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Predictive value of some risk stratification models in patients with acute myocardial infarction with ST elevation

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Acronyms
ACS: acute coronary syndrome
AMI: acute myocardial infarction
STEMI: ST segment elevation myocardial infarction
PCI: percutaneous coronary intervention

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ABSTRACT

Introduction and Objectives: Establishing appropriate prognosis in patients who have suffered a myocardial infarction has been an expectation of physicians since ancient times. The aim of this study was to determine the predictive value of three risk stratification models in patients with acute myocardial infarction with ST elevation.

Method: A longitudinal study was conducted in 150 patients with this disease, admitted to the cardiology department of Arnaldo Milián Castro Provincial University Hospital in Villa Clara, Cuba, from January 2010 to December 2011.

Results: Patients had a mean age of 66.47 years. Males (62%) and inferior infarction (57.3%) were predominant. All complicated or dead patients were classified as high risk, according to the GRACE registry, and the "C" index for serious complications and in-hospital death had very good predictive ability. In the prognostic index, 57.2% of patients with complications and 46.4% of deaths were high risk, with a "C" index of 0.67 and 0.65, respectively; there was also a poor predictive ability for both events. The ICR scale obtained a "C" index of 0.45 for severe complications and 0.41 for in-hospital mortality, both with very poor predictive ability.

Conclusions: The GRACE registry presented very good ability to predict severe complications and in-hospital death, however, the predictive index scale showed poor prognostic ability for both events by failing to properly classify patients with extreme values. The ICR scale presented a "C" index with poor predictive ability for both events.

Key words: Myocardial Infarction, Risk Assessment, Hospital Mortality, Cardiovascular complications.

Valor predictivo de algunos modelos de estratificación de riesgo en pacientes con infarto agudo de miocardio con elevación del ST

RESUMEN

Introducción y objetivos: Establecer el pronóstico adecuado en pacientes que han su-

frido un infarto de miocardio ha sido una expectativa de los médicos desde tiempos remotos. El objetivo de este estudio fue determinar el valor predictivo de tres modelos de estratificación de riesgo en pacientes con infarto agudo de miocardio con elevación del ST.

Método: Se realizó un estudio descriptivo longitudinal en 150 pacientes con esta enfermedad, ingresados en el Servicio de Cardiología del Hospital Provincial Universitario "Arnaldo Milián Castro" de Villa Clara, Cuba, en el período comprendido de enero de 2010 a diciembre de 2011.

Resultados: Los pacientes presentaron una edad media de 66,47 *a*ños. Predominaron el sexo masculino (62 %) y el infarto de cara inferior (57,3 %). Todos los pacientes complicados o fallecidos fueron clasificados como alto riesgo, según la escala GRACE; y el índice "C" para complicaciones graves y muerte intrahospitalaria tuvo muy buena capacidad predictiva. En el Índice pronóstico, el 57,2 % de los pacientes complicados y el 46,4 % de los fallecidos fueron de alto riesgo, con un índice "C" de 0,67 y 0,65, respectivamente, también existió una pobre capacidad predictiva para ambos eventos. La escala ICR obtuvo un índice "C" de 0,45 para complicaciones graves y 0,41 para mortalidad intrahospitalaria, ambos con muy mala capacidad predictiva.

Conclusiones: La escala GRACE presentó muy buena capacidad para predecir complicaciones graves y muerte intrahospitalaria; sin embargo, la escala Índice pronóstico mostró pobre capacidad predictiva para ambos suceso al no clasificar adecuadamente a los pacientes con valores extremos. La escala ICR presentó un índice "C" con mala capacidad predictiva para ambos sucesos.

Palabras clave: Infarto de miocardio; Rotura Cardíaca Postinfarto; Choque Cardiogénico

INTRODUCTION

Since ancient times, one of the objectives of doctors was to determine the prognosis of their patients[1]. As the Hippocratic aphorism states, to properly inform the prognosis to patients or to their families can avoid being censored by them. However, risk assessment in patients with acute coronary syndrome (ACS) has currently broader objectives which can be grouped into four categories[1]: a) informing and advising the patient and his/her family; b) identifying patients with high risk of death or infarction, who may improve their prognosis with proper treatment, c) identifying patients with a very low risk who do not require invasive studies, which avoids unnecessary costs and risks of these techniques, and c) planning cardiac rehabilitation and secondary prevention after the acute episode[2].

