

## Special Article

## USE OF CARDIAC PROCEDURES AND OUTCOMES IN ELDERLY PATIENTS WITH MYOCARDIAL INFARCTION IN THE UNITED STATES AND CANADA

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**ABSTRACT**

**Background** Acute myocardial infarction is a leading cause of morbidity and mortality in the United States and Canada. We performed a population-based study to compare the use of cardiac procedures and outcomes after acute myocardial infarction in elderly patients in the two countries.

**Methods** We compared the use of invasive cardiac procedures and the mortality rates among 224,258 elderly Medicare beneficiaries in the United States and 9444 elderly patients in Ontario, Canada, each of whom had a new acute myocardial infarction in 1991.

**Results** The U.S. patients were significantly more likely than the Canadian patients to undergo coronary angiography (34.9 percent vs. 6.7 percent,  $P < 0.001$ ), percutaneous transluminal coronary angioplasty (11.7 percent vs. 1.5 percent,  $P < 0.001$ ), and coronary-artery bypass surgery (10.6 percent vs. 1.4 percent,  $P < 0.001$ ) during the first 30 days after the index infarction. These differences in the use of cardiac procedures narrowed but persisted through 180 days of follow-up. The 30-day mortality rates were slightly but significantly lower for the U.S. patients than for the Canadian patients (21.4 percent vs. 22.3 percent,  $P = 0.03$ ). However, the one-year mortality rates were virtually identical (34.3 percent in the United States vs. 34.4 percent in Ontario,  $P = 0.94$ ).

**Conclusions** Short-term mortality after an acute myocardial infarction was slightly lower in the United States than in Ontario, but these differences did not persist through one year of follow-up. The strikingly higher rates of use of cardiac procedures in the United States, as compared with Canada, do not appear to result in better long-term survival rates for elderly U.S. patients with acute myocardial infarction. (N Engl J Med 1997;336:1500-5.)

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**T**HE debate over health care reform in the United States has stimulated interest in comparing medical care in Canada and the United States, two countries with very different methods of financing health care. In particular, recent studies of acute myocardial infarction in the two countries, notably the Survival and Ventricular Enlargement (SAVE) and Global Utilization of

Streptokinase and Tissue Plasminogen Activator for Occluded Coronary Arteries (GUSTO) trials, suggested that the higher rates of revascularization in the United States than in Canada in the immediate postinfarction period slightly improve the quality of life, although convincing benefits in terms of survival have not been demonstrated.<sup>1,2</sup> These studies, however, had limited statistical power to detect clinically significant differences in mortality, because they involved relatively small numbers of patients. Furthermore, the patients were enrolled in randomized clinical trials and are therefore not representative of the full spectrum of patients with myocardial infarction in the two countries. For example, patients in Ontario, Canada, who were enrolled in the GUSTO trial were younger, had fewer coexisting illnesses, and were much more likely to undergo coronary revascularization procedures than patients in Ontario with myocardial infarction who were not enrolled in the GUSTO trial.<sup>3</sup> Elderly patients constitute the majority of patients with myocardial infarctions in both countries but are often excluded from clinical trials of new therapeutic strategies.<sup>4,5</sup> For these reasons, we undertook a study to compare the use of cardiac procedures and mortality in two population-based cohorts of elderly patients who had new acute myocardial infarctions in 1991 — one cohort in the United States and one in Ontario.

**METHODS****Sources of Data**

In this study we used data on demographic characteristics, coexisting illnesses, use of procedures, and survival obtained from linked administrative and claims data bases in the two countries. The U.S.

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data were for calendar year 1991, whereas the Canadian data were for fiscal 1991 (April 1, 1991, through March 31, 1992).

