Comparison of the performance of the CRUSADE, ACUITY-HORIZONS, and ACTION bleeding risk scores in STEMI undergoing primary PCI: insights from a cohort of 1391 patients

European Heart Journal: Acute Cardiovascular Care
2(1) 19–26

© The European Society of Cardiology 2012

Reprints and permission:

sagepub.co.uk/journalsPermissions.nav

DOI: 10.1177/2048872612469885

acc.sagepub.com

**X Flores-Ríos, D Couto-Mallón, J Rodríguez-Garrido,
M García-Guimaraes, P Gargallo-Fernández, P Piñón-Esteban,
G Aldama-López, J Salgado-Fernández, R Calviño-Santos,
N Vázquez-González and A Castro-Beiras**

Abstract

Aims: To compare the performance of the CRUSADE, ACUITY-HORIZONS, and ACTION risk models in the ST-segment elevation myocardial infarction (STEMI) undergoing primary percutaneous coronary intervention (PPCI).

Methods: We studied all consecutive patients with STEMI who underwent PPCI at our institution between 2006 and 2010 ($n=1391$). The CRUSADE, ACUITY-HORIZONS, and ACTION risk scores were calculated based on the patients' clinical characteristics. The occurrence of in-hospital major bleeding (defined as the composite of intracranial or intraocular bleeding, access site haemorrhage requiring intervention, reduction in haemoglobin ≥ 4 g/dl without or ≥ 3 g/dl with overt bleeding source, reoperation for bleeding, or blood transfusion) reached 9.8%. Calibration and discrimination of the three risk models were evaluated by the Hosmer–Lemeshow test and the C-statistic, respectively. We compared the predictive accuracy of the risk scores by the DeLong non-parametric test.

Results: Calibration of the three risk scores was adequate, given the non-significant results of Hosmer–Lemeshow test for the three risk models. Discrimination of CRUSADE, ACUITY-HORIZONS, and ACTION models was good (C-statistic 0.77, 0.70, and 0.78, respectively). The CRUSADE and ACTION risk scores had a greater predictive accuracy than the ACUITY-HORIZONS risk model ($z=3.89$, p -value=0.0001 and $z=3.51$, p -value=0.0004, respectively). There was no significant difference between the CRUSADE and ACTION models ($z=0.63$, $p=0.531$).

Conclusions: The CRUSADE, ACUITY-HORIZONS, and ACTION scores are useful tools for the risk stratification of bleeding in STEMI treated by PPCI. Our findings favour the CRUSADE and ACTION risk models over the ACUITY-HORIZONS risk score.

Keywords

Bleeding, ischaemic heart disease, myocardial infarction, primary percutaneous coronary intervention, risk score

Received: 9 July 2012; accepted: 10 November 2012

Introduction

Bleeding is frequent among patients with acute coronary syndromes (ACS) and is associated with a high risk of death and myocardial infarction.^{1,2} Given its clinical importance, bleeding risk stratification is a key part of the management of patients presenting with ACS.¹

Complejo Hospitalario Universitario A Coruña, A Coruña, Spain

Corresponding author:

Dr Xacobe Flores Ríos, Interventional Cardiology Unit, Complejo Hospitalario Universitario A Coruña, As Xubias 84, 15009 A Coruña, Spain.

Email: xacobeflores@yahoo.es

Table 1. Bleeding risk scores in acute coronary syndromes.

	CRUSADE (2009)	ACUITY-HORIZONS (2010)	ACTION-GWTG (2011)
Study population	CRUSADE quality improvement initiative Derivation cohort (n=71,277) Validation cohort (n=17,857)	ACUITY trial (n=13,819) HORIZONS-AMI trial (n=3602)	ACTION-GWTG registry Derivation cohort (n=72,313) Validation cohort (n=17,960)
Type of ACS	NSTEMI	NSTEMI (ACUITY) and STEMI (HORIZONS)	NSTEMI and STEMI
Risk model variables	Female sex Diabetes CrCl Vascular disease Haematocrit <36% Heart failure Heart rate Systolic BP ≤ 110 mmHg Systolic BP ≥ 180 mmHg	Female sex Age Baseline creatinine White blood cell count Anaemia Clinical presentation Antithrombotic medications	Age Body weight Female sex Warfarin use Diabetes Vascular disease Baseline haemoglobin Baseline creatinine Heart failure/shock Heart rate Systolic BP ECG changes
C-statistic	Derivation cohort 0.71 Validation cohort 0.70	0.74	Derivation cohort 0.73 Validation cohort 0.71

CRUSADE, Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY, Acute Catheterization and Urgent Intervention Triage strategy; HORIZONS, Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry.

