

Prognostic value of shock index in patients admitted with non-ST-segment elevation myocardial infarction: the ARIC study community surveillance

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Aims

Shock index (SI), defined as the ratio of heart rate (HR) to systolic blood pressure (SBP), is easily obtained and predictive of mortality in patients with ST-segment elevation myocardial infarction. However, large-scale evaluations of SI in patients with non-ST-segment elevation myocardial infarction (NSTEMI) are lacking.

Methods and results

Hospitalizations for acute myocardial infarction were sampled from four US areas by the Atherosclerosis Risk in Communities (ARIC) study and classified by physician review. Shock index was derived from the HR and SBP at first presentation and considered high when ≥ 0.7 . From 2000 to 2014, 18 301 weighted hospitalizations for NSTEMI were sampled and had vitals successfully obtained. Of these, 5753 (31%) had high SI (≥ 0.7). Patients with high SI were more often female (46% vs. 39%) and had more prevalent chronic kidney disease (40% vs. 32%). TIMI (Thrombolysis in Myocardial Infarction) risk scores were similar between the groups (4.3 vs. 4.2), but GRACE (Global Registry of Acute Coronary Syndrome) score was higher with high SI (140 vs. 118). Angiography, revascularization, and guideline-directed medications were less often administered to patients with high SI, and the 28-day mortality was higher (13% vs. 5%). Prediction of 28-day mortality by SI as a continuous measurement [area under the curve (AUC): 0.68] was intermediate to that of the GRACE score (AUC: 0.87) and the TIMI score (AUC: 0.54). After adjustments, patients with high SI had twice the odds of 28-day mortality (odds ratio = 2.02; 95% confidence interval: 1.46–2.80).

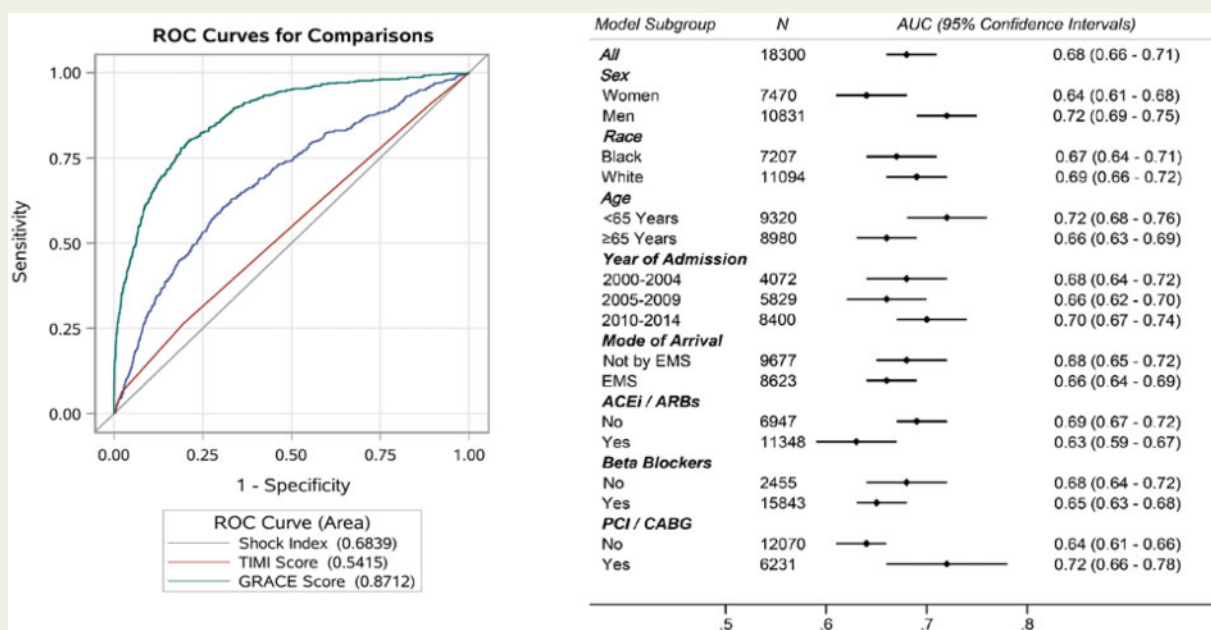
Conclusion

The SI is easily obtainable, performs moderately well as a predictor of short-term mortality in patients hospitalized with NSTEMI, and may be useful for risk stratification in emergency settings.