The U.S. data base included all elderly Medicare patients with a principal diagnosis of acute myocardial infarction (codes 410.0 through 410.9 in the *International Classification of Diseases, 9th Revision, Clinical Modification* [ICD-9-CM]).<sup>6</sup> The data came from the Health Care Financing Administration's Health Insurance Skeletonized Write-off data base and were linked to longitudinal data on the use of cardiac procedures in the Medicare Provider Analysis and Review and Standard Analytical Outpatient files, as described elsewhere.<sup>4</sup>

The Canadian data included all elderly patients in Ontario with a primary diagnosis of acute myocardial infarction (ICD-9-CM codes 410.0 through 410.9). These data came from the Canadian Institute for Health Information (CIHI) data base, an administrative data base containing hospital-discharge abstracts, and were linked to longitudinal data on the use of cardiac procedures in the CIHI data base and provincial vital-statistics data (from the Ontario Cancer Treatment and Research Foundation) by means of unique patient identifiers.<sup>5</sup> Coding for cardiac procedures was based on the *Canadian Classification of Diagnostic, Therapeutic, and Surgical Procedures*.<sup>7</sup>

A primary diagnosis in Ontario is the discharge diagnosis most responsible for the length of a patient's hospital stay, whereas a principal diagnosis in the United States is the discharge diagnosis responsible for the hospital admission.<sup>4,5</sup> An audit of data on Canadian patients with a primary diagnosis of acute myocardial infarction at one hospital in Ontario has shown that this is the equivalent of a principal diagnosis of acute myocardial infarction in the United States 98 percent of the time (data not shown).

#### Study Cohorts

We identified comparable cohorts of elderly patients with a new myocardial infarction in the two countries using a variety of exclusion criteria.<sup>4</sup> Patients excluded from both cohorts were those who were not representative of the elderly U.S. population (i.e., patients under the age of 65 years and patients with end-stage renal disease), patients who were likely to have been misclassified as having an acute myocardial infarction (i.e., those discharged from the hospital after a stay of less than 5 days and those transferred to another hospital within 2 days after admission when the admitting diagnosis at the receiving hospital was not a myocardial infarction), and patients with a myocardial infarction in the preceding 365 days. In the U.S. cohort, patients enrolled in health maintenance organizations were also excluded, because they were unlikely to have complete longitudinal data available. After these exclusions, a total of 224,258 patients remained in the U.S. cohort.

Two other exclusion criteria were applied to the Canadian cohort, in addition to those just described, to ensure comparability with the U.S. sample. Patients who were initially admitted for noncardiac surgery were excluded on the assumption that these patients probably had postoperative myocardial infarctions, and patients who died of a myocardial infarction outside a coronary care unit or intensive care unit on the day of admission were excluded on the assumption that they had died in the emergency room. Patients in the first category would not have been included in the U.S. cohort because their principal diagnosis would have been the type of surgery being performed, whereas patients in the second category would not have been included in the U.S. cohort because deaths in the emergency room are not considered hospital admissions for purposes of Medicare reimbursement. Patients without a valid Ontario health-card number were also excluded because we could not obtain complete follow-up data on them. After these additional exclusions, 9444 patients remained in the Canadian cohort.

#### Coexisting Illnesses, Use of Procedures, and Mortality

Coexisting conditions were considered to be those identified by the first seven secondary-diagnosis codes for each patient in

the two data bases.<sup>8</sup> Rates of coronary angiography, percutaneous transluminal coronary angioplasty (PTCA), and coronary-artery bypass grafting (CABG) were determined 30 days and 180 days after the index infarction. Data on outpatient coronary-angiography procedures were not uniformly available in either country. However, previous studies have shown that they constitute only a small percentage of all angiography procedures in elderly patients in the early postinfarction period<sup>9</sup>; including them in the analysis would therefore not have affected the overall conclusions substantially. The unadjusted 30-day and 1-year mortality rates among patients in the two countries were compared. Mortality rates adjusted for age and sex were also calculated for the Canadian cohort, with standardization to the age and sex distribution of the U.S. cohort.<sup>10</sup>

#### Characteristics of the Hospitals

The availability of facilities for catheterization and revascularization (PTCA, CABG, or both) at hospitals in both countries was determined. Hospitals were considered to provide catheterization only if they performed 5 or more cardiac catheterizations and fewer than 10 revascularization procedures annually in elderly patients with myocardial infarction, whereas hospitals were categorized as providing revascularization if they performed 10 or more revascularization procedures annually in elderly patients with myocardial infarction.<sup>11</sup>

