

Relationship Between Pain Severity and Outcomes in Patients Presenting With Potential Acute Coronary Syndromes

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Study objective: Although lay people often assume that severe pain is more commonly associated with worse outcomes, the relationship between pain severity and outcome for patients presenting with potential acute coronary syndrome has not been well described. We hypothesize that pain severity will not be associated with acute myocardial infarction or 30-day cardiovascular complications.

Methods: We conducted a secondary analysis of a prospective cohort study of patients presenting to the emergency department (ED) with potential acute coronary syndrome. Trained research assistants collected data, including demographics, medical history, symptoms, hospital course, and 30-day outcomes (record review and telephone). Pain score on arrival (0 to 10) was abstracted from nurses' triage documentation in the electronic record. Severe pain was defined as 9 or 10. The main outcomes were the prevalence of acute myocardial infarction during index visit and composite of death, acute myocardial infarction, revascularization including percutaneous coronary intervention, or coronary bypass artery grafting at 30 days. Multivariable modeling was prespecified to adjust for age, race, sex, pain duration, thrombolysis in myocardial infarction (TIMI) score, and mode of arrival. Data are presented as relative risk (RR) with 95% confidence intervals (CI).

Results: Patients (3,306) had pain documented (mean age 51.0 years; SD 12.6 years; 57% women; 66% black). Follow-up was 93%. By 30 days, 34 patients had died, 105 patients underwent revascularization (94 percutaneous coronary intervention, 14 coronary bypass artery grafting), and 111 patients experienced acute myocardial infarction. There was not a relationship between severe pain and acute myocardial infarction (RR 1.28; 95% CI 0.93 to 1.76) or 30-day composite outcome (1.19; 95% CI 0.91 to 1.56). After adjusting for potential confounding variables, we found that the prevalence of in-hospital acute myocardial infarction was related to TIMI score (adjusted relative risk [aRR] 2.00; 95% CI 1.05 to 3.80), male sex (aRR 1.48; 95% CI 1.00 to 2.18), and arrival by emergency medical services (EMS) (aRR 1.73; 95% CI 1.13 to 2.63) but not age (aRR 1.42; 95% CI 0.68 to 2.95), white race (aRR 1.25; 95% CI 0.85 to 1.86), pain duration greater than 1 hour (aRR 1.36; 95% CI 0.89 to 2.07), or severe pain (aRR 1.43; 95% CI 0.91 to 2.22). Thirty-day composite outcome was related to male sex (aRR 1.53; 95% CI 1.16 to 2.01), white race (aRR 1.43; 95% CI 1.09 to 1.87), and higher TIMI score (aRR 2.24; 95% CI 1.39 to 3.60) but was not related to age (aRR 1.26; 95% CI 0.75 to 2.11), pain duration greater than 1 hour (aRR 0.8; 95% CI 0.60 to 1.06), EMS arrival (aRR 1.23; 95% CI 0.96 to 1.60), or severe pain (aRR 1.39; 95% CI 0.95 to 1.97).

Conclusion: For patients who present to the ED with potential acute coronary syndrome, severe pain is not related to likelihood of acute myocardial infarction at presentation or death, acute myocardial infarction or revascularization within 30 days. [Ann Emerg Med. 2011;58:501-507.]

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INTRODUCTION

Background

For patients with chest pain and related symptoms, there are 6 million visits to the emergency department (ED) and approximately 2 million hospital admissions each year; in the end,

only a minority of these patients receive a diagnosis of an ischemic cause of their chest pain.^{1,2} Still, 2% to 5% of patients with acute myocardial infarction are inappropriately discharged from the ED, with a resultant increase in morbidity and mortality.³⁻⁶ In addition, failure to accurately diagnose acute myocardial infarction is the

Editor's Capsule Summary

What is already known on this topic

Pain scores are routinely measured in all emergency department patients.

What question this study addressed

Is pain score severity associated with the final diagnosis of acute myocardial infarction?

