Unequal access to interventional cardiac care in Nova Scotia in patients with acute myocardial infarction complicated by cardiogenic shock

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BACKGROUND: The optimal treatment of cardiogenic shock (CS) complicating acute myocardial infarction (AMI) remains controversial and continues to be associated with a high mortality rate. The present study evaluated the outcomes of all patients having AMI complicated by CS in a single Canadian province.

METHODS: All consecutive patients diagnosed with AMI and CS from October 1997 to December 2002 in Nova Scotia were included in the present study. The Improving Cardiac Outcomes in Nova Scotia (ICONS) registry was used as the principal source of data. The outcome of interest was in-hospital mortality.

RESULTS: During the study period, a total of 11,300 patients with AMI were identified, with 707 complicated by CS, for an incidence of AMI+CS of 6.3%. The overall mortality rate for patients with AMI+CS was 60.1%. Multivariate regression analysis identified age older than 65 years (OR 2.0; 95% CI 1.4 to 2.9) and renal insufficiency (OR 2.1; 95% CI 1.4 to 3.2) as independent predictors of mortality, while access to invasive cardiac care (defined as admission or transfer to the only cardiac catheterization-capable centre in Halifax, Nova Scotia) was found to be an independent predictor of survival (OR 0.4; 95% CI 0.3 to 0.5). Access to invasive cardiac care was limited to 414 (59%) patients, 250 (35%) of whom actually underwent cardiac catheterization.

CONCLUSIONS: Admissions to a tertiary care centre that can provide invasive care was independently associated with improved survival, and older age and renal insufficiency were associated with death among patients with AMI and CS.

Key Words: Catheterization; Health outcomes; Myocardial infarction; Shock

Cardiogenic shock (CS) is a condition that complicates 5% to 15% of all patients suffering from an acute myocardial infarction (AMI) (1). Over the past 20 years, this rate has been established as fairly stable despite a drop in the incidence of AMI and attempts to prevent CS from occurring (1). Furthermore, the observed mortality rates associated with CS complicating AMI are consistently reported to be as high as 80% (1). The overall prognosis for patients admitted to hospital with CS remains very grim (2). In fact, CS in AMI has been established as the leading cause of in-hospital death in some

Un accès inégal à des soins cardiovasculaires interventionnels en Nouvelle-Écosse pour les patients atteints d'un infarctus aigu du myocarde compliqué par un choc cardiogène

HISTORIQUE : Le traitement optimal de l'infarctus aigu du myocarde (IAM) compliqué par un choc cardiogène (CC) demeure controversé et continue de s'associer à un taux de mortalité élevé. La présente étude a évalué l'issue de tous les patients atteints d'un IAM compliqué par un CC dans une seule province du Canada.

MÉTHODOLOGIE : Tous les patients consécutifs atteints d'un IAM et d'un CC diagnostiqués entre octobre 1997 et décembre 2002 en Nouvelle-Écosse ont été inclus dans la présente étude. Le registre du projet ICONS sur l'amélioration des issues cardiovasculaires en Nouvelle-Écosse a servi de source principale de données. L'issue d'intérêt était la mortalité à l'hôpital.

RÉSULTATS : Pendant la période de l'étude, un total de 11 300 patients atteints d'IAM a été repéré, dont 707 cas compliqués par un CC, pour une incidence d'IAM+CC de 6,3 %. Le taux de mortalité global des patients atteints d'IAM+CC était de 60,1 %. L'analyse de régression multivariée a permis d'établir que le fait d'avoir plus de 65 ans (RR 2,0; 95 % IC 1,4 à 2,9) et de souffrir d'insuffisance rénale (RR 2,1; 95 % IC 1,4 à 3,2) était un prédicteur indépendant de mortalité, tandis que l'accès à des soins cardiaques effractifs, défini comme une hospitalisation ou un transfert au seul centre apte à procéder à des cathétérismes cardiaques (à Halifax, en Nouvelle-Écosse), constituait un prédicteur indépendant de survie (RR 0,4; 95 % IC 0,3 à 0,5). L'accès à des soins cardiaques effractifs s'est limité à 414 patients (59 %), dont 250 (35 %) ont subi un cathétérisme cardiaque.

