Research

Impact of a regionalised clinical cardiac support network on mortality among rural patients with myocardial infarction

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Abstract

Objective: To evaluate the impact of the regionalised Integrated Cardiovascular Clinical Network (ICCNet) on 30-day mortality among patients with myocardial infarction (MI) in an Australian rural setting.

Design, setting and patients: An integrated cardiac support network incorporating standardised risk stratification, point-of-care troponin testing and cardiologist-supported decision making was progressively implemented in non-metropolitan areas of South Australia from 2001 to 2008. Hospital administrative data and statewide death records from 1 July 2001 to 30 June 2010 were used to evaluate outcomes for patients diagnosed with MI in rural and metropolitan hospitals.

Main outcome measure: Risk-adjusted 30-day mortality.

Results: 29 623 independent contiguous episodes of MI were identified. The mean predicted 30-day mortality was lower among rural patients compared with metropolitan patients, while actual mortality rates were higher (30-day mortality: rural, 705/5630 [12.52%] v metropolitan, 2140/23 993 [8.92%]; adjusted odds ratio [OR], 1.46; 95% CI, 1.33–1.60; $P < 0.001$). After adjustment for temporal improvement in MI outcome, availability of immediate cardiac support was associated with a 22% relative odds reduction in 30-day mortality (OR, 0.78; 95% CI, 0.65–0.93; $P = 0.007$). A strong association between network support and transfer of patients to metropolitan hospitals was observed (before ICCNet, 1102/2419 [45.56%] v after ICCNet, 2100/3211 [65.4%]; $P < 0.001$), with lower mortality observed among transferred patients.

Conclusion: Cardiologist-supported remote risk stratification, management and facilitated access to tertiary hospital-based early invasive management are associated with an improvement in 30-day mortality for patients who initially present to rural hospitals and are diagnosed with MI. These interventions closed the gap in mortality between rural and metropolitan patients in South Australia.

Modern evidence-based acute myocardial infarction (MI) care incorporates a rich array of therapeutic strategies associated with demonstrable reductions in mortality.[1,2] However, their optimal implementation is dependent on timely access to expert clinical assessment, risk stratification and resource-intensive coronary reperfusion or revascularisation.[3-5] Consequently, many patients with MI continue to experience disparities in clinical care and outcome because of geographical location.[6]

To optimise management of acute coronary syndromes, many regions have begun developing cardiac clinical networks aimed at supporting the capacity of primary care to manage acute coronary syndromes. This is achieved through providing expert risk stratification at the point of initial patient presentation combined with efficient systems for transferring patients in a time-critical manner to centralised, skilled and resource-intensive management, such as coronary revascularisation.[7-9] These networks require careful design, coordination and engagement with primary care practitioners, combined with ongoing clinical commitment and resources, but they may provide benefits that exceed the gains achievable by many new innovations in therapy.[10] Hence, we sought to evaluate the impact of such a cardiac clinical network on 30-day mortality among patients with acute MI presenting to hospitals in a rural setting.

Methods

Study population

South Australia is a state of about 1.64 million people spanning just under 1 000 000 km^2. Adelaide has seven metropolitan hospitals, while the 66 rural cities and towns have local hospital facilities serving their population of over 600 000 people. In rural areas, the four largest cities have populations of 15 000–24 000 with access to three consultant general physicians. The next 20 large towns have < 15 000 people (most have < 5 000 residents) and are served by small rural hospitals and occasional visits by visiting cardiologists. For this study, all hospitals outside the seven metropolitan hospitals were classified as rural hospitals. Invasive services are only available within the metropolitan hospitals.

The Integrated Cardiovascular Clinical Network

From 2001 to 2008, the Integrated Cardiovascular Clinical Network (ICCNet), designed to support general medical practitioners and nurses in rural areas, was implemented in rural South Australia. The ICCNet "clinical network" integrated three key design features (Box 1): standardised risk stratification and evidence-based treatment protocols;[3,4] point-of-care testing for whole-blood troponin T levels with central quality control; and a designated on-call consultant cardiologist with redundancy to ensure response within 10 minutes with facsimile-based electrocardiogram interpretation, and facilitation of transfer to metropolitan hospitals by the Royal Flying Doctor Service with emergency medical retrieval team support if deemed necessary. Rural participants in the network also received regular education (Box 1). By

1 Essential components of the Integrated Cardiovascular Clinical Network service

- Clinician with advanced life-support skills who is able to interpret history and electrocardiograms of patients with chest pain
- Cardiac monitor and defibrillator on site
- Clinical history by medical or nursing clinician
- Onsite electrocardiograph and remote interpretation capability
- Biochemical markers available at point of care
- Acute medications guided by agreed protocols
- Timely access to coronary angiography, percutaneous coronary intervention, coronary artery bypass graft surgery and a cardiac rehabilitation service coordinated though metropolitan hospital services
- Regular comprehensive clinical follow-up, combined with clinical and technical quality assurance ◆

2008, this service was available to all 66 rural hospitals.

