CRUSADE bleeding risk score validation for ST-segment-elevation myocardial infarction undergoing primary percutaneous coronary intervention

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Abstract

Introduction

The CRUSADE bleeding risk score (CBRS) accurately predicts major bleeding in non-ST segment elevation myocardial infarction NSTEMI patients. However, little information exists about its application in ST segment elevation myocardial infarction STEMI. We aimed to assess the ability of CBRS to predict in-hospital major bleeding in STEMI patients undergoing primary percutaneous coronary intervention (PPCI).

Materials and Methods

We prospectively analyzed consecutive STEMI patients undergoing PPCI. Baseline characteristics, in-hospital complications and mid term mortality were recorded. Major bleeding was defined by the CRUSADE definition. Predictive ability of the CBRS was assessed by logistic regression method and the area under the ROC curve (AUC).

Results

We included 1064 patients (mean age 63 years). Mean CBRS value was 24. Most of patients (740/1064 (69.6%)) were in the two lowest risk quintiles of CBRS. Incidence of in-hospital major bleeding was 33/1064 (3.1%). The rates of in-hospital bleeding across the quintiles of risk groups were 0.4% (very low risk), 2.6% (low), 4.6% (moderate), 7.2% (high), and 13.4% (very high) (p 0.001). AUC was 0.80 (95% CI 0.73-0.87 p 0.001). In patients with radial access angiography (n = 621) AUC was 0.81 (95% CI: 0.65-0.97). Mean follow up was 344 days. Patients with bleeding events had higher mortality during follow up (HR 6.91; 95% CI 3.72-12.82; p 0.001).

Conclusions

Our patients had a significantly lower bleeding risk as compared to CRUSADE NSTEMI population. CBRS accurately predicted major in-hospital bleeding in this different clinical scenario, including patients with radial artery approach.

Keywords: ST segment elevation myocardial infarction, Bleeding, Prognosis.

Introduction

Major bleeding events are associated with worse outcomes in patients with acute coronary syndromes (ACS) [1], [2], [3]. Bleeding risk assessment in this clinical scenario is much more limited than ischemic risk stratification. Most of the few existing predictive models of bleeding in ACS [4], [5] have been derived from populations included in clinical trials in which high-risk patients are clearly underrepresented and prevalence of comorbidities is usually low. In contrast, the Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA guidelines (CRUSADE) bleeding risk score [6] (CBRS) was developed in a broad population of community treated non-ST segment elevation myocardial infarction (NSTEMI) patients and showed an accurate predictive power of major bleeding in patients with NSTEMI, and has become one of the most important tools for bleeding risk stratification in this clinical scenario. However, little information exists about its application in patients with ST segment elevation myocardial infarction (STEMI). Therefore, the aim of this study was a) to assess baseline characteristics and overall bleeding risk in a cohort of non-selected STEMI patients undergoing primary percutaneous coronary intervention (PCI) and b) to assess the ability of CBRS to predict major in-hospital bleeding non related to surgery in this clinical setting.

Materials and Methods

Study Design and Population

All consecutive patients admitted to the Coronary Care Unit of our center with diagnosis of STEMI and undergoing primary PCI between October 2009 and April 2012 were prospectively included. Afterwards, patients under chronic anticoagulant treatment and patients with missing CBRS values were excluded from the analysis. Informed consent was given by all patients before their inclusion. Confidential information of the patients was protected according to national normative. The study protocol was reviewed by the Clinical Research Ethics Committee of Bellvitge University Hospital (IRB00005523).

Study Protocol

Criteria for primary PCI were presentation within 12 hours of onset of chest pain suggestive of AMI and ST segment elevation > 0.2 mV in 2 adjacent chest leads or > 0.1 mV in 2 or more adjacent limb leads; or new-onset (or presumed new-onset) left bundle-branch block. Patients were pretreated with a loading oral dose of 250–300 mg of aspirin, 600 mg of clopidogrel and an intravenous dose of unfractionated heparin and aferwards they were directly transferred to the cath lab. Access site, antithrombotic

treatments during angiography and choice of stents and other devices was left to operator's discretion, according to current recommendations [7].

Data Collection and Definitions

Data were prospectively collected on site by trained physicians using a standardized case report form. Baseline characteristics, medical history, biochemical and electrocardiographic findings, treatments administered during hospitalization, incidence of in-hospital bleeding events and their anatomic location were collected. All elements included in the CRUSADE definition categories (baseline and lowest recorded haemoglobin, need for transfusion, bleeding location) were included in the case report form. All the elements included in the Mehran [4] and ACTION [8] bleeding risk scores were also included in the case report forms.
Both CBRS, ACTION and Mehran bleeding risk scores value were calculated for each patient. The development of the CBRS and the rest of bleeding risk scores has been described in detail previously [4], [6], [8].
In-hospital bleeding events were recorded using the CRUSADE definition [6]. Major bleeding events were also categorized by the TIMI [9], Mehran [4] and BARC [10] definitions.
Creatinine clearance was calculated using the Cockcroft-Gault formula [11]. Body surface area was calculated using the Mosteller formula [12] Haemodynamic parameters (heart rate, systolic blood pressure) and Killip class were measured at admission. The quality of data collection was assessed by checking source documentation in random samples.

