Emergency Department Triage of Acute Myocardial Infarction Patients and the Effect on Outcomes

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Study objective: More than half of all acute myocardial infarction patients still do not meet benchmark reperfusion times, and the triage assessment that all patients receive when they arrive at an emergency department (ED) is a hospital-level process that has not been studied as a potential contributor to delays. Our objective was to examine the triage of acute myocardial infarction patients (ST-elevation and non–ST elevation myocardial infarction) and determine whether it is associated with subsequent delays in acute myocardial infarction processes of care.

Methods: We conducted a retrospective cohort analysis of a population-based cohort of acute myocardial infarction patients admitted to 102 acute care hospitals in Ontario, Canada, from July 2000 to March 2001. Main outcome measures were the rate of low-acuity triage (defined as a Canadian Triage and Acuity Scale score of III, IV, or V) among acute myocardial infarction patients and its association with delays in time from ED arrival to initial ECG (door-to-ECG time) and to administration of fibrinolysis (door-to-needle time).

Results: Among 3,088 acute myocardial infarction patients, the rate of low acuity triage was 50.3%. Median door-to-ECG and door-to-needle time was 12.0 and 40.0 minutes, respectively. In adjusted quantile regression analyses, low-acuity triage was independently associated with a 4.4-minute delay in median door-to-ECG time and a 15.1-minute delay in median door-to-needle time. The adjusted odds of achieving benchmark door-to-ECG and door-to-needle times were 0.54 (95% confidence interval 0.46 to 0.65) and 0.44 (95% confidence interval 0.30 to 0.65), respectively, for acute myocardial infarction patients assigned a low-acuity ED triage score.

Conclusion: Half of acute myocardial infarction patients were given a low acuity triage score when they presented to an ED in Ontario, which was independently associated with substantial delays in ECG acquisition and to reperfusion therapy. The quality of ED triage may be an important factor limiting performance on key measures of quality of acute myocardial infarction care. [Ann Emerg Med. 2009;53:736-745.]

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INTRODUCTION

Background

Acute myocardial infarction remains a leading cause of mortality in the US[1] despite numerous therapies known to increase survival.[2-6] Given that 6 million patients with chest pain are evaluated in US emergency departments (EDs) each year,[7] a key challenge is ensuring that acute myocardial infarction patients are appropriately identified and that time-sensitive treatments are rapidly administered. Currently, performance on key acute myocardial infarction quality measures,[8,9] such as time to reperfusion, exceeds the recommended benchmark time in more than half of all acute myocardial infarction patients.[10-15]

The influence of ED systems factors on these acute myocardial infarction quality measures is not well understood. Virtually all patients who present to an ED are initially assessed by a trained triage nurse; despite potentially determining such crucial factors as the timing and the location of subsequent ED care,[16] the effect of the ED triage score on acute myocardial infarction quality of care has not been studied, to our knowledge. In Canada, virtually all EDs[17] use the Canadian Triage and Acuity Scale[18] to

Editor's Capsule Summary

What is already known on this topic

Patients with acute myocardial infarction often do not meet guideline-recommended process-of-care times.

What question this study addressed

Whether triage class is associated with delays in ECG acquisition and door-to-needle times.

What this study adds to our knowledge

In this retrospective analysis of a database of 3,088 patients from 102 emergency departments in Ontario, Canada, patients with acute myocardial infarction assigned to lower categories at triage had longer delays in times to ECG and time until fibrinolytic administration.

How this might change clinical practice

For patients with possible acute myocardial infarction, the role of triage needs to be refined and improved.

perform ED triage. This uniformity provides an opportunity to study the effect of triage across a population level. Australia uses a similar tool,[19] whereas in the United States several triage tools are used.[20]

Goals of This Investigation

Triage assessments may be an important modifiable factor influencing treatment delays for acute myocardial infarction patients. We hypothesized that a relatively small proportion of acute myocardial infarction patients are assigned a low-acuity triage score and that this would be associated with subsequent diagnostic and treatment delays. Because the ED is a complex environment, however, a low triage score may not automatically result in fixed delays: a previous study on ED triage found that patients who are given a triage score of III actually wait longer to see a physician than those who receive a IV or V.[21] Nor is it known to what extent triage delays acute myocardial infarction management, if it does. Our objectives in this study were to establish the frequency of low triage scores among acute myocardial infarction patients presenting to EDs in Ontario, Canada, and to determine the magnitude of the effect of a low ED triage score on time to ECG and time to reperfusion.