Three risk scores have been recently developed and validated to assess the bleeding risk of ACS patients: the Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines (CRUSADE) bleeding score,³ the Acute catheterization and urgent intervention triage strategy and The Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction (ACUITY-HORIZONS) risk score,⁴ and the Acute Coronary Treatment and Intervention Outcomes Network Registry – Get With the Guidelines (ACTION Registry-GWTG) risk score (Table 1).⁵

Nevertheless, the performance of these three risk models has not been compared to date in the ST-segment elevation myocardial infarction (STEMI). Moreover, none of these risk scores has been validated to date in the setting of trans-radial approach for percutaneous coronary intervention (PCI).⁶

We sought to evaluate their predictive accuracy in a contemporary cohort of patients with STEMI undergoing primary PCI (PPCI), mainly using radial access.

Methods

Study population

All consecutive patients with STEMI undergoing PPCI at our hospital between January 2006 and December 2010

composed our study population. Patients who underwent rescue PCI were excluded from the present analysis.

STEMI was defined as typical chest pain lasting >30 minutes but <12 hours with documented ST-segment elevation ≥1 mm in ≥2 contiguous leads (or reciprocal ST-segment depression ≥1 mm in V1 or V2) or (presumed) new left bundle branch block and elevated markers of myocardial necrosis (CK-MB, troponins).⁷

According to our treatment protocol, patients received at least 250 mg aspirin at the moment of diagnosis and a loading dose of clopidogrel (300 or 600 mg) before PCI. An intravenous IIb-IIIa glycoprotein inhibitor (abciximab, loading dose 0.25 mg/kg followed by a continuous infusion of 0.15 µg/kg/min for 12 hours) was strongly encouraged. Anticoagulation was accomplished using weight-adjusted intravenous unfractionated heparin as per standard recommendations. After the procedure, a maintenance dose of 75 mg/day of clopidogrel was recommended for at least 1 month if a bare metal stent was implanted or for 12 months if it was a drug-eluting stent. Use of thrombectomy, selection of stent type, and use of predilatation, post-dilatation, and/or other technical aspects were left to the operator's discretion.^{8–10} Regarding haemostasis after PCI, in patients undergoing trans-radial PCI the arterial sheath was immediately removed after the procedure and a compression bandage was then applied. Vascular closure devices were the default method of immediate closure of the femoral artery after PCI.¹¹ The use of these devices was

only precluded if the arterial insertion site was not in the common femoral artery, if the common femoral artery was <5 mm in diameter, or if severe angiographic arterial disease was present.

Demographic characteristics, cardiovascular risk factors, medical history, clinical presentation, electrocardiographic findings, drug treatment, and angiographic and procedural data were collected in a prospective fashion by the main operator of the procedure using a computerized database.

Clinical endpoint and variables definitions

An exhaustive review of the patients' clinical records was performed in a retrospective fashion in order to determine the occurrence of in-hospital major bleeding, as defined as the composite of intracranial or intraocular bleeding, access site haemorrhage that required intervention, reduction in haemoglobin of ≥ 4 g/dl without or ≥ 3 g/dl with an overt bleeding source, reoperation for bleeding, or blood transfusion, was determined.⁴

Clearance of creatinine was estimated using the Cockcroft–Gault formula.¹² Prior vascular disease was defined as it was done in the CRUSADE registry (prior stroke and/or peripheral artery disease).³

Statistical analysis

Continuous variables are presented either as median (interquartile range). Categorical variables are summarized as absolute and relative frequencies (percentages). Associations between categorical variables were studied by the χ^2 test or the Fisher Exact test, as appropriate. Comparisons between two mean values were performed with the Student t or Mann–Whitney tests as appropriate.