#### Statistical Analysis

All continuous variables were compared with use of unpaired *t*-tests; categorical variables were compared with use of the chi-square statistic.<sup>12</sup> Relative rates of use of cardiac procedures 30 days and 180 days after the index infarction in the United States as compared with Ontario were calculated, with 95 percent confidence intervals determined with use of a Taylor series expansion.<sup>10</sup> The cumulative procedure-rate curves and cumulative mortality curves in the two cohorts were compared with use of a log-rank statistic.<sup>12</sup> All *P* values are two-sided. The SAS statistical package was used for statistical analysis.<sup>13</sup>

## RESULTS

#### Characteristics of the Cohorts

Table 1 shows the demographic characteristics and coexisting illnesses of the two cohorts of elderly patients with acute myocardial infarction in 1991. Patients in the U.S. cohort were slightly older, and this cohort contained a greater proportion of women ( $P < 0.001$  for both comparisons). The prevalence of coexisting diseases in the two cohorts was similar; the largest difference was in the prevalence of chronic pulmonary disease, which was higher in the U.S. cohort ( $P < 0.001$ ).

#### Rates of Cardiac Procedures

Rates of use of cardiac procedures are shown in Table 2 and Figures 1 and 2. Overall, the relative rate of coronary angiography in the U.S. patients as compared with the Canadian patients was 5.2 (95 percent confidence interval, 4.8 to 5.7), and the relative rate of revascularization was 7.9 (95 percent confidence interval, 7.0 to 8.9) during the first 30 days after the myocardial infarction. The rates of use of PTCA were higher than the rates of use of CABG in the early postinfarction period, whereas in the late postinfarction period the rates of use of CABG were higher

**TABLE 1. CHARACTERISTICS OF ELDERLY PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN THE UNITED STATES AND ONTARIO, 1991.**

CHARACTERISTIC	UNITED STATES (N=224,258)	ONTARIO (N=9444)
Mean (±SD) age (yr)	76.3±7.4	75.4±7.1
Age 75–84 yr (%)	39.5	39.1
Age ≥85 yr (%)	15.2	12.1
Female sex (%)	48.9	45.2
Coexisting diseases (%)		
Cancer	1.9	2.3
Cerebrovascular disease	4.6	4.8
Chronic angina	28.1	28.7
Chronic pulmonary disease	12.1	9.2
Diabetes	18.8	20.0
Hypertension	18.5	17.7
Uncomplicated renal disease	2.0	2.8

than those of PTCA (Fig. 2). Eighty-one percent of the U.S. patients, as compared with 48 percent of the Canadian patients, who underwent revascularization within the first 180 days after a myocardial infarction underwent the procedure within 30 days after the index infarction. Differences in rates of use of cardiac procedures persisted through 180 days of follow-up; 6 months after the index infarction, the rate of revascularization procedures in the U.S. cohort was quadruple that in the Canadian cohort. The cardiac-procedure-rate curves in the 26 weeks after the acute myocardial infarction were all significantly higher ( $P<0.001$ ) for the U.S. cohort than for the Canadian cohort (Fig. 1 and 2).

**Characteristics of the Hospitals**

A higher proportion of U.S. than Canadian patients were initially admitted to hospitals that were able to

perform both catheterization and revascularization procedures (34.5 percent vs. 14.0 percent,  $P<0.001$ ) as well as to hospitals that performed catheterization only (22.8 percent vs. 4.1 percent,  $P<0.001$ ). Overall, approximately four times as many U.S. hospitals had the capability to perform revascularization procedures, and about eight times as many were catheterization-only hospitals (Table 3).