MATERIALS AND METHODS

Study Design

This retrospective cohort study linked a population-based sample of acute myocardial infarction patients to an administrative database of all ED records in the province of Ontario, Canada, from July 2000 to March 2001, the period during which the 2 data sets overlapped. We obtained ethics approval from Sunnybrook Health Sciences Centre.

Setting

The Enhanced Feedback For Effective Cardiac Treatment (EFFECT) study contains a population-based sample of acute myocardial infarction patients from the province of Ontario. It has been described in detail elsewhere.[22,23] Briefly, it includes clinical data from retrospective chart reviews of 11,510 acute myocardial infarction patients discharged from 102 acute care hospitals in Ontario from April 1999 to March 2001. All but 1 of the 85 eligible hospital corporations in Ontario that treated 30 or more acute myocardial infarction patients per year agreed to participate. Chart reviews were performed by trained nurse abstractors on a random sample of 125 acute myocardial infarction patients per hospital (or all acute myocardial infarction patients at that hospital if there were fewer than 125), according to prespecified chart review rules. Interrater reliability demonstrated high reliability for all of the indicators assessed by EFFECT.

The National Ambulatory Care Reporting System began in April 2000 and is an administrative database that contains abstracted data on all ED patient visits in Ontario, Canada. Each acute myocardial infarction admission in EFFECT was linked to the ED visit that prompted the admission through the unique encrypted patient health care number. Because reporting of ED visits only began in 2000 and became mandatory by 2002, participation in the National Ambulatory Care Reporting System by all Ontario hospitals was not complete until 2002 because of technical and implementation delays in some sites. During our study period, 87 (85%) of the 102 acute care hospitals in EFFECT were participating.

Canadian Triage and Acuity Scale implementation guidelines were published in 1998 and were disseminated throughout the next several years by training of educators from each Ontario ED. These educators in turn taught the Canadian Triage and Acuity Scale to the nursing staff at their hospitals, usually with a course that was suggested to be 8 hours long, but this could vary according to site choice and resources. Canadian Triage and Acuity Scale training could also take the form of a self-learning package, a Web-based package/compact disc, or video- or teleconference.[17] In a 2005 report on triage training in Ontario,[17] it was noted that although most hospitals reported median percentages of triage nurses trained in adult Canadian Triage and Acuity Scale of between 90% and 100%, some hospitals reported medians in the low 60% range, indicating that even in 2005 not all triage nurses were formally Canadian Triage and Acuity Scale trained. New triage nurses are trained by the site educator as necessary; this continues today as it did during the study period.

Selection of Participants

The inclusion and exclusion criteria of EFFECT patients, as well as the rationale for them, are described elsewhere.[24] In brief, EFFECT includes Ontario residents who are between the

ages of 20 and 105 years, with a valid Ontario Health Care number, and who were admitted to an acute care hospital with a most responsible diagnosis of acute myocardial infarction. The discharge diagnosis of acute myocardial infarction was confirmed using the European Society of Cardiology/American College of Cardiology (ACC) clinical criteria of acute myocardial infarction, which includes presence of any 2 of the following: ECG changes, symptoms, and positive enzyme results.[25] Thus, our sample comprised patients with non–ST-elevation myocardial infarctions (NSTEMIs) and ST-elevation myocardial infarctions (STEMIs). Patients were excluded if the acute myocardial infarction was an inhospital complication, and patients who were transferred to a second site were counted only once according to their first admission. We chose a priori to exclude patients whose initial therapy was percutaneous coronary intervention because there were relatively few patients (n=48) who underwent primary percutaneous coronary intervention in EFFECT,[22,23] and in particular only 6 during our study period.

Outcome Measures

We defined 2 outcome measures a priori: (1) door-to-ECG time, and (2) door-to-needle time. For both outcomes, we analyzed the effect of low triage score on the median and the 90th percentile times and on the odds of achieving the ACC/American Heart Association (AHA) benchmark target times (10 minutes for door-to-ECG time and 30 minutes for door-to-needle time[8]). Door-to-ECG time was defined as the interval between time of arrival at the ED and the time of the initial ECG. Because out-of-hospital ECGs constituted less than 0.5% of the initial ECGs, these were removed from the analysis. Door-to-needle time was the interval between arrival in the ED and the time when the fibrinolysis infusion was started. Time of arrival in the ED was defined in EFFECT as the time the patient was treated by a triage nurse in the ED; in Ontario, triage occurs before registration. Time of the initial ECG was taken from the ECG, which uses a clock internal to the ECG machine. Time of fibrinolysis infusion was taken from the ED chart.

