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Medical Practice Variations in Acute Myocardial Infarction

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Abstract

The incidence of and mortality from acute myocardial infarction (AMI) have declined over the past decade likely due to improvements in acute reperfusion management and preventative treatments. However, recent evidence still demonstrates significant interhospital, interregional, and interjurisdictional variations in AMI care and outcomes suggesting that service availability, practice patterns, and/or therapeutic effectiveness across populations may vary. The primary objective of this chapter is to examine temporal and regional variations in AMI health-care delivery and outcomes. A secondary objective of this chapter is to examine the extent to which such variations in AMI outcomes are attributable to variations in health-care delivery. This chapter is subdivided into prehospitalization, acute management and stabilization, the use of coronary procedures, and discharge planning, transitional care, and follow-up. The final sections of this chapter will explore the relationship between variations in care delivery and outcomes and will conclude by providing suggested future direction for health services and outcomes research in AMI.

Introduction

Acute myocardial infarction not only remains a leading cause of death and hospital admission (Tu et al. *2009a*) currently in North America but also is projected to be the most common cause of death worldwide by 2020 (Lopez and Murray *1998*). Over the past decade, the incidence of and mortality from AMI have declined (Tu et al. *2009a*; Krumholtz et al. *2009*) likely owing to improvements in acute reperfusion management and preventative treatments (Velagaleti et al. *2008*). With the advancing ages of populations combined with increasing chronic diseases such as type II diabetes, the case mix and complexity of patients presenting with AMI will also likely change over time (Roger et al. *2011*). Accordingly, future trends in AMI outcomes may not necessarily mirror those observed most recently. Moreover, available evidence still demonstrates significant interhospital, interregional, and interjurisdictional variations in AMI care and outcomes, suggesting that service availability, practice patterns, and/or therapeutic effectiveness across populations may vary.

Over the past decade, studies have explored the interrelationship between the availability of specialized cardiovascular services, quality of care, and outcomes. For example, do regions or hospitals that have greater availability of specialized cardiovascular services and/or utilize more evidence-based therapies have better AMI outcomes than those with fewer services and/or those with poorer delivery of evidence-based care? As will be discussed in this chapter, AMI outcome variations are unlikely explained by one singular factor, but rather a complex myriad of patient-level, physician-level, hospital-level, and community-level characteristics. It is also challenging to demarcate where along the AMI care pathway outcome variations are attributable, since clinical care is a continuum that begins prior to and extends beyond the hospitalization itself. While the majority of AMI outcome studies have focused on the examination of health-care delivery provided during the episode of hospitalization, emerging evidence suggests that fragmentation and coordination of care during times of posthospitalization transitions may be important determinants of AMI outcomes as ambulatory patients convalesce and rehabilitate within their communities.

The continuum of AMI care pathways applies not only to the location of care delivery but also applies to the bio-pathophysiologic spectrum of a patient′s disease. Whereas 20 years ago, AMI used to be distinguished from unstable angina, today both are categorized as acute coronary syndromes given that both share the similar pathophysiology of plaque rupture. The recognition of plaque rupture and thrombosis as a central mechanism of both AMI and unstable angina has resulted in a transformative change and evolution of management. Patients who present with ST segment elevation myocardial infarctions (STEMI) on presenting ECG are channeled down one care pathway which includes acute reperfusion therapy, whereas patients without ST segment elevation are channeled down an alternate care pathway regardless of whether or not they have a non-ST segment elevation myocardial infarction (herein, termed NSTEMI) or unstable angina. The distinction between NSTEMI and unstable angina relates to the presence or absence of myocardial necrosis as detected by elevated serum cardiac enzyme biomarkers. While the risk severity of patients with NSTEMI is usually greater than those with unstable angina, exceptions do occur that necessitate more aggressive acute coronary syndrome management in the absence of myocardial infarction. An appreciation of this change in clinical nomenclature toward acute coronary syndrome is important for three reasons. First, the management principles that underlie the treatment of AMI and unstable angina now overlap; a resource that historically may have been allocated to AMI is now shared. This may have important health service resource allocation implications, particularly in regions where access to cardiovascular services is constrained. Second, the risk severities of the patients who are hospitalized with acute coronary syndromes will vary. Accordingly, risk stratification takes on greater importance and necessity so that those patients who are at highest risk of death or reinfarction are managed most aggressively and expeditiously. Third, as new, emerging and more sensitive cardiac enzyme biomarkers emerge, patients who would have historically been classified as unstable angina could theoretically in the future be classified as AMI. Accordingly the epidemiology of AMI will evolve with newer more sensitive biomarkers (Chan and Ng *2010*). For the purposes of this chapter, AMI will be the focus. However, management principals, variations, and outcomes apply to all acute coronary syndrome presentations inclusive of unstable angina.

The primary objective of this chapter is to examine temporal and regional variations in AMI health-care delivery and outcomes. A secondary objective of this chapter is to examine the extent to which such variations in AMI outcomes are attributable to variations in health-care delivery. This chapter attempts to examine AMI variations in care within the context of emerging clinical evidence and cardiovascular resource availability issues, which are two determinants of local practice patterns. The AMI care pathway is conceptualized as a patient journey that begins with symptom recognition prior to hospital arrival and extends beyond hospitalization, as patients transition back into the community. This conceptualization was done in an attempt to underscore the interrelationship between patient factors, provider factors, and system factors to interpret AMI practice variations and their complex associations with outcomes.

