Contemporary risk model for inhospital major bleeding for patients with acute myocardial infarction: The acute coronary treatment and intervention outcomes network (ACTION) registry®–Get With The Guidelines (GWTG)®

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Background Major bleeding is a frequent complication for patients with acute myocardial infarction (AMI) and is associated with significant morbidity and mortality.

Objective To develop a contemporary model for inhospital major bleeding that can both support clinical decision-making and serve as a foundation for assessing hospital quality.

Methods An inhospital major bleeding model was developed using the Acute Coronary Treatment and Intervention Outcomes Network Registry–Get With the Guidelines (ACTION Registry–GWTG) database. Patients hospitalized with AMI between January 1, 2012 and December 31, 2013 across 657 hospitals were used to create a derivation cohort (n=144,800) and a validation cohort (n=96,684). Multivariable hierarchal logistic regression was used to identify significant predictors of major bleeding. A simplified risk score was created to enable prospective risk stratification for clinical care.

Results The rate of major bleeding in the overall population was 7.53%. There were 8 significant, independent factors associated with major bleeding: presentation after cardiac arrest (OR 2.99 [2.77-3.22]); presentation in cardiogenic shock (OR 2.22 [2.05-2.40]); STEMI (OR 1.72 [1.65-1.80]); presentation in heart failure (OR 1.55 [1.47-1.63]); baseline hemoglobin less than 12 g/dL (1.55 [1.48-1.63]); heart rate (per 10 beat per minute increase) (OR 1.13 [1.12-1.14]); weight (per 10 kilogram decrease) (OR 1.12 [1.11-1.14]); creatinine clearance (per 5-mL decrease) (OR 1.07 [1.07-1.08]). The model discriminated well in the derivation (C-statistic = 0.74) and validation (C-statistic = 0.74) cohorts. In the validation cohort, a risk score for major bleeding corresponded well with observed bleeding: very low risk (2.2%), low risk (5.1%), moderate risk (10.1%), high risk (16.3%), and very high risk (25.2%).

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Wilbert S. Aronow, MD served as guest editor for this article.

Dr Cohen has received research grant support from Abbott Vascular, AstraZeneca, Biomet, Boston Scientific, Cardiovascular Systems, Inc, Daiichi-Sankyo, Edwards Lifesciences, Eli Lilly, Medtronic, Merck; has received consulting income from Edwards Lifesciences, Medtronic, and AstraZeneca; and speaking honoraria from AstraZeneca. Dr Diercks has received consulting honoraria from Janssen, Novartis, and Siemens; and research grant support from Roche. Dr Moscucci has received book royalties from Lippincott Williams and Wilkins and owns stocks of Gilead Sciences. Dr Ramee has received consulting income from Edwards, Large Bore, Marvenray, Medtronic, Ocular Therapeutics. Dr Wang has received research grant support to the Duke Clinical Research Institute from Eli Lilly and Company, Daiichi-Sankyo, Gilead Sciences, GlaxoSmithKline, AstraZeneca, Bristol-Myers Squibb, Boston Scientific, and Regeneron; and has received honoraria from Astra-Zeneca and the American College of Cardiology Foundation. Dr Spertus has received research grants and contracts from the American College of Cardiology Foundation, Eli Lilly, Gilead, and Genentech; has consulted for Novartis, Regeneron, Bayer and Amgen; holds the copyright to the SAQ, KCCQ, and PAQ; and has an equity interest in Health Outcomes Sciences. Dr McNamara serves on a clinical trials endpoint adjudication committee for Pfizer. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Submitted July 12, 2017; accepted August 4, 2017.

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0002-8703

http://dx.doi.org/10.1016/j.ahj.2017.08.004

Conclusion The new ACTION Registry–GWTG inhospital major bleeding risk model and risk score offer a robust, parsimonious, and contemporary risk-adjustment method to support clinical decision-making and enable hospital quality assessment. Strategies to mitigate risk should be developed and tested as a means to lower costs and improve outcomes in an era of alternative payment models. (Am Heart J 2017;194:16-24.)

