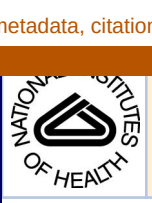

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Trends in Myocardial Infarction Rates and Case Fatality by Anatomical Location In Four US Communities, 1987-2008 (From the Atherosclerosis Risk in Communities [ARIC] Study)

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Abstract

Although the incidence of and mortality following ST-segment elevation myocardial infarction (STEMI) is decreasing, time-trends in anatomical location of STEMI and associated short-term prognosis have not been examined in a population-based community study. We determined 22-year trends in age- and race-adjusted, gender-specific incidence rates and 28-day case fatality of hospitalized STEMI by anatomic infarct location among a stratified random sample of 35-74 year old residents of four communities in the Atherosclerosis Risk in Communities (ARIC) study. STEMI infarct location was assessed by 12-lead electrocardiograms (ECG) from the hospital record, and was coded as anterior, inferior, lateral and multi-location STEMI using the Minnesota Code. Between 1987 and 2008, a total of 4,845 patients had an incident STEMI; 37.2% were inferior STEMI; 32.8% were anterior; 16.8% occurred in multiple infarct locations and 13.2% were lateral STEMI. For inferior, anterior and lateral STEMI in both men and women, significant declines were observed in the age-adjusted annual incidence rate and the associated 28-day case fatality. In contrast, for STEMI in multiple infarct locations, neither the annual incidence rate nor the 28-day case fatality changed over time. The age- and race-adjusted annual incidence rate and associated 28-day case fatality of STEMI in anterior, inferior and lateral infarct locations declined

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over 22 years of surveillance; however, no decline was observed for STEMI in multiple infarct locations. In conclusion, our findings suggest there is room for improvement in the care of patients with multi-location STEMI.

Keywords

ST segment elevation myocardial infarction; Epidemiology; Trends

Introduction

Detailed evaluation of temporal trends in myocardial infarction (MI) rates is essential to monitor the population burden of cardiovascular disease (CVD), and to understand the determinants of coronary heart disease (CHD) mortality over time.[1] During a STEMI, the distribution of ST-elevations on a surface electrocardiogram (ECG) corresponds to anatomic locations of ischemic myocardium [2] and has prognostic importance.[3] Recent studies have demonstrated declines in the incidence,[1,4,5] severity,[6, 7] and mortality after an MI.[1,5] Some STEMI consensus treatment guidelines [7] and clinical practice monographs [8] draw from historic patterns in STEMI infarct location, and suggest that STEMI treatment may differ by infarct location.[9] However, whether patterns of STEMI infarct location by ECG have changed and apply to STEMI in the contemporary era is unknown. We describe herein twenty-two year trends in rates of incident STEMI by ECG infarct location and associated survival in a community setting.

Methods

Since 1987, the Atherosclerosis Risk in Communities (ARIC) study has conducted surveillance of hospitalized MI and deaths due to CHD among residents 35 to 74 years of age in four communities: Forsyth County, North Carolina; Jackson, Mississippi; suburban Minneapolis, Minnesota; and Washington County, Maryland. The combined study population of these four communities was approximately 396,000 persons in 2008. Twenty-four percent of the population in ARIC communities under surveillance were black. Forsyth County, North Carolina and the city of Jackson, Mississippi were 20% and 50% black, respectively, while the remaining two communities in ARIC Community Surveillance are predominantly white.[6] Details of the surveillance methods used have been previously reported and are only briefly described here.[10,11]

A stratified random sample of suspected hospitalized MIs was identified from electronic discharge lists obtained from all hospitals (n=23) serving the four communities.[6] Trained ARIC staff abstracted data from medical records, selected on age, community of residence and discharge code (ICD-9-CM codes 402, 410-414, 427, 428, and 518.4). Detailed descriptions of investigation and validation of selected ICD codes used in ARIC surveillance have been provided elsewhere.[12,6] Sampling probabilities varied by race, sex, field center and discharge code stratum and were adjusted periodically.[13] Medical records were abstracted for presence of chest pain, history of MI or CVD and cardiac biomarkers.[7] Copies of up to three ECGs (first, last and third) were obtained from each hospitalization and sent to the University of Minnesota Electrocardiographic Reading Center for classification by the

Minnesota Code.[14,15] A computerized algorithm was applied to data on chest pain, biomarkers and electrocardiographic findings to classify MI.[10] Criteria for each of these three diagnostic elements in the algorithm remained constant over the study period and have been described in detail.[5] All eligible hospitalized events were classified as definite, probable, suspect or no MI.[10] Definite and probable MI were combined to define MI events for this analysis. Definite and probable MI events with abnormal biomarkers were further classified by Minnesota Code of the ECGs obtained as ST-segment elevation MI (STEMI) or non ST-segment elevation MI (NSTEMI).[14] This analysis was restricted to validated STEMI events without a history of prior MI noted in the medical record.