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Graphical Abstract



Keywords

NSTEMI • Acute myocardial infarction • Risk score • Mortality • Epidemiology

Introduction

Shock index (SI) is defined as the ratio of heart rate (HR) to systolic blood pressure (SBP), which is universally obtained on initial clinical presentation. Shock index has been previously utilized to predict adverse outcomes in patients with sepsis,^{1,2} pneumonia,^{3,4} and pulmonary embolism^{5,6} and is closely associated with early recognition of cardiogenic, septic, and hypovolaemic shock.⁵⁻⁹ Shock index is also reported to effectively predict short- and long-term mortality in patients with ST-segment elevation myocardial infarction (STEMI).¹⁰⁻¹³ Rapid risk stratification is crucial for clinical decision-making and management of patients presenting with acute myocardial infarction (AMI). However, large-scale evaluations of SI in patients admitted with non-ST-segment elevation myocardial infarction (NSTEMI) are lacking, and prior studies are limited to patients undergoing coronary angiography.¹⁴ Established risk scores such as TIMI (Thrombolysis in Myocardial Infarction) and GRACE (Global Registry of Acute Coronary Syndrome) have demonstrated effective risk stratification in patients with AMI¹⁵⁻²² and are recommended by the American Heart Association and the American College of Cardiology for assessing prognosis of patients with NSTEMI.²³ However, the algorithms require extensive clinical inputs, such as laboratory tests, making them difficult to apply especially in resource limited settings. The present study, therefore, aims to evaluate the prognostic utility of the SI in a large-scale, unselected sample of patients admitted with NSTEMI.

Methods

ARIC study community surveillance

Since 1987, the Atherosclerosis Risk in Communities (ARIC) study has conducted ongoing surveillance of hospitalized AMI in four geographically defined regions of the USA: Forsyth County, North Carolina; Washington County, Maryland; Jackson, Mississippi; and eight northwest suburbs of Minneapolis, Minnesota. As previously described,²⁴ eligible hospitalizations were selected on the basis of age, residence in the community, and discharge code [International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 402 (hypertensive heart disease); 410 to 414 (AMI, other acute, subacute ischaemic heart disease, old myocardial infarction (MI), angina pectoris, and other forms of chronic ischaemic heart disease); 427 (cardiac dysrhythmias); 428 (heart failure); and 518.4 (acute oedema of the lung)], through random sampling within discharge code strata. The study sample for this analysis is limited to hospitalizations in the contemporary era with discharge dates between 1 January 2000 and 31 December 2014.

Electrocardiography, biomarkers, and chest pain

The first, third, and the last 12-lead electrocardiograms (ECGs) over the course of hospitalization were obtained from the medical record and coded electronically at the Minneapolis ECG Reading Center. Laboratory values for cardiac troponin were abstracted chronologically, recording up to three measurements per day and noting the laboratory-specified upper limit of normal (ULN) for each hospitalization. Presence of acute

chest pain was abstracted from the medical record, with origin determined by review of the physician notes.

Acute myocardial infarction classification

As previously described,²⁴ events were classified by a validated computer algorithm with a physician panel review, as definite, probable, suspected, or no AMI, based on ECG evidence (evolving diagnostic, diagnostic, evolving ST-segment/T-wave changes, equivocal, or absent/uncodable), presence of chest pain, and cardiac biomarkers (which were considered 'abnormal' if $\geq 2 \times$ ULN), and 'equivocal' if exceeding the ULN but $< 2 \times$ the ULN. Classification of an event as definite or probable AMI required the presence of at least one of the following: (i) evolving diagnostic ECG pattern, (ii) diagnostic ECG pattern and abnormal biomarkers ($\geq 2 \times$ ULN), (iii) cardiac pain and abnormal biomarkers ($\geq 2 \times$ ULN), (iv) cardiac pain and equivocal biomarkers (exceeding the ULN but $< 2 \times$ the ULN) with evolving ST-segment/T-wave pattern or diagnostic ECG pattern, or (v) abnormal biomarkers with evolving ST-segment/T-wave pattern.

