Subxiphoid Pericardiocentesis Guided by Contrast Two-dimensional Echocardiography in Cardiac Tamponade: Experience of 110 Consecutive Patients*

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Aims: We evaluated echo-guided pericardiocentesis with contrast study in cardiac tamponade management.

Patients and Methods: From 1982 to 1998 we performed pericardiocentesis in 110 patients (56 ± 14 years old). Sub-xiphoid approach was used in 109. Cardiac tamponade was idiopathic (n=16), secondary to malignant disease (n=50) and miscellaneous disorders (n=44).

Results: Pericardial fluid was bloody (n=75), serous (n=29) or turbid (n=6). Mean volume of fluid removed was 585 ± 370 ml. When prolonged drainage (60 ± 26 h) was used (n=41), total effusion volume was 850 ± 340 ml. Eleven deaths were observed during the early period following pericardiocentesis. No relation with procedure was demonstrated by autopsy in 10, and death always occurred in critically-ill patients (five malignant diseases, five cardiac ruptures and one septic shock). Other complications were: right ventricular puncture (n=11) with deleterious effect in one, vasovagal hypotension (n=6) and paroxysmal arrhythmia (n=6). Surgical drainage was mandatory in 19 patients. It had to be done as an emergency (within 6 h), because of failure of the procedure in four patients. In 14 patients without prolonged drainage a delayed surgical evacuation was indicated, because of persistent (n=3) or recurrent (n=11) cardiac tamponade. Only one surgical procedure was required after prolonged drainage.

Conclusions: Echo-guided pericardiocentesis with contrast study is an effective technique which reduces the risk of cardiac tamponade management. It should be considered in patients with critical haemodynamic condition or advanced malignancy, and in patients with poor short-term prognosis.

Key Words: Contrast echocardiography; Pericardiocentesis; Tamponade.

Introduction

Cardiac tamponade is a life-threatening condition. Once the diagnosis has been established immediate decompression is required, using either pericardiocentesis or surgical drainage. Pericardiocentesis, a method used successfully since 184011, is associated with a significant incidence of complications12. Accordingly, many authors have recommended direct surgical drainage3,4 but unfortunately this procedure is not totally innocuous5.

Echocardiography has become the technique of choice for the diagnosis of pericardial effusion, and thereby greatly facilitates the diagnosis of tamponade6. A-mode, M-mode7 and two-dimensional8,9 (2D) echocardiography have been used during pericardiocentesis to guide needle insertion and monitor fluid removal. Two-dimensional echocardiographic guidance has been reported to be a safe procedure with a low incidence of complications10-12. However, even with echocardiography localization of the needle tip is often uncertain, and when bloody fluid is withdrawn it is difficult to
distinguish a haemopericardium from an accidental puncture of a cardiac chamber. Opacification of the punctured cavity by an echographic contrast method allows the nature of this cavity to be instantly determined. Contrast studies during M-mode and 2D echocardiography appear to be useful in locating needle position. The purpose of this study is to report on our extended experience with contrast studies during pericardiocentesis in patients with clinical manifestations of cardiac tamponade.

Methods

Study Population

From April 1982 to September 1998, 110 consecutive patients (68 men, 42 women; mean age 56 ± 14 years old) were admitted to the intensive care unit with clinical signs of cardiac tamponade, i.e. presence of venous congestion or pulses paradoxus defined as an inspiratory decrease of systolic blood pressure greater than 10 mmHg associated with echocardiographic evidence of pericardial effusion. Tamponade was confirmed by M-mode and 2D echocardiographic examination (ATL Mark 500, ATL UM9 HDI, ATL HDI 3000, KONTRON Sigma 44), using the following criteria:

- presence of both anterior and posterior echo-free spaces;
- reduction in the mitral E to F slope;
- premature closure of aortic valve during inspiration;
- Compression of right ventricle at end inspiration;
- diastolic posterior motion of the anterior wall of the right ventricle;
- inspiratory reciprocal changes in the right-to-left ventricular dimension ratio and Doppler velocities and
- prolonged right to left atrial inversion.

Pericardial effusion was idiopathic (n=16) and secondary to malignancy (n=50), cardiac surgery (n=8), infection (n=8), radiotherapy (n=8), acute myocardial infarction (n=7), autoimmune disease (n=4) and chronic renal failure (n=3).