**Outcomes after Acute Myocardial Infarction**

The outcomes of the patients with acute myocardial infarction in the two cohorts are shown in Figure 3. The cumulative mortality rates diverged relatively early and slightly favored the U.S. cohort throughout the early postinfarction period. The divergence in the mortality curves coincided with the period in which many U.S. patients were undergoing revascularization procedures (Fig. 2). The unadjusted 30-day mortality rates were slightly but significantly lower in the U.S. cohort than in the Canadian cohort (21.4 percent vs. 22.3 percent,  $P=0.03$ ). However, this small difference in early mortality gradually narrowed over time, and the unadjusted one-year mortality rates were virtually identical in the U.S. and Canadian cohorts (34.3 percent and 34.4 percent,  $P=0.94$ ). The age- and sex-adjusted one-year mortality in the Canadian cohort (35.1 percent) was still not significantly different from that in the U.S. cohort after standardization to the age and sex distribution of the U.S. cohort ( $P=0.14$ ). Overall, the cumulative mortality curves for the two cohorts, shown in Figure 3, did not differ significantly ( $P=0.36$ ).

**DISCUSSION**

In this study we compared the use of invasive cardiac procedures and the mortality rates for two population-based cohorts of elderly patients with acute

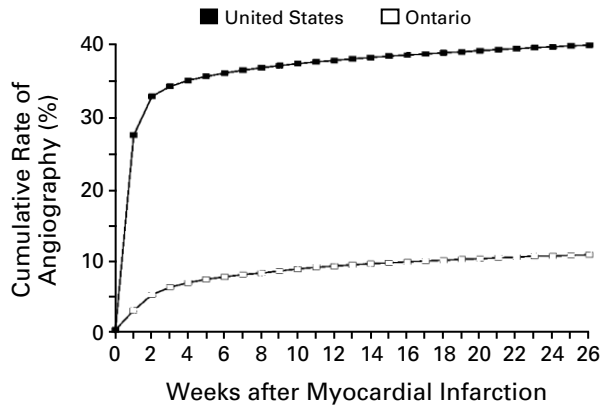
**TABLE 2. RATES OF CARDIAC PROCEDURES AMONG ELDERLY PATIENTS WITH ACUTE MYOCARDIAL INFARCTION IN THE UNITED STATES AND ONTARIO, 1991.\***

PROCEDURE	WITHIN 30 DAYS OF INFARCTION			WITHIN 180 DAYS OF INFARCTION		
	UNITED STATES	ONTARIO	RELATIVE RATE (95% CI)†	UNITED STATES	ONTARIO	RELATIVE RATE (95% CI)†
Coronary angiography	34.9	6.7	5.2 (4.8–5.7)	39.5	10.4	3.8 (3.5–4.1)
PTCA	11.7	1.5	7.7 (6.6–9.1)	14.0	2.8	5.0 (4.2–5.9)
CABG	10.6	1.4	7.8 (6.6–9.3)	14.5	3.5	4.1 (3.4–4.9)
Revascularization‡	21.8	2.8	7.9 (7.0–8.9)	26.9	5.8	4.6 (4.1–5.2)

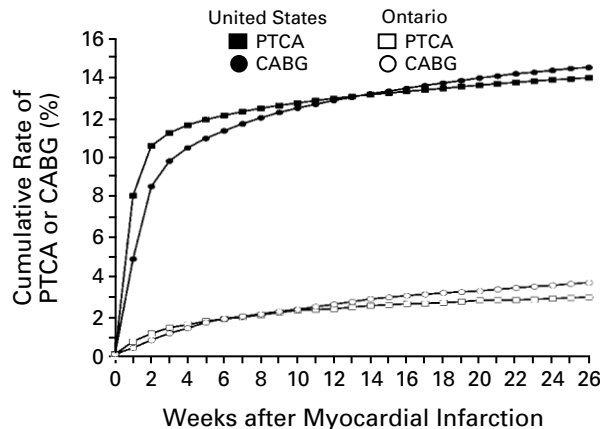
\*PTCA denotes percutaneous transluminal coronary angioplasty, CABG coronary-artery bypass grafting, and CI confidence interval. The rates for coronary angiography do not include procedures performed on an outpatient basis in either country.

†The relative rates show the frequency of the procedures in U.S. patients as compared with that in the patients in Ontario.