The CRUSADE,³ ACUTY-HORIZONS,⁴ and ACTION,⁵ bleeding risk scores were calculated from patients' clinical characteristics. The individual rating for each variable established in each score was assigned. The total score of each patient was calculated by summing the individual result for each prognostic variable included in the score.

On the basis of the original publications of the risk scores, patients were classified into risk categories.^{3–5} The CRUSADE and ACTION models distinguished five risk categories of bleeding (very low, low, moderate, high, and very high risk). In the ACUTY-HORIZONS, patients were stratified in four risk categories for bleeding (low, moderate, high, and very high risk).

Risk model calibration was assessed by the Hosmer–Lemeshow goodness-of-fit test, which determines how close the predicted and observed incidence of events are over a range of scores. In this test, a significant result indicates lack of model adjustment.¹³ We assessed the discriminatory capacity of the risk models for major bleeding

by deriving their C-statistics, using receiver operating characteristic (ROC) curves. In general, a model with a C-statistic above 0.70 has acceptable discriminatory capacity.¹³ The C-statistics for the three risk models were compared to each other using a nonparametric test.¹⁴ Both calibration and discrimination of the model were assessed with respect to the entire patient population. A separate analysis was performed for the patients undergoing PPCI using a trans-radial approach.

SPSS version 19.0 (SPSS, Chicago, IL, USA) was used for the statistical analysis, whereas the areas under the ROC curve for clinical event models were compared using MedCalc version 11.6.1 (MedCalc Software, Mariakerke, Belgium). A bilateral value of $p < 0.05$ was considered statistically significant.

This study complies with the Declaration of Helsinki. The local ethics committee has approved our research protocol. Informed consent has been obtained from the subjects included in the present analysis.

Results

Baseline characteristics

The study cohort was composed of 1391 patients. Baseline characteristics are shown in Table 2.

The median of the CRUSADE score in our series was 24 points (interquartile range 13–35). According to CRUSADE risk categories, 40.6, 25.7, 14.7, 11.8, and 7.2% of our patients were at very low, low, moderate, high, and very high risk of bleeding.

The median of ACUTY-HORIZONS score was 15 points (interquartile range 10–20). After applying the ACUTY-HORIZONS risk categories to our cohort, 19.8, 22.6, 25.4, and 32.1% of our patients were found to be at low, moderate, high, and very high risk of bleeding, respectively.

For the ACTION score, the median was 28 points (interquartile range 20–36). A total of 5.4, 57.2, 27.4, 7.7, and 2.4% of our patients were at very low, low, intermediate, high, and very high risk of bleeding, respectively, according to the ACTION risk categories.

Incidence of major bleeding

The overall incidence of major bleeding was 9.8%. The incidence of the individual components of major bleeding was 0.1% for intracranial bleeding, 0.5% for access site haemorrhage needing intervention, 5.7% for reduction in haemoglobin of ≥ 4 g/dl without clinical bleeding, 0% for reoperation for bleeding after cardiac surgery and 0.9% for a fall in haemoglobin ≥ 3 g/dl with an evident bleeding source, and 3.9% for blood transfusion.

The observed rates of major bleeding increased steadily across increasing CRUSADE, ACUTY-HORIZONS, and

Table 2. Baseline characteristics of the study population.

	STEMI cohort (n=1391)
Cardiovascular risk factors	
Age (years)	64 (54–75)
Weight (kg)	79 (72.5–86.5)
Women	21.3 (296)
Hypertension	48.4 (673)
Diabetes	19.2 (267)
Current smoker	35.6 (495)
Hyperlipidaemia	39.5 (550)
Medical history	
Prior MI	6.5 (91)
Previous PCI	6.7 (93)
Previous CABG	1.2 (17)
Vascular disease ^a	6.3 (87)
Prior vitamin K antagonists use	2.6 (36)
Clinical presentation and admission data	
Inferior MI	51.0 (710)
Anterior MI	43.5 (605)
Systolic blood pressure (mmHg)	122 (108–136)
Heart rate (bpm)	75.0 (64.5–85.5)
Heart failure	18.7 (260)
Cardiogenic shock	7.7 (107)
Baseline haematocrit (%)	42.0 (35.8–48.2)
Creatinine clearance (ml/min) ^b	81.5 (59.8–103.2)
Abciximab pre-treatment	68.0 (946)
Vascular access	
Radial	81.3 (1131)
Femoral	18.7 (260)
Use of vascular closure devices after femoral PCI	90.8 (236)

