Consecutive 1127 Therapeutic Echocardiographically Guided Pericardiocenteses: Clinical Profile, Practice Patterns, and Outcomes Spanning 21 Years

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- **Objectives:** To evaluate consecutive therapeutic echocardiographically (echo)-guided pericardiocenteses performed at Mayo Clinic, Rochester, Minn, from 1979 to 2000 and to determine whether patient profiles, practice patterns, and outcomes have changed over time.
- **Patients and Methods:** Consecutive echo-guided pericardiocenteses performed between February 1, 1979, and January 31, 2000, for treatment of clinically significant pericardial effusions were identified in the Mayo Clinic Echocardiographic-guided Pericardiocentesis Registry. The medical records of these patients were examined, and a follow-up survey was conducted. Clinical profiles, echocardiographic findings, procedural details, and outcomes were determined for 3 periods: February 1, 1979, through January 31, 1986; February 1, 1986, through January 31, 1993; and February 1, 1993, through January 31, 2000.
- **Results:** During the 21-year study period, 1127 therapeutic echo-guided pericardiocenteses were performed in 977 patients. The mean ± SD age at pericardiocentesis increased from 49 ± 14 years in period 1 to 57 ± 14 years in period 3. In recent years, cardiothoracic surgery replaced malignancy as the leading cause of an effusion requiring pericardiocentesis and together with malignancy and perforation from catheter-based procedures accounted for nearly 70% of all pericardiocenteses performed. The procedural success rate was 97% overall, with a total complication rate of 4.7% (major, 1.2%; minor, 3.5%). These rates did not change significantly over time. The use of a pericardial catheter for extended drainage increased from 23% in period 1 to 75% in period 3 (P < 0.001), whereas rates of effusion recurrence and pericardial surgery decreased significantly (P < 0.001).
- **Conclusions:** The profile of patients presenting with clinically significant pericardial effusion has changed over time. Increasing numbers of older patients and those who have undergone cardiothoracic surgery or catheter-based procedures develop effusions that can be rapidly, safely, and effectively managed with echo-guided pericardiocentesis. Extended drainage with use of a pericardial catheter has become standard practice, and concomitantly, recurrence rates and need for surgical management have decreased considerably.


CI = confidence interval; HR = hazard ratio

Using percutaneous pericardiocentesis for treating pericardial effusion dates back to the early 18th century. Historically, this was performed as a blind procedure and was associated with a high complication rate. The development of 2-dimensional echocardiography in the 1970s allowed confirmation of the presence and accurate localization of the fluid and substantially enhanced the safety of percutaneous pericardiocentesis. The early experience of echocardiographically (echo)-guided pericardiocentesis at the Mayo Clinic has been published. The procedure was simple, safe, and effective for immediate relief of pericardial fluid and tamponade but was not regarded as definitive treatment because of high rates of recurrence. Extended catheter drainage was incorporated into the original echo-guided pericardiocentesis procedure in an attempt to reduce recurrence. The safety of this practice, based on the initial 42 cases at Mayo Clinic, Rochester, Minn, has been reported.

We conducted a comprehensive follow-up study of all therapeutic echo-guided pericardiocenteses performed at Mayo Clinic, Rochester, Minn, since February 1979. The objectives were to evaluate the experience of this treatment modality in its entirety and to determine whether the patient population, practice patterns, and outcomes have changed over time.

**PATIENTS AND METHODS**

**Data Collection**

With approval from the Institutional Review Board, we examined the Mayo Clinic Echocardiographic-guided Pericardiocentesis Registry. The study population included a...
total of 977 consecutive patients who underwent 1127 therapeutic echo-guided pericardiocenteses between February 1, 1979, and January 31, 2000, for treatment of clinically significant pericardial effusions, defined as hemodynamically significant, symptomatic, and/or large effusions. Thirteen patients (8 men and 5 women) were excluded because they had not given permission for use of their records for research purposes.

Clinical characteristics, procedural details, and outcomes of interest, including success and complications, effusion recurrence, and survival, were determined. Records from the Echocardiographic-guided Pericardiocentesis Registry, Mayo Clinic charts, and available external records were reviewed. For each patient identified in the registry as having undergone pericardiocentesis with echocardiographic guidance, data with respect to clinical presentation, etiology and characteristics of the effusion, echocardiographic findings, adjunctive or surgical procedures used, and outcomes including success and complications, effusion recurrence, and survival were abstracted from the medical record. In cases in which there was inadequate follow-up data for at least 6 months after pericardiocentesis, patients or their next of kin (202 of 1127 cases (18%)) were surveyed. The survey questions were limited to vital status, whether the patient had experienced any recurrence of a pericardial effusion, and, if so, how the effusion was managed. For all deceased patients, the cause of death was obtained from the medical record, if the information was available, or from the death certificate. We were unable to contact patients (or next of kin) in 13 cases.