Background

Bleeding complications commonly occur among patients with acute coronary syndromes and are associated with worse clinical outcomes.[1-4] A risk model to predict the development of bleeding complications would enable providers to more optimally balance competing risks of ischemic and bleeding complications, leading to more individualized care and improved outcomes. In addition, a robust bleeding model would enable risk adjustment to more accurately assess hospital performance, identify opportunities to improve patient care, and focus quality improvement interventions.

Although several risk models of inhospital major bleeding have been developed for patients with AMI, few have included a representative sample from real-world clinical practice.[2,3,5,6] A prior model from the Acute Coronary Treatment and Intervention Outcomes Network (ACTION) Registry®–Get With The Guidelines™ (ACTION Registry–GWTG) included patients from over 250 hospitals presenting with AMI from January 2007 through September 2008.[7] However, since that time, the number of hospitals participating in the ACTION Registry–GWTG has increased considerably, and new, prognostically important data elements, such as presentation with cardiac arrest have been added. In addition, use of background antiplatelet and antithrombotic therapy has evolved and may have important implications for bleeding complications.[8]

In order to provide more comprehensive, generalizable, and contemporary risk assessment, we aimed to develop and validate a risk model to predict inhospital bleeding for patients after AMI using data collected at presentation in ACTION Registry–GWTG from January 2012 through December 2013. This risk model could be used to provide specific feedback to hospitals for quality improvement efforts. In addition, we aimed to create a parsimonious risk score based on this model to facilitate and inform clinical decision-making at the bedside. Taken together, this work could lay the foundation for more efficient and safer care, which is increasingly essential as payers introduce new payment models for AMI care.[9,10]

Methods

The ACTION Registry–GWTG is an ongoing National Cardiovascular Data Registry (NCDR) program for patients with acute myocardial infarction (AMI). Inclusion and exclusion criteria, data collection, and variables have been described previously.[11] Briefly, participating hospitals collect data using standardized data collection tools that do not require direct patient contact. Data collected include patient demographics; presenting features; pre-hospital, inhospital, and hospital discharge therapy; timing of care delivery; laboratory tests; procedure use; and inhospital patient outcomes. The NCDR has a data quality program, including data abstraction training, data quality thresholds for inclusion, site data quality feedback reports, independent auditing, and data validation. Regular audits have demonstrated 93% agreement between registry data and clinical chart data.[12]

Study population

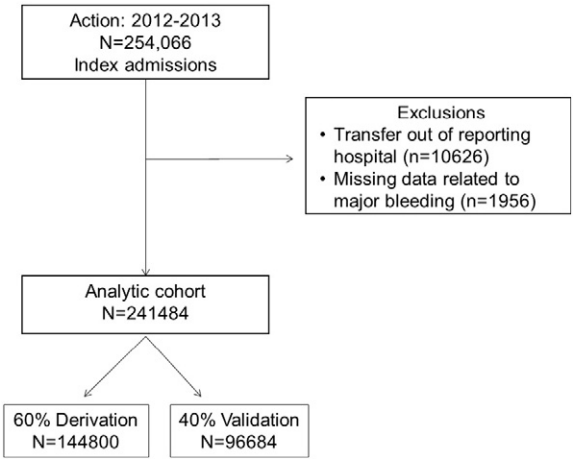
All patients admitted with AMI and reported to the ACTION Registry–GWTG from January 1, 2012, to December 31, 2013, were included in the initial study population (n = 254,066, Figure 1). We excluded patients who were transferred out of the reporting hospitals to ensure complete capture of bleeding events (n = 10,626) and patients with missing data related to major bleeding (n = 1959). The remaining study population (n = 241,484) was divided by random sampling into a derivation cohort (60%, n = 144,800) for model development and a validation cohort (40%, n = 96,684).

