Canadian Journal of Cardiology 27 (2011) 731–738

Clinical Research

Temporal Associations of Early Patient Transfers and Mortality With the Implementation of a Regional Myocardial Infarction Care Model

Alka B. Patel, MGIS,[a] Hude Quan, MD, PhD,[a] Peter Faris, PhD,[a] Merril L. Knudtson, MD,[b,c] Mouhieddin Traboulsi, MD,[b,c] Bing Li, MA,[d] and William A. Ghali, MD, MPH[a,b]

[a] Department of Community Health Sciences, University of Calgary, Calgary, Alberta, Canada

[b] Department of Medicine, University of Calgary, Calgary, Alberta, Canada

[c] Libin Cardiovascular Institute, University of Calgary, Calgary, Alberta, Canada

[d] Alberta Health Services, Calgary, Alberta, Canada

ABSTRACT

Background: In order to reduce the delays encountered through patient transfer, regional care models have been developed that directly transport subsets of acute myocardial infarction (AMI) patients to hospitals with percutaneous coronary intervention (PCI) facilities. Calgary is a Canadian city that implemented this type of model in 2004.

Methods: The study population included 9768 AMI patients admitted to Calgary hospitals between 1997 and 2007. Administrative data were used to define patients who were directly admitted to the PCI hospital and those transferred there after initial admission to a hospital without specialized cardiac care. The differences in clinical characteristics and mortality trends of patients grouped by hospital delivery site and transfer practice are described.

Results: The proportion of patients directly admitted to a PCI hospital has increased with the implementation of a regional care model. Among patients admitted to non-PCI facilities, the patients who are

RÉSUMÉ

Introduction : Pour réduire les délais lors du transfert du patient, des modèles régionaux de soins ont été développés afin de transporter directement les sous-ensembles de patients atteints d'un infarctus aigu du myocarde (IAM) vers des hôpitaux ayant des services d'intervention coronarienne percutanée (ICP). Calgary est une ville canadienne qui a mis en place ce type de modèle en 2004.

Méthodes : La population à l'étude incluait 9 768 patients atteints d'un IAM admis aux hôpitaux de Calgary entre 1997 et 2007. Les données administratives étaient utilisées pour déterminer les patients qui étaient directement admis à l'hôpital pour une ICP et ceux qui y étaient transférés après leur admission initiale dans un hôpital sans soins cardiaques spécialisés. Les différences dans les caractéristiques cliniques et les tendances dans la mortalité des patients regroupés par hôpital et pratique du transfert sont décrites.

There have been several studies that have shown the superiority of percutaneous coronary intervention (PCI) as a treatment for ST-elevation myocardial infarction (STEMI) when compared with thrombolytic therapy in terms of reducing mortality rate and recurrence of myocardial infarction (MI).[1-4] This success of PCI is dependent on a number of factors, in particular the influence of time to treatment.[5-7] Current American and European guidelines suggest performing PCI for STEMI within 90 minutes of the first medical contact.[8,9]

Delaying PCI increases STEMI mortality. For every 30 minutes of delay in treatment, it has been reported that the relative risk for 1-year mortality is 1.075.[10] Because a minority of hospitals are able to perform PCI, STEMI patients are increasingly transferred emergently from their presenting hospital to ones with specialized procedural cardiac care. An early invasive strategy is also beneficial for those patients who have non-ST–elevation MI (NSTEMI). A meta-analysis that included 7 randomized trials found that for NSTEMI patients a prompt invasive strategy was superior to a selective invasive strategy over an average 17-month follow-up period in terms of reducing MI and rehospitalization.[11] These studies thus collectively show that timely access to PCI and surgical revascularization is important for both NSTEMI and STEMI patients, although the optimal revascularization time window for NSTEMI patients is in need of further definition.

Health systems are responding to this evidence. Regional care models have been developed in some jurisdictions to allow for expedited diagnosis and the direct transport of STEMI patients to hospitals with catheterization and PCI facilities.[12-15]

Received for publication June 19, 2011. Accepted August 1, 2011.

Corresponding author: Dr William A. Ghali, Faculty of Medicine: University of Calgary, 3330 Hospital Drive NW, Calgary, Alberta T2N 4N1, Canada. Tel.: +1-403-210-9317; fax: +1-403-210-3818.

E-mail: wghali@ucalgary.ca

See page 737 for disclosure information.

doi:10.1016/j.cjca.2011.08.114

transferred are younger, more likely to be male, have a shorter length of stay, and have lower proportions of several comorbid conditions. The risk-adjusted in-hospital mortality odds ratio for patients who received care at the PCI hospital postmodel relative to those treated at non-PCI hospitals premodel was 0.38 (95% confidence interval, 0.31-0.47). The corresponding adjusted odds ratio was 0.60 (0.47-0.76).
Conclusions: Our results suggest changing care over time and trends toward improved outcomes. Patients' clinical characteristics appear to play a major role in the decision to transfer. Avoidance of the risk treatment paradox through refinement of regional transfer protocols ought to be a priority.

