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Background—Clinical trials have demonstrated that emergent revascularization improves survival of patients with acute myocardial infarction (AMI) complicated by cardiogenic shock (CS). However, rates of uptake and impact on outcomes remain uncertain.

Methods and Results—We identified 9750 patients (3.1%) with CS among 311 183 AMI patients in the Ontario Myocardial Infarction Database between 1992 and 2008 (55.8% men; mean age, 73 years). CS incidence, mortality, revascularization, and transfers from nonrevascularization sites were studied over 3 periods: period 1, before the 1999 American College of Cardiology/American Heart Association AMI guidelines recommending urgent revascularization for patients <75 years; period 2 (1999 to 2004); and period 3, after 2004 guideline revisions suggesting revascularization for patients ≥75 years. Compared with period 1, period 3 was marked by significantly lower CS incidence (3.4% versus 2.6%), increase in transfers from nonrevascularization sites (10.6% versus 23.9%), and adjusted 1-year mortality rates (81.9% versus 71.5%; all comparisons statistically significant). Admission to nonrevascularization sites was associated with lower revascularization rates (8.6% versus 46.6%, P<0.001) and higher adjusted 1-year mortality rates (78.8% [95% confidence interval, 77.4 to 80.2] versus 71.9% [95% confidence interval, 69.8 to 74.1]). Patients ≥75 years of age were less likely to be revascularized or transferred. The greatest increase in transfers from nonrevascularization sites occurred between periods 1 and 2 for patients <75 years (16.5% to 31.4%; P<0.001) and between periods 2 and 3 for patients ≥75 years (6.7% to 12.8%; P<0.001).

Conclusions—Publication of American College of Cardiology/American Heart Association guidelines was followed by increased revascularization and transfer rates, along with declining mortality rates among Ontario AMI patients with CS. These results highlight possibilities for further improvement, particularly among patients eligible for transfer from nonrevascularization sites. (Circ Cardiovasc Qual Outcomes. 2011;4:440-447.)

Key Words: shock ■ revascularization ■ catheterization ■ epidemiology ■ survival

Cardiogenic shock (CS) is the most common cause of death after acute myocardial infarction (AMI).1 The Should We Emergently Revascularize Occluded Coronaries for Cardiogenic ShockK (SHOCK) Trial demonstrated that urgent revascularization improves survival among AMI patients with CS.2 Subgroup analyses, constrained by small patient numbers, suggested worse outcomes with urgent revascularization for patients age ≥75 years.3 Accordingly, the 1999 American College of Cardiology/American Heart Association (ACC/AHA) AMI guidelines recommended urgent revascularization in patients age <75 years with CS after ST-elevation–myocardial infarction.4 Registry data subsequently showed revascularization to be associated with improved survival in elderly CS patients,5 prompting the 2004 revision of ACC/AHA guidelines to include a class IIa recommendation for revascularization of CS patients age ≥75 years.6

However, the impact of treatment strategies in routine practice can be different than in clinical trials7 that often include selected patients, highly motivated clinicians, and high-volume operators. Furthermore, there can be considerable delay between guideline dissemination and practice changes, which can be partly explained by hospital characteristics, geographical constraints,8 and patient characteris-
tics.7 Thus, it is important to monitor the uptake of revascularization in patients with development of CS after AMI and its effect on patient flow and outcomes to aid in health care planning. Accordingly, we studied the incidence of CS and corresponding revascularization and survival rates among AMI patients in Ontario between 1992 and 2008 with a focus on patient age, availability of revascularization at the hospital of presentation, and rates of transfer from hospitals without on-site revascularization. We hypothesized that CS incidence and mortality rates may have decreased, coinciding with increasing revascularization and transfer from nonrevascularization sites after the ACC/AHA AMI guideline changes in 1999 and 2004. We also anticipated lower revascularization and survival rates among elderly patients and those presenting to nonrevascularization sites.

WHAT IS KNOWN

- Urgent revascularization has been shown to improve outcomes among patients with cardiogenic shock after myocardial infarction.
- The uptake and impact of this strategy has not been examined, particularly in relation to patient age and the availability of revascularization at site of initial hospitalization.