To enhance the conceptualization of AMI care, this chapter is subdivided into prehospitalization, acute management and stabilization, the use of coronary procedures, and discharge planning, transitional care, and follow-up. These subcategories are not mutually exclusive as AMI survival is dependent on interventions throughout a patient's journey through the health-care system both in and out of hospital. The final sections of this chapter will explore the relationship between variations in care delivery and outcomes and will conclude by providing suggested future directions for health services and outcomes research in AMI.

Prehospital Care

Prehospital care, for the purpose of this discussion, includes care provided by emergency medical personnel in the community and by health-care professionals in the emergency department of a hospital. Improvements in out-of-hospital cardiac arrest survival (Tu et al. *2009a*), diagnostic sensitivity (Albert et al. *2000*), and acute reperfusion methods (Ontario Health Technology Advisory Committee) (Cardiac Care Network *2010*) contribute to the downward trend in the prevalence of AMI mortality.

The majority of AMI deaths reported in North America occur out of hospital (Roger et al. *2011*). However, the number of out-of-hospital deaths attributed to a cardiac event is decreasing (Tu et al. *2009a*). A study of out-of -hospital cardiac arrest (OHCA) across ten regions in North America found that treatment provided by emergency medical personnel was contributed to a survival rate of 6–16 % compared to a survival rate of less than 5 % in cases where there were no EMS interventions (Nichol et al. *2008*). Variations in EMS-attended OHCA survival were attributed to CAD severity, transportation times, and treatment interventions upon arrival to hospital (Nichol et al. *2008*).

Recent studies show that the proportion of people getting to the hospital within the optimal time of ≤6 h from the time of symptom onset has improved (Roe et al. *2010*). In a study using data from two large-scale, national registry programs in the United States, an increase in the timeliness of patient presentation within 6 h after symptom onset was observed for both STEMI [69.7 % (2005) to 78.2 % (2009)] and NSTEMI [30 % (2005) to 38.4 % (2009)] patients (Roe et al. *2010*). Limited awareness of cardiac event warning signs and symptoms contributes to patient delays in receiving treatment. Awareness of cardiac event warning signs and symptoms has shown variation across regions ranging from 16 % in Washington, D.C., to highest rates of awareness found in West Virginia (36 %) with educational achievement and socioeconomic status appearing to be distinguishing characteristics across the regions (Centers for Disease Control and Prevention *2008*). Psychosocial (e.g., social support or marital status) and demographic factors have been found to influence the amount of time elapsed before a patient presents to hospital with AMI with married, male patients more likely to present to hospital within 6 h of experiencing chest pain as compared with single male or single (or even married) females (Atzema et al. *2011*). A study by Jackevicius and colleagues (*2006*), using data from national and provincial registries, observed that over 80 % of patients presented to hospital within 12 h of symptom onset; however women (83 %) were more likely than men (88 %) to delay presentation to hospital with older women, greater than 75 years of age, having the lowest rate (75 %) of presentation after symptom onset.

Acute Management and Acute Stabilization

Methods available to diagnose AMI have been expanded and taken up in the past decade. The analysis of over 40 years of physician data shows that AMI rates diagnosed by ECG declined by approximately 50 %, while the rate of AMI diagnosis using biomarkers increased twofold (Roger et al. 2011). A change in the biomarker of choice in 2000 from creatine-kinase MB (CKMB) to the more sensitive and specific cardiac troponins resulted in a more accurate diagnosis of AMI (Albert et al. 2000). Diagnostic sensitivity has contributed to AMI survival as a result of early detection and accurate diagnosis increasing the likelihood of a patient receiving the most appropriate treatment, thereby reducing the mortality rate associated with a cardiac event. That said, the initial management of acute coronary syndromes, and particularly STEMI, is based on symptoms and ECG criteria rather than cardiac enzyme elevations, given the time delay between coronary occlusion and enzymatic evidence of myocardial necrosis. Accordingly, early acute stabilization and management relies upon appropriate triage mechanisms to prioritize and tend to patients who are suspected clinically of having AMI.

Available evidence has shown that the appropriate assignment of acuity scores to AMI patients when presenting to the emergency room department was associated with lower rates of readmissions or death (Stukel et al. 2010). This study was conducted in Ontario, Canada, where a common triage tool is used by all emergency departments (ED) to assign an acuity score to all patients upon emergency room arrival. The assignment of an appropriate score is important as it guides decisions about key investigations such as electrocardiograms and treatments such as aspirin and reperfusion therapy (Beveridge et al. 1999). Stukel and colleagues (2010) determined twofold variations in the assignment of high acuity ED scores for AMI patients (43–88 %) across hospitals in Ontario, with acuity scores positively correlating with the intensity of downstream coronary interventions within 30 days of AMI presentation, suggesting that initial ED triage and the assignment of acuity may be an important determinant of the care pathways that occur thereafter.

The administration of aspirin immediately upon the recognition of signs and symptoms of an AMI has long been shown to reduce 1-month AMI mortality and reinfarction (Antiplatelet Trialists' Collaboration 1994). For STEMI, early evidence demonstrated that aspirin alone had relative risk reductions for AMI mortality similar to older-generation fibrinolytic agents (e.g., Streptokinase) and that the two treatments combined had additive mortality effects (Second International Study of Infarct Survival Collaborative Group 1988). The early administration of B-blockers has also been shown to improve outcomes among STEMI patients (Roberts et al. 1991). Available evidence suggests that older well-established therapies, such as the early administration of aspirin and B-blockers, are well utilized among AMI patients across hospitals and jurisdictions. For example, in some jurisdictions, the rate of the use of aspirin has approached or surpassed 80 % among patients without contraindications to therapy (George et al. 2012). Nonetheless, hospital and regional variations in the use of these established agents still exist (Ko et al. 2007).

