Frequency and Predictors of Urgent Coronary Angiography in Patients With Acute Pericarditis

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OBJECTIVES: To determine the frequency of urgent coronary angiography in patients with acute pericarditis and to examine clinical characteristics associated with coronary angiography.

PATIENTS AND METHODS: This is a retrospective analysis of all incident cases of acute viral or idiopathic pericarditis evaluated at Mayo Clinic's site in Rochester, MN, between January 1, 2000, and December 31, 2006. The main outcome measures were use of urgent coronary angiography and rate of concomitant coronary artery disease in patients with pericarditis.

RESULTS: There were 238 patients with a final diagnosis of acute pericarditis (mean age, 47.7 ± 17.9 years; 157 [66.0%] were male). On the initial electrocardiogram, 146 patients (61.3%) had ST-segment elevation, and 92 (38.7%) had no ST-segment elevation. Coronary angiography was performed in 40 patients (16.8% of all patients); the frequency was 5-fold higher among those with ST-segment elevation (24.7% vs 4.3%; $P < .001$). Additionally, 7 patients (4.8%) with ST-segment elevation received thrombolytics before transfer to our institution; no patients without ST-segment elevation received thrombolysis ($P = .05$). Characteristics associated with a higher likelihood of coronary angiography included typical anginal chest pain, ST-segment elevation, previous percutaneous coronary intervention, elevated troponin T values, diaphoresis, and male sex. Coronary angiography revealed concomitant mild to moderate coronary artery disease in 14 (35.0%) of the 40 patients who underwent this procedure.

CONCLUSION: Urgent coronary angiography is commonly performed in patients with acute pericarditis, particularly those with ST-segment elevation, typical myocardial infarction symptoms, and elevated troponin T values. Coronary artery disease was present angiographically in one-third of patients undergoing the procedure. Although patients with ST-segment elevation myocardial infarction must receive prompt reperfusion, clinicians must also consider the diagnosis of pericarditis to avoid unneeded coronary angiography.

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CI = confidence interval; ECG = electrocardiogram; MI = myocardial infarction; OR = odds ratio; PCI = percutaneous coronary intervention

An emphasis on the prompt recognition of ST-segment elevation myocardial infarction (MI) and timely reperfusion has led to substantial improvement in post-MI outcomes. Rapid recognition and triage to the cardiac catheterization laboratory with correspondingly short "door-to-balloon" time has been shown to significantly improve survival in this setting.^{1,2} Several common nonischemic causes of ST-segment elevation present a diagnostic challenge to clinicians attempting to select the most appropriate management while avoiding unnecessary angiography.

Acute pericarditis classically presents with diffuse, up-sloping ST-segment elevation on an electrocardiogram (ECG) and may also be accompanied by elevation of cardiac biomarkers.³⁻⁵ These findings may be misinterpreted as evolving MI, leading to implementation of diagnostic and treatment pathways for acute MI.⁶ Interestingly, few data exist to describe the influences of ST-segment changes and other clinical manifestations of acute pericarditis on the initial diagnostic work-up and medical management. Previous studies have reported the use of thrombolytics for what was later determined to be pericarditis,^{7,8} and recent data indicate that patients with pericarditis make up a substantial portion of patients with presumed evolving MI who have no culprit lesion on coronary angiography.⁹ Although angiography is not warranted on the basis of suspected pericarditis, it may be necessary if clinical suspicion for MI remains high after the initial history, physical examination, and ECG.

Given that timely percutaneous coronary intervention (PCI) is the preferred mode of reperfusion therapy, coronary angiography may be performed in patients with pericarditis because there are common clinical elements in the presentation of these conditions. We examined all cases of acute viral or idiopathic pericarditis evaluated at Mayo Clinic's site in Rochester, MN, from January 2000 through December 2006. We hypothesized that diagnostic coronary angiography would be used commonly in this population and sought to determine the frequency of coexistent coronary artery disease when diagnostic angiography was performed. Therefore, we quantified the frequency of urgent coronary angiography and prehospital administration of thrombolytics in these patients. We also studied these patients' clinical, ECG, and laboratory findings to determine which variables were associated with performing coronary angiography.