Unfortunately, the methods of risk assessment in ACS patients are far from perfect[1-4].The prognosis of patients with acute myocardial infarction (AMI) is highly variable due to the existence of a combination of individual clinical factors that are associated with a higher or lower presentation risk of short term major cardiac adverse events (MACE). Currently, some important therapeutic developments fundamentally influence early mortality, so they must be properly selected and applied to higher-risk subgroups, in order to generate a positive impact on health systems[3].

The true natural history of ST segment elevation myocardial infarction (STEMI) is difficult to establish for a number of reasons: the frequent occurrence of silent infarction, the frequency of prehospital sudden death, and the different methods and definitions used to diagnose this disease. Population studies have consistently shown that the total mortality rate in patients with a presumptive diagnosis of AMI or ACS during the first month is 50%, and about half of these deaths occur during the first 2 hours[5]. This high initial mortality has not changed much in recent years, unlike what has happened with in-hospital mortality[6], where contrary to pre-hospital, there has been a sharp decline.

Before the introduction of Coronary Care Units in the sixties, in-hospital mortality reached an average of 25-30%. In a systematic review of mortality studies conducted in the era before reperfusion, by the mid-eighties, there was an in-hospital mortality of 16%. With the widespread use of percutaneous coronary

intervention (PCI), fibrinolytic agents, antithrombotic treatment and secondary prevention, monthly total mortality was reduced to 4-6%, at least in patients participating in randomized large scale studies and those with fibrinolysis or PCI[7,8]. However, actual mortality rates are much higher, indicating that patients included in randomized studies present a lower risk than those who are in the 'real world'[9].

Prompt diagnosis and early risk stratification in patients presenting with acute chest pain are important to identify patients in whom early intervention may improve prognosis[10].

It should be noted that the possibility of risk stratification of patients with any other risk markers, other than the conventional ones, has not been proven in significant clinical studies[11-13].

Some of the proposed models attempt to predict the risk of death at 30 days through the analysis of multiple variables at admission, and others related to the treatment in cohorts of patients in large randomized controlled trials that tested the use of fibrinolytic agents[4,14-16]. These models give us useful information for a population with similar clinical conditions, but probably not always equal to that found in daily medical practice. The creation of a simple and universally applicable statistical model of hospitalization could classify the risk, allowing appropriate use of current therapeutic strategies[3].

The presence of chronic non-communicable diseases in the Cuban population is increasing as primary health care is prioritized and the rate of communicable diseases decreases, which favors the high presence of cardiovascular diseases. In 2009, 22,659 people died from cardiovascular disease and death rate per 100,000 inhabitants was 197,8[2,17].

Globally, the predictive power of risk stratification models, especially in the ACS, is noted in unselected populations, but in Cuba such studies are much more infrequent[2,16,17] and in the Cardiology Department of Arnaldo Milián Castro Hospital, in Santa Clara, only one previous study has been conducted, which we decided to continue because there is not an application of scores yet to predict the development of MACE and death in the treated population.

The benefits of this research include the scientific and healthcare areas as it provides new data on the subject that allow optimizing the treatment of ACS patients with ST-elevation, and help define therapeutic strategies according to risk, which favors the reduction of complications and loss of economic resources to the countr[2,18].

For these reasons we decided to determine the predictive value of MACE and in-hospital death in three models of risk stratification in STEMI patients admitted to the cardiology department of that hospital.

METHOD

A descriptive, longitudinal, prospective study was performed in 150 STEMI patients, admitted to the Cardiology Department of Arnaldo Milián Castro Clinical Surgical Provincial University Hospital, in the province of Villa Clara, Cuba, during the period from January 2010 to December 2011.