Patients with ECG evidence of STEMI are eligible for acute reperfusion therapy with thrombolysis or percutaneous coronary intervention (PCI). The goal of reperfusion therapy is to restore normal blood flow in the infarct-related artery as quickly as possible. Reperfusion therapy has represented a major advancement in the treatment of acute STEMI, with fibrinolysis (clot busters) associated with a 30 % reduction in 30-day mortality (Fibrinolytic Therapy Trialists' Collaborative Group 1994). However, the mortality benefits associated with fibrinolytic therapy diminish exponentially as the time between symptom onset and the administration of therapy progresses. Available evidence suggests negligible or no survival benefits associated with fibrinolytic therapy beyond 12 h following symptom onset (Boersma et al. *1996*; Weaver et al. *1993*). Accordingly, the effectiveness associated with fibrinolytic therapy is heavily dependent upon appropriate symptom recognition, expeditious hospital arrival, and efficient ED triage, STEMI detection, and management processes. The time between hospital arrival and fibrinolytic administration (i.e., "door-to-needle times") continues to be one of the most important performance benchmarks for acute STEMI management (Tu et al. *2008*). Significant interhospital variations in door-to-needle times exist, which is likely attributable to differences in the effectiveness of ED triage and management processes.

Primary PCI (received ≤90 min after symptom onset) has been identified as a more effective reperfusion method than fibrinolytic therapy to reduce mortality and readmission among STEMI patients (Cardiac Care Network *2010*; Nunn et al. *1999*). However, unlike fibrinolytic therapy, which is available at virtually all acute hospitals, primary PCI is only available at selected centers. For example, in Ontario, Canada, fewer than 20 of the approximately 150 acute care hospitals have on-site PCI capabilities. Accordingly, rapid coordinated processes are required to both appropriately diagnose and transport the STEMI patient to hospitals with on-site PCI facilities capable of providing 24/7 primary PCI. In Ontario, for example, during the beginning half of last decade, fewer than 2 % of patients received primary PCI (Tu et al. *1997*). With the implantation of provincial coordinated rapid transport STEMI strategies, an annual change of up to 16 % of STEMI patients in Ontario received primary PCI as their reperfusion modality during the latter half of the decade (Ko et al. *2010*). In other jurisdictions, the rates of primary PCI are even higher. For example, for patients registered in the United States National Cardiovascular Data Registry, the utilization rates of PCI use over fibrinolytics have increased over time with an increase in the use of PCI [75.3 % (2007) to 83 % (2009)] and a corresponding decrease in fibrinolytics [17.3 %(2007) to 12.5 % (2009)] (Roe et al. *2010*). Nonetheless, the utilization of primary PCI for STEMI remains variable and dependent on the availability of on-site PCI facilities and organizational processes for rapid STEMI response and transport (Labinaz et al. *2006*). In those more "geographically removed" regions with limited access to primary PCI (e.g., rural communities), the utilization rates of primary PCI remain low throughout North America (Patel et al. *2010*; Nallamothu et al. *2006*). A recent review of cardiovascular care in the United States found that less than two-thirds of STEMI patients received revascularization with residents of rural areas having lower rates of access compared to urban area residents. Despite the fact that the expansion of evidence-based, high-value revascularization techniques, including primary PCI, had include 6–8 % more hospitals in the United States since 1996, a recent review of service utilization shows that the majority of expansions occurred in urban areas and specifically in areas where access was already high and that the population increase in geographic access to primary PCI was only 5 % (Horwitz et al. *2013*). Investigators concluded that despite the expansion of cardiac services, there was very little effect on reducing variations in access to care between urban and rural residents. For patients who did receive primary PCI, the door-to-balloon time consistently improved from 2005 to 2009. However, despite a significant improvement in door-to-balloon time with up to 83 % of patients in 2009 being treated with primary PCI in 90 min or less, there is no significant change in in-hospital mortality or 30-day mortality (Menees et al. *2013*). Such results indicate that such metrics as door-to-balloon time may no longer be an appropriate measure of quality care associated with primary PCI.

Patients who initially receive fibrinolytic therapy but who do not successfully achieve reperfusion are candidates for rescue PCI (Wijeysundera et al. *2007*). This has created added complexity to care strategies particularly in rural communities where PCI services are unavailable and geographically removed. First, the evaluation of whether or not a patient has successfully perfused with fibrinolytic therapy is sometimes challenging clinically and may require time to appropriately assess. Second, arranging transfer to facilitate a rescue PCI only after unsuccessful reperfusion results in additional time delays, decreasing the effectiveness of any subsequent PCI to the infarct-related artery (Goodman and Cantor 2009; Leira et al. 2008; Sutton et al. 2004).

Current guidelines for the acute management and stabilization of patients with NSTEMI continue to recommend the administration of aspirin immediately after symptom onset with continued use as long as tolerated; immediate catheterization and invasive interventions do not offer any incremental benefits (Jneid et al. 2012).

Evidence emerging over the last decade has expanded the role of antiplatelets, demonstrating that the combination of aspirin and clopidogrel has incremental outcome benefits (Hirsh and Bhatt 2004; Yusuf et al. 2001). The emergence of clinical trial evidence that have demonstrated incremental effectiveness of newer antiplatelets, such as glycoprotein IIb/GPIIIa inhibitors, low molecular weight heparins (LMWH), and newer anticoagulants over the past decade, has necessitated modifications to consensus guidelines for in-hospital AMI management (Jneid et al. 2012). Such rapidly evolving evidence has had variable dissemination and penetration into clinical care, resulting in heterogeneity in the uptake and utilization of such medical therapies (Ko et al. 2007).