For editorial comment, see page 5

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PATIENTS AND METHODS

Patients were retrospectively identified through a search of the Mayo Medical Index, which includes the electronic documentation of all clinical encounters during the period of interest, from January 1, 2000, through December 31, 2006. *Hospital Adaptation of the International Classification of Diseases*¹⁰ codes associated with pericarditis were used to detect incident cases of acute pericarditis. Of the 984 patients identified, 958 (97.4%) had given consent for use of their medical records in clinical research. The consenting patients' records were then reviewed for inclusion in the study. Adult patients with a clinical dismissal diagnosis of acute pericarditis of viral or idiopathic origin and ECG findings consistent with acute pericarditis⁴ were included, provided the patient had at least 1 ECG during the index clinical encounter and received care at Mayo Clinic's site in Rochester, MN. Included patients initially presented for evaluation at our facility or were transferred to our facility for further care. Cases excluded from these analyses included pericarditis after MI or pericardiotomy, cases due to misplaced device leads, and patients with a history of relapsing or constrictive pericarditis.

A total of 245 patients with a dismissal diagnosis of acute pericarditis met these requirements and were included in the analyses. This included both patients who were admitted to the hospital and patients who were treated in the emergency department and released for outpatient care. Chart abstractions detailed patients' medical histories, medical management on presentation to the hospital, findings reported on echocardiography or coronary angiography (or both), and follow-up care at Mayo Clinic. Seven patients with uninterpretable or inconclusive ECG findings (left bundle branch block or paced rhythm) were excluded from these analyses. The remaining patients were divided into 2 groups according to ECG findings: those with ST-segment elevation on the initial ECG and those without ST-segment elevation (patients with ST-segment depression, nonspecific ST-segment changes, or T-wave changes). The primary outcome measure was the frequency of coronary angiography on the day of hospital admission. The Mayo Clinic Institutional Review Board approved this study.

STATISTICAL ANALYSES

For descriptive purposes, categorical data were summarized as frequencies, and differences between groups were compared with χ^2 or Fisher exact test when the frequency in any given cell was less than 5. Continuous data were summarized as mean $\pm$ SD, and differences were compared using *t* tests. Univariable logistic regression was used to identify variables associated with an increased likelihood of coronary angiography, and results were summarized as

odds ratios (ORs). Two-sided $P < .05$ was considered statistically significant. Additionally, multivariable linear regression was used to assess the association between ST-segment elevation and coronary angiography, correcting for selected variables that differed between patients with and without ST-segment elevation. Because of the relatively small number of patients who underwent coronary angiography, our models were limited to 4 clinically significant variables that differed between the groups. Variables included in the model were sex, ST-segment elevation on the admission ECG, elevated levels of troponin T, and history of viral illness preceding development of chest pain. Statistical analyses were performed with JMP version 6.0.0 (SAS Institute, Cary, NC).

RESULTS

Of the 238 patients with acute pericarditis, 146 (61.3%) presented with ST-segment elevation, and 92 (38.7%) had no ST-segment elevation on their initial ECG. Patients' demographic and clinical characteristics, medications, and admission laboratory results are presented in Table 1. Patients were relatively young (mean age, 47.7 ± 17.9 years), and 157 (66.0%) were male. Patients commonly described a chest pain syndrome consistent with classic acute pericarditis. Chest pain was described as positional by 118 patients (49.6%) and as pleuritic by 164 patients (68.9%); 29 patients (12.2%) complained of chest pain consistent with typical angina. Troponin T values were elevated in 30 patients (12.6%). A recent viral illness was also common (90/238 patients; 37.8%). Echocardiography was performed in 112 patients (47.1%) before initiation of treatment and in 161 (67.6%) after initiation of treatment. A substantial percentage of patients had both pericardial effusions (60/112; 53.6%) and absence of regional wall motion abnormalities (107/112; 95.5%) on their pretreatment echocardiogram.