Clinical data abstraction and covariate definitions

Clinical data were collected from the hospital record by trained abstractors following a standardized protocol, using the physician notes, laboratory reports, patient histories, and discharge summaries. Laboratory values were abstracted by recording the first and worst value during the course of hospitalization. The first recorded value was used for the purposes of this analysis. We estimated the glomerular filtration rate using the CKD-EPI (Chronic Kidney Disease - Epidemiology Collaboration) formula and abstracted serum creatinine. Chronic kidney disease was defined by an estimated glomerular filtration rate < 45 mL/min/1.73 m² or receipt of dialysis. Hypertension was defined by known history of hypertension, antihypertensive medication use, SBP ≥ 140 , or diastolic blood pressure ≥ 90 mmHg. Diabetes mellitus was defined by documented history in the medical record or diabetic medication use. Current smoking and prior history of coronary revascularization were classified by documentation in the medical record.

Shock index

The SI (ratio of HR/SBP) was derived using the first recorded blood pressure and pulse rate, excluding any recorded during cardiopulmonary resuscitation. Based on availability, the ARIC study abstracted the first blood pressure and pulse rate from the ambulance record, the emergency department sheet, the clinical graph, or the nursing admission sheet, in that order. We considered an SI ≥ 0.7 to be high, based on cut-points used in the previous literature.²⁵

Thrombolysis in myocardial ischaemia score

TIMI risk scores for unstable angina/NSTEMI were derived from medical histories and presenting features at admission, using data abstracted from the hospital record. Clinical inputs for the TIMI risk score include age ≥ 65 , presence of three or more coronary artery disease (CAD) risk factors (family history of CAD, hypertension, hypercholesterolaemia, diabetes, or tobacco use), known history of CAD (stenosis $\geq 50\%$), and aspirin use within the past 7 days, severe angina, ST-segment deviation on ECG, and elevated cardiac biomarkers.²⁶ Diagnosis of hypercholesterolaemia was not abstracted by the ARIC surveillance but was inferred by lipid-lowering medication use. Likewise, family history of CAD was not abstracted from the medical record. Known history of CAD was inferred by history of prior angioplasty or coronary bypass graft. Severe angina was inferred by acute chest pain precipitating hospitalization. Routine aspirin use was abstracted from the medical record, and from this aspirin

use within the past 7 days was inferred. A TIMI score of 2–4 was considered 'low risk', and a score of 5–7 was considered 'high risk'.

Global Registry of Acute Coronary Syndrome score

The GRACE score was derived from the presenting features at admission and over the course of hospitalization, using clinical data abstracted from the medical record. Clinical inputs include patient age, HR, SBP, serum creatinine level, Killip class, cardiac arrest, ST-segment deviation, and abnormal cardiac enzymes. Clinical inputs for the Killip class include presence of jugular venous distension, s3 gallop, acute pulmonary oedema/congestive heart failure, and cardiogenic shock. The Killip class ranges from 1 to 4, with a value of ≥ 3 considered elevated. Cardiac arrest was abstracted by the ARIC study as a composite of ventricular arrhythmia/cardiac arrest/asystole. Because the ARIC study began routine abstraction of creatinine levels in 2004, derivation of the GRACE score was limited to 2004–2014. A GRACE score > 140 was considered elevated.²⁷

Medical therapies and cardiac procedures

Medications were recorded if administered during hospitalization or prescribed at hospital discharge. Aspirin required routine rather than *pro re nata* administration for abstraction. Non-aspirin antiplatelet therapy was recorded as a single category and included P2Y₁₂ inhibitors (clopidogrel, prasugrel, ticagrelor, and ticlopidine), glycoprotein IIb/IIIa inhibitors (abciximab, eptifibatid, and tirofiban), phosphodiesterase 3 inhibitors (cilostazol), phosphodiesterase 5 inhibitors (dipyridamole), and protease-activated receptor-1 antagonists. Beta blockers included β_1 adrenergic antagonists. Angiotensin-converting enzyme inhibitors and angiotensin II receptor blockers (ACEis/ARBs) were recorded as a single category. Lipid-lowering agents included statins, niacin, and fibrates. Coronary angiography and revascularization procedures were abstracted from the medical record. Revascularization included percutaneous coronary intervention (PCI) or coronary artery bypass graft surgery (CABG).

Mortality outcomes

Mortality was ascertained within 28 days and 1 year of hospital admission by the ARIC Community Surveillance study, by linking hospitalizations with the National Death Index.

