Heart, Lung and Circulation (2019) **28,** 567–574
1443-9506/04/$36.00
https://doi.org/10.1016/j.hlc.2018.02.012

ORIGINAL ARTICLE

Comparison of CRUSADE and ACUITY-HORIZONS Bleeding Risk Scores in Patients With Acute Coronary Syndromes

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Received 26 October 2017; received in revised form 20 January 2018; accepted 11 February 2018; online published-ahead-of-print 2 March 2018

Background Compare the discriminative performance of two validated bleeding risk models for in-hospital bleeding events in a non-selected cohort of acute coronary syndrome (ACS) patients.

Methods CRUSADE (Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines) and ACUITY-HORIZONS (Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction) scores were calculated in 501 consecutive patients (median age 68 years (IQR 57–77), 31% female) admitted for ACS to the coronary care unit (CCU) of San Paolo Hospital in Milan (Italy). In-hospital haemorrhagic events and mortality were recorded and calibration and discrimination of the two risk models were evaluated using the Hosmer-Lemeshow test and the C-statistic, respectively.

Results Overall bleeding events were observed in 32 patients and major bleedings in 11 (with an incidence of 6.4% and 2.2%, respectively). In-hospital mortality was 2.6%. Regarding major bleedings both risk scores demonstrated an adequate calibration (H-L test $p > 0.20$) and a moderate discrimination with no significant difference in predictive accuracy between the two models (C-statistic 0.69 for CRUSADE and 0.73 for ACUITY-HORIZONS). We also tested the performance of the two risk models in predicting in-hospital mortality, showing an adequate calibration and a very good discrimination (C-statistic 0.88 and 0.89 for the CRUSADE and ACUITY-HORIZONS scores, respectively), with no significant difference in predictive accuracy.

Conclusions In our ACS population the CRUSADE and the ACUITY-HORIZONS risk scores showed a fairly good and comparable predictive accuracy regarding in-hospital bleeding events and they appeared to be very good predictors of in-hospital mortality.

Keywords Bleeding • Coronary disease • Haemorrhage • Risk Scores

Introduction

Haemorrhagic events represent the most common non cardiac in-hospital complication in patients with acute coronary syndromes (ACS), occurring with a frequency of up to 12% [1–3]. The variability of the observed incidence relates to the clinical characteristics of the populations studied and to the bleeding definitions used [4]. In any case, major bleedings

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represent an independent risk factor for subsequent mortality in patients with ACS, showing a hazard equivalent to or greater than that of myocardial infarction, and minimising their occurrence seems to translate to an improved survival [1,5–12]. Therefore, in the present ACS therapeutic scenario combining potent antithrombotic therapies with the widespread use of invasive procedures, bleeding risk stratification should represent, in addition to ischaemic risk stratification, an important step in the management of ACS patients, as suggested by current International Guidelines on ACS [13,14]. In recent years various risk models have been developed and validated in order to predict bleeding events in ACS patients [15–19]. In particular, the Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines (CRUSADE) score was derived in a non-ST elevation acute coronary syndrome (NSTEACS) registry population and was successively validated in NSTEACS and in ST-Elevation myocardial infarction (STEMI) patients [15–17], and the Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction (ACUITY-HORIZONS) model was derived from a mixed ACS population from randomised clinical trials, offering a predictive tool for a broader spectrum of patients [18]. As of now, however, it is not definitively clear which of these predictive models performs better in the every day clinical practice, as far as the studies that directly compared each to the other, the different risk scores did not provide definitive results [16,20–22].

The aim of this study was, therefore, to directly compare the performance of the CRUSADE and the ACUITY-HORIZONS scores in predicting in-hospital bleeding events in the non-selected patients consecutively admitted at our institution for ACS in order to define their performances in our every day clinical practice and, if possible, improve our awareness about bleeding complications.

