Temporal changes in the outcomes of acute myocardial infarction in Ontario, 1992–1996

Evidence

Études

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Abstract

Background: There is relatively little information available on recent population-based trends in the outcomes of patients who have had an acute myocardial infarction (AMI). We, therefore, conducted a study of temporal trends in the outcomes of AMI patients in Ontario, Canada, between the 1992 and 1996 fiscal years.

Methods: 114 618 AMI patients were discharged from hospitals in Ontario between Apr. 1, 1992, and Mar. 31, 1997. After specific exclusion criteria were applied the final sample of 89 456 patients was divided into 5 cohorts according to the fiscal year of discharge. As part of the Ontario Myocardial Infarction Database project the linked administrative data pertaining to these patients were used to examine cohort characteristics, cardiac procedures used and mortality rates for each of the 5 cohorts over time.

Results: There was a significant increase in the percentage of patients in Ontario receiving coronary angiography, percutaneous transluminal coronary angioplasty and coronary artery bypass grafting surgery ($p < 0.001$) after an AMI between 1992 and 1996. In addition, the overall 30-day risk-adjusted mortality rate declined from 15.5% in 1992 to 14.0% in 1996 ($p = 0.001$) and the 1-year risk-adjusted mortality rate declined from 23.7% in 1992 to 22.3% in 1996 ($p = 0.017$). Virtually all of the improvement occurred within 30 days of admission. The absolute decline in 1-year mortality rates was significant for patients under the age of 65 (2.3%, 95% confidence interval [CI] 1.4% to 3.2%) and for males (1.2%, 95% CI 0.2% to 2.2%); absolute declines were not significant for patients 65 years of age or older (0.7%, 95% CI –0.6% to 2.0%) and for female patients (–0.1%, 95% CI –1.7% to 1.5%). Interestingly, post-infarction coronary angiography and coronary artery bypass grafting rates were consistently lower in the older and the female patients throughout the study period.

Interpretation: There was a modest improvement in the short- and long-term survival of patients in Ontario after an AMI between 1992 and 1996. The Ontario experience suggests that recent advances in AMI management have been of more benefit to younger and male AMI patients.

Despite multiple therapeutic advances in the treatment of acute myocardial infarction (AMI) over the past 2 decades (e.g., thrombolytics, β-blockers, aspirin, angiotensin-converting-enzyme inhibitors) AMI continues to be a leading cause of death throughout the industrialized world. Population-based studies published in the 1980s reported significant improvements in short- and long-term survival rates after an AMI. For instance, the 30-day AMI mortality rate of elderly patients on Medicare in the United States declined from 26% in 1987 to 23% in 1990, and the 1-year mortality rate declined from 40% in 1987 to 36% in 1990.[1] There is relatively little information available on population-based trends in short- and long-term survival after an AMI in the 1990s, however.

To evaluate these and other trends our group initiated the Ontario Myocardial

Infarction Database (OMID) project in 1998. All of Ontario's major health care administrative databases were linked, and the resulting comprehensive AMI database is being used to study the quality of AMI care in Ontario. The database contains information on patient demographics, comorbidities, cardiac procedures used, hospital admissions, physician visits, drug utilization (for elderly patients only) and vital status. In this study, we examined temporal trends in patient outcomes after an AMI in Ontario, Canada, between the 1992 and 1996 fiscal years and were thus able to evaluate whether recent advances in AMI management have led to improved patient outcomes and whether they have been of equal benefit to all patient subgroups.

Methods

We obtained hospital discharge data from the Canadian Institute for Health Information (CIHI) administrative database for all patients discharged from an acute care hospital in Ontario with a most responsible diagnosis (that which accounted for most of the patient's stay) of an AMI (*International Classification of Diseases*, 9th revision code 410) between Apr. 1, 1992 and Mar. 31, 1997. The CIHI database contains patient demographic, comorbidity, procedure and mortality information on all patients discharged from hospitals in Ontario. We linked these data using unique anonymized patient identifiers (i.e., scrambled Ontario health card numbers that are unique to each individual and recorded in all of the databases) to the Ontario Health Insurance Plan (OHIP) physician billing database and the Ontario Registered Persons Database (RPDB). Each of these databases has electronic safeguards for validating health card numbers.