Statistical analysis

Statistical tests and models accounted for the stratified sampling design and were weighted by the inverse of the sampling probabilities.²⁸ Baseline characteristics of the study population were compared with stratification by SI. Continuous variables were compared using the difference in least square means from weighted linear regression and categorical variables were compared using Rao–Scott χ^2 tests. The association between decile of SI with 28-day mortality was first visualized by constructing a bar graph. The prognostic value of the SI (as a continuous value) for prediction of 28-day mortality was analysed by logistic regression, by calculating the area under the curve (AUC) from receiver operating characteristics. For comparison, the AUC was also calculated for the TIMI and GRACE risk scores. Calibration of the SI prediction model was assessed within subgroups based on demographics (sex, race, and age categories), half-decade of admission (2000–2004, 2005–2009, and 2010–2014), mode of arrival (ambulance vs. other transportation), and clinical management (medical vs. invasive strategy). Because antihypertensive and beta blocker medication use may influence the assessment of SI, we also examined model calibration among patients who were vs. were not managed by these therapies. As a sensitivity analysis, predictions of 28-day mortality by SI were compared to predictions by SBP or HR alone.

The association between high SI (dichotomized by the 0.7 partition value) and 28-day mortality was assessed by logistic regression, with adjustment for demographics (age, race, sex, and year of admission), comorbidities (smoking, diabetes mellitus, chronic kidney disease, prior coronary revascularization, and history of stroke), and medical therapies (aspirin, antiplatelets, ACEi/ARBs, lipid-lowering medications, and revascularization either by PCI or CABG). To examine the outcomes of invasive strategy among patients with high SI, we analysed the relationship between coronary revascularization (vs. medical management) and 28-day mortality in the subset of patients classified with high SI, using multi-variable logistic regression models adjusted for demographics and comorbidities.

Results

A total of 52 641 eligible hospitalizations were sampled from 2000 to 2014. Of these, 11 507 were classified as definite or probable AMI upon physician review, and 8889 were classified as NSTEMI. After the omission of transfer patients, those with in-hospital onset of AMI, or those with unobtainable vitals, 7785 remained, corresponding to 18 301 weighted events. The study population selection flowchart is shown in [Supplementary material](#) online, [Figure S1](#). All subsequent results are presented with weighting by the sampling fraction.

The overall distribution of SI values was approximately normal but skewed slightly right, with a median value of 0.59 ([Supplementary material](#) online, [Figure S2](#)). Nearly a third of the included patients (31%) had a high SI (≥ 0.7), [Table 1](#). Compared to patients with SI < 0.7 , those

Table 1 Demographics and characteristics of patients admitted with non-ST-segment elevation myocardial infarction, stratified by shock index

| Characteristic | Shock index < 0.7 (N = 12 548) | Shock index ≥ 0.7 (N = 5753) | P-value |
|--|----------------------------------|-----------------------------------|------------|
| Demographics | | | |
| Age | 63 \pm 0.2 | 65 \pm 0.2 | 0.0006 |
| Female | 4846 (39%) | 2624 (46%) | < 0.0001 |
| White | 7499 (60%) | 3595 (62%) | 0.1 |
| Medical history | | | |
| Smoker | 3951 (31%) | 1723 (30%) | 0.9 |
| Diabetes mellitus | 5261 (42%) | 2463 (43%) | 0.6 |
| Chronic kidney disease | 3200 (32%) | 1946 (40%) | < 0.0001 |
| Prior coronary revascularization | 4317 (34%) | 1655 (29%) | 0.0007 |
| In-hospital clinical course | | | |
| Acute pulmonary oedema/heart failure | 3712 (30%) | 2408 (42%) | < 0.0001 |
| Ventricular fibrillation/arrest/asystole | 558 (4%) | 634 (11%) | < 0.0001 |
| Cardiogenic shock | 200 (2%) | 311 (5%) | < 0.0001 |
| Risk scores | | | |
| Killip class | 1.6 \pm 0.01 | 2.0 \pm 0.02 | < 0.0001 |
| Elevated Killip class (≥ 3) | 3775 (30%) | 2503 (44%) | < 0.0001 |
| TIMI score | 4.3 \pm 0.01 | 4.2 \pm 0.02 | 0.0003 |
| Elevated TIMI score (≥ 5) | 5058 (40%) | 2111 (37%) | 0.04 |
| GRACE score ^a | 118 \pm 0.9 | 142 \pm 1.3 | < 0.0001 |
| Elevated GRACE score (> 140) | 2914 (29%) | 2449 (50%) | < 0.0001 |
| Hospital procedures | | | |
| Cardiopulmonary resuscitation/cardiopercutaneous coronary intervention | 409 (3%) | 495 (9%) | < 0.0001 |
| Angiography | 7304 (58%) | 2052 (36%) | < 0.0001 |
| Coronary revascularization | 5162 (41%) | 1069 (19%) | < 0.0001 |
| Hospital medications | | | |
| Aspirin | 11253 (90%) | 4810 (84%) | < 0.0001 |
| Antiplatelets | 7349 (59%) | 1978 (34%) | < 0.0001 |
| Beta blockers | 11181 (89%) | 4662 (81%) | < 0.0001 |
| Statins/lipid-lowering agents | 9588 (76%) | 3495 (61%) | < 0.0001 |
| ACEi/ARB | 8123 (65%) | 3225 (56%) | < 0.0001 |

The community surveillance component of the Atherosclerosis Risk in Communities Study, 2000–2014.