What this study adds to our knowledge

Of 3,306 patients, 3.2% were diagnosed with a myocardial infarction. Severe pain, defined as an 11-point numeric rating scale 9 or 10, was not strongly associated with a diagnosis of myocardial infarction (adjusted RR 1.43; 95% confidence interval 0.91 to 2.22).

How this is relevant to clinical practice

Pain severity should not be used as a predictor of myocardial infarction.

single greatest contributor to financial losses in malpractice claims against emergency physicians, accounting for 20% of malpractice dollars lost.⁷⁻⁹

Importance

Attorneys often question an emergency physician's clinical judgment to discharge a patient believed to be at minimal risk for acute coronary syndrome when the patient gives a high pain score. This reasoning may be based on traditional textbook teachings that chest pain of acute myocardial infarction is greater than that of angina or atypical chest pain.¹⁰ However, there is little evidence to suggest that pain severity is related to likelihood of acute myocardial infarction. For patients admitted to the cardiac care unit, Eriksson et al¹¹ found no significant difference in the severity of chest pain in patients with acute coronary syndrome as opposed to nonischemic chest pain.

Goals of This Investigation

This study aims to investigate the relationship between severity of pain and likelihood of in-hospital acute myocardial infarction, as well as risk of 30-day cardiovascular events. We hypothesized that pain severity would not be associated with acute myocardial infarction or 30-day cardiovascular events.

MATERIALS AND METHODS

Study Design

This study was a secondary analysis of a prospective cohort study that was designed to risk-stratify patients who present to the ED with symptoms consistent with possible acute coronary syndrome.¹²⁻¹⁴ The study was approved by the local institutional review board.

Setting and Selection of Participants

The study setting was the ED of the Hospital of the University of Pennsylvania, an urban, tertiary-level teaching hospital. The ED has an annual census of 57,000 adult visits per year and consists of 33 rooms, with an additional clinical diagnostic and observational unit. The study population was a convenience sample of patients older than 30 years who presented to the ED with a primary complaint of chest pain with a potential acute coronary syndrome, including chest pain or other potential ischemic equivalents. Patients were enrolled from 2005 through 2009. Patients who had traumatic chest pain, chest pain of a noncardiac cause, were non-English speaking, or were pregnant were excluded from inclusion to the primary studies.¹²⁻¹⁴ For this study, we included only patients with reported pain scores in our analysis. Patients with ischemic equivalents (for example, shortness of breath) as the chief complaint were not included if they did not have pain. Management of all patients was at the discretion of the treating physician and independent of study enrollment.

Methods of Measurement

The ED was staffed 16 to 17 hours a day, 7 days a week, with trained research assistants who recorded demographic information, cardiac risk factors, medical history, symptom characteristics, and disposition information according to the Standardized Reporting Guidelines for Emergency Department Chest Pain Studies.¹⁵ Nurses at triage documented the pain score reported by the patient. The patient was instructed to rate his or her pain on an 11-point numeric rating scale from zero to 10, in which a score of zero indicated no pain and a score of 10 was the worst pain imaginable. For this study, we electronically downloaded pain scores from the medical records to obtain the pain score originally documented by the triage nurse.

Each patient's hospital course was followed by our investigators and trained research assistants, who documented any diagnostic testing performed, their results, and interventions (eg, percutaneous coronary intervention). Our investigators contacted the patients at 30 days to determine outcomes. Results from testing or procedures were obtained by medical records for studies performed at the home institution and by patients' report for studies performed at outside institutions.

Outcome Measures

The primary outcome measured was the prevalence of acute myocardial infarction, as defined by increased troponin level above the laboratory threshold for normal in setting of symptoms with or without ECG changes according to European Society of Cardiology/American College of Cardiology criteria.¹⁶ The secondary outcome was assessed at 30 days and included the rate of composite endpoint of death, acute myocardial infarction, and revascularization procedure, including percutaneous coronary intervention or coronary artery bypass grafting.

Table 1. Baseline characteristics of patients.