Values are median (interquartile range) or % (n). ^aVascular disease defined as prior history of cerebrovascular disease and/or peripheral artery disease. ^bCreatinine clearance was calculated with the Cockcroft-Gault formula. CABG, coronary artery bypass graft; MI, myocardial infarction; PCI, percutaneous coronary intervention.

ACTION risk categories (Figure 1), with significant results for the χ^2 test for trend ($p < 0.001$).

Among the trans-radial PCI subgroup ($n=1131$, 81%), the incidence of bleeding reached 6.3%. The incidence of the individual components was 0.1, 0.1, 3.7, 0.7, 0, and 2.0%, respectively.

Risk model calibration and discrimination

Table 3 summarizes the calibration and discrimination of the three risk scores. The calibration of these three models was good for our study population, as shown by the non-significant results of the Hosmer–Lemeshow tests. The three models showed an adequate discriminatory capacity for major bleeding (C-statistic 0.77, 0.70, and 0.78 for the CRUSADE, ACUITY-HORIZONS, and ACTION scores, respectively) (Figure 2).

The C-statistic for the ACUITY-HORIZONS model was statistically significantly lower for the prediction of major bleeding compared to that of the CRUSADE and ACTION-GWTG models. No differences were observed when the CRUSADE and ACTION-GWTG scores were compared to each other (Table 4).

For the trans-radial PPCI subgroup of patients, calibration and discrimination of these three risk models was adequate (Table 5). We found only statistical differences between the CRUSADE and ACUITY-HORIZONS risk scores predictive accuracy, favouring the former one. There were no differences in the remaining head-to-head comparisons (Table 6).

Discussion

In the present study, we have evaluated the performance of the CRUSADE, ACUITY-HORIZONS, and ACTION-GWTG risk scores for the prediction of major bleeding in a contemporary cohort of patients with STEMI treated by PPCI. The three risk scores showed good calibration and discrimination in our series, as it was demonstrated by the non-significant results of the Hosmer–Lemeshow test and their C-statistics, respectively. In addition to this, the three risk scores for major bleeding corresponded well with observed bleeding, with increasing rates of bleeding across increasing risk categories.

As mentioned, the CRUSADE and ACTION risk scores had greater predictive value for major bleeding than the ACUITY-HORIZONS risk model in our cohort. This difference in bleeding discrimination might be explained by differences in the variables that comprise each model. The three risk scores include female sex, renal function, and anaemia, variables that are clearly associated with bleeding in ACS.^{1,2} The CRUSADE,³ and ACTION⁵ models have several variables in common, such as heart rate, systolic blood pressure, heart failure, diabetes, and vascular disease, that are clearly linked to bleeding in ACS.^{1,2} The ACUITY-HORIZONS risk model did not include these variables;⁴ we think that this has contributed to the superiority of both CRUSADE and ACTION models in comparison to the ACUITY-HORIZONS risk score. Moreover, the performance of the ACUITY-HORIZONS⁴ may have been negatively affected by the fact that none of the patients of this cohort received treatment with bivalirudin.

The three scores may be useful tools to identify those patients with an STEMI undergoing primary PCI at a higher risk for major bleeding and may help physicians to select the most appropriate adjunctive antithrombotic regimen for them. Although none of these scores was developed specifically for the STEMI, they are composed of several clinical variables independently associated with bleeding;^{1,2} this might explain their accuracy for major bleeding prediction in the present cohort of STEMI patients undergoing PPCI.

Figure 1. Rates of major bleeding across the CRUSADE (A), ACUTY-HORIZONS (B), and ACTION (C) risk groups p trend <0.001 for the three analyses.

Table 3. Calibration and discrimination of the CRUSADE, ACUTY-HORIZONS, and ACTION risk scores.

