Costs and Outcomes of Patients Admitted with Chest Pain and Essentially Normal Electrocardiograms

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Summary

Background: Although inroads have been made in the outpatient evaluation of chest pain, the majority of hospitals in the United States do not have chest pain centers and the direct costs associated with hospital admissions in low-risk patients is unknown.

Hypothesis: The study was undertaken to evaluate the cost and outcomes of admission to the hospital for patients with acute chest pain and essentially normal electrocardiograms (ECGs).

Methods: For that purpose, we reviewed 1,670 patients presenting to our emergency department with chest pain over a 5-month period in 1994. Of these, 567 [34.0%, confidence interval (CI) 95%, 31.7–36.3%] patients were considered to be low risk by ECG criteria alone.

Results: Complete clinical and financial data were available in 445 cases of which 152 had a previous history of coronary artery disease (CAD) and 31 (7.0%, CI 95%, 4.9–9.6%) were ultimately proven to have acute myocardial infarction (AMI). There were no deaths. All patients initially underwent noninvasive evaluation, and an additional 177 (39.8%) underwent subsequent cardiac catheterization. Of those, 107 (60.5%) had significant CAD (at least one vessel >70% stenosis). We assumed an expected mortality rate of 1% in the AMI group based on previously reported series with all the mortalities preventable by hospitalization. This yielded a valuation of $1.7 million dollars per life saved. Sensitivity analysis revealed the practice of admission and in-patient evaluation for this group of patients was cost ineffective at all assumption levels.

Conclusion: The practice of hospital admission for patients with chest pain and essentially normal ECGs is not cost favorable, and all-hospital facilities should consider outpatient chest pain evaluation strategies.

Key words: chest pain, cost analysis, electrocardiography, patient admission

Introduction

The exclusion of myocardial ischemia as the cause of acute chest pain is a clinically demanding and resource-intensive process. An estimated 3 to 5 million patients present to emergency centers in the United States each year with chest pain of undetermined etiology.[1] The majority of these patients will not have myocardial ischemia as the cause of their discomfort.[2,3] Unfortunately, clinical history and physical examination, although suggestive, are not definitive for myocardial ischemia in most patients;[4] however, for those with clear-cut ischemic changes on the electrocardiogram (ECG), the need for in-hospital evaluation and therapy is well defined.[5–7]

An essentially normal ECG does not rule out myocardial infarction (MI) or unstable angina.[2,3] Furthermore, an estimated 2–13% of acute MIs (AMIs) each year are misdiagnosed and the patients are inappropriately sent home from the emergency department, resulting in a greater than 25% mortality rate.[8,9] These cases account for nearly 25% of malpractice claims against emergency physicians and are among the leaders in terms of indemnity dollars paid to plaintiffs.[10] Accordingly, there is a clinical and medicolegal expectation of zero tolerance for missed MI and its consequences, which leads to routine expensive in-hospital monitoring and testing to rule out myocardial ischemia.[11] In fact, the extraordinary resource demands and expense incurred by the large numbers of patients presenting with this clinical problem have stimulated the development of numerous, novel noninvasive strategies and specialized observation units designed to facilitate the assessment of such patients. However, at present, there is no consen-

sus on the most cost-effective approach. In preparation for a randomized prospective trial comparing conventional care versus immediate low-cost angiography, the present study was designed to evaluate the existing practice pattern in our institution in terms of hospital cost per AMI, per ischemic heart disease patient detected, and per life saved, in a community hospital taken from a societal perspective.

Materials and Methods

Study Sample

This study was approved by the Human Investigations Committee at William Beaumont Hospital, a 929 bed tertiary care center. We screened 1,670 consecutive patients presenting to our emergency department with chest discomfort over a 5-month period in 1994. In 567 patients, the ECG interpretation was normal or near-normal and, of those, complete financial data were available in 445.

Chart Abstraction

Hospital charts were abstracted for clinical outcomes and identification of diagnostic pathways. All patients were admitted to the hospital for a "rule out myocardial infarction" protocol as per hospital practice at that time prior to the initiation of a chest pain center. Ischemic heart disease was defined as having angiographically at least one coronary vessel with a >70% stenosis. Acute myocardial infarction was defined by enzymatic criteria with characteristic rise in creatine phosphokinase (CK) and myocardial band (MB) isoenzymes corresponding to the time of suspected ischemia. Electrocardiograms were interpreted by readers blinded to patient outcome and defined as essentially normal by having the absence of Q waves, ischemic ST-segment or T-wave changes, conduction delays, or nonsinus rhythms. Hospital costs were calculated in 1994 dollars using the Medicare cost to charge ratio for each cost center (i.e., radiology, laboratory, emergency center, etc.). Reliable data regarding physician costs were not available.

