Medical emergencies

Cardiac tamponade

Summary

Cardiac tamponade is a cardiolo- gical emergency requiring prompt treatment in order to avoid a fatal outcome. It can complicate a number of medical conditions and it is important, therefore, that all practitioners are aware of its presentation, diagnosis and man- agement. These are outlined. We suggest that, with certain specific and important exceptions, percu- taneous catheter pericardiocent- esis is to be recommended in the management of cardiac tampo- nade. We include a review of 51 consecutive cases treated at our own institution. Catheter pericar- diocentesis was successful in 49 (96%) cases and 36 (80%) patients did not require any further inter- vention. There were no major and only two minor complications which required no additional treatment. We review previous literature concerning percuta- neous pericardiocentesis. Using recommended procedures, per- icardiocentesis is successful in 90–100% of cases and major com- plications are rare.

Keywords: pericardiocentesis, cardiac tam- ponade

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The pericardial space usually contains 15–50 ml of fluid. When a pericardial fluid collection develops, its effect on the intrapericardial pressure is dependent upon the volume of fluid, its rate of accumulation and the physical characteristics of the pericardium itself. If fluid accumulates slowly, the normal pericardium will stretch and the pericardial space may accommodate up to two litres of fluid without any rise in intrapericardial pressure. In contrast, a marked rise in intrapericardial pressure will accompany rapid accumulation of only 150–200 ml of fluid. Further, less fluid is required to raise the intrapericardial pressure when the pericardium is abnormally stiff owing to fibrosis or malignant infiltration. Cardiac tamponade occurs when the intrapericardial pressure exceeds intracardiac pressures, producing a progressive reduction in diastolic ventricular filling and a consequent reduction in stroke volume and cardiac output. Cardiac tamponade is a cardiological emergency. Diagnosis must be made swiftly and treatment initiated immediately, as the untreated condition is fatal.

Aetiology of cardiac tamponade

A pericardial collection can complicate a variety of medical and surgical conditions. Hence, it will present to practitioners of a wide variety of specialties. Those conditions most commonly associated with collections which require drainage are listed in box 1. The relative frequencies of these diagnoses are obtained from a review of four large published series.^{1–4}

Clinical features of cardiac tamponade

Prompt diagnosis is essential but difficult to achieve in all cases, as symptoms of cardiac tamponade are often mild and nonspecific (box 2). The classical signs of tamponade include hypotension, arterial pulsus paradoxus, elevation of the jugular venous pressure and muffled heart sounds. However, these features are not always present and atypical signs may be found, including low-grade fever, atrial arrhythmia or leucocytosis. It is important to maintain a high index of suspicion and arrange immediate investigation when cardiac tamponade is suspected.

Investigation of cardiac tamponade

The accumulation of fluid in the pericardial space can result in a reduction in the QRS voltage on the electrocardiogram. However, the development of electrical alternans or cyclical variation in the QRS voltage is more specific for cardiac tamponade. Intra-atrial pressure changes can provoke the atrial arrhythmias mentioned above.

When pericardial fluid accumulates slowly, as may occur in association with chronic medical conditions, the pericardium distends and the chest radiograph will show an enlarged cardiac silhouette typically with a globular or 'flask-like' configuration (figure 1). However, these appearances provide no information regarding the haemodynamic significance of the collection and, therefore, do not help in the diagnosis of cardiac tamponade.

Further, when pericardial fluid accumulates quickly, following trauma or surgery, tamponade may occur without any appreciable change in the size of the cardiac silhouette.

Transthoracic echocardiography is the single most useful investigation in the diagnosis of pericardial collections and cardiac tamponade. Since the development of M-mode echocardiography in 1955, it has been possible to confirm the presence of fluid collections in the pericardial space quickly and safely (figure 2). Further, it is possible to assess the haemodynamic significance of the collection. Compression or collapse of the right atrium and ventricle in diastole indicate the development of cardiac tamponade. The development of two dimensional echocardiography in the late 1970s allowed easier interpreta-

Prevalence of causes of pericardial collection	
Aetiology	Reported cases (%)
• neoplasia	15–40
• idiopathic	13–14
• trauma	7–9
• uraemia	5–10
• radiation	4–7
• postpericardiotomy	2–16
• infection	2–14
• connective tissue disease	2–11

Box 1

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Accepted 29 March 1996

Clinical features of cardiac tamponade

Symptoms

- general malaise
- shortness of breath and fatigue
- dizziness and lightheadedness
- palpitations
- chest pain

Signs

- tachycardia
- hypotension
- pulsus paradoxus
- raised jugular venous pressure (with attenuated ‘y’ descent)
- muffled heart sounds
- atrial arrhythmia
- low-grade fever

Box 2

Figure 1 Chest radiograph showing flask-like enlargement of the cardiac shadow in the presence of a large pericardial effusion

Figure 2 M-mode echocardiogram demonstrating the appearance of a large pericardial effusion which is compressing the right ventricle

tion and produced clearer visualisation of the size and distribution of the pericardial effusion (figure 3). It also increased the sensitivity of the investigation to diagnose cardiac tamponade.