Procedures and Techniques

For all pericardiocentesis procedures, standard 2-dimensional echocardiographic images were obtained with commercially available equipment. Doppler assessment with a respirometer for evaluating the hemodynamic consequences of pericardial effusions was initiated in 1987. In emergency situations, the echocardiographic study was abbreviated to provide essential information for rapid management decisions.

Large or symptomatic effusions, or effusions accompanied by tamponade physiology, were considered "clinically significant." An effusion was classified as large if it was qualitatively described as such based on 2-dimensional echocardiographic findings and/or if more than 400 mL of fluid was obtained by initial aspiration. Medium-sized effusions were those that were qualitatively described as such and/or if the volume obtained on initial aspiration was between 100 and 400 mL. Emergency procedures were those performed immediately after diagnostic echocardiographic studies.

All echo-guided pericardiocentesis procedures were supervised by experienced echocardiologists. The location and distribution of the pericardial effusion were confirmed by 2-dimensional echocardiography, and the ideal entry site (the point at which the distance from skin to maximal fluid accumulation is minimized, with no intervening vital organs) was identified. Once the polyethylene-sheathed needle was entered into the pericardial space, the steel needle core was withdrawn, and the sheath was advanced. Continuous visualization of the needle tip by echocardiography during the procedure was unnecessary and often not possible. However, the sheath position was readily confirmed by injecting a small amount of agitated saline, a procedure that was performed routinely and invariably when bloody fluid was withdrawn.

Extended catheter drainage referred to placement of a pericardial catheter for intermittent drainage until the fluid return had decreased substantially. When extended catheter drainage was desired, a standard dilator and an introducer sheath (5-8F) were advanced over a guidewire. The guidewire was withdrawn, and a pigtail angiographic catheter (60-65 cm) was then inserted through the sheath. The effusion was initially drained completely, as assessed by repeated echocardiography. Subsequently, intermittent aspirations were performed as clinically indicated, usually every 4 to 6 hours, until the fluid return over a 24-hour period had decreased to less than 25 mL and follow-up 2-dimensional echocardiographic assessment was satisfactory.

Sclerotherapy, if selected as adjunctive therapy, typically was performed with use of tetracycline hydrochloride (250-1000 mg) dissolved in normal saline (10-25 mL) and instilled through the pigtail catheter. The catheter was then clamped and drained every 6 hours. This procedure was repeated every 1 to 2 days until the drainage decreased to less than 25 mL in a 24-hour period. In 1996, the Food and Drug Administration withdrew the approval for use of tetracycline for sclerotherapy.

Surgical decompression procedures, including pericardiectomy (complete or partial), pericardial window, and evacuation of effusion or hematoma, were performed according to standard techniques at the time.

Outcomes

Outcomes of interest included procedural success, major and minor complications, effusion recurrence, and survival. Pericardiocentesis was considered successful if the pericardial space was entered and fluid was drained with relief of tamponade. Major complications included any undesirable events occurring as a result of pericardiocentesis that required intervention. Minor complications were those that required no management, except appropriate monitoring and follow-up. Recurrence was defined as
reaccumulation of fluid requiring intervention and was further categorized as to whether it occurred within or beyond 90 days of the initial pericardiocentesis.

**Statistical Analyses**

For purposes of analyses, procedures performed during the 21-year study period were divided into three 7-year periods (period 1, February 1979-January 1986; period 2, February 1986-January 1993; period 3, February 1993-January 2000) based on the date of pericardiocentesis. Continuous variables were expressed as absolute numbers, percent, mean ± SE, or median and range when applicable. Logistic or linear regression analyses were used to test for significance of trends over time. Univariate analyses were performed to evaluate the contribution of each relevant variable independently, and those found to be significant were entered into a Cox regression model in which selection of variables was achieved in a stepwise fashion. Kaplan-Meier analysis of recurrence-free survival, stratified by the 3 periods, was displayed in graphics. Hazards ratios (HRs) with 95% confidence intervals (CIs) were provided when appropriate. All P values were 2-tailed, and \( P<.05 \) was considered statistically significant.