Admissions, transfers and mortality among patients with MI

Using administrative data, patients with a final diagnosis of MI between 1 July 2001 and 30 June 2010 were identified for analysis. Within the dataset, patients' age, sex, principal diagnosis, significant comorbidities (including diabetes, hypertension, significant renal and hepatic dysfunction, prior stroke, left ventricular failure and dementia) and components of the Charlson index, as well as inhospital procedural data (angiography), length of stay, transfers and final patient disposition were available for analysis.[11] The principal diagnosis of MI and subclassifications of MI were identified using the International Classification of Diseases 10th revision Australian modification classification I21.0-5. Routine identification of discharge status and destination and transfer-related admissions permitted linkage of records for the same patient receiving acute care in several hospitals and avoided double-counting of contiguous admissions. Patients were classified as "rural" or "metropolitan" based on the location of the hospital where they first presented. Total length of stay was calculated as the time from admission to the first hospital to the time of discharge from acute care, regardless of final hospital location. Linkage of these data to the state death registry enabled the capture of 30-day mortality. Since cause of death was not reliably available, all-cause mortality was used to avoid any systemic biases in the coding of causality. The ICCNet project was approved through the Flinders Medical Centre Human Research Ethics committee, and access to these data was granted by the office of the Chief Executive, SA Health.

Statistical analysis

To evaluate the relationship between availability of the ICCNet service and mortality, 30-day death rates among patients with MI presenting to rural hospitals before and after the clinical network implementation were compared. These comparisons were contrasted with mortality rates among primary MI presentations in metropolitan hospitals. A full description of the statistical approach is provided in Appendix 1 (online at mja.com.au).

Results

Population characteristics

From July 2001 to June 2010, 34 172 admissions of patients with a diagnosis of acute MI were identified. Of these, 4549 patients were transferred from rural centres to metropolitan hospitals, resulting in 29 623 independent episodes of contiguous acute care. Overall, 5630 patients presented initially to a rural hospital. The mean predicted inhospital mortality rate was slightly lower among rural patients (rural 7.3% v metropolitan 7.6%; $P<0.001$). The risk profiles of the populations by rural and metropolitan category and before and after joining the clinical network are displayed in Appendix 2 (online at mja.com.au). There was a small decline in predicted risk over time.

Mortality rates

Thirty-day mortality rates were higher among patients presenting in rural areas compared with metropolitan hospitals (rural, 705/5630 [12.52%] v metropolitan, 2140/23 993 [8.92%]; risk-adjusted odds ratio [$OR_{risk\text{-}adj}$], 1.46 [95% CI, 1.33–1.60]; $P<0.001$). Overall, annual mortality rates declined over the 9 years (per year, $OR_{risk\text{-}adj}$ 0.97 [95% CI, 0.95–0.99]; $P<0.001$). However, these declines were greater in rural areas (interaction between year and rural location, $P=0.04$). In 2001, the adjusted OR for patients presenting in rural areas was 1.69 (95% CI, 1.40–2.04; $P<0.001$), but by 2010 this was no longer significant ($OR_{risk\text{-}adj}$ 0.92 [95% CI, 0.75–1.13]; $P=0.44$) (Appendix 3; online at mja.com.au).

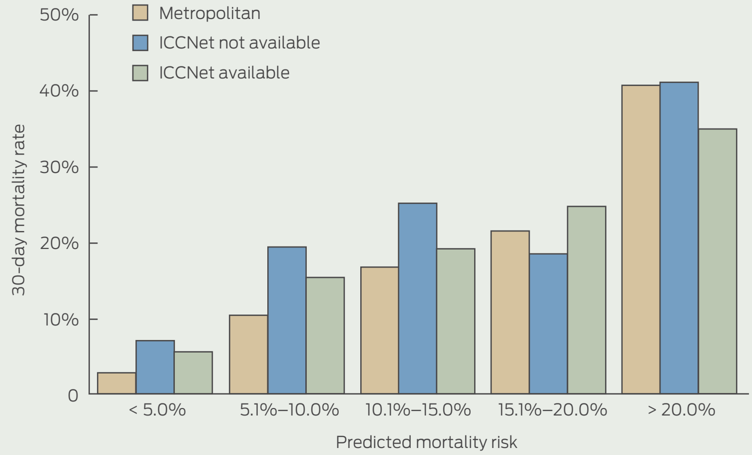
Compared with patients presenting to rural hospitals before the availability of the network, 30-day mortality was lower among patients presenting to hospitals integrated into the clinical network (rural before ICCNet, 337/2419 [13.93%] v rural after ICCNet, 368/3211 [11.46%] v metropolitan, 2140/23 993 [8.92%]; $P<0.001$). After adjusting for baseline comorbidities and MI characteristics, presentation to an ICCNet hospital was associated with a 22% relative odds reduction in the risk of 30-day mortality ($OR_{risk\text{-}adj}$ 0.78 [95% CI, 0.65–0.93]; $P=0.007$) compared with other rural centres, although these patients remained at increased risk of 30-day mortality compared with patients presenting to metropolitan hospitals ($OR_{risk\text{-}adj}$ 1.57 [95% CI, 1.38–1.79]; $P<0.001$).