The Use of Invasive Cardiac Procedures Following AMI

This section draws a distinction between primary PCI for STEMI discussed above and the use of invasive cardiac procedures for the remainder of AMI population (NSTEMI and STEMI beyond 24 h). The last decade has also witnessed a rapid growth in the use of cardiac procedures (coronary angiography and PCI) during (or soon following) AMI hospitalization worldwide (Burwen et al. 2003; Fuster and Kelly 2010). Even within a 2-year period of time, a significant increase in the use of cardiac procedures was observed across the United States between 2007 and 2009 with catheterization within 48 h of admission for STEMI [82.4 % (2007) to 90.9 % (2009)] and NSTEMI [59.3 % (2007) to 62.5 % (2009)] patients (Roe et al. 2010).

Trends in methods used to treat NSTEMI during the acute phase are a direct result of the development and clinical application of novel drugs along with the availability of more effective technology (e.g., stents) (Shehzad and Willerson 2010). Prior to 1990 evidence did not support early invasive strategies. Indeed, throughout the 1990s, the risk stratification of patients to determine eligibility and need for coronary angiography post-MI was routinely done several weeks following hospitalizations and incorporated noninvasive stress nuclear imaging (Kulick and Rahimtoola 1991). Those patients who were deemed to be at high risk as a result of post-AMI risk stratification were then referred to coronary angiography.

During the 1990s, access to coronary angiography was variable with significant interregional differences in cardiac catheterization laboratory capacity worldwide (Hippisley-Cox and Pringle 2000; Pilote et al. 1995). Despite clinical guidelines that advocated for risk stratification processes, access to on-site cardiac catheterization facilities at the time was shown to be one of the most important determinants of use for coronary angiography and revascularization procedures post-AMI (Pilote et al. 1995; Wharton 2005).

Throughout the past decade, there has been a rapid proliferation in the availability of cardiac catheterization facilities throughout North America, which corresponded to a rapid increase in the use of coronary interventions following AMI (Alter et al. 2006). In Ontario, the mean utilization rate for coronary angiography within 30 days of AMI was 25 % back in 1995 (Khaykin et al. 2002); by 2004, this rate had more than doubled.

Available evidence has demonstrated that access to coronary angiography serves as a key determinant of subsequent utilization of revascularization. Once coronary angiography is undertaken, there are fewer variations in the use of PCI or bypass surgery (Jones et al. *2011*). Indeed, the relative proliferation of PCI post-AMI has correlated with the proliferation of coronary angiography. For example, in the United States, available evidence has demonstrated that 30-day revascularization rates post-AMI increased from 41 to 50 % over a 10-year period in the United States (Yeh et al. *2010*). In other studies from other US jurisdictions, the utilization rate for revascularization within 30 days post-AMI has approached 70 % in 2008. However, variations in rates of PCI and CABG vary as noted by a study of utilization rates in Canada (Pilote et al. *2004*).

However, unlike PCI, the use of coronary artery bypass surgery post-AMI has not seen dramatic growth over the past several years (Hassan et al. *2010*). Indeed, rates for CABG have stabilized as a result of a shift toward the use of PCI as the preferred intervention to treat AMI (Hassan et al. *2010*) and the associated high rate of successful reperfusion of up to 95 % (Keeley et al. *2003*). Despite the overall increasing trend in the use of PCI, available evidence has demonstrated significant variation in the proportion of PCI:CABG. Tu and colleagues (*2010*) observed a threefold variation in the PCI:CABG ratio in Ontario, Canada.

Is the Growth of Post-AMI Coronary Angiography and PCI Driven by Evidence or by Improved Service Availability?

The answer lies probably in both explanations. More recent clinical evidence has since demonstrated outcome advantages associated with routine early invasive strategies for medium- to high-risk patients after AMI (Jneid et al. *2012*). Moreover, research conducted in Canada, where access to coronary procedures has been historically constrained, has demonstrated improvements in AMI mortality that are correlated with, and likely attributable partially to, the increased use of coronary interventions post-AMI (Alter et al. *2001*; Wijeysundera et al. *2010*). The shift in revascularization modality from bypass surgery to PCI also in part reflects clinical trial and/or clinical guideline recommendations. North American and European guidelines for non-STEMI recommend the use of PCI in the acute phase, reserving the use of CABG, when necessary and appropriate, for a time when the patient is more stable or when PCI has failed or is contraindicated. Available evidence suggests that for most patient subgroups (with the exception of those who have left main disease, multivessel disease in LV dysfunction, or multivessel disease in patients with diabetes), survival outcomes are similar between the two (Hlatky et al. *2009*). Given the less intensive infrastructure requirements, decreased recovery times, shorter lengths of stay, and a disproportionate increase in the number of cardiologists performing PCI relative to the number of surgeons who perform bypass surgery, the shift toward PCI relative to bypass surgery is understandable and likely justified.

Nonetheless, the utilization of coronary angiography and PCI is still likely driven by variations in hospital access to on-site cardiac catheterization and PCI facilities, irrespective of clinical evidence (Yeh et al. *2010*). For example, as demonstrated in Fig. 1 below, wide variations in revascularization post-AMI still exist, suggesting the presence of unexplained factors driving utilization beyond evidence. Patients admitted to hospitals with on-site catheterization laboratory capacity or those admitted to hospitals in close geographical proximity to on-site cardiac catheterization facilities will be more likely to receive coronary angiography and PCI during the index AMI hospitalization than those patients admitted to hospitals without on-site procedural cardiac catheterization capacity (Alter et al. 2003). Moreover, the proliferation in capacity and corresponding increase in post-AMI coronary angiography preceded any supportive clinical trial evidence (Singh et al. 2007). On-site procedural capacity has also been shown to be a determinant of post-AMI revascularization wait times and revascularization modality. For example, available evidence from Ontario has demonstrated that post-AMI patients admitted to hospitals with on-site revascularization procedures were more likely to undergo earlier revascularization with PCI, whereas those admitted to hospitals without on-site procedural capacity were more likely to undergo later revascularization with bypass surgery (Alter et al. 2003). Finally, many studies have demonstrated that patients with advancing age, those who are socioeconomically disadvantaged, and those with high comorbidity continue to receive fewer coronary angiography and PCI procedures than their younger, more affluent, and healthier counterparts. Such patient-level determinants of cardiac procedural use after AMI, particularly among those residing in countries with universal health care, suggest inherent referral biases which preferentially favor the selection of patients with fewer competing non-cardiovascular comorbidities.

