Original research article

Pericardiocentesis guided by echocardiography performed in echocardiography laboratory – Safety profile of the single center prospective registry

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ABSTRACT

Introduction: Pericardiocentesis is an invasive procedure for treatment of large pericardial effusion or cardiac tamponade and for diagnostics of pericardial effusion of unknown origin. Fluoroscopy navigation has been the preferred method during the last decades. Nevertheless, new imaging methods such as echocardiography emerged as an alternative guiding method for pericardiocentesis. These methods may improve safety of the procedure.

Methods: All consecutive pericardiocenteses performed in noninvasive cardiology department of a tertiary cardiovascular center during the period between 1998 and 2012 were prospectively recorded. We focused on the procedural safety and procedural success rate.

Results: During a 15-year period, 253 pericardiocenteses were performed in 185 patients. Most of the procedures (240 cases) were performed under echocardiographic control in our noninvasive cardiology laboratory under strictly sterile conditions and with equipment for cardiopulmonary resuscitation on site. Etiology of effusion was heart transplantation in 38 patients (25%), postoperative in 20 patients (14%), infective pericarditis in 25 patients (16%), malignancy in 18 patients (12%), and invasive procedures in 19 patients (8%). Apical approach was the most frequent in 218 patients (92%), parasternal in 13 patients (5%) and subxiphoid in 7 patients (3%). The procedural success rate was 97% overall, with a total complication rate of 3% (2 major complications (0.3%; 7 minor complications (2.7%). Minor complications included 2 cases of small pneumothorax, 2 cases of pericardial fluid drainage into pleural space, 2 cases of transient right chamber entries, and in 1 case the procedure was complicated by hemopericardium without the need for surgical management. Major complications included 2 cases due to ventricular perforation, one with left ventricle wall laceration in a loculated effusion and one complication due to right ventricular laceration, both resulting in hemopericardium and requiring emergency surgical repair.

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Conclusion: Echocardiography-guided pericardiocentesis performed by echocardiologists in noninvasive cardiology department under strictly sterile conditions and with equipment for cardiopulmonary resuscitation is a safe procedure with infrequent complications. Apical entry site is safe and the dominant approach for pericardiocentesis under echocardiographic navigation.

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Introduction

Pericardial effusion is defined as a presence of abnormal accumulation of fluid in the pericardial cavity either as an incidental finding or a manifestation of cardiac as well as systemic disease. Cardiac tamponade is a clinical syndrome resulting from increase of pericardial pressure, and chamber compression leading to hemodynamic compromise [1]. The clinical presentation of pericardial effusion depends on the speed of pericardial fluid accumulation and pericardial compliance. In slowly accumulated pericardial fluid, as in chronic cardiac or systemic disease, the pericardium stretches allowing accumulation of significant amount of pericardial fluid, till 1.5–2L, without the manifestation of cardiac tamponade [2–4]. Pericardial tamponade is a life-threatening medical emergency with serous hemodynamic impact including shock, and death, which requires urgent management. Pericardiocentesis is an invasive procedure for treatment of large pericardial effusion or cardiac tamponade and for diagnostic purposes. Blind pericardial aspiration via a subxiphoid approach is advisable only as an emergency procedure as it may be associated by high complication rate with recorded mortality and morbidity rates of 6% [5,6]. Fluoroscopy navigation has been the preferred method during the past decades. Currently, 2-dimensional echo-guided pericardiocentesis appears to be an alternative technique for guidance of pericardiocentesis [6–10].

Methods

We evaluated our single center experience with echocardiographically guided pericardiocentesis performed in noninvasive cardiology department. All pericardiocenteses guided by 2-dimensional echocardiography performed in our noninvasive cardiology department were prospectively recorded in the period between 1998 and 2012. The main focus was on efficacy and safety of the procedure with evaluation of procedural complications.

Echocardiographic evaluation

All pericardiocenteses were performed by 15 participating echocardiologists under strictly sterile conditions and with equipment for cardiopulmonary resuscitation on site. All procedures were guided by echocardiography; no fluoroscopy for navigation was used. Standard 2-dimensional echocardiographic images with commercially available equipment were obtained (Image point – Hewlett Packard, Accuson Soquoia 512, Vivid i, Vivid 5, Vivid 7 – General Electric). Right atrial systolic collapse (>1/3 of systole duration), diastolic chamber compression or collapse of right ventricle, inferior vena cava plethora (inspiratory decrease of diameter by <50%) [11], and respiratory variation of mitral and tricuspid inflow velocities were used to evaluate the hemodynamic impact of pericardial effusion [11–16]. Mitral and tricuspid valve velocities were obtained by using PW Doppler ultrasound by placing the sample volume on the tip of the leaflets to record antegrade flow. The cut-off value of >25% was considered as sign of hemodynamically significant pericardial effusion [15].