Material and Methods

Study Population

Our study population was composed of consecutive patients admitted for ACS at the Coronary Care Unit (CCU) of San Paolo Hospital in Milan (Italy). The diagnosis of ACS was based on new onset symptoms consistent with cardiac ischaemia plus at least one of the following objective criteria: electrocardiographic changes indicative of myocardial ischaemia; troponin elevation above the 99th percentile threshold of a healthy reference population, with 10% coefficient of variability. Patients were classified as having STEMI and NSTEACS according to the standardised electrocardiographic criteria. The diagnosis of unstable angina required the absence of diagnostic elevation of troponin. All-comers design study was adopted with no restriction on age or on critically ill patients' inclusion. The study complies with the Declaration of Helsinki and was approved by the Clinical Research Ethics Committee of the San Paolo Hospital. All the patients signed a standard consent regarding sensitive personal data treatment.

Table 1 CRUSADE and ACUITY-HORIZONS models variables.

CRUSADE	ACUITY-HORIZONS
Sex	Sex
Diabetes	Age
Renal function	Renal function
Vascular disease	White blood cell count
Anaemia	Anaemia
Heart failure	Clinical presentation
Heart rate	Antithrombotic therapy
Systolic blood pressure	

Abbreviations: CRUSADE, Can Rapid Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY-HORIZONS, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction;
Clinical presentation: STEMI or NSTEACS with or without markers elevation; Antithrombotic therapy: utilisation of bivalirudin.

Clinical Endpoints and Variables Definitions

Baseline clinical characteristics, medical history, biochemical and electrocardiographic findings, angiographic data, treatments administered during hospitalisation and incidence of in-hospital adverse events were collected on a computer database designed for ACS patients admitted to our CCU. In particular, in the database were included all the elements pertinent to the definition of the CRUSADE and ACUITY-HORIZONS scores (Table 1). Thus, for all the patients, both scores were calculated based on admission clinical and laboratory data. On the basis of the original publications of the risk scores [15,18], patients were stratified into bleeding risk categories: five for the CRUSADE model (very low, low, moderate, high and very high risk) and four for the ACUITY-HORIZONS model (low, moderate, high and very high risk). Moreover, for all patients the Global Registry of Acute Coronary Events (GRACE) score [23] was calculated using admission data. Finally, the analysis of the database allowed determination of the incidence of bleeding events, the site of bleedings, and in-hospital mortality. Bleedings were recorded in the database using the Bleeding Academic Research Consortium (BARC) standardised definition criteria [4].

Statistical Analysis

Continuous variables are described as medians and interquartile ranges. Categorical variables are described as absolute values and percentages. Comparisons between continuous variables were performed with nonparametric tests as appropriate and associations between categorical variables were studied by the $\chi 2$ test, the Fisher's Exact test,

or the Cochran-Armitage Trend test, as appropriate. Each risk model calibration was assessed by the Hosmer-Lemeshow test which determines how close is the correspondence between predicted and observed incidence of events. In this test, a $p < 0.05$ indicates a lack of model adjustment [24]. The discriminatory capacity of the risk models was assessed deriving their C-statistics, using receiver operating characteristic (ROC) curves. Both the calibration and discrimination of the CRUSADE and ACUITY-HORIZONS models were assessed with respect to overall bleeding events, major bleeding events (defined as type 3 or type 5 according to the BARC criteria; coronary artery bypass graft (CABG)-related bleedings were not considered in our study), and in-hospital mortality. The C-statistics of the risk models were compared using the DeLong's test [25]. MedCalc Statistical Software version 16.2.0 (MedCalc Software bvba, Ostend, Belgium; https://www.medcalc.org; 2016) was used for all the statistical analysis. Statistical significance was defined as $p < 0.05$.