Definitions

ACTION Registry–GWTG defines inhospital major bleeding as any of the following: intracranial hemorrhage, documented or suspected retroperitoneal bleed, any red cell blood transfusion with baseline hemoglobin ≥9 g/dl, any red cell transfusion with hemoglobin <9 g/dl in a patient with a suspected bleeding event [defined by a hemoglobin drop of ≥3 g/dL or procedural intervention/surgery at the bleeding site to reverse/stop or correct the bleeding (e.g. surgical repair/exploration of the arteriotomy site, balloon angioplasty to seal an arterial tear, endoscopy with cautery of a GI bleed)] or an absolute hemoglobin decrease of ≥4 g/dl (baseline to nadir).[7] Patients undergoing CABG were classified as having a major bleeding event if they fulfilled the above criteria with the exception of site-adjudicated CABG-related transfusions.

Standard definitions for the data elements captured in the ACTION Registry–GWTG database are available online.[13] Cardiac arrest was an added variable to this

Figure 1



Study cohort.

updated analysis, and is defined as "evaluated by EMS or ED personnel and either (1) received attempts at external defibrillation (by lay responders or emergency personnel) or chest compressions by organized EMS or ED personnel or (2) were pulseless at the time of presentation." Heart failure on admission was defined by unusual dyspnea with light exertion, recurrent dyspnea occurring in the supine position, fluid retention, rales, jugular venous distension, pulmonary edema on physical examination, or pulmonary edema on chest x-ray presumed to be due to cardiac dysfunction. Previous peripheral artery disease was defined as claudication (either with exertion or at rest), amputation for arterial vascular insufficiency, vascular reconstruction, bypass surgery or percutaneous intervention to the extremities, documented aortic aneurysm with or without repair, and positive noninvasive test results (ultrasound, magnetic resonance, computed tomography, or angiographic imaging) demonstrating >50% diameter stenosis in any peripheral artery. Cardiogenic shock on presentation was defined as an episode of hypotension due to cardiac dysfunction, lasting >30 minutes, with a systolic blood pressure of <90 mm Hg or a cardiac index <2.2 L/min/m^2 or the need for inotropic or vasopressive agents or mechanical support to maintain blood pressure and cardiac index. Creatinine clearance was calculated using the Cockcroft-Gault formula.[14]

The percentage of missing data was low (<1%) for all covariates in the model. For systolic blood pressure and heart rate on admission, missing values were imputed to the STEMI- or NSTEMI-specific median of non-missing values. For weight, baseline hemoglobin and baseline serum creatinine, missing values were similarly set to the gender and STEMI/NSTEMI-specific median of non-missing values. For categorical variables, missing values were imputed to the most frequent group.

Statistical analysis

The overall cohort was divided into derivation and validation cohorts by random number generation from a uniform (0,1) distribution. Initial candidate variables were selected on the basis of their previous associations with bleeding events or clinical importance as well as their availability at the time of hospital presentation.[7] Continuous variables are presented as mean (standard deviation) and categorical variables are presented as frequencies. Continuous variables (age, weight, baseline hemoglobin, baseline serum creatinine, baseline estimated creatinine clearance, heart rate, and systolic blood pressure on presentation) were tested for nonlinear associations with major bleeding. When applicable, plots for each continuous variable versus rates for inhospital major bleeding were examined to create dichotomous cut points.

Bivariate associations between each candidate variable and bleeding were examined using Student's t-test for continuous variables and Chi-square tests for categorical variables. To account for clustering of patients within hospitals, hierarchical logistic regression was used with site as a random effect to generate the risk model from the selected variables, along with associated odds ratios (OR) and 95% confidence intervals (CI). To establish a parsimonious model, we used a backward selection process until 90% of the full model R-square was retained.[15] We assessed discrimination using the c-statistic and compared the reduced model with the full model with IDI statistics.[16] We then tested calibration in the validation cohort and computed the c-statistic and calibration slope and intercept, with a slope of 1 and intercept of 0 indicating perfect calibration. Calibration and the range of predicted risks were visualized by plotting the predicted versus observed rate of inhospital major bleeding, according to population deciles of predicted risk. Model performance was examined in pre-specified subgroups of age, sex, race, diabetes, type of MI, cardiac arrest, cardiogenic shock, and renal function.

