Safety and efficiency of emergency department assessment of chest discomfort

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Abstract

Background: Most Canadian emergency departments use an unstructured, individualized approach to patients with chest pain, without data to support the safety and efficiency of this practice. We sought to determine the proportions of patients with chest discomfort in emergency departments who either had acute coronary syndrome (ACS) and were inappropriately discharged from the emergency department or did not have ACS and were held for investigation.

Methods: Consecutive consenting patients aged 25 years or older presenting with chest discomfort to 2 urban tertiary care emergency departments between June 2000 and April 2001 were prospectively enrolled unless they had a terminal illness, an obvious traumatic cause, a radiographically identifiable cause, severe communication problems or no fixed address in British Columbia or they would not be available for follow-up by telephone. At 30 days we assigned predefined explicit outcome diagnoses: definite ACS (acute myocardial infarction [AMI] or definite unstable angina) or no ACS.

Results: Of 1819 patients, 241 (13.2%) were assigned a 30-day diagnosis of AMI and 157 (8.6%), definite unstable angina. Of these 398 patients, 21 (5.3%) were discharged from the emergency department without a diagnosis of ACS and without plans for further investigation. The clinical sensitivity for detecting ACS was 94.7% (95% confidence interval [CI] 92.5%–96.9%) and the specificity 73.8% (95% CI 71.5%–76.0%). Of the patients without ACS or an adverse event, 71.1% were admitted to hospital or held in the emergency department for more than 3 hours.

Interpretation: The current individualized approach to evaluation and disposition of patients with chest discomfort in 2 Canadian tertiary care emergency departments misses 5.3% of cases of ACS while consuming considerable health care resources for patients without coronary disease. Opportunities exist to improve both safety and efficiency.

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Every year approximately 62 000 Canadians are admitted to hospital with acute myocardial infarction (AMI).[1] Probably an equal number are admitted with unstable angina. An estimated 300 000 to 500 000 present to Canadian emergency departments with chest pain; Canadian registry (FASTRAK II) and clinical trial[2] data suggest that most are admitted to hospital or held for long periods in the emergency department so that AMI can be ruled out. However, some are discharged inappropriately, and "missed MI" remains a serious clinical and medicolegal concern.[3–7] US studies have revealed that approximately 2% of patients with AMI or unstable angina are discharged inappropriately.[5,8]

Several risk stratification tools have been developed for use in patients with chest pain and acute coronary syndrome (ACS),[9,10–17] but none helps clinicians determine which patients can safely be discharged from the emergency department after a brief assessment. Despite the important and controversial nature of this problem, no Canadian data describe disposition and clinical outcomes of emergency department patients with chest discomfort.

Our objective was to determine the proportion of patients with ACS who are inappropriately discharged from the emergency department and to estimate the hospital stay of patients without ACS. We hypothesized that more than 2% of patients with ACS would be discharged without ACS being suspected.

Methods

This prospective, observational cohort study was conducted from June 2000 to April 2001 at St. Paul's and Vancouver General hospitals, which are urban cardiac referral centres. Consecutive patients aged 25 years or older who presented to the emergency departments with chest discomfort were eligible. We excluded those with a clear traumatic cause, a cause that was evident on initial radiographs, enrolment in this study in the previous 30 days, a terminal noncardiac illness with life expectancy of less than 1 year, severe communication problems, no fixed address in British Columbia or no available telephone number for follow-up. Clinical practice was not affected by the study, and no testing was mandated by protocol.

During daytime hours, research nurses obtained informed consent and enrolled eligible patients. Every morning, eligible patients who had presented during the night were phoned and asked for consent. Information collected for the index visit included time of pain onset, admission and discharge times, initial vital signs, risk factors, disposition, length of hospital stay, results of cardiac consultation, discharge diagnoses, cardiac medications, electrocardiogram (ECG) features, results of tests for cardiac serum markers and other cardiac investigations, and details of adverse events.

Follow-up telephone calls after 30 days included a structured interview to document all health care visits and diagnostic test-

ing within 30 days after the index presentation. Information was collected on physician and hospital visits and diagnoses, cardiac investigations, adverse events and cardiac medications. For patients lost to phone follow-up, the research nurses contacted local hospital health records departments and searched BC vital statistics databases to identify all hospital visits, diagnoses, procedures and deaths.