Results

Baseline Characteristics

The study cohort consisted of 501 patients (median age 68 years, 31% females), 55% of whom had a NSTEACS and 45% had a STEMI. Baseline clinical characteristics and in-hospital treatments are shown in Table 2. The GRACE score calculated on the admission data showed a median value of 139 (interquartile range 113–167). Most patients were treated with dual oral antiplatelet therapy while only 24% received glycoprotein IIb/IIIa antagonists. Bivalirudin was used in 21% of patients. Patients on oral anticoagulants at admission were switched to low molecular weight or unfractionated heparins. Coronary angiography was performed in 95% of patients with a vascular radial approach in 56% of cases. Percutaneous coronary interventions were performed in 75% of patients. None of the patients included in the study was referred for acute CABG. Finally, in seven patients (1.4%) an intra-aortic balloon pump was used. In the whole population, the median CRUSADE score was 27 points (interquartile range 15–40), with values of 29 (17–40) in NSTEACS and of 24 (12–38) points in STEMI patients ($p < 0.04$). According to the model risk categories, 36.1, 21.6, 18.8, 13.4 and 10.2% of patients were at very low, low, moderate, high, and very high risk of bleeding. The median of ACUITY-HORIZONS score was 16 points (interquartile range 11–21) in the whole population, with values of 16 (10–20) in NSTEACS and of 17 (12–23) points in STEMI patients ($p < 0.02$). Applying the model risk classification, 23.4, 48.5, 21.8, and 6.4% of patients were at low, moderate, high, and very high risk of bleeding, respectively.

In-Hospital Adverse Events

In the whole population, 32 patients underwent a bleeding event, in 21 cases a BARC type 2 and in 11 cases a BARC type 3 bleeding. The incidence rate of BARC type 2 plus type 3 bleedings was 6.4% and of BARC type 3 (major bleedings) was 2.2%. No fatal bleedings were observed. No significant differences about bleeding incidences were found between NSTEACS and STEMI patients. Considering major bleedings, in 36.3% of cases the event was related to the vascular access site, in 27.2% of cases to gastrointestinal bleeding, in 27.2% of cases to genitourinary bleeding, and in 9% of cases to bronco-pulmonary bleeding. As shown in Table 3 the incidence of overall and major bleedings rises across the CRUSADE and

Table 2 Baseline clinical characteristics and in-hospital management of study population.

	n = 501
Age (years)	68 (57–77)
Female sex	157 (31)
BMI	26 (23–29)
Medical history	
Diabetes	136 (27.1)
Arterial hypertension	317 (63.3)
Dyslipidaemia	213 (42.5)
Prior AMI	108 (21.6)
Prior PCI	89 (17.8)
Prior CABG	38 (7.6)
Prior stroke	25 (5)
Peripheral arteriopathy	83 (16.6)
Clinical presentation	
NSTEACS	276 (55)
STEMI	225 (45)
Killip class >1	78 (15.6)
GRACE score	139 (113–167)
EF (%)	54 (45–58)
Serum creatinine (mg/dL)	0.9 (0.7–1.1)
eGFR (ml/min/mq)	80.7 (59.3–100.4)
Renal failure ≥ grade 3	125 (25)
Haematocrit (%)	41.5 (39–44)
Anaemia	92 (18.4)
Leucocyte (giga/l)	9.6 (7.6–11.9)
In-hospital management	
Aspirin	488 (97.4)
P2Y12 inhibitors	470 (93.8)
Clopidogrel	230 (45.9)
Ticagrelor	148 (29.5)
Prasugrel	92 (18.4)
Glycoprotein IIb/IIIa inhibitors	120 (24)
Bivalirudin	105 (21)
Fondaparinux	100 (20)
Coronary angiography	477 (95.2)
Radial vascular access	266 (56)
PCI	356 (75)
IABP	7 (1.4)

Values are n (%) or median (interquartile range).
Abbreviations: AMI, acute myocardial infarction; BMI, body mass index; PCI, percutaneous coronary intervention; CABG, coronary artery bypass grafting; NSTEACS, non-ST-elevation acute coronary syndrome; STEMI, ST-elevation myocardial infarction; GRACE, Global Registry of Acute Coronary Events; EF: ejection fraction; IABP, intra-aortic balloon pump.