All ECGs were visually coded using Minnesota code categories of ST-segment elevations into one of four anatomic locations based on conventional anatomic grouping of surface ECG leads: V1-V5; II, III, AVF; or I, AVL, V6. Using these three lead groups, four anatomic locations (anterior, inferior, lateral or multiple) were derived for this study. Anterior STEMI was defined as ST-segment elevation ≥ 2.0mm in any of leads V1-V4 or an ST-segment elevation ≥ 1.0mm in V5; inferior STEMI as ST-segment elevation ≥ 1.0mm in any of leads II, III or aVF; and lateral STEMI as ST-segment elevation ≥ 1.0mm in any of leads I, aVL, and V6 alone or in the presence of anterior ST-segment elevations.[16,6] ST-elevations in the anterior and lateral ECG lead-groups were combined to increase sensitivity to detect lateral STEMI, as ischemia of the lateral wall may be poorly represented by the lateral leads (I, aVL, V6) alone.[17,18] Finally, to represent ischemia in multiple anatomic locations, a multi-location STEMI was defined as ST-segment elevations in 2 or more of anterior, inferior or lateral locations.

Vital status post-hospital discharge was determined through linkage with the National Death Index (NDI). Twenty-eight day case fatality was determined for all incident STEMI cases and, due to limited events by infarct location, we grouped 28-day case-fatality into two time period categories (1987-1996 and 1997- 2007) for comparison. Case fatality results are not reported for 2008 due to a lag in NDI reporting.

All analyses were weighted and standard errors were computed using stratified random sampling methodology to account for the sampling scheme.[5,12,21] Descriptive statistics for baseline characteristics were computed by year group and by STEMI infarct locations. The annual percent changes in event rates were computed across the year groups for each baseline characteristic, and the corresponding standard errors were approximated by the delta method. Wald tests were used to compare baseline characteristics between STEMI locations. Age- and race-adjusted, sex-specific, annual incidence rates per 10,000 persons of STEMI by anatomic location were computed based on population denominator estimates using interpolation and extrapolation of 1990 and 2000 U.S. Census population estimates. Age and race adjustment was by the direct method using the 2000 U.S. population estimates as the standard. Twenty-two year trends in incident STEMI are reported by location and gender based on linear or quadratic Poisson regression models. Quadratic trends are reported only when the quadratic term in the model is significant at the 0.05 level. Pairwise comparisons of the bootstrapped average annual percent change estimated from the location-specific linear regression models were made at the 0.05 level with Bonferroni adjustment for multiple comparisons. Logistic regression was used to model age and race-adjusted 28-day

case fatality percentages as a function of location, time interval (1987-1996 and 1997-2007), and gender. Contrasts were specified to test differences in case fatality between year-groups for each location. The differences of trends in case fatality trends between genders were tested; gender-specific trends were not reported due to insignificant p-values and small numbers of events. Event-rate trends analysis was conducted in the statistical package SUDAAN Loglink and case fatality analyses were conducted in SUDAAN Logistic.

Results

From 1987 through 2008, there were an estimated 4,845 incident hospitalized STEMIs in the four ARIC study communities among residents 35 to 74 years of age. Over the twenty-two year study period, 31.3% of STEMIs occurred in women. There were statistically significant changes in both the characteristics of STEMI patients and the methods used to treat these patients over the study duration (Table 1).

Overall for all years combined, 37.2% of STEMIs were inferior; 32.8% anterior; 16.8% occurred in multiple infarct locations; and 13.2% were lateral. There were differences in age and race by STEMI infarct location (Table 2).

For all STEMI infarct locations combined, from 1987 through 2008 there was an age- and race-adjusted average annual decrease in STEMI incidence rates in both men and women for inferior, anterior and lateral STEMI (Table 3 and Figure 1). The decline was most notable for inferior STEMI in men (Table 3 and Figure 2). In contrast, there was no substantial change in the rates of STEMI in multiple infarct locations for either men or women. A quadratic trend was observed in anterior STEMIs for both genders; trends in the remaining locations and genders were linear with a statistically significant difference between the inferior and multiple location trends in both genders.