After reviewing all information available for the 30 days after presentation, we assigned an outcome diagnosis of AMI, definite unstable angina, possible unstable angina or no ACS. The diagnoses were hierarchic, mutually exclusive and predefined with the use of explicit criteria (Box 1). If such a diagnosis could not be assigned, or if the only criterion was an elevated serum troponin level, 2 cardiologist co-investigators, blinded to each other's assessment, reviewed all the clinical data and assigned an adjudicated outcome diagnosis. The final outcome was determined by agreement of any 2 of the adjudicators and the primary investigator. If all 3 disagreed, the most significant diagnosis was assigned. Cases of AMI and definite unstable angina were classified as definite ACS.

Adverse events defined explicitly before data collection included death, tachycardia, bradycardia or hypotension requiring intervention, proven pulmonary thromboembolism, proven aortic aneurysm or dissection, new congestive heart failure requiring intravenous therapy, and instances of either assisted ventilation or chest compressions.

Descriptive statistics, including proportions, medians, means and standard deviations, are reported. Diagnostic sensitivity and specificity, with 95% confidence intervals (CIs), were calculated with the standard formula for a proportion to classify patients as having definite ACS or not.

This study was approved by the University of British Columbia/Providence Health Care Research Ethics Board.

Box 1: Explicit criteria for outcome diagnoses by 30 days after emergency department presentation with chest discomfort

Acute myocardial infarction (AMI): at least 1 of the following criteria

- Increase in serum creatine kinase MB definite for AMI according to specific hospital criteria or troponin I level ≥ 1.0 μg/L
- Diagnostic increase in serum troponin I level (> 0.1 but < 1.0 μg/L) and changes consistent with ischemia demonstrated by dynamic electrocardiogram (ECG), > 70% lesion demonstrated by coronary angiography, positive results of stress test (by radionuclide scan, echocardiography or ECG) or urgent need for revascularization
- ECG evolution consistent with AMI
- Fibrinolytic therapy or primary angioplasty and a clinical diagnosis of AMI
- Death with no other definite cause found

Definite unstable angina: rest pain for ≥ 20 min and at least 1 of the following criteria

- Increase in serum troponin I level of 0.1 to 0.99 μg/L alone (all adjudicated)
- Dynamic ECG changes consistent with ischemia in 2 contiguous leads (dynamic ST-segment depression > 0.5 mm or dynamic deep T-wave inversion) but no persistent ST-segment elevation
- > 70% lesion demonstrated by coronary angiography and hospital admission for acute coronary syndrome (ACS)
- Positive results of stress test (by radionuclide scan, echocardiography or ECG)

Possible unstable angina: rest pain for ≥ 20 min and a firm clinical diagnosis of unstable angina, with treatment for unstable angina; however, the case did not meet the above criteria for AMI or definite unstable angina

No ACS: applied when the case did not meet the criteria for the other 3 diagnoses

Results

Of the 4376 patients screened, 1907 were enrolled. However, 40 (2.1%) were excluded after enrolment, and 48 (2.5%) had incomplete follow-up. Thus, data for 1819 patients were analyzed. Table 1 summarizes baseline characteristics for the 1819 patients, of whom 241 (13.2%) had AMI and 157 (8.6%) definite unstable angina. Only 18 patients required adjudication of the outcome diagnosis. The 30-day mortality rate was 1.0% overall, 5.9% among patients with AMI and 0.7% among those with definite unstable angina.

Fig. 1 relates patient outcome to emergency department disposition. Of the 660 patients admitted to hospital, 244 (37.0%) did not have ACS or an adverse event. Of the 1334 patients without ACS or an adverse event, 948 (71.1%)