	All Patients, n=3,306 (%)	Pain Score 1–8, n=2,708 (%)	Severe Pain 9–10*, n=598 (%)	% Difference Between Pain Groups (95% CI)
Mean age, y (SD)	51.0 (12.6)	51.1 (12.6)	50.3 (12.5)	0.86 (0.24 to 1.97)
Sex				
Male	1,429 (43)	1,201 (44)	228 (37)	6.26 (1.93 to 10.58)
Female	1,875 (57)	1,505 (56)	370 (62)	6.26 (1.87 to 10.64)
Race				
White	908 (27)	796 (30)	112 (19)	10.93 (6.92 to 14.94)
Black	2,185 (66)	1,730 (65)	455 (78)	12.42 (8.25 to 16.59)
Other	138 (4)	120 (5)	18 (3)	1.49 (–0.32 to 3.31)
Cardiac risk factors				
Family history	521 (16)	432 (16)	89 (15)	0.96 (–2.36 to 4.3)
Tobacco use	1,263 (38)	1,004 (38)	259 (45)	6.55 (2.17 to 10.94)
Cocaine use	195 (6)	140 (5)	55 (10)	4.20 (2.05 to 6.34)
Medical history				
Congestive heart failure	267 (8)	213 (8)	54 (9)	1.26 (–1.23 to 3.75)
Diabetes	593 (18)	470 (18)	123 (21)	3.41 (–0.08 to 6.9)
Hypertension	1,660 (50)	1,331 (51)	329 (57)	6.31 (1.82 to 10.8)
Hyperlipidemia	788 (24)	667 (25)	121 (21)	4.45 (0.57 to 8.32)
Coronary artery disease	461 (14)	381 (14)	80 (14)	0.62 (–2.56 to 3.78)
Pain duration >1 h	2,182 (66)	1,767 (65)	415 (69)	4.46 (0.26 to 8.66)
TIMI score				
0–2	2,758 (83)	2,249 (83)	509 (85)	2.32 (–0.82 to 5.47)
3–4	411 (12)	348 (13)	63 (11)	2.35 (–0.65 to 5.35)
≥5	49 (1)	40 (2)	9 (2)	0.03 (–1.1 to 1.1)

*% unless otherwise stated.

Primary Data Analysis

Our main outcome was the prevalence of in-hospital acute myocardial infarction and 30-day events in patients grouped according to the 11-point numeric rating scale pain index, with nonsevere pain defined as pain score 1 to 8 and severe pain defined as pain score 9 to 10. Multivariable modeling was prespecified to adjust for age, race, sex, thrombolysis in myocardial infarction (TIMI) score, mode of arrival (emergency medical services [EMS] or not), and duration of chest pain. We controlled for duration of chest pain by stratifying patients whose pain duration was more than 1 hour because these patients were thought to be at increased risk for acute myocardial infarction.^{17,18} The secondary outcome was the relative risk of 30-day cardiovascular outcomes, stratified into 2 groups according to severity of pain on the 11-point numeric rating scale, controlling for age, race, sex, TIMI score, mode of arrival to the ED, and duration of chest pain.

Data are presented with percentage frequency of occurrence with 95% confidence intervals (CIs) for outcomes. Comparisons among patients with differing pain intensities were performed with Poisson regression analysis with robust error variance.¹⁹ Because we did not know precise cutoffs for a numeric rating scale for ratings for pain, we used the literature as our guide for proposed cutoffs,^{20–22} as well as interquartile ranges for our range of scores. We then conducted sensitivity analysis with pain as a continuous variable and also using various cutoffs for mild, moderate, and severe pain. We also conducted sensitivity analysis to account for patients who are lost to follow-up. Relative risks and 95% CIs are presented. Data were analyzed

Table 2. In-hospital events stratified by pain score.