Follow Up Criteria

In-hospital and mid-term overall mortality were also assessed. Information on deaths was obtained from hospital records, death certificates, or telephone contact with relatives of the patient or referring physician.

Statistical Analysis

Quantitative variables were expressed as mean and standard deviation. For baseline variables, t Student test was used for comparison of quantitative variables and chi-square test or Fisher's exact test, when appropriate, were used for categorical variables (PASW Statistics 18, Chicago, IL, USA and MedCalc software, Belgium). The analysis of normal distribution of variables was performed using the Shapiro-Wilk test.
For validation of the CBRS in our population we used binary logistic regression method, using major CRUSADE bleeding events as dependent variable and CBRS value as independent variable. We calculated the ROC curves of the model obtained. The area under the ROC curve (AUC) was calculated in order to assess predictive accuracy of the model. Calibration of the model was assessed by the Hosmer-Lemeshow test.

The ability of the CBRS, Mehran and ACTION for predicting major in-hospital bleeding according to different definitions (CRUSADE, Mehran, TIMI and BARC) was also assessed by binary regression logistic method, calculating ROC curves and their corresponding AUC. The non-parametric method described by DeLong [13] was used in order to compare the predictive ability of the different bleeding risk scores.
For the association between CBRS and major bleeding, CBRS values were categorized in quintiles of risk, as previously described [6] (0–20: very low risk, 21–30: low risk; 31–40: moderate risk; 41–50 high risk; > 50: very high risk).
The association between the CBRS quintiles and in-hospital mortality was assessed by Chi square test. The association between CBRS quintiles and mid-term mortality, as well as the association between major CRUSADE bleeding and mid-term mortality were assessed by the Cox regression method. Survival curves were performed using the actuarial method.

Results

Of a population of 1177 consecutive patients treated with primary PCI we included 1064 patients. We excluded 24 (2%) patients on chronic oral anticoagulation, and 93 (7.9%) with missing data on CBRS.

Baseline Characteristics, CBRS and Bleeding Risk

Baseline characteristics of patients are shown in Table 1. Ours was a relatively young population (mean age 61.7 years), with almost 80% of male and low rates of cardiovascular risk factors and other comorbidities. Overall bleeding risk was low, with a mean CBRS value of 24.6. Most of the patients in our series were in the lowest risk quintiles of CBRS (Fig. 1), in contrast to CRUSADE NSTEMI population.

Patients who suffered major in-hospital bleeding were less often men than patients without bleeding, with higher rates of diabetes mellitus, worse renal function, more unstable haemodynamic status on admission, poorer left ventricular systolic function and higher CBRS score. In addition, patients with bleeding underwent more often angiography via the femoral approach, showed higher requirements of in-hospital invasive procedures and higher rates of in-hospital complications (Table 2).

In-hospital Major Bleeding

The rate of major bleeding was 3.1% (n = 33). Among patients with major bleeding, the (nonexclusive) occurrence of the individual components of the CRUSADE major bleeding definition was as follows: Intracranial hemorrhage 9.1%; documented retroperitoneal bleed 3%; hematocrit drop > 12% (baseline to nadir) 78.8%, and any red blood cell transfusion when baseline hematocrit was > 28% 33.3%.

Most of in-hospital major bleeding events according to CRUSADE definition were of unknown location both in patients with femoral access angiography (15/26, 57.7%) and in patients with radial access (6/7, 85.7%). In patients with femoral approach and known bleeding location, angiography site related bleeding was the most common origin (4/11, 36.3%) followed by intracranial bleeding (3/11, 27.3%).
The rate in-hospital major bleeding according to different definitions was as follows: Mehran major bleeding 41/1064 (3,8%); TIMI major bleeding 14/1064 (1,3%) and BARC 3 and 5 bleeding 19/1064 (1,8%)).

CBRS and Major Bleeding

The CBRS accurately discriminated patients with major in-hospital bleeding. As shown in Fig. 2, the rates of major in-hospital bleeding across the quintiles of CBRS groups were 0.4% (very low risk), 2.6% (low risk), 4.6% (moderate risk), 7.2% (high risk), and 13.4% (very high risk) (p 0.001). The area under the ROC curve of the predictive model was 0.80 (95% CI 0.73-0.87 p 0.001).