Methods of Measurement

The main predictor variable was whether patients were assigned a low acuity triage score, defined as a Canadian Triage and Acuity Scale score of III, IV, or V (corresponding to urgent, less urgent, and nonurgent, respectively). This definition is based on formal Canadian Triage and Acuity Scale recommendations that patients suspected of having an acute myocardial infarction be assigned a score of I or II, corresponding to resuscitation and emergency assessment by a physician, respectively.[18] The Canadian Triage and Acuity Scale uses clinical symptoms (such as recent, nontraumatic chest pain) and medical history (such as acute myocardial infarction risk factors), as well as vital signs and an abbreviated physical examination, to determine which patients could be having an acute myocardial infarction.

A STEMI was defined as either greater than or equal to 1 mm ST-segment elevation in 2 contiguous ECG leads or a (not known to be old) left bundle-branch block, in the presence of chest pain.[8] Patients who did not have an initial ECG result that was diagnostic of a STEMI but developed such findings within the first 2 hours of their ED course were included in the study cohort (n=62). These patients were included because the effect of low triage on subsequent care may differ from patients with a diagnostic first ECG, a difference we wanted to capture. All models included a variable to control for the presence of a nondiagnostic first ECG.

We accounted for 24 potential confounders in the relationship between low triage and door-to-ECG time and door-to-needle time (including the covariates of several validated predictor instruments of acute myocardial infarction severity[26,27]). These included (1) patient demographics (age, sex, socioeconomic status based on median neighborhood household income), (2) clinical features (systolic blood pressure, pulse rate, respiratory rate, chest pain, shortness of breath, cardiac arrest or shock, pulmonary edema), (3) medical history (diabetes mellitus, hypertension, smoking, hypercholesterolemia, coronary artery disease, percutaneous coronary intervention or coronary artery bypass graft surgery, congestive heart failure, cardiac medications), (4) hospital factors (type of hospital, yearly ED acute myocardial infarction volumes, presence of a catheterization laboratory on site), and (5) contextual factors (arrival by ambulance, time of day, day of week). In our door-to-needle analysis, we also included location of fibrinolysis (ED or ward), nondiagnostic initial ECG, and bundle-branch block or paced rhythm on ECG. Cardiac arrest was documented if it occurred in the 6 hours before or 10 minutes after arrival in the ED, as documented by a physician. Cardiac medications were those that the patient was taking in the 2 weeks before ED arrival, including aspirin, β-blockers, angiotensin-converting enzyme inhibitors, statins, angiotensin receptor blockers, nitroglycerin, and clopidogrel (total number of these medications out of a possible 7).

Primary Data Analyses

We modeled the independent effect of low triage on median and 90th percentile time intervals by using quantile regression.[28] Quantile regression is particularly suited to analysis of highly skewed distributions such as time intervals. It also permits analysis at other percentiles, which is useful because the 90th percentile reflects how the system performs for most patients.[28] Bootstrap resampling was used to estimate standard errors and confidence intervals (CIs). In the quantile regression analysis of door-to-ECG time, we analyzed STEMI and NSTEMI patients separately, as well as together. Multivariable logistic regression modeling was used to model the odds of achieving benchmarks times. Generalized estimating equation methods were used to account for the clustering of patients within EDs. We tested for an age and sex interaction in each model, and all models were examined for collinearity and goodness-of-fit characteristics where appropriate. Quantile

regression was performed with Stata software (version 9; StataCorp, College Station, TX), whereas all other analyses were done with SAS software (version 9.1; SAS Institute, Inc., Cary, NC).

Sensitivity Analyses

We conducted several sensitivity analyses: we used linear regression with logarithmic transformation of door-to-ECG and door-to-needle time (using generalized estimating equations) to check whether the results of our primary analysis were consistent with both approaches. Next, we used both quantile regression modeling and linear regression with logarithmic transformation to assess the effect of very low triage, defined as a Canadian Triage and Acuity Scale score of IV or V, on outcomes. In addition, because 26.7% of the patients in EFFECT were not linked to the National Ambulatory Care Reporting System because of incomplete hospital participation during the study period, we performed several analyses to assess whether this introduced a bias to our cohort. First, we evaluated whether acute myocardial infarction patients whose data could not be linked were systematically different from others by comparing 6 preselected characteristics in a univariate analysis (using χ^2 and t tests as appropriate): age, sex, door-to-ECG time, mortality at 30 days, hospital length of stay, and Global Registry of Acute Coronary Events score.[27] Finally, we performed a logistic regression model to see whether it was possible to predict whether a patient would receive a triage score or not; we included all the covariates in our door-to-ECG model except hospital factors and added Global Registry of Acute Coronary Events score[27] and presence of STEMI.