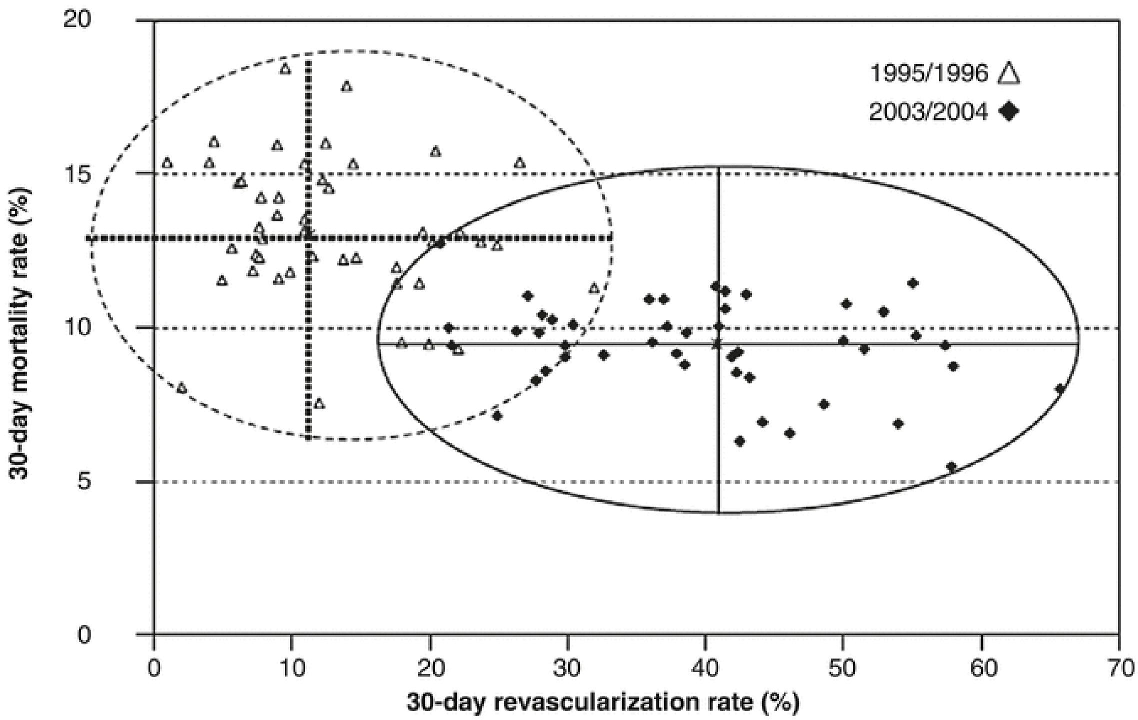

Fig. 1

Thirty-day revascularization and 30-day mortality rates of acute myocardial infarction patients. Thirty-day revascularization and 30-day mortality rates of acute myocardial infarction patients, health regions with at least 100,000 population, seven provinces (NS, NB, QC, ON, Man, Sask, AB), 1995/1996 and 2003/2004 (Stats Canada 2009)

Discharge Planning, Transitional Care, and Follow-Up

Discharge planning and the transition from hospital to community settings represent several challenges given the discontinuity of care between the two settings. Physicians managing patients in the community may or may not be the same providers managing patients in hospitals. The extent and effectiveness of communicating and managing “hand off” between hospitals and communities remains unclear. Patients are also left to self-monitor and self-manage their recovery. Accordingly, symptom recognition, health-seeking behaviors, medication self-management, and self-care become key factors in the posthospitalization convalescence and recovery after AMI. While there are established post-AMI evidence-based pharmacotherapies, which have significant proven survival benefits, suboptimal adherence to these therapies continues to undermine their effectiveness in the real world (Rasmussen et al. 2007).

Available evidence has demonstrated that the utilization of post-AMI evidence-based pharmacotherapies, such as aspirin, beta-blockers, ACE inhibitors, and statins, is increasing over time (Jackevicius et al. 2009; Kildemoes et al. 2008), with rates that are approaching population targets among patients without contraindications (Neugaard et al. 2003; Tu et al. 2008). However, regional variations still exist throughout North America (Krumholz et al. 2003) with care gaps to these established evidence-based pharmacotherapies observed particularly in rural regions or among those patients discharged from small-volume hospitals (Baldwin et al. 2010). In contrast, utilization rates of evidence-based therapies at AMI discharge remain higher among those patients admitted to teaching hospitals, large-volume hospitals, and/or cardiology attending physicians (Alter et al. 2001; Fox et al. 2002; Stukel et al. 2012; Tu et al. 2001). Patient factors have also been shown to influence the physician prescribing patterns of evidence-based therapies at discharge. For example, the elderly, women, the socioeconomically disadvantaged, and those with greatest comorbidities have been shown to be associated with lower utilization rates of evidence-based therapies at discharge (Lee et al. 2008; Pilote et al. 2006). The reason for these hospital-level, physician-level, and patient-level variations in the use of evidence-based therapies following AMI is unclear, but underscores continued opportunities for quality improvement.