CONCLUSIONS : L'hospitalisation dans un centre de soins tertiaires capable d'offrir des soins effractifs s'associait de manière indépendante à une amélioration de la survie, tandis que le fait d'être âgé et de souffrir d'insuffisance rénale s'associait au décès chez les patients atteints d'IAM et de CC.

centres, while in most others, CS has been firmly established as the leading cause of death of patients hospitalized with AMI (3-5).

Invasive therapy in the form of revascularization, however, can have a significant impact on survival in select populations of patients with AMI complicated by CS (3,4,6-10). However, treatment modality alone is not the only major factor affecting survival in patients with CS as a result of an AMI. The timing of treatment delivery is a key factor in determining the effectiveness of treatment and, ultimately, the outcomes achieved.

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Thus, some studies (4,7,11,12) have shown that earlier interventions lead to better long-term outcomes, and in particular fast access to a medical facility that can provide invasive treatment in the form of cardiac catheterization and revascularization of patients with AMI complicated by CS. Based on these findings, the American College of Cardiology and the American Heart Association made a class I recommendation that revascularization be performed in patients with AMI complicated by CS (13,14).

The province of Nova Scotia offers a unique opportunity to assess health care delivery because it has a stable population base of approximately one million people served by regional hospitals and a single centre capable of cardiac catheterization and revascularization for the entire province. Therefore, the primary objectives of the present study were to evaluate the delivery of invasive cardiac care to all patients with AMI complicated by CS in Nova Scotia who survived to hospital admission from 1997 to 2002.

METHODS

Patient population

All consecutive patients admitted to any adult acute care Nova Scotia hospital with a diagnosis of AMI complicated by CS were identified between October 1997 and December 2002.

The treatment and outcomes of such patients were evaluated using the population-based disease-specific clinical registry of the Improving Cardiovascular Outcomes in Nova Scotia (ICONS) study (15). ICONS is a large, prospective, cohort disease management study whose rationale and methods have been described previously (15). In short, enrollment to the registry began October 15, 1997, and remains ongoing today under institutional ethics approval, although responsibility for the registry has since devolved to the Provincial Department of Health. This database contains detailed clinical information obtained via primary chart abstraction on all consecutive Nova Scotia residents hospitalized with, among other things, AMI and CS. Data management and quality was ensured such that collection for the ICONS study commenced only after an accuracy level of at least 95% for data abstraction was achieved. Maintaining this high degree of accuracy required the implementation of several quality-control mechanisms, as described elsewhere (15). These mechanisms included a combination of quarterly test cases, monthly site visits with random chart reabstraction, software logic checks around key data fields and provision of a second data entry person to independently review a random sample of entered cases on a periodic basis for immediate error detection and correction (15).

For the purposes of the present study, relevant clinical information pertaining to patients with a recorded admission date between October 15, 1997, and December 31, 2002, was retrieved from the ICONS database and analyzed. Specially trained nurses and medical record technologists abstracted information from each patient chart, including documentation of parameters pertinent to the clinical syndrome of CS.

AMI diagnosis was based on the *International Classification of Diseases*, 9th revision, *Clinical Modification* (16) (ICD-9-CM) coding, while CS was defined by one of the following: admitting or discharge diagnosis of CS by the attending physician; or any diagnosis of CS occurring during hospital stay and noted in patients' records combined with appropriate clinical presentation. The clinical findings of shock were defined as blood pressure less than 90 mmHg and clinical signs of hypoperfusion or end

organ dysfunction. Note that the ICD-9 infarction definition used in the present manuscript also included non-ST elevation infarctions.