Pain Score	No. (%)	
	1–8, N=2,708 (81.7%)	9–10, N=598 (18.1%)
Death	10 (0.4)	6 (1.0)
Acute myocardial infarction	82 (3.0)	23 (3.9)
Percutaneous coronary intervention or coronary bypass artery grafting	78 (2.9)	17 (2.8)
Composite	135 (5.0)	36 (6.0)

with SAS statistical software (version 9.2; SAS Institute, Inc., Cary, NC).

RESULTS

Characteristics of Study Subjects

During the initial study period enrollment, data were collected on a total of 4,863 patients; 509 patients did not have a documented pain score in triage; 1,048 patients had a pain score of zero. This left 3,306 patients for analysis, with average mean age 51.0 years (SD 12.6 years), of whom 57% were women and 66% were black (Table 1). Follow-up information was available for 93% (3,084) of patients.

Main Results

There were 2,708 (82%) total patients with a pain score of 1 to 8 at triage and 598 (18%) with a pain score of 9 to 10 (Table 2). Of these patients, 1,683 (51%) were discharged from the

Table 3. Adjusted relative risk of severe pain for in-hospital acute myocardial infarction and 30-day composite outcomes of acute myocardial infarction, death, and revascularization.

	Adjusted RR (95% CI) for In-hospital Acute Myocardial Infarction	Adjusted RR (95% CI) for 30- Day Composite
Severe pain (score 9–10)	1.43 (0.91–2.22)	1.39 (0.98–1.97)
Male sex	1.48 (1.00–2.18)	1.53 (1.16–2.01)
White	1.25 (0.85–1.86)	1.43 (1.09–1.87)
TIMI score (0–2, 3–4, 5–7)	2.00 (1.05–3.80)	2.24 (1.39–3.60)
Age (10-y increment)	1.42 (0.68–2.95)	1.26 (0.75–2.11)
EMS arrival	1.73 (1.13–2.63)	1.23 (0.96–1.60)
Pain >1 h	1.36 (0.89–2.07)	0.80 (0.60–1.06)

RR, Relative risk.

ED and the rest were hospitalized, but all were included in the analysis. During initial hospitalization, 16 patients died, 95 patients underwent a revascularization procedure (85 percutaneous coronary intervention, 13 coronary bypass artery grafting), and 105 patients had an acute myocardial infarction. By 30 days, 18 additional (34 total) patients had died, 10 additional patients underwent a revascularization procedure (105 total with 94 percutaneous coronary intervention, 14 coronary bypass artery grafting), and 6 additional (111 total) patients experienced acute myocardial infarction. One hundred thirty-nine patients had a catheterization but no intervention and were not included in our analysis. Thus, at 30-day follow-up, the number of patients meeting the composite endpoint of death, revascularization, or acute myocardial infarction was 200 (6%; 95% CI 5.9% to 7.2%). Some patients had more than one of these endpoints.

Patients with severe pain were no more likely to have a cardiovascular event during initial hospitalization; 82 (3.0%) with a pain score of 1 to 8 versus 23 (3.9%) with a pain score of 9 to 10 had acute myocardial infarction (Table 2). There was not a relationship between severe pain and acute myocardial infarction (1.27; 95% CI 0.81 to 2.00). After adjusting for potential confounding variables, we found that risk of in-hospital acute myocardial infarction was related to TIMI score (aRR 2.00; 95% CI 1.05 to 3.80), male sex (aRR 1.48; 95% CI 1.00 to 2.18), and arrival by EMS (aRR 1.73; 95% CI 1.13 to 2.63). However, there was no relationship between acute myocardial infarction and age (aRR 1.42; 95% CI 0.68 to 2.95), white race (aRR 1.25; 95% CI 0.85 to 1.86), pain duration of greater than 1 hour (aRR 1.36; 95% CI 0.89 to 2.07), or severe pain (aRR 1.43; 95% CI 0.91 to 2.22) (Table 3).