Values are presented as mean \pm standard error or number (percentage).

ACEi/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; GRACE, Global Registry of Acute Coronary Syndrome; TIMI, thrombolysis in myocardial ischaemia.

^aChronic kidney disease and GRACE score limited to hospitalizations from 2004 to 2014 with available serum creatinine abstracts (N = 14 911; 3390 missing).

with high SI were more often women (46% vs. 39%) and slightly older (65 vs. 63 years), but racial distributions were similar. Smoking and history of diabetes mellitus were comparable between the groups, but patients with high SI had a greater prevalence of chronic kidney disease (40% vs. 32%). NSTEMI hospitalizations with high SI were more often complicated by acute pulmonary oedema/heart failure (42% vs. 30%), ventricular fibrillation/cardiac arrest (11% vs. 4%), and cardiogenic shock (5% vs. 2%). The mean Killip class increased with high SI (2.0 vs. 1.6), and participants with high SI more often had an elevated Killip class (44% vs. 30%). Interestingly, the mean TIMI risk score was comparable between the groups (4.3 vs. 4.2), and a high TIMI score was slightly less prevalent among participants with high SI (37% vs. 40%). The mean GRACE score was substantially higher in patients with high SI (142 vs. 118), as was prevalence of a high GRACE score (50% vs. 29%).

Patients with high SI were differentially managed, compared to patients with SI <0.7. Those with high SI received less guideline-directed medications, such as aspirin (84% vs. 90%), antiplatelets (34% vs. 59%), lipid-lowering agents (61% vs. 76%), and ACEi/ARBs (56% vs. 65%); and were less frequently evaluated by angiography (36% vs. 58%). Coronary revascularization was less often performed in patients with high SI, both overall (19% vs. 41%) and among the subset undergoing coronary angiography (51% vs. 70%).

Within 28 days of hospital admission, there were 1331 deaths. The 28-day all-cause mortality was nearly three times higher (13% vs. 5%; $P < 0.0001$) with high SI. An increasing proportion of participants died within 28 days of hospitalization with increasing decile of SI (Supplementary material online, Figure S3). When examined as a continuous value, the SI performed moderately well as a predictor of 28-day mortality [AUC = 0.68; (95% confidence interval (CI): 0.66–0.71)], with predictive performance that was intermediate to the GRACE score [AUC = 0.87; (95% CI: 0.86–0.89)] and the TIMI score [AUC = 0.54; (95% CI: 0.52–0.57)], Figure 1. Model calibration was similar by race (Black vs. White), half-decade of admission (2000–2004, 2005–2009, and 2010–2014), and mode of arrival (by ambulance or by car). However, the SI was a slightly better predictor of 28-day mortality in men compared to women (AUC: 0.72 vs. 0.64), in younger patients compared to those ≥ 65 years (AUC: 0.72 vs. 0.66), in patients undergoing coronary revascularization (AUC: 0.72 vs. 0.64), Figure 2. In patients who were revascularized, the prediction of 28-day mortality by SI (AUC: 0.72; 95% CI: 0.66–0.78) was better than predictions by either SBP alone (AUC: 0.68; 95% CI: 0.63–0.74) or by HR alone (AUC: 0.63; 95% CI: 0.57–0.69). Predictions of 28-day mortality by SI value were comparable for patients managed by ACEi/ARBs or beta blockers compared to those not managed by these therapies.

When dichotomized by the partition value of 0.7, high SI was associated with nearly three times the odds of 28-day mortality, relative to SI <0.7 [odds ratio (OR) = 2.89; 95% CI: 2.24–3.6]. The association persisted after adjustment for demographics, year of admission, smoking, diabetes mellitus, chronic kidney disease, prior revascularization, history of stroke, and history of hypertension (OR = 2.46; 95% CI: 1.81–3.33), and upon further adjustment for aspirin, antiplatelets, ACEi/ARBs, lipid-lowering medications, and coronary revascularization (OR = 2.02; 95% CI: 1.46–2.80), Table 2.

