ST-Elevation Acute Myocardial Infarction in Australia—Temporal Trends in Patient Management and Outcomes 1999–2016

Bernadette Aliprandi-Costa, PhD [a*], Lucy Morgan, BMed, PhD [b],
Lan-Chi Snell, BBus, Grad Cert Res Meth [c], Mario D Souza, PhD [d],
Leonard Kritharides, MBBS, PhD [e], John French, MBBS, PhD [f],
David Brieger, MBBS, MMed [e],
Isuru Ranasinghe, MBChB, MMed (Clin Epi) [g]

[a]The University of Sydney, Faculty of Medicine, Sydney, NSW, Australia
[b]The University of Sydney, Concord Clinical School, Sydney, NSW, Australia
[c]UTS Business School, Sydney, NSW, Australia
[d]Sydney Local Health District, Sydney, NSW, Australia
[e]Cardiology Department Concord Hospital, Sydney, NSW, Australia
[f]Cardiology Department, Liverpool Hospital, Sydney, NSW, Australia
[g]Discipline of Medicine, University of Adelaide, Queen Elizabeth Hospital, Adelaide, SA, Australia

Background	Increased access to reperfusion for ST elevation myocardial infarction (STEMI) has contributed to reduced mortality internationally. We describe temporal trends in pre-hospital care, in-hospital management and outcomes of the STEMI population in Australia.
Methods	Temporal trends with multiple regression analysis on the management and outcomes of STEMI patients enrolled across 46 Australian hospitals in the Australian cohort of the Global Registry of Acute Coronary Events (GRACE) and the Cooperative National Registry of Acute Coronary Care Guideline Adherence and Clinical Events (CONCORDANCE) between February 1999 and August 2016.
Results	4,110 patients were treated for STEMI, mean age 62.5 ± 13.7 years (SD). The median door-to-balloon time of primary percutaneous coronary intervention (PPCI) decreased by 11 minutes ($p < 0.01$) although there was no increase in rates of PPCI ($p = 0.35$). Access to non-primary PCI increased by 39% ($p < 0.01$), provisioning of fibrinolysis decreased by 13% ($p < 0.01$) and the median door-to-needle time of 35 minutes remained unchanged ($p = 0.09$). Prescription of medical therapies in-hospital remained high, and at discharge there was an increase in prescription of statins ($p < 0.01$); aspirin including antiplatelets ($p < 0.01$), beta blockers ($p = 0.023$) and ACE/ARB ($p = 0.02$). The occurrence of any in-hospital adverse clinical events declined by 78% ($p < 0.01$) albeit, there was no reduction in mortality in-hospital ($p = 0.84$) or within 6 months ($p = 0.81$).
Conclusions	Over time, there has been increased access to non-primary PCI; shorter door-to-balloon times for PPCI; less adverse events in-hospital and fewer readmissions for unplanned revascularisation without the realisation of reduced mortality in-hospital or at 6 months.
Trial registration	CONCORDANCE Registry ACTRN: 12614000887673.
Keywords	Acute coronary syndromes • ST-elevation myocardial infarction • Quality outcomes • Clinical registry

*Corresponding author at: Faculty of Medicine, Edward Ford Building (A27), Fisher Road, University of Sydney, NSW 2006, Australia., Email: bernadette.aliprandicosta@sydney.edu.au

Introduction

In 2009, we published the first bi-national report on temporal trends in the management of patients admitted to hospital with an acute coronary syndrome (ACS) across 11 Australian and New Zealand Hospitals [1], and provided evidence of adherence with evidence-based care and improved in-hospital survival and survival at 6 months. Decreasing mortality rates from acute myocardial infarction (MI) have been attributed to earlier acute treatment and improved medical management locally and internationally [2–4], and the benefits of both early reperfusion for ST elevation myocardial infarction (STEMI) through pre-hospital triage [5] and the benefits of revascularisation for non ST elevation acute coronary syndrome (NSTEACS) [6] have also been realised. There is also an appreciation that both patient risk [7] and access to clinical services such as a percutaneous coronary intervention (PCI) capable hospitals impacts long-term survival [8–11].

The Australian cohort of The Global Registry of Acute Coronary Events (GRACE) and, subsequently, the Cooperative National Registry of Acute Coronary Care Guideline Adherence and Clinical Events (CONCORDANCE) are observational registries [12,13] developed within a clinical quality framework. Collectively, the GRACE and CONCORDANCE registries present the most extensive data on outcome measures of patients admitted to hospital with STEMI in Australia. These data include process and outcomes measures that are reproducible and build on current knowledge on the management and outcomes of patients admitted to hospital with an ACS. The Australian arm of the GRACE registry reported outcome data on more than 5,600 patients recruited from nine Australian hospitals between 1999 and 2007. The CONCORDANCE registry was launched in 2009 in 10 hospitals and expanded over time so that by 2016, the management and outcomes of more than 9,500 patients have been reported across 41 Australian hospitals.

In this merging of the GRACE and CONCORDANCE Registry cohorts we provide a maturity exemplar of the STEMI population for the purpose of informing health policy and health service provision for this population in Australia. The aim of this analysis is to describe temporal trends on the characteristics of the STEMI population, their pre-hospital and in-hospital management, clinical events and mortality in-hospital and at 6 months following the index event.