Résultats : La proportion de patients directement admis à un hôpital ayant des services d'ICP a augmenté avec la mise en place d'un modèle régional de soins. Parmi les patients admis aux établissements non équipés pour les ICP, les patients qui sont transférés sont plus jeunes, plus susceptibles d'être des hommes, ont une durée de séjour plus courte et ont des proportions plus faibles de comorbidité. Le risque ajusté du risque relatif approché de la mortalité intrahospitalière des patients qui recevaient des soins d'un hôpital avec des services d'ICP par rapport à ceux qui étaient traités dans des hôpitaux sans service d'ICP était de 0,38 (intervalle de confiance de 95 %, 0,31-0,47). Le risque relatif approché ajusté correspondant était de 0,60 (0,47-0,76).
Conclusions : Nos résultats suggèrent un changement dans les soins au fil du temps et des tendances vers l'amélioration. Les caractéristiques cliniques des patients semblent jouer un rôle majeur dans la décision du transfert. L'évitement du paradoxe de traitement du risque par l'amélioration des protocoles de transferts régionaux devrait être une priorité.

Calgary is a large Canadian city that implemented a regionalized care model for STEMI patients in 2004.[15] Calgary has 3 tertiary care hospitals, and of these, only 1 (the Foothills Medical Centre [FMC]) offers specialized procedural cardiac care. The regional care model in Calgary focuses on rapid onsite assessment of suspected STEMI patients by the emergency medical services team with electronic transmission of 12-lead electrocardiograms (ECGs). Those patients with electrocardiogram changes that suggest STEMI are directly transferred by emergency medical services from the scene to the interventional site at FMC, bypassing the non-PCI hospitals if they are closer.[15]

The objective of this study is to describe the clinical characteristics, process of care, and outcomes of acute MI (AMI) patients both before and after the implementation of a regional care model in Calgary, a city with 1 of the lowest AMI mortality rates in Canada.[16] The study being undertaken adds to the current literature by addressing 3 questions using Calgary as a case study: (1) How has the pattern of inter-hospital transfer of AMI patients changed with the implementation of a regional care model?; (2) How do the clinical characteristics of AMI patients transferred differ from those patients who are not transferred before and after the implementation of a regional care model?; and (3) Is there an association between AMI patient hospital delivery site and/or transfer practice and mortality?

Methods

Study population

Administrative inpatient records were collected from Alberta Health Services. Patients admitted to the 3 Calgary acute care hospitals between April 1, 1997 and March 31, 2007 with a primary diagnosis of AMI represented the study population. All data for this study were analyzed on a fiscal year basis (April 1 of one calendar year to March 31 of the subsequent year). The primary diagnosis of AMI was defined using the International Classification of Disease (ICD) codes. ICD-9 codes were used prior to April 1, 2002 (410.x), a coding that captures all AMI without distinction of STEMI and NSTEMI types. ICD-10 codes (I21 and I22), allowing some distinction between STEMI (I21.0-I21.3) and NSTEMI (I21.4) were used after April 2002.

The AMI study adopted exclusionary criteria similar to previous studies using ICD codes and administrative data.[17,18] Patients under 20 years of age, without a valid Alberta Provincial Healthcare Number (PHN), nonresidents of Alberta, and patients admitted to a noncardiac surgical service were excluded from our study. Those patients who were admitted more than once with a primary diagnosis of AMI within the 10-year period were also excluded as it was expected that patients with multiple admissions for AMI would have clinical profiles that would be unlike patients who were initially presenting with AMI. A total of 9768 AMI patient records met these criteria (Fig. 1). Because this study focused on the transfer of patients, exclusionary criteria based on length of stay (LOS) or transfer from another acute care facility were not used. In addition to the inpatient database, emergency room records from Alberta Health Services were collected for the Calgary zone for the defined time period. This ensured that those patients who were not admitted but directly transferred from emergency rooms (in a non-PCI hospital) to a hospital with specialized procedural cardiac care could be tracked as transfer patients.

Study variables

From the study population, 3 groups of AMI patients were created. The 'not transferred' group consisted of AMI patients admitted to non-PCI hospitals and not transferred to the PCI facility. The 'transferred' group comprised patients transferred from a non-PCI hospital to the PCI facility. The 'directly admitted' comparator group was composed of AMI patients admitted directly to the PCI hospital. Transfer for AMI has previously been defined "as occurring when a patient is admitted to one acute care hospital and discharged from a different hospital during an episode of care for an AMI."[19] The transfer of patients was therefore defined by linking unique anonymous patient records based on scrambled unique healthcare numbers. When a patient was admitted to the PCI hospital within 24 hours after an admission or an emergency room visit to a non-PCI hospital they were recorded as a transfer. This type of deterministic linkage is usually complete and any nonlinkage is due to rare events of coding error. The 24-hour transfer period was chosen to ensure that only urgent transfers were recorded.

The characteristics of interest in the 3 groups were sex, age, length of stay, in-hospital mortality, and the Elixhauser comor-