WHAT THE STUDY ADDS

- The publication of American College of Cardiology/American Heart Association guidelines was followed by increased rates of revascularization in Ontario and increased transfers of patients presenting to hospitals without revascularization capabilities. However, the uptake of transfer and revascularization was less prominent in elderly patients.
- Adjusted mortality rates were lower in patients presenting to hospitals with revascularization capabilities, possibly related to higher revascularization rates.
- Although improved, transfer rates of patients with acute myocardial infarction complicated by cardiogenic shock to tertiary care centers continue to be low, indicating an opportunity to further optimize care of these critically ill patients.

Methods

Patients

The Ontario Myocardial Infarction Database (OMID) is a linked administrative database of all patients age ≥20 years who were discharged (dead or alive) from an acute-care hospital in Ontario since April 1, 1992, with a primary discharge diagnosis of AMI. The database has been described previously,9 and its validity has been established through province-wide chart audits.10 In brief, the Canadian Institute of Health Information Discharge Abstract Database was used to identify hospitalizations with a primary discharge diagnosis of AMI (ICD-9 code 410, ICD-10 code I21). Episodes of care for each patient were created that linked contiguous hospital admissions and transfers. Patients were analyzed according to the site of first admission. The OMID excluded patients with a primary address outside of Ontario, an invalid Ontario Health Card number, AMI hospitalization in the prior 365 days, those initially admitted to a noncardiac surgical service, and those with development of AMI as an in-hospital complication. The present study included patients for whom CS was documented as a type 1 (preadmission) or type 2 (postadmission) comorbidity using ICD9 code 785.5 or ICD10 code R57.x.

Outcomes

The primary outcome was 1-year mortality, defined as the proportion of patients dying within 1 year of hospital admission. Secondary outcomes were (1) incidence of cardiogenic shock; (2) rates of revascularization within the episode of care; and (3) rates of patient transfers from nonrevascularization sites.

Data Sources

Patients were linked across administrative databases using their unique encrypted Ontario Health Card number. Patient demographics, comorbidities, site of initial presentation, and interhospital transfers were obtained from the OMID database. The occurrence of percutaneous coronary intervention and coronary artery bypass grafting was identified from physician claims in the Ontario Health Insurance Plan database. Mortality data were obtained from the Ontario Registered Persons Database that contains vital statistics data for the province. Data on revascularization availability at Ontario hospitals were obtained from the Cardiac Care Network of Ontario.

Statistical Analysis

The sensitivity and specificity of a diagnosis of CS in the OMID was determined by using data from the Enhanced Feedback for Effective Cardiac Treatment (EFFECT) study, which included patients hospitalized with AMI in Ontario during April 1999 to March 2001 and April 2003 to March 2004.11 Thus, EFFECT included the same AMI population as OMID during those fiscal years. The EFFECT study used detailed chart reviews to determine the development of CS, against which diagnoses of CS in OMID were compared. We also compared the mortality of CS patients identified in both databases.

The study period was divided into period 1 (1992 to 1999; before publication of the 1999 ACC/AHA AMI guidelines); period 2 (April 1, 1999, to 2004; between the 1999 and 2004 guideline revisions); and period 3 (2004 to March 31, 2008; after the 2004 guideline revisions). Patients were divided into groups on the basis of availability of on-site revascularization at the hospital of initial presentation. Patients presenting at nonrevascularization sites were further classified on the basis of whether they were transferred or treated on-site. Patients were also analyzed according to the receipt of revascularization during the episode of care. These analyses were repeated with the patient population separated into the young (defined as age <75 years) and elderly (age ≥75 years). Differences across groups were compared using the Wilcoxon rank-sum and the Kruskal-Wallis tests for continuous variables and the χ² statistic for dichotomous variables.