Methods

Study Design

The designs of the GRACE [14] and CONCORDANCE [15] registries have been reported previously. Both GRACE and CONCORDANCE are prospective, observational registries reporting on the medical management, clinical events and 6 months outcomes of the first 10 consecutively admitted ACS patients per month. CONCORDANCE was designed within a comparative effectiveness research framework (CER) to facilitate web-based real-time reporting of clinical process indicators (CPIs) to participating clinicians for quality review and process improvement. In order to ensure data were similar across the two datasets, standardised data definitions and data collection methods were applied. Trained hospital staff abstracted data, and the data captured were audited to ensure accuracy and consistency with the registry protocols. All participating hospitals received human research ethics approval to participate in both registries (Tables 1 and 2).

Inclusion and Exclusion Criteria

Patients were enrolled into both registries based on symptoms of an ACS and one or more of either ST segment electrocardiographic (ECG) changes of >0.5 mm, and/or elevation of cardiac biomarkers, new or previous documentation of heart disease. Additionally, patients were enrolled into CONCORDANCE based on symptoms of ACS and/or two high risk features of ACS including; haemodynamic compromise (BP < 90 mmHg and HR >100 bpm), left ventricular systolic dysfunction (LVEF < 40%), presence of known diabetes and/or documentation of chronic kidney disease (estimated GFR <60 mls/min). Patients admitted to hospital with a co-existent condition such as trauma or bleeding or those patients hospitalised for less than 24 hours were excluded from both registries with the exception of those patients who died within 24 hours of admission and death was attributed to an ACS. Patients with a non-ACS diagnosis and hospitals with fewer than 10 patients' data were excluded from the analysis [9,15].

Patient consent was required for participation in the GRACE registry with a waiver of consent applied to patients who had died in-hospital a result of an ACS. To ensure consecutive participant recruitment, an opt-out consent process was approved for participation in the CONCORDANCE Registry.

Table 1   GRACE registry hospitals in Australia and New Zealand.

Concord Hospital (NSW)	Dandenong Hospital (Vic)
Canterbury Hospital (NSW)	Liverpool Hospital (NSW)
Royal Prince Alfred Hospital (NSW)	Bankstown Hospital (NSW)
Bathurst Hospital (NSW)	Christchurch Hospital (NZ)
Coffs Harbour Hospital (NSW)	Waikato Hospital (NZ)
Royal Melbourne (Vic)	

Table 2   CONCORDANCE registry hospitals in Australia.

Alfred Health (Vic)	Concord Hospital[*]	Maitland Hospital	Royal Darwin Hospital
Alice Springs Hospital	Dubbo Hospital	Monash Heart	Royal Hobart Hospital
Austin Hospital	Flinders Medical Centre	Nambour General Hospital	Royal Perth Hospital
Bairnsdale Regional	Geelong Hospital	Nepean Hospital	Royal Prince Alfred[*]
Bankstown Hospital[*]	Gold Coast Hospital	Northern Hospital	Sir Charles Gairdner Hospital
Bathurst Hospital[*]	John Hunter Hospital	Nowra Base Hospital	St Vincent's Hospital (Victoria)
Box Hill Hospital	Launceston General	Orange Base Hospital	The Queen Elizabeth Hospital
Campbelltown Hospital	Lismore Base Hospital	Port Macquarie Hospital	Toowoomba Hospital
Canberra Hospital	Liverpool Hospital[*]	Prince Charles Hospital	Townsville Hospital
Coffs Harbour Hospital[*]	Lyell McEwin Hospital	Royal Brisbane Hospital	Westmead Hospital
			Wollongong Hospital

[*]Hospitals that had also participated in the GRACE registry.

Analysis

This analysis was limited to patients with a discharge diagnosis of STEMI. Patient demographic and clinical characteristics and in-hospital management including time from symptom onset to presentation were stratified by year of enrolment and the merged registry datasets were divided into six time periods. Categorical data are presented using frequency and percentage. The Cochrane Armitage test was performed to assess trend across time and Rao-Scott Chi-square test was used to account for clustering within hospitals. Numeric data are presented using summary statistics, differences in means were tested using a general linear mixed modelling that accounted for clustering within hospitals and difference in medians were tested using the non-parametric Kruskal-Wallis test. Multiple Logistic Regression analysis determined the association between admission time period and outcomes including in-hospital mortality, (re)MI, heart failure, and mortality to 6 months and unscheduled readmission within 6 months after adjustment for admission characteristics including age, previous history of exertional angina, coronary intervention, coronary artery bypass grafts (CABG), stroke, peripheral arterial disease (PAD) and smoking. All statistical analyses were conducted using SAS version 9.4 SAS Institute Inc. Cary, NC, USA.

Results

This analysis includes 4,110 STEMI patients enrolled into either the GRACE (n = 1,279) or CONCORDANCE (n = 2,832) registries between February 1999 and August 2016 across 46 Australian hospitals. Data are complete for 96% of data items in both datasets relating to pre-hospital and in-hospital and outcomes.