Table 3 **Distribution of observed and estimated bleeding rates across CRUSADE and ACUITY-HORIZONS risk categories.**

CRUSADE	VLR	LR	MR	HR	VHR
BARC 2 + 3					
Observed*	6 (3.3)	6 (5.6)	5 (5.3)	5 (7.5)	10 (19.6)
Estimated	5.4 (2.9)	4.9 (4.5)	6.5 (6.9)	7.0 (10.4)	7.9 (15.4)
BARC 3					
Observed**	1 (0.6)	3 (2.8)	2 (2.1)	2 (3)	3 (5.9)
Estimated	1.7 (0.9)	1.6 (1.5)	2.2 (2.3)	2.4 (3.6)	2.8 (5.5)
ACUITY-HORIZONS	**LR**	**MR**	**HR**	**VHR**	
BARC 2 + 3					
Observed*	1 (0.9)	16 (6.6)	10 (9.2)	5 (15.6)	
Estimated	3.0 (2.6)	12.5 (5.1)	10.6 (10.7)	5.7 (17.8)	
BARC 3					
Observed**	0	5 (2.1)	4 (3.7)	2 (6.2)	
Estimated	0.8 (0.7)	3.8 (1.6)	3.8 (3.5)	2.4 (7.5)	

Abbreviations: CRUSADE, Can Rapid Stratification of Unstable Angina Patients Suppress Adverse Outcomes With Early Implementation of the ACC/AHA Guidelines; ACUITY-HORIZONS, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; BARC, Bleeding Academic Research Consortium; LR, low risk; MR, moderate risk; HR, high risk; VHR, very high risk; VLR, very low risk.
Values are n (%). VLR: very low risk, LR: low risk, MR: moderate risk, HR: high risk, VRH: very high risk. Cochran-Armitage test for trend: * $p < 0.001$ ** $p < 0.04$.

Table 4 **Calibration and discrimination of the CRUSADE and ACUITY-HORIZONS risk scores.**

	X^2 statistic H-L test	p-value H-L test	C-statistic (95% CI)
CRUSADE			
BARC 2 + 3	6.76	0.56	0.68 (0.64–0.72)
BARC 3	4.62	0.79	0.69 (0.64–0.72)
Mortality	12.07	0.14	0.88 (0.85–0.91)
ACUITY-HORIZONS			
BARC 2 + 3	5.64	0.68	0.68 (0.64–0.72)
BARC 3	7.28	0.50	0.73 (0.69–0.77)
Mortality	1.69	0.98	0.89 (0.86–0.91)

Abbreviations: CRUSADE, Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines; BARC, Bleeding Academic Research Consortium; ACUITY-HORIZONES, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction; H-L test: Hosmer-Lemeshow test.

ACUITY-HORIZONS risk categories, with significant results for the Cochran-Armitage test for trend. Finally, in-hospital mortality was 2.6% in the whole population, without significant difference between NSTEACS and STEMI patients.

Risk Scores Calibration and Discrimination

In Table 4 are summarised the calibration and discrimination of the two risk scores for overall bleedings, major bleedings, and in-hospital mortality. As can be seen, the calibration of the two risk models was good, as shown by the non-significant results of the Hosmer-Lemeshow tests. The discriminatory capacity was moderate for overall bleedings [C-statistic 0.68 for both CRUSADE (95% CI 0.64–0.72) and ACUITY-HORIZONS (95% CI 0.64–0.72) scores] and BARC type 3 bleedings [C-statistic 0.69 (95% CI 0.64–0.72) and 0.73 (95% CI 0.69–0.77) for CRUSADE and ACUITY-HORIZONS scores, respectively] (Figure 1), while it was very good for in-hospital mortality [C-statistic 0.88 (95% CI 0.85–0.91) and 0.89 (95% CI 0.86–0.91) for CRUSADE and ACUITY-HORIZONS scores, respectively] (Figure 2). No statistically significant differences were found between the discriminatory capacity of the two risk models for bleeding events and mortality. Finally, the discriminatory capacity of the two bleeding risk models for in-hospital mortality was compared with that of the GRACE score and no statistically significant difference was found (Figure 3).