DIAGNOSTIC WORK-UP AND MEDICAL MANAGEMENT

There were several important treatment differences between patients with and without ST-segment elevation during the first 24 hours (Table 2). Overall, 40 patients (16.8%) with acute pericarditis underwent coronary angiography. It was performed 5 times more frequently among patients with (vs without) ST-segment elevation (24.7% vs 4.3%; $P < .001$). Among patients with ST-segment elevation, 7 (4.8%) received thrombolytics at another facility before transfer to our institution (vs none of the patients without ST-segment elevation; $P = .05$). No severe bleeding complications related to this therapy were noted in the medical records. Mild to moderate coronary artery disease was diagnosed at coronary angiography in 14 (35%) of the 40 patients who underwent the procedure. None of these lesions were thought to be the

TABLE 1. **Characteristics of Patients With Acute Pericarditis With and Without ST-Segment Elevations^a**

Variable	ST-segment elevation (n=146)	No ST-segment elevation (n=92)	P value
Demographic and clinical characteristics			
Age (y)	47±17	49±19	.41
Male	119 (81.5)	38 (41.3)	<.001
Hypertension	40 (27.4)	22 (23.9)	.55
Diabetes mellitus	12 (8.2)	6 (6.5)	.63
Hyperlipidemia	39 (26.7)	22 (23.9)	.63
Current smoker	40 (27.4)	17 (18.5)	.11
Former smoker	25 (17.1)	18 (19.6)	.63
Family history of premature CAD	30 (20.5)	23 (25.0)	.59
COPD	15 (10.3)	8 (8.7)	.69
Chronic renal failure	7 (4.8)	3 (3.3)	.74
History of MI	2 (1.4)	2 (2.2)	.64
History of stable angina	5 (3.4)	3 (3.3)	>.99
Previous PCI	7 (4.8)	5 (5.4)	.83
CABG	2 (1.4)	0 (0.0)	.52
Home medications			
β-Blocker	16 (11.0)	12 (13.0)	.63
Calcium channel blocker	6 (4.1)	9 (9.8)	.08
ACE inhibitor	16 (11.0)	10 (10.9)	.98
Nitrate	2 (1.4)	2 (2.2)	.64
Digoxin	2 (1.4)	3 (3.3)	.38
Aspirin	24 (16.4)	19 (20.7)	.41
Diuretic	15 (10.3)	13 (14.1)	.37
Statin	18 (12.3)	9 (9.8)	.55
Clinical findings at admission			
Positional chest pain	68 (46.6)	50 (54.4)	.24
Pleuritic chest pain	100 (68.5)	64 (69.6)	.86
Anginal chest pain	20 (13.7)	9 (9.8)	.36
Previous viral illness	47 (32.2)	43 (46.7)	.03
Pericardial friction rub	18 (12.3)	25 (27.2)	.004
Fever	26 (17.8)	22 (23.9)	.26
Nausea	15 (10.3)	10 (10.9)	.88
Diaphoresis	24 (16.4)	13 (14.1)	.63
Dyspnea	33 (22.6)	29 (31.5)	.13
Jugular venous distention	9 (6.2)	15 (16.3)	.01
Pulsus paradoxus	1 (0.7)	3 (3.3)	.30
Laboratory and echocardiographic findings at admission			
Troponin T >0.05 ng/mL ^b	23 (15.8)	7 (7.6)	.06
Leukocytosis (leukocytes >10,000/μL) ^c	61/144 (42.4)	27/85 (31.8)	.11
Pretreatment echocardiography	63 (43.2)	49 (53.3)	.13
Ejection fraction (%)	59.8±7.3	59.7±6.6	.99
Regional wall motion abnormalities	3/63 (4.8)	2/49 (4.1)	>.99
Pericardial effusion	24/63 (38.1)	36/49 (73.5)	<.001

^a Continuous data are expressed as mean ± SD; categorical data, as number of patients (percentage of sample). For variables with missing data, the smaller sample size is indicated. ACE = angiotensin-converting enzyme; CABG = coronary artery bypass graft; CAD = coronary artery disease; COPD = chronic obstructive pulmonary disease; MI = myocardial infarction; PCI = percutaneous coronary intervention.

^b SI conversion factor: To convert troponin T value to μg/L, multiply by 1.0.

^c SI conversion factor: To convert leukocyte value to 10⁹/L, multiply by 0.001.