Among the subset of patients with high SI who underwent coronary revascularization, the 28-day mortality rate was 7%, which was

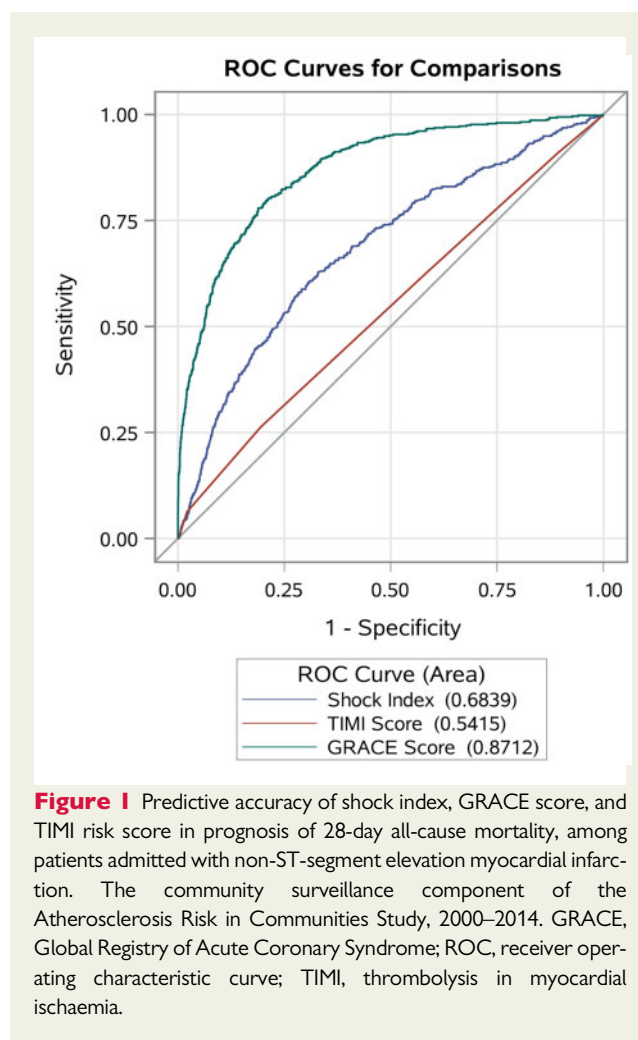


Figure 1 Predictive accuracy of shock index, GRACE score, and TIMI risk score in prognosis of 28-day all-cause mortality, among patients admitted with non-ST-segment elevation myocardial infarction. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2000–2014. GRACE, Global Registry of Acute Coronary Syndrome; ROC, receiver operating characteristic curve; TIMI, thrombolysis in myocardial ischaemia.

nearly half the mortality rate of patients with high SI who were managed by medical therapy alone (14%). After adjustment for age, race, sex, and year of admission, the mortality OR for patients with high SI who received coronary revascularization was 0.49 (0.29–0.82). The mortality OR was largely unchanged after additional adjustments for smoking, diabetes, hypertension, history of stroke, and history of prior revascularization [OR = 0.49 (95% CI: 0.29–0.81)].

Discussion

In this large, multi-year surveillance of patients admitted with NSTEMI, we evaluate the predictive value SI and make the following observations: (i) the SI predicted short-term mortality moderately well in patients with NSTEMI, with predictive accuracy that was intermediate to the GRACE score and the TIMI risk score. (ii) Patients with high SI, as defined by the partition value of ≥ 0.7 , were more often older, women, had a higher prevalence of chronic kidney disease, and a more severe clinical course during hospitalization. (iii) Patients with high SI less often received guideline-directed NSTEMI therapies and had three times the mortality within 28 days of hospitalization, compared to patients with an SI <0.7.