Outcomes were determined as a proportion of the referent patient group at yearly intervals from April 1 of one calendar year to March 31 of the subsequent year. The risk of death for patients in each year was adjusted using the Ontario AMI mortality prediction rule risk score, which incorporates age, sex, acute renal failure, cardiac dysrhythmias, cerebrovascular disease, chronic renal failure, congestive heart failure, diabetes with complications, cancer, and pulmonary edema.12,13 We used a modified version that used the variable “diabetes” instead of “diabetes with complications,” and that was recalibrated for this study.14 The adjusted mortality outcomes were assessed for significance by comparing 95% confidence intervals (CI). A stratified analysis was also performed comparing outcomes in patients who had developed CS after hospitalization compared with those with shock at presentation. All analyses were performed using SAS software, version 9.1 (SAS Institute Inc, Cary, NC). Statistical significance was defined by a 2-sided probability value <0.05. Data cells involving ≤5 patients were censored in accordance with the Institute of Clinical and Evaluative Sciences privacy regulations.
years during the study, whereas it increased from 72.6 to 74.8
revascularization-capable sites decreased from 72.6 to 71.1
3, respectively). The mean age of patients admitted to
sites (CS incidence rates of 3.4% and 2.0% in periods 1 and
incidence of CS among AMI patients admitted to revascular-
ization-capable sites (5.2% in period 1; 4.6% in period 3),
Congestive heart failure, %
35.3
37.3
33.8
Diabetes, %
23.8
24.2
30.7
Cancer, %
2.3
3.1
3.5
Pulmonary edema, %
4.0
4.9
2.6
AMI score, mean (median)
0.69 (0.78)
0.71 (0.78)
0.71 (0.78)
PCI, % received
4.3
13.4
31.0
CABG, % received
2.9
4.0
4.0
Any revascularization, % received
6.9
16.8
34.0
1-Year mortality, crude rate
81.1
75.3
71.8
1-Year mortality, adjusted (95% CI)*
81.9 (80.4–83.4)
74.3 (72.5–76.1)
71.5 (69.5–73.5)
PCI indicates percutaneous coronary intervention; CABG, coronary artery bypass graft.
*Mortality rates were adjusted using a modified version of the Ontario AMI mortality prediction rule risk score incorporating age, sex, acute renal failure, cardiac dysrhythmias, cerebrovascular disease, chronic renal failure, congestive heart failure, diabetes, cancer, and pulmonary edema. If there was no overlap with the 95% CI, P was assumed to be <0.05.

Results
Patients and Hospitals
We identified 9750 patients with CS (mean age, 73.0 years; 55.8% men) of 311,183 (3.1%) AMI patients. CS was identified with a sensitivity of 47% in the 1999 to 2001 fiscal years and 42% in the 2004 fiscal year. The diagnosis was made with a specificity of 81% in both time periods. Overall patient characteristics are listed in Table 1. The incidence of cardiogenic shock declined from 3.4% in period 1 to 2.6% in period 3 (P<0.001 for trend). Whereas the proportion of revascularization-capable sites increased from 5% in 1992 to 8% in 2008, the proportion of CS patients initially admitted to revascularization-capable sites grew at a faster rate, from 9.8% in period 1 to 36.2% in period 3 (P<0.001 for trend). The mean age and the proportion of male patients increased slightly between periods 1 and 3. The prevalence of diabetes mellitus and renal dysfunction increased over time. The prevalence of other comorbidities showed less prominent changes.

The characteristics of CS patients, divided by site of admission, are listed in Table 2. We observed a higher incidence of CS among AMI patients admitted to revascularization-capable sites (5.2% in period 1; 4.6% in period 3), with a growing difference relative to nonrevascularization sites (CS incidence rates of 3.4% and 2.0% in periods 1 and 3, respectively). The mean age of patients admitted to revascularization-capable sites decreased from 72.6 to 71.1 years during the study, whereas it increased from 72.6 to 74.8 years in nonrevascularization sites. Rates of diabetes, renal dysfunction, cancer, and cerebrovascular disease rose at a higher rate among patients admitted to nonrevascularization sites, whereas cardiac dysrhythmias were higher among patients in revascularization-capable sites.

Overall Mortality and Management Patterns
Figure 1 shows unadjusted 1-year mortality rates among CS patients in Ontario. Adjusted 1-year mortality rates declined steadily from 81.9% (95% CI, 80.4 to 83.4) in period 1 to 71.5% (95% CI, 69.5 to 73.5) in period 3 (P<0.05). Mortality rates were similar among patients with CS identified from the OMID or the EFFECT database. The overall risk-adjusted 1-year mortality rate was significantly lower among patients presenting to revascularization-capable sites (78.8% [95% CI, 77.4 to 80.2] versus 71.9% [95% CI, 69.8 to 74.1]). The trends in 30-day mortality mirrored the 1-year rates. The stratified analysis demonstrated lower mortality rates among patients presenting to revascularization-capable sites regardless of whether CS developed before or after admission (see online-only Data Supplement Appendix 1).