By strata of predicted risk, the observed mortality rates among rural patients were greater than among those presenting to metropolitan centres across the spectrum of risk, although most of the excess mortality was observed in the intermediate risk groups (5%–20% predicted risk) (Box 2). Reductions in rural mortality rates among these intermediate risk patients accounted for most mortality reductions over time.

Transfers and angiography

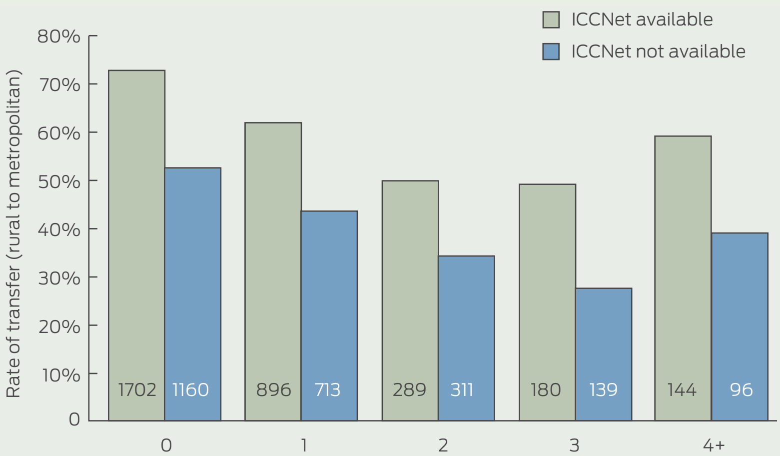
There was a strong association between clinical network implementation and the rate of transfer of rural patients to metropolitan hospitals (before ICCNet, 1102/2419 [45.56%] v after ICCNet, 2100/3211 [65.40%]; $P<0.001$). Increased transfers were not associated with an increase in the total median length of stay for each admission compared with metropolitan presentations, but were associated with a lower total length of stay compared with admissions before ICCNet

2 Rates of 30-day mortality, angiography and transfer to a metropolitan hospital among rural patients diagnosed with myocardial infarction 1 Jul 2001 – 30 Jun 2010, with and without availability of the Integrated Cardiovascular Clinical Network (ICCNet) and contrasted with metropolitan patients, stratified by predicted mortality risk



Total no. patients	15 001	1428	1976	4182	513	627	1904	222	250	1016	108	153	1890	148	205
Transferred (%)		58.4	80.0		27.5	48.8		29.3	33.2		15.7	28.1		30.4	42.2
Angiography (%)	59.6	22.2	46.2	32.2	9.8	25.8	16.1	8.6	14.4	13.7	1.9	9.8	17.6	3.4	15.6

3 Rates of transfer among rural patients with a final diagnosis of myocardial infarction between 1 Jul 2001 and 30 Jun 2010,* with and without availability of the Integrated Cardiovascular Clinical Network (ICCNet), stratified by weighted Charlson Index



* Numbers on columns are total no. of patients. $P < 0.001$ for all comparisons between ICCNet available and ICCNet not available. ◆

(metropolitan, 4.78 days [IQR, 3.10–7.78 days] v after ICCNet, 4.63 days [IQR, 2.03–7.92 days] v before ICCNet, 5.08 [IQR, 2.69–7.93 days]; $P = 0.001$).

Increased transfer rates were paralleled by increased rates of invasive management. Nevertheless, the proportion of patients receiving angiography was lower for patients presenting to rural hospitals compared with metropolitan hospitals during the entire analysis period (rural, 1551/5630 [27.55%] v metropolitan, 11 019/23 993 [45.93%]; $P < 0.001$) This difference diminished over the 9 years (Appendix 4; online at mja.com.au). After adjusting for comorbidities and year of presentation, treatment at a hospital where the ICCNet was available was associated with a higher relative rate of angiography (relative $risk_{risk\text{-}adj}$ 1.30 [95% CI, 1.08–1.55]; $P = 0.004$). Mortality among rural patients treated at a hospital where the ICCNet was available was also lower compared with before the network was implemented, after accounting for angiography ($OR_{risk\text{-}adj}$ 0.82 [95% CI, 0.67–0.97]; $P = 0.012$). Mortality rates among rural patients receiving angiography were comparable to patients presenting to metropolitan hospitals (metropolitan, 457/11 019 [4.15%] v rural, 46/1551 [2.97%]; $OR_{risk\text{-}adj}$ 0.73 [95% CI, 0.52–1.02]; $P = 0.062$).