Selection of patients

The universe consisted of 216 patients with AMI treated at the Cardiology Hospital, which was the home base during the study period. The sample consisted of 150 STEMI patients who met the inclusion criteria.

Unit of analysis: Risk stratification scores of the Global Registry of Acute Coronary Events (GRACE)[9,19], InTIME (Intravenous nPA for Treatment of Infarcting Myocardium Early)[20,21] and ICR (*Instituto Cardiovascular de Rosario*)[2,3].

Sample type: No probabilistic.

Sampling type: No probabilistic, by convenience.

Inclusion criteria for the sample:

- Diagnosis of STEMI.
- Belonging to the province of Villa Clara.
- Admission to the hospital in the first 24 hours of symptom onset.
- Possibility of in-hospital follow-up until discharge.

Exclusion criteria are limited to those patients who did not meet the inclusion criteria.

Variables

MACE was considered that one that appears as direct complication of AMI, and which immediately endangers the patient's life: pump failure with Killip-Kimbal

class III and IV, maintained ventricular arrhythmia, re-infarction, recovered cardiac arrest mechanical complication or need for urgent PCI or surgical treatment.

In-hospital death was considered that one considered biological death, of irreversible character.

GRACE risk score[22-24]

It predicts probability of death both in-hospital and at 6 months after discharge. It uses the following variables: age, heart rate, systolic blood pressure, serum creatinine, Killip class, presence of cardiac arrest at the time of AMI, ST depression and elevated cardiac enzymes.

According to the score obtained by the scale (0-258), patients were stratified into three risk categories: low (≤ 108), intermediate (109-140) and high (> 140).

Prognostic Index risk score [14,20,21,25]

The Prognostic Index is a model based on the formula of Morrow[14,20] for the InTIME II substudy, with the purpose of predicting the likelihood of death at 30 days, which was used in an intensive care unit in Mexico to assess mortality in the first 24 hours, in STEMI patients during hospital stay. It was designed to qualify the initial risk by significant and, at the same time, simple variables. Its formula is: HR (age/10) ^{2} /SBP, where HR is heart rate and SBP, systolic blood pressure.

Risk categories are: low (<12.5 points), intermediate 1 (12.5 - 17.5), intermediate 2 (> 17.5 to 22.5), intermediate 3 (> 22.6 to 30) and high (> 30).

ICR[2,3] Risk Score

The ICR score was developed in order to predict, with simple variables, the risk of cardiogenic shock or death in the hospital phase of AMI. It uses four variables: age, systolic blood pressure, heart rate and anterior infarction, and predicts the likelihood of death and cardiogenic shock at admission[2,3]. Its risk categories are: 0 (0-11 points) 1 (12-20) and 2 (> 20).

Variable	Puntos
Age > 65 years	2
SBP ≤ 105	17
Heart Rate	7
Anterior AMI	3

Information analysis

Interviews and physical examinations of patients studied were taken as a primary source of information to conduct the investigation, and the hospital charts as a secondary source.

The variables obtained were stored and analyzed using SPSS for Windows®, 15.0 (SPSS, Chicago, IL, USA).

For the evaluation of each of the scores their discriminating and calibration power was calculated. Discrimination was analyzed by constructing the ROC curve, which is a function of sensitivity and specificity,

GRACE score (0–258)									
Age (years)		Heart rate		Systolic BP (mmHg)		Creatinine (mg/dl)		Killip class	
Range	Points	Range	Points	Range	Points	Range	Points	Range	Points
40–49	18	< 70	0	< 80	63	≤ 0,39	2	Class I	0
50–59	36	70-89	7	80-99	58	0,4–0,79	5	Class II	21
60–69	55	90-109	13	100-119	47	0,8–1,19	8	Class III	43
70–79	73	110-149	23	120-139	37	1,2–1,59	11	Class IV	64
≥ 80	91	150-199	36	140-159	26	1,6–1,99	14		
		≥ 200	46	160-199	11	2–3,99	23		
				≥ 200	0	≥ 4	31		
Cardiorespiratory arrest at admission: 43									
Elevated cardiac enzymes: 15									
ST segment deviation: 30									

and the calculation of the "c" index or area under the curve. Calibration reflected the power to predict the onset of complications studied over a wide range of scores, i.e. the relationship between the estimated and actual risk. To evaluate the calibration the Hosmer-Lemeshow method was used which qualifies the index predictive value, according to the ROC area in the following categories[1,17]:

C Index	Qualifier
< 0,50	Bad predictive power
0,50-0,60	Failed predictability
0,60-0,70	Poor predictive power
0,70-0,80	Acceptable predictive power
0,80-0,90	Good/very good predictive power
0,90-1,00	Excellent predictive power

For certain quantitative variables, the median was used as a measure of central tendency, and the standard deviation as a measure of dispersion.

The information obtained is presented through statistical tables and graphs with ROC curves.

Ethical parameters

Ethical principles were respected and the consent of the Institution to carry out this research was obtained.

RESULTS

The total number of patients admitted for ACS in the Cardiology Department of Arnaldo Milian Castro University Hospital of Villa Clara during the years 2010 and 2011 was 236 and 294, respectively; and correspondingly, 93 and 123 patients had a diagnosis of STEMI at discharge. These findings needed further scientific research to address the predictive power of risk stratification models of ACS.

The patients studied had a mean age of 66.47 ± 10.95 years, with a minimum of 38 and maximum of 94. Males were predominant accounting for 62% of the sample (Table 1).

Infarct topography in the studied patients is shown in Table 2. The extent and location of infarcted myocardium has important prognostic implications. In this respect, inferior AMI predominated (57.3%), the anterior ones accounted for 35.3% and the rest (7.3%) was from other topographies.

Table 1. Distribution of patients by gender. Arnaldo Milian Castro University Hospital. January 2010 - December 2011.

Gender	Nº	%
Female	57	38,0
Male	93	62,0
Total	150	100

Table 2. Distribution of patients, according to topography of infarction.

AMI topography	Nº	%
Inferior	86	57,3
Anterior	53	35,3
Other topographies	11	7,3
Total	150	100

The distribution of patients according to the GRACE score and development of MACE and in-hospital death is shown in Table 3. The 49 high-risk patients had severe complications and among those who did not have them, 63.4% were high risk. All 28 deceased patients (100% of total deaths and 18.6% of all patients) were previously classified in the high risk group and regarding the patients with intermediate and low risks, none had MACE or in-hospital death.

Chart 1 shows the ROC curve determined for the GRACE score according to the predictive value for MACE and in-hospital death in the patients studied. It is important to note that the "C" index for MACE (0.90) and death (0.87) has high values that show very good predictive power.

Of the 49 patients who had MACE, 28 (57.2%) were classified as high risk, according to the Prognostic Index score (Table 4), also 13 patients (26.6%) were included in intermediate risk 3; 7 (14.2%) in interme-

Table 3. Patient distribution according to the GRACE score and onset of major complications and in-hospital death.

GRACE Score	MACE				Death				Total	
	Yes		No		Yes		No			
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
High risk	49	100	64	63,4	28	100	85	69,7	113	75,3
Intermediate risk	0	0	30	29,7	0	0	30	24,6	30	20,0
Low risk	0	0	7	6,9	0	0	7	5,7	7	4,7
Total	49	32,6	101	67,4	28	18,6	122	81,4	150	100