Overall revascularization rates within the episode of care increased approximately 5-fold. As shown in Figure 2, patients presenting at revascularization-capable sites were more likely to be revascularized; 46.6% of that group were revascularized during the episode of care compared with 8.6% of their counterparts at nonrevascularization sites (P<0.001). The mean time to revascularization decreased at
Table 2. Demographic and Medical Characteristics of Ontario Patients With CS Between 1992 and 2008

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>Revascularized</td>
<td>Nonrevascularized</td>
<td>P Value</td>
<td>Treated on Site</td>
<td>Transferred, Not Revascularized</td>
</tr>
<tr>
<td>n (% of all total)</td>
<td>128 (25.6)</td>
<td>371 (74.3)</td>
<td>&lt;0.001</td>
<td>4106 (89.4)</td>
<td>264 (5.8)</td>
</tr>
<tr>
<td>Age, y, mean (median)</td>
<td>65.3 (66)</td>
<td>75.1 (76)</td>
<td>0.006</td>
<td>73.5 (76)</td>
<td>66.0 (68)</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>68.8</td>
<td>54.7</td>
<td>0.25</td>
<td>7.7</td>
<td>5.3</td>
</tr>
<tr>
<td>Acute renal failure, %</td>
<td>5.5</td>
<td>8.6</td>
<td>0.40</td>
<td>21.5</td>
<td>20.1</td>
</tr>
<tr>
<td>Cardiac dysrhythmias, %</td>
<td>23.4</td>
<td>27.2</td>
<td>0.003</td>
<td>5.6</td>
<td>2.3</td>
</tr>
<tr>
<td>Cerebrovascular disease, %</td>
<td>&lt;5 patients</td>
<td>6.5</td>
<td>0.066</td>
<td>4.0</td>
<td>1.9</td>
</tr>
<tr>
<td>Chronic renal failure, %</td>
<td>9.9</td>
<td>8.9</td>
<td>&lt;0.001</td>
<td>35.3</td>
<td>33.0</td>
</tr>
<tr>
<td>Congestive heart failure, %</td>
<td>21.1</td>
<td>44.2</td>
<td>0.003</td>
<td>24.4</td>
<td>21.2</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>14.8</td>
<td>24.8</td>
<td>0.02</td>
<td>2.5</td>
<td>&lt;5 patients</td>
</tr>
<tr>
<td>Cancer, %</td>
<td>&lt;5 patients</td>
<td>3.2</td>
<td>0.31</td>
<td>4.3</td>
<td>3.4</td>
</tr>
<tr>
<td>Pulmonary edema, %</td>
<td>&lt;5 patients</td>
<td>2.2</td>
<td>0.31</td>
<td>4.3</td>
<td>3.4</td>
</tr>
<tr>
<td>AMI score, mean (median)</td>
<td>0.57 (0.54)</td>
<td>0.76 (0.8)</td>
<td>&lt;0.001</td>
<td>0.71 (0.75)</td>
<td>0.59 (0.56)</td>
</tr>
<tr>
<td>Death at 1 y, (%)</td>
<td>47.7</td>
<td>87.6</td>
<td>&lt;0.001</td>
<td>85.1</td>
<td>61.0</td>
</tr>
<tr>
<td>1-Year mortality, adjusted (95% CI)*</td>
<td>57.3 (48.8–65.1)</td>
<td>84.8 (82.3–87.3)</td>
<td>&lt;0.001</td>
<td>84.3 (82.9–85.8)</td>
<td>69.8 (64.4–74.9)</td>
</tr>
<tr>
<td>Overall adjusted mortality (95% CI)*</td>
<td>78.8 (75.8–81.8)</td>
<td>N/A</td>
<td>82.2 (80.6–83.7)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>n (% of all total)</td>
<td>193 (42.0)</td>
<td>267 (58.0)</td>
<td>&lt;0.001</td>
<td>1697 (82.1)</td>
<td>137 (6.6)</td>
</tr>
<tr>
<td>Age, y, mean (median)</td>
<td>66.9 (69)</td>
<td>75.0 (77)</td>
<td>0.006</td>
<td>75.9 (78)</td>
<td>66.7 (69)</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>63.2</td>
<td>56.9</td>
<td>0.18</td>
<td>13.4</td>
<td>9.5</td>
</tr>
<tr>
<td>Acute renal failure, %</td>
<td>8.3</td>
<td>12.7</td>
<td>0.20</td>
<td>24.6</td>
<td>20.4</td>
</tr>
<tr>
<td>Cardiac dysrhythmias, %</td>
<td>33.7</td>
<td>28.1</td>
<td>0.059</td>