Table 1: Baseline characteristics for 1819 consecutive, consenting patients

Previous conditions, no. (and %) of patients	
AMI	389 (22.0)
Angina	618 (35.1)
Cocaine use	28 (1.6)
Logistics	
Arrived by ambulance, no. (and %) of patients	563 (31.0)
Median time, minutes (25th, 75th percentiles)	
From pain onset to arrival	125 (61, 316)
From arrival to first electrocardiogram	31 (19, 56)
Demographic characteristics	
Age, mean (and SD), yr	58.2 (16.1)
Male, no. (and %) of patients	1051 (57.8)
Vital signs, mean (and SD)	
Blood pressure, mm Hg	
Systolic	144.1 (27.1)
Diastolic	81.5 (15.4)
Heart rate, beats/min	80.9 (20.8)
Respiratory rate, breaths/min	18.8 (3.5)
30-day diagnosis, no. (and %) of patients	
Definite AMI	241 (13.2)
Definite unstable angina	157 (8.6)
Possible unstable angina	50 (2.7)
Adverse event but no ACS	83 (4.6)
No ACS or adverse event	1288 (70.8)

Note: Percentages are based on the number of patients with confirmed, accurate data. SD = standard deviation, AMI = acute myocardial infarction, ACS = acute coronary syndrome.

were admitted or stayed longer than 3 hours in the emergency department.

At the end of the evaluation in the emergency department, ACS was suspected in 750 cases and unsuspected in 1069 (Table 2). Of the 398 patients with a 30-day diagnosis of definite ACS, 21 (5.3%) were discharged without suspicion of the disease; thus, the clinical sensitivity for ACS was 94.7%. These 21 patients included 11 (4.6%) of the 241 with AMI and 10 (6.4%) of the 157 with definite unstable angina. One of the 21 patients died during the 30-day follow-up period. The true diagnosis was made from 8 hours to 28 days after the index presentation and most commonly during a return visit because of recurrent symptoms. Only 7 of the 21 patients had negative results of serum marker tests and a normal ECG during the index presentation. The other 14 had low-level serum marker elevations or high-risk ECG features. The most common discharge diagnoses at the index presentation of these 21 patients were chest pain not yet determined[5] and atypical chest pain.[3]

Percutaneous intervention was performed in 48.1% of the patients with AMI and 33.8% of the patients with unstable angina. The rates of coronary artery bypass grafting (CABG) were 10.4% and 19.7% respectively. Pulmonary embolism was confirmed in 4 patients, 1 of whom died in hospital; no cases were missed at the index presentation. Aortic aneurysm or dissection was confirmed in no patients.

Interpretation

In this study, 398 of 1819 patients evaluated for chest discomfort had a diagnosis of ACS confirmed within 30 days; 21 (5.3%) of the 398 had been discharged from the emergency department without suspicion of ACS. This "miss rate" is more than twice that reported by Pope and colleagues[8] from a large US study (2.1%). In a previous survey of Canadian emergency physicians,[18] only 5% reported using a systematic follow-up process to identify missed cases, but half estimated that their miss rate for AMI was greater than 2%. Most (94%) indicated that an early-discharge prediction tool would be helpful as long as it did not increase the rate of missed AMI above 2%. Canadian emergency physicians would probably consider the miss rate of 5.3% for ACS in this study unacceptable.

Many emergency departments in the United States have developed chest pain evaluation units (CPEUs) to reduce the likelihood of discharge of patients with ACS. For 6 to