Risk score	χ^2 statistic of Hosmer–Lemeshow	Hosmer–Lemeshow test p -value	C-statistic (95% CI)
CRUSADE	11.26	0.187	0.77 (0.75–0.79)
ACUTY-HORIZONS	2.42	0.965	0.70 (0.67–0.72)
ACTION	9.55	0.298	0.78 (0.76–0.80)

CRUSADE, Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUTY, Acute Catheterization and Urgent Intervention Triage strategY; HORIZONS, Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry.

The relative superiority of CRUSADE and ACTION models seems to favour their use over the ACUTY-HORIZONS score for bleeding prediction in STEMI. In view of our results, it is not possible to choose between these CRUSADE and ACTION models, as there was no significant difference regarding their predictive value. Despite our study is underpowered for finding statistically significant differences in this head-to-head comparison, due to its modest sample size, this lack of difference is not surprising at all, because both scores had only minor differences in their composition. While the CRUSADE score incorporates age, weight, and creatinine as a single variable using creatinine clearance,³ the ACTION model incorporates the three variables in a independent fashion, so their influence is more directly accounted for. The ACTION score comprises prior warfarin use and ECG changes,

variables that are not included in the CRUSADE model. However, none of these differences seems to be relevant for bleeding prediction in our cohort. Despite the concerns regarding the impact of systemic anticoagulation in the management of ACS,¹⁵ prior warfarin use was uncommon in our cohort, having so a low impact in bleeding. Given the fact that all our patients had a STEMI, the inclusion of ECG changes, as defined by the ACTION researchers, did not have a significant influence in bleeding prediction in the present population. Despite it has been stated that the ACTION risk model may have increased generalizability in comparison with the CRUSADE score,⁵ as it was developed in patients with both NSTEMI and STEMI, our findings support the use of the CRUSADE risk model in the STEMI, not only in the NSTEMI, thus questioning this affirmation. On the basis of the present results, we believe

Figure 2. Receiver operating characteristic curves of the CRUSADE, ACUITY-HORIZONS, and ACTION models for major bleeding prediction.

that both models may be employed for the analysis of bleeding risk in both NSTEMI and STEMI.

To the best of our knowledge, this is the first study to date validating the usefulness of risk models for bleeding prediction in trans-radial PCI. This becomes even more important given that the 2011 European Society of Cardiology guidelines for the care of NSTEMI have questioned the predictive value of the CRUSADE risk score in a radial access setting for PCI,⁶ as it was developed from a US cohort where femoral access was predominantly used.³ Trans-radial approach

for PCI, widely employed in Europe, is associated with fewer bleeding complications than femoral access and may allow more aggressive antithrombotic adjunctive treatment.^{16–18} The predictive ability of the CRUSADE, ACUITY-HORIZONS, and ACTION risk scores was adequate in the trans-radial PPCI subgroup. In this subgroup of patients, the CRUSADE model yielded a higher C-statistic than the ACUITY-HORIZONS model, but there were no differences in the remaining comparisons between risk scores. It is not easy to explain why the ACTION score had a lower predictive accuracy in the trans-radial PPCI subgroup of patients when compared to the entire cohort, but we think that it might be due to chance.

Our findings are not decisive when choosing one of the three models in particular to be employed in the trans-radial PPCI, given the absolute value of the C-statistics obtained for the three risk models. Instead of making a recommendation on which score should be employed, we would rather underscore the usefulness of the three risk models for bleeding risk stratification in the PPCI performed using the radial approach.

Our study may have several limitations, mainly with regard to its design. This was a nonrandomized cohort observational single-centre registry and may have the inherent bias of this type of studies. The modest sample size of our cohort is another limitation of the present analysis.¹⁹ As the study population comprised only patients with an STEMI undergoing primary PCI, these results may not be applicable to STEMI patients undergoing PCI after failed thrombolysis (rescue PCI). This study population was treated with clopidogrel and, many of them, abciximab. As none of them received bivalirudin or new antiplatelet agents (prasugrel, ticagrelor), these results need to be replicated in patients undergoing primary PCI with these new antithrombotic therapies.

Table 4. Comparison of the C-statistics of the CRUSADE, ACUITY-HORIZONS, and ACTION risk scores.