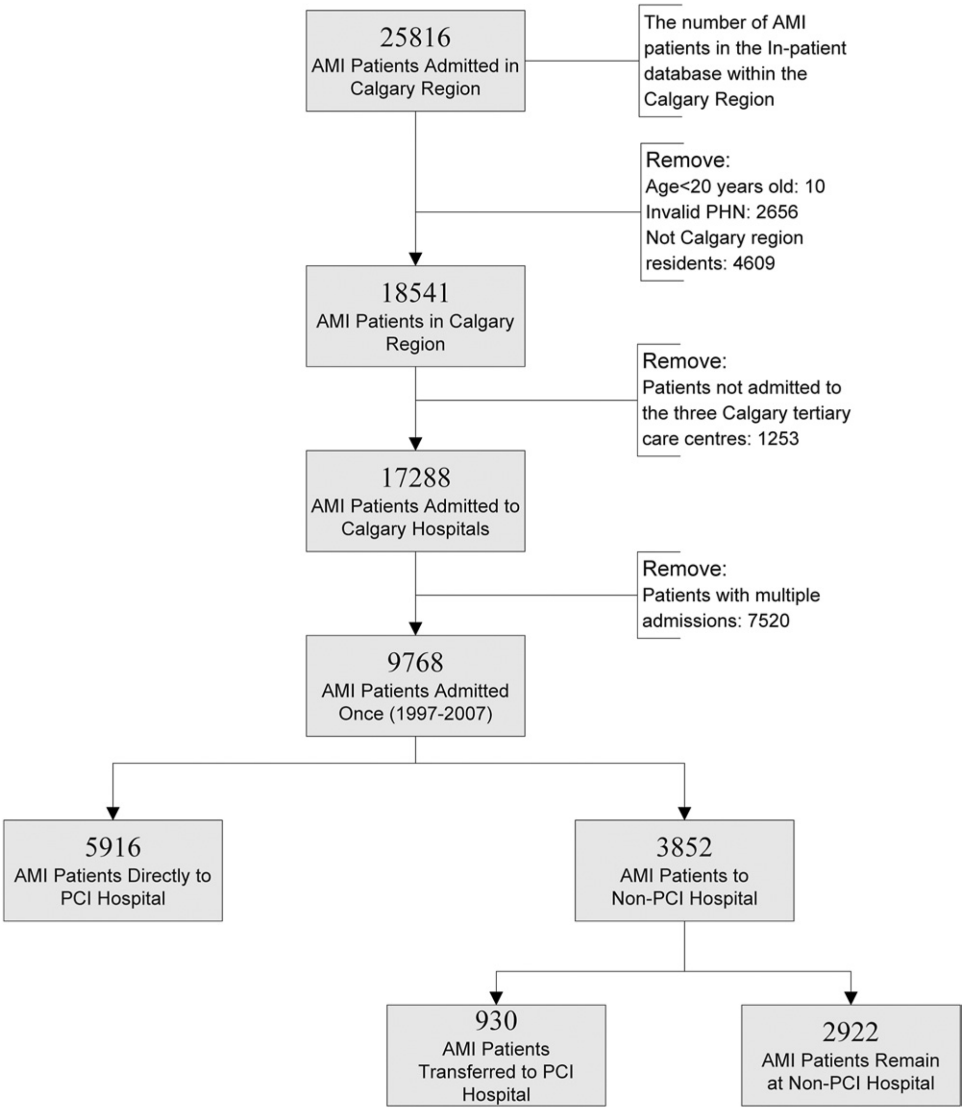

Figure 1. Study population of patients. AMI, acute myocardial infarction; PCI, percutaneous coronary intervention; PHN, Provincial Healthcare Number.

bidity measures.[20,21] The Elixhauser comorbidity measures have been proven superior in predicting mortality for MI patients in comparison with the Charlson comorbidity index[22] and thus were chosen here as a risk adjustment tool.

Statistical analysis

The change over time in the proportion of patients in the transferred, not transferred, and direct admission groups were first evaluated. The differences in the clinical characteristics of the 3 groups were described over 2 time periods (before and after the implementation of a regional care model). Changes over time in the proportion of crude patient mortality were evaluated for the 3 groups. Two-sample difference of proportions *t* tests were used to evaluate differences for 2 group comparisons. Finally, logistic regression modelling was used to determine the crude and risk adjusted odds of in-hospital mortality for patients before vs after the implementation of a regional care model. To examine the potential effects of the increased care at PCI facilities (through either increased direct admits or transfer) vs improvements over time (arising from other possible factors such as improved medical therapy), we extended our outcome modelling to stratify the time effect by whether patients received care at the PCI hospital or not. All risk adjusted models included age, sex, and the Elixhauser comorbidity measures. All statistical analysis was conducted using Stata version 10.1 (Stata Corp, College Station, TX). This study was approved by the Conjoint Health Research Ethics Board at the University of Calgary.

Results

Study population

There were 9768 AMI patients meeting our inclusion criteria admitted to the 3 Calgary hospitals during the study period (Fig. 1). The overall number (*N*) of AMI patients admitted annually increased steadily from 1997 to 2007 (from 767 to 1189). A total of 5916 (60.6%) patients were admitted directly