<td>4.7</td>
<td>&lt;5 patients</td>
</tr>
<tr>
<td>Chronic renal failure, %</td>
<td>5.2</td>
<td>10.9</td>
<td>0.031</td>
<td>9.6</td>
<td>7.3</td>
</tr>
<tr>
<td>Congestive heart failure, %</td>
<td>33.2</td>
<td>46.1</td>
<td>0.005</td>
<td>37.1</td>
<td>35.8</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>24.9</td>
<td>26.6</td>
<td>0.09</td>
<td>24.0</td>
<td>25.6</td>
</tr>
<tr>
<td>Cancer, %</td>
<td>&lt;5 patients</td>
<td>3.8</td>
<td>0.35</td>
<td>3.5</td>
<td>&lt;5 patients</td>
</tr>
<tr>
<td>Pulmonary edema, %</td>
<td>&lt;5 patients</td>
<td>2.2</td>
<td>0.31</td>
<td>4.3</td>
<td>3.4</td>
</tr>
<tr>
<td>AMI score, mean (median)</td>
<td>0.63 (0.62)</td>
<td>0.73 (0.8)</td>
<td>&lt;0.001</td>
<td>0.74 (0.8)</td>
<td>0.62 (0.62)</td>
</tr>
<tr>
<td>Death at 1 y, (%)</td>
<td>47.7</td>
<td>87.6</td>
<td>&lt;0.001</td>
<td>85.1</td>
<td>61.0</td>
</tr>
<tr>
<td>1-Year mortality, adjusted (95% CI)*</td>
<td>57.9 (51.6–63.9)</td>
<td>78.4 (74.9–81.9)</td>
<td>&lt;0.001</td>
<td>79.1 (77.2–81.0)</td>
<td>75.5 (69.3–81.4)</td>
</tr>
<tr>
<td>Overall adjusted mortality (95% CI)*</td>
<td>70.5 (66.9–74.0)</td>
<td>N/A</td>
<td>75.1 (73.3–76.9)</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>n (% of all total)</td>
<td>486 (63.0)</td>
<td>286 (37.0)</td>
<td>&lt;0.001</td>
<td>1035 (76.1)</td>
<td>87 (6.40)</td>
</tr>
<tr>
<td>Age, y, mean (median)</td>
<td>67.6 (69)</td>
<td>77.1 (79)</td>
<td>0.001</td>
<td>77.2 (79)</td>
<td>68.5 (71)</td>
</tr>
<tr>
<td>Male sex, %</td>
<td>64.2</td>
<td>58.4</td>
<td>0.11</td>
<td>52.8</td>
<td>60.9</td>
</tr>
<tr>
<td>Acute renal failure, %</td>
<td>9.67</td>
<td>18.9</td>
<td>&lt;0.001</td>
<td>18.9</td>
<td>13.8</td>
</tr>
<tr>
<td>Cardiac dysrhythmias, %</td>
<td>28.2</td>
<td>25.2</td>
<td>0.36</td>
<td>19.0</td>
<td>18.4</td>
</tr>
<tr>
<td>Cerebrovascular disease, %</td>
<td>1.0</td>
<td>3.5</td>
<td>0.016</td>
<td>3.9</td>
<td>&lt;5 patients</td>
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<tr>
<td>Chronic renal failure, %</td>
<td>7.6</td>
<td>12.6</td>
<td>0.022</td>
<td>15.6</td>
<td>12.6</td>
</tr>
<tr>
<td>Congestive heart failure, %</td>
<td>27.6</td>
<td>35.7</td>
<td>0.018</td>
<td>36.9</td>
<td>35.6</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>30.7</td>
<td>28.3</td>
<td>0.06</td>
<td>32.7</td>
<td>31.0</td>
</tr>
<tr>
<td>Cancer, %</td>
<td>1.4</td>
<td>3.5</td>
<td>0.95</td>
<td>4.9</td>
<td>&lt;5 patients</td>
</tr>
<tr>
<td>Pulmonary edema, %</td>
<td>2.9</td>
<td>2.8</td>
<td>0.95</td>
<td>2.1</td>
<td>&lt;5 patients</td>
</tr>
<tr>
<td>AMI score, mean (median)</td>
<td>0.63 (0.62)</td>
<td>0.75 (0.80)</td>
<td>&lt;0.001</td>
<td>0.76 (0.80)</td>
<td>0.65 (0.63)</td>
</tr>
<tr>
<td>Death at 1 y, (%)</td>
<td>53.9</td>
<td>85.7</td>
<td>&lt;0.001</td>
<td>87.4</td>
<td>47.1</td>
</tr>
<tr>
<td>1-Year mortality, adjusted (95% CI)*</td>
<td>59.4 (55.3–63.5)</td>
<td>81.3 (78.3–84.2)</td>
<td>&lt;0.001</td>
<td>81.8 (79.8–83.7)</td>
<td>50.6 (41.4–59.0)</td>
</tr>
<tr>
<td>Overall adjusted mortality (95% CI)*</td>
<td>68.3 (65.3–71.3)</td>
<td>N/A</td>
<td>73.2 (71.1–75.2)</td>
<td>N/A</td>
<td></td>
</tr>
</tbody>
</table>