Characteristics of the Study Population

Patient characteristics by year group are presented in Table 3. Throughout this period 3,062 males and 1,048 females were treated for STEMI (p < 0.01). There was an overall decrease of 2 years in the mean age of the STEMI cohort from 64.5 years in 1999–2002 to 62.5 years in 2015 (p < 0.01). On admission to hospital, these patients reported less history of heart failure (p < 0.01), exertional angina (p < 0.01), peripheral arterial disease (p < 0.01) and stroke and/or episodes of transient ischaemia (p < 0.01). There was no change in the rates of smoking (p = 0.12) and these patients were more likely to have undergone prior revascularisation with percutaneous coronary intervention (PCI) (p < 0.01) or coronary artery bypass graft surgery (p < 0.01). Temporal changes in presenting clinical characteristics included reduced systolic blood pressure on presentation (p < 0.01), a lower GRACE Risk Score (p < 0.01), lower serum creatinine concentration (p = 0.03) and a lower mean total cholesterol (p < 0.01). There were also decreasing rates of heart failure at presentation (p < 0.01).

Pre-Hospital Treatment

Pre-hospital strategies inclusive of timing of first medical contact, pre-hospital ECG and the receipt of pre-hospital fibrinolysis were captured from 2009 in the CONCORDANCE Registry only. From 2009 to 2016 there was a trending reduction in the time from symptom onset to first medical contact either by ambulance or patient arrival to hospital from a median time of 1.48 to 1.21 hours (p = 0.09). There was no change in the proportion of patients presenting by ambulance (1,619/4,111; 61%; p = 0.97) or performance of pre-hospital ECG (875/1,619; 57%; p = 0.41), and there was no change in the provision of pre-hospital fibrinolysis overtime (p = 0.26) (Table 4).

In-Hospital Management

Medical Management

The use of aspirin or coplavix remained static over the study period so that 96% of STEMI patients received either of these therapies in-hospital (p = 0.98) (Figure 1). Rates of prescription of aspirin including antiplatelets with either clopidogrel,

Table 3 Patient Characteristics.

	1999-2002 n (%)	2003-2005 n (%)	2006-2008 n (%)	2009-2011 n (%)	2012-2014 n (%)	2015-2016 n (%)	Overall n (%)	P value
Female	186 (31)	106 (25)	58 (23)	159 (24)	407 (25)	132 (25)	1048 (25)	0.0611
Male	415 (69)	323 (75)	191 (77)	506 (76)	1231 (75)	396 (75)	3062 (75)	.
Age (years) Mean (SD)	64.5(13.3)	63.7(13.5)	62.5 (13.3)	61.2 (13.6)	62.4 (13.4)	62.5 (15.4)	62.6 (13.7)	0.0013
Past Medical History								
Previous Myocardial Infarction (MI)	100 (17)	71 (17)	43 (17)	104 (16)	241 (15)	66 (13)	625 (15)	0.2558
Heart Failure	40 (7)	26 (6)	17 (7)	30 (5)	47 (3)	7 (1)	167 (4)	<0.0001
Exertional Angina	208 (35)	76 (18)	49 (20)	63 (9)	158 (10)	32 (6)	586 (14)	<0.0001
Positive Stress Test	22 (4)	9 (2)	6 (2)	13 (2)	26 (2)	8 (2)	84 (2)	0.0207
Coronary Intervention	30 (5)	31 (7)	16 (6)	59 (9)	175 (11)	59 (11)	370 (9)	0.0006
Coronary Arterial Bypass Graft (CABG)	30 (5)	15 (4)	17 (7)	24 (4)	47 (3)	12 (2)	145 (4)	0.0064
Hypertension	311 (52)	199 (47)	131 (53)	321 (49)	842 (51)	257 (49)	2061 (50)	0.6225
Dyslipidaemia	266 (44)	174 (41)	118 (47)	299 (46)	692 (42)	223 (42)	1772 (43)	0.6408
Diabetes	138 (23)	95 (22)	54 (22)	141 (21)	329 (20)	110 (21)	867 (21)	0.7791
Chronic Renal Failure	26 (4)	28 (7)	11 (4)	27 (4)	82 (5)	15 (3)	189 (5)	0.2869
Stroke or Transient Ischaemic Attack (TIA)	54 (9)	30 (7)	13 (5)	27 (4)	90 (5)	17 (3)	231 (6)	0.0017
Peripheral Arterial Disease (PAD)	41 (7)	24 (6)	15 (6)	19 (3)	76 (5)	11 (2)	186 (5)	0.0077
Current smoker	198 (34)	147 (35)	84 (34)	285 (44)	627 (38)	203 (39)	1544 (38)	0.1276
Clinical characteristics at hospital admission								
Heart rate Mean (SD)	80.6 (22.9)	79.9 (22.3)	80.3 (23.3)	80.8 (21.2)	78.4 (20.2)	77.0 (18.4)	79.2 (21)	0.0104
Systolic Blood Pressure (mmHg) Mean (SD)	140.1 (28.2)	139.4 (29.2)	142.5 (30.2)	136.9(29.1)	136.0 (28.1)	137.7 (27.7)	137.7 (28.5)	0.0041
Diastolic Blood Pressure (mmHg)Mean (SD)	81.7 (17.8)	80.6(18.5)	82.8(19.1)	83.3(18.4)	81.1(18)	81.8(17.2)	81.7 (18.1)	0.2396
Killip Class I	451 (76)	346 (84)	201 (82)	577 (87)	1470 (90)	495 (94)	3540 (87)	<0.0001
Creatinine Mean (SD)	99.8 (37.5)	97.3 (44.2)	100.9 (37.9)	94.6 (54.9)	94.8 (53.6)	90.8 (45.2)	95.6 (49)	0.0307
GRACE Risk Score (Mean)	112.6 (33.7)	110.4 (32.3)	108.3(32.8)	113.4(32.6)	115.5 (31.8)	115.6 (26.2)	113.6 (32.3)	0.0091

Table 4 Pre-hospital investigations and treatment.