We also stratified 30-day events according to pain score to demonstrate that there was no relationship between pain severity and cardiovascular outcome. The composite endpoint was not more likely in patients with increased pain severity, with 156 (5.8%) patients with pain score of 1 to 8 versus 44 (7.3%) with pain score of 9 to 10 reaching the outcomes of

death, revascularization, or acute myocardial infarction at 30 days (1.28; 95% CI 0.93 to 1.76) (Table 3).

In multivariate modeling, 30-day composite outcome was related to male sex (aRR 1.53; 95% CI 1.16 to 2.01), white race (aRR 1.43; 95% CI 1.09 to 1.87), EMS arrival (aRR 1.23; 95% CI 0.96 to 1.60), and higher TIMI score (aRR 2.24; 95% CI 1.39 to 3.60) but was not related to age (aRR 1.26; 95% CI 0.75 to 2.11), pain duration greater than 1 hour (aRR 0.80; 95% CI 0.60 to 1.06), or severe pain (aRR 1.39; 95% CI 0.95 to 1.97).

We performed sensitivity analyses by exploring pain as a continuous variable and using various cut points for low, moderate, and severe pain. With pain as a continuous variable, there was no association with pain and in-hospital acute myocardial infarction (aRR 0.94; 95% CI 0.87 to 1.02) and decreased likelihood of 30-day composite events with increased pain severity (aRR 0.92; 95% CI 0.86 to 0.98). We also used various cutoff points for classifying pain into low, moderate, and severe. According to the literature, we also varied the cut point of mild, moderate, and severe pain in several ways. Our first model defined low pain as 1 to 4, moderate as 5 to 8, and severe as 9 to 10. We then changed the cut points to 1 to 3 as low pain, 4 to 6 as moderate, and 7 to 10 as severe pain. We also used a model that used the interquartile range of pain scores, which gave us cut points of 1, 2 to 5, 6 to 7, and 8 to 10 as our groupings. Using a cut point of either 7 or 8 for severe pain gave us similar results in multivariable modeling; pain was not associated with in-hospital acute myocardial infarction or 30-day composite outcomes. We also performed sensitivity analysis for patients who were lost to follow-up and found that only if greater than 90% of missing patients had a cardiovascular event would severe pain become a significant risk factor for our outcome.

LIMITATIONS

This was a secondary analysis of previously collected data, and therefore confounding variables may have affected outcomes. Despite our efforts, there are other variables that may have contributed for which our study was unable to control or were not collected a priori. For instance, a confounding variable may be whether patients received nitroglycerin en route. We did not have this information. However, we did adjust for mode of arrival to help account for this possible confounder. Furthermore, we attempted to minimize other confounding factors by adjusting for age, sex, race, cardiac risk factors, medical history, TIMI score, pain duration, and mode of arrival to the ED.

Other limitations included research associates staffing the ED for only 16 to 17 hours each day and follow-up not being completed for all patients. Failure to enroll patients presenting at night may have affected our study because these patients constitute a clinically different population. In addition, follow-up was not completed for all patients. Those who could not be reached were not included; however, this was only 7% of the total number of patients. The majority of follow-up was

obtained by patient reports and therefore could be inaccurate or contain an element of recall bias, but record review was performed for most patients who received follow-up studies at our hospital. Our sensitivity analysis found that results would be different only if more than 90% of the patients lost to follow-up had an adverse event; this is extremely unlikely.

For this study, nurses recorded the pain score at triage. It is likely that there is variability in the way different nurses asked patients about pain, which in turn would affect internal consistency. We are also unable to gauge pain intensity before arrival, or when triage nurses questioned the patient, or how the patient interpreted the question. However, the 11-point numeric rating scale has been validated as a tool for inquiring about patients' pain severity in clinical situations.²³

The 11-point numeric rating scale is a useful tool because it allows health care workers to easily assess a change in patients' perceived pain, which may be more clinically meaningful than absolute pain score. Our study did not examine changes in pain score over time because we were primarily interested in triage pain score to assess the relationship between pain at presentation and likelihood of acute myocardial infarction. This limited us from examining how pain score changes with nitroglycerin or other medications; however, previous studies have explored this relationship and found that a response in chest pain to sublingual nitroglycerin is not a reliable indicator of cardiac cause.²³ Although the numeric rating scale is helpful for changes in pain severity, literature shows that it is useful even for single measurement of pain intensity.^{24,25}