*Mortality rates were adjusted using a modified version of the Ontario AMI mortality prediction rule risk score incorporating age, sex, acute renal failure, cardiac dysrhythmias, cerebrovascular disease, chronic renal failure, congestive heart failure, diabetes, cancer, and pulmonary edema. If there was no overlap with the 95% CI, P was assumed to be <0.05.

Data are divided into the 3 time periods of interest and classified on the basis of hospital type at presentation, in addition to intertransfer, and receipt of revascularization during the episode of care.
both types of sites, although they remained significantly higher for patients presenting at nonrevascularization sites. Revascularized patients were more likely to survive, regardless of site of presentation (Table 2). The bulk of the survival improvement in nonrevascularization sites was observed in transferred patients, whose proportion grew from 10.6% in period 1 to 23.9% in period 3 (Figure 3). Transferred patients were younger, more often male, and had a lower AMI mortality risk score compared with patients treated on-site. The rate of transfers from nonrevascularization sites among patients <75 years of age increased prominently from period 1 to period 2 (16.5% to 31.4%), followed by a smaller rise in period 3 (31.4% to 39.2%).

**Elderly Patients**

We identified 4924 patients with CS age ≥75 years, of whom 48.4% were male. Rates of revascularization among elderly patients increased during the study period at both types of sites (Table 3). Only 2.4% of elderly patients with CS were revascularized in period 1, compared with 21.4% in period 3. Transfer rates increased from 6.7% to 12.8% between periods 2 and 3, compared with a rise from 4.2% to 6.7% between the first 2 periods. Adjusted 1-year mortality rates also improved among elderly patients, from 78.8% (95% CI, 75.8 to 81.8) in period 1 to 68.3% (95% CI, 65.3 to 71.3) in period 3. However, the uptake of transfers and revascularization were more modest among elderly patients compared with those age <75 years. The discrepancy was most notable between periods 1 and 2 but was somewhat ameliorated in period 3.

**Discussion**

This population-based study shows that the incidence and mortality of CS after AMI declined in Ontario between 1992 and 2008. This was coincident with a 5-fold increase in revascularization rates and is concordant with previous studies.15–17 It was previously reported that AMI patients admitted to revascularization-capable sites are more frequently revascularized with modest or no survival advantage.9,18,19 The SHOCK trial, however, demonstrated that AMI patients with CS who were randomly assigned to emergency revascularization had an absolute risk reduction of 12.8% in 6-month mortality rate.2 Yet, the impact of admission hospital type on survival remains unknown in this setting. Two studies conducted before the SHOCK trial publication provided conflicting results.20,21 Our study, encompassing more contemporary data, shows that the increases in survival and revascularization were most prominent among patients presenting or transferred to revascularization-capable sites. The survival advantage associated with initial admission to revascularization-capable site advantage was also observed in patients with cardiogenic shock developing before hospitalization. It is unclear if the survival advantage is due to revascularization itself, earlier revascularization, or other elements within the package of care such as intra-aortic balloon pump counterpulsation,20,21 specialized cardiology care, or a combination of these factors.9,21
vascularization sites. We observed a near doubling of transfer rates of patients age <75 years after the publication of the SHOCK Trial and ACC/AHA AMI guidelines in 1999. We also demonstrated a distinct increase in transfer of elderly patients after the 2004 guideline changes. This patient group, however, is less likely to receive evidence-based therapy in a variety of settings,\textsuperscript{7,16} and our results suggest that this inequality possibly extends to the setting of CS after AMI.