Statistical Analysis

Univariate statistics are reported as means ± standard deviation for continuous variables and percents for proportions with 95% exact mid-p confidence intervals (CI) as appropriate. Comparisons were made using chi-square, analysis of variance, or Kruskal-Wallis H test where appropriate. Multiple logistic regression was used to identify independent predictors of angiography utilization and need for coronary intervention. Valuations were generated by tabulating the total costs of medical care for the entire group (n = 445) and dividing this by clinical outcome (cases of significant coronary disease detected, MI, or death). This method provided for a program cost perspective as opposed to an individual patient cost perspective. A sensitivity analysis was performed by varying the assumption that potential mortality due to the chest pain

etiology could be prevented by hospitalization. This assumption was taken at three levels: all lives saved, 50% of the lives saved, and 25% of the lives saved. Willingness to pay from a societal perspective was derived by taking the calculated annualized, aggregate hospital costs for the entire group and adjusting these for the diagnostic categories ultimately proven: those with AMI, ischemic heart disease, and no ischemic heart disease. All financial data are given in 1994 dollars with no discounting.

Results

Of the 1,670 patients screened, 567 (34.0%, CI 95%, 31.7–36.3%) were found to have an essentially normal ECG. The proportions of patients with ST-segment elevation and clearly abnormal ECGs are shown in Figure 1. Baseline characteristics for the 445 patients with essentially normal ECGs, for whom all financial and clinical data were available, are given in Table I, stratified by a prior history of coronary disease at the time of presentation (history of definite prior infarction, clear stable angina evaluated in the past, or a history of prior cardiac catheterization demonstrating any coronary disease).

Diagnostic patient flow after admission to the hospital is shown in Figure 2. Thirty-one (7.0%, CI 95%, 4.9–9.6%) patients ruled in for AMI, cost per case $13,512 ± 8,688 and length of stay (LOS) 6.1 ± 5.3 days versus $5,173 ± 3,669 and 2.4 ± 5.3 days for 414 patients who ruled out for AMI as shown in Figure 3 (both comparisons p < 0.01). Sixty patients were found to have new, significant coronary disease with a mean cost per case of $8,276 ± 3,861. Fourteen patients with a history of previous coronary disease were evaluated and found now to have significant coronary disease (at least one lesion > 70%) with a mean cost per case of $9,269 ±5,436.

In all, 174 patients (39%) were discharged home with outpatient stress tests arranged; 134 patients (30.1%) underwent in-hospital stress testing; and, ultimately, 177 (39.8%) of patients underwent cardiac catheterization. The majority, 96
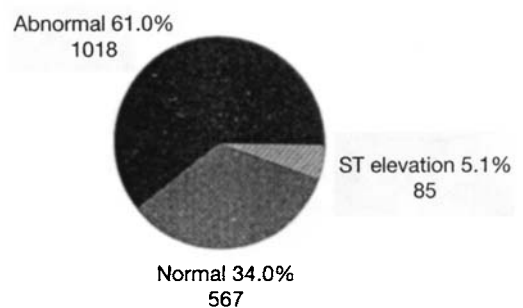

FIG. 1 Consecutive patients (n = 1,670) who presented with chest discomfort over a 5-month period divided by electrocardiogram (ECG) classification. Essentially normal ECGs were defined as having no Q waves, ischemic ST- or T-wave changes, conduction delay, or nonsinus rhythms.

TABLE I   Baseline characteristics of the 445 patients who presented with chest pain and an essentially normal electrocardiogram stratified by prior history of coronary artery disease

Characteristic	History of CAD (n = 146)	No history of CAD (n = 299)	Entire group (n = 445)	p Value
Age (years)	62.6 ± 11.9	54 ± 12.8	57.2 ± 13.0	<0.01
Gender	67 (45.9%) female	155 (51.8%) female	222 (49.9%) female	NS
Smoker (%)	28 (19.2)	70 (23.4)	98 (22)	NS
Dyslipidemia (%)	61 (41.8)	63 (21.1)	124 (27.9)	<0.01
Diabetes (%)	29 (19.7)	30 (10.0)	59 (13.3)	0.03
Family history of premature CAD (%)	24 (16.4)	80 (26.8)	104 (23.4)	<0.01
HTN (%)	106 (72.6)	109 (36.5)	215 (48.3)	<0.01

Abbreviations: HTN = history of hypertension, CAD = coronary artery disease, NS = not significant.