DISCUSSION

Our study undertook an evaluation of patients who presented to the ED with chest pain and who rated their pain severity on the 11-point numeric rating scale. The clinical course of these patients was then followed so that we were able to evaluate for likelihood of acute myocardial infarction with initial hospitalization and assess for relationship between pain score and cardiac outcome. We were also able to follow 93% of our patients for 30 days and so were able to reliably detect 30-day events and assess for relationship between pain score and 30-day outcomes. Our study adjusted for factors shown to influence cardiac outcome, including sex, race, and TIMI score. We controlled for duration of pain by analyzing a subgroup whose pain had lasted more than 1 hour because it was thought that these patients would be at greater risk for a cardiovascular event.^{26,27} In addition, we controlled for arrival by EMS because these patients were believed to be different in 2 ways. First, they were thought to be at increased risk for a cardiovascular event. Second, they may have received nitroglycerin en route to the ED, which may have influenced report of pain score. Our study demonstrated that the patient's pain score severity was not related to his or her likelihood of acute myocardial infarction at hospital discharge and furthermore that the reported pain score was not a risk factor for 30-day events.

We believe that our findings might contribute to a discussion on how assessment of acute coronary syndrome risk informs a physician's discharge decisionmaking. We believe that it is common for lay people and attorneys to cite high pain score as an indication for a patient to remain in the hospital for further cardiac evaluation, yet our study demonstrates that this should not necessarily be the case.

The belief that pain severity is related to likelihood of acute myocardial infarction is probably due to traditional medical teachings.¹⁰ In addition, studies among patients already having received a diagnosis of acute myocardial infarction have shown that patients with larger infarcts, as assessed by increased cardiac enzyme activity, have higher pain scores.²⁸ Ledwich²⁸ studied patients with acute myocardial infarction and found that patients who described their pain intensity as moderate compared with a group who described their pain as very severe had significantly lower cardiac enzyme values, which was interpreted as smaller area of infarct.

Pain severity has also been described in other organ systems. Studies of patients with abdominal pain have found that the severity of the pain is generally related to the severity of the disorder, especially if acute in onset. As an example, mesenteric infarction causes pain of high intensity, whereas the pain of gastroenteritis is less marked.²⁹ One study of 600 patients with abdominal pain found that the proportion of patients with severe pain was highest among patients with perforation (93%) and lowest in patients with nonspecific abdominal pain (18%).³⁰

However, the issue of chest pain severity in the ED is complex. Chest pain is an important symptom to study because it is the chief complaint in the majority of patients with acute myocardial infarction, yet as many as one third of myocardial infarctions may go unrecognized by patients.³¹ Chest pain is further complicated by the difficulty of pain severity assessment in clinical settings. Pain scores are viewed as subjective, and methods for assessing pain severity are often regarded as imprecise.³² In our study, we used the 0 to 10 verbal numeric rating scale (11-point numeric rating scale), which is an easy-to-use tool with widespread use in EDs.^{23,33} The simplicity of application of the 11-point numeric rating scale allows for frequent assessment of pain and easy documentation of changes in pain score, and it therefore remains a valuable tool. The 11-point numeric rating scale has been shown to be effective when used within the context of an individual patient's goals and in one study demonstrated effective pairing or similar trending with the visual analog scale, which is the most reliable and validated tool for measuring pain severity.^{32,33}

Yet despite the Veterans Administration's launching of the "Fifth Vital Sign" initiative to integrate pain assessment into routine vital sign monitoring,³² physicians and nurses often struggle with how to incorporate pain score into patient management, perhaps because of the sparse guidance offered to them in interpreting a pain scale. Although it is important to

treat a patient's pain, it is often still unclear how a patient's reported pain severity is associated with clinical diagnosis.