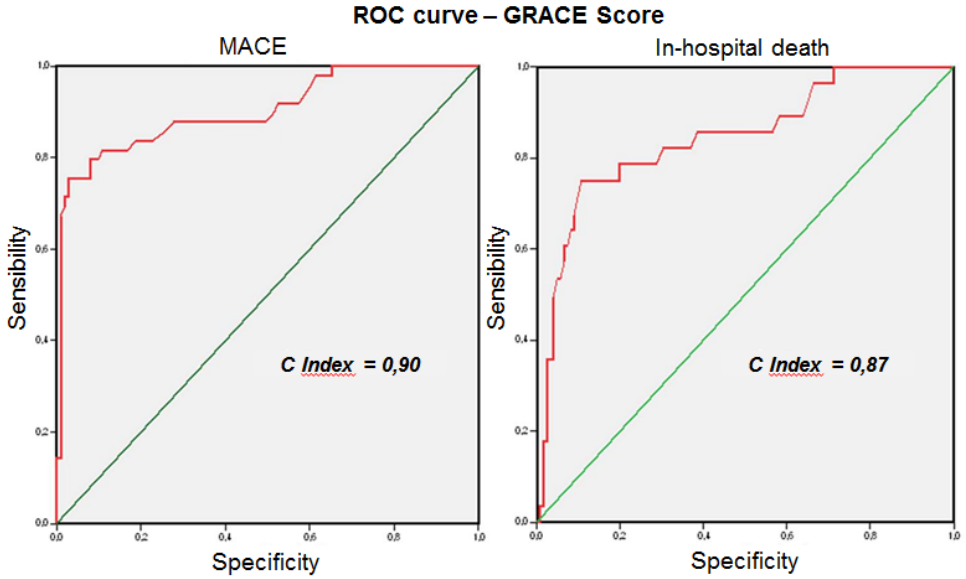

Chart 1. GRACE score validation to predict the development of MACE and in-hospital death.

diate 2, and only 1 patient (2.0%) in intermediate risk 1; however, all of them had MACE. The Prognostic Index aims mainly to adjust ACS treatment to the individual risk of the patient; however, the results regarding the predictive power of this score were not the expected ones at the time of writing the curve (Chart 2).

This table also shows that of the 28 deceased patients (18.6%), 13 (46.4%) were classified as high risk of in-hospital death, according to the Prognostic Index, 5 (17.9%) were included in the intermediate risk group 3, 2 (7.1%) had an intermediate risk 2 and 4 (14.3), an intermediate risk 1. Patients with high-risk score and intermediate risk score 3 showed a significantly increased risk of mortality that after adding their percentages accounted for 66.7% of all deaths.

Chart 2 shows the ROC curves of the Prognostic Index relative to the prediction of severe complications and in-hospital death. The validation of this index showed poor predictive power, with "C" indexes of 0.67

Table 4. Distribution of patients according to the prognostic Index and onset of major complications and in-hospital death.

Prognostic Index Score	MACE				Death				Total	
	Yes		No		Yes		No			
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
High risk	28	57,2	39	38,6	13	46,4	54	44,3	67	44,7
Intermediate risk 3	13	26,6	20	19,8	5	17,9	28	23,0	33	22,0
Intermediate risk 2	7	14,2	10	9,9	2	7,1	15	12,2	17	11,3
Intermediate risk 1	1	2,0	22	21,8	4	14,3	19	15,6	23	15,3
Low risk	0	0	10	9,9	4	14,3	6	4,9	10	6,7
Total	49	32,6	101	67,4	28	18,6	122	81,4	150	100