Pericardiocentesis

The location, distribution, and the ideal entry site were determined first by echocardiography [17]. After local infiltration with lidocaine, a needle (16–18 gauge) was introduced and by reaching the pericardial fluid a guidewire was inserted into the pericardium. After dilation of the puncture site with a dilator, the catheter was then inserted and the guidewire withdrawn. Drainage was performed by large volume syringe until the pericardial sac was nearly emptied. In some patients the pericardial catheter was left for complete drainage and was removed once the amount of fluid drained was <30 ml/24 h and follow-up echocardiography showed no significant residual effusion. Pericardiocentesis was considered successful if the pericardial fluid was drained with relief of symptoms of tamponade. Minor complication is an event requiring noninvasive monitoring only. Major complication is considered as an undesirable event occurring as a result of pericardiocentesis that required invasive intervention such as need for emergency surgery or pleural drainage. Procedural complications were evaluated till hospital discharge. Patients on anticoagulation therapy on admission with hemodynamic stability were managed after the decrease of INR <2.

Definitions

Large pericardial effusion was defined as echocardiographically free space of >10 mm [18]. Recurrence was defined as any accumulation of fluid within 21 days requiring repetition of pericardiocentesis. Large symptomatic effusions including those with hemodynamic collapse were considered as clinically significant; effusions with hemodynamic collapse were accompanied by hypotension (<90 mmHg) and/or requiring vasopressors. Emergent pericardiocentesis was a procedure performed in patients with hemodynamic collapse immediately after echocardiographic diagnosis in the emergency department,
otherwise the procedure was performed within 90 min after the diagnosis of symptomatic effusion and performing blood tests.

**Statistical analysis**

Descriptive results were reported as mean ± standard deviation (SD), median with range or as frequency percentages. Statistical analysis was performed by program Statistica version 10.

**Results**

During a 15-year period, 253 pericardiocenteses were performed in 185 patients, 83 (32%) female and 170 (67%) male patients, with a mean age of 55 ± 14.9 years. The main symptoms of patients were malaise and exertional dyspnea in 82%, hypotension in 30 patients (13%), and tachycardia in 60 patients (26%).

In our cohort the etiology of effusion accounted for previous heart transplantation in 44 patients (28%), malignancy in 21 patients (13%) mostly due to bronchogenic cancer (11 cases) and in sporadic cases due to lymphoma, gastric cancer, renal adenocarcinoma and breast cancer. Postoperative etiology was in 31 patients (14%), previous invasive procedure (after pacemaker implantations and electrode perforations in 8 cases, after endomyocardial biopsy in 2 cases and due to perforated coronary sinus in 1 case during right heart catheterization) in 18 patients (8%), pericarditis in 33 patients (11%), and chronic renal disease in 10 patients (6%); in 28 patients the etiology was unspecified (Graph 1).

The effusion was large (echocardiographically defined as >10 mm echo free space) in 213 cases (86%), from which 195 cases (92%) had circumferential distribution, and loculated distribution in 4 cases (1%). The mean volume of effusion was 842 ± 504 ml. Color of the effusions was bloody in 130 cases (53%), serosanguineous in 28 cases (12%), and serous in 94 cases (36%).

The apical entry site was the most frequent in 218 patients (92%), parasternal in 13 patients (5%), subxiphoideal in 7 patients (3%) and in 15 patients (6%) the entry site was unspecified (Table 2).

There were 28 patients (11%) on anticoagulation therapy on admission, 97 patients (38%) with acetylsalicylic acid, and 2 patients on dual antiaggregation therapy.