Previous reports examining the relationship between chest pain severity and likelihood of cardiac diagnosis have been small and not in large undifferentiated ED populations. However, our findings are consistent with these previous studies. Eriksson et al¹¹ studied 80 consecutive cardiac care unit patients with chest pain, categorizing them into patients with acute myocardial infarction and patients without acute myocardial infarction, according to 12-lead ECG and enzyme activity levels. They found no differences in quality and intensity distributions between acute myocardial infarction patients and patients without acute myocardial infarction. Similarly, Horner³⁴ investigated severity of chest pain in 51 patients and found no significant difference in the pain scores between the group of patients with myocardial infarction and the group without myocardial infarction. These were patients presenting to the ED, but pain scores were obtained within the first 24 hours rather than at triage, and follow-up was not performed. Our study examined a much larger cohort of patients who had pain score recorded at triage and followed the patients to evaluate for 30-day outcomes.

We demonstrated that patients with severe pain are not at increased risk for acute coronary syndrome and that, although pain management is an important issue to address clinically, pain severity itself should not be a factor in evaluating patients' risk for acute coronary syndrome in terms of discharge decisions. Of course, it would still be important to relieve the pain for the sake of patient comfort.

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REFERENCES

- Pitts SR, Niska RW, Xu J, et al. *National Hospital Ambulatory Medical Care Survey 2006. Emergency Department Summary*. Atlanta, GA: Centers for Disease Control and Prevention; 2008: 20, 35. National Health Statistics Reports.
- Gibler WB, Runyon J, Levy R, et al. A rapid diagnostic and treatment center for patients with chest pain in the emergency department. *Ann Emerg Med*. 1995;25:1-8.
- Pope JH, Aufderheide TP, Ruthazer R, et al. Missed diagnoses of acute cardiac ischemia in the emergency department. *N Engl J Med*. 1982;342:1163-1170.
- Christenson J, Innes G, McKnight D. Safety and efficiency of emergency department assessment of chest discomfort. *CMAJ*. 2004;170:1803-1807.
- Kontos M, Jesse R. Evaluation of the emergency department chest pain patient. *Am J Cardiol*. 2000;85:32B-39B.
- Lee TH, Rouan GW, Weisberg MC, et al. Clinical characteristics and natural history of patients with acute myocardial infarction sent home from the emergency room. *Am J Cardiol*. 1987;60: 219-224.
- Rusnak RA, Stair TO, Hansen K, et al. Litigation against the emergency physician: common features in cases of missed myocardial infarction. *Ann Emerg Med*. 1989;18:1029-1034.
- Dunn J. *ACEP Foresight: Chest Pain: 1-3*. Dallas, TX: ACEP Publications; 1986.
- Kirk JD, Diercks D, Turnipseed S, et al. Evaluation of chest pain suspicious for ACS: use of an accelerated diagnostic protocol in a chest pain evaluation unit. *Am J Cardiol*. 2000;5: 40B-48B.
- Cannon CP, Lee TH. Approach to the patient with chest pain. In: Libby P, Bonow RO, Mann DL, et al, eds. *Braunwald's Heart Disease: A Textbook of Cardiovascular Medicine*. 8th ed. Philadelphia, PA: Saunders-Elsevier; 2007:1195-1197.
- Eriksson B, Vuorisalo D, Sylven C. Diagnostic potential of chest pain characteristics in coronary care. *J Intern Med*. 1994;235: 473-478.
- Hollander JE, Chang AM, Shofer FS, et al. One-year outcomes following coronary computerized tomographic angiography for evaluation of emergency department patients with potential acute coronary syndrome. *Acad Emerg Med*. 2009;16:693-698.
- Weisenthal BM, Chang AM, Walsh KM, et al. Relation between thrombolysis in myocardial infarction risk score and one-year outcomes for patients presenting at the emergency department with potential acute coronary syndrome. *Am J Cardiol*. 2010;105: 441-444.
- Chang AM, Mumma B, Sease KL, et al. Gender bias in cardiovascular testing persists after adjustment for presenting characteristics and cardiac risk. *Acad Emerg Med*. 2007;14:599-605.
- Hollander JE, Blomkalns AL, Brogan GX, et al. Standardized reporting guidelines for studies evaluation risk stratification of emergency department patients with potential acute coronary syndromes. *Ann Emerg Med*. 2004;44:589-598.
- Alpert JS, Thygesen K, Antman E, et al. Myocardial infarction redefined: a consensus document of the Joint European Society of Cardiology/American College of Cardiology committee for the redefinition of myocardial infarction. *J Am Coll Cardiol*. 2000;36: 959-969.
- Swap C, Nagurney J. Value and limitations of chest pain history in the evaluation of patients with suspected acute coronary syndromes. *JAMA*. 2005;294:2623-2629.
- Constant J. The diagnosis of nonanginal chest pain. *Keio J Med*. 1990;39:187-192.
- Zou G. A modified Poisson regression approach to prospective studies with binary data. *Am J Epidemiol*. 2004;159:702-706.