Hospital of admission was defined as the hospital to which the patient initially presented. Access to invasive cardiac care was defined as any patient admitted or transferred to the Queen Elizabeth II Health Sciences Centre (QEII HSC), which is the sole cardiac catheterization-capable centre in Nova Scotia.

The outcome of interest was all-cause, in-hospital mortality. Patients were further stratified into two main groups: patients with or without access to invasive cardiac care. For both groups, data concerning prehospital and in-hospital parameters were recorded, as was basic patient demographic information.

Statistical analysis

All analyses were performed with the Statistical Analysis Systems software package (release 8.2, SAS Inc, USA). Descriptive statistics included continuous and discrete variables, which were analyzed as appropriate with an unpaired Student's *t* test, Wilcoxon rank sum test, χ^2 test or Fisher's exact test. Statistical significance was defined as $P < 0.05$. The independent predictors of in-hospital mortality were identified by logistic regression. All clinically relevant variables were included in the model, and by backward elimination, independent predictors were retained at $P < 0.05$. Interaction terms were not assessed. Sensitivity and specificity of the model were evaluated by the receiver operating characteristic. The clinically relevant variables included patient demographics (age, sex), previous history of heart disease (previous myocardial infarction or intervention), additional organ failure (renal insufficiency), intervention (thrombolytics), era (defined as before or after the publication of the SHould we emergently revascularize Occluded coronaries for Cardiogenic shock? [SHOCK] trial [4]), and access to cardiac invasive care.

RESULTS

In Nova Scotia, 11,300 patients were hospitalized and found to have a diagnosis of AMI between October 1997 and December 2002. From this group of patients, 707 eventually developed CS, for an AMI+CS incidence of 6.3%. The findings presented in the present manuscript are only from the 707 patients with AMI+CS.

A total of 416 patients (59%) were treated at QEII HSC, which is the sole cardiac catheterization-capable centre in Nova Scotia. Two hundred ninety-one patients (41.2%) were admitted initially to the QEII HSC, while an additional 125 patients were transferred to the QEII HSC from another institution. The clinical characteristics of patients with AMI+CS are shown in Table 1. The average age of all patients was 71.2 ± 11.7 years, and 198 patients (28%) were 65 years of age or younger. Patients with access to invasive cardiac care were more likely to be younger, not have a history of congestive heart failure, renal insufficiency or diabetes, and were more likely to be on a statin for dyslipidemia.

Very few patients had findings of shock on admission with an average systolic blood pressure on admission of 123 mmHg (Table 2). Consequently, the majority of patients developed clinical signs of shock following their admission (83%). Patients with access to invasive cardiac care were more likely to have chest pain on admission but fewer received thrombolytics (Table 2).

Four hundred twenty-five patients died in hospital, resulting in an in-hospital mortality rate of 60.1% (Figure 1).

TABLE 1
Cardiac risk profile of the patient population (n=707)

Cardiac risk profile	Access to invasive cardiac care (n=416), n (%)	No access (other hospital) (n=291), n (%)	P
Older than 65 years of age	271 (65)	238 (82)	<0.0001
Male sex	244 (59)	155 (53)	0.16
Previous cardiac history			
Myocardial infarction	137 (33)	105 (36)	0.39
Percutaneous coronary intervention	26 (6)	15 (5)	0.54
CABG	33 (8)	27 (9)	0.53
Congestive heart failure	865 (21)	88 (30)	0.004
Diabetes mellitus	141 (34)	122 (42)	0.02
Hypertension	247 (59)	153 (53)	0.07
Hyperlipidemia	173 (42)	74 (25)	<0.0001
Renal insufficiency	69 (17)	86 (30)	<0.0001
Medications on admission			
Beta-blocker	187 (45)	125 (43)	0.60
Angiotensin-converting enzyme	147 (35)	113 (39)	0.34
Statin	117 (28)	57 (20)	0.009
Acetylsalicylic acid	169 (41)	114 (39)	0.70