‡The overall rates of revascularization are slightly lower than the sum of the rates for PTCA and CABG because some patients underwent both procedures.



**Figure 1.** Cumulative Rates of Coronary Angiography after Acute Myocardial Infarction among Elderly Patients in the United States and Ontario, 1991.

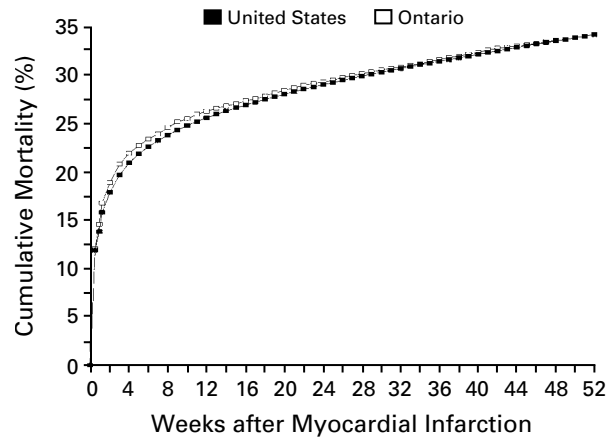


**Figure 2.** Cumulative Rates of Percutaneous Transluminal Coronary Angioplasty (PTCA) and Coronary-Artery Bypass Grafting (CABG) after Acute Myocardial Infarction among Elderly Patients in the United States and Ontario, 1991.

**TABLE 3.** CHARACTERISTICS OF HOSPITALS IN THE UNITED STATES AND ONTARIO, 1991.

AREA	NO. OF HOSPITALS	AVAILABILITY OF PROCEDURES (%)*			NO. OF BEDS	
		NONE	PTCA, CABG, OR BOTH	CATHETERIZATION	<100	>500
United States	5075	55.4	24.6	20.0	43.8	7.5
Ontario	193	91.7	3.1	5.2	41.5	8.3

\*PTCA denotes percutaneous transluminal coronary angioplasty, and CABG coronary-artery bypass grafting. Catheterization-only hospitals are those that offered cardiac catheterization but not revascularization procedures.



**Figure 3.** Cumulative Mortality after Acute Myocardial Infarction among Elderly Patients in the United States and Ontario, 1991.

myocardial infarction — one in the United States and one in Ontario, Canada. Ontario is Canada's largest province, home to 37 percent of its population and 21 percent of its hospitals. We found striking differences in the rates of use of invasive cardiac procedures, with the elderly U.S. patients undergoing substantially more coronary angiography and revascularization procedures, particularly during the 30 days immediately after the index infarction. We also found significant differences in the short-term outcomes of patients in the two countries, with lower 30-day mortality among the U.S. cohort, although these differences in mortality were not sustained at 1 year of follow-up. The results of our study suggest that the greater use of revascularization procedures in the United States does not improve the long-term survival rates of elderly U.S. patients with acute myocardial infarction.

The differences we found in the use of cardiac procedures are larger than those found in previous studies and could explain the small short-term difference in mortality favoring the United States. The SAVE and GUSTO comparison studies noted two-to-threefold differences in the use of revascularization procedures and similar mortality rates among nonelderly patients in the two countries enrolled in those clinical trials,<sup>1,2</sup> whereas we found that on a population-wide basis, there were larger differences in the rates of use of cardiac procedures for elderly patients with myocardial infarction between the two countries (relative rate of procedure use in the United States as compared with Ontario, 3 to 7). Revascularization procedures were used soon after the index infarction in approximately 3 percent of the elderly Canadian patients in our study, as compared with 12 percent and 14 percent of the Canadian patients enrolled in the SAVE and GUSTO trials,

respectively.<sup>1,2</sup> Elderly patients are at significantly higher risk of dying shortly after a myocardial infarction and may be significantly more likely to benefit from the use of revascularization procedures during this period. The results of our study are consistent with the findings of the Thrombolysis in Myocardial Infarction (TIMI) IIB clinical trial, which showed that the aggressive use of revascularization procedures (coronary angiography in all patients within 48 hours of admission, followed by revascularization if appropriate) significantly improved the short-term survival rates among patients 65 years of age or older who presented with unstable angina or a non-Q-wave infarction.<sup>14</sup>