The ACTION Registry–GWTG inhospital bleeding risk score was created by assigning weighted integers to each variable on the basis of each variable's coefficient in the final inhospital major bleeding model. The final risk score was calculated by adding the individual weighted values. To assess risk score performance, rates of observed inhospital major bleeding were determined in the derivation and validation cohorts across five risk groups: very low risk (≤15 points), low risk (16 to 20), moderate risk (21 to 25), high risk (26 to 30), and very high risk (>30).

All comparisons were 2-tailed, and $P < .05$ was considered statistically significant. Institutional review

Table I. Candidate data elements and baseline characteristics of the derivation cohort according to the presence of in-hospital major bleeding

Category	Candidate data element	Overall derivation cohort (n = 144,800)	Derivation cohort with inhospital major bleeding (n = 10,898)	Derivation cohort without inhospital major bleeding (n = 133,902)
Demographics	Age (y), mean ± SD	64.7 ± 13.8	67.5 ± 13.5	64.4 ± 13.8
	Body mass index (kg/m^2)	29.7 ± 13.3	28.8 ± 12.6	29.7 ± 13.3
	Weight (kg)	86.5 ± 22.1	81.7 ± 22.3	86.9 ± 22.1
	Sex (% female)	50,119 (34.6%)	4907 (45.0%)	45,212 (33.8%)
	Race—White (%)	122,860 (84.8%)	9154 (84.0%)	113,706 (84.9%)
	Race—African American (%)	16,645 (11.5%)	1315 (12.1%)	15,330 (11.4%)
	Race—Asian (%)	2964 (2.0%)	236 (2.2%)	2728 (2.0%)
Past Medical History	Prior history of diabetes mellitus	48,422 (33.5%)	4348 (39.9%)	44,074 (32.9%)
	Prior history of hypertension	107,593 (74.3%)	8532 (78.3%)	99,061 (74.0%)
	Prior history of dyslipidemia	88,815 (61.4%)	6542 (60.1%)	82,273 (61.5%)
	Current/recent smoker	49,662 (34.3%)	3535 (32.4%)	46,127 (34.5%)
	Prior history of chronic lung disease	21,169 (14.6%)	2213 (20.3%)	18,956 (14.2%)
	Current dialysis	3630 (2.5%)	536 (4.9%)	3094 (2.3%)
	Prior history of myocardial infarction	36,662 (25.3%)	2854 (26.2%)	33,808 (25.3%)
	Prior history of heart failure	18,036 (12.5%)	2122 (19.5%)	15,914 (11.9%)
	Prior percutaneous coronary intervention	36,395 (25.1%)	2605 (23.9%)	33,790 (25.2%)
	Prior coronary artery bypass surgery	19,869 (13.7%)	1580 (14.5%)	18,289 (13.7%)
	Prior history of atrial fibrillation	10,911 (7.5%)	1118 (10.3%)	9793 (7.3%)
	Prior cerebrovascular disease	17,480 (12.1%)	1867 (17.1%)	15,613 (11.7%)
	Prior peripheral arterial disease	13,986 (9.7%)	1574 (14.5%)	12,412 (9.3%)
Presentation	After cardiac arrest	5845 (4.0%)	1575 (14.5%)	4270 (3.2%)
	In cardiogenic shock	5568 (3.8%)	1539 (14.1%)	4029 (3.0%)
	In heart failure	19,427 (13.4%)	2820 (25.9%)	16,607 (12.4%)
	Heart rate (beats per minute)	84.3 ± 24.0	89.5 ± 30.6	83.9 ± 23.3
	Systolic blood pressure (mmHg)	145.6 ± 34.7	136.6 ± 44.2	146.3 ± 33.7
Presentation Electrocardiogram	STEMI	56,360 (38.9%)	5138 (47.1%)	51,222 (38.3%)
	New or presumed new ST depression	17,164 (11.9%)	1443 (13.2%)	15,721 (11.7%)
	New or presumed New T wave inversion	11,708 (8.1%)	716 (6.6%)	10,992 (8.2%)
	Transient ST elevation lasting <20 min	1797 (1.2%)	114 (1.0%)	1683 (1.3%)
Initial Laboratory Values	Troponin ratio (× ULN)	2.2 (0.5, 14.1)	3.4 (0.7, 27.0)	2.1 (0.4, 13.5)
	Creatinine (mg/dL)	1.3 ± 1.2	1.7 ± 1.6	1.3 ± 1.1
	Creatinine clearance (mL/min)	69.0 ± 25.3	56.4 ± 26.4	70.0 ± 25.0
	Hemoglobin (g/dL)	13.8 ± 2.2	13.3 ± 2.9	13.8 ± 2.1
Home Medications	Aspirin	63,266 (43.7%)	4711 (43.3%)	58,555 (43.8%)
	Coumadin	7086 (4.9%)	747 (6.9%)	6339 (4.7%)
	P2Y12 inhibitor	21,626 (14.9%)	1859 (17.1%)	19,767 (14.8%)