RESULTS

We linked inhospital records to ED visits for 3,088 (73.4%) of 4,210 acute myocardial infarction patients in EFFECT. Baseline characteristics of the entire study cohort are provided in Table 1. Of the 3,088 acute myocardial infarction patients, 1,552 (50.3%) were assigned a low acuity triage score. Almost half of the cohort had criteria for a STEMI (47.9%). The median door-to-ECG time for the cohort was 12.0 minutes (interquartile range [IQR] 5.0 to 24.0), and the median door-to-needle time for those who received fibrinolysis was 40.0 minutes (IQR 25.0 to 74.0). Of the 2,925 patients in the study cohort with a documented door-to-ECG time, 45.9% (95% CI 44.1% to 47.8%) met the benchmark door-to-ECG time of 10 minutes, and 36.6% (95% CI 33.4% to 39.9%) of the patients who received fibrinolysis met the benchmark door-to-needle time of 30 minutes. The 30-day mortality rate was 12.1% (95% CI 11.0% to 13.3%), consistent with other large studies of acute myocardial infarction patients.[29,30]

Although a larger proportion of patients with STEMI criteria received a high acuity triage score than those without STEMI criteria, almost 43.7% of these patients still received a low acuity triage score (Table 2). Centers that treated very high volumes of acute myocardial infarction patients were less likely

Table 1. Baseline characteristics of the study cohort.

Characteristic	No. of Patients
Canadian Triage and Acuity Scale triage score, No. (%)	
I	140 (4.5)
II	1,396 (45.2)
III	1,336 (43.3)
IV	154 (5.0)
V	62 (2.0)
Mean age, y (SD)	67.5 (14.0)
Male, No. (%) (3 patients with missing data)	2,002 (64.9)
Income quintile, No. (%) (102 patients missing data)	
Quintile 1	659 (21.3)
Quintile 2	659 (21.3)
Quintile 3	590 (19.1)
Quintile 4	536 (17.4)
Quintile 5	542 (17.6)
Presenting signs and symptoms	
Systolic blood pressure, mm Hg, mean (SD)	147.0 (32.6)
Pulse rate, beats/min, mean (SD)	85.1 (25.8)
Respiratory rate, breaths/min mean (SD)	21.2 (5.9)
Chest pain within 48 h, No. (%)	2,671 (86.5)
Shortness of breath, No. (%)	947 (30.7)
Presenting cardiac arrest or shock, No. (%)	121 (3.9)
Presenting pulmonary edema, No. (%)	175 (5.7)
Medical history	
One or more risk factors,* No. (%)	2,519 (81.6)
Two or more risk factors,* No. (%)	1,289 (41.7)
History of coronary artery disease, No. (%)	1,306 (42.3)
History percutaneous coronary intervention or coronary artery bypass surgery, No. (%)	278 (9.0)
Number of cardiac medications patient is receiving, median (IQR)	1.0 (2.0)
ED visit details	
Arrival by ambulance, No. (%)	1,339 (43.4)
Time of day, No. (%)	
Morning (8 AM to 4 PM)	1,343 (43.5)
Evening (4 PM to midnight)	1,013 (32.8)
Night (midnight to 8 AM)	732 (23.7)
Day of week, No. (%)	
Sunday	475 (15.4)
Monday	500 (16.2)
Tuesday	430 (13.9)
Wednesday	415 (13.4)
Thursday	430 (13.9)
Friday	420 (13.6)
Saturday	418 (13.5)
Hospital-level characteristics	
Hospital type, No. (%)	
Teaching (7 sites)	305 (9.9)
Community (69 sites)	2,588 (83.8)
Small (11 sites)	195 (6.3)
Cardiac catheterization laboratory hospital	386 (12.5)
ED acute myocardial infarction volume, No. (%)	
Very low (7 sites)	114 (3.7)
Low (17 sites)	424 (13.7)
Moderate (14 sites)	508 (16.5)
High (14 sites)	502 (16.2)
Very high (35 sites)	1,540 (49.9)

*Diabetes mellitus, hypertension, smoker, dyslipidemia.

Table 2. Proportion of STEMI and NSTEMI patients in each triage category.