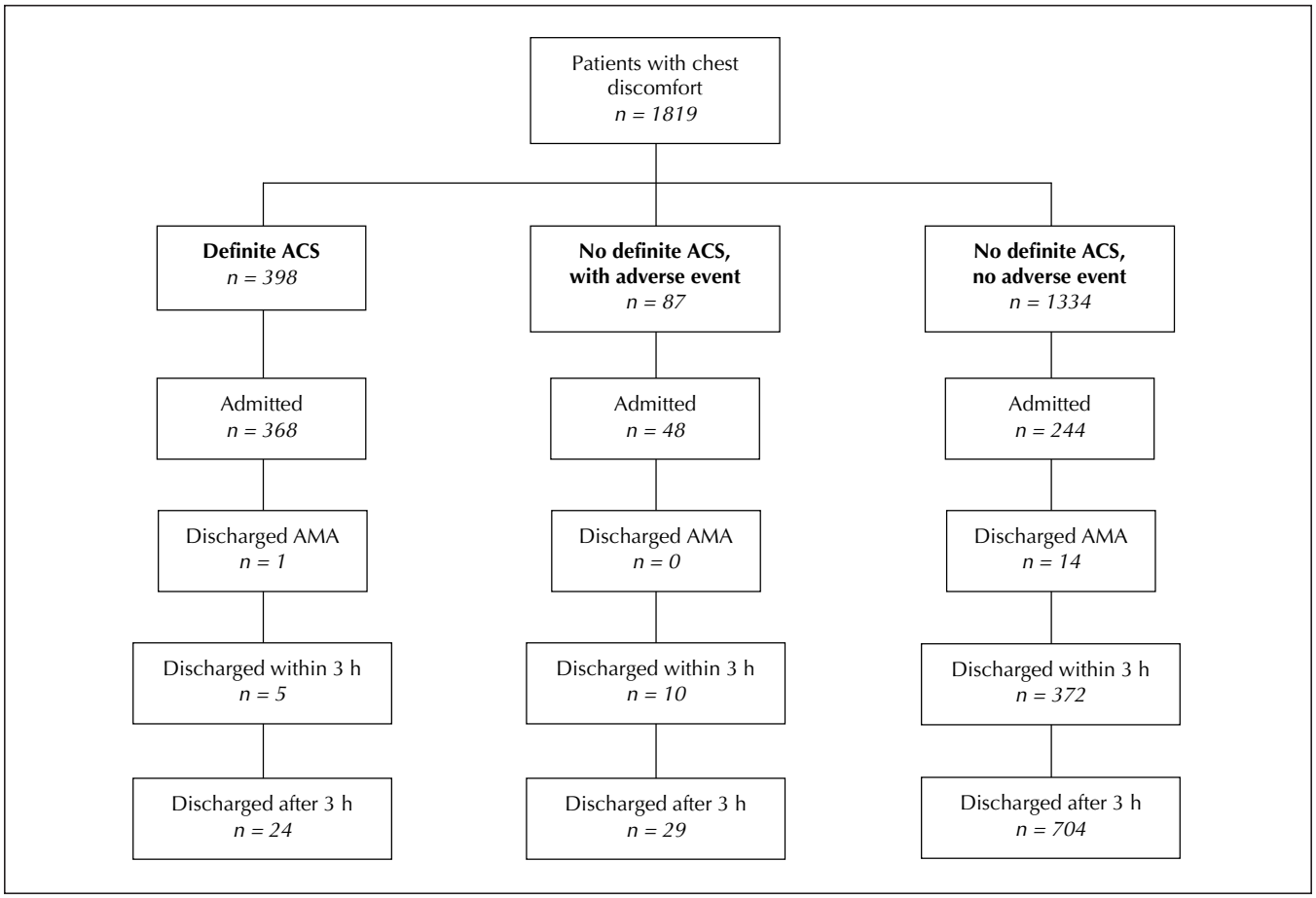

Fig. 1: Disposition and 30-day outcomes of consecutive consenting patients aged 25 years or older presenting with chest discomfort to 2 urban tertiary care emergency departments. ACS = acute coronary syndrome, AMA = against medical advice.

12 hours, these CPEUs apply intensive diagnostic pathways that incorporate continuous monitoring, serial ECGs, serial marker assays, stress tests and advanced imaging for patients with a low prevalence of ACS (2%–5%).[19–27] This approach may improve diagnostic safety, but it increases costs and has not been widely embraced in Canada. CPEUs are cost-effective relative to admitting all low-risk patients to coronary care units[21,24,28–32] but have never been compared with the unstructured diagnostic approach used in most Canadian hospitals. Existing diagnostic pathways and guidelines[10,13,16,17,33–38] do not include clear guidance for the early discharge of patients with a very low likelihood of disease. To ensure that we miss less than 2% of patients, clinicians need effective tools and diagnostic pathways. To maximize efficiency and preserve limited health care resources, administrators and clinicians need evidence that new models are more cost-effective than current Canadian practice.

This study has provided the most current and accurate information on ACS diagnosis in Canadian emergency departments. We attempted to enrol consecutive consenting patients with a presenting symptom of chest discomfort; hence, our study sample is more representative of patients arriving with chest pain than are samples in randomized, interventional clinical trials. Our findings are more robust than registry data because we developed explicit definitions *a priori* and used structured data-collection and follow-up mechanisms. Our 97% direct follow-up rate is excellent, and at 30 days only 2.7% of the patients remained in the ill-defined diagnostic category of possible unstable angina.