Comparison	z	p-value
CRUSADE vs. ACUITY-HORIZONS	3.89	0.0001
ACTION vs. ACUITY-HORIZONS	3.51	0.0004
CRUSADE vs. ACTION	0.63	0.531

The null-hypothesis z-test result is shown for the comparisons of the C-statistic for the three risk models and the respective p-value, obtained by the DeLong nonparametric method. CRUSADE, Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY, Acute Catheterization and Urgent Intervention Triage strategy; HORIZONS, Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry.

Table 5. Calibration and discrimination of the risk models in the trans-radial PPCI subgroup (n=1131 patients).

Risk score	χ^2 statistic of Hosmer–Lemeshow	Hosmer–Lemeshow test p-value	C-statistic (95% CI)
CRUSADE	13.38	0.100	0.75 (0.72–0.78)
ACUITY-HORIZONS	2.75	0.949	0.70 (0.67–0.72)
ACTION	4.80	0.779	0.71 (0.69–0.74)

CRUSADE, Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY, Acute Catheterization and Urgent Intervention Triage strategy; HORIZONS, Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry.

Table 6. Comparison of the C-statistics of the risk scores in the trans-radial PPCI subgroup (n=1131 patients).

Comparison	z	p-value
CRUSADE vs. ACUITY-HORIZONS	2.14	0.0326
ACTION vs. ACUITY-HORIZONS	0.46	0.6468
CRUSADE vs. ACTION	1.26	0.2081

The null-hypothesis z-test result is shown for the comparisons of the C-statistic for the three risk models and the respective p-value, obtained by the DeLong nonparametric method. CRUSADE, Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY, Acute Catheterization and Urgent Intervention Triage strategy; HORIZONS, Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; ACTION, Acute Coronary Treatment and Intervention Outcomes Network Registry.

Several other scoring systems for bleeding risk stratification are available, such as those developed in the STEEPLE (Safety and Efficacy of Enoxaparin in PCI Patients, an International Randomized Evaluation) trial,²⁰ and REPLACE (Randomized Evaluation in Percutaneous Coronary Intervention Linking Angiomax to Reduced Clinical Events) –1 and –2 studies.²¹ We did not include them in this comparative analysis, as they were developed in stable ischaemic disease. Despite any risk score may discriminate well at the group level, it is now recognized that it may not necessarily perform well at the individual level.²² None of these risk scores was developed for use with single patients. Although the discriminatory capacity is high, it will never be perfect. The scores can be used in a specific patient only as an approximate guideline, as they may indicate a particular risk but do not unequivocally predict the final clinical outcome.²²

In summary, the CRUSADE, ACUITY-HORIZONS, and ACTION risk scores showed good calibration and discrimination for major bleeding prediction in patients experiencing a STEMI undergoing PPCI. For this reason, these risk scores are useful for the stratification of bleeding risk in these patients. In our study population, the CRUSADE and ACTION risk models had a greater predictive capacity for major bleeding than the ACUITY-HORIZONS risk score. Our study also highlights the usefulness of bleeding risk scores for the trans-radial PPCI, given the adequate calibration and discrimination of the three risk models for bleeding prediction demonstrated in the subgroup of patients with STEMI treated by PPCI using the radial approach.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors declare that there are no conflicts of interest.