CABG Coronary artery bypass graft surgery

TABLE 2
Admission characteristics of the patient population (n=707)

Characteristics on admission	Access to invasive cardiac care (n=416)	No access (other hospital) (n=291)	P
Shock diagnosis, n (%)	68 (16)	53 (18)	0.52
Chest pain, n (%)	273 (66)	154 (53)	0.001
SBP (mmHg), mean $\pm$ SD	124 $\pm$ 32	123 $\pm$ 31	0.63
Thrombolytics, n (%)	67 (16)	66 (23)	0.03

SBP Systolic blood pressure

Unadjusted increased mortality rates were found for patients older than 65 years of age ($P<0.0001$), those without access to cardiac invasive care ($P<0.0001$) or those who would not undergo a diagnostic cardiac catheterization ($P<0.0001$). The incidence of AMI+CS per 100,000 population during the five-year study period was evaluated based on the hospital of admission and data from the Canadian 2001 Census (Statistics Canada, unpublished data). The incidence of AMI+CS was 81 patients per 100,000 during five years admitted to the QEII HSC compared with 76 patients admitted to other institutions.

Among patients with access to invasive cardiovascular facilities, a total of 250 patients, or 35% of all patients admitted with AMI+CS, underwent diagnostic cardiac catheterization. The mean time from admission to catheterization was 4.0 ± 5.9 days for the overall group (median of two days). The mean length of hospitalization for survivors was 23.7 ± 25.1 days (median of 15 days). Younger patients (younger than 65 years of age) were more likely to undergo cardiac catheterization (55%). Of the patients who did undergo diagnostic cardiac catheterization, the majority were revascularized (97 underwent percutaneous coronary intervention [PCI] and 155 underwent coronary artery bypass graft surgery [CABG]). The in-hospital mortality rate for patients who did undergo PCI or CABG was 44% and 35%, respectively, and was significantly lower than for patients who did not undergo revascularization ($P<0.001$).

Figure 1 Histogram illustrating unadjusted in-hospital mortality for various groups of patients (n=707). CABG Coronary artery bypass graft surgery; Cath Catheterization; PCI Percutaneous coronary intervention

A multiple logistic regression analysis was performed on the entire cohort of 707 patients with in-hospital mortality as the outcome of interest. In the fully-adjusted model, two independent predictors of in-hospital mortality were identified: age older than 65 years (OR 2.0; 95% CI 1.4 to 2.9) and renal insufficiency defined by a maximal creatinine concentration greater than 177 mmol/L (OR 2.1; 95% CI 1.4 to 3.2). Access to invasive cardiac care was associated with a significant survival benefit (OR 0.4; 95% CI 0.3 to 0.5). The c statistic for the model was 0.7.

DISCUSSION

Nova Scotia offers an ideal clinical laboratory to evaluate the delivery of care because it offers a single, centralized, invasive cardiac care centre providing services for the entire area. During a five-year period (1997 to 2002), 707 consecutive patients with AMI complicated by CS were identified, for an incidence of 6.3%, with an in-hospital mortality of 60.1%. These findings were in keeping with established age- and sex-standardized in-hospital AMI mortality rates in Canada (reported to reach 11.8%), with the incidence and mortality rates associated with CS complicating AMI being 5.9% and 59%, respectively (17).

In the present study, we defined access to invasive cardiac care as any patient admitted or transferred to the QEII HSC, which is the sole cardiac catheterization-capable centre in Nova Scotia. We have demonstrated that access of patients with AMI+CS was limited to 59% of Nova Scotians. Unadjusted mortality was significantly lower in patients with access to the QEII HSC, with an in-hospital mortality of 49% compared with 76% elsewhere ($P<0.0001$). After adjusting for patient variables, including era, access to invasive cardiac care was shown to be independently associated with improved patient in-hospital survival, with an OR of 0.4 (95% CI 0.3 to 0.5). Indeed, several observational studies (18-22) suggest that access to a catheterization laboratory on-site is associated with survival benefit in patients with CS. Similarly, the SHOCK study reported a significant survival advantage for patients treated with early revascularization compared with patients who did not receive early revascularization at both six months (50% versus 63%; $P=0.027$) and 12 months (53% versus 66%; $P<0.03$) (4,23). Our findings also show that unadjusted mortality was significantly lower in revascularized patients than in all other patients. Taken together, one could