Procedure

Pericardiocentesis with contrast study was performed in the intensive coronary care unit, with continuous clinical, electrocardiographic and echocardiographic monitoring. Pericardial puncture was performed using the subxiphoid route in 109 patients and the left parasternal approach in one, according to a technique previously reported. The procedure was performed with patients in a slightly semi-seated position. Under local anaesthesia, an 18-gauge needle connected to a three-way stopcock was introduced subxiphoidally at the junction of the xiphoid with the left costal cartilages. The needle was then advanced towards the right shoulder with the tip bent downwards while gentle continuous suction was performed under continuous echocardiographic monitoring. Twenty to twenty-five ml of fluid returning from the pericardiocentesis needle was immediately discarded to alleviate the haemodynamic consequences of tamponade and was collected for bacteriological, chemical and cytological analyses. Then the emulsion of 9 ml of saline solution shaken with 1 ml of air was systematically injected through the needle while its position was monitored via ultrasonography.

After confirming the proper location, the syringe was removed from the needle and a curved guide-wire was advanced into the pericardial sac. A 6F multiple-hole, 30-cm-long catheter was then advanced by means of the guide-wire into the posterior pericardium and positioned as close as possible to the atroventricular junction. Continuous monitoring of the position of the catheter was obtained by 2D-echo imaging (apical four-chamber view or parasternal short- and long-axis views). For better identification of the catheter tip, small amounts of saline injection were repeatedly injected. When the correct position was demonstrated by the appearance of contrast material into the pericardial sac, evacuation was performed. Accidental entry into a cardiac chamber was signalled by the appearance of a cloud of echoes in this cavity. The needle was withdrawn immediately and reintroduced. In the case of prolonged drainage, a guide-wire was inserted through the plastic sheath, over which a short flexible catheter could be advanced, and held in position for a maximum period of 72 h. This catheter was connected to a closed drainage system. The correct position of the needle or of the catheter could thus be checked at any time by a new injection of contrast material. When prolonged drainage was used, the position of the catheter was checked on a chest radiograph.

Results

Clinical presentation of the patients was as follows: severe dyspnoea in 107, right-sided heart failure with tachycardia in 98, and marked hypotension in 73. A paradoxical pulse was found in 43 patients. The echocardiographic signs were: sinus tachycardia in 91 patients, supraventricular arrhythmia in seven and electrical alternation in 10.

In all patients, the pericardial effusion was demonstrated by the presence of an anterior and posterior echo-free space. End-diastolic and early-systolic right atrial compression were found in 97 patients, posterior diastolic movement of the anterior right ventricular wall in 83, reduction of the E-F slope (rate of diastolic mitral
valve closure) in 80, inspiratory reciprocal changes in the right-to-left ventricular ratio in 71, and premature closure of the aortic valve in 69. Doppler velocities analysis was recorded in most patients from 1988, and significant inspiratory changes of tricuspid, mitral or aortic flows were observed in 68 patients.

Pericardial contrast demonstrated immediate adequate needle positioning in 99 patients (Fig. 1). In 11 patients, contrast initially opacified the right ventricle (Fig. 2), and the needle could be correctly repositioned in all patients. Pericardiocentesis removed an average amount of pericardial fluid of 585 ± 370 ml. Bloody fluid was withdrawn in 75 patients, serous fluid in 29 and turbid fluid in six. In 95 patients, pericardial evaluation led to immediate disappearance of clinical and echocardiographic signs of cardiac tamponade. Chemical analysis always confirmed high protein content (45 ± 5 g/l). Cytological studies were uniformly negative in effusions unrelated to malignancy. When effusion was caused by or related to carcinoma, there were 27 positive (malignant or abnormal cells) and 23 negative studies. In 41 patients a prolonged drainage was used for a mean period of time of 60 ± 26 h, corresponding to a mean residual pericardial effusion of 340 ± 80 ml and to a mean pericardial effusion total volume of 850 ± 340 ml.

Partial failure of the procedure, defined by a removed volume smaller than 100 ml and non-disappearance of clinical and echocardiographic signs of cardiac tamponade, occurred in nine patients. In these patients cardiac tamponade was due to cardiac rupture following an acute myocardial infarction in six patients, and pericardial bands with loculated effusion in three. Five of these patients died before surgery could be performed (three with myocardial rupture and two with pericardial bands).

During the early period following pericardiocentesis (less than 24 h), 11 patients died. In six patients death occurred during puncture. In five patients post-mortem examination revealed partially thrombosed haemopericardium due to rupture of the left ventricular free wall in an infarcted zone. Three other patients had cardiac tumoral extension. One patient had a loculated...
pericardial effusion secondary to Hodgkin lymphoma. Another patient had purulent pericarditis: although pericardiocentesis relieved tamponade, the patient ultimately died several hours later from septic shock and autopsy excluded any causal relation of death with the procedure. The remaining patient with malignant pericardial effusion died suddenly: no cardiac chamber puncture during the contrast study was observed, but post-mortem examination was not available.