References

1. Steg PG, Huber K, Andreotti F, et al. Bleeding in acute coronary syndromes and percutaneous coronary interventions: position paper by the Working Group on Thrombosis of the European Society of Cardiology. *Eur Heart J* 2011; 32: 1854–1864.
2. Manoukian SV. Predictors and impact of bleeding complications in percutaneous coronary intervention, acute coronary syndromes, and ST-segment elevation myocardial infarction. *Am J Cardiol* 2009; 104(5 Suppl): 9C–15C.
3. Subherwal S, Bach RG, Chen AY, et al. Baseline risk of major bleeding in non-ST-segment-elevation myocardial infarction: the CRUSADE (Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines) Bleeding Score. *Circulation* 2009; 119: 1873–1882.
4. Mehran R, Pocock SJ, Nikolsky E, et al. A risk score to predict bleeding in patients with acute coronary syndromes. *J Am Coll Cardiol* 2010; 55: 2556–2566.
5. Mathews R, Peterson ED, Chen AY, et al. In-hospital major bleeding during ST-elevation and non-ST-elevation myocardial infarction care: derivation and validation of a model from the ACTION Registry(R)-GWTG. *Am J Cardiol* 2011; 107: 1136–1143.
6. Hamm CW, Bassand JP, Agewall S, et al. ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation: The Task Force for the management of acute coronary syndromes (ACS) in patients presenting without persistent ST-segment elevation of the European Society of Cardiology (ESC). *Eur Heart J* 2011; 32: 2999–3054.
7. Thygesen K, Alpert JS and White HD. Universal definition of myocardial infarction. *Eur Heart J* 2007; 28: 2525–2538.
8. Barge-Caballero E, Vazquez-Rodriguez JM, Estevez-Loureiro R, et al. Primary angioplasty in Northern Galicia: care changes and results following implementation of the PROGALIAM protocol. *Revista Espanola de Cardiologia* 2012; 65: 341–349.
9. Estevez-Loureiro R, Calvino-Santos R, Vazquez-Rodriguez JM, et al. Direct transfer of ST-elevation myocardial infarction patients for primary percutaneous coronary intervention from short and long transfer distances decreases temporal delays and improves short-term prognosis: the PROGALIAM Registry. *EuroIntervention* 2010; 6: 343–349.
10. Barge-Caballero E, Vazquez-Rodriguez JM, Estevez-Loureiro R, et al. Prevalence, etiology and outcome of catheterization laboratory false alarms in patients with suspected ST-elevation myocardial infarction. *Revista Espanola de Cardiologia* 2010; 63: 518–527.
11. Prada-Delgado O, Estevez-Loureiro R, Calvino-Santos R, et al. Safety and efficacy of femoral vascular closure devices in patients undergoing primary percutaneous coronary intervention for ST-elevation myocardial infarction. *Am Heart J* 2011; 161: 1207–1213.
12. Cockcroft DW and Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron* 1976; 16: 31–41.
13. Nunez E, Steyerberg EW and Nunez J. [Regression modeling strategies]. *Revista Espanola de Cardiologia*. 2011; 64: 501–507.

14. DeLong ER, DeLong DM and Clarke-Pearson DL. Comparing the areas under two or more correlated receiver operating characteristic curves: a nonparametric approach. *Biometrics* 1988; 44: 837–845.
15. Wang TY, Chen AY, Peterson ED, et al. Impact of home warfarin use on treatment patterns and bleeding complications for patients with non-ST-segment elevation acute coronary syndromes: observations from the CRUSADE quality improvement initiative. *Eur Heart J* 2008; 29: 1103–1109.
16. Amoroso G and Kiemeneij F. Transradial access for primary percutaneous coronary intervention: the next standard of care? *Heart* 2010; 96: 1341–1314.
17. Vink MA, Amoroso G, Dirksen MT, et al. Routine use of the transradial approach in primary percutaneous coronary intervention: procedural aspects and outcomes in 2209 patients treated in a single high-volume centre. *Heart* 2011; 97: 1938–1942.
18. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet* 2011; 377: 1409–1420.
19. Jepsen P, Johnsen SP, Gillman MW, et al. Interpretation of observational studies. *Heart* 2004; 90: 956–960.
20. Montalescot G, Gallo R, White HD, et al. Enoxaparin versus unfractionated heparin in elective percutaneous coronary intervention 1-year results from the STEEPLE (SafeTy and efficacy of enoxaparin in percutaneous coronary intervention patients, an international randomized evaluation) trial. *JACC Cardiovasc Interv* 2009; 2: 1083–1091.
21. Nikolsky E, Mehran R, Dangas G, et al. Development and validation of a prognostic risk score for major bleeding in patients undergoing percutaneous coronary intervention via the femoral approach. *Eur Heart J* 2007; 28: 1936–1945.
22. Abu-Assi E, Gracia-Acuna JM, Ferreira-Gonzalez I, et al. Evaluating the Performance of the Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines (CRUSADE) bleeding score in a contemporary Spanish cohort of patients with non-ST-segment elevation acute myocardial infarction. *Circulation* 2010; 121: 2419–2426.