In contrast to evidence-based pharmacotherapies, the state of evidence for non-pharmacological processes of care post-AMI is less established. AMI patients potentially have contact with numerous providers beyond their primary care most responsible physicians. One may reasonably hypothesize that the organization flow, accountability, coordination, and communication between various physicians following AMI hospitalization would be an important determinant of AMI care and outcomes. As with other chronic diseases (e.g., heart failure), one may logically assume that post-AMI patients may benefit from a shared care model approach to follow-up (Lee et al. 2008), especially among those with multiple complex chronic diseases. However, few studies have begun to evaluate and disentangle the care pathways associated with AMI patients who are discharged from hospitals into ambulatory care. In sum, the implementation of a comprehensive chronic disease management care pathway during transitions following AMI hospitalization has, in large part, been poorly described and evaluated. Cardiac rehabilitation (CR), however, serves as an exception.

Cardiac rehabilitation provides a model of comprehensive care for a cardiac patient that is designed to improve functional capacity through exercise and to employ other aspects related to lifestyle modification and pharmacological management through multidisciplinary care. Patients enrolled in CR receive a medical assessment, guided and graded programs for physical exercise, patient and family education, and strategies to self-manage CVD risk factors (Stone et al. 2009). Available evidence suggests that participation in CR, after treatment for AMI, reduces mortality by as much as 25 % (Stone et al. 2009; Taylor et al. 2004). Despite available evidence showing the benefits of cardiac rehabilitation in reducing readmission to hospital and AMI mortality, cardiac rehabilitation is underused in North America with enrollment rates as low as 13.1 % reported (Suaya et al. 2007) with lower participation rates for women (55 % less than men to participate) and the elderly (only 32 % of men and women ≥70 years of age participated) (Witt et al. 2004). Overall rates for enrollment in CR for eligible patients vary within and across regions with rates ranging from 19 % in the United States (Suaya et al 2007), 29 % in the United Kingdom (Bethell et al. 2007), and 34 % in Canada (Candido et al. 2011). Within Canada, rates vary with New Brunswick reporting a rate of 19 % (Cardiac Rehab New Brunswick 2008) and Ontario reporting a utilization rate of 22 % (Swabey et al. 2004). All of these utilization rates are far below national targets set as high as 85 % enrollment in CR (Bethell et al. 2007). Although patient adherence following through with referrals to CR contributes to enrollment rates, lack of referrals made by any source is the primary factor driving low enrollment rates (Grace et al. 2002; Pasquali et al. 2008). Referrals to CR originate from a physician's office, inpatient units, or outpatient clinics; however available evidence suggests that referrals originating from an inpatient unit result in less time between hospitalization and enrollment in CR (Grace et al. 2007).

Notwithstanding cardiac rehabilitation care gaps, and the limited understanding of care processes during transitional periods following AMI hospitalization, available evidence has demonstrated that risk factor management and control among patients with known cardiovascular disease has improved and has contributed to reduced hospital readmission rates and mortality after AMI. Improvements in modifiable lifestyle and dietary risk factors and improvements in the uptake of evidence-based, medical treatments accounted for 48 % and 43 %, respectively, of the reduction in mortality associated with coronary heart disease that included AMI (Wijeysundera et al. 2010). Changes in lifestyle and dietary intake between 1994 and 2005 resulted in reduced cholesterol levels and systolic blood pressure of Ontarians accounted for 23 % and 20 %, respectively, of the reduction in CHD mortality. The same study demonstrated that while primary angioplasty was attributed to have prevented or delayed 105 deaths in 2005, the uptake of secondary prevention in the form of statin therapy proved to be the most influential contributing to the prevention or delay or 320 AMI deaths in 2005 compared to AMI deaths in 1994 (Wijeysundera et al. 2010). Reductions in smoking and physical inactivity rates contributed to a reduction in CHD mortality but to a lesser extent than lifestyle and dietary improvements.

Nonetheless, significant gaps remain in secondary prevention ambulatory care management after AMI. For example, a recent study from the United States demonstrated that the prevalence rate for smoking cessation among CVD patients was only 37 %, while only 68 % of individuals being treated for hypertension actually achieved blood pressure targets. Similar care gaps were also shown for cholesterol management (Roger et al. 2011).

In summary, there is accumulating evidence that intensive secondary prevention and lifestyle management following AMI impact on survival. However, the implementation and uptake of comprehensive programs, such as cardiac rehabilitation, remains suboptimal and underscores a need for innovative health policy solutions to bridge the process gap between established evidence and the provision of care. Future health services and outcomes research must evaluate processes and models of care within communities to better understand the complex transitional periods following AMI hospital discharge, during times that patients remain vulnerable and high risk for mortality and reinfarction.

The Relationship Between Interregional and Interhospital Variations in Care and Outcomes

Available evidence has demonstrated wide interregional and interhospital variations in access to, spending of, and quality in cardiovascular care worldwide (Fisher et al. 2003a, b). Consequently, some regions and hospitals have greater availability of cardiovascular specialized services and greater uptake in higher-quality care than others. The rapidly increasing health-care spending and continuing disparity in the quality of care have led to the exploration of whether spending more on AMI care results in better outcomes in terms of quality, survival, and patient satisfaction?