Overall, the 28-day age- and gender-adjusted case fatality for STEMI decreased from 8.9% (95% CI 7.5, 10.1) in 1987-1996 to 5.4% (95% CI 4.1, 6.6) in 1997-2007. Changes in age- and gender-adjusted 28-day case fatality from 1987-96 to 1997-2007 differed significantly among STEMI locations (*P* value = 0.041). The decline in age and gender-adjusted 28-day case fatality from 1987-96 to 1997-2007 was statistically significant for anterior, inferior and lateral STEMI (Table 4). In contrast, no significant change in 28-day case fatality for multi-location STEMI was observed.

Discussion

The principle findings of this investigation are that between 1987 and 2008 (1) the rate and 28-day case fatality for inferior, anterior and lateral STEMI declined while (2) the rate and 28-day case fatality for multi-location STEMI did not change. By 2008, multi-location STEMI was the second most common and had the highest 28-day case fatality. The difference in rates and outcomes by anatomic location may relate to the distribution of CAD risk factors in the ARIC study population. Obesity, diabetes and hypertension have remained prevalent in the United States[19,20] and the age at first MI has increased.[21] Older age, diabetes and hypertension are risk factors for multi-vessel CAD,[22,23] and may increase risk for multi-location STEMI.

There are several potential explanations as to why the 28-day case fatality for multi-location STEMI did not improve. First, infarct size is an independent predictor of post-MI prognosis [24] and is likely greater for multi-location versus single anatomic location STEMI. Second, multi-location STEMI has been associated with multi-vessel CAD and poor prognosis after an MI.[25] Third, percutaneous revascularization may be more difficult in patients with multi-vessel CAD and multi-location STEMI.[26] Lastly, incomplete revascularization has been associated with poor post-MI prognosis [27] and may be more common in patients with multi-location STEMI and multi-vessel CAD.

As in other studies,[28] we observed a shift in STEMI revascularization strategies over time from urgent CABG and thrombolytics towards the widespread use of PCI. However, the increase in PCI was not associated with improved 28-day case fatality for multi-location STEMI. This finding may have implications for the revascularization of patients with multi-vessel CAD, including patients with multi-location STEMI. [34]

Strengths of our study include the population-based design; the inclusion of African-Americans from multiple communities in the United States; and the standardized validation of events and ECG coding. To our knowledge, no other study has used surveillance ECG data to detail trends in rates of STEMI by anatomic location.

The main imitation of the current study is the imprecise nature of the surface ECG to localize infarct location.[30] However, the ECG lead-groups used represent large regions of myocardium with prognostic value,[3] and are more accurate than administrative codes of STEMI location.[4] While multi-location STEMI may indicate multi-vessel CAD, multi-location STEMI could arise from proximal CAD or from a coronary artery subtending multiple regions of myocardium. Since STEMI diagnosis is much less biomarker dependent than NSTEMI,[4,5] the lack of biomarker adjustment in our study is unlikely to have significantly affected our findings. We do not have information on STEMI infarct location for patients who died before reaching a hospital in the ARIC surveillance study. However, sudden cardiac death as an initial manifestation of CAD has decreased over time,[29] and is therefore unlikely to have altered our findings.

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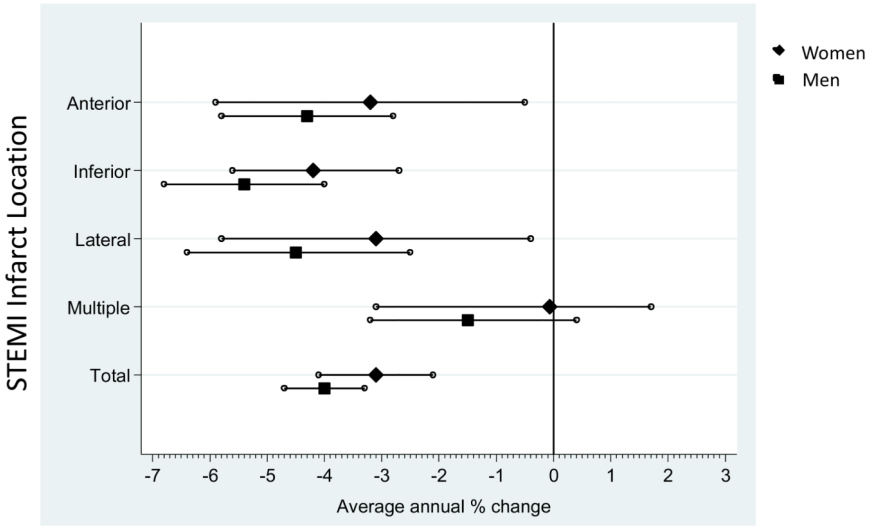