20. Kelly AM. The minimum clinically significant difference in visual analogue scale pain score does not differ with severity of pain. *Emerg Med J*. 2001;18:205-207.
21. Jones KR, Vojir CP, Hutt E, et al. Determining mild, moderate, and severe pain equivalency across pain-intensity tools in nursing home residents. *J Rehabil Res Dev*. 2007;44:305-314.
22. Palos GR, Mendoza TR, Mobley GM, et al. Asking the community about cutpoints used to describe mild, moderate, and severe pain. *J Pain*. 2006;7:49-56.
23. Diercks D, Boghos E, Guzman H, et al. Changes in numeric descriptive scale for pain after sublingual nitroglycerin do not predict cardiac etiology of chest pain. *Ann Emerg Med*. 2005;45:581-585.
24. Jensen MP, Turner JA, Romano JM, et al. Comparative reliability and validity of chronic pain intensity measures. *Pain*. 1999;83:157-162.
25. Bijur PE, Latimer CT, Gallagher EJ. Validation of a verbally administered numerical rating scale of acute pain for use in the emergency department. *Acad Emerg Med*. 2003;10:390-392.
26. Berger JP, Buclin T, Haller E, et al. Right arm involvement and pain extension can help to differentiate coronary diseases from chest pain of other origin: a prospective emergency ward study of 278 consecutive patients admitted for chest pain. *J Intern Med*. 1990;227:165-172.
27. Herlitz J, Richter A, Hjalmarson A, et al. Variability of chest pain in suspected acute myocardial infarction according to subjective assessment and requirement of narcotic analgesics. *Int J Cardiol*. 1986;9:22.
28. Ledwich JR. Chest pain in the early recognition of large infarcts. *CMAJ*. 1977;116:38-43.
29. Fishman M, Aronson M. History and physical examination in adults with abdominal pain. In: *UpToDate*, Fletcher RH (ed); UpToDate, Waltham, MA, 2010.
30. Staniland JR, Ditchburn J, De Dombal FT. Clinical presentation of acute abdomen: study of 600 patients. *Br Med J*. 1972;3:393-398.
31. Sigurdsson E, Thorgeirsson G, Sigvaldason H, et al. Unrecognized myocardial infarction: epidemiology, clinical characteristics, and the prognostic role of angina pectoris. The Reykjavik Study. *Ann Intern Med*. 1995;122:96-102.
32. Hartrick C, Kovan J, Shapiro S. The numeric rating scale for clinical pain measurement: a ratio measure? *Pain Pract*. 2003;3:310-316.
33. Stahmer S, Shofer F, Marino A, et al. Do quantitative changes in pain intensity correlate with pain relief and satisfaction? *Acad Emerg Med*. 1998;5:851-857.
34. Horner SM. Chest pain—no difference in severity between those having a myocardial infarction and chest pain from other causes. *Int J Cardiol*. 1989;24:371-372.