Over the past decade, several studies have evaluated the relationship of resource availability of specialized cardiovascular services and AMI outcomes (Stukel et al. 2012). Studies have yielded inconsistent results. A review of Medicare spending for patients with myocardial infarction in the United States demonstrated that high per capita Medicare spending translated into higher rates of specialized cardiac service use, but poorer preventative therapies, poorer utilization rates of traditional quality indicators (e.g., B-blockers), and higher mortality rates as compared with regions in the United States that had more conservative patterns of Medicare spending (Fisher et al. *2003a*, *b*). This landmark "is more better?" study suggested that more cardiovascular specialized services did not necessarily translate into "better" care, but, instead, resulted in "inefficiencies" and/or "inappropriate" overutilization of specialized cardiovascular services, and did so at a cost both in terms of higher medical spending and higher mortality. For example, a study of patterns of hospital performance in AMI 30-day mortality showed varied risk-standardized mortality rates among hospitals in the United States (Krumholtz et al. *2009*).

Another study of over 40,000 Medicare fee-for-service beneficiaries hospitalized with AMI between 1998 and 2001 has shown that although higher-risk patients and those with more appropriate indicators for invasive procedures may have the most benefits, higher invasive health regions did not differentiate procedure selection based on appropriateness (Ko et al. *2008*). Such results support health-care policy reform initiatives that advocate for greater accountability and models of care that tie spending to performance.

Nonetheless, the US results may not necessarily be generalizable to all regions. A recent study in Canada demonstrated contrasting results. Stukel and colleagues (*2012*) undertook a follow-up evaluation in Ontario, Canada, and employed similar methodologies to that incorporated in the United States, but focused the evaluation on hospital rather than regional spending among a number of disease-specific cohorts. The study demonstrated that for AMI patients, higher spending hospitals yielded higher cardiovascular specialized service use, higher use of evidence-based therapies, and lower mortality and readmission rates than lower spending hospitals (Stukel et al. *2012*). While the process-outcome causal pathways that explained the better outcomes with higher spending were not elucidated in the study, the authors hypothesized that higher hospital spending may have not only improved the underutilization of specialized cardiovascular technology utilization which was historically lower than those observed in other jurisdictions (including the United States) but may have induced a number of indirect "ripple" effects in care, as a result of higher nursing-patient staff ratios, better discharge planning, and post-discharge transitional care (Stukel et al. *2012*). In short, for some regions, higher spending may be associated with improved outcomes, while in other regions, higher spending may be associated with poorer outcomes. The inconsistencies may relate to differences in local practice patterns and variations in access to cardiovascular services, which for some may be inappropriately too low, while for others may be inappropriately too high.

Over the last decade, many have advocated for a more targeted approach to improving quality and outcomes of care following AMI, through initiatives which may include incentivized pay for performance and hospital public reporting of performance indicators. The American Heart Association released a health policy statement about standards for measures used for publicly reporting health-care efficiency (Krumholz et al. *2008*). The statement described four domains of attributes to be considered for publicly reported efficiency measures which included integration of the quality and cost, valid cost measurement and analysis, minimal incentive to provide poor quality care, and proper attribution of the measure (Krumholz et al. *2008*). These domains are in addition to those recognized by the American Heart Association for the public reporting of outcome measures which include the following: clear and explicit definition of an appropriate patient sample, clinical coherence of the variables used in statistical models, sufficiently high-quality and timely data, designation of an appropriate reference time before which covariates are derived and after which outcomes are measured, use of an appropriate outcome and a standardized period of outcome assessment, application of an analytical approach that accounts for the multilevel structure of data, and disclosure of the methods used to compare outcomes (Krumholz et al. *2006*). Quality of in-hospital care for patients with AMI is determined by how effective hospitals provide eligible patients with the best care based on the available evidence guided by AMI quality care indicators.

A population-based, randomized trial of 86 hospitals in Ontario, Canada, was completed to evaluate whether the public release of data on cardiac quality indicators was effective in stimulating hospitals to change their practice to improve health-care processes and patient outcomes (Tu et al. *2009b*). While the public release of hospital performance through the use of a publicly released report card did not result in an improvement in AMI process-of-care indicators, it was associated with a 2.5 % lower AMI mortality rate (Tu et al. *2009b*). The reduction in AMI mortality was thought to be the result of changes in the utilization rates of specific medical treatments for AMI including ACE inhibitors and beta-blockers that may have improved 30-day mortality rates without impacting process-of-care indicators (Tu et al. *2009b*). This controversial study has generated significant debate regarding the interpretation and the merits of public report cards for AMI quality indicators. Some have suggested that public reporting does not improve quality and that observed improvements in AMI outcomes were a spurious finding. Others argue that outcome improvements from public reporting may have been the result in changes in unobserved or undocumented processes of care, coordination in care, or culture of care and that the absence of any significant changes in the traditional quality indicators may have meant that other important process improvements existed but were not identified or documented in the study.

As with public reporting, studies examining the effects of pay for performance on AMI outcomes have been equally controversial but for other reasons. Namely, programs that reimburse physicians and/or hospitals for appropriately adhering to quality indicators have been shown to yield higher rates of evidence-based therapies and greater adherence rates to specific quality indicators, but no differences in outcomes (Jha et al. *2012*). In sum, these results suggest that improvements in the use of traditional performance evidence-based indicators may not in themselves explain differences in AMI outcomes – perhaps they are just one piece of the puzzle.