speculate that the benefit associated with access to invasive cardiac care could be secondary to access to cardiac catheterization, from which follows the subsequent decision to offer revascularization. However, because there was significant collinearity between revascularization (PCI or CABG) and access to cardiac invasive care, we were unable to demonstrate conclusively that revascularization was the driving force predicting survival.

The barriers to access are quite complex and cannot simply be explained by the sheer distance to the QEII HSC. Rather, access is likely influenced by multiple variables, including the way the system treats selected transfer patients who could benefit for invasive cardiac care (22,24). Despite attempts at adjusting for differences between patient populations, it is possible that the higher mortality observed in patients not treated at the QEII HSC was due to a higher severity of illness not accounted for, a higher rate of patients who do not resuscitate orders outside of Halifax or, possibly, demographic differences (residual confounding) that were not accounted for. This means that the interpretation of our findings could be limited by unaccounted-for variable(s) (residual confounding), which could be potentially responsible for the apparent survival benefit of diagnostic cardiac catheterization.

We documented an overall rate of cardiac catheterization of 35%, which appears low when compared with other jurisdictions, where rates above 50% are often reported in similar patients (18,25). This practice pattern exists despite evidence that lower rates of intervention may result in significantly poorer long-term patient survival (16,24,26). It is difficult to speculate on the exact reasons for the low rates of catheterization observed. While differential catheterization in many circumstances reflect different practice patterns, the relatively lower rates for referral of patients with AMI and CS in Nova Scotia suggest that these resources may be overly constrained and centralized, thereby impeding timely patient access. Our observation raises important concerns about inequities in care in a publicly funded 'universal' health care system that should, in principle, ensure equal access to such potentially life-saving health care services to all eligible Canadians. It is especially puzzling that such variation in practice and outcome could additionally exist in such a geographically circumscribed health care system as pertains in Nova Scotia.

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Using multiple logistic regression analysis, advanced age was found to be a significant and independent predictor of in-hospital mortality. Patients with AMI+CS older than 65 years were found to have a mortality rate of 65% compared with 45% in younger patients ($P<0.0001$). Similar findings have been reported by others (1,8). A post hoc study group analysis conducted on the SHOCK study data suggested that patients older than 75 years of age had a significant decreased survival advantage, which was likely related to the increased risk of adverse events despite intervention (4). A recent observational study that specifically targeted elderly patients found no significant survival advantages for those revascularized early at both 30-day and one-year intervals (27). We have shown that renal insufficiency developing or present at the time of admission was an independent predictor for in-hospital mortality. These findings are supported by increasing evidence suggesting that isolated renal insufficiency contributes to the poor outcome seen in patients postmyocardial infarction (28).

There are several limitations to our study. First, the analysis was retrospective. This complicates both the identification of patients with a clinical diagnosis of CS and the understanding of the manner in which they were managed. Unmeasured patient characteristics, physician decision-making, local resource constraints or other clinical or nonclinical considerations could have affected process of care. Second, the present study was not designed or powered to identify variations in the delivery of care between centres or caregivers, which limited our ability to draw conclusions in this regard. Nonetheless, important strengths include the large sample size that is truly population-based and the extensive data available relating to individual cases.

CONCLUSION

We have shown that admission to a tertiary care centre capable of invasive care was independently associated with improved survival, and that older age and renal insufficiency were associated with death among patients with AMI and CS. Further study to determine the reasons for the improved outcome among those managed in the tertiary care setting is warranted.

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