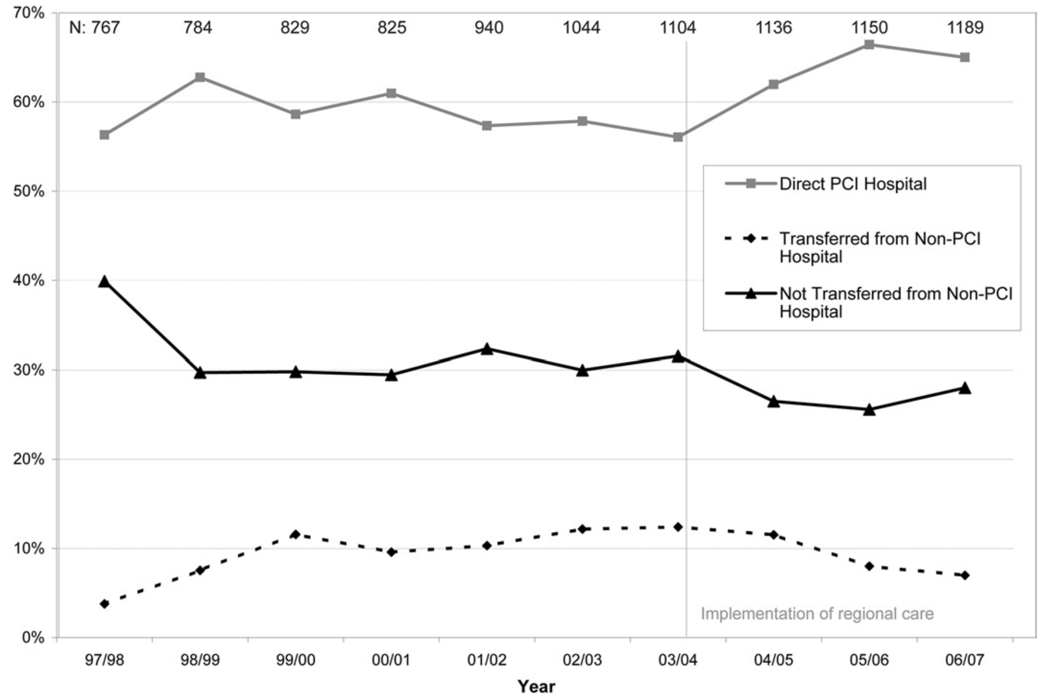

Figure 2. Changes in acute myocardial infarction patient transfer over time in Calgary. PCI, percutaneous coronary intervention.

to the PCI hospital, and 3852 (39.4%) patients were admitted to non-PCI hospitals. Of all patients, only 930 (9.5%) were transferred from a non-PCI hospital to the PCI hospital.

Change in transfer over time

During the study period we observed changes in the rate of direct admissions and transfers to PCI hospitals as summarized in Figure 2. The proportion of patients transferred between hospitals had decreased with the implementation of the regional care model (12% transferred in 2003-2004, and 7% in 2006-2007, $P < 0.001$). During the same time period the proportion of AMI patients directly admitted to the PCI hospital increased from 56% to 65% ($P < 0.001$). The proportion of patients not transferred decreased from the 2003-2004 fiscal year to the 2004-2005 fiscal year but then plateaued.

Population characteristics

The characteristics of the population of AMI patients stratified by time (pre- and postregionalized care model) are shown in Table 1. Overall, the mean age of AMI patients transferred is significantly lower than those who are not both before (59.8 vs 70.0) and after (60.2 vs 70.9) the implementation of a regional care model ($P < 0.001$). Among patients admitted to non-PCI hospitals there is a significantly lower proportion of females transferred compared with proportion of females not transferred (25.4% vs 40.5%, $P < 0.001$). The patients who are transferred are younger, more likely to be male, have a shorter overall length of stay (across all care sites involved), and have lower proportions of several comorbid conditions.

There was a difference observed in the percentage of suspected STEMI patients among the 3 groups. Between 2002 and 2007 among STEMI patients 20.1% were transferred from a non-PCI to the PCI hospital, 12.7% were not transferred from a non-PCI hospital, and 67.2% were directly admitted to the PCI hospital. The corresponding percentages for suspected NSTEMI cases between 2002 and 2007 were 1.5% transferred from a non-PCI to the PCI hospital, 46.9% not transferred from a non-PCI hospital, and 51.6% admitted directly to the PCI hospital. Similar percentages could not be derived for earlier years because of limitations of the coding system.

In-hospital mortality

The proportion of patients with the end point of in-hospital mortality has decreased over the 10-year study period for the transferred, not transferred, and comparator groups as shown in Figure 3. Of those patients who were directly admitted to the PCI hospital, 8.5% died in-hospital before the implementation of a regional care model and 6.1% after the implementation (Table 1). Over the entire study period, of those patients who were initially admitted to a non-PCI hospital, the proportion of AMI patients who died before discharge was lower for those AMI patients transferred to the PCI hospital when compared with those patients remaining at the non-PCI hospital (4.6% vs 12.5%; $P < 0.001$). The unadjusted and risk-adjusted (for age, sex, and Elixhauser comorbid conditions) odds ratios for all AMI cases in the years that followed implementation of the regional care model relative to preceding years were 0.67 (95% confidence interval [CI], 0.57-0.78) and 0.92 (0.77-1.10), respectively. The supplementary analysis, which examined the potential effects of the increased care at PCI facilities, revealed that both time and site of care (PCI hospital vs non-PCI hospital) were potentially independent determinants on in-hospital mortality (Table 2). The crude odds ratio was 0.38 (0.31-0.47) for patients who received care at the PCI hospital after the care model was introduced (relative to those treated at non-PCI hospitals before the care model). The crude odds ratio for

Table 1. Characteristics of AMI patients pre- and postimplementation of regionalized care