Future Directions

Evidence shows that the quality of AMI care has improved over the past two decades; however such improvements have not been realized at a similar rate across regions and countries. Comparing health-care outcomes across hospitals, regions, and countries helps to identify important variations in care quality and care appropriateness. When it comes to making decisions about health service resource expenditures allocated to AMI care, the contrasting evidence between the United States and Canada with regard to spending and outcomes, combined with the lack of a clear relationship between improved quality of care and outcomes, underscores the complexity in the interpretation of AMI care variations. Clearly, a *one-size-fit-all* solution to AMI care does not exist. Neither quality of care nor outcomes are directly attributable to spending, technology use, or even evidence-based medicine in a consistent reproducible manner. Rather it is likely how and where the money is spent and care that is targeted has the greatest impact on practice patterns, practice culture, and outcomes. Disentangling the causal pathways that bridge AMI quality of care with outcomes necessitates better understanding of care delivery, care culture, and care coordination that move beyond hospital boarders and/or beyond the traditional performance indicators examined. Moreover, patient factors, such as self-management and health-seeking behaviors, may ultimately be proven to be a far more important determinant of AMI outcomes than AMI practice variations. Indeed, one may reasonably hypothesize that interactions may exist across system level (e.g., organization of health-care delivery, cardiovascular service availability), physician level (e.g., practice and referral behaviors), and patient level (e.g., self-management, health-seeking behaviors).

Addressing the issue of overuse of resources may require a change in the way health-care systems reward program and services that are based on the amount of care provided and not always on the quality of care. For example, accountability frameworks that pay physicians, hospitals, and facilities more only when they do more contribute to the overuse of discretionary services such as those provided after the acute stabilization and acute management phase of care. Incentive programs designed to provide access to good quality AMI care need to be informed by evidence about access to the right treatment, at the right time, and for the right patient. Increased accountability for quality AMI care requires that patients become better informed about evidence-based medical and technical interventions and the quality of their care providers so as to be in a position to advocate for the best care rather than the most care. This type of information goes beyond that provided in hospital report cards and will require reporting systems that include quality indicators such as in-hospital and out-of-hospital process of care indicators and also performance measures associated with specific care providers.

Access and adherence to medical therapies for risk factor management and secondary prevention requires change to the way in which medical therapies are translated, marketed, and funded. Increased access to evidence-based pharmacologic interventions requires appropriate prescribing and patient-education strategies. Shared decision-making through the use of patient decision aids and well-designed modes of patient information has been shown to improve treatment adherence (Murray et al. *2009*; O'Connor et al. *2003*). Costs associated with prescribed treatments are often cited as reasons patients do not fill prescriptions or do not adhere to the recommended dose of prescribed treatments. Access to affordable medical treatments and the provision of government-supported medical programs that support evidence-based, cardiovascular treatments have the potential to reduce the burden of health-care expenses associated with readmission to hospital (Hanley et al. *2011*; Lu et al. *2011*).

Post-discharge care that is collaborative with a cardiac specialist and the patient's primary care physician appears to correlate with survival (Stukel et al. *2012*) and can be realized in primary care-based models of managed care (Jha et al. *2003*). Risk factor management and secondary prevention are best situated in the primary health-care environment. More patients have access to a primary care physician and a team of primary health-care professionals who are most familiar with a patient's medical profile and involved in all aspects of patient care. Prevention strategies including smoking cessation and weight management have been shown to be effective in the primary health-care setting. Successful management of cardiac risk factors including weight management, smoking cessation, hypertension, and diabetes control not only benefits individual patients but also reduces the utilization of scarce health-care resources such as those required for the acute management and stabilization of AMI.

Greater attentiveness must be given to strategies that address exercise, fitness, and non-sedentary behaviors, which have been shown to improve AMI survival (Stone et al. *2009*; Taylor et al. *2004*). For example, addressing the sizable unmet population needs to evidence-based cardiac rehabilitation programs will require transformative policy and clinical innovation to outreach, fund, allocate, and deliver such models of care to broader populations.

Finally, based on an assumption that the AMI care pathway is a continuum, which begins well prior to and ends well after an AMI hospitalization itself, who is most accountable? The lack of a single accountability framework has created challenges, given that care, funding, and delivery still remain somewhat of a silo. Hospitals may be faced with bed-capacity constraints that encourage lower lengths of stay, leaving some high-risk patients to convalesce in communities without the necessary ambulatory care plans and supports in place. Yet, is it fair for hospitals to be held accountable for care that is received after discharge? Is it fair for physicians to be held accountable for the non-adherent behaviors of their patients? As with many other chronic diseases, the future direction of AMI care must address the issue of accountability, so that funding, care pathways, and outcomes are better aligned.

Conclusion

Health services research has contributed to a better understanding of variations in AMI care and associated outcomes over time and across regions. Evidence-based, quality care at each point of a patient's journey through AMI care contributes to survival. Yet, the net effects of evidence-based care on outcomes at a single point of time (e.g., during the acute stabilization phase of hospitalization) remain less clear. Mortality risk appears to be reduced when the appropriate patient receives the most appropriate treatment, at the most appropriate time, by the most appropriate providers. While it appears that it is the quality of care that contributes to survival and not necessarily the quantity of care, it is likely that the multiplicative and interconnected patient factors, process factors, provider factors, and system factors account for variations in AMI outcomes over time. A multidisciplinary approach, which casts a wide net covering all known and potential determinants of variations in AMI outcomes, is required in order to reduce disparity in AMI care. While trends in AMI incidence and mortality have significantly improved over the past decade, these trends may be short lived. The aging of the population combined with the rising incidence of obesity, diabetes, and the westernization of developing countries will likely hallmark the resurgence of cardiovascular disease within the next two decades. This resurgence may accompany changes to the complexity of AMI management, given the expected coexistence of other chronic diseases. Future research must move beyond the confines of traditional quality indicators and beyond the walls of hospitals in order to better address, evaluate, and respond to changes in the epidemiological profile of cardiovascular disease, so that the continuum of the AMI care pathway remains grounded and informed by best evidence.

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