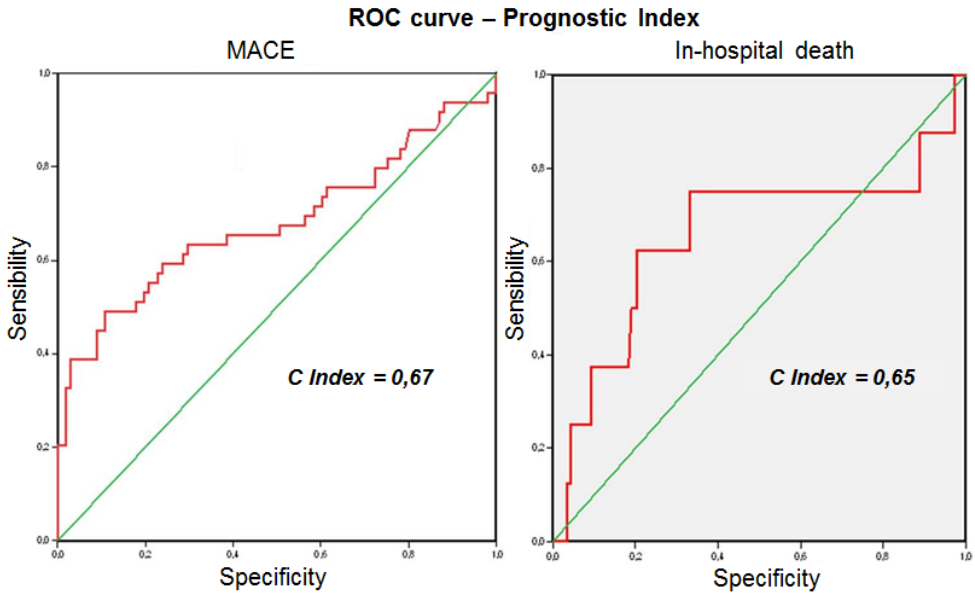

Chart 2. Validation of the Prognostic Index score to predict MACE and in-hospital death.

and 0.65, respectively.

Table 5 shows the distribution of patients according to the ICR score for the development of serious complications and in-hospital death. As can be seen, of the 49 patients with such complications (32.6%), 55.1% belong to the score 0, 28.6% to the score 1 and the remaining 16.3%, to the score 2. We noted that most patients who had MACE were included in the score 0 to 1 for this risk stratification model, which does not really correspond with the individual risk each patient had, so there is not a good result when performing validation. Most patients were older than 65 years; however, to include them on a score 2 they should be mostly in early phase of shock, in correspondence with the validated criteria for that score.

In analyzing in-hospital death, score 0 was the most

Table 5. Patient distribution according to the ICR score and onset of major complications and in-hospital death.

ICR Score	MACE				Death				TOTAL	
	Yes		No		Yes		No			
	Nº	%	Nº	%	Nº	%	Nº	%	Nº	%
Score 0	27	55,1	32	31,6	17	60,7	42	34,4	59	39,4
Score 1	14	28,6	47	46,6	8	28,6	53	43,4	61	40,6
Score 2	8	16,3	22	21,8	3	10,7	27	22,2	30	20,0
Total	49	32,6	101	67,4	28	18,6	122	81,4	150	100

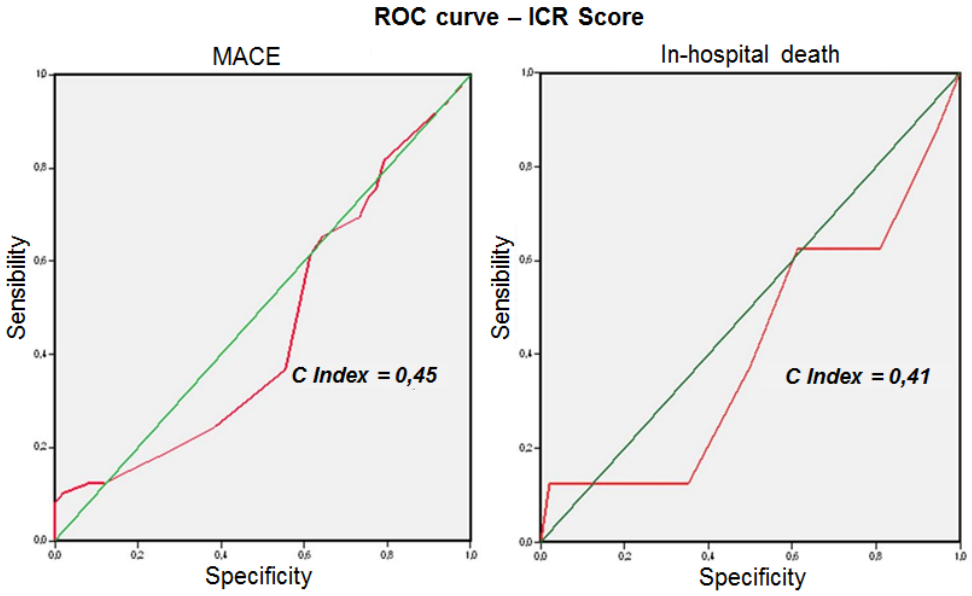

Chart 3. ICR score validation to predict MACE and in-hospital death.

representative with 17 patients (60.7%), and in score 1 there were 8 (28.6%), corresponding to a significant number of total deaths. These data indicate a poor predictive value since the majority of cases are included in lower risk groups, which coincided with the results obtained from ROC curves of such score (Chart 3), where validation shows poor predictive power for MACE, with an area under the curve of 0.45, and 0.41 related to in-hospital mortality.