	2009-2011	2012-2014	2015-2016	Overall	P value
Symptom onset to first medical contact[*] (hours)	1.48	1.28	1.21	1.33	0.0949
	2009-2011 n (%)	2012-2014 n (%)	2015-2016 n (%)	Overall n (%)	p Value
STEMI patients presenting by ambulance	384 (62)	939 (61)	296 (61)	1,619 (61)	0.9685
STEMI presenting by ambulance who have a pre hospital ECG	235 (64)	481 (54)	159 (56)	875 (57)	0.4068
STEMI patients who present by ambulance who have pre-hospital fibrinolysis	89 (23)	250 (27)	98 (33)	437 (27)	0.2615

Abbreviation: STEMI, ST elevation myocardial infarction; ECG, electrocardiograph.

[*]Ambulance arrival or hospital arrival.

prasugrel or ticagrelor varied overtime, however in aggregate, 91% of this cohort were prescribed anti-platelets in-hospital (p < 0.01). Overall, 88% of STEMI patients were prescribed statins (p < 0.01) reflecting a 19% increase overtime from 69% in 1999–02 to 93% in 2016. Throughout this period rates of prescription of beta blockers remained unchanged, 85% of patients received a beta blocker in-hospital (p = 0.03) and overtime 78% of patients received other
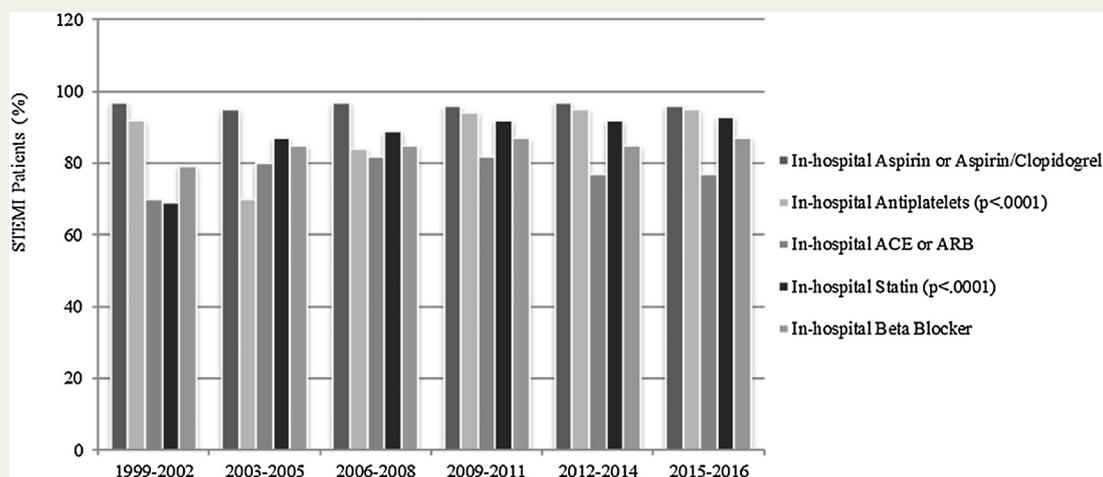
Figure 1 Medical therapies in-hospital.

ACE or ARB (p = 0.27). At hospital discharge aspirin was frequently prescribed so that overall, 95% of STEMI patients were prescribed aspirin or coplavix with no change over time. Eighty-three per cent (83%) of STEMI patients were prescribed a second antiplatelet (either clopidogrel, prasugrel or ticagrelor) at discharge, and, although the rates of prescription fluctuated initially, there was an increase for trend overtime (p < 0.01). There was a 10% increase for trend in the prescription ACE or ARB (p = 0.02); a 19% increase in the prescription of statin therapy (p < 0.01) and a 12% increase in the prescription of beta blockers (p = 0.03) (Figure 2).

Reperfusion

From 1999 there was an increase in the provision of PPCI, so that 65% of STEMI patients (n = 1,663) underwent PPCI throughout the study period (Figure 3). Overall, the median time from door-to-primary PCI fell from 95 to 84 minutes (n = 1,428/4,110; p < 0.01). The median time from door-to-rescue PCI was 7.3 hours with little change over time

(p = 0.06). Coronary angiography rates for the STEMI population increased by 46% (49% to 95%, p < 0.01), and PCI at any time in hospital increased by 55%, (23% to 78%, p < 0.01). For STEMI patients not receiving emergent revascularisation with primary PCI, the median door-to-non-primary PCI was 27 hours with no improvement over time (p = 0.09). The use of fibrinolysis decreased by 13% from 51% (1,999/02) to 38% (2,015/16) (p < 0.01), with the median door-to needle time remaining constant at 35 minutes (p = 0.09). Rates of failure to deliver reperfusion approximated 8% and did not change throughout the period and CABG was performed in less than 5% of STEMI patients (p = 0.10) (Figure 4).