**RESULTS**

**Baseline and Echocardiographic Characteristics**

Between February 1, 1979, and January 31, 2000, 1127 consecutive echo-guided pericardiocenteses were performed in 977 patients. Of these procedures, 623 (55.3%) were performed in male patients. The mean ± SD age for the overall cohort was 54±14 years. Complete follow-up was achieved in 964 patients (98.7%). The mean ± SD follow-up time for the population was 3.8±4.5 years (range, 184 days to 19.8 years). From period 1 to period 3, the proportion of patients age 65 years or older increased significantly (Table 1).

Of the etiology of effusions, there was a significant increase over time in the proportion of cases that were postoperative (\( P=.02 \)) and secondary to cardiac perforation from catheter-based procedures (\( P<.001 \)).

Echocardiographically, tamponade physiology associated with an effusion that was not considered large has become an increasingly common finding at the time of pericardiocentesis (Table 2). In recent years, procedures were more likely to be performed on an emergency basis. Most notably, the likelihood of pericardial catheter use with the initial pericardiocentesis as part of the primary
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<tr>
<td>Circumferential</td>
<td>176 (80)</td>
<td>328 (80)</td>
<td>412 (83)</td>
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<tr>
<td>Loculated</td>
<td>33 (15)</td>
<td>71 (17)</td>
<td>57 (12)</td>
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<td>Not specified</td>
<td>12 (5)</td>
<td>12 (3)</td>
<td>25 (5)</td>
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<td>Size of effusion, No. (%)</td>
<td></td>
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<tr>
<td>Large, with tamponade</td>
<td>73 (33)</td>
<td>180 (44)</td>
<td>122 (25)</td>
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<td>Large, without tamponade</td>
<td>73 (33)</td>
<td>39 (9)</td>
<td>44 (9)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Not large, with tamponade</td>
<td>25 (11)</td>
<td>139 (34)</td>
<td>181 (37)</td>
<td>&lt;.001</td>
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<td>Color of effusion</td>
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<td>Bloody</td>
<td>106 (48)</td>
<td>193 (47)</td>
<td>250 (51)</td>
<td>.39</td>
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<td>Serosanguineous</td>
<td>61 (28)</td>
<td>119 (29)</td>
<td>109 (22)</td>
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<td>Serous</td>
<td>42 (19)</td>
<td>79 (19)</td>
<td>110 (22)</td>
<td>.24</td>
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<td>Other</td>
<td>12 (5)</td>
<td>21 (5)</td>
<td>25 (5)</td>
<td>.85</td>
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<td>Procedures performed on emergency basis, No. (%)</td>
<td>76 (34)</td>
<td>194 (47)</td>
<td>225 (46)</td>
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<td>Ideal entry site, No. (% of all entries)</td>
<td>Chest wall, No.</td>
<td>175 (79)</td>
<td>313 (76)</td>
<td>402 (81)</td>
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<td>Para-apical</td>
<td>147 (67)</td>
<td>257 (62)</td>
<td>310 (63)</td>
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<td>Left axillary</td>
<td>6 (3)</td>
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<td>Left parasternal</td>
<td>19 (9)</td>
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<td>Right parasternal</td>
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<td>1 (0)</td>
<td>2 (0)</td>
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<td>89 (22)</td>
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<td>Needle attempts, No. (%)</td>
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<td>199 (90)</td>
<td>366 (89)</td>
<td>436 (88)</td>
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<td>2</td>
<td>11 (5)</td>
<td>13 (3)</td>
<td>27 (5)</td>
<td>.55</td>
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<td>3</td>
<td>3 (1)</td>
<td>8 (2)</td>
<td>6 (1)</td>
<td>.72</td>
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<td>&gt;3 or unspecified</td>
<td>8 (4)</td>
<td>25 (6)</td>
<td>24 (5)</td>
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<td>Procedures using extended catheter drainage, No. (%)</td>
<td>50 (23)</td>
<td>220 (53)</td>
<td>370 (75)</td>
<td>&lt;.001</td>
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<td>Mean ± SD fluid volume initially withdrawn (mL)</td>
<td>451±323</td>
<td>463±347</td>
<td>495±396</td>
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<td>Mean ± SD fluid volume from extended drainage (mL)</td>
<td>386±479</td>
<td>216±341</td>
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<td>Mean ± SD duration of pericardial catheter drainage (d)</td>
<td>4.9±4.4</td>
<td>3.8±2.3</td>
<td>3.8±2.5</td>
<td>.05</td>
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Clinical Outcomes

Success and Complications of Pericardiocentesis.— Echo-guided pericardiocentesis was successful for withdrawing pericardial fluid and/or relieving tamponade in 97% (n=1097) of all procedures (Table 3). In 89% (n=1001) of the procedures, only 1 attempt at needle passage was necessary to gain access into the pericardial space (Table 2). Major and minor complication rates were similar across the 3 periods (Table 3). Throughout the 21-year period, a total of 14 major complications (1.2%) occurred.