The performance of the CBRS across treatment subgroups was confirmed by formal testing. Among patients receiving glycoprotein IIb/IIIa inhibitors (n = 288), the AUC was 0.86 (IC 95%: 0.77-0.96). The rate of major in-hospital bleeding was higher if patients received glycoprotein IIb/IIIa inhibitors in every CBRS quintile: 0.6% versus 0.3% (very low risk), 4.5% versus 1.6% (low risk), 6.9% versus 4.2% (moderate risk), 14.3% versus 6.2% (high risk), and 35.7% versus 9.0% (very high risk) (P = 0.0001).
A good performance was found both in patients undergoing radial angiography (58.4%; n = 621) and patients undergoing femoral angiography (41.6%; n = 443). Rates of major in-hospital bleeding across the quintiles of risk in patients with radial approach were 0.3% (very low risk), 1.3% (low risk), 0% (moderate risk), 5.6% (high risk), and 11.1% (very high risk) (p 0.009). AUC of the model in patients with radial angiography was 0.81 (95% CI: 0.65-0.97). Likewise, rates of major in-hospital bleeding across the quintiles of risk in patients with femoral approach were 0.7% (very low risk), 4.0% (low risk), 9.6% (moderate risk), 8.5% (high risk), and 14.8% (very high risk) (p 0.001). AUC of the model in patients with femoral angiography was 0.73 (95% CI: 0.65-0.81).
Fig. 3 shows AUC for the ability of the CBRS for predicting major in-hospital bleeding in patients undergoing radial (A) and femoral angiography (B).

The specific contribution of each of the components of the CBRS for the prediction of bleeding in our series was also analyzed (Table 3). Heart rate, creatinine clearance and systolic blood pressure remained as independent predictors of CRUSADE major in-hospital bleeding in our patients. In the radially treated group the ndependent predictors of bleeding were both heart rate and systolic blood pressure at admission.

CBRS and Mortality

A significant association was found between CBRS quintiles and mortality. Patients in higher risk quintiles had higher in-hospital mortality (Fig. 4).
This association was observed regardless the access site on angiography. Rates of in-hospital mortality across the quintiles of risk in patients with radial approach were 0% (very low risk), 1.2% (low risk), 2.5% (moderate risk), 0% (high risk), and 21.1% (very high risk) ($p < 0.001$). Likewise, rates of major in-hospital mortality across the quintiles of risk in patients with femoral approach were 0% (very low risk), 5.0% (low risk), 2.7% (moderate risk), 10.3% (high risk), and 11.7% (very high risk) (p 0.001).
A significant association was also found between CBRS quintiles and mid-term mortality (Fig. 5).

Comparison of the Predictive Ability of the Bleeding Risk Scores

There were no significant differences between predictive ability of the three bleeding risk scores for any of the different definitions of bleeding (Table 4a, Table 4b). The performance of the three scores was worse for predicting BARC 3/5 bleeding than for the rest of definitions. On the other hand, calibration was acceptable (HL $p > 0.2$) for CRUSADE and ACTION scores, but not fore Mehran score for any of the definitions used.

Major Bleeding and Mortality

A significant association between in-hospital major bleeding events and mid term mortality was also found. As shown in Fig. 6, patients with in-hospital bleeding had higher mortality during follow up (HR 6.91; 95% CI 3.72-12.82; p 0.001)

Discussion

Tha main findings of our study were: a) our population of non selected STEMI patients undergoing primary PCI had lower overall bleeding risk than CRUSADE NSTEMI population; b) the CBRS had a good performance in this different clinical scenario and c) major CRUSADE in-hospital bleeding events was associated with a significantly higher mid term mortality in or series.

Bleeding risk assessment in patients with ACS is much more limited than ischemic risk stratification [14], [15], [16]. The CBRS [6] has become one of the most important tools of bleeding risk stratification in patients with NSTEMI. Although some authors have provided data supporting its application in patients with STEMI [17], [18], to date no study has analyzed this particular subject.

Validation of CBRS in STEMI is a clinically relevant issue since these patients usually have lower prevalence of comorbidities [19], [20] and different timing of in-hospital treatments and procedures, thus potentially leading to a different overall bleeding risk. As suspected, baseline characteristics of our series were clearly different than CRUSADE NSTEMI population. Our patients were younger (62 vs 67 years), more often males (79.8% vs 60.2%), with a lower incidence of cardiovascular factors and other comobidities. In addition, overall bleeding risk was significantly lower in our population, with most of the patients in the lowest risk quintile of CBRS, in contrast to CRUSADE NSTEMI population [6].

Interestingly, we observed some differences regarding the specific contribution of each of the components of the CBRS for the prediction of bleeding in our series as compared to CRUSADE NSTEMI population [6]. Certain variables remained clearly as independent predictors of bleeding, such as heart rate, creatinine clearance or systolic blood pressure at admission. In contrast, other variables clearly lost its association with bleeding, such as baseline hematocrit. However, these data should be interpreted with caution due to small sample size of our series as compared to CRUSADE NSTEMI population.