The OHIP database contains information on all fee-for-service physician claims in the Ontario health care system including claims for coronary angiography, percutaneous transluminal coronary angioplasty (PTCA), and coronary artery bypass graft (CABG) surgery. The Ontario Registered Persons Database contains information on the vital status of all Ontario residents covered under the Ontario health insurance plan. Deaths that might not have been recorded in this database were determined by searching the CIHI database for any subsequent hospital admissions associated with death. The accuracy of the mortality data was validated by linking the AMI data directly to provincial vital statistics data at Cancer Care Ontario (agreement = 99.6%).

Overall, 114 618 patients 20 years of age or older were discharged from an acute care hospital in Ontario between Apr. 1, 1992, and Mar. 31, 1997, with a most responsible diagnosis of an AMI. Previous multicentre audits of AMI coding accuracy in Ontario's CIHI database revealed a sensitivity of 95% and a specificity of 88% for the coding of a most responsible diagnosis of AMI.[2] To improve the specificity for an AMI diagnosis a series of exclusion criteria was applied to the original cohort before dividing the population into yearly cohorts. Patients discharged with a total length of stay of less than 3 days (3.8% of the original cohort), including days at a receiving hospital if they were transferred, were excluded under the assumption that these patients had "ruled-out" AMIs rather than true AMIs. We also excluded the admissions of patients who were readmitted to hospital with an AMI in the past year (6.1% of the original cohort) and those transfered from another acute care institution (5.5%) to avoid counting patients twice. Only the first (i.e., index) admission for a transfer patient was included in our cohort. Patients who were not Ontario residents (1.8%), had an invalid health card number (1.9%), who were initially admitted to a noncardiac surgical service (0.5%) or who had an AMI as a complication after admission to hospital (2.4%) were also excluded. Thus, 22% of the original cohort was excluded, leaving a total of 89 456 patients to be included in our study. Based on the fiscal year of each patient's discharge (Apr. 1 of a calendar year to Mar. 31 of the next year) 5 yearly cohorts (1992 to 1996) were created from the remaining patient population.

To further establish the accuracy of AMI coding in our cohorts, we sent the 196 acute care hospitals in Ontario a list of the AMI patients with our inclusion–exclusion decisions so that they could independently validate the accuracy of the AMI diagnosis; 70% of the hospitals responded. Most hospitals validated a random sample of 50–100 AMI patients, but some validated all of their charts. All but 1 of these hospitals indicated that the true diagnosis was AMI in 94% or more of their patients; many hospitals reported 100% accuracy.

Data on the use of coronary angiography, PTCA, and CABG surgery were obtained from both the OHIP and CIHI databases and were cross-validated (agreement was 99.4% for PTCA and 99.9% for CABG). Nine patient comorbidities were determined using the *International Classification of Diseases*, 9th revision, codes contained in the 15 secondary diagnosis fields in the CIHI database.[3] The comorbidities chosen are included in the Ontario AMI mortality prediction rule, a logistic regression model developed by our group with the fiscal 1994–1996 OMID cohort to predict mortality after an AMI.[4] Only the comorbidities present at hospital admission were included in the model. The area under the receiver-operating-characteristic (ROC) curve of this model was 0.78 for 30-day mortality and 0.79 for 1-year mortality, indicating very good predictive performance.[5]

Temporal changes in patient demographics and comorbidities, cardiac procedure rates and mortality rates were analyzed using a χ^2 test for trend. Temporal changes in continuous variables (e.g., length of stay) were assessed using linear regression. Age-adjusted relative risks (RRs) and 95% confidence intervals (CIs) for cardiac procedures and mortality among women (compared with men) were calculated using standard epidemiological methods.[5] Kaplan–Meier survival curves were constructed and were compared using a log-rank statistic to determine age- and sex-specific changes in mortality in specific subgroups between 1992 and 1996.

Trends in the 30-day and 1-year risk-adjusted mortality rates between 1992 and 1996 were calculated by dividing the crude mortality rate by the expected mortality rate for each year and then multiplying the value by the average mortality rate over the 5-year study period. The expected mortality rates were determined by applying a logistic regression model with age, female sex, and the 9 comorbidities in the Ontario AMI mortality prediction rule.[4]

Results

The demographic and comorbidity characteristics of the 89 456 patients who met the inclusion–exclusion criteria and were divided into 5 cohorts are shown in Table 1. There was an overall trend toward an increasing proportion of older (65 years of age and older) AMI patients in Ontario, but the proportions of most patient comorbidities were relatively stable between 1992 and 1996. The average length of stay for AMI patients in Ontario decreased from a mean (median) of 9.5 (8) days in 1992 to 8.2 (7) days in 1996 ($p < 0.001$ for both comparisons, data not shown).