(54.2%), of these patients had either ruled in for AMI or had a prior history of coronary artery disease (CAD). Coronary intervention was performed in 85 of 177 (48.0%) of the invasively managed patients. Multiple logistic regression found that a previous history of CAD (OR = 2.6, CI 95%, 1.6-4.1, p = 0.001), positive CK enzymes (OR = 2.8, CI 95%, 1.2-6.7, p = 0.02), and a history of tobacco use (OR = 1.7, CI 95%, 1.0-2.8, p = 0.04) to be independent predictors of angiography utilization. However, positive CK enzymes (OR = 6.1, CI 95%, 1.2-29.8, p = 0.03) and a history of diabetes (OR = 3.5, CI 95%, 1.0-12.4, p = 0.05) independently predicted need for coronary intervention.

Valuations per new individual outcome, such as detecting AMI or discovering a new case of CAD, are shown in Figure 4, with the sensitivity analysis for the valuation of dollars per lived saved tested by the assumption that hospitalization saves lives. These results are based on the premise of an expected mortality of ≤ 1% in this low-risk group. We actually observed no deaths in the study group. If the assumption of 50% lives saved is operative, the valuation per life saved by admitting patients who present with chest pain and normal ECGs is 1.7 million dollars for those who would be suffering from AMI. Similarly, $853,228 would be the cost to save a life of a similar

individual with unstable angina but ruling out for AMI (Fig. 4). Willingness to pay from a societal perspective, in terms of hospital costs expended annualized to fiscal 1994, for each ultimate diagnosis, is illustrated in Figure 5. The aggregate estimated costs to our institution for the practice of admitting patients with chest pain and essentially normal ECGs was 2.5 million dollars during the study period (annualized to 6.1 million dollars for fiscal 1994, Fig. 5).

Discussion

When considered in terms of resources consumed, the evaluation of patients with chest pain is a major public health concern in the United States. The zero tolerance for missed AMI and the recognition of the limitations of previous in-hospital evaluation strategies have given rise to the development of chest pain centers and application of various novel noninvasive protocols. However, the most definitive and cost-effective strategy for the evaluation and triage of patients with chest pain has not been established.[12–18] Moreover, chest pain evaluation is a serious problem for smaller community hospitals where an outpatient chest pain center is not feasible and trans-
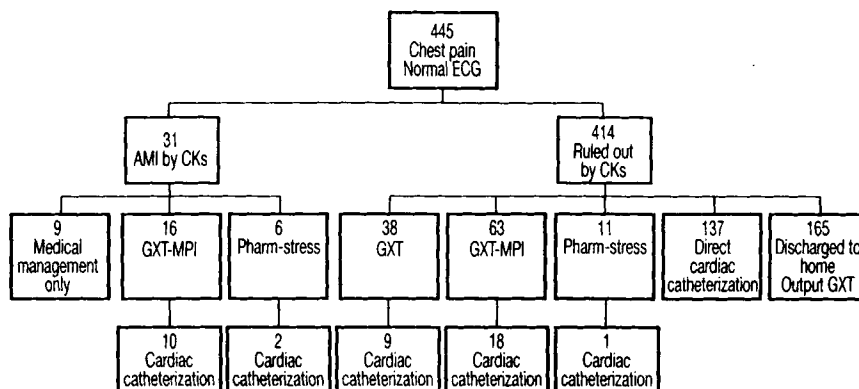

FIG. 2   Diagnostic patient flow of 445 patients admitted with chest pain and essentially normal ECGs. AMI = acute myocardial infarction, CK = creatinine phosphokinase, GXT = graded exercise test, pharm-stress = pharmacologic-persantine or dobutamine stress test, MPI = myocardial perfusion imaging with technetium-99m sestamibi.
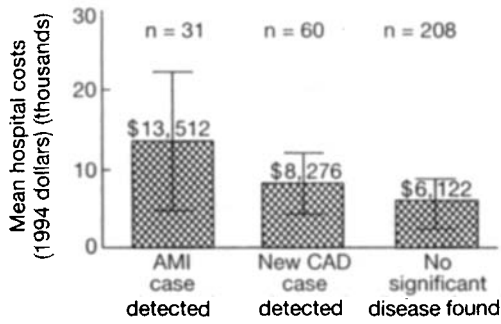
FIG. 3   Mean hospital charges per single case of detected acute myocardial infarction (AMI) and coronary artery disease (CAD), and per case in which no significant coronary disease was detected by noninvasive or invasive testing. This graph excludes 146 patients who had a prior history of CAD.
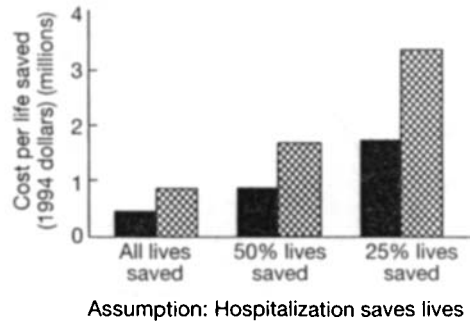