Figure 1. Age- and race-adjusted Average Annual Percent Change of STEMI by Infarct Location, stratified by gender: The ARIC Study – Community Surveillance, 1987-2008

Key:

Abbreviations: STEMI, ST elevation myocardial infarction

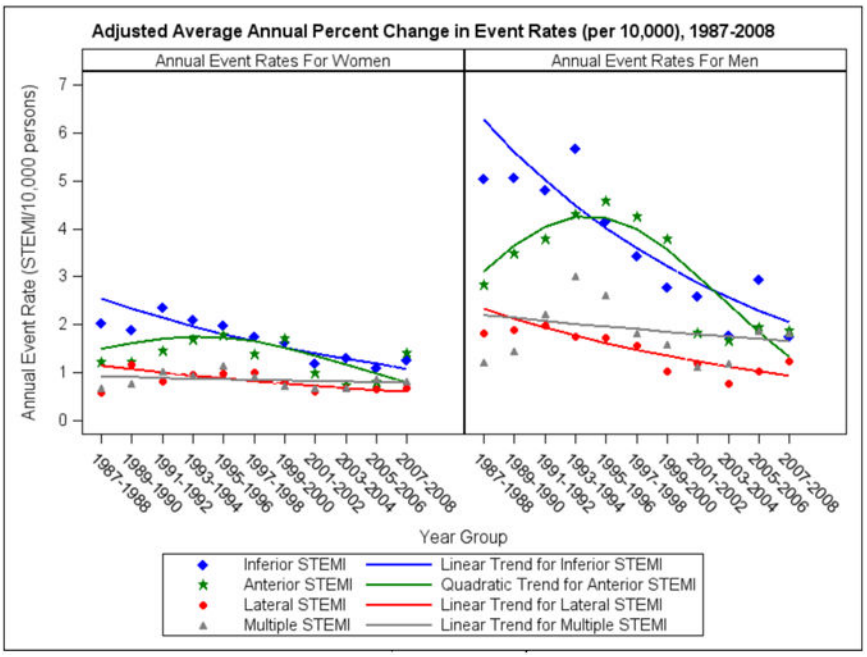

Figure 2. Age- and race-adjusted Annual Rates (per 10,000 persons) of STEMI by Infarct Location, stratified by gender: The ARIC Study – Community Surveillance, 1987-2008

Key:

Abbreviations: STEMI, ST elevation myocardial infarction

Table 1

Characteristics of Patients with ST-segment Elevation Myocardial Infarction by Year Groups: The ARIC Study - Community Surveillance, 1987-2008

	Year Group											
Variable	**1987-1988 (n 420)***	**1989-1990 (n 474)***	**1991-1992 (n 548)***	**1993-1994 (n 630)***	**1995-1996 (n 599)***	**1997-1998 (n 516)***	**1999-2000 (n 437)***	**2001-2002 (n 290)***	**2003-2004 (n 240)***	**2005-2006 (n 334)***	**2007-2008 (n 357)***	**Annual % change (95% CI)**
Age (years)	58.8	58.0	57.8	58.4	58.4	57.9	58.6	57.6	58.1	58.7	56.8	-0.1 (-0.2, 0.1)
Women	30.3%	30.3%	31.4%	29.3%	32.2%	30.5%	33.7%	30.0%	35.5%	26.6%	36.9%	0.5 (-0.5, 1.5)
Black	11.8%	12.0%	14.2%	20.8%	21.7%	27.4%	23.6%	21.5%	25.1%	25.5%	36.3%	4.6 (3.3, 5.9)
Age > 65 years	27.8%	25.7%	30.4%	30.6%	32.0%	28.2%	33.2%	27.4%	30.3%	25.2%	19.8%	-0.7 (-1.8, 0.3)
History of Hypertension	48.7%	50.7%	48.1%	53.9%	51.1%	56.7%	58.7%	53.4%	59.0%	54.2%	62.3%	1.1 (0.4, 1.7)
Diabetes Mellitus†	NA	NA	NA	21.9%	25.8%	26.8%	23.7%	24.0%	25.5%	26.6%	26.3%	0.8 (-1.1, 2.6)
PCI within 24hrs†	NA	NA	NA	15.6%	20.8%	23.3%	31.3%	52.7%	63.2%	59.8%	53.9%	9.9 (7.7, 12.1)
CABG within 24hrs†	NA	NA	NA	2.3%	4.1%	2.0%	2.0%	0.8%	0.9%	0.0%	0.7%	-14.0 (-20.6, -7.3)
Thrombolytic therapy	39.2%	52.7%	60.0%	54.0%	41.4%	39.0%	32.6%	29.4%	8.5%	1.7%	2.4%	-8.7 (-9.4, -8.0)