These included the death of a 50-year-old woman with severe primary pulmonary hypertension who did not survive an attempted surgical rescue after a right ventricular puncture that led to hemorrhagic tamponade. Nonfatal complications included chamber lacerations requiring surgery (5), injury to an intercostal vessel necessitating surgery (1), pneumothoraces requiring chest tube placement (5), ventricular tachycardia (1), and bacteremia possibly related to pericardial catheter placement (1). A total of 40 minor complications (3.5%) occurred that required no specific interventions, except for monitoring and appropriate follow-up. These included transient chamber entries (11), small pneumothorax noted on radiographs (8), vagovagal response with transient decrease in blood pressure.
(2), nonsustained supraventricular tachycardia (2), pericardial catheter occlusion (8), and probable pleuropericardial fistulas (9).

**Recurrence of Effusion.**—In the current series, the recurrence rate within 6 months of the initial procedure was 27% for patients who underwent simple pericardiocentesis and 14% for those who had extended drainage ($P<.001$). The frequency of effusion recurrence leading to repeated pericardiocentesis or surgery decreased significantly over time ($P<.001$) (Table 3, Figure 1). The frequency of recourse to surgery as a primary treatment strategy or as a secondary procedure for management of recurrence decreased significantly over time ($P<.001$) (Table 3). Among the 158 patients who underwent pericardial surgery, 17 had effusive-constrictive disease. In univariate Cox regression analysis, significant correlates of recurrence included absence of extended catheter drainage, malignancy, positive cytology, large effusion, and renal failure. In multiple Cox regression modeling, absence of extended catheter drainage (HR, 2.62; 95% CI, 1.86-3.68; $P<.001$), malignancy with positive cytology (HR, 2.11; 95% CI, 1.47-3.05; $P<.001$), and large effusion (HR, 2.08; 95% CI, 1.44-3.00; $P<.001$) remained independently correlated with recurrence of effusion. The use of extended pericardial catheter drainage was the most significant variable in the model. Age, sex, hemodynamics at the time of pericardiocentesis, color of effusion, and whether the procedure was performed on an emergency basis were not associated with recurrence of effusion. Sclerotherapy, commonly used before 1993, was also not a significant predictor of recurrence by univariate or multivariate analyses. Corticosteroid use as concomitant therapy was more common in the first 7-year period. Its use, or the use of nonsteroidal anti-inflammatory agents, was also not predictive of recurrence.

**Survival.**—The mean ± SD follow-up time for the entire cohort was 3.8±4.5 years. A univariate Cox regression analysis identified age, malignancy, positive cytology, unstable presentation (clinical tamponade or hemodynamic collapse), renal failure, and emergency procedure as significant correlates of survival. In a multiple Cox regression analysis, age, malignant etiology, positive cytology, and renal failure (all $P<.001$) remained independently correlated with survival. Patients who developed a pericardial effusion in association with malignancy had an extremely poor prognosis, with a median survival of 134 days. Whether a pericardial catheter was used as a primary procedure or whether surgical management was involved did not correlate with survival.

**DISCUSSION**

**Changing Patient Profile**

Consistent with the growth of the older segment of the general population, the mean age at which the echo-guided pericardiocentesis was performed also increased over the 3 study periods. This may be a reflection of a greater number of adults with cancer who are surviving to be at risk of complications related to the disease, plus the growth in the use of coronary catheterization and percutaneous and surgical interventions in an expanding elderly patient population. Postoperative effusions, malignancy-related effusions, and effusions secondary to cardiac perforation associated with catheter-based procedures were the 3 most important causes of pericardial effusion leading to echo-guided pericardiocentesis in this series, accounting for nearly 70% of all the procedures performed. Of note, ma-
lignancy-related effusions, which were the most common etiology of effusion during the earliest period, were preceded by postoperative effusions in the most recent cohort. This likely reflects the increased number of surgical procedures performed for cardiovascular diseases over the years, a trend that is anticipated to continue with the growth of older age segments of the society.13