The comparison of the performance of CBRS with different bleeding risk scores has been previously assessed. Flores-Rios et al. [18] described an acceptable predictve ability of the three bleeding risk scores, but slightly better for CBRS and ACTION as compared to Mehran in a series of 1391 STEMI patients undergoing primary percutaneous coronary intervention. The authors did not find significant differences regarding calibration for the three risk scores. Abu-Assi et al. [17] analyzed a large series of 4500 patients with acute coronary syndromes, finding a good predictive ability of the three bleeding risk scores in patients undergoing coronary angiography, and describing the CBRS as the most accurate quantitative tool for patients with acute coronary syndrmes undergoing coronary angiography.

Our results are not significantly different to those previously reported. We also found a similar discrimination for the three bledding risk scores, slightly better for the CBRS for most definitions used. The finding of a poorer calibration for the Mehran score in our patients needs futher investigation.

Another interesting question is the influence of radial approach angiography on bleeding risk. The radial approach has demonstrated in several observational studies a reduction in bleeding complications [21], [22], as well as a change in its most common location [23]. The RIVAL trial [24] randomized 7021 patients with ACS to radial or femoral artery coronary angiography, showing a significant interaction for the primary outcome (death, MI, stroke and non CABG related major bleeding) with benefit for radial access in highest tertile volume radial centres and in patients with ST-segment elevation myocardial infarction. We also observed a lower bleeding risk and different bleeding location in patients with radial coronary angiography. The application of CBRS in this different

clinical setting has not been extensively studied. Therefore, the validation of the ability of the CBRS for predicting bleeding and mortality in patients undergoing radial angiography is another interesting contribution of this paper.

This study has the inherent limitations of being a single center registry. The number of bleeding events was relatively small. In addition, the use of novel antithrombotic drugs like prasugrel or ticagrelor was virtually absent in our patients. Finally, excluding patients with missing CBRS values might have implied certain bias. However, the analysis of baseline characteristics of these patients showed no significant differences from the remaining patients. In spite of these limitations, we believe our findings strongly support the application of the CBRS in patients with STEMI undergoing primary PCI, including patients with radial coronary angiography.

In conclusion, our population of non-selected STEMI patients undergoing primary PCI had different clinical characteristics and lower overall bleeding risk than CRUSADE NSTEMI population. The CBRS showed a good ability to predict in-hospital major bleeding in this different clinical setting, including patients undergoing radial approach angiography

Conflict of Interest Statement

There are no conflicts of interest regarding this paper.

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Tables

Table 1
Baseline and clinical characteristics according to CRUSADE major in-hospital bleeding evets.

	Whole cohort (n = 1064)	Bleeding (n = 33)	No bleeding (n = 1031)	p
Male sex	849 (79.8)	21 (63.6)	828 (80.3)	0.019
Age	61.7 (13)	63.0 (12)	61.7 (13)	0.571
Body mass index	27.8 (4)	27.7 (6)	27.8 (4)	0.937
BSA[a]	1.90 (0.2)	1.87 (0.3)	1.90 (0.2)	0.518
Diabetes mellitus	253 (23.8)	14 (42.4)	239 (23.2)	0.011
Hypertension	572 (53.8)	20 (60.6)	552 (53.5)	0.423
Dyslipidemia	569 (53.5)	15 (45.5)	554 (53.7)	0.348
Active smoking	516 (48.5)	18 (54.5)	498 (48.2)	0.480
Previous MI[b]	113 (10.6)	1 (3)	112 (10.9)	0.245
Previous PCI[c]	90 (8.5)	1 (3)	89 (8.6)	0.354
Previous stroke	63 (5.9)	1 (3)	62 (6)	0.716
PAV[d]	81 (7.6)	6 (18.2)	75 (7.3)	0.034
Haematocrit	41.8 (5)	43.0 (6)	41.8 (5)	0.294
Creatinine clearance (ml/min)	94.2 (51)	69.7 (25)	95.1 (52)	0.005
Previous bleeding	30 (2.8)	1 (3)	29 (2.8)	0.617
Anterior location	475 (44.6)	19 (57.6)	456 (44.2)	0.129
Killip class				0.001
I	875 (82.2)	17 (51.5)	858 (83.2)	
II	137 (12.9)	4 (12.1)	133 (12.9)	
III	24 (2.3)	4 (12.1)	20 (1.9)	
IV	28 (2.6)	8 (24.2)	20 (1.9)	
SBP[e]	128 (26)	111 (25)	128 (26)	0.001
HRf	81 (17)	98 (22)	80 (17)	0.001
LVEF[g]	51.2 (10)	44 (13)	52 (10)	0.001
Mean CBRS value[h]	24.6 (15)	41.5 (15)	24 (15)	0.001
Angiographic data				
Femoral acces site	436 (41.2)	26 (78.8)	410 (40)	0.001
Num vessels involved				0.267
1	680 (63.9)	17 (51.5)	663 (64.3)	
2	266 (25)	12 (36.4)	254 (24.6)	
3	91 (8.6)	4 (12.1)	87 (8.4)	
TIMI 3 flow post PCI in culprit	954 (93.3)	25 (78.1)	929 (93.8)	0.001