Nonrevascularization sites admitted the majority of patients who had CS in Ontario, highlighting the importance of patient transfer to facilitate urgent revascularization. Almost all the survival improvements observed in nonrevascularization sites. We observed a near doubling of transfer rates of patients age <75 years after the publication of the SHOCK Trial and ACC/AHA AMI guidelines in 1999. We also demonstrated a distinct increase in transfer of elderly patients after the 2004 guideline changes. This patient group, however, is less likely to receive evidence-based therapy in a variety of settings,\textsuperscript{7,16} and our results suggest that this inequality possibly extends to the setting of CS after AMI.

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tion sites in Ontario were among patients who were transferred, including those age ≥75 years. This undoubtedly reflects an element of selection and survival bias. Nevertheless, these results suggest that the practice of transferring well-selected patients with CS to revascularization-capable sites is safe and associated with improved survival. Our results are supported by prior observations from the SHOCK trial and registry, which showed that transferred patients with CS after AMI derive a similar benefit from revascularization as patients initially admitted to revascularization-capable sites despite a longer time to treatment.23 Yet, >75% of CS patients presenting to nonrevascularization hospitals in period 3 continued to be treated on-site. This suggests a significant opportunity for further improvement, particularly among well-selected elderly patients, 82% of whom were never transferred.

It should be emphasized that our observations do not necessarily establish a cause-and-effect relationship between transfer to revascularization-capable hospitals and decreased mortality rates. Nonetheless, physicians responsible for care of CS patients should be aware that there is probably a survival advantage associated with transfer and revascularization of appropriately selected patients. Our data also highlight the importance of creating well-organized networks of care to streamline the transfer of these patients. This has been effectively implemented in the context of ST-elevation–myocardial infarction management24 and can serve as the backbone for a similar infrastructure for CS patients. Several models have been developed to predict onset of CS after AMI by using data available early in the course of hospitalization.1,16,25 Thus, consideration should be given to preemptively transferring patients who may benefit from revascularization before hemodynamic instability develops.

Our data suggest that this may have already been occurring with increasing frequency in Ontario. We noted a higher incidence of CS in revascularization-capable sites with a growing disparity from periods 1 to 3. Furthermore, CS patients presenting at revascularization-capable sites were younger and more likely to be male, with higher rates of cardiac dysrhythmias but lower rates of noncardiac comorbidity. Such patterns have been previously reported15,20 and possibly reflect decisions by emergency personnel to transfer “sicker” patients with a high likelihood for CS but less noncardiac morbidities directly to revascularization-capable sites. This might have also been facilitated by primary and rescue percutaneous coronary intervention programs for ST-elevation–myocardial infarction that would have funneled younger patients at high risk of development of CS to revascularization-capable sites.24

Limitations
The incidence of CS in this study is notably lower than in previous reports15–17 because of the low sensitivity of our database and the exclusion of recurrent AMIs in the same year. However, these incidence rates are similar to prior studies based on administrative data.21,26 Moreover, mortality rates were similar to CS patients in prior studies,11,15–17 which suggests against but does not rule out a considerable selection bias. Furthermore, our data did not allow determination of the time of revascularization relative to the onset of CS. Moreover, the relative contribution of revascularization versus other care elements received at revascularization-capable sites cannot be determined. Finally, our data may be susceptible to differences in coding practices among different institutions.

Conclusions
There were substantial survival improvements among AMI patients with CS in Ontario between 1992 and 2008. This was accompanied by large increases in revascularization and transfer rates that were temporally linked to ACC/AHA AMI guideline dissemination. Improvements were most prominent among CS patients initially admitted to revascularization-capable sites, patients eventually transferred there, and patients <75 years of age. Our data identify an inequality in health outcomes among patients that is based on the type of hospital they present to and possibly on age. It also indicates a significant opportunity for improvement in treating CS patients presenting to nonrevascularization sites.