Cardiac catheterisation allows determination of the haemodynamic significance of a pericardial effusion with a high degree of sensitivity. However, it is an invasive procedure and is unnecessary when echocardiographic diagnosis is available.

Management options

The aim of treatment is simple. The intrapericardial pressure must be reduced by removal of the accumulated fluid. This can be achieved either by ‘indirect’ percutaneous methods, or by direct surgical approach. When a patient’s condition is life-threatening, one should choose the swiftest, safest and most effective approach to pericardial drainage. Further, as tamponade occurs in patients suffering from a range of general medical and surgical conditions, the procedure must be within the capabilities of those not specially trained in cardiothoracic surgery.

In the emergency situation, when a cardiothoracic surgeon is not available, an open surgical approach may not be an option. Percutaneous catheter drainage allows treatment of cardiac tamponade under local anaesthesia by any appropriately trained physician. However, opinions differ with regard to the safety and efficacy of percutaneous pericardiocentesis for the treatment of pericardial effusions.

We reviewed a series of 51 percutaneous pericardiocenteses performed at our institution. In all cases, the presence of an effusion, its size and distribution were confirmed by echocardiography. The pericardiocenteses were performed via the subxiphoid route using a modification of the Seldinger technique⁵ to introduce an in-dwelling catheter. Details of the procedure have been published recently⁶. Effective drainage of the effusion was confirmed by repeat two-dimensional echocardiography. The median duration of drainage was 24 hours.

Fluid was obtained at pericardiocentesis in 49 (96%) cases. Failure in two cases was related to loculation of the effusion posteriorly. Thirty-six (80%) patients required no further intervention and were successfully treated by a single pericardiocentesis. There was re-accumulation of pericardial effusion in eight patients. Three were successfully treated by further pericardiocentesis while four patients were treated by open surgical drainage. The eighth patient developed re-accumulation of a malignant effusion but was in the terminal stage of his disease and unfortunately succumbed before a further pericardiocentesis could be attempted.

Figure 3 Two-dimensional echocardiographic images of large pericardial effusions from the parasternal long axis (A), parasternal short axis (B), apical four chamber (C) and subcostal (D) views. RA - right atrium, RV - right ventricle, LA - left atrium, LV - left ventricle, Ao - aorta, PE - pericardial effusion

There were only two complications resulting from the procedure. One patient suffered a brief episode of hypotension which responded to rapid intravenous fluid infusion without sequelae. In the second patient, with a posterior effusion, the right atrium was punctured with the guide wire (as confirmed by fluoroscopy), and the procedure was abandoned without ill effect to the patient.

The first percutaneous pericardiocentesis was performed in 1840 by Franz Schuh, a Viennese physician.⁷ Since this time there have been many modifications of the technique,⁸⁻¹⁴ but not until recently have publications specifically addressed the question of its safety and efficacy. In 1979, Wong *et al* published a series of 52 cases, together with a review of six published reports.² We have found a further 11 series of reasonable size which have included details of the safety and efficacy of the procedure (table 1). All are retrospective analyses and are not directly comparable, owing to differences in patient groups and techniques used. Reviewing these series, it is obvious that high rates of morbidity and mortality in relation to pericardiocentesis are historical. They result from a lack of echocardiographic diagnosis and guidance, and the use of a needle aspiration technique rather than an indwelling catheter. In the more recent series,^{4,24-27} the use of echocardiography prior to pericardiocentesis is routine. For these series, the rates of failure to aspirate an effusion are less than 10%, emphasising the importance of this investigation. Two series involved the routine use of two-dimensional echocardiography to guide the insertion of the pericardial catheter, and drainage was successful in all 159 cases.^{4,24}