a) BSA: Body surface area; b) MI: Myocardial infarction; c) PCI: Percutaneous coronary intervention; d) PAV: peripheral arterial vasculopathy;e) SBP: Systolic blood pressure; f) HR: Heart rate; g) LVEF: Left ventricular ejection fraction; CBRS: h) CRUSADE bleeding risk score.

Table 2
Management and in-hospital clinical course according to CRUSADE major in-hospital bleeding events.

	Overall cohort (n = 1064)	Bleeding (n = 33)	No bleeding (n = 1031)	p
Anti-thrombotic treatments and in-hospital procedures performed				
Aspirin	1063 (99.9)	33 (100)	1030 (99.9)	0.858
Clopidogrel	1057 (99.3)	33 (100)	1024 (99.3)	0.635
Enoxaparin	185 (17.4)	9 (27.3)	176 (17.1)	0.128
UFH[a]	897 (84.3)	28 (84.8)	869 (84.3)	0.930
Bivalirudin	219 (20.6)	4 (12.6)	215 (20.9)	0.222
Abciximab	288 (27.1)	13 (39.4)	275 (26.7)	0.105
IABP[b]	46 (4.3)	11 (33.3)	35 (3.4)	0.001
Swan-Ganz catheter	28 (2.6)	18 (54.5)	10 (1)	0.001
Hemodyalsis	6 (0.6)	2 (6.1)	4 (0.4)	0.013
Invasive mechanical ventilation	57 (5.4)	16 (48.5)	41 (4)	0.001
Transient pacemaker	43 (4.3)	7 (21.2)	36 (3.7)	0.001
Therapeutic hypothermia	20 (1.8)	7 (17.9)	13 (1.2)	0.001
In-hospital clinical course				
Atrio-ventricular block	93 (8.8)	7 (21.2)	86 (8.4)	0.020
Ventricular fibrillation	87 (8.4)	10 (31.3)	77 (7.5)	0.001
Reinfarction	9 (0.8)	3 (9.1)	6 (0.8)	0.002
VSD[c]	2 (0.2)	0	2 (0.2)	0.939
Ischemic MR[d]	2 (0.2)	0	2 (0.2)	0.939
Cardiac rupture	4 (0.4)	0	4 (0.4)	0.941
Infections[e]	40 (3.8)	18 (54.5)	22 (2.1)	0.001
In-hospital mortality	27 (2.5)	7 (21.2)	20 (1.9)	0.001

a) UF: Unfractionated heparin; b) IABP: Intra-aortic balloon pump; c) VSD: Ventricular septal defect; d) MR: Mitral regurgitaton; e) Infections were defined as infectious complications requiring antibiotics.

Table 3
Specific contribution (Odds Ratio and 95% Confidence interval) of each of the components of the CRUSADE bleeding risk score for the prediction of in´hospital major CRUSADE bleeding.

	Overall		Radial approach		Femoral approach	
	Univariate	Mutivariate	Univariate	Multivariate	Univariate	Multivariate
Baseline hematocrit <36% (vs >=36)	1.09 (0.42-2.85)	0.42 (0.13-1.33)	3.14 (0.62-15.9)	1.44 (0.21-10.6)	0.60 (0.18-2.04)	0.22 (0.05-1.05)
CrCl (per 10 mL/min decrease)	1.22 (1.09-1.35)	1.15 (1.03-1.30)	1.21 (0.96-1.51)	1.22 (0.89-1.65)	1.14 (1.01-1.29)	1.09 (0.95-1.24)
HR (per 10 bpm increase)	1.78 (1.48-2.14)	1.56 (1.28-1.91)	2.46 (1.61-3.75)	2.32 (1.42-3.78)	1.52 (1.23-1.86)	1.33 (1.07-1.66)
Female sex	2.19 (1.12-4.27)	1.69 (0.79-3.62)	1.55 (0.31-7.70)	0.65 (0.06-6.79)	1.96 (0.92-4.17)	2.09 (0.88-4.99)
CHF	5.11 (2.67-9.75)	1.70 (0.79-3.66)	2.04 (0.41-10.3)	0.16 (0.01-2.18)	5.05 (2.39-10.7)	2.31 (0.94-5.66)
SBP <= 110 mmHg (vs 110–180)	3.35 (1.75-6.43)	2.54 (1.23-5.24)	10.5 (2.09-52.5)	12.8 (1.98-82.8)	2.48 (1.16-5.27)	1.76 (0.75-4.14)
Prior vascular disease	2.58 (1.11-6.01)	2.14 (0.78-5.89)	4.76 (0.93-24.3)	3.66 (0.46-29.4)	1.88 (0.69-5.15)	1.82 (0.53-6.19)
Diabetes mellitus	1.81 (0.93-3.53)	1.50 (0.72-3.14)	3.77 (0.93-15.3)	1.80 (0.32-10.0)	1.27 (0.58-2.78)	1.49 (0.63-3.54)