	AMI patients preimplementation of regional care, N (%)*			AMI patients postimplementation of regional care, N (%)*		
Total	Transfer N = 624	Not transferred N = 1994	FMC direct N = 3675	Transfer N = 306	Not transferred N = 928	FMC direct N = 2241
Age, mean (95% CI)	59.8 (58.8-60.7)	70.0 (69.4-70.6)	65.6 (65.1-66.0)	60.2 (58.8-61.6)	70.9 (69.9-71.8)	65.8 (65.3-66.4)
Female	158 (25.3)	805 (40.4)	1079 (29.4)	78 (25.5)	377 (40.6)	624 (27.8)
Length of stay, median (IQR)	6 (4-8)	7 (5-11)	6 (4-10)	5 (4-7)	6 (4-10)	5 (3-10)
In-hospital mortality	34 (5.5)	273 (13.7)	314 (8.5)	9 (2.9)	92 (9.9)	136 (6.1)
Congestive heart failure	125 (20.0)	510 (25.6)	927 (25.2)	38 (12.4)	195 (21.0)	355 (15.8)
Cardiac arrhythmia	157 (25.2)	456 (22.9)	1061 (28.9)	58 (19.0)	178 (19.2)	458 (20.4)
Valvular disease	18 (2.9)	207 (10.4)	288 (7.8)	5 (1.6)	61 (6.6)	85 (3.8)
Pulmonary circulation disorders	4 (0.6)	65 (3.3)	56 (1.5)	1 (0.3)	22 (2.4)	20 (0.9)
Peripheral vascular disorders	22 (3.5)	131 (6.6)	241 (6.6)	4 (1.3)	34 (3.7)	84 (3.8)
Hypertension uncomplicated	248 (39.7)	786 (39.4)	1659 (45.1)	132 (43.1)	416 (44.8)	1108 (49.4)
Hypertension complicated	7 (1.1)	71 (3.6)	156 (4.2)	3 (1.0)	68 (7.3)	90 (4.0)
Paralysis	4 (0.6)	20 (1.0)	36 (1.0)	2 (0.7)	9 (1.0)	8 (0.4)
Other neurological disorders	20 (3.1)	73 (3.7)	161 (4.4)	7 (2.3)	24 (2.6)	62 (2.8)
Chronic pulmonary disease	50 (8.0)	333 (16.7)	401 (10.9)	14 (4.6)	130 (14.0)	140 (0.6)
Diabetes uncomplicated	75 (12.0)	369 (18.5)	610 (16.6)	32 (10.5)	114 (12.3)	247 (11.0)
Diabetes complicated	19 (3.0)	91 (4.6)	175 (4.8)	24 (7.8)	101 (10.9)	222 (9.9)
Hypothyroidism	36 (5.8)	140 (7.0)	278 (7.6)	4 (1.3)	39 (4.2)	49 (2.2)
Renal failure	12 (1.9)	153 (7.7)	212 (5.8)	6 (2.0)	106 (11.4)	121 (5.4)
Liver disease	4 (0.6)	13 (0.7)	33 (0.9)	2 (0.7)	11 (1.2)	13 (0.6)
Peptic ulcer disease excluding bleeding	3 (0.5)	21 (1.1)	21 (0.6)	1 (0.3)	8 (0.9)	3 (0.1)
Lymphoma	0 (0.0)	5 (0.3)	11 (0.3)	1 (0.3)	7 (0.8)	10 (0.5)
Metastatic cancer	0 (0.0)	17 (0.9)	28 (0.8)	1 (0.3)	16 (1.7)	8 (0.4)
Solid tumour without metastasis	4 (0.6)	44 (2.2)	97 (2.6)	2 (0.7)	33 (3.6)	39 (1.7)
Rheumatoid arthritis	11 (1.8)	42 (2.1)	84 (2.3)	4 (1.3)	16 (1.7)	28 (1.3)
Coagulopathy	16 (2.6)	10 (0.5)	106 (2.9)	7 (2.3)	12 (1.3)	32 (1.4)
Obesity	20 (3.2)	74 (3.7)	137 (3.7)	17 (5.6)	23 (2.5)	62 (2.8)
Weight Loss	1 (0.2)	11 (0.6)	15 (0.4)	0 (0.0)	9 (1.0)	3 (0.1)
Fluid and electrolyte disorders	87 (13.9)	172 (8.6)	656 (17.9)	8 (2.6)	52 (5.6)	60 (2.7)
Blood loss anemia	4 (0.6)	18 (0.9)	16 (0.4)	1 (0.3)	10 (1.1)	12 (0.5)
Deficiency anemia	2 (0.3)	41 (2.1)	46 (1.3)	2 (0.7)	26 (2.8)	19 (0.9)
Alcohol abuse	11 (1.8)	47 (2.4)	88 (2.4)	4 (1.3)	21 (2.3)	32 (1.4)
Drug abuse	4 (0.6)	12 (0.6)	34 (0.9)	0 (0.0)	5 (0.5)	15 (0.7)
Psychoses	2 (0.3)	18 (0.9)	24 (0.7)	0 (0.0)	7 (0.8)	6 (0.3)
Depression	13 (2.1)	56 (2.8)	105 (2.9)	4 (1.3)	23 (2.5)	44 (2.0)

AMI, acute myocardial infarction; CI, confidence interval; FMC, Foothills Medical Centre; IQR, interquartile range.
* Unless otherwise specified.

postmodel care at non-PCI hospitals was 0.69 (0.54-0.89). The corresponding risk adjusted odds ratios were 0.60 (0.47-0.76) and 0.73 (0.55-0.96).

Discussion

Our findings show that the proportion of patients admitted directly to a PCI hospital has increased with the implementation of a regional AMI care model, a model that encourages ambulance diversion to the hospital with specialized cardiac care. In-hospital mortality for AMI patients, meanwhile, has decreased over the 10-year study period. Among patients first admitted to non-PCI hospitals, the patients who are transferred to PCI hospitals are younger, more likely to be male, have a shorter length of stay, and have lower proportions of several comorbid conditions. Those patients who are not transferred within 24 hours are more likely to be NSTEMI patients. Both time and site of care (PCI hospital vs non-PCI hospital) appear to be potentially independent determinants on in-hospital mortality.