	CTAS 1, %	CTAS 2, %	CTAS 3, %	CTAS 4, %	CTAS 5, %	Total, %
NSTEMI	3.3	40.3	48.5	5.3	2.5	/100
STEMI	5.5	50.7	37.6	4.7	1.5	/100

CTAS, Canadian Triage and Acuity Scale.

Table 3. Distribution of triage categories for acute myocardial infarction patients by ED annual acute myocardial infarction volume (87 sites).

Annual ED Acute Myocardial Infarction Volume	CTAS 1 or 2, %	CTAS 3, 4, or 5, %
Very low-volume (<50) EDs	38.6	61.4
Low-volume (50–99) EDs	45.3	54.7
Moderate-volume (100–199) EDs	41.7	58.3
High-volume EDs (200–299)	46.6	53.4
Very-high-volume EDs (>300)	55.4	44.6

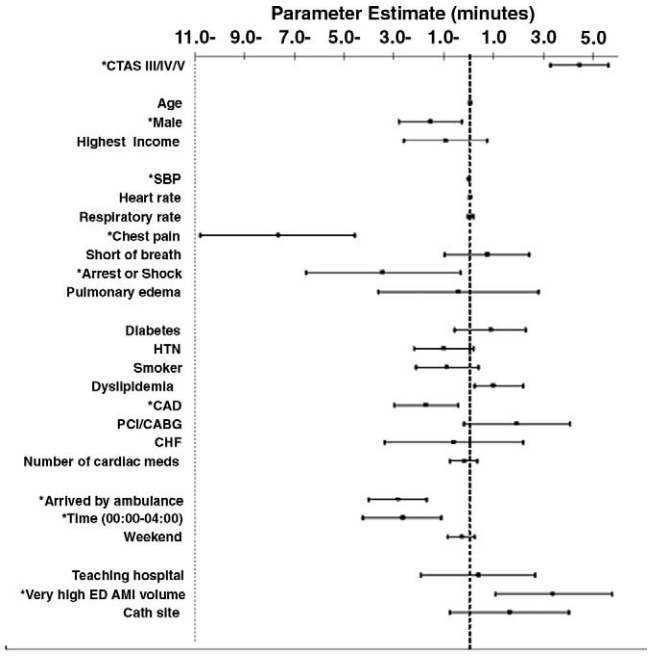

Figure 1. Independent effect in minutes of patient, contextual, and hospital factors on median door-to-ECG time, with 95% confidence intervals.

*Variables marked with an asterisk are statistically significant ($P< 0.05$). CTAS: Canadian Triage and Acuity Scale; SBP: Systolic Blood Pressure; HTN: Hypertension; CAD: Coronary Artery Disease; PCI: percutaneous coronary intervention; CABG: coronary artery bypass surgery; CHF: Congestive Heart Failure; ED: emergency department; AMI: acute myocardial infarction.

to assign low acuity triage scores to acute myocardial infarction patients than low-volume centers (Table 3).

Figure 1 provides the results of the multivariable door-to-ECG quantile regression analysis. The regression parameters in this model can be interpreted as the effect on median door-to-ECG time in minutes for each covariate: the assignment of a low acuity triage score was associated with an adjusted increase in median door-to-ECG time of 4.4 minutes (95% CI 3.2 to 5.6 minutes; $P<.001$) compared with receiving a high acuity triage score, representing a 36.7% increase in the overall median time. Complaining of chest pain had the greatest effect on door-to-ECG time in the model, decreasing it by 7.7 minutes relative to those patients without chest pain. Triage also had a significant, independent effect at the 90th percentile of door-to-ECG times, where the difference in door-to-ECG time between the low- and high acuity triage groups was 26.1 minutes (95% CI 13.6 to 38.6 minutes; $P<.001$). In this model, only 2 other predictors were significant: complaining of chest pain and being treated at an ED with very high acute myocardial infarction volumes. The results in both the median and 90th percentile models were similar when patients with STEMI and NSTEMI were analyzed separately (95% CIs overlapped). Acute myocardial infarction patients given a low acuity triage score had significantly lower adjusted odds of meeting the ACC/AHA benchmark door-to-ECG time of 10 minutes (0.54; 95% CI 0.46 to 0.65).