### Table 1 – Patient characteristics, etiology, and hemodynamic status.

<table>
<thead>
<tr>
<th>Characteristics of patients</th>
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</thead>
<tbody>
<tr>
<td>Total number of patients</td>
<td>185</td>
</tr>
<tr>
<td>Mean age ± SD (years)</td>
<td>56 ± 15</td>
</tr>
<tr>
<td>Male, no. (%)</td>
<td>170 (67%)</td>
</tr>
<tr>
<td>Female, no. (%)</td>
<td>83 (32%)</td>
</tr>
<tr>
<td>Total number of procedures</td>
<td>253</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Etiology of pericardial effusion, no. (%)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Malignancy</td>
<td>21 (13%)</td>
</tr>
<tr>
<td>Postoperative</td>
<td>31 (20%)</td>
</tr>
<tr>
<td>Pericarditis</td>
<td>33 (21%)</td>
</tr>
<tr>
<td>Heart transplantation</td>
<td>44 (28%)</td>
</tr>
<tr>
<td>Invasive procedures</td>
<td>18 (11%)</td>
</tr>
<tr>
<td>Others</td>
<td>10 (6%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hemodynamic status, no. (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Echocardiographic signs of tamponade</td>
<td>102 (46%)</td>
</tr>
<tr>
<td>Without clinical and echocardiographic</td>
<td>109 (50%)</td>
</tr>
<tr>
<td>signs of tamponade</td>
<td></td>
</tr>
<tr>
<td>Clinical tamponade</td>
<td>59 (28%)</td>
</tr>
<tr>
<td>Hemodynamic collapse</td>
<td>30 (13%)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Antithrombotic therapy, no. (%)</th>
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<tbody>
<tr>
<td>Anticoagulation</td>
<td>28 (11%)</td>
</tr>
<tr>
<td>Acetylsalicylic acid</td>
<td>97 (38%)</td>
</tr>
<tr>
<td>Dual antiplatelet therapy</td>
<td>2 (1%)</td>
</tr>
</tbody>
</table>

In our study the echocardiographic tamponade was reported in 102 patients (46%), clinical tamponade in 59 patients (25%), and hemodynamic collapse accounting for in 30 patients (13%). There were 109 patients (50%) with large pericardial effusion without clinical and echocardiographic signs of tamponade (Table 1). The sensitivity of echocardiography for clinical tamponade was 77% with a specificity of 65%. The negative predictive value was 89% with a positive predictive value around 45%.

We report 62 patients (33%) who required further pericardiocentesis during 21 days of follow-up. According to the etiology of effusion, 24 patients (38%) had a recent history of heart transplantation, 14 patients (22%) underwent cardiac surgery recently, malignancy was documented in 6 patients (9%), 21 patients (33%) were diagnosed with pericarditis, and in 6 patients (9%) the etiology was not documented.

### Table 2 – Echocardiographic characteristics of pericardial effusion and entry sites.

<table>
<thead>
<tr>
<th>Distribution of effusion, no. (%)</th>
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<tbody>
<tr>
<td>Circumferential</td>
<td>195 (92%)</td>
</tr>
<tr>
<td>Loculated</td>
<td>4 (0.5%)</td>
</tr>
<tr>
<td>Not specified</td>
<td>36 (14%)</td>
</tr>
</tbody>
</table>

| Volume of effusion (mean ± SD)            | 842 ± 504 ml |

<table>
<thead>
<tr>
<th>Appearance of effusion, no. (%)</th>
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<tbody>
<tr>
<td>Bloody</td>
<td>130 (53%)</td>
</tr>
<tr>
<td>Serosanguine</td>
<td>28 (12%)</td>
</tr>
<tr>
<td>Serous</td>
<td>94 (36%)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Entry site, no. (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Para-apical</td>
<td>218 (92%)</td>
</tr>
<tr>
<td>Parasternal</td>
<td>13 (5%)</td>
</tr>
<tr>
<td>Subxiphoideal</td>
<td>7 (3%)</td>
</tr>
<tr>
<td>Unspecified</td>
<td>15 (6%)</td>
</tr>
</tbody>
</table>
Surgical management was considered in 11 patients (4%) due to the recurrence of large pericardial effusion requiring repeated pericardiocentesis. In our study the procedural success rate was 97% overall, with a total complication rate of 3% (2 major complications (0.3%); 7 minor complications (2.7%). Minor complications included 2 cases of small pneumothorax, 2 cases of pericardial fluid drainage into pleural space, transient right chamber entries in 2 patients, and in 1 patient the procedure was complicated by hemopericardium due to anticoagulation therapy without the need for surgical management. Major complications included 2 cases due to ventricular perforation, one with left ventricle wall laceration in a loculated effusion and one complication due to right ventricular perforation, both resulting in hemopericardium and requiring emergency surgical repair.