Temporal changes in the 1-year rates of use of cardiac procedures post-MI are shown in Table 2. These data show a significant increase in the proportion of patients receiving coronary angiography, PTCA and CABG surgery ($p < 0.001$) after an AMI between 1992 and 1996. Although the absolute rate increases were similar for patients under 65 and those 65 years of age or older, the rates of cardiac procedure use were consistently lower for the older patient groups. The lower rate of procedure use among women was partially accounted for by their older age at presentation. After adjusting for age differences, women had consistently lower relative risks of receiving coronary angiography at 1-year (0.85 RR in 1992 [95% CI 0.79 to 0.91] v. 0.94 in 1996 [95% CI 0.89 to 1.00]) and CABG surgery (0.71 RR in 1992 [95% CI 0.62 to 0.81] v. 0.76 in 1996 [95% CI 0.68 to 0.85]) but a similar risk of receiving PTCA (RR 1.11 in 1992 [95% CI 0.97 to 1.28] v. 1.01 in 1996 [95% CI 0.90 to 1.14]).

The temporal trends in 30-day and 1-year mortality rates after an AMI are shown in Table 3. There was a gradual decline in the 30-day overall risk-adjusted mortality rate from 15.5% in 1992 to 14.0% in 1996 ($p = 0.001$) and in the 1-year overall risk-adjusted mortality rate from 23.7% in 1992 to 22.3% in 1996 ($p = 0.017$). Virtually all of the improvement in 1-year survival occurred within 30 days of the AMI. The absolute decline in 1-year mortality rates was significant for patients younger than 65 (2.3%, 95% CI 1.4% to 3.2%) and for males (1.2%, 95% CI 0.2% to 2.2%), but was not significant for the older patients (≥ 65 years of age, 0.7%, 95% CI –0.6% to 2.0%) and for female patients (–0.1%, 95% CI –1.7% to 1.5%). Significant improvements were observed in the 1-year survival curves for patients younger than 65 years ($p < 0.001$) and male

Table 2: Age- and sex-specific 1-year rates of use of cardiac procedures in acute myocardial infarction patients in Ontario*

Procedure; characteristic	Rate, %				
	1992	1993	1994	1995	1996
Coronary angiography					
Age < 65 yr	44.2	44.3	46.5	48.5	50.1
Age ≥ 65 yr	14.1	15.5	17.6	18.9	20.6
Male	31.4	31.1	33.9	35.2	36.3
Female	17.0	19.2	20.5	22.0	23.8
Overall	26.2	26.9	29.0	30.3	31.7
PTCA					
Age < 65 yr	11.7	12.4	12.3	13.5	16.2
Age ≥ 65 yr	2.7	3.5	3.8	4.2	4.9
Male	7.2	8.0	7.9	8.9	10.5
Female	4.8	5.3	5.9	5.9	7.0
Overall	6.3	7.0	7.1	7.8	9.2
CABG					
Age < 65 yr	12.8	12.6	13.0	13.4	14.5
Age ≥ 65 yr	5.4	5.9	7.1	6.7	8.1
Male	10.2	10.3	11.4	11.2	12.3
Female	5.1	5.4	6.0	6.0	7.2
Overall	8.4	8.5	9.4	9.3	10.5

Note: PTCA = percutaneous transluminal coronary angioplasty, CABG = coronary artery bypass grafting.
*All trends between 1992 and 1996 are significant at $p \leq 0.05$.

Table 1: Demographic characteristics of the acute myocardial infarction (AMI) cohorts, 1992–1996

Characteristic	1992	1993	1994	1995	1996
No. of patients	17 400	17 642	17 615	17 961	18 838
Median age, yr	68	68	68	69	69
% of patients ≥ 65 yr	59.8	60.4	60.5	61.2	62.4
Female, %	36.3	35.8	36.8	36.8	36.8
Comorbidities (and ICD-9 codes);* % of patients					
Acute renal failure (584.x, 586.x, 788.5)	1.5	1.3	1.4	1.5	1.7
Cardiac dysrhythmias (427.0–427.9)	13.6	13.7	14.5	13.9	15.1
Cerebrovascular disease (430.0–438.x)	4.2	3.7	3.9	4.2	4.0
Chronic renal failure (585.x, 403.x, 404.x, 996.7, 39.4, 39.9, v451)	2.1	1.9	2.0	2.1	2.8
Congestive heart failure (428.x)	19.3	19.4	20.0	19.7	21.5
Diabetes with complications (250.1–250.9)	1.6	1.6	1.8	2.0	2.3
Cancer (140.0–208.9)	4.1	2.4	2.1	1.7	1.8
Pulmonary edema (518.4, 514.x)	1.5	1.4	1.4	1.3	1.2
Shock (785.5)	2.5	2.5	2.4	2.3	2.5

*Derived from the *International Classification of Diseases*, 9th revision, codes in the 15 secondary diagnosis fields of the Canadian Institute for Health Information database.