*CrCl: Creatinine clearance; HR: Heart rate; CHF: Signs of congestive heart failure at admission; SBP: Systolic blood pressure at admission.

Table 4a
Calibration and discrimination for the CRUSADE, Mehran and ACTION risk scores for the prediction of major bleeding according to different definitions.

	CRUSADE bleeding		Mehran bleeding		TIMI major		BARC 3/5	
	AUC	HL (p)	AUC	HL (p)	AUC	HL (p)	AUC	HL (p)
CRUSADE score	0.80 (0.73-0.87)	0.368	0.74 (0.69-0.80)	0.263	0.76 (0.70-0.82)	0.264	0.66 (0.60-0.73)	0.270
Mehran score	0.76 (0.71-0.82)	0.041	0.69 (0.61-0.76)	0.040	0.72 (0.67-0.78)	0.012	0.66 (0.61-0.72)	0.017
ACTION score	0.75 (0.69-0.80)	0.905	0.71 (0.65-0.78)	0.875	0.74 (0.68-0.79)	0.375	0.65 (0.54-0.75)	0.738

*AUC: area under the ROC curve. HL: Hosmer-Lemeshow test.

Table 4b
Comparisons of the ability of CRUSADE, ACTION and Mehran scores for predicting major bleeding according to different definitions.

Comparison of scores	CRUSADE bleeding (p)	Mehran bleeding (p)	TIMI major bleeding (p)	BARC 3/5 (p)
CUSADE vs ACTION	0.146	0.215	0.561	0.809
CRUSADE vs Mehran	0.204	0.063	0.364	0.905
ACTION vs Mehran	0.915	0.589	0.727	0.752

*p values were obtained by the non-parametric method described by DeLong.

Figures

Figure 1. Patients (%) of each cohort on every CRUSADE bleeding risk quintile.

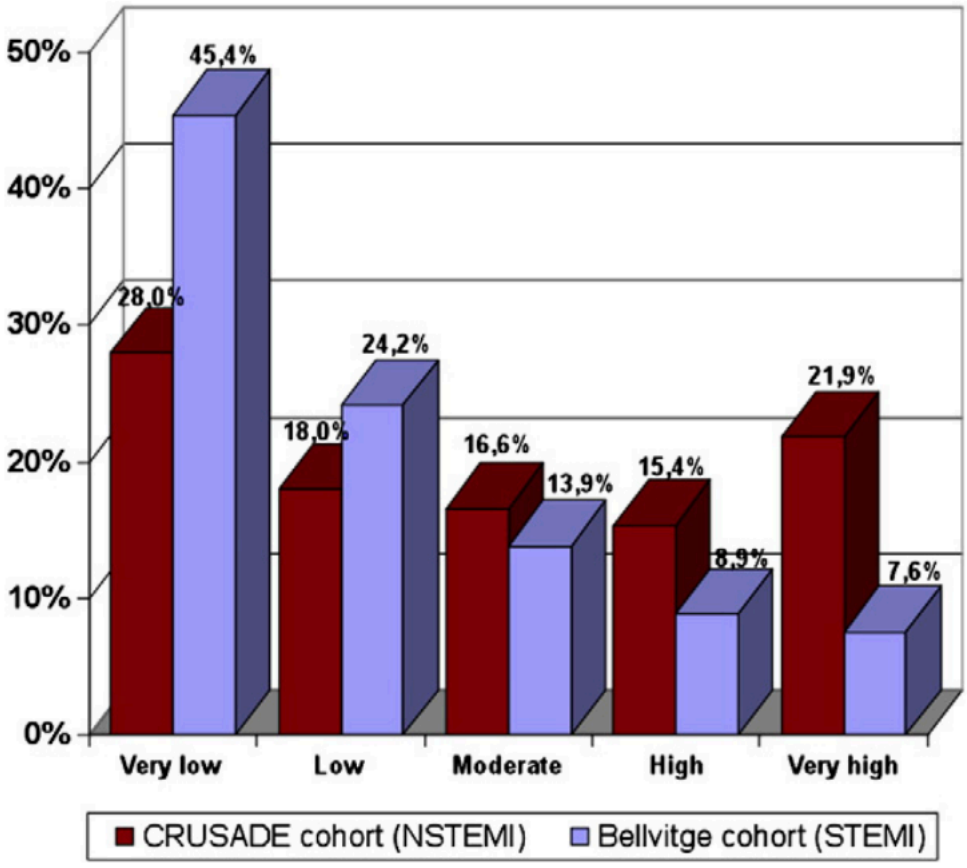


Figure 2. % of major in-hospital bleeding according to CRUSADE bleeding risk score quintiles.