Discussion

The main findings of our study can be summarised as follows: 1) our population of non- selected ACS patients showed a quite high incidence of overall in-hospital bleedings, but a low incidence of major bleedings; 2) both the CRUSADE and the ACUITY-HORIZONS risk scores demonstrated a moderate and comparable predictive accuracy for in-hospital bleedings; and, 3) both scores demonstrated a very good and comparable predictive accuracy for in-hospital mortality. In our study, the incidence rate of major bleedings appears to be relatively low compared to previous studies [15,18,22]. Many factors might explain these differences. Amongst them, the type of

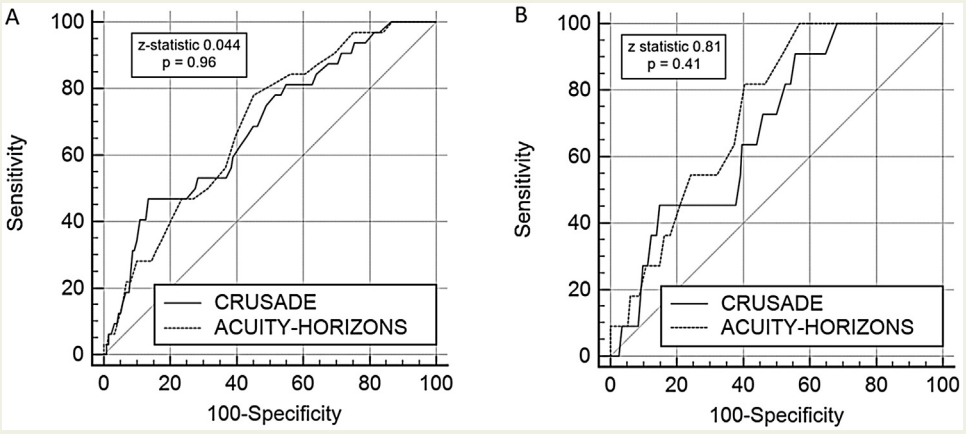

Figure 1 Receiver operating characteristic curves of the CRUSADE and ACUITY-HORIZONS models for bleeding events. 1A: All bleeding events, 1B: BARC 3 type bleeding events. C-statistic values are shown in Table 4.
Abbreviations: CRUSADE, Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines; BARC, Bleeding Academic Research Consortium; ACUITY-HORIZONS, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction

population studied (STEMI, NSTEACS or mixed patients) with a different baseline bleeding risk, the aggressiveness of the antithrombotic approach and the selection of the vascular access site might have played a role. Our population was an unselected cohort of mixed ACS patients with a low overall baseline bleeding risk: the median values of the CRUSADE and ACUITY-HORIZONS scores were respectively 27 and 16, with nearly 58% of patients in the very low and low risk quintiles of CRUSADE score and nearly 72% in the low and moderate quartiles of ACUITY-HORIZONS score. Although almost one-half of our patients received a new P2Y12 inhibitor

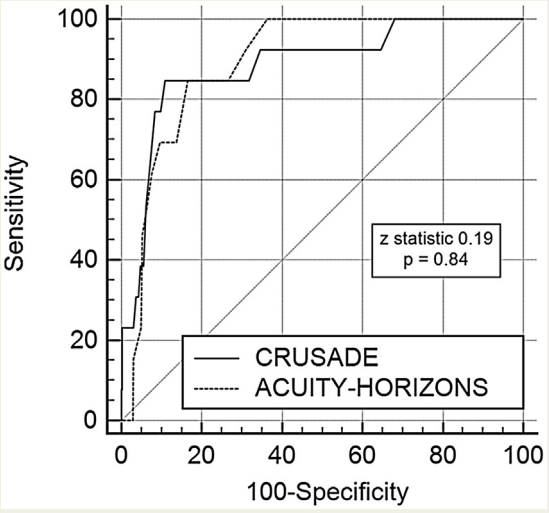

Figure 2 Receiver operating characteristic curves of the CRUSADE and ACUITY-HORIZONS models for in-hospital mortality. C-statistic values are shown in Table 4.
Abbreviations: CRUSADE, Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines; ACUITY-HORIZONS, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction

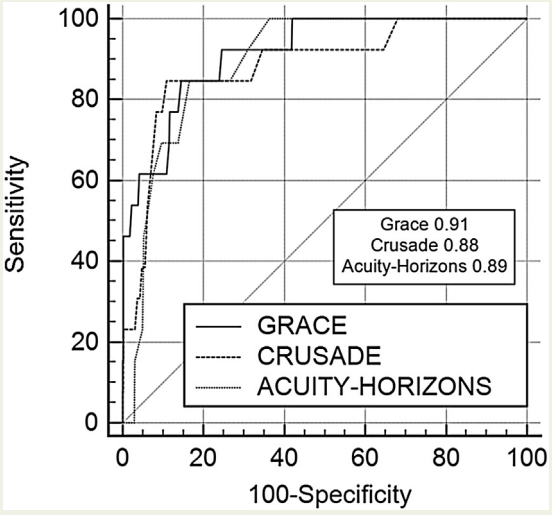

Figure 3 Receiver operating characteristic curves of the GRACE, CRUSADE and ACUITY-HORIZONS scores for in-hospital mortality. No statistically significant difference was found between the ROC curves of the three models.
Abbreviations: CRUSADE, Can Rapid risk stratification of Unstable angina patients Suppress ADverse outcomes with Early implementation of the ACC/AHA Guidelines; GRACE, Global Registry of Acute Coronary Events; ACUITY-HORIZONS, Acute Catheterization and Urgent Intervention Triage strategY-Harmonizing Outcomes with Revascularization and Stents in Acute Myocardial Infarction

(prasugrel or ticagrelor), GPI were administered only in 24% of the cases, while bivalirudin and fondaparinux were used respectively in 21% and 20% of the patients, thus balancing the aggressiveness of the antithrombotic approach with a possible reduction of major bleedings. Finally, although 95% of our patients underwent coronary angiography and almost 75% of them underwent PCI, the radial approach was used in 56% of the cases. This has led to four vascular access site major bleedings compared to 21 femoral puncture site major bleedings observed in the study by Correia et al. [22] and, globally, to a lower incidence of major bleedings compared to the CRUSADE registry [15]. As matter of fact, the transfemoral artery approach was the only one used in both the aforementioned studies. As far as predictive accuracy is concerned, our results are not substantially different from those obtained in the previous studies. In our population, the CRUSADE and ACUITY-HORIZONS scores showed an adequate calibration (H-L test $p > 0.20$) and a moderate performance in bleedings discrimination with a C-statistic of 0.68 for both scores for overall bleedings and with a C-statistic of 0.69 and of 0.73 respectively for major bleedings. Our data are consistent with the results of the two scores derivation studies [15,18], in which similar values of C-statistic were obtained: 0.68 and 0.73 for the CRUSADE model in the invasive and the conservative treatment groups respectively and 0.74 for the ACUITY-HORIZONS model. Ariza-Solè et al. [16] obtained C-statistic values of 0.80 and 0.76 for the CRUSADE and for the ACUITY-HORIZONS scores respectively in a non-selected cohort of STEMI patients, using the CRUSADE definition for major bleedings adjudication. However, using the BARC bleedings definition, a lower incidence of major bleedings was reported (1.8% vs 3.1%) and lower C-statistic values were obtained (0.66 for both CRUSADE and ACUITY-HORIZONS scores). These observations underscore the effects exerted by the bleedings definition on the bleedings incidence observed and, consequently, on the predictive accuracy obtained testing a bleedings risk model. In our population, we used the standardised BARC bleeding definitions [4] for the adjudication of in-hospital bleeding events. Moreover, we tested the predictive accuracy of the two risk models not only for the BARC type 3 bleedings (major bleedings) but also for the cumulative incidence of the type 2 and the type 3 bleedings, considering that also type 2 bleedings can have a significant clinical impact and exert a negative prognostic role in everyday clinical practice.