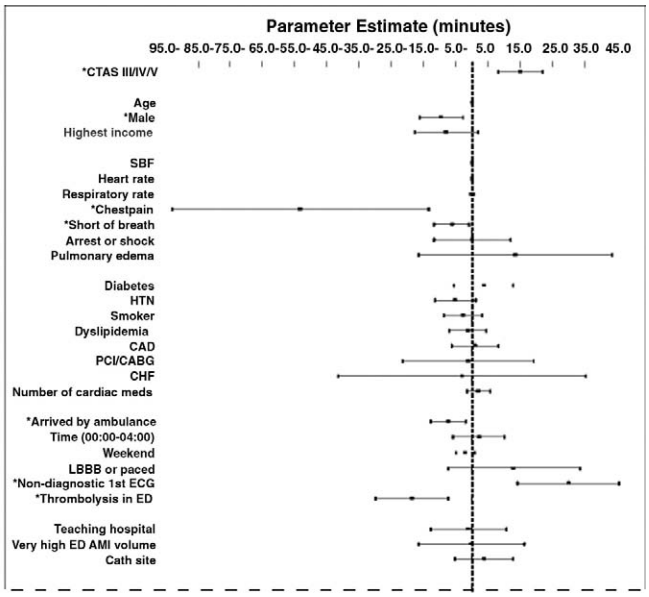

Figure 2. Independent effect in minutes of patient, contextual, and hospital factors on median door-to-needle time, with 95% confidence intervals.

*Variables marked with an asterisk are statistically significant ($P< 0.05$). n = 833. CTAS: Canadian Triage and Acuity Scale; SBP: Systolic Blood Pressure; HTN: Hypertension; CAD: Coronary Artery Disease; PCI: percutaneous coronary intervention; CABG: coronary artery bypass surgery; CHF: Congestive Heart Failure; LBBB: Left Bundle Branch Block; ECG: electrocardiogram; Left ED: emergency department; AMI: acute myocardial infarction.

The results of the multivariable door-to-needle time analysis are provided in Figure 2. The assignment of a low acuity triage score was associated with an independent increase in median door-to-needle time of 15.1 minutes (95% CI 8.1 to 22.0

minutes; $P<.001$), representing a 38% increase in the overall median time. A low acuity triage score was a significant predictor at the 90th percentile of the door-to-needle times, with an adjusted increase of 36.6 minutes (95% CI 12.7 to 60.6 minutes; $P=.003$) compared with patients who received a high triage score. There were only 2 other significant predictors of door-to-needle time at the 90th percentile: a nondiagnostic initial ECG and a complaint of shortness of breath. Acute myocardial infarction patients given a low acuity triage score had significantly lower adjusted odds of meeting the ACC/AHA benchmark door-to-needle time of 30 minutes (0.44; 95% CI 0.30 to 0.65).

Sensitivity analyses using linear regression modeling of the logarithmic-transformed door-to-ECG and door-to-needle time confirmed a significant effect of ED triage on both outcomes. In sensitivity analyses of very low triage (Canadian Triage and Acuity Scale scores of IV and V), even longer delays in outcomes were found. Our analyses of acute myocardial infarction patients excluded because of the inability to link to a triage score in the National Ambulatory Care Reporting System found no difference in age, sex, door-to-ECG time, mortality at 30 days, hospital length of stay, and Global Registry of Acute Coronary Events score[27] compared with linked acute myocardial infarction patients. Our logistic regression model had a *c* statistic of 0.54, similar to chance, suggesting that the model could not discriminate between patients who could be linked versus those who could not. We concluded that there was no evidence of selection bias in our cohort.

LIMITATIONS

One limitation of this study was the use of only admitted acute myocardial infarction patients. This probably results in a conservative bias because we did not capture the patients who were discharged home from the ED (ie, their acute myocardial infarction was missed entirely), which might occur more frequently in acute myocardial infarction patients who are given a low-acuity triage score. Another limitation was retrospective data collection, with some of the inherent limitations of chart review, including documentation of important clinical features such as reoccurrence of chest pain. However, rigorous training of nurse chart abstractors, standardized data collection instruments, and evaluation of interrater reliability should limit bias.[31] The adjusted increase that we found in door-to-ECG and door-to-needle time was less than the delay associated with each Canadian Triage and Acuity Scale score; this may be because many nonacademic centers are not crowded,[32] so patients can be moved into a room earlier than the guidelines suggest (the guidelines are suggested maximum wait times[18]). Just as important, our models included some variables that could be considered part of the triage process itself, such as patient vital signs, so in our attempt to isolate the independent effect of triage on outcome times, we may have overaccounted for some variables and underestimated the effect of triage on door-to-ECG and door-to-needle time (a conservative bias).