The number of pericardiocenteses performed for tamponade related to cardiac perforations secondary to catheter-based procedures increased significantly over the 21-year study period (Table 1). This occurred in the context of a marked increase in the performance of coronary angiography, percutaneous interventions for coronary artery disease, electrophysiologic studies, and ablation procedures during this time.14-16

Patients were more often confirmed to have echocardiographic and clinical evidence of tamponade in the latter part of the study period, and pericardiocentesis was more frequently performed on an emergency basis. Whether this reflects greater precision in the assessment of hemodynamics, with improved technology and use of Doppler echocardiography, or whether the acuity level actually has changed over the years could not be determined conclusively. It is well known that malignancy-related effusions generally develop insidiously, and the presentation of these patients is often inconsistent with classic overt clinical tamponade.17 In contrast, cardiac perforation secondary to catheter-based procedures, which was seen with increasing frequency over the years, generally presents acutely with marked hemodynamic compromise.18 Postoperative effusions may develop subacutely but generally become symptomatic within the initial months of surgery.19

Outcomes of Echo-Guided Pericardiocentesis

Success Rates and Complications.—The Mayo echo-guided pericardiocentesis technique was first reported as safe and effective in pilot studies in the early 1980s.20 In this follow-up series, the largest ever reported to our knowledge, echo-guided pericardiocentesis was confirmed to be safe and effective for treatment of clinically significant pericardial effusions. The procedural success rate was 97% (Table 3). The overall total complication rate of 4.7% (Table 3) was substantially lower than that reported for blind pericardiocenteses, for which morbidity approached 20%2 and mortality rates were as high as 6%.19,21

Recurrence of Pericardial Effusion.—Simple pericardiocentesis, without extended catheter drainage, has been associated with recurrence rates of up to 55%.22 In our study, the omission of extended catheter drainage was the single most important independent predictor of recurrence. The exact mechanism by which extended pericardial cath-

Figure 1. Recurrence-free survival, with use of Kaplan-Meier analysis, stratified by time (P<.001).
strategy; however, for malignant effusion, this approach was associated with a 60% recurrence rate. In balloon pericardiostomy, a tear of the pericardium is introduced with inflation of a balloon to allow fluid to be drained into the thoracic cavity or externally via a catheter. In a series involving 104 patients, the procedural success rate was 88%. However, 12% of the patients required further surgical treatment because of complications or recurrence of effusion. In addition, a significant number of patients required chest tube drainage of pleural effusion after the procedure.

**Practical Advantages of Echo-Guided Pericardiocentesis**

Echo-guided pericardiocentesis is well tolerated by patients, including children, and can be performed quickly even in unstable patients. Symptoms associated with the pericardial effusion are relieved rapidly. Pericardial catheters for extended drainage may remain in place without compromising patient mobility. The necessary equipment is widely available and portable, and the technique is adaptable to a broad spectrum of circumstances. Excellent results associated with emergency pericardiocenteses performed in critically unstable patients as a result of cardiac perforation during invasive cardiac procedures have been published. In carefully selected and stable patients, the procedure can be performed safely on an outpatient basis. For all these reasons, echo-guided pericardiocentesis appears to be a more practical and useful procedure than other reported percutaneous techniques.

There are some important differences between our technique and other percutaneous pericardiocentesis procedures. At the Mayo Clinic, a polytet-fsheathed needle was invariably used, minimizing risk of inadvertent perforations, and selection of the ideal entry site was determined strictly by 2-dimensional echocardiography. In our series, the chest wall was the preferred location in 79% of the cases, compared with the subcostal approach preferentially selected for other techniques.

**Limitations**

This retrospective study is subject to biases inherent to this design. However, this large consecutive series with nearly complete follow-up for all patients provides a comprehensive understanding of the characteristics of patients presenting with clinically significant pericardial effusions and the spectrum of both patient and procedure-related outcomes.

**CONCLUSIONS**

Over a 21-year period, the patient population presenting with clinically significant pericardial effusions has changed, with a shift toward an increasing proportion of older individuals. Pericardial effusions that develop postoperatively and secondary to cardiac perforation related to catheter-based procedures have become more common. Echo-guided pericardiocentesis is safe, and the rate of complications has remained stable despite the fact that a greater number of procedures have been performed on an emergency basis. Using a pericardial catheter for extended drainage has become essentially standard practice, and recurrence rates, as well as surgical treatment of pericardial effusions, have decreased considerably.

**REFERENCES**