Numbers are mean +/− (SD) or n(%); STEMI, ST-segment elevation myocardial infarction; mmHg, millimeters of mercury; ULN, upper limit of normal.

board approval for these analyses was obtained by Saint Luke's Mid America Heart Institute (Kansas City, MO) and data were analyzed using SAS version 9.4 (SAS Institute Inc, Cary, NC). No extramural funding was used to support this work. The authors are solely responsible for the design and conduct of this study, all study analyses, the drafting and editing of the manuscript, and its final contents. This research was conducted in compliance with federal guidelines, including the Common Rule (45 CFR 46). Chesapeake Research Review Incorporated serves as the internal review board. ACTION Registry®–GWTG™ has submitted a protocol to the IRB and has been granted a waiver of informed consent.

Results

Between January 2012 and December 2013, a total of 254,066 patients with AMI were admitted to 659 participating hospitals. After exclusions, the final population consisted of 241,484 patients enrolled across 657 United States centers, who were randomly assigned to a derivation (n = 144,800; 60%) and validation (n = 96,684; 40%) cohorts (Figure 1). Baseline characteristics of the derivation cohort and bivariate relationships between patients' characteristics and inhospital major bleeding are shown in Table I. The observed rate of inhospital major bleeding in the derivation and validation cohorts was 7.5% and 7.6% respectively.

Table II. Univariable and multivariable model of inhospital mortality

	Derivation cohort		
	Unadjusted model	Adjusted model	Validation cohort
Data element	OR (CI)	OR (CI)	OR (CI)
Heart rate (per 10-beat/min increase)	1.12 (1.11-1.14)	1.13 (1.12-1.14)	1.13 (1.12, 1.15)
Weight (per 10-kg decrease)	1.16 (1.14, 1.17)	1.12 (1.11, 1.14)	1.10 (1.08, 1.12)
STEMI on electrocardiogram	1.82 (1.73-1.92)	1.72 (1.65-1.80)	1.81 (1.71, 1.91)
Presentation in heart failure	1.47 (1.39-1.55)	1.55 (1.47-1.63)	1.46 (1.37, 1.56)
Presentation in cardiogenic shock	1.99 (1.83-2.16)	2.22 (2.05-2.40)	2.37 (2.16, 2.60)
Presentation after cardiac arrest	2.95 (2.72-3.19)	2.99 (2.77-3.22)	2.81 (2.56, 3.08)
Creatinine clearance (per 5 mL/min per 1.73 m^2 decrease)	1.17 (1.15-1.19)	1.07 (1.07-1.08)	1.07 (1.07, 1.08)
Hemoglobin less than 12 g/dL	1.49 (1.42-1.57)	1.55 (1.48-1.63)	1.56 (1.46, 1.65)
Age (per 5 year increase)	0.99 (0.98-1.00)	–	
Female sex	1.12 (1.06-1.17)	–	
Troponin (× upper limit of normal)	1.03 (1.02-1.04)	–	
Current or past smoker	1.09 (1.03-1.14)	–	
Hypertension	1.09 (1.03-1.16)	–	
Hyperlipidemia	0.91 (0.87-0.96)	–	
Prior MI	0.98 (0.92-1.04)	–	
Prior PCI	0.97 (0.91-1.03)	–	
Home coumadin use	1.25 (1.14-1.36)	–	
Home aspirin use	0.93 (0.89-0.98)	–	
Home clopidogrel use	1.03 (0.97-1.10)	–	

STEMI, ST-segment elevation myocardial infarction.