The data in our study are from 2000 and 2001, and door-to-ECG and door-to-needle times may have improved since then. However, the results of several studies with data from 1999 to 2006[33-35] suggest that there is not a trend of improved door-to-ECG times. A study of 68,439 STEMI patients at more than 1,000 hospitals in the United States found that there was no statistically significant improvement of door-to-needle times from 1999 to 2002,[13] whereas STEMI patients in the Global Registry of Acute Coronary Events registry from 1999 to 2006 had slightly improved median door-to-needle times, from 40 to 34 minutes, although 52% still had a door-to-needle time of greater than 30 minutes in 2006.[12] These studies suggest that our findings remain relevant. It is possible that there has been some improvement in the triage process itself since 2001, but there is no published evidence supporting this, to our knowledge. Canadian Triage and Acuity Scale training in Ontario may have improved in terms of dissemination since the guidelines were released in 1998,[18] but training was in place then as it is now (and some triage nurses still do not have Canadian Triage and Acuity Scale training[17]), so is unlikely to have changed enough to alter our results.

Because all acute myocardial infarction patient charts were collected at small hospitals, compared with a maximum of 125 at larger hospitals, these patients may have been proportionately overrepresented in this study. However only 13% of the hospitals were small hospitals, so the bias is likely small (and all models contained a variable for hospital type), and sampling was purposely done this way to avoid having such a small sample of these acute myocardial infarction patients that their care was not able to be assessed in statistical analyses. The ED clocks (including the one internal to the ECG machine) were not synchronized; however, this would likely have led to misclassification bias and only diminished the strength of our results. Last, our study cannot differentiate whether the cause of low triage was (1) inappropriate application of the Canadian Triage and Acuity Scale by the triage nurse, (2) a problem with the Canadian Triage and Acuity Scale system itself, or (3) an inherent difficulty in identifying acute myocardial infarction patients (via the necessarily brief triage assessment). Disentangling the role of the triage nurse and the triage system itself would make an excellent future study.

DISCUSSION

This population-based study of acute myocardial infarction patients in the province of Ontario found that half of all acute myocardial infarction patients, including 44% who had criteria for a STEMI, were assigned an inappropriately low triage score when they arrived in an ED. Low acuity triage score assignment was associated with substantial independent increases in median and 90th percentile door-to-ECG and door-to-needle times, including a 15-minute increase in median door-to-needle time and a 37-minute increase at the 90th percentile. The odds of achieving acute myocardial infarction benchmark times for both ECG acquisition and fibrinolysis were about half as good for

acute myocardial infarction patients assigned low-acuity triage scores as for other acute myocardial infarction patients.

There is substantial evidence suggesting that earlier reperfusion is associated with lower mortality,[4,36-39] with the benefit increasing nonlinearly the earlier it is given.[36] By one calculation, every 60 minutes of delay in door-to-needle time results in 43 lives lost at 5 years per 1,000 patients treated.[36] Therefore, we can estimate that an additional 11 lives per 1,000 patients treated would be lost because of the observed 15-minute delay in median door-to-needle time of low-triage patients. These estimates suggest that about 100 acute myocardial infarction patients in Ontario die each year because of delays associated with low ED triage.

The delay in door-to-needle time from low-triage may be put into perspective by comparing it to the improvement in door-to-needle time when fibrinolysis is administered in the ED, instead of in the cardiac care unit. Until the mid to late 1990s, only cardiologists administered fibrinolysis, usually in the cardiac care unit. When studies revealed significantly shorter door-to-needle times (by about 20 minutes) when fibrinolysis was administered in the ED by an emergency physician,[40-43] a systemwide change was instituted at hospitals across North America, the United Kingdom, and Australia, among others, where the responsibility for giving thrombolytics was transferred to the emergency physician. In our study, the adjusted time gained by ED fibrinolysis, 18.7 minutes, was almost equivalent to the delay introduced by low acuity triage, 15.1 minutes. Just as ED fibrinolysis was an important issue that was addressed at various hospital levels to improve patient care, so too is the evaluation of triage of acute myocardial infarction patients.

Although the emphasis in reperfusion therapy has in recent years shifted from fibrinolysis to percutaneous coronary intervention,[12] between 60% and 70% of acute myocardial infarction patients in the United States present to hospitals without ready access to percutaneous coronary intervention.[44] Regardless of the reperfusion modality, the ED steps preceding it are the same, including triage and acquisition of an ECG. Thus, we believe the results of this study likely apply to acute myocardial infarction patients who receive percutaneous coronary intervention as well, though the magnitude of the effect may differ. This is significant, given that door-to-balloon times are currently longer than the recommended benchmark time in the majority of patients.[12,14,15,45]