The administrative data used in this study allowed for a retrospective view of the changes in the transfer of AMI patients over a 10-year time period. Few studies have been conducted to show how transfer patterns have changed over time with the implementation of a regional care model for AMI patients. The development of regional care models has ultimately reduced the time to reperfusion for STEMI patients through expedited diagnosis and direct transport to facilities with procedural cardiac care when STEMI is suspected.[14,15] Long-term outcomes for STEMI patients who were treated with PCI within a regional system of care are improved when compared with reperfusion treatments prior to these systems being in place.[23] In the current study it was found that the implementation of a regional care model has been successful in transporting more AMI patients directly to a hospital with specialized cardiac care thereby making it possible to reduce the time to procedural treatment for a greater proportion of AMI patients.

Our study also revealed that the characteristics of patients transferred to the PCI hospital after initial presentation to a non-PCI hospital are markedly different than those who remain at the non-PCI site. It appears that AMI patients who are younger and have fewer comorbid conditions are the ones that are transferred from a general acute care hospital to one with specialized procedural cardiac care. Similar results have been found in the US for AMI patients who experienced interhospital transfer; they were significantly younger, less critically ill,

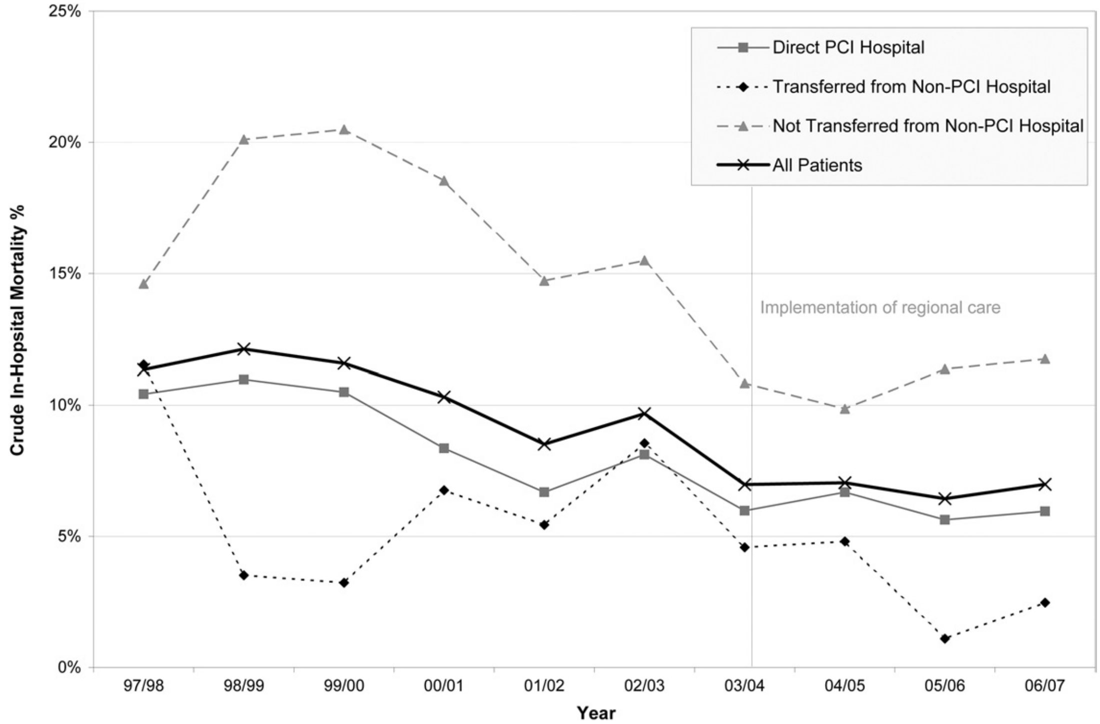

Figure 3. Changes in crude acute myocardial infarction patient mortality over time in Calgary. PCI, percutaneous coronary intervention.

and had lower comorbidity than nontransferred patients.[19] The lower proportion of women being transferred in our study is likely to be a result of the risk factor profiles of the women rather than a true inequality in service provision. Studies have shown that although male and female AMI patients are treated differently, the less intensive treatment of older patients, who are more often female, is the reason for this discrepancy.[24] However, the significant differences observed in our study between the clinical characteristics of the patients transferred vs those remaining at the non-PCI hospital leaves the question of whether the selection process for transfer is appropriate, or whether we are observing a risk treatment paradox (ie, not transferring seemingly high-risk patients who stand to benefit considerably from transfer, but who paradoxically are not transferred because of fear of risks).

We found a trend in decreased mortality over the 10-year period. It is difficult to attribute this directly to the implementation of a regional care model but it could be part of the decrease observed. The adjusted odds ratio of in-hospital mortality for AMI patients postmodel relative to earlier years shows that the clinical characteristics of patients have changed. A possible reason for this is the introduction of troponins in 2001 that may have changed the overall clinical profile of 'MI cases,' with inclusion in later years of patients with only mild enzyme abnormalities who would not have been classified as 'MI cases' in earlier years.[25] There is also the possibility that improvements in medical care that are independent of transfer are the reason for the decreased mortality during this time period. Nevertheless, there is a compelling temporal association between the care model and decreased mortality especially when the time effect (pre- vs postmodel) is stratified according to whether patients received care at a PCI hospital, either directly or through transfer.