TABLE 2. **Initial Management of Acute Pericarditis in Patients With and Without ST-Segment Elevations^a**

Variable	ST-segment elevation (n=146)	No ST-segment elevation (n=92)	P value
Coronary angiography	36 (24.7)	4 (4.3)	<.001
Thrombolytic	7 (4.8)	0 (0.0)	.05
Heparin	48 (32.9)	14 (15.2)	.003
Clopidogrel	2 (1.4)	0 (0.0)	.25
Intravenous β-blocker	41 (28.1)	10 (10.9)	.002
Morphine	46 (31.5)	13 (14.1)	.003
Nitroglycerin drip	45 (30.8)	15 (16.3)	.01
Aspirin	86 (58.9)	21 (22.8)	<.001
Ibuprofen	26 (17.8)	14 (15.2)	.60
Indomethacin	45 (30.8)	31 (33.7)	.64
Naproxen sodium	3 (2.1)	8 (8.7)	.02
Any NSAID	73 (50.0)	53 (57.6)	.25
Corticosteroid	6 (4.1)	4 (4.3)	.96

^a Data are expressed as number of patients (percentage of sample). NSAID = nonsteroidal anti-inflammatory drug.

cause of patients' chest pain, and no percutaneous interventions were performed. No major complications such as serious bleeding, stroke, or MI after cardiac catheterization were reported in these cases.

Patients presenting with ST-segment elevation were also significantly more likely to receive medications used to treat acute coronary syndromes, including intravenous β-blockers, nitroglycerin, heparin, and morphine. Overall, use of nonsteroidal anti-inflammatory drugs and corticosteroids was similar between the groups, but aspirin was selected much more commonly to treat patients with ST-segment elevation.

VARIABLES ASSOCIATED WITH INCREASED LIKELIHOOD OF CORONARY ANGIOGRAPHY

Examining all 238 patients presenting with acute pericarditis, we sought to determine which variables were univariately associated with an increased likelihood of diagnostic coronary angiography. Variables significantly associated with increased use of coronary angiography included typical anginal chest pain (OR, 7.8; 95% confidence interval [CI], 3.4-18.4); ST-segment elevation on admission ECG (OR, 7.2; 95% CI, 2.8-24.7); previous PCI (OR, 3.9; 95% CI, 1.1-12.9); elevated troponin T value at admission (OR, 4.7; 95% CI, 2.0-11.0); diaphoresis (OR, 2.8; 95% CI, 1.3-6.5); and male sex (OR, 1.7; 95% CI, 1.1-5.8). Patients with positional chest pain (OR, 0.2; 95% CI, 0.01-0.4) or pleuritic chest pain (OR, 0.3; 95% CI, 0.1-0.6) were less likely to have undergone coronary angiography. Finally, a multivariable model correcting for sex, previous viral illness, elevated troponin T value, and ST-segment elevation was used to examine the independent association between these variables and coronary angiography. ST-segment elevation on the admission ECG remained signifi-

cantly associated with increased selection of diagnostic angiography (OR, 5.9; 95% CI, 2.1-21.4) as did elevated troponin T value (OR, 5.3; 95% CI, 2.1-13.4). Neither male sex (OR, 1.2; 95% CI, 0.5-3.1) nor previous viral illness (OR, 0.6; 95% CI, 0.2-1.2) was statistically significant in these analyses.

DISCUSSION

Our study examined a contemporary series of patients with acute pericarditis to determine the frequency of urgent coronary angiography in this population and to identify clinical variables associated with angiography. We found that coronary angiography was a common diagnostic modality; it was performed in 16.8% of patients presenting at our center with acute viral or idiopathic pericarditis. Among this relatively young group of patients, 1 in 4 who presented with ST-segment elevation had undergone the procedure, 35% of whom had concomitant coronary artery disease. Variables associated with increased use of coronary angiography included a chest pain syndrome consistent with typical angina, elevated troponin T value, history of previous PCI, diaphoresis, and male sex. On the contrary, patients who had pleuritic or positional chest pain were less likely to undergo diagnostic angiography.

Although the exact incidence of acute pericarditis is unknown, this condition is common among patients presenting to the emergency department with chest pain.¹¹ Importantly, acute pericarditis typically follows a benign clinical course in the absence of poor prognostic indicators and can often be managed conservatively and in the outpatient setting.^{12,13} In contrast, failure to identify and appropriately treat MI prevents administration of potentially lifesaving interventions. Both patients with MI and patients with pericarditis can present with ST-segment elevation, and in many cases the pattern of ST-segment elevation can help distinguish pericarditis from acute MI. However, there may be overlap in history, symptoms, and even laboratory findings between these conditions, and ECG findings may be ambiguous. In these cases of diagnostic uncertainty, cardiac catheterization may be necessary to rule out MI. Of note, Larson et al⁹ published a series of cardiac catheterization laboratory activations initiated by community hospital physicians transferring patients to a tertiary center for PCI in the setting of presumed ST-elevation MI, noting that 14% of these patients had no culprit coronary lesion at the time of coronary angiography. Individuals later diagnosed with pericarditis or myocarditis represented 18.7% of these patients, underscoring that in many cases these diseases can mimic MI.