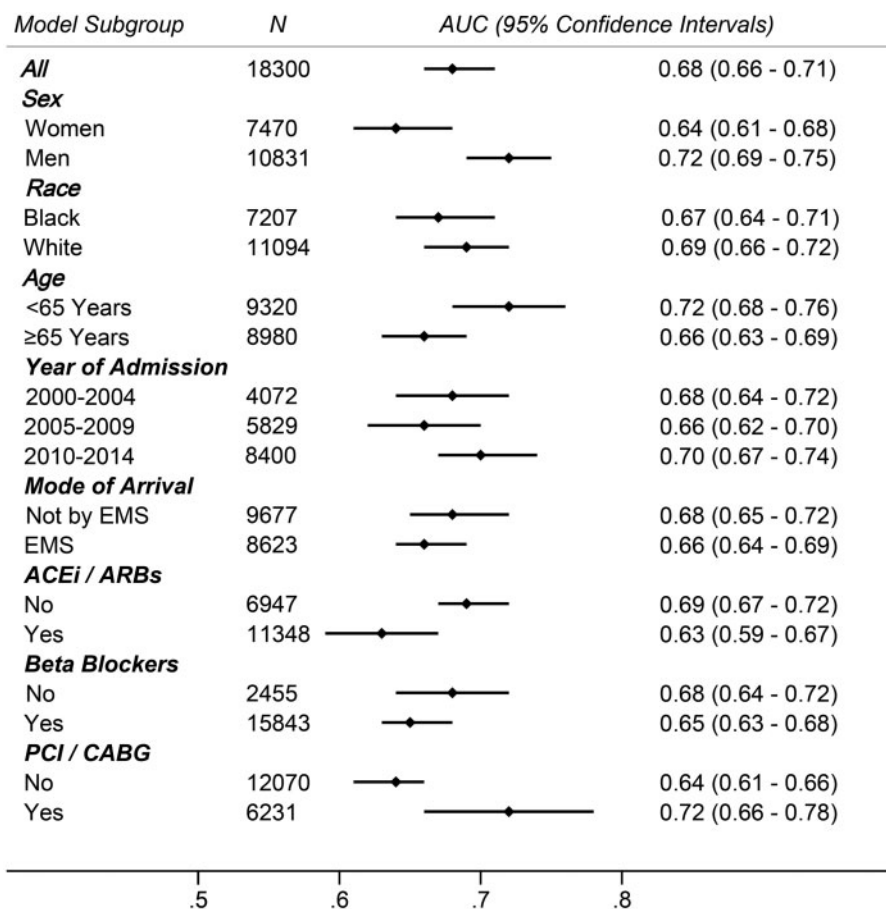


Figure 2 Predictive accuracy of shock index in prognosis of 28-day all-cause mortality, among various subgroups of patients admitted with non-ST-segment elevation myocardial infarction. The community surveillance component of the Atherosclerosis Risk in Communities Study, 2000–2014. ACEi/ARB, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker; AUC, area under the curve from receiver operating characteristics; CABG, coronary artery bypass graft; EMS, emergency medical services; PCI, percutaneous coronary intervention.

Table 2 Adjusted odds ratios of 28-day mortality associated with elevated shock index (≥0.7) relative to shock index <0.7, among patients admitted with non-ST-segment elevation myocardial infarction

| Model adjustment ^a | OR (95% CI) |
|--|------------------|
| Crude | 2.89 (2.24–3.69) |
| Demographics | 2.77 (2.15–3.59) |
| Demographics, comorbidities | 2.46 (1.81–3.33) |
| Demographics, comorbidities, therapies | 2.02 (1.46–2.80) |

The community surveillance component of the Atherosclerosis Risk in Communities Study, 2000–2014.

^aDemographics = age, race, sex, and year of hospital admission. Comorbidities = smoking, diabetes mellitus, chronic kidney disease, prior coronary revascularization, and history of stroke. Therapies = aspirin, antiplatelets, angiotensin-converting enzyme inhibitor/angiotensin receptor blocker, lipid-lowering medications, and coronary revascularization either by percutaneous coronary intervention or by coronary artery bypass graft.

The SI is a simple metric for gauging the degree of hypovolaemia in haemorrhagic and infectious shock states²⁹ and is widely used in critically ill patients to indicate severity of disease, response to treatment, and need for intensive care therapy. Prognostic value of the SI has been demonstrated in patients with trauma,^{30,31} with better predictions of adverse events than either SBP or HR alone.³² In the setting of acute coronary syndrome, the SI reflects sympathetic neural hyperactivity compensating left ventricular systolic dysfunction.³³ Several prior studies have investigated the association of SI with mortality and major adverse cardiovascular events in patients with STEMI.^{11,12,34} A recent meta-analysis of patients hospitalized with STEMI reported an 11-fold higher risk of in-hospital mortality and twice the risk of longer-term adverse outcomes for patients with high SI.³⁵ A high SI has also been shown to correspond to larger areas of myocardial injury in patients with STEMI and higher rates of adverse cardiovascular events.³⁶ Both SBP and HR have been shown to predict mortality in patients with NSTEMI^{37,38}; however, to date, there have been no large-scale evaluations of the SI in patients admitted with NSTEMI, and previous studies have been limited to patients undergoing cardiac catheterization.¹⁴