A complete model including all predictor variables had a C-statistic of 0.77. In creating a more parsimonious model, 8 significant, independent factors were identified: presentation after cardiac arrest (OR 2.99 [2.77-3.22]); presentation in cardiogenic shock (OR 2.22 [2.05-2.40]); STEMI (OR 1.72 [1.65-1.80]); presentation in heart failure (OR 1.55 [1.47-1.63]); baseline hemoglobin less than 12 g/dL (1.55 [1.48-1.63]); heart rate per 10 beat per minute increase (OR 1.13 [1.12-1.14]); creatinine clearance per 5 mL/minute decrease (OR 1.07 [1.07-1.08]), weight per 10 kilogram decrease (OR 1.12 [1.11, 1.14]) (Table II).

The ACTION Registry-GWTG bleeding model showed good calibration between observed and predicted rates of bleeding, with a slope of 0.98 and an intercept of 0.003. (Figure 2). The model also showed good discrimination between patients who did and did not have major bleeding events in both the derivation (C-statistic = 0.74) and validation (C-statistic = 0.74) cohorts. In addition, the model had good discrimination across subgroups of age, sex, race, diabetes, AMI type, transfer status, and renal function (Table III). Given their strong association with bleeding, model performance among patients with cardiac arrest and cardiogenic shock was more modest (0.60 and 0.59 respectively, Table III).

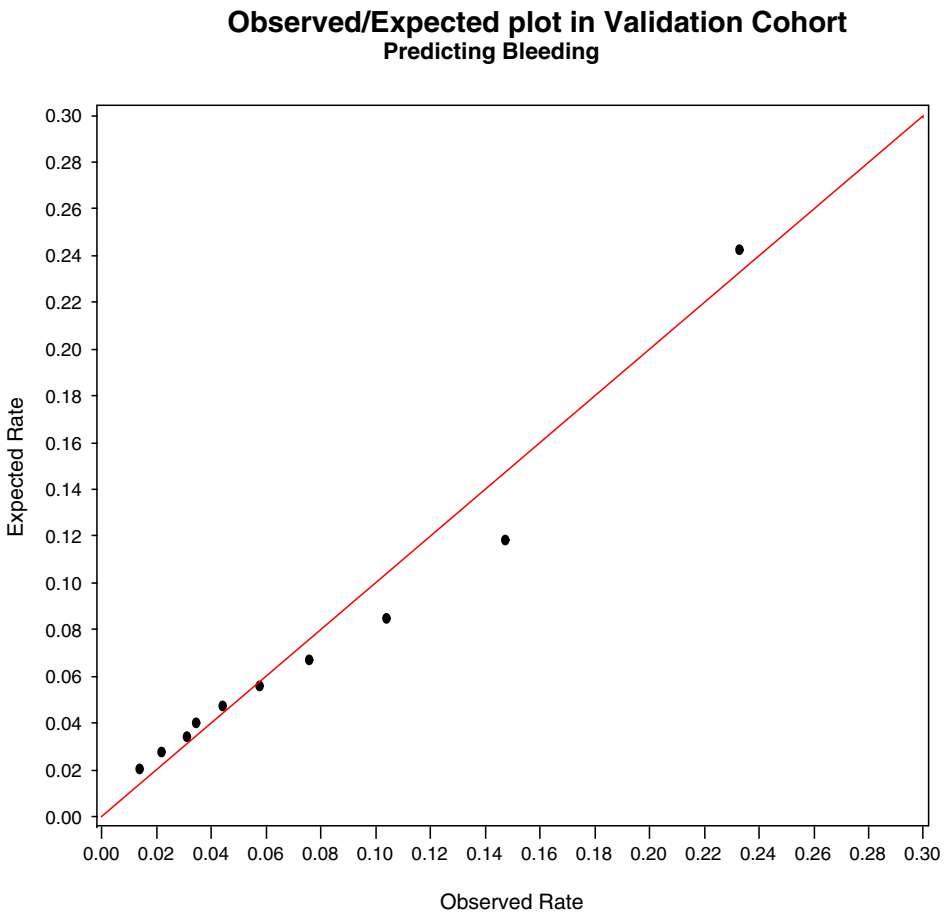
The ACTION Registry–GWTG inhospital bleeding risk score was derived by assigning weighted values to the covariates in the multivariable model (Figure 3). The distribution of bleeding score in the validation cohort was: ≤15 points, n = 30,847 (32%), 16 to 20 points, n = 30,939 (32%); 21 to 25 points, n = 18,717 (19%); 26 to 30 points, n = 10,054 (10%); and >30 points, n = 6127 (6%). The observed rates of inhospital major bleeding increased steadily across increasing risk score categories in the derivation and validation cohorts (Figure 3).