FIG. 4   Sensitivity analysis of the cost per life saved for patients with acute myocardial infarction (AMI) or new coronary artery disease (CAD) diagnosed after being admitted with chest pain and an essentially normal ECG. This shows that the cost ineffectiveness of hospitalization is robust to the assumption that hospitalization saves lives, since the valuations per life saved are far above conventional benchmarks. ■ = New CAD case, ▨ = AMI.

fer of patients is inconvenient and costly. Capitated health care systems, where the underlying societal and legal demands for clinical perfection remain unchanged, but the financial pressures to reduce expenditures per covered life have been increasing, highlight the need for cost-effective but definitive diagnostic strategies.[19]

Our study has shown the unequivocal cost ineffectiveness of the practice of admitting patients to the hospital with chest pain and essentially normal ECGs. In terms of dollars per life saved, at any level in the sensitivity analysis, we have shown the costs are in the millions of dollars. These findings are consistent with a prior theoretical model estimate in the literature.[20] Even if this amount is amortized over a lifespan of remaining perfect health ahead for the saved individual (15 years or more without a recurrent cardiac event), the valuation per quality-adjusted life year (QALY) is over $100,000 and would still be considered highly cost ineffective compared with many other strategies and treatments for cardiovascular patients.[21-25]

Currently, it is estimated that over 80% of patients with chest pain present to hospitals without chest pain centers, in which the results of this study would be directly applicable. In these centers, hospital length of stay is predominately dictated by the availability of noninvasive testing.[26] Although guidelines for in-patient chest pain evaluation have been proposed, they have had little impact on practice patterns even in protocol form.[27] For larger hospitals with chest pain centers, the long-term burden to society in terms of cost incurred by a patient evaluated in a chest pain center and then released home has not been measured. However, given the lack of definitive diagnostic data obtained from such noninvasive evaluations, the additional costs of further diagnostic tests (repeat stress tests, echocardiography, angiography, gastrointestinal and pulmonary consultations) are estimated to be substantial.[20] In this regard, observations from our study document that a substantial number of patients with chest pain ultimately underwent cardiac catheterization even after inhospital noninvasive evaluation. Furthermore, nearly half of

these required some form of intervention. Independent predictors of invasive procedure utilization were limited to a prior history of CAD, diabetes, tobacco use, and especially early enzymatic evidence of AMI. These findings taken together suggest that immediate angiography employed as a primary diagnostic strategy in such patients with chest pain and essentially normal ECGs can provide more definitive and cost-effective evaluation as well as offer the potential for therapeutic benefit. In fact, recent analyses have shown that, compared with noninvasive testing, angiography is cost favorable in patients with moderate pretest probabilities of coronary disease.[28] Randomized, prospective trials are needed to evaluate these pathways for outcomes, with minimization of operator and institutional bias. Finally, long term, the conclusive documentation of coronary disease in a patient with an essentially normal ECG would provide the rationale for aggressive lipid-lowering therapy and other beneficial cardioprotective measures.[29, 30]
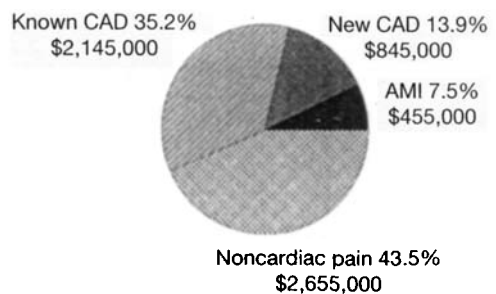

FIG. 5   Annualized hospital costs in 1994 dollars for a 929 bed tertiary care center by ultimate diagnosis: Detection of myocardial infarction (AMI) or new coronary artery disease (CAD), evaluation of known CAD, and evaluation of noncardiac pain. Over 2.6 million dollars per year were spent in 1994 at this institution to rule out CAD in patients with chest pain and essentially normal ECGs.

Conclusions

The practice of hospital admission and sequential diagnostic testing is cost ineffective in terms of costs paid per life saved. Direct angiography for those with positive enzymatic markers for AMI or those with a prior history of CAD could provide a more cost-efficient strategy for definitive evaluation. Ongoing and future studies at our institution employing an inexpensive, portable, fluoroscopic unit designed to facilitate rapid coronary angiography in an outpatient chest pain center may reduce the prohibitive costs to third party payers associated with traditional evaluation strategies observed in the present study.

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