It is important to recognize that regional AMI care models have multiple components (eg, expedited diagnosis, direct transport, critical pathways to medication administration, and intervention team mobilization). This study focuses only on the prehospital component of direct transport or transfer to a facility with procedural cardiac care. Our focus in this study was on a tight time window of 24 hours that represented pur-

Table 2. Odds ratio of in-hospital mortality by care received pre- and postimplementation of regionalized care

Care received*	*N* (%)	Crude OR (95% CI)	Risk-adjusted† OR (95% CI)‡
Pre- vs postmodel	–	0.67 (0.57-0.78)	0.92 (0.77-1.10)
Premodel, non-PCI hospital	1994 (20.4)	1.0 (reference)	1.0 (reference)
Premodel, PCI hospital	4299 (44.0)	0.56 (0.47-0.66)	0.54 (0.45-0.66)
Postmodel, non-PCI hospital	928 (9.5)	0.69 (0.54-0.89)	0.73 (0.55-0.96)
Post-model, PCI hospital	2547 (26.1)	0.38 (0.31-0.47)	0.60 (0.47-0.76)

CI, confidence interval; OR, odds ratio; PCI, percutaneous coronary intervention.

* PCI hospital reached either from direct admission or transfer.

† Adjusted for age, sex, and Elixhauser comorbid conditions.

‡ C-statistic, 0.84 (95% CI, 0.83-0.85); Hosmer-Lemeshow χ^2, 42.7; $P < 0.001$.

poseful transfer. There could be transfers that occur beyond this 24-hour time window that we captured, particularly in patients who develop problems such as recurrent ischemia or arrhythmias. This study evaluates the changes in the transfer patterns of patients and the possible in-hospital mortality benefit of being transferred to a hospital with procedural cardiac services vs remaining at a presenting hospital without these services. Although this is a case study in an urban area, patients from suburban and rural areas have been included. Our study, conducted using general administrative data forms a baseline understanding of how regionalized AMI care models have affected patient transfer, the types of patients that are being transferred, and the potential benefits of receiving care at a PCI hospital when compared with remaining at the presenting hospital. This understanding is fundamental to future studies on specific procedural cardiac care.

An important limitation of this study is our use of administrative data. In particular, this dictated an inability to clinically distinguish STEMI from NSTEMI for the entire study period (ICD-10 coding permitting this distinction was introduced in 2002). As such, we are studying all AMIs to gain insight into STEMI care in particular (where emergent transfer is ideal in the early period of MI). Due to the inability to distinguish between the 2 AMI subtypes for the entire study period, we have not presented in-hospital mortality for these 2 groups. Although regional care models focus first and foremost on reducing time to reperfusion for STEMI patients, NSTEMI patients clearly also benefit from early reperfusion. The Fragmin and Fast Revascularization During Instability in Coronary Artery Disease (FRISC)-II trial showed at 5-year follow-up that early invasive strategies were beneficial when compared with noninvasive strategies in terms of reducing the risk of reinfarction and death for moderate- to high-risk NSTEMI patients.[26] The Treat Angina With Aggrastat and Determine Cost of Therapy With an Invasive or Conservative Strategy (TACTICS) trial showed a significant reduction in the rate of death or nonfatal myocardial infarction at 6 months for those NSTEMI patients who underwent early invasive treatment when compared with those who underwent selectively invasive treatment (odds ratio, 0.74; 95% CI, 0.54-1.00; $P < 0.05$).[27] A systematic review confirmed these findings showing that early revascularization benefits NSTEMI patients in the short-term when compared with conservative medical treatments through reduced rates of refractory angina and rehospitalization.[28] Our study findings do indeed show that a diagnosis of NSTEMI (rather than STEMI) is a strong predictor of nontransfer.

Our study findings demonstrate: (1) an increase in the proportion of patients directly admitted to a PCI hospital over time; and (2) a trend of steadily decreasing mortality over this 10-year period. This type of care evolution is complex. It is hard to disentangle the simultaneous potential effects of the care model, transfers, evolving medical therapies, and other temporal factors. However, our results do suggest changing care over time and trends toward improved outcomes. These findings are in a context of clinical trial evidence in the published literature demonstrating benefits of early procedural intervention in both STEMI and NSTEMI. Clearly, moving to aggressive intervention for all AMI patients would not be a realistic or appropriate goal. Yet, avoidance of the risk treatment paradox through refinement of regional transfer protocols ought to be a priority.

Acknowledgements

The authors thank the research members of the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) for their comments on this study.

Funding Sources

Alka Patel is supported by a Canadian Institutes of Health Research (CIHR) Doctoral Research Award and an Alberta Heritage Foundation for Medical Research (AHFMR) Incentive Award. William Ghali is supported by a Government of Canada Research Chair in Health Services Research and a Senior Health Scholar Award from the Alberta Heritage Foundation for Medical Research. Hude Quan is supported by a Health Scholar Award from the Alberta Heritage Foundation for Medical Research.

Disclosures

The authors have no conflicts of interest to disclose.