The observed complications were of three types. Accidental puncture of the right ventricle was demonstrated in 11 instances, as shown by the appearance of contrast into the right ventricular chamber (Fig. 2). There was no adverse haemodynamic effect in all patients but one, who required volume loading (with macromolecular infusion). Arrhythmias occurred in six patients, including supraventricular tachycardia in four patients, and an episode of non-sustained ventricular tachycardia in two patients without right ventricular puncture, and their reversal immediately followed mere displacement of the needle. No other therapeutic measure was required. Vasovagal hypotension was observed in six patients and did not give rise to a syncope.

A surgical drainage was mandatory in 19 patients. It had to be done on emergency (within 6 h), because of failure of the procedure in four patients: two with pericardial bands, one with left ventricular rupture after acute myocardial infarction, and one with haemostatic disorder. In 14 patients without prolonged drainage, a delayed surgical evacuation (48 h after the initial drainage) was indicated, because of persistent (n=3) or recurrent (n=11) cardiac tamponade. Only one surgical procedure was required after a prolonged drainage because of recurrent pericardial effusion with cardiac tamponade signs.

In spite of successful pericardiocentesis, at 1 month, nine patients died because of initial causal disease.

**Discussion**

Pericardiocentesis was introduced into medical practice in 1840 \[1\]. The subxiphoid approach was recommended by Martin in 1911 \[2\] to reduce the incidence of complications. It has been suggested that pericardiocentesis guided by echocardiography could improve the procedure. Initial studies were carried out using A-mode and M-mode monitoring, and the results were often unsuccessful because of lack of spatial orientation with this technique \[6,20\]. Two-dimensional echocardiography markedly improves spatial orientation possibilities \[8,29\]. Cikes \[29\] used a transducer fitted with a supporting guide for the puncture needle. This method requires the use of a special transducer, which must be sterilized, making manipulations difficult. In addition, when bloody fluid is removed, echocardiography cannot differentiate accidental puncture of a cardiac chamber from primary haemopericardium. The classical methods for distinguishing between these two possibilities, i.e. pH and haematocrit measurements \[15,30,31\] have obvious practical limitations. Contrast 2D echocardiography studies make up a major contribution to echo-guided pericardiocentesis using a standard equipment \[6,10,11,14\].

Our practice of pericardiocentesis largely relies on the subxiphoid approach. This classical route \[1\] has the main advantage of being associated with the lowest incidence of complications in cardiac tamponade \[11,32\]. To select the optimal pericardiocentesis entry site, other echo-guided routes have been suggested: the left parasternal approach (one case in our series), the anterior axillary window or the medioclavicular site. However, these approaches have been used in large pericardial effusion and not in cardiac tamponade, often associated with 'swinging heart' \[41\]. Our failure rate was 8.3%, and mainly depended on the cause of cardiac tamponade, which was secondary to ischaemic cardiac rupture in six patients and to loculated effusion in three patients. This failure rate was close to that reported by other investigators \[10,12,33\] and suggested that in these clinical settings echo-guided pericardiocentesis was a vain attempt. In contrast, in the majority of patients, contrast echo was very useful in recognizing either adequate pericardial or accidental right ventricular puncture. This was especially relevant when the fluid collected was haemorrhagic, because it excluded the contingency of accidental puncture of a cardiac chamber. The contrast echo proved to be superior to conventional 2D-echo for needle localization. With the latter techniques the needle tip could only be visualized in 56–75% of cases \[10,34,35\], while intrapericardial contrast showed adequate needle positioning or cardiac chamber puncture in all our patients.

Prolonged drainage attached to a closed system was performed in 41 patients, and remained in place for 48–72 h without complication. This technique allowed complete evacuation without additional surgical drainage, as reported by Callahan et al. \[31\]. Surgical drainage was mandatory in 19 patients. It had to be done as an emergency (within 6 h), because of failure of the procedure in four patients. In 14 patients pericardiocentesis relieved cardiac tamponade but had to be surgically completed because of effusion recurrence or incomplete evacuation. Incomplete evaluation (n=3) was related to the presence of pericardial bands or asymmetric effusion, namely after cardiac surgery. In these clinical settings contrast-echocardiography was especially useful in visualizing the heterogeneous distribution of contrast material within the pericardial sac. Only one surgical procedure was required after prolonged drainage.