In-Hospital Outcomes

Rates of in-hospital congestive heart failure declined by 16% (p < 0.01) and there were fewer episodes of recurrent ischaemia (p < 0.01). Following adjustment for age, previous history of exertional angina, coronary intervention, coronary artery bypass grafts (CABG), stroke, peripheral arterial disease (PAD) and smoking, the reduction in in-hospital events
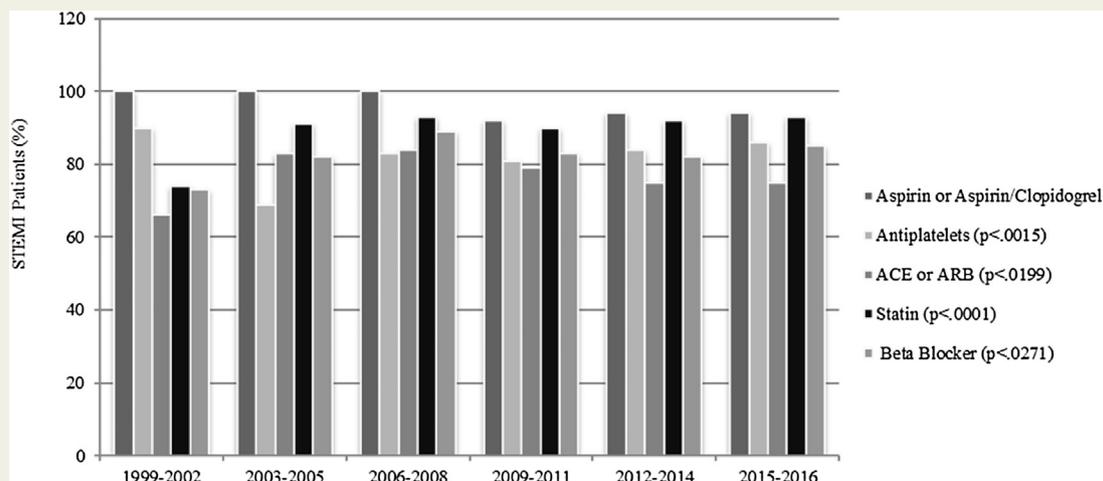

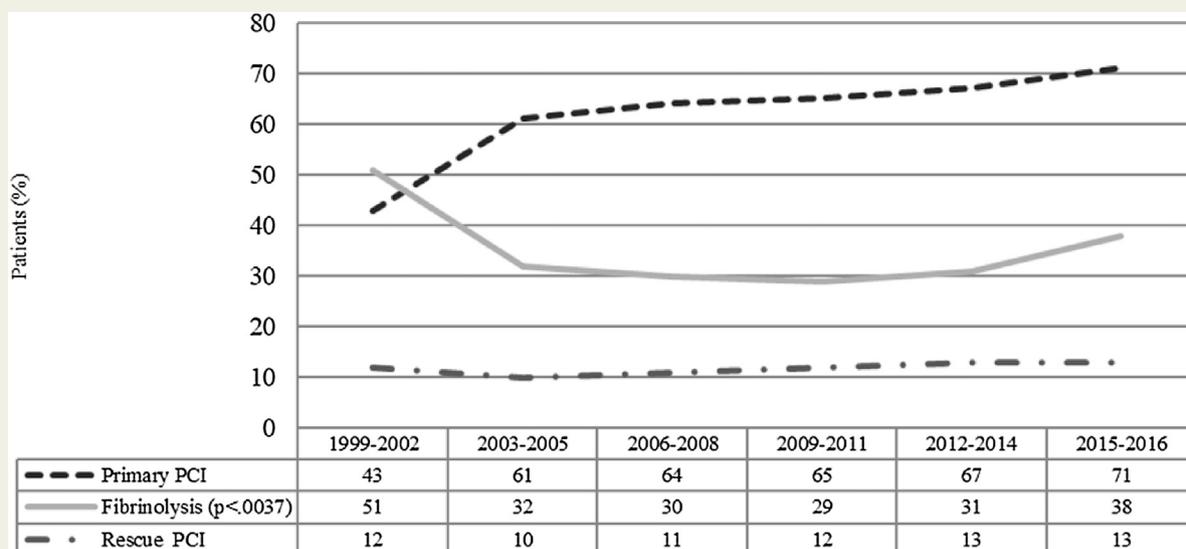**Figure 2** Medical therapies at hospital discharge.

	1999-2002	2003-2005	2006-2008	2009-2011	2012-2014	2015-2016
Primary PCI	43	61	64	65	67	71
Fibrinolysis (p<.0037)	51	32	30	29	31	38
Rescue PCI	12	10	11	12	13	13

Figure 3 Receipt of reperfusion in-hospital.