**Discussion**

Cardiac tamponade is curable, but when unrecognized it might result in cardiogenic shock with high risk of mortality [19]. The predominant clinical signs of patients in our cohort who presented with tamponade were exertional dyspnea 89% and tachycardia 26%.

Large effusions, defined as echocardiographically >10 mm, accounted for 86%, mostly with circumferential distribution 92%. Echo-guided pericardiocentesis can be performed by subxiphoid and chest wall approaches. In the present study, the apical approach was preferred in most patients due to dominant circumferential distribution of the effusion.

Concerning the etiology, pericardial effusion due to heart transplantation, pericarditis and postoperative were the leading causes accounting for 28%, 21% and 20% respectively. Moderate to large effusions in the setting of orthotopic heart transplantation have been reported in earlier studies in about 20% of patients within the first 3 months [20,21], however the majority usually resolve within 3 months [22]. In our cohort, pericardial effusion after heart transplantation was diagnosed during echocardiography follow-up during hospitalization. The average time between transplantation and pericardiocentesis was 42 days. Potential mechanisms of pericardial effusion in the early phase are autoimmune reaction or postpericardiotomy syndrome; lately pericardial perfusion is usually due to transplant rejection. Pericardiocentesis was performed only when these effusions were symptomatic with tendency for progression to larger sizes (>15 mm).

In patients on anticoagulation therapy and without signs of hemodynamic compromise, the intervention was postponed until the INR decreased (INR <2). In 4 patients with INR 2–3, the procedure was performed due to hemodynamic collapse without further complications.

The mere presence of pericardial effusion does not define clinical tamponade. Echocardiography is a sensitive and available diagnostic tool for detecting pericardial effusion and determining findings suggestive for tamponade physiology [11,13–16,23,24].

We reported 102 patients (46%) with echocardiographic tamponade and 59 patients (25%) with clinical tamponade, and hemodynamic collapse accounting for in 30 patients (13%). Cardiac tamponade is a continuum of hemodynamic effects; the echocardiographic findings in our cohort are sensitive with lower specificity, which may overdiagnose cardiac tamponade in patients with slight evidence of hemodynamic compromise [24–26].

All pericardiocenteses performed were successful for relieving tamponade in most patients with a success rate of 97% and a total complication rate of 3% (minor 2.7%, major 0.3%). Minor complications included small pneumothorax noted on radiographs in 2 patients which resolved spontaneously. Perforation of the pleura with partial drainage of the pericardial fluid into the pleural cavity was detected in 2 cases and was managed by repeated pericardiocentesis, which was successful. Transient right chamber laceration was in 2 patients without significant progression of pericardial effusion and the need for invasive treatment. One patient developed hemopericardium due to anticoagulation therapy applied after the procedure and was managed by further aspiration from the pericardial catheter.

Concerning major complications, 1 case with a loculated effusion on anterolateral left ventricular wall with signs of organization results in worsening of pericardial effusion due to transient chamber entry and the second case was nonfatal complication due to right ventricle perforation resulting in hemopericardium, both cases required surgical management. Both patients survived without further complications or recurrence of effusion. No death occurred as a result of pericardiocentesis.

These results in our cohort regarding safety of echo-guided pericardiocentesis are consistent with the findings of other investigators [10]. Using these inclusion criteria, this study is unique by providing clear evidence of the safety of the procedure performed in noninvasive cardiology department with equipment of cardiopulmonary resuscitation on board and without fluoroscopy.

**Limitations**

The main limitation of our prospective registry is the absence of a control group which is the reason we can not calculate the sensitivity and specificity of various echocardiographic signs of tamponade. The strength of this evaluation is by utilizing the data from our prospective registry of consecutive echo-guided pericardiocenteses with around 95% follow-up till hospital discharge.

**Conclusion**

Echo-guided pericardiocentesis, performed in noninvasive cardiology department, under strictly sterile conditions and with equipment for cardiopulmonary resuscitation on board, is a safe procedure with infrequent complications. Apical entry is safe and the dominant approach for pericardiocentesis under echocardiographic navigation [10,19]. Echocardiography is a sensitive and available diagnostic tool for detecting pericardial effusion and determining its hemodynamic impact. Increased safety and markedly lower cost compared
with surgery ensure that echo-guided pericardiocentesis is a procedure of choice.

**Conflict of interest**

None declared.

**Ethical statement**

The work described in this case report was done according to ethical standards.

**Funding body**

None.

**Informed consent**

All patients have signed informed consent before performing pericardiocentesis.

**Further reading**

[27–32].

**References**