The main aim of pericardiocentesis is to remove pericardial fluid and relieve cardiac tamponade. However, simply removing fluid does not reverse the process which led to its accumulation. Our review of published series reveals that re-accumulation occurred in up to 77% of cases, but prolonged drainage via a pericardial catheter reduces the prevalence of re-accumulation to less than 25%.^{4,23-27} This variation in prevalence is due, in part, to differences in aetiology. For example, there were no cases of re-accumulation in the series of 29 pericardiocenteses for effusion following open heart surgery.²⁷ In contrast, 50% of the uraemic effusions recurred.^{17,19,20,22}

The rates of complications associated with pericardiocentesis range from 4-40% (table 2). However, for echocardiographically guided aspirations, the complication rate is only 4.4%.^{4,24} In the table, the complications resulting from pericardiocentesis are sub-divided into 'minor' and 'major' categories. Minor complications either required no additional treatment or were treated medically and had no sequelae. Major complications either required surgical treatment or cardiopulmonary resuscitation, or resulted in death.

There were 14 deaths amongst 716 pericardiocenteses. This gives an overall mortality rate of about 2%, although where echocardiography was used to guide aspiration there were no deaths following 159 aspirations.

Table 1 Prevalence of failed pericardiocentesis and re-accumulation of effusion following pericardiocentesis in published series

First author (ref)	Year of publication	Number of pericardiocenteses	Nonproductive aspiration (%)	Re-accumulation of effusion (%)
Bishop (15)	1956	40	no record	no record
Kilpatrick (7)	1965	20	0 (0)	no record
Fredriksen (16)	1971	21	0 (0)	4 (19)
Ribot (17)	1974	13	0 (0)	10 (77)
Pradham (18)	1976	5	0 (0)	3 (60)
Connors (19)	1976	10	3 (30)	5 (50)
Morin (20)	1976	6	0 (0)	4 (67)
Silverberg (21)	1977	21	0 (0)	6 (29)
Kwasnik (22)	1978	21	0 (0)	6 (29)
Krikorian (1)	1978	123	17 (14)	44 (36)
Wong (2)	1979	52	15 (29)	0 (0)
MacAlpin (23)	1980	12	3 (25)	0 (0)
Guberman (3)	1981	46	6 (13)	9 (20)
Callahan (4)*	1985	117	0 (0)	29 (25)
Kopecky (24)*	1986	42	0 (0)	6 (14)
Morgan (25)*	1989	46	4 (9)	1 (2)
Zahn (26)*	1992	41	1 (2)	3 (7)
Susini (27)*	1993	29	3 (10)	0 (0)
Ball (present)*	1997	51	2 (4)	8 (16)

*Studies using echocardiographic diagnosis and/or guidance and catheter drainage

Investigations for cardiac tamponade

- electrocardiography
- chest radiograph
- echocardiography
- (cardiac catheterisation)

Box 3

Management options

- percutaneous catheter drainage
- video-assisted thoracoscopy and drainage
- open surgical drainage (sternotomy/thoracotomy/subxiphoid)
- balloon pericardiotomy

Box 4

It should be noted that right ventricular puncture is not usually a fatal complication, and that the seven cases of right ventricular puncture precipitating severe cardiac tamponade and requiring surgical pericardiotomy occurred in series where echocardiographic diagnosis was not routine.^{1,18,19} None of these patients died. All other cases of myocardial puncture are listed among the minor complications, as none required any additional treatment. Myocardial puncture is the most common of the minor complications, although this occurs in only 2–7% of cases in recent series using echocardiographic diagnosis and

Table 2 Prevalence of complications in published series

First author (ref)	Number of complications (%)	Minor complications (n)	Major complications (n)
Bishop (15)	6 (15)	RV puncture (6)	none
Kilpatrick (7)	8 (40)	myocardial puncture (7)	death (1)
Fredriksen (16)	3 (14)	RA puncture (1)	none
		RV puncture (2)	
Ribot (17)	2 (15)	none	death (2)
Pradham (18)	1 (20)	none	RV puncture requiring surgery (1)
Connors (19)	2 (20)	none	RV laceration requiring surgery (2)
Morin (20)	2 (33)	none	death (2)
Silverberg (21)	1 (5)	none	cardiac arrest (1)
Kwasnik (22)	5 (24)	myocardial puncture (2)	
		pneumoperitoneum (1)	none
		pneumothorax (1)	
		costochondritis (1)	
Krikorian (1)	11 (9)	VT (1)	myocardial puncture requiring surgery (4)
		myocardial puncture (1)	death (5)
Wong (2)	8 (15)	vasovagal reactions (?)	death (1)
		RV puncture (5)	cardiac arrest (1)
		aspiration of subdiaphragmatic abscess (1)	
MacAlpin (23)	1 (8)	PUO (1)	none
Guberman (3)	3 (7)	RV puncture (1)	RV puncture and death (2)
Callahan (4)*	5 (4)	RV puncture (2)	none
		pneumothorax (1)	
		pneumopericardium (1)	
		vasovagal reaction (1)	
Kopecky (24)*	2 (5)	vasovagal reaction (1)	none
		Staph. pericarditis (1)	
Morgan (25)*	10 (22)	RA puncture (2)	none
		SVT (8)	
Zahn (26)*	4 (10)	myocardial puncture (2)	death (1)
		pneumopericardium (1)	
Susini (27)*	4 (14)	RV puncture (2)	none
		SVT (2)	
Ball (present)*	3 (6)	RA puncture (1)	none
		vasovagal reaction (1)	