Abbreviations: STEMI, ST-elevation myocardial infarction. ARIC, Atherosclerosis Risk in Communities. CI, confidence interval. PCI, percutaneous intervention. CABG, coronary artery bypass graft

Characteristics presented by mean or percentage

*Weighted number of incident, unadjusted hospitalized STEMI per year group

†Data on diabetes, PCI or CABG were unavailable prior to 1993.

Table 2

Characteristics by ST-segment Elevation Myocardial Infarct Location The ARIC Study – Community Surveillance, 1987-2008

Variable	Inferior (n 1804)*	Anterior (n 1590)*	Lateral (n 640)*	Multiple (n 813)*	P-value†
Age (years)	58.6 (0.3)	58.3 (0.4)	57.9 (0.5)	56.9 (0.5)	0.03
Women	34.0% (1.3)	29.8% (1.6)	28.3% (1.9)	31.5% (2.3)	0.06
Black	12.4% (0.9)	31.3% (1.8)	23.7% (2.1)	17.5% (2.0)	<0.01
Center					
Jackson, MS	17.0% (1.1)	25.5% (1.5)	21.4% (1.8)	23.7% (2.3)	<0.01
Forsyth Co., NC	41.4% (1.4)	43.3% (1.8)	40.5% (2.3)	36.6% (2.4)	
Minneapolis, MN	24.2% (1.5)	17.4% (1.2)	21.8% (1.8)	24.8% (2.0)	
Washington Co., MD	17.5% (1.0)	13.8% (1.0)	16.3% (1.5)	14.9% (1.6)	

Abbreviations: STEMI, ST elevation myocardial infarction.

Numbers in parentheses are standard error for estimates

*Weighted number of incident, unadjusted hospitalized STEMI by infarct location.

†P-value for differences in characteristics across STEMl locations using Wald test.

Table 3

Average annual percent change (95% confidence interval) in event rates (per 10,000 persons) of STEMI by infarct location, adjusted for age and race. The ARIC Study – Community Surveillance, 1987-2008

	Women		Men	
STEMI location	**Avg. annual % change (95% C.I.)**	**P-value†**	**Avg. annual % change (95% C.I.)**	**P-value†**
Anterior	-3.2 (-5.9, -0.5)†	0.10‡	-4.3 (-5.8, -2.8)†	<0.001‡
Inferior	-4.2 (-5.6, -2.7)	<0.001	-5.4 (-6.8, -4.0)	<0.001
Lateral	-3.1 (-5.8, -0.4)	0.03	-4.5 (-6.4, -2.5)	<0.001
Multiple	-0.7 (-3.1, 1.7)	0.55	-1.5 (-3.2, 0.4)	0.13
Total	-3.1 (-4.1, -2.1)	<0.01	-4.0 (-4.7, -3.3)	<0.01

Abbreviations: STEMI, ST elevation myocardial infarction

*Negative numbers indicate a decrease in incidence rates

†P-value from Wald test of hypothesis that average annual percent change is zero.

‡Average annual percent change and P-value from a quadratic regression model. All other estimates and P-values from a linear regression model using a Wald test.

Table 4

Age- and gender- adjusted 28-day Case Fatality by STEMI Infarct Location The ARIC Study – Community Surveillance, 1987-2007*

	Year Group			
STEMI infarct location	**1987-1996**	**1997-2007**	**All years**	**P-value†**
Anterior	11.0 (7.9, 14.1)	5.3 (3.1, 7.5)	8.5 (6.5, 10.5)	<0.01
Inferior	6.0 (4.5, 7.5)	3.3 (1.9, 4.8)	5.0 (3.9, 6.0)	0.02
Lateral	14.8 (8.8, 20.7)	5.9 (2.9, 9.0)	11.0 (7.2, 14.8)	<0.01
Multiple	7.7 (5.1, 10.3)	9.1 (5.3, 12.9)	8.4 (6.1, 10.6)	0.54
Total	8.9 (7.5, 10.4)	5.4 (4.2, 6.6)	7.4 (6.5, 8.5)	<0.001

Abbreviations: STEMI, ST elevation myocardial infarction

*Models also adjusted for gender. Data was complete through 2007.

†P-value for comparison of 1987-1996 to 1997-2007 by Wald test