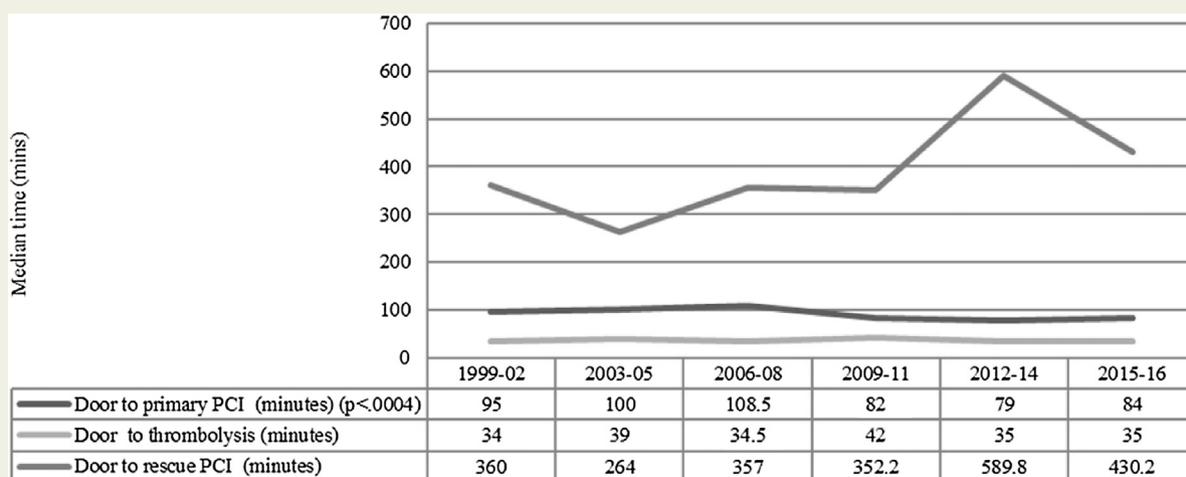|	1999-02	2003-05	2006-08	2009-11	2012-14	2015-16
Door to primary PCI (minutes) (p<.0004)	95	100	108.5	82	79	84
Door to thrombolysis (minutes)	34	39	34.5	42	35	35
Door to rescue PCI (minutes)	360	264	357	352.2	589.8	430.2

Figure 4 Median time to reperfusion.

persisted so that patients admitted early in the study period were 3.66-fold more likely to experience heart failure and more than 10 times more likely to experience recurrent ischaemia than those admitted during the latter years of the study. Death in-hospital was 6% overall, with no difference observed overtime either before (p = 0.84) or after (p = 0.55) adjustment (Table 5; Appendix).

Outcomes at 6 Months

Consistent with the unadjusted results, mortality at 6 months did not change over time after adjusting for covariates inclusive of age, previous history of exertional angina, coronary intervention, coronary artery bypass grafts (CABG), stroke, PAD and a past history of smoking. Follow-up data are complete for 93% of patient reported outcomes in the GRACE Registry and 65% of the cohort in the CONCORDANCE Registry. Of these, 97% were alive

following treatment for the index event (p = 0.81). There was no change in mortality during the time period either before (p = 0.81) or after (p = 0.74) adjustment. However, readmission for unplanned revascularisation fell significantly during the study period (p < 0.01), a difference that persisted following adjustment for differences in baseline characteristics (Table 3; Appendix).

Discussion

In this analysis of patients presenting with STEMI across 46 Australian hospitals over a 17-year period, we found some gains in pre-hospital care and an overall increase in access to PCI although PPCI rates were not significantly different despite achieving shorter door-to-balloon times. Over time, there was a reduction in the occurrence of in-hospital clinical events, and

Table 5   In-hospital outcomes and outcomes at 6 months.

	1999-02 n (%)	2003-05 n (%)	2006-08 n (%)	2009-11 n (%)	2012-14 n (%)	2015-16 n (%)	Overall n (%)	P value
Congestive cardiac failure	133 (22)	76 (18)	34 (14)	101 (15)	148 (9)	33 (6)	525 (13)	<0.0001
Recurrent ischaemia	267 (45)	185 (44)	98 (40)	68 (10)	109 (7)	22 (4)	749 (18)	<0.0001
In-hospital adverse event[*]	359 (60)	238 (56)	125 (51)	228 (35)	443 (27)	108 (21)	1,501 (39)	<0.0001
In-hospital death	37 (6)	32 (7)	12 (5)	51 (8)	104 (6)	24 (5)	260 (6)	0.84
Death at 6 months follow-up	65 (5)	20 (3)	16 (4)	50 (4)	133 (5)	20 (3)	304 (4)	0.87
Readmission for unplanned CABG or PCI at 6 months	47 (9)	21 (6)	6 (4)	14 (3)	26 (2)	4 (2)	118 (4)	<0.0001

Abbreviations: CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention.

[*]Inclusive: Myocardial infarction (MI) or re-MI, congestive cardiac failure, cardiogenic shock, recurrent ischaemia and stroke.

readmission for urgent revascularisation without the realisation of a reduction in in-hospital or 6-month mortality.

There was a declining trend, although non-significant, in the time taken for this population to make initial contact with medical care following symptom onset, which may have contributed to the falling incidence of congestive cardiac failure on presentation, and possibly the lower incidence of in-hospital adverse clinical events. Overall rates of access to PPCI did not change, although an 11-minute improvement in door-to-balloon time was achieved for those who underwent emergent revascularisation with PPCI. There was a fall in the provision of fibrinolysis, and no change in the timely delivery of this therapy during the 17-year period of this study.