(p = 0.014) but not for patients aged 65 and over (p = 0.149) and female (p = 0.934) (Fig. 1). After adjusting for differences in age the RRs for mortality among women continued to be higher than those among men (30-day RR of 1.16 in 1992 [95% CI 1.07 to 1.26] v. 1.18 in 1996 [95% CI 1.09 to 1.28] and 1-year RR of 1.09 in 1992 [95% CI 1.02 to 1.17] v. 1.15 in 1996 [95% CI 1.08 to 1.22]).

Interpretation

The goal of this study was to evaluate temporal changes in the outcomes of care in a large population-based cohort of AMI patients in Ontario between 1992 and 1996. We observed a modest improvement in both 30-day and 1-year survival after an AMI during this period, primarily in younger and male patients. Virtually all of the improvement occurred within 30 days of the AMI, with little change observed beyond that time. Although the generalizability of our findings is uncertain at this time, this study suggests that recent advances in AMI management have predominantly benefited younger and male AMI patients; for reasons yet to be determined, significant long-term mortality declines were not observed among the older patients or the female patients.

Our study builds upon a number of previous studies that examined temporal trends in outcomes of AMI patients. The results of these studies were limited, however, because they focused on changes that occurred in an earlier timeframe,[1,6,7] or only in selected communities, they only included data on inhospital mortality[6,7] or did not consider patients of all ages groups.[1,7,8] Our data suggest that the decline in mortality rates for AMI patients in the 1990s has slowed in comparison with declines reported for the late 1980s. For example, data from the Minnesota Heart Survey

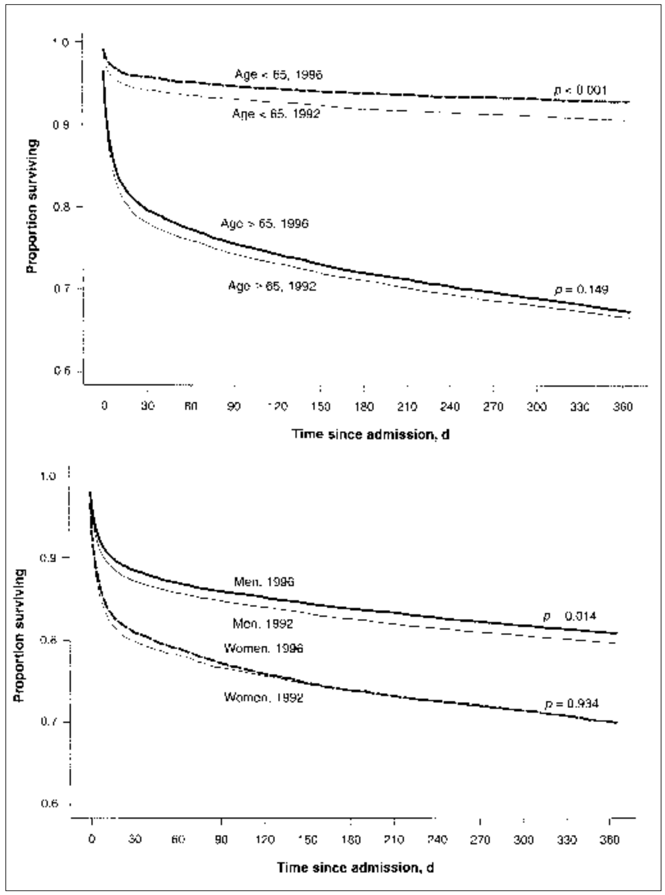

Fig. 1: Upper panel: crude 1-year survival curves of acute myocardial infarction (AMI) patients younger than 65 years of age and 65 years of age or older in Ontario, 1992 and 1996. Lower panel: crude 1-year survival curves for male and female AMI patients in Ontario, 1992 and 1996.