Discussion

Using a large, national registry of patients with AMI, we developed and validated a contemporary risk model to predict inhospital major bleeding. Specifically, weight, heart rate, presentation after cardiac arrest, presence of cardiogenic shock, heart failure, and STEMI on admission, creatinine clearance, and baseline hemoglobin were identified as significant, independent factors associated with major bleeding complications. The model performed well in an independent validation cohort, as well as across various clinically important subgroups and served as the basis for the development of a simplified integer score that correlated well with observed rates of bleeding. Taken together, these tools will facilitate risk adjustment required for meaningful assessment of hospital quality as well as support prospective risk stratification and clinical decision-making.

The currently developed ACTION Registry–GWTG major bleeding model builds upon and further extends prior risk models. Many of the initial major bleeding

Figure 2



Calibration curve for the validation cohort. The expected inhospital major bleeding rate plotted against expected inhospital major bleeding rate for each decile of patient risk.

models were derived from clinical trial datasets. While robust in their predictive capacity, not only are there well-established selection biases in clinical trial cohorts as compared with the general population, but the models often included adjunctive antithrombotic therapy and other treatment-related factors as covariates.[2,3,5,6] Given that models used for comparing outcomes across hospitals should not include treatments provided after presentation, such models are not appropriate for quality assessment purposes.[17] Previous registry based models also had limitations, particularly with regard to patient population as they included patients with unstable angina (a heterogeneous group of patients) while other efforts did not include patients with STEMI.[18,19] A model from ACTION Registry–GWTG was developed prior to the introduction of cardiac arrest as a new variable in the registry.[7] In our analysis, presentation after cardiac arrest was the strongest independent predictor of major bleeding and as such, strengthens the ability of the model to adequately adjust for patient-risk and provide more accurate estimates of hospital performance.

The updated ACTION Registry–GWTG bleeding risk model discriminated well in both the derivation and validation cohorts (c-statistics of 0.74) as well as across key subgroups. However, its performance was more modest among the less than 4% of patients with cardiogenic shock and cardiac arrest, in part because all of these patients are at high risk for adverse events including bleeding and the other variables did not discriminate as much in this cohort of patients. Nevertheless, the inclusion of these patients in the recent ACTION Registry–GWTG mortality model[20] and the

Table III. Inhospital major bleeding model performance overall and in key subgroups

Subgroup	Sample size	C-statistic
Full validation cohort	96,684	0.742
Caucasian	81,838	0.739
African American	11,327	0.753
Other race	3587	0.759
Male	63,069	0.756
Female	33,615	0.700
Age <75 years	71,917	0.761
Age ≥75	24,767	0.690
Transfer in	28,094	0.753
Not transfer in	68,590	0.737
Diabetes mellitus	32,475	0.728
No diabetes mellitus	64,171	0.745
Creatinine clearance <50 mL/min per 1.73 m^2 years	20,329	0.650
Creatinine clearance ≥50 mL/min per 1.73 m^2	76,355	0.732
STEMI	37,556	0.738
NSTEMI	59,128	0.736
Cardiac arrest	3877	0.601
No arrest	92,519	0.724
Shock	3900	0.590
No shock	92,732	0.721

STEMI, ST-segment elevation myocardial infarction; NSTEMI, Non-ST-segment elevation myocardial infarction.

desire to fully capture the quality of AMI care with our complementary bleeding model as well as the desire to focus attention on the care of these challenging patients, supports including them in the model.[21] As such, this new model represents the most contemporary, representative, and parsimonious inhospital major bleeding model for patients with AMI. Not only is this model suitable for risk-adjustment and hospital performance assessment, but it can also be leveraged to support quality improvement activities, such as care pathways for patients with AMI and adoption of bleeding avoidance strategies.