Over time, STEMI patients were more likely to be younger males with fewer comorbid medical conditions and were increasingly more likely to have undergone a previous PCI. The patient demographics reported here are consistent with previous studies reporting STEMI patients are younger with a current history of smoking [16,17]. These studies suggest improved survival may be in line with improved pre-hospital primary prevention strategies including better management of hypercholesterolaemia, hypertension and diabetes [17]. In this analysis, the prescription of medical therapies with anti-platelets and statins increased significantly and there were more modest increases in the prescription of aspirin, ACE/ARB and beta blockers.

Other cohort studies suggest the ability to demonstrate the association between risk-adjusted short-term survival benefit in patients receiving PPCI has become increasingly difficult to achieve at a population level [18]. However, when these data are calculated at the patient level, improved time to reperfusion therapy resulted in a reduction in in-hospital mortality [19] and an overall survival benefit. The authors attributed this finding to reduced ischaemia time quantified by shorter door-to-balloon times [20].

The observation of no temporal change in mortality in this analysis may be influenced by the fact that approximately 35% of patients exceeded the 90-minute threshold for realisation of a mortality benefit with primary PCI. Thus, despite expanded access to non-primary PCI and improved use of medical therapy, a large proportion of STEMI patients did not undergo PPCI fast enough to benefit from the mortality gain associated with this procedure. Bearing in mind the nature of Australia's geography, where approximately 30% of ACS patients live in rural locations, there are limitations in improvements that can be made in the timely provision of primary PCI. So, the imperative becomes one of improving access to reperfusion (either primary PCI or fibrinolysis with timely transfer to a catheterisation laboratory capable hospital) earlier if we are to realise the benefits of these strategies.

An additional explanation for our lack of mortality benefit may be explained by a survivor cohort effect that has been described as a consequence of improving systems of care being offered to our STEMI population [21,22]. That is, we are now treating patients such as late presenters who, in the earlier years, may have died outside of hospital and therefore were not been included in the registry. These patients still have an increased mortality relative to the overall cohort and thus may mask the benefits of shorter door to balloon times.

Finally, these data augment our understanding on the management and outcomes of people admitted to hospital with STEMI. Assigning the likely contribution of differences in patient characteristics and substantial changes in treatment overtime highlight the benefit of CER initiatives such as clinical quality registries to provide a continuous data source on adherence with evidence based processes of care and measure clinical effectiveness. The data reported here were collected and reported systematically to facilitate comparisons for benchmarking clinical practice thereby enabling clinicians and health administrators to monitor and report on practice patterns and patient outcomes. Clinical registries in the Australian health care system should be engineered to realise their potential to contribute to health service delivery evaluation and inform health policy development.

Limitations

This analysis reports observed and risk adjusted outcomes from two prospective observational registries and although

data capture for in-hospital management are complete, follow-up data were complete for 65% of patients enrolled in the CONCORDANCE Registry. Although there was no pattern in the manner of missing data at follow-up in the CONCORDANCE registry. The diminished follow-up rates in the CONCORDANCE registry could represent a potential bias and other potential factors such as changing temporal prevalence of unmeasured confounders may have influenced our findings. Additionally, although there was the application of the consent waiver in the GRACE Registry and the early adoption of the opt-out consent in the CONCORDANCE Registry, it is not inconceivable that selection bias may have impacted our ability to demonstrate a difference in mortality in-hospital and during the follow-up period because of failure to include the sickest of the cohort.

Conclusion

Describing the management and outcomes of STEMI patients in Australia over a 17-year period has not been undertaken previously. International studies have demonstrated the benefits of improved access to early reperfusion on reduced mortality for STEMI, and in this analysis of the combined Australian GRACE and CONCORDANCE registries we found an encouraging although non-significant reduction in the time taken to access medical care from the time of symptom onset; increased access non-primary PCI, and reduced door-to-balloon times for primary PCI. We found improved adherence to the prescription of evidence based medical therapies in-hospital and at hospital discharge and an overall decrease in in-hospital clinical events, and reduced readmission for urgent revascularisation. Yet despite these gains, we found no increase in access to reperfusion with PPCI or thrombolysis and no reduction in in-hospital mortality or mortality at 6 months. Ongoing data capture and reporting would facilitate continuous monitoring of systems of care to inform future health policy development in this high risk population.

Disclosures

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.hlc.2018.05.191.

References

[1] Aliprandi-Costa B, Ranasinghe I, Chow V, Kapila S, Juergens C, Devlin G, et al. Management and outcomes of patients with acute coronary syndromes in Australia and New Zealand, 2000-2007. Med J Aust 2011;195:116–21.

[2] Smolina K, Wright FL, Rayner M, Goldacre M. Determinants of the decline in mortality from acute myocardial infarction in England between 2002 and 2010: linked national database study. Br Med J 2012;344:d8059.

[3] Krumholz HM, Bradley EH, Nallamothu BK, Ting H, Batchelor WB, Kline-Rogers E, Stern AF, Byrd JR, Brush Jr JE. A campaign to improve the timeliness of primary percutaneous coronary intervention: Door-to-Balloon: An Alliance for Quality Journal of the American College of Cardiology. Cardiovasc Interv 2008;1:97–104.