Table 3: Age-specific, sex-specific and risk-adjusted mortality rates in AMI patients in Ontario

Characteristic	Rate, % 1992	1993	1994	1995	1996	Absolute decline, 1992 v. 1996 (and 95% CI)	Relative decline, 1992 v. 1996 (and 95% CI)
30-day mortality rate							
Age < 65 yr	5.8	5.7	4.8	4.7	4.3*	1.5 (0.8 to 2.2)	26.2 (14.7 to 36.2)
Age ≥ 65 yr	21.9	21.0	21.2	20.6	20.4*	1.5 (0.4 to 2.6)	6.9 (2.0 to 11.5)
Male	12.8	12.3	12.1	11.9	11.6*	1.2 (0.3 to 2.1)	9.5 (3.0 to 15.6)
Female	20.1	19.7	19.2	18.7	19.1	1.0 (–0.4 to 2.4)	4.9 (–1.8 to 11.3)
Overall	15.5	15.0	14.8	14.4	14.4*	1.1 (0.4 to 1.8)	7.1 (2.4 to 11.6)
Risk-adjusted rate†	15.5	15.3	14.9	14.5	14.0*	1.5 (0.8 to 2.2)	10.7 (5.4 to 15.6)
1-year mortality rate							
Age < 65 yr	9.4	8.9	7.9	7.5	7.1*	2.3 (1.4 to 3.2)	24.3 (15.4 to 32.2)
Age ≥ 65 yr	33.4	32.6	33.1	31.8	32.7	0.7 (–0.6 to 2.0)	2.1 (–1.6 to 5.7)
Male	20.3	19.7	19.5	18.6	19.1*	1.2 (0.2 to 2.2)	6.1 (1.0 to 10.9)
Female	29.8	29.5	29.4	29.0	29.9	–0.1 (–1.7 to 1.5)	–0.4 (–5.8 to 4.7)
Overall	23.7	23.2	23.1	22.4	23.1*	0.6 (–0.3 to 1.5)	2.9 (–0.8 to 6.4)
Risk-adjusted rate†	23.7	23.7	23.4	22.5	22.3*	1.4 (0.6 to 2.2)	6.3 (2.4 to 9.6)

*Test for trend between 1992 and 1996 significant at p ≤ 0.05.
†Adjusted for changes in age, sex and the 9 comorbidities shown in Table 1.

indicated a 3% absolute improvement in 30-day mortality and an absolute improvement of 6% among men and 5% among women in 3-year mortality between 1985 and 1990; these improvements also coincided with large increases in the use of aspirin and thrombolytic drugs.[8]

Our analyses revealed a more modest decline between 1992 and 1996 in 30-day mortality rates after an AMI. Assuming that aspirin and thrombolytics were commonly used in Ontario in the early 1990s, the declines in our study might reflect a further increase in the use of these and other beneficial therapeutic agents (e.g., β-blockers and angiotensin-converting-enzyme inhibitors), a decrease in the use of harmful agents (e.g, calcium-channel blockers and antiarrythmics), a decline in AMI severity, earlier hospital admissions or a combination of these factors. Additional studies involving detailed chart review are required to elucidate the relative contribution of each of these factors.

The lack of significant improvement in long-term mortality in the older and female patient groups may be attributable to several factors. These patient groups have historically been under-represented in clinical trials,[9] and questions have been raised about whether they experience the same benefits from new AMI therapies as younger and male patient groups.[10] Although we did not have data on inhospital medications, other investigators have shown that older and female patients are much less likely to receive thrombolytics, aspirin and β-blockers for an AMI;[11–13] they also tend to arrive at the hospital later and have more atypical AMI presentations, thereby restricting their eligibility for acute therapies such as thrombolytics.[14,15] Although the analyses are not conclusive, there is also some data to suggest that aspirin and thrombolytics may be less effective in female patients.[10]

Our study has certain limitations as well. Because we did not have detailed information on the inhospital management of these AMI patients we could not make definitive conclusions about why mortality declined and why the decline was more evident in the younger and male patient groups. The generalizability of our findings to jurisdictions outside Ontario remains to be determined, but short- and long-term outcomes among elderly AMI patients in Ontario and the United States in 1991 were found to be similar.[16]

Conclusions

Analyses of ongoing population-based trends in AMI outcomes using administrative databases are important for evaluating the impact of recent advances in AMI treatment on patient outcomes in the community setting. We found a modest improvement in short- and long-term survival after an AMI in Ontario between 1992 and 1996. Although we cannot be certain about all of the factors responsible for these changes, the greater improvements found in younger and male patients suggest that recent advances in AMI management have not been of equal benefit to all subgroups. Further studies are required to determine if a differential use of the existing AMI therapies across population subgroups might explain these data.

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