The absence of a sustained survival benefit over the one-year follow-up period probably reflects factors other than the differences in the use of revascularization procedures. Many medical therapies (e.g., beta-blockers and aspirin) are known to improve long-term survival after acute myocardial infarction,<sup>15</sup> and it is possible that they were used more frequently in the Canadian cohort. The GUSTO study suggested that Canadian physicians were more likely to follow published guidelines for the medical care of nonelderly patients with myocardial infarction than their colleagues in the United States,<sup>2</sup> although we did not have the data to test this hypothesis. The phenomenon of similar or better short-term survival rates in the United States followed by equivalent or better long-term survival rates in Canada has also been observed in other studies comparing the outcomes of elderly postsurgical patients and patients with cancer in the two countries.<sup>16-18</sup> It has been suggested that the better short-term outcomes in the United States may be a reflection of the intensity and timeliness of U.S. hospital care, whereas the better long-term outcomes in Canada may reflect greater access to primary care, prescription drugs, and long-term care, which are universally provided to the elderly with minimal copayments, or none, under the Canadian health care system.<sup>16,17,19,20</sup>

Our results should also be interpreted in the context of other studies that have shown marked regional, national, and international variation in the use of cardiac procedures in the period after myocardial infarction.<sup>1,2,21,22</sup> Most of these studies have focused on nonelderly patients enrolled in randomized clinical trials and have not found significant differences in mortality between areas with high rates of use and those with low rates. The number of patients in our study is several times as high and the differences in procedure rates are several times as large as in most other studies, yet we also found no substantial differences in outcome. The results of our study are likely to stimulate debate about the costs and effectiveness of the more aggressive U.S. approach to revascularization in the elderly. Although some patients' lives may have been saved by the greater use

of coronary revascularization procedures in the United States and many more may have received symptomatic benefit, there may also have been other U.S. patients whose lives ended prematurely because of the high risks associated with cardiac procedures in the elderly.<sup>23</sup>

Our study has several important limitations. First, we did not have data on the quality of life of the patients in the two cohorts, and it is possible that there were important differences in functional status between the elderly U.S. and Canadian patients; such differences have been observed in other studies of nonelderly U.S. and Canadian patients with myocardial infarction.<sup>1,2</sup> Second, one can never be sure that confounding has been completely controlled for in observational comparisons of data from administrative data bases, and it is possible that unmeasured differences in patients' characteristics or medical therapies other than those we measured may explain the short-term and long-term outcomes we found. Third, we had data on procedure rates and outcomes after a myocardial infarction only for the province of Ontario, and our results may not be generalizable to other parts of Canada.

In conclusion, we found that one-year mortality rates for elderly patients with myocardial infarction were similar in the United States and Ontario in 1991, in spite of a small short-term survival difference favoring the United States. Higher rates of use of cardiac procedures did not translate into better long-term survival rates for elderly patients in the United States. Given the many other factors known to influence short-term and long-term survival after a myocardial infarction,<sup>24,25</sup> additional population-based studies with more detailed data on medical treatments and patients' characteristics are required before firm conclusions can be drawn about the reasons for the outcomes in our study. Although the overall results of our study appear to favor the more conservative Canadian approach to revascularization, the difference in short-term mortality favoring the United States and the question of the quality of life of elderly patients with myocardial infarction in the two countries warrant further investigation.

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The opinions and conclusions in this study are those of the authors, and no official endorsement by the Ontario Ministry of Health is intended or should be inferred.

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## CORRECTION

### Use of Cardiac Procedures and Outcomes in Elderly Patients with Myocardial Infarction in the United States and Canada

Use of Cardiac Procedures and Outcomes in Elderly Patients with Myocardial Infarction in the United States and Canada . On page 1503, in Table 3, the headings for columns 4 and 5 were reversed. The columns should have read as follows:

Corrected Table Headings.

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