In our study the 17.3% incidence of delayed surgical drainage or in emergency was lower than the 25% and 26% reported by Callahan et al. \[31\] and Martins et al. \[33\].

Pericardial puncture may induce arrhythmias through mechanical stimulation of the atrial or ventricular wall. Such accidents are, as a rule, without consequence, and regress following displacement of the needle \[12\], as in our study. The occurrence of premature ventricular contractions is usually considered to be a marker of ventricular...
Table 1. Major complications of pericardiocentesis in the different series.

<table>
<thead>
<tr>
<th>Author</th>
<th>n</th>
<th>Contrast study</th>
<th>Death during puncture</th>
<th>RVP (%)</th>
<th>Arrhythmia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callahan[11]</td>
<td>117</td>
<td>No</td>
<td>0 (0%)</td>
<td>2 (1.7%)</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Guberman[24]</td>
<td>56</td>
<td>No</td>
<td>1 (1.8%)</td>
<td>6 (11.7%)</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Chandraratna[31]</td>
<td>16</td>
<td>Yes</td>
<td>0 (0%)</td>
<td>3 (18.7%)</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Susini[32]</td>
<td>29</td>
<td>Yes</td>
<td>0 (0%)</td>
<td>2 (6.9%)</td>
<td>2 (6.9%)</td>
</tr>
<tr>
<td>Krikorian[37]</td>
<td>123</td>
<td>No</td>
<td>5 (4.1%)</td>
<td>11 (8.9%)</td>
<td>1 (0.8%)</td>
</tr>
<tr>
<td>Present study</td>
<td>110</td>
<td>Yes</td>
<td>6 (5.4%)</td>
<td>11 (10%)</td>
<td>6 (5.4%)</td>
</tr>
</tbody>
</table>

n = number of patients.
RVP = right ventricular puncture.

injury. In addition, cardiac puncture can be responsible for wall laceration and thereby be harmful because of adverse haemodynamic effects or coronary artery injury. It is worth noting that when pericardiocentesis was not guided by contrast echo, right ventricular puncture rate ranged 2–11%[11,24,36], while it was higher (7–19%) in those using contrast echocardiography[31,38] as in the present study (Table 1). The relatively higher incidence of ventricular puncture might be explained by the better sensitivity of the contrast method in detecting such a complication. Furthermore, in our study pericardial fluid was most often haemorrhagic and favoured pendular movements of the heart, and consequently stabbing by the puncture needle[31]. While the contrast method seems useful in assessing the true incidence of traumatic punctures, it does not allow its complete prevention. However, it does allow its immediate recognition and quick removal of the needle. Eleven patients died within the 24 h following the procedure. No relation with the puncture was found at autopsy in 10 patients. The remaining patient died suddenly, and although no traumatic puncture during the contrast study was identified, it could not be ruled out, since post-mortem examination was not available. Taking into account only immediate deaths, the mortality rate was less than 6%. However, on short-term it averaged 32% in the series of Guberman et al.[24] and 10% in the present study, depending on the cause of cardiac tamponade.

Several authors have questioned the usefulness of pericardiocentesis in establishing the aetiological diagnosis as compared to surgical drainage and tissue examination[2,3]. However, the rate of successful histological diagnosis was somewhat disappointing, since it ranged from 18 to 33%[40]. Although in our study pericardiocentesis was always carried out with a therapeutic purpose, the aetiological diagnosis of tamponade never required subsequent recourse to surgical biopsy.

Apart from classical surgical drainage, which is not entirely free from complications, two other procedures have been proposed: videosurgery[40] and percutaneous balloon pericardiectomy.[41-43] Videosurgery provides an excellent view of the thoracic cavity and allows selection of pericardial, pleural, pulmonary or mediastinal biopsy sites[40]. However, this technique requires a skilled physician and must be restricted to patients without tamponade or critical haemodynamic condition, because it requires general anaesthesia with lateral decubitus and left lung exclusion. Percutaneous balloon pericardiectomy[41-43] is an effective technique, but its success criterion is the occurrence of a pleural effusion, often large, and is complication rate is high (40%).

**Conclusions**

- Echo-guided pericardiocentesis using the subxiphoid approach is a safe and effective technique for cardiac tamponade management.
- Percutaneous contrast injection is a convenient means to localize the needle tip.
- Prolonged pericardial drainage allows more complete fluid evacuation and thereby limited indication to surgical drainage.
- Echo-guided pericardiocentesis is the treatment of choice, as an emergency in patients with critical haemodynamic condition or advanced malignancy.

**References**

Echo-guided Pericardiocentesis in Cardiac Tamponade


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