Abbreviations: RA, right atrium; RV, right ventricle; VT, ventricular tachycardia; SVT, supraventricular tachycardia; PUO, pyrexia of unknown origin. *Studies using echocardiographic diagnosis and/or guidance and catheter drainage

Summary points

- cardiac tamponade requires prompt diagnosis and treatment. When suspected, echocardiography should be performed immediately to confirm the presence, and define the size and distribution of an effusion, in addition to its haemodynamic effects
- the subcostal echocardiographic view is important as it demonstrates the approach made by a percutaneous needle from the subxiphoid route
- high rates of morbidity and mortality in relation to pericardiocentesis result from a lack of echocardiographic diagnosis and guidance and the use of needle aspiration rather than catheter drainage
- if the effusion is small, loculated posteriorly, or contains a significant amount of thrombus, pericardiocentesis is unlikely to be successful and should not be attempted
- the use of a modified Seldinger technique, to insert a catheter into the pericardial space, and either echocardiographic or fluoroscopic guidance reduces the risk of myocardial puncture to less than 7%
- pericardial catheters allow prolonged drainage which reduces the risk of re-accumulation, the risk of re-accumulation depends on the aetiology of the effusion.
- percutaneous catheter pericardiocentesis is safe and effective resulting in successful aspiration in 97%, minor complications in only 8% and death in as few 0.3% of cases.

Box 5

catheter aspiration.^{4,24–27} In those series which differentiated, right ventricular puncture was more common than right atrial puncture as would be expected from the orientation of the heart in relation to the subxiphoid approach.

Special situations

OPEN HEART SURGERY

Cardiac tamponade occurring within 24 hours of open heart surgery is managed by open surgical drainage as it is essential to identify and treat sources of bleeding. This will usually require general anaesthesia and an approach through the original sternotomy or thoracotomy. It may be possible to drain the collection via a limited subxiphoid approach, opening only the lower end of the sternotomy but again this is often performed under general anaesthesia. However, later postoperative presentation can be treated safely and effectively by percutaneous pericardiocentesis.²⁸ Echocardiographic localisation is particularly important as these collections may either be loculated posteriorly or contain thrombus, both of which situations preclude percutaneous catheter drainage.

LOCULATED COLLECTIONS

Circumferential and anteriorly loculated collections may be drained percutaneously. However, the percutaneous approach should not be attempted for posteriorly loculated collections. These require open surgical drainage.

INFECTED COLLECTIONS

Infected effusions should always be drained by an open surgical approach to ensure complete drainage. In addition it may be necessary to perform a pericardiectomy to avoid the later development of restrictive pericarditis.

RECURRENT COLLECTIONS

Certain conditions predispose to recurrent pericardial collections. Malignant pericardial effusions commonly recur. In these situations, percutaneous drainage is initially effective but the benefit is shortlived and such patients are often referred for open surgical drainage with pericardiectomy or the excision of a pleuropericardial window. Unfortunately, the associated 30-day mortality is up to 60%.²⁹ Recently, the technique of video-assisted thoracoscopy has been used to allow effective surgical drainage without the need for a thoracotomy. However, both of these procedures require general anaesthesia. Percutaneous balloon pericardiotomy is a less invasive procedure which can be performed under local anaesthesia. A balloon dilating catheter is passed percutaneously via a subxiphoid approach. The balloon is dilated when it lies across the pericardium, producing a tear approximately 2 cm in diameter. This technique has been shown to have more prolonged efficacy than percutaneous catheter drainage without the risks of general anaesthesia and thoracotomy.³⁰

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