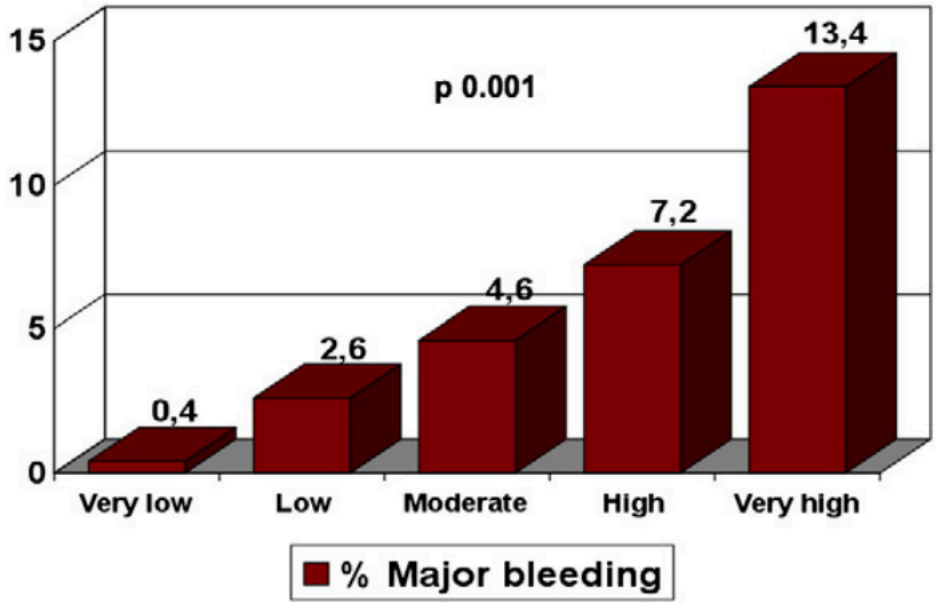


Figure 3. Area under the curve for the ability of the CRUSADE bleeding risk score for predicting major in-hospital CRUSADE bleeding in patients undergoing radial (A) or femoral (B) angiography.