[4] Herrett E, Smeeth L, Walker L, Weston C. The Myocardial Ischaemia National Audit Project (MINAP). Heart 2010;96:1264–7.

[5] Hutchison AW, Malaiapan Y, Jarvie I, Barger B, Watkins E, Braitberg G, et al. Prehospital 12-lead ECG to triage ST-elevation myocardial infarction and emergency department activation of the infarct team significantly improves door-to-balloon times: ambulance Victoria and Monash Heart Acute Myocardial Infarction (MonAMI) 12-lead ECG project. Circ Cardiovasc Interv 2009;2:528–34.

[6] Van de Werf F, Bax J, Betriu A, Blomstrom-Lundqvist C, Crea F, Falk V, et al. Management of acute myocardial infarction in patients presenting with persistent ST-segment elevation: the Task Force on the management of ST-segment elevation acute myocardial infarction of the European Society of Cardiology. Eur Heart J 2008;29:2909–45.

[7] Simms AD, Reynolds S, Pieper K, Baxter PD, Cattle BA, Batin PD, et al. Evaluation of the NICE mini-GRACE risk scores for acute myocardial infarction using the Myocardial Ischaemia National Audit Project (MINAP) 2003-2009: National Institute for Cardiovascular Outcomes Research (NICOR). Heart 2013;99:35–40.

[8] Gale CP, Allan V, Cattle BA, Hall AS, West RM, Timmis A, et al. Trends in hospital treatments, including revascularisation, following acute myocardial infarction, 2003-2010: a multilevel and relative survival analysis for the National Institute for Cardiovascular Outcomes Research (NICOR). Heart 2014;100:582–9.

[9] Aliprandi-Costa B, Sockler J, Kritharides L, Morgan L, Snell L, Gullick J, Brieger D, Ranasinghe I. The contribution of the composite of clinical process indicators as a measure of hospital performance in the management of acute coronary syndromes—insights from the CONCORDANCE registry. Eur Heart J Qual Care Clin Outcomes 2016;3:37–46.

[10] Chew DP, Amerena JV, Coverdale SG, Rankin JM, Astley CM, Soman A, et al. Invasive management and late clinical outcomes in contemporary Australian management of acute coronary syndromes: observations from the ACACIA registry. Med J Aust 2008;188:691–7.

[11] Chew DP, French J, Briffa TG, Hammett CJ, Ellis CJ, Ranasinghe I, et al. Acute coronary syndrome care across Australia and New Zealand: the SNAPSHOT ACS study. Med J Aust 2013;199:185–91.

[12] Ray WA. Evaluating medication effects outside of clinical trials: new-user designs. Am J Epidemiol 2003;158:915–20.

[13] Myers WO, Blackstone EH, Davis K, Foster ED, Kaiser GC. CASS registry long term surgical survival. Coron Artery Surg Study JACC 1999;33:488–98.

[14] GRACE Investigators. Rationale and design of the GRACE (Global Registry of Acute Coronary Events) Project: a multinational registry of patients hospitalized with acute coronary syndromes. Am Heart J 2001;141:190–9.

[15] Aliprandi-Costa B, Ranasinghe I, Turnbull F, Brown A, Kritharides L, Patel A, et al. The design and rationale of the Australian Cooperative National Registry of Acute Coronary care, Guideline Adherence and Clinical Events (CONCORDANCE). Heart Lung Circ 2013;22:533–41.

[16] Jernberg T, Johanson P, Held C, Svennblad B, Lindback J, Wallentin L, et al. Association between adoption of evidence-based treatment and survival for patients with ST-elevation myocardial infarction. JAMA 2011;305:1677–84.

[17] Schiele F, Hochadel M, Tubaro M, Meneveau N, Wojakowski W, Gierlotka M, et al. Reperfusion strategy in Europe: temporal trends in performance measures for reperfusion therapy in ST-elevation myocardial infarction. Eur Heart J 2010;31:2614–24.

[18] Menees DS, Peterson ED, Wang Y, Curtis JP, Messenger JC, Rumsfeld JS, et al. Door-to-balloon time and mortality among patients undergoing primary PCI. N Engl J Med 2013;369:901–9.

[19] Nallamothu BK, Normand SL, Wang Y, Hofer TP, Brush Jr JE, Messenger JC, et al. Relation between door-to-balloon times and mortality after primary percutaneous coronary intervention over time: a retrospective study. Lancet 2015;385:1114–22.

[20] Dasari TW, Hamilton S, Chen AY, Wang TY, Peterson ED, de Lemos JA, et al. Non-eligibility for reperfusion therapy in patients presenting with ST-segment elevation myocardial infarction: contemporary insights from the National Cardiovascular Data Registry (NCDR). Am Heart J 2016;172:1–8.

[21] Terkelsen CJ, Sorensen JT, Maeng M, Jensen LO, Tilsted HH, Trautner S, et al. System delay and mortality among patients with STEMI treated with primary percutaneous coronary intervention. JAMA 2010;304:763–71.

[22] Hutchison AW, Malaiapan Y, Cameron JD, Meredith IT. Pre-hospital 12 lead ECG to triage ST elevation myocardial infarction and long term improvements in door to balloon times: the first 1000 patients from the MonAMI project. Heart Lung Circ 2013;22:910–6.