Comorbid risk

Increasing comorbidities, as measured by the Charlson index, were associated with a lower likelihood of transfer among rural patients, with an OR for transfer of 0.73 (95% CI, 0.70–0.77; $P < 0.001$) for each additional point of the Charlson index. Presentation to a hospital where the ICCNet was available was associated with a 2.2-fold increase in the likelihood of transfer to a metropolitan hospital across all degrees of comorbid risk (OR, 2.23 [95% CI, 1.99–2.49]; $P < 0.001$) with an associated reduction in mortality among those with increased comorbidities (Box 3).

Discussion

There are ongoing challenges in delivering modern, evidence-based care to patients with MI in remote regions serviced almost exclusively by primary care physicians without ready access to immediate expert clinical advice and technologies for invasive management. Consequently, disparity between MI mortality rates for rural patients and others remains.[12-14] Our temporal analysis shows a reduction in acute mortality associated with a networked approach to MI care that facilitated early cardiac specialist opinion and refined risk stratification through point-of-care testing of whole-blood troponin, enabling the early application of evidence-based therapies and coordinated transfer of high-risk patients to tertiary referral centres for early invasive management and revascularisation as needed. In demonstrating a population-wide reduction in acute mortality, this analysis shows the effectiveness of a management paradigm that supported clinical decision making in primary care and improved the availability of cardiovascular technologies among rural patients. Such observations may have relevance for other regions where an expansive geographical area compromises the delivery of evidence-based therapies, and may also have resonance in the developing world where limitations in cardiac specialist capacity will necessitate more streamlined approaches to the management of cardiac emergencies.

Substantial debate has focused on regional reperfusion services for ST-segment elevation MI, arguing for timely, coordinated transfer of patients to high-volume centres for primary percutaneous coronary intervention (PCI) or facilitated PCI.[7,15-17] Such debates are of limited relevance in populations where distances to PCI centres exceed 250 km, and for the larger proportion of patients with MI who present without ST-elevation. Remote support for risk stratification in primary care within the context of substantial geographical distances and limited local facilities may well provide greater mortality reductions than many emerging therapeutic innovations currently undergoing intense research, and achieve this with lower costs.[18]

Key to a networked program is an integrated intervention.[8] Although remote approaches have shown efficacy in the management of chronic heart conditions, merging decision making with technology-dependent care remains challenging.[19] Timely clinical expertise was combined with enhanced local risk assessment, standardised clinical protocols, and central commitment to the urgent transfer of higher risk patients in this intervention. This integrated approach more closely replicates care in metropolitan centres and led not only to a reduction in mortality, but also to a decrease in the overall length of stay for rural patients, suggesting efficiency gains combined with outcome benefits. These data help quantify the benefits associated with such an intervention and inform health policy "value" choices for these rural settings.[20]

However, the interpretation of this study should consider the non-randomised nature of the intervention. While we cannot exclude a temporal improvement in outcomes among rural patients with MI, as seen among the metropolitan population, these benefits were temporally associated with an increase in invasive management and alternative explanations for the improvement in rural MI outcomes would also need to account for the disproportionately greater benefit among rural patients than that seen among patients from metropolitan areas.

This study has potential application for other geographically challenging regions of Australia, and may also provide an approach for developing countries where economic and geographical challenges mean that a greater proportion of acute care falls to primary care services with less access to specialist services. A critical health policy consideration in such environments is how to effectively increase risk stratification and decision-making capacity locally, and to efficiently provide timely access to expensive technologies and therapies. These issues are even more pressing in the developing world, where limitations of clinical specialist expertise are substantial even within more urban centres, and the density of high-end cardiac experts and technologies is lower than observed in the developed world.[8,9] By documenting improved outcomes and reduced disparities in the rural areas of a wealthy, developed country, an integrated cardiac clinical network approach may represent a relevant health-service design consideration in the developing world which needs to meet the looming burden of acute cardiovascular disease foreshadowed by their increasingly urbanising population.

A clinical network with remote specialist-supported risk stratification and decision making in primary care, standardised management protocols including early thrombolysis and increased access to early invasive management is associated with an improvement in hospital mortality for acute MI presentations and was able to reduce the gap in mortality between rural and metropolitan patients.

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