There are, however, important study limitations. Some very sick patients who could not provide informed consent were excluded. This might account for the relatively low 30-day mortality rate in our AMI population and would also increase our apparent miss rate. It is possible that the standard of practice improved during the study, since clinicians were aware of outcome monitoring. We based inclusion on the presence of chest discomfort and therefore, by design, did not enrol ACS patients who had no pain. Although this is a limitation, it was necessary so that we could focus on a definable patient population. We did not mandate follow-up marker tests and ECGs for all patients. Therefore, it is possible that some AMIs were undetected; but, if so, there were no apparent sequelae by 30 days. Mandating a structured set of diagnostic tests for all patients would have increased study costs prohibitively for a small and, arguably, unnecessary gain in diagnostic confidence. We relied on patient contact at about 30 days to determine outcome but did not rely on the patient's interpretation of events. The patient informed research assistants of hospital and physician visits and all diagnostic testing. We contacted the physicians to confirm the diagnostic impression and reviewed all admission documentation and diagnostic reports to accurately determine the explicitly defined final outcome.

Many ACS studies have combined "softer" outcomes, such as percutaneous intervention or CABG, or readmission because of unstable angina, in a composite outcome. Since some patients undergo elective percutaneous intervention or CABG during the 30 days after initial presentation with chest discomfort, we tried to determine outcome independent of these events using *a priori* definitions and an adjudication panel when necessary.

Information from other Canadian settings is needed to clarify misdiagnosis rates and utilization of hospital resources across the country.

Conclusion

The current individualized approach to evaluation and disposition of cases of chest discomfort in 2 Canadian emergency departments misses 5.3% of cases of ACS while consuming considerable health care resources in dealing with most of the patients without ACS. Opportunities exist to improve both safety and efficiency. Clinical tools are needed to help clinicians identify patients who can safely be discharged after a short period of investigation.

This article has been peer reviewed.

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Table 2: Accuracy of diagnostic suspicion about ACS at index presentation

	30-day diagnosis; no. of patients		
Suspected diagnosis	AMI or definite unstable angina	No AMI or definite unstable angina	Total no. of patients
ACS*	377	373	750
No ACS†	21	1048	1069
Total no. of patients	398	1421	1819

*No. of patients admitted or discharged with a diagnosis of definite or possible ACS.
†No. of patients discharged with a diagnosis of no ACS.
Sensitivity 94.7% (377/398), 95% confidence interval (CI) 92.5%–96.9%.
Specificity 73.8% (1048/1421), 95% CI 71.5%–76.0%.
Positive predictive value 50.3% (377/750), 95% CI 46.7%–53.8%.
Negative predictive value 98.0% (1048/1069), 95% CI 97.2%–98.9%.

Competing interests: None declared.

Contributors: Principal investigator Jim Christenson envisioned and designed the trial and was responsible for all aspects; he led the data analysis, results interpretation and manuscript writing. The project's initial instigators, Grant Innes and Eric Grafstein, evaluated resource utilization in the emergency department at St. Paul's Hospital and contributed to analysis and interpretation and to manuscript writing. Douglas McKnight was responsible for data collection at one site and contributed to outcome designations and results interpretation. Barb Boychuk was responsible for patient enrolment, oversaw data collection and processing, and managed the research staff; she wrote portions of the manuscript. Christopher Thompson critically evaluated trial design, methodology and analysis. Frances Rosenberg coordinated the additional laboratory testing and was responsible for its quality; she also aided in interpretation and manuscript writing. Aslam Anis contributed to design of methodology. Jessica Tilley was responsible for data cleaning and analysis. Hubert Wong oversaw the analysis and contributed to writing of the methods. Joel Singer provided critical advice on research design and was responsible for implementation of the database, data entry and data analysis. Christopher Thompson, Aslam Anis, Ken Gin, Jessica Tilley, Hubert Wong and Joel Singer provided critical review of the manuscript for important intellectual content. All authors approved the version to be published.

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