeding, decrease in fibrinolytic activity, postpericardiotomy syndrome, and the use of povidone-iodine (Betadine) solution for irrigation of the pericardial cavity.

In experimental models, it has been shown that pericardial adhesions will occur if two conditions are present, i.e., if spilled blood comes into contact with an injured serosal surface.[18] Mild mesothelial injury alone or blood clots inside a normal serosal cavity do not lead to adhesions. The degree of trauma to the pericardium during cardiac surgery and blood in the pericardial cavity could be contributing factors.

The presence of blood in the pericardial cavity is inevitable during cardiac surgery. It has been proposed that mesothelial tissues contain fibrinolytic activators that play an important role in resolving mesothelial clots.[19] A decrease in fibrinolytic activator activity was proposed to be the contributing factors in the 2 patients with postoperative constrictive pericarditis reported by Kendall et al.[5]

The question of whether the pericardium should be closed or left open during cardiac surgery is debatable.[20] Most surgeons, however, leave the pericardium open because of the possibility of acute and chronic pericardial compression. Of the 33 patients in whom the operative procedure was described in detail, only 2 had the pericardium closed at the end of surgery, one of whom had partial closure to the base of the great vessels with interrupted silk sutures before closure of the sternum. The pericardium was left open in all 19 patients in the Miller et al[15] series and also in 9 of 10 patients in our series. It has been suggested that primary pericardial closure decreases the incidence of intrapericardial blood accumulation, and the site of postoperative bleeding is commonly extrapericardial.[21] An organized hematoma was found in the posterior pericardial space of 5 of the 19 patients in the Miller et al[15] series. In our series, one patient (patient 4) was found to have a posterior pericardial clot, and in another patient, 100 ml of wine-colored blood was drained from the posterior diaphragmatic portion of both ventricles (patient 10). This patient had had bleeding problems from excessive anticoagulation before presenting to the Cleveland Clinic. Early or late postoperative bleeding into the pericardial space from anticoagulation therapy could be a contributing factor in the development of constrictive pericarditis, especially in the presence of mesothelial injury. However, the pathogenesis in patients who had only coronary artery bypass surgery and did not receive anticoagulants postoperatively is not well explained by this mechanism.

The use of povidone-iodine (Betadine) for irrigation of the pericardial cavity at the end of the operation was considered as a possible cause.[10, 13, 15] Povidone-iodine irrigation was used in 10 of the 19 patients in the Miller et al[15] series. Marsa et al[10] reported the use of povidone-iodine irrigation in their 3 cases. Povidone-iodine was not used in the 10 patients who were operated on at the Cleveland Clinic. Two patients had had their initial surgery at another hospital, and

whether or not this irrigation was used is not known. Miller et al[15] reported 10 cases of constrictive pericarditis in approximately 300 patients in whom povidone-iodine irrigation was used. Although povidone-iodine could be a contributing factor, this does not explain the development of constrictive pericarditis following operation in which povidone-iodine irrigation was not used.

Postpericardiotomy syndrome has been considered to be an etiological factor in the development of constrictive pericarditis following cardiac surgery. Postpericardiotomy syndrome was present in 4 of the 5 patients described by Rice et al,[16] 11 of the 19 patients in the Miller et al[15] series, and 4 of the 12 patients from our series. It is possible that some patients could have developed forms of postpericardiotomy syndrome that were not recognized clinically and that later resulted in constrictive pericarditis.

In patient 12, the use of bovine periguard pericardium at the time of a second operation for mitral valve replacement may have been a possible etiologic factor and may have started a tissue reaction to the bovine pericardium. However, to our knowledge, there has been no report in the literature implicating bovine periguard pericardium in constrictive pericarditis following cardiac surgery.

The clinical findings of constrictive pericarditis following surgery are not different from those reported for constrictive pericarditis from other causes.[14] Symptoms referable to the gastrointestinal system (exertional abdominal pain, anorexia, and nausea) are prominent features due to hepatic distension resulting from elevated venous pressure. Definitive diagnosis is made by cardiac catheterization. In a few cases, however, even after cardiac catheterization, differentiation of constrictive pericarditis from restrictive cardiomyopathy was possible only during operation.

Two of our patients were treated medically; 10 patients did not respond to conservative therapy and required surgery. The findings were thickened pericardium, fibrosis, and adhesions. Histological findings uniformly showed nonspecific fibrosis and chronic inflammation. In one patient, giant cell reaction was reported, perhaps in response to the presence of bovine pericardium.

Constrictive pericarditis developing after cardiac surgery is probably the end point of multiple pathogenetic factors. The degree of mesothelial injury and bleeding are likely important factors. Bleeding in patients on anticoagulant therapy for valve replacement is probably an important contributory factor. Postpericardiotomy syndrome could lead to pericardial constriction in some patients. Povidone-iodine irrigation, whether primarily due to its irritant nature or the setting in which it is used, has been identified as a possible etiological factor. The presence of an open pericardium at the end of surgery does not prevent the development of pericardial constriction.

Constrictive pericarditis as a long-term complication of cardiac surgery is a distinct entity. The cases reported have been the severe ones often requiring surgical therapy. It is likely that mild cases of constrictive pericarditis have not been recognized clinically. Unless there is a high index of suspicion of this entity, patients with a mild form of constrictive pericarditis following surgery may not be identified even during cardiac catheterization, and this entity should be considered in the postoperative cardiac patients who develop right-sided heart failure.

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