DISCUSSION

There are clear indications for pharmacological or mechanical reperfusion in AMI[26-28]. The benefit of fibrinolytic therapy is well established[29,30], as about 30 early deaths per 1,000 patients treated before 6 hours of symptom onset are avoided, and 20 deaths per 1000 patients treated between 7 and 12 hours. In general, the higher absolute benefit is observed in patients with higher risk[30-32].

There is need for the use of risk scores based on parameters readily identifiable in the acute phase of infarction, with the aim of quickly treating the patient that presents increased risk of MACE and even death[20,28,33]. Because the risk of MACE decreases with time, its early assessment is indicated.

There are currently many studies in order to facili-

tate the use of a risk stratification score to help us group patients at a given level, according to their risk and to establish the most appropriate treatment option. In this research we evaluate three risk models: GRACE, Prognostic Index and ICP.

Other risk stratification studies[3,14] have found similar results to ours regarding age and sex; also, Garcia Almagro *et al.*[34], found ages of 54 ± 19 years in patients with ACS, with higher prevalence in men.

The results of Rizo *et al.*[2] are also very similar, but we decided not to compare these to ours because, as stated earlier, this research is a continuation of the one conducted by the aforementioned authors[2] two years earlier in the same hospital, with patients of similar sociodemographic origin.

The American Heart Association (AHA) considers age as a significant predictor of death in patients with AMI, as there is a proportional increase between this and the reported death rates. The risk of death is increased 1.49 times for every 10 years of increased age[34]. Lenderink *et al.*[35] assessed the validity of mortality measures in patients ≥ 75 years compared with TIMI and InTIME scores, and found that Killip-Kimball class III and IV was the most important risk factor for mortality, and delayed arrivals to emergency services, hyperglycemia, and advanced age as contributors to increased risk, with a very good "C" index of 0.86.

There is a relationship between the number of electrocardiographic leads with ST segment elevation and mortality. Patients with 8 or 9 affected leads have mortality 3 to 4 times higher than those in whom the ST elevation affects only 3 or 4 leads[36].

In our study the most frequent location was on the underside. Califf *et al.*[37] reported similar results, noting the underside (58.65%), as the most common topography, followed by the anterior one (37.3%).

The frequent association of anterior AMI with the appearance of MACE in the short and long term is well known. Changes related to the size, shape and thickness of the left ventricle as a consequence of the infarct, affect not only the infarcted segment but also the surrounding segments (ventricular remodeling), a phenomenon influenced by ventricular load, the permeability of the infarct-related artery and its size[38]. These factors affect the systolic-diastolic function of the heart, which directly affects the prognosis of our patients, which is why left ventricular function is used in many studies today, not only as an important risk factor for MACE and in-hospital death, but also for the risk assessment and stratification in the short and long terms[39].

Raposeiras-Roubín *et al.*[40] indicate that anterior AMI are twice as likely to die than those with inferior infarction because of its frequent association with cardiogenic shock. The probability of presenting clinical symptoms that evolve into cardiogenic shock and death is related to specific parameters of left ventricular function[39-43]. Knowledge of these aspects supports the use of different risk stratification scores, given the existing relationship between the infarct-related artery, its size and the possibility of serious electrical complications that compromise the patient's life from the beginning of the ischemic process, or the presence of hemodynamic deterioration and mechanical complications that require timely surgical intervention[44-46].

For two decades, various models coming from applied mathematics, statistics, and other sciences have helped in the sense that the predictions we usually make about the future evolution of patients, are being helped by quantitative methods that allow, with certain limitations, to give numerical values to our predictions, so we can make, in many cases, more rational and effective decisions[2,47]. For this purpose risk scores arise, which may be defined as an algorithm or clinical prediction rule, which help doctors interpret the obtained information[2,3,48].