In parallel, variables that are available at the time of hospital presentation can be used to calculate the ACTION Registry–GWTG bleeding risk score and guide clinical care. For instance, it could be used to provide patients individualized estimates of bleeding, facilitating more informed choices and allowing providers to help tailor treatment approaches based on a patient's predicted risk.[22,23] Selection of the optimal adjunctive antithrombotic therapy, arterial access location for angiography, use of an arterial closure device, and even the type of stent may all be informed by a patient's risk of bleeding complications.

These data should be interpreted in the context of the following limitations. First, while ACTION Registry–GWTG is the largest national registry of AMI, participation in the registry is voluntary and therefore patients, care patterns, and outcomes including major bleeding in these centers may not be generalizable to all hospitals. Second, patients transferred from one hospital to another pose a challenge for outcome attribution. For this model, patients transferred into an ACTION Registry–GWTG hospital were included and major bleeding was attributed to the receiving hospital. In this regard, it is reassuring that the model performed similarly in these patients compared with patients not transferred in. On the other hand, patients transferring out of the ACTION Registry–GWTG hospital were excluded, as major bleeding could not be captured, but they represented a small proportion of patients (4.2%). Third, the candidate risk adjustment variables were limited to those available in the ACTION Registry–GWTG. It is conceivable that more information regarding patients' baseline health status, such as frailty, and other acute non-cardiac, co-existing conditions, may be strongly associated with bleeding. In addition, a prior history of bleeding is likely an infrequent but important predictor of future bleeding events but is not a data element in the ACTION Registry–GWTG. Next, the ACTION Registry–GWTG only assesses inhospital outcomes. While this information can support decision-making in the acute setting, longer-term assessment of bleeding risk would provide valuable information to patients and clinicians in optimizing care.[24] Finally, as patterns of care for patients with AMI continue to change over time, the bleeding model will likely need to be updated in the future.

In conclusion, the new ACTION Registry–GWTG inhospital major bleeding risk model and risk score represent robust, parsimonious, and contemporary risk-adjustment methodology to enable meaningful assessment of hospital quality as well as support individualized clinical decision-making.

Figure 3

A.

HR	Pts
<40	0
41-60	2
61-70	3
71-80	4
81-100	6
101-110	7
111-120	8
121-130	9
131-150	11
>=151	12

Weight	Pts
>200	0
181-200	2
171-180	4
161-170	6
151-160	9
131-150	10

CrCL	Pts
>95	0
60-90	3
45-60	6
30-45	8
<30 or Dialysis	10

Cardiac Arrest	Pts
No	0
Yes	9

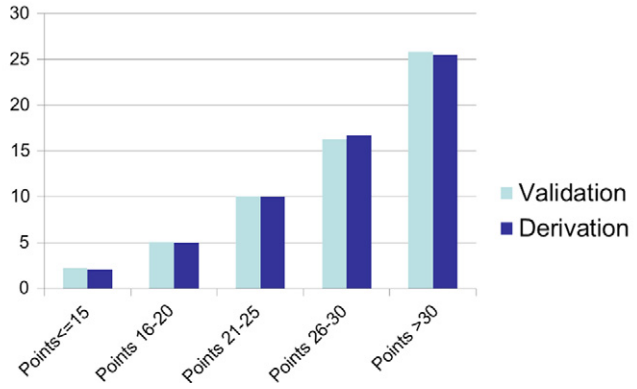
STEMI	Pts
No	0
Yes	5

Heart Failure	Pts
No	0
Yes	5

Shock	Pts
No	0
Yes	7

Hgb<12	Pts
No	0
Yes	4

B.



In-hospital major bleeding risk score and validation. (A) Point assignment for each value for each parameter. (B) Observed inhospital major bleeding for the derivation and validation cohorts by risk score subgroups.

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