Not surprisingly, review of our data suggests that patient characteristics that likely raised "red flags" for evolving MI

appeared to be the major drivers of the use of diagnostic coronary angiography. Each variable significantly associated with selection of diagnostic coronary angiography is also frequently noted in the presentation of patients with MI. Conversely, patients reporting chest pain with features more consistent with classic pericarditis were less likely to undergo coronary angiography. The common finding of coronary artery disease at the time of cardiac catheterization in our series supports a cautious approach, including coronary angiography if suspicion for MI is high, when a patient presenting with chest pain has important risk factors for MI. This approach is also supported by the low complication rate associated with diagnostic cardiac catheterization, generally less than 1%.

Although differentiating acute pericarditis from MI can be difficult, several key distinctions can be made between the ECG findings. Recognizing ST-segment elevations of acute pericarditis and differentiating them from those of MI are critical. Classic stage I pericarditis is characterized by diffuse, upsloping concave ST-segment elevations, often with accompanying PR-segment depressions due to atrial involvement. This is distinguished from the localized ST-segment elevations with reciprocal changes that result from MI, which would infrequently involve multiple vascular distributions. If ECG findings are more subtle, other aspects of the tracing may help clarify the cause of acute pericarditis. ST-segment elevation associated with pericarditis should not result in the reciprocal depressions in aVL that accompany inferior MI, although this may not apply in some cases of localized pericarditis.⁵ Likewise, although ST-segment elevations in patients with MI may be greater than 5 mm, this degree of elevation is uncommon in patients with acute pericarditis. Authors have noted that pericarditis is suggested by a ratio of the height of the ST segment to the height of the T wave greater than 0.25.⁴ Nevertheless, when MI is suspected clinically, prompt coronary angiography can be lifesaving and should be strongly considered.

There may be a role for urgent echocardiography before coronary angiography in equivocal cases. Although our results did not show a statistically significant association between the presence of a pericardial effusion or absence of regional wall motion abnormalities on the pretreatment echocardiogram and diagnostic angiography, echocardiography was performed soon after angiography rather than before in many cases. If echocardiography were performed early in the patient's evaluation, these findings could help support or refute a diagnosis of pericarditis or ST-segment elevation MI and clarify the role of coronary angiography. The possible role of echocardiography for risk stratification before angiography in these cases is supported by our finding of a substantial percentage of patients with pericardial effusions (60/112; 53.6%) and no regional wall motion

abnormalities (107/112; 95.5%) on their pretreatment echocardiogram. An echocardiogram during an early stage of ST-segment elevation MI should show akinetic segments subtended by an involved coronary artery. Despite this possible role for echocardiography, when the diagnosis of pericarditis is unclear, clinicians must consider aggressive evaluation if risk factors for MI are present. The potential benefit from echocardiography should be balanced with the potential delay in door-to-balloon time for patients with atypical presentation.

Several limitations of the current study should be considered when interpreting the results. This was a retrospective examination of clinical data at our center, and, if possible, these results should be confirmed in multicenter prospective investigations. Prospective patient enrollment with defined diagnostic criteria for acute pericarditis would also be desirable since our definition of *acute pericarditis* relied on the individual opinion and diagnosis of the treating physician. This study was a single-center study, and results may not be generalizable to other institutions. However, the frequency of urgent coronary angiography in patients with acute pericarditis may be even higher at other institutions. Future work is needed to assess patient risks for clinically significant adverse outcomes after coronary angiography and to determine their magnitude.

CONCLUSION

Coronary angiography was performed frequently in this contemporary series of patients with acute pericarditis, particularly among patients with ST-segment elevation, patients with symptoms that mimic MI, and patients with elevated levels of cardiac biomarkers. Coronary artery disease was present angiographically in one-third of patients

undergoing the procedure. Although it is imperative that patients with ST-segment elevation MI receive prompt reperfusion, it is also essential for clinicians to consider the diagnosis of pericarditis to avoid unneeded coronary angiography, including its additional cost and procedural risk.

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