Evidence suggests that high-risk patients with NSTEMI benefit from early revascularization.^{39–41} The American Heart Association (AHA)/American College of Cardiology (ACC) guidelines for the management of NSTEMI recommend immediate revascularization within 2 h for patients with haemodynamic instability,²³ and assign a Class 1A recommendation for assessing prognosis by risk scores. Our study suggests that SI may be an important tool for rapid identification of patients with impending haemodynamic instability, who may benefit from immediate or early invasive strategy. In our analysis of patients admitted with NSTEMI, prediction of 28-day mortality by SI was better than predictions by either SBP or HR alone. While the TIMI risk score for non-ST-elevation acute coronary syndrome is widely used as a risk stratification tool for predictions of all-cause mortality, urgent revascularization, and recurrent MI in patients with NSTEMI,^{26,42,43} in our study, SI was more predictive of 28-day mortality than the TIMI score, both overall and among the subset of patients who were revascularized. The GRACE score was the best overall predictor of 28-day mortality, but its use in emergency settings may be less convenient, owing to the time required to process blood for serum creatinine. In contrast, the SI can be rapidly calculated, and unlike the TIMI and GRACE scores does not require extensive clinical inputs for the algorithm. Unlike both the SI and GRACE score, the TIMI score for NSTEMI relies upon historical data from the medical record, such as history of cardiovascular risk factors (hypertension, hypercholesterolaemia, diabetes, or tobacco use), known history of coronary disease, and family history of coronary disease. The differences in clinical inputs for the three risk scores likely explains the closer alliance of the SI with the GRACE score, evidenced by the higher prevalence of elevated GRACE score among patients with an elevated SI.

Interestingly, a lower utilization of coronary angiography and revascularization was observed for patients in the highest risk category (SI ≥ 0.7). Similar results have been emphasized in the CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines) trial, which showed an inverse relationship between cardiac catheterization and probability of severe CAD in patients with NSTEMI.⁴⁴ The higher utilization of coronary catheterization for patients with SI < 0.7 may have been influenced by hospital, geographic, or temporal factors, such as availability of cardiac catheterization facilities and cardiac catheterization volumes. Alternatively, treatment decisions may have been more influenced by clinical variables associated with lower complication rates, such as younger age and preserved renal function.^{45–48} This emphasizes the need for improvement in quality that could promote appropriate use of cardiac catheterization procedures among patients with the greatest potential benefit. Although our analysis from the ARIC study community surveillance encompassed a wide time interval, during which standard treatment evolved both in terms of revascularization strategy and medical treatment, predictions of 28-day mortality by a SI > 0.7 were fairly consistent from 2000 to 2004, 2005 to 2009, and 2010 to 2014.

Our study has some limitations. This was an observational analysis, and data were limited to availability in the medical record. The ARIC study did not include classifications of type 1 or type 2 AMI, and we were unable to consider any differential predictions of short-term mortality by AMI type. However, increasing SI was more predictive of mortality among the subset of patients undergoing coronary

revascularization, who presumably would have had type 1 MI. Although measurements of HR and SBP were unstandardized and may have been subject to interobserver variability, our analysis reflects clinical practice which increases generalizability of these findings. Our investigation also has several noteworthy strengths. The ARIC Study provides a large, multi-year surveillance of four diverse US communities, allowing an analysis of contemporary trends spanning 15 years. All hospitalizations for NSTEMI were validated by a standardized physician review of the medical record, minimizing misclassification of events, and mortality outcomes were verified by the National Death Index.

Conclusions

The SI is easily obtainable, performs moderately well as a predictor of short-term mortality in patients hospitalized with NSTEMI, and may be useful for risk stratification in emergency settings.

Supplementary material

Supplementary material is available at *European Heart Journal: Acute Cardiovascular Care* online.

Data availability

The Atherosclerosis Risk in Communities (ARIC) study's data are owned by the National Heart Lung and Blood Institute (NHLBI). The data are publicly available to qualified investigators with an approved manuscript proposal and data use agreement. Upon reasonable request, the ARIC coordinating center may make the data, analytic methods, and study materials available to other researchers for purposes of reproducing the results or replicating the procedure.

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