References

1. Andersen HR, Nielsen TT, Rasmussen K, et al. A comparison of coronary angioplasty with fibrinolytic therapy in acute myocardial infarction. N Engl J Med 2003;349:733-42.
2. Henriques JPS, Zijlstra F, van't Hof AWJ, et al. Primary percutaneous coronary intervention versus thrombolytic treatment: long term follow up according to infarct location. Heart 2006;92:75-9.
3. Keeley EC, Boura JA, Grines CL. Primary angioplasty versus intravenous thrombolytic therapy for acute myocardial infarction: a quantitative review of 23 randomised trials. Lancet 2003;361:13-20.
4. Widimsky P, Budesinsky T, Vorac D, et al. Long distance transport for primary angioplasty vs immediate thrombolysis in acute myocardial infarction - Final results of the randomized national multicentre trial - PRAGUE-2. Eur Heart J 2003;24:94-104.
5. Carstensen S, Nelson GCI, Hansen PS, et al. Field triage to primary angioplasty combined with emergency department bypass reduces treatment delays and is associated with improved outcome. Eur Heart J 2007; 28:2313-9.
6. Nallamothu BK, Fox KAA, Kennelly BM, et al. Relationship of treatment delays and mortality in patients undergoing fibrinolysis and primary percutaneous coronary intervention. The Global Registry of Acute Coronary Events. Heart 2007;93:1552-5.
7. Steg PG, Juliard JM. Primary percutaneous coronary intervention in acute myocardial infarction: time, time, and time! Heart 2005;91:993-4.
8. Antman EM, Hand M, Armstrong PW, et al. 2007 focused update of the ACC/AHA 2004 guidelines for the management of patients with ST-elevation myocardial infarction - A report of the American college of cardiology/American heart association task force on practice guidelines. Circulation 2008;117:296-329.
9. Van de Werf F, Bax J, Betriu A, et al. Management of acute myocardial infarction in patients presenting with persistent ST-segment elevation: the Task Force on the Management of ST-Segment Elevation Acute Myocardial Infarction of the European Society of Cardiology. Eur Heart J 2008; 29:2909-45.

10. De Luca G, Suryapranata H, Ottervanger JP, Antman EM. Time delay to treatment and mortality in primary angioplasty for acute myocardial infarction - Every minute of delay counts. Circulation 2004;109:1223-5.

11. Mehta SR, Cannon CP, Fox KAA, et al. Routine vs selective invasive strategies in patients with acute coronary syndromes - A collaborative meta-analysis of randomized trials. JAMA 2005;293:2908-17.

12. Gross BW, Dauterman KW, Moran MG, et al. An approach to shorten time to infarct artery patency in patients with ST-segment elevation myocardial infarction. Am J Cardiol 2007;99:1360-3.

13. Khot UN, Johnson ML, Ramsey C, et al. Emergency department physician activation of the catheterization laboratory and immediate transfer to an immediately available catheterization laboratory reduce door-to-balloon time in ST-elevation myocardial infarction. Circulation 2007;116:67-76.

14. Le May MR, Davies RF, Dionne R, et al. Comparison of early mortality of paramedic-diagnosed ST-segment elevation myocardial infarction with immediate transport to a designated primary percutaneous coronary intervention center to that of similar patients transported to the nearest hospital. Am J Cardiol 2006;98:1329-33.

15. de Villiers JS, Anderson T, McMeekin JD, Leung RCM, Traboulsi M. Expedited transfer for primary percutaneous coronary intervention: a program evaluation. Can Med Ass J 2007;176:1833-8.

16. CIHI. Health Indicators 2008. Ottawa, ON: Canadian Institute of Health Information, 2008.

17. Tu JV, Austin PC, Chan BTB. Relationship between annual volume of patients treated by admitting physician and mortality after acute myocardial infarction. JAMA 2001;285:3116-22.

18. Tu JV, Naylor CD, Austin PC. Temporal changes in the outcomes of acute myocardial infarction in Ontario, 1992-1996. Can Med Assoc J 1999;161:1257-61.

19. Westfall JM, Kiefe CI, Weissman NW, et al. Does interhospital transfer improve outcome of acute myocardial infarction? A propensity score analysis from the Cardiovascular Cooperative Project. BMC Cardiovasc Disord 2008;8:22.

20. Elixhauser A, Steiner C, Harris DR, Coffey RN. Comorbidity measures for use with administrative data. Med Care 1998;36:8-27.

21. Quan HD, Sundararajan V, Halfon P, et al. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. Med Care 2005;43:1130-9.

22. Southern DA, Quan H, Ghali WA. Comparison of the Elixhauser and Charlson/Deyo methods of comorbidity measurement in administrative data. Med Care 2004;42:355-60.

23. Saia F, Marrozzini C, Guastaroba P, et al. Lower long-term mortality within a regional system of care for ST-elevation myocardial infarction. Acute Card Care 2010;12:42-50.

24. Hanratty B, Lawlor DA, Robinson MB, et al. Sex differences in risk factors, treatment and mortality after acute myocardial infarction: an observational study. J Epidemiol Comm Health 2000;54:912-6.

25. Antman EM, Bassand JP, Werner K, 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. Eur Heart J 2000;36:959-69.

26. Lagerqvist B, Husted S, Kontny F, et al. 5-year outcomes in the FRISC-II randomised trial of an invasive versus a non-invasive strategy in non-ST-elevation acute coronary syndrome: a follow-up study. Lancet 2006;368:998-1004.

27. Cannon CP, Weintraub WS, Demopoulos LA, et al. Comparison of early invasive and conservative strategies in patients with unstable coronary syndromes treated with the glycoprotein IIb/IIIa inhibitor tirofiban. N Engl J Med 2001;344:1879-87.

28. Hoenig MR, Aroney CN, Scott IA. Early invasive versus conservative strategies for unstable angina and non-ST elevation myocardial infarction in the stent era. Cochrane Database Syst Rev 2006;3:CD004815.