Our analysis of door-to-ECG time suggests one causal mechanism for reperfusion delays because we showed that a low ED acuity triage score is independently associated with a longer door-to-ECG time. A longer door-to-ECG time has been shown in another study to be associated with increased mortality at 30 days in STEMI patients,[35] presumably because the delay in completing an ECG results in a delay to fibrinolysis or percutaneous coronary intervention. Delays in door-to-ECG time for *all* potential acute myocardial infarction patients, not just STEMI patients, are important because differentiation of STEMI from all the other patients evaluated for an acute myocardial infarction can occur only *after* the ECG has been done. Efforts to reduce ECG and reperfusion delays have focused in large part on out-of-hospital ECGs, yet implemention remains spotty in emergency medical services, and more than half of all acute myocardial infarction patients do not arrive by ambulance.[46,47] Therefore, we believe that more research attention needs to be allocated to decreasing the time to the initial ECG in the ED, including evaluating the value of specific ED triage criteria for acute coronary syndrome patients,[48,49] a physical space for acquiring a triage ECG, formal triage staff training in acute myocardial infarction recognition, and others.[50] The results of this study strongly suggest that we acquire a triage ECG on all potential acute coronary syndrome patients, regardless of their triage score. However, although triage ECGs are now common in many large institutions, we do not know whether triage ECGs actually reduce times to reperfusion for those who need it or if they are worth the time invested (acquiring the ECG, showing it to a physician) that could result in slower care for the other patients in the ED. At a minimum, our results suggest the need for further research into the net benefit of triage ECGs, and for individual EDs to monitor the rate of low acuity triage assignment for their acute myocardial infarction patients.

The most surprising finding in this study was that half of patients who were having an acute myocardial infarction were given low ED triage scores. We hypothesize that several factors may increase the rate of low triage. ED crowding is common in many EDs,[10,51-53] and there may be an element of "down-triage" that occurs as a result of it[17]: potential acute myocardial infarction patients may be assigned a lower triage score corresponding to when they are *able* to be treated, instead of when they *should* be treated. Alternatively, there may be errors in the triage process itself, given that triage training, after the initial 4 to 8 hours of Canadian Triage and Acuity Scale training, is not standardized.[17] Last, and perhaps most important, acute myocardial infarction presentations can be subtle (not all acute myocardial infarction patients are identified even after a full evaluation by a physician, including ancillary testing[30,54]), and current triage evaluations, even when properly done, may not be sufficiently sensitive to detect many acute myocardial infarction patients. Future studies could evaluate potential patient- and hospital-level predictors of ED triage score, the use of triage ECGs and more standardized triage training, as well as assess the relationship of ED triage to door-to-balloon times. Disentangling errors in application of the triage system from flaws in the system itself is another area ripe for further study.

Almost half of patients who were having an acute myocardial infarction were given an inappropriately low triage score when they arrived at an Ontario ED. Low-acuity triage of acute myocardial infarction patients was associated with substantial delays in both door-to-ECG and door-to-needle time. The importance of the quality and completeness of the very first contact between patient and medical staff has perhaps been underestimated in terms of its effect on downstream events for these seriously ill patients. Our results suggest that the triage process is an important determinant of quality of care for acute

myocardial infarction patients and that efforts to reduce reperfusion delays really must begin at the door.

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IMAGES IN EMERGENCY MEDICINE

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DIAGNOSIS:

Posterior sternoclavicular joint dislocation. Computed tomography (CT) demonstrated posterior dislocation at the right sternoclavicular joint (Figure 4). Posterior sternoclavicular dislocations are rare and less common than anterior sternoclavicular dislocations, but they are important to recognize because compromise of the great vessels, esophagus, and trachea can occur.[1,2] Involvement of these structures results in a variety of clinical symptoms, including dysphagia, shortness of breath, venous engorgement, and hypotension from arterial laceration.[3] The injury is usually a result of high-energy trauma, such as motor vehicle crashes, that cause posterolateral shoulder compressive forces that dislocate the medial aspect of the clavicle posterior to the sternum.[4] Cases have also been reported in which posterior dislocation results from direct blunt trauma to the medial clavicular head.

Contrast-enhanced CT is the imaging modality of choice because the great vessels need to be evaluated and plain radiography may not adequately assess joint alignment. Closed reduction is the preferred treatment, but patients presenting more than 48 hours after injury, as in our case, often require surgical intervention.[5] Posterior sternoclavicular dislocation is an uncommon entity that may present with a variety of signs and symptoms. The diagnosis may be suspected on physical examination, but CT is required for definitive diagnosis and can be lifesaving.

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