In addition, we found no significant differences in the predictive accuracy of the two scores for overall and major bleedings when compared to each other. Our results are consistent with the study by Ariza-Solè et al. [16], which enrolled exclusively patients with STEMI, and with the results of Costa et al. [26] that obtained similar accuracy between CRUSADE and ACUITY-HORIZONS scores in the prediction of out-of-hospital major bleedings in an all-comer population treated with coronary stent and prolonged dual antiplatelet therapy. Finally, two studies compared the two scores in a mixed ACS population. Abu-Assi et al. [21] demonstrated the superiority of the CRUSADE and the ACTION risk models over the ACUITY-HORIZONS score using risk models specific bleeding definitions (C-statistic values of 0.80, 0.83 and 0.74, respectively), while the superiority was confirmed only in NSTEACS patients using the TIMI (minor plus major) bleedings definition. On the other hand, Correia et al. [22] showed a better predictive accuracy for major bleedings for the ACUITY-HORIZONS model as compared to the CRUSADE score (C-statistic values of 0.73 and 0.62 respectively). It is difficult to ascertain the reasons for these different results. Probably, beside the different variables composition of the two models, again the bleedings definitions used and the characteristics of the patient populations enrolled might have played a major role. For instance, the patients with STEMI were poorly represented in both studies (32.8% and 22% respectively) in comparison to our study in which they composed nearly half of the overall population, thus probably favouring the CRUSADE prediction model that was developed in a NSTEACS population. On the other hand, in the study of Correia et al. [22] only 41% and 37% of patients underwent coronary angiography and percutaneous coronary intervention respectively. In fact, the majority of patients were treated conservatively, a situation in which the CRUSADE model performance appears to be worse [15]. Finally, we tested the performances of the CRUSADE and the ACUITY-HORIZONS models in order to predict in-hospital mortality. Both scores showed a very good predictive accuracy for in-hospital mortality, with a C-statistic of 0.88 for the CRUSADE model and of 0.89 for the ACUITY-HORIZONS model, without significant differences when compared to each other and when compared to that of the GRACE score. To the best of our knowledge, no study has investigated the performance of the ACUITY-HORIZONS score in predicting in-hospital mortality. Manzano-Fernandez et al. [27] compared the CRUSADE and the GRACE scores against each other in order to predict both in-hospital mortality and major bleedings in a population of mixed ACS patients. Unlike our results, they showed a significantly worse performance of the CRUSADE score in predicting in-hospital mortality (C-statistics of 0.79 and 0.86 for the CRUSADE and the GRACE scores respectively), but also in predicting in-hospital major bleedings (C-statistics of 0.73 and 0.80 respectively). At the moment, it is not possible to draw definitive conclusions about this topic and more data are needed. However, we find attractive the possibility of using a ''multipurpose'' single score for predicting in-hospital adverse events in the every day clinical practice.

The present study shows, indeed, some limitations. The first one is the relatively limited sample size and the consequent small number of events. This did not allow the evaluation of the two risk models in patients' subgroups, such as STEMI and NSTEACS patients, patients with different vascular accesses and so on. A second limitation is that this is a single-institution experience and this might reduce the generalisability of our findings to other populations. However, we think that our population, although relatively small, is a well balanced mix of ACS patients. As matter of fact, it represents a contemporary population of ACS, being almost equally subdivided between STEMI and NSTEACS patients

managed according to current clinical practice: the great majority of patients have been referred to coronary angiography and almost 75% to percutaneous coronary intervention and nearly 50% have been treated with new P2Y12 agents. Moreover, a relatively large proportion of patients received bivalirudin or fondaparinux, with a possible reduction of bleeding events. A third limitation is that the performance of the ACUITY-HORIZONS score was assessed regarding in-hospital bleedings while it was originally developed to predict 30-days events.

Conclusions

Our study shows a reasonable predictive accuracy of the CRUSADE and the ACUITY-HORIZONS scores regarding in-hospital bleeding events and no significant differences were found between their performances. Moreover, we found that both risk models perform very well in predicting in-hospital mortality with a discriminatory capacity almost equal to that of the GRACE score. Although these results need further confirmation, they appear attractive because one ''multipurpose'' risk model might simplify the risk stratification of ACS patients in daily clinical practice.

In conclusion, our results show that the two scores perform in a similar way in predicting in-hospital bleeding events and mortality in a non-selected population of ACS patients and could be used interchangeably in the clinical practice. However, in choosing between the two scores, two factors, amongst others, may be taken into account in our opinion. The first concerns the derivation and validation processes obtained in a huge, non-selected, registry-based ACS population for the CRUSADE score while the ACUITY-HORIZONS score was derived in a mixed randomised trial-based population without an external validation. The second factor concerns simplicity of use in the clinical daily practice and this is in favour of CRUSADE score utilisation since web-based risk calculators for it are readily available.

Conflicts of Interest

None.

Acknowledgements

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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