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SUPPLEMENTAL MATERIAL

Appendix 1. A comparison of management and outcomes among the two different patient groups over the three time periods. After adjustment for baseline comorbidities (using the AMI score), patients with CS at the time of admission had a lower risk of death, but this did not reach statistical significance. The difference in the magnitude of death was more pronounced in Periods 2 and 3. Presentation with CS to revascularization-capable sites was associated with improved survival regardless whether CS was present at admission or developed thereafter. This is consistent with the overall results of our study.

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th></th>
<th>Period 2</th>
<th></th>
<th>Period 3</th>
<th></th>
<th>Overall</th>
<th></th>
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<tbody>
<tr>
<td></td>
<td>CS at admission</td>
<td>CS post admission</td>
<td>p-value</td>
<td>CS at admission</td>
<td>CS post admission</td>
<td>p-value</td>
<td>CS at admission</td>
<td>CS post admission</td>
</tr>
<tr>
<td>AMI score (SD)</td>
<td>0.701 (0.17)</td>
<td>0.658 (0.18)</td>
<td>0.01</td>
<td>0.692 (9.17)</td>
<td>0.685 (0.19)</td>
<td>0.7</td>
<td>0.670 (0.18)</td>
<td>0.685 (0.20)</td>
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<tr>
<td>Revascularized (%)</td>
<td>20.9</td>
<td>34.7</td>
<td>&lt;0.001</td>
<td>37.5</td>
<td>49.2</td>
<td>0.013</td>
<td>64.0</td>
<td>61.1</td>
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<tr>
<td>1-year mortality - unadjusted</td>
<td>78.2</td>
<td>75.7</td>
<td>0.63</td>
<td>67.8</td>
<td>72.9</td>
<td>0.25</td>
<td>63.4</td>
<td>69.6</td>
</tr>
<tr>
<td></td>
<td>78.3 (74.8, 81.7)</td>
<td>79.8 (75.2, 84.3)</td>
<td>68.1 (63.6, 72.5)</td>
<td>74.3 (69.4, 79.0)</td>
<td>66.4 (62.6, 70.1)</td>
<td>71.6 (67.4, 70.1)</td>
<td>70.5 (67.9, 73.0)</td>
<td>74.6 (71.6, 77.5)</td>
</tr>
</tbody>
</table>

Presenting to Non-Revascularization capable sites
<table>
<thead>
<tr>
<th>AMI score (SD)</th>
<th>0.703 (0.16)</th>
<th>0.671 (0.17)</th>
<th>&lt;0.001</th>
<th>0.724 (0.17)</th>
<th>0.705 (0.16)</th>
<th>0.016</th>
<th>0.731 (0.17)</th>
<th>0.722 (0.17)</th>
<th>0.37</th>
<th>0.713 (0.17)</th>
<th>0.689 (0.17)</th>
<th>&lt;0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transferred (%)</td>
<td>9.3</td>
<td>13.0</td>
<td>&lt;0.001</td>
<td>17.2</td>
<td>19.0</td>
<td>0.29</td>
<td>24.4</td>
<td>23.1</td>
<td>0.59</td>
<td>13.8</td>
<td>16.4</td>
<td>0.002</td>
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<tr>
<td>Revascularized %</td>
<td>4.5</td>
<td>5.5</td>
<td>0.16</td>
<td>11.6</td>
<td>10.6</td>
<td>0.47</td>
<td>17.7</td>
<td>17.1</td>
<td>0.79</td>
<td>8.5</td>
<td>8.9</td>
<td>0.6</td>
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<tr>
<td>1-year mortality - unadjusted</td>
<td>82.4</td>
<td>79.9</td>
<td>0.042</td>
<td>74.5</td>
<td>79.9</td>
<td>0.005</td>
<td>73.0</td>
<td>79.4</td>
<td>0.009</td>
<td>78.8</td>
<td>79.8</td>
<td>0.29</td>
</tr>
<tr>
<td>1-year mortality - adjusted (95% CI)</td>
<td>82.0 (80.3, 83.6)</td>
<td>82.6 (80.6, 84.7)</td>
<td>72.8 (70.5, 75.0)</td>
<td>79.3 (76.7, 81.8)</td>
<td>71.0 (68.3, 73.6)</td>
<td>77.1 (74.2, 80.1)</td>
<td>77.8 (76.3, 79.3)</td>
<td>80.7 (79.0, 82.4)</td>
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