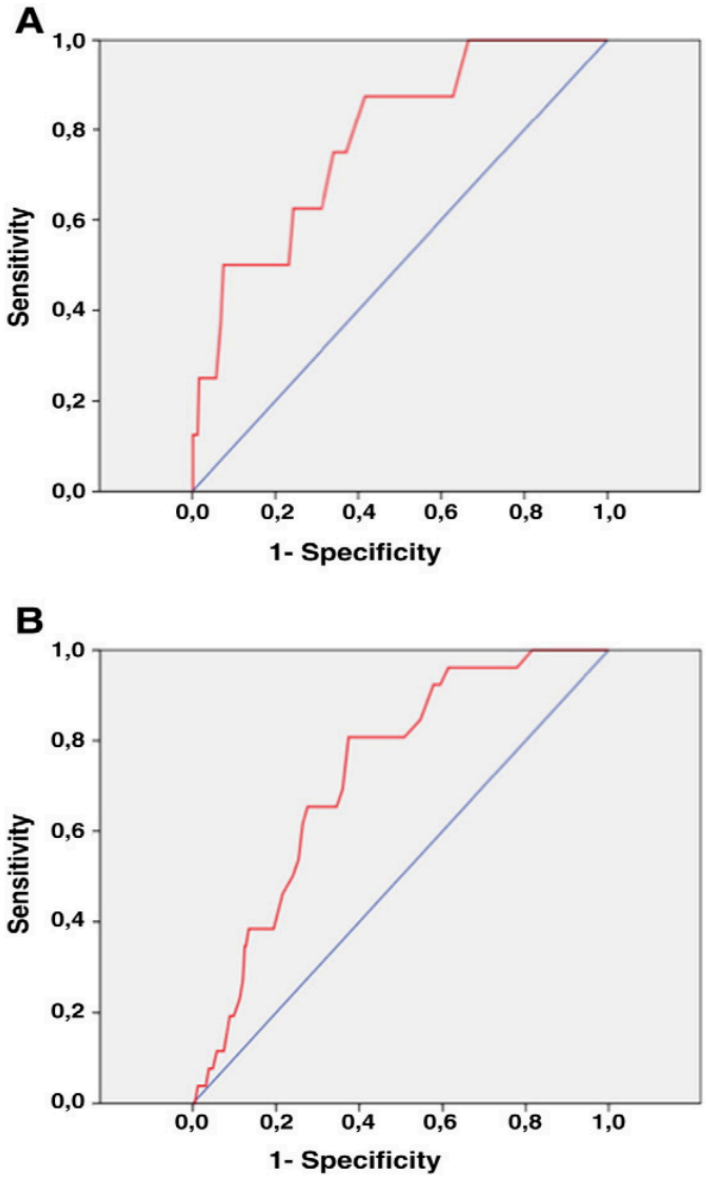


Figure 4. % of in-hospital mortality according to CRUSADE bleeding risk score quintiles.

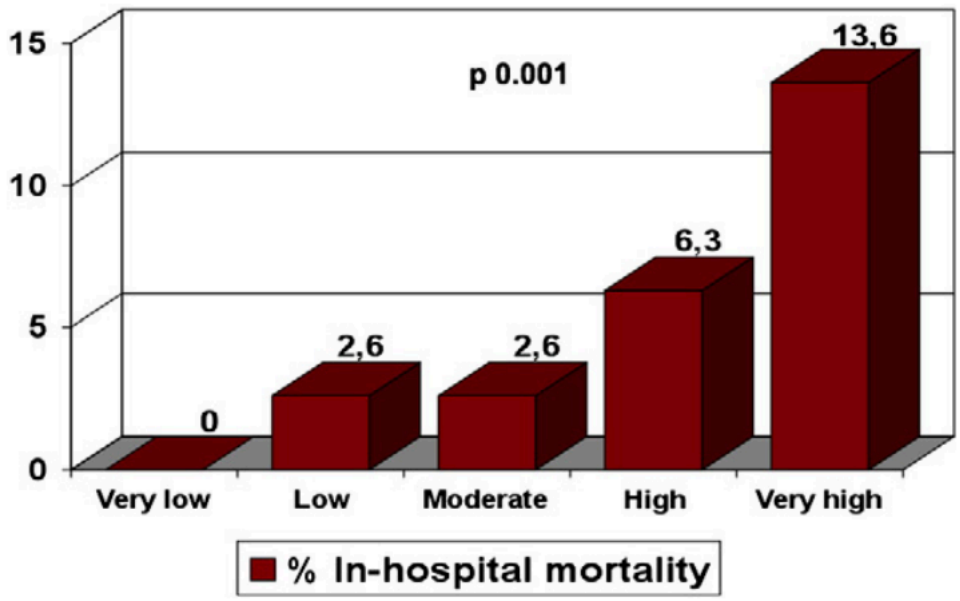
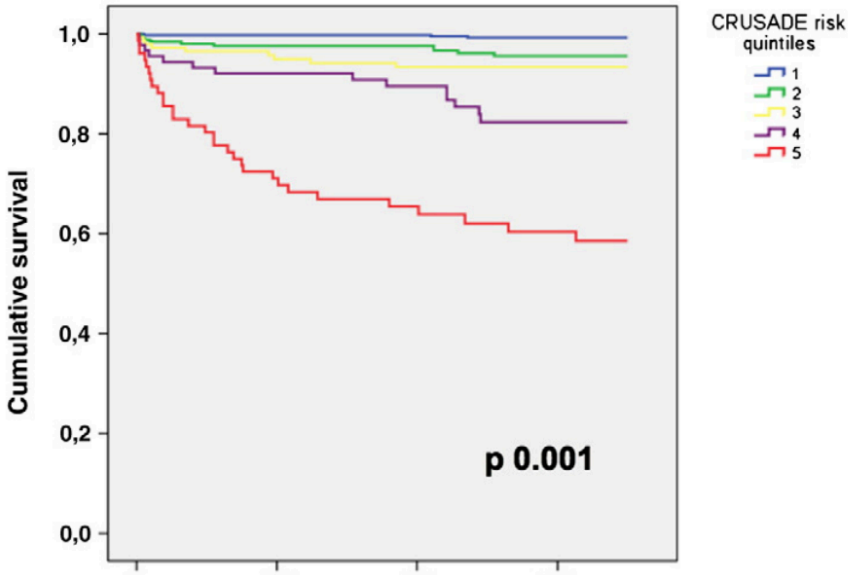


Figure 5. Mid-term mortality according to CRUSADE bleeding risk score quintiles.



Patients at risk				
Q1 (very low risk)	450	429	396	286
Q2 (low risk)	249	226	206	162
Q3 (moderate risk)	142	124	115	84
Q4 (high risk)	90	76	67	45
Q5 (very high risk)	76	53	42	35

Figure 6. Mid-term mortality according to major in-hospital CRUSADE bleeding events.