The finding that 32.6% of patients developed MACE and that initially all of them were included in the high risk group according to the GRACE score, allowed making the timeliest therapeutic intervention, favoring evolution as well as short and long term prognosis. We believe that the results obtained can be related to the wide range of values provided by this score, which facilitates the possibility to include more individual characteristics not only in correspondence with the ACS, but also with associated comorbidities that could in parallel affect the patient.

The GRACE study is a multinational registry, including patients with ACS, whose main objective is to improve the quality and expectancy of life, and to describe appropriate diagnostic and treatment strategies in patients with this type of disease[22-24].

Granger *et al.*[49], using a multiple logistic regression analysis, performed a model to assess the probability of in-hospital death in 11,380 patients, which was validated in a prospective cohort of 3,972 patients; similarly 12,142 patients in the GUSTO IIb trial were eva-

luated. In both studies the risk factors and the prognostic level found, related with the GRACE score were similar to our results, just like those found by Araujo-Gonçalves *et al*[46]. However, other studies[2,50] suggest that the GRACE score loses some of its power to discriminate when applied in a different, less selected population.

In our research, the ROC curves of this score showed good sensitivity and specificity for predicting MACE and in-hospital death. Fox *et al.*[19] indicate that the predictive reliability of GRACE model is good, with a "C" statistic of 0.82 for in-hospital death, and takes into account nine factors that are associated with an independent predictive value of the main criteria of analysis between the time of admission and at 6 months. These include age, conges-tive heart failure, peripheral vascular disease, systolic blood pressure, Killip class, baseline serum concentration of creatinine, positive cardiac markers at baseline, cardiac arrest at the time of hospitalization and number of leads with ST deviation.

It is important to note that, according to this author[19], some groups believe that the mortality model that emerged from the GRACE[49] study is superior to TIMI or to the model proposed by Boersma *et al.*[51], due to its good predictive power of cumulative risk in patients with different ACS, which is associated with a prospective and external validity. The simplified model provides most of the information and is applicable for individual patients.

Despite the good predictive capability and easy application of the GRACE score, its use is very limited in clinical practice. Data from the GRACE registry[2,19,49] show that the use of PCI in patients with ACS is independent of the estimated risk, as PCI was conducted in 60% of ACS patients with ST segment elevation and low risk, in comparison to 41% of high risk patients. Similar data were obtained in the DESCARTES registry[2,3,52], in which the prognosis of STEMI patients, estimated by the TIMI score, did not influence the decision to perform PCI. However, these observations have nothing against the score referred to; it is simply a sign of poor adherence to it in determining what action to take regarding the patient.

Moreover, the Eagle *et al.*[53] study can serve as a warning to remember that in ACS patients, the Killip and Kimbal score has a significant independent predictive value. For this reason, it seems reasonable to suggest that the incorporation of simple measurements of ventricular function within the scores developed for risk assessment should not be forgotten. In our research, 65.5% of patients with complications had a functional class III or IV.

Data published by Rathore *et al.*[25] indicate that 48.69% of complicated cases were previously classified as high risk, according to the GRACE score, which coincides with our results. The same happens when predicting mortality, where it is stated that mortality at 30 days was 21.7%, similar to that found in our research.

The poor predictive power of the Prognostic Index score to predict the development of severe complications (0.60) and in-hospital death (0.69) was similar to that found by other authors[14,25]. Although this index seems to have a good performance in small populations, it has limitations when applied to community-based cohort of elderly patients[2], which suggests that this risk score works poorly when used in a nationwide representative cohort[25].

It is noteworthy that patients who were located at intermediate scores, according to the Prognostic Index, did not show a direct relationship between these and the risk of death, so we could state that this score, based on the formula of Morrow[14,20], defines and stratifies properly the probability of death for patients with extreme values, but not for intermediate ones.

The ICP score was developed in order to predict, with simple variables (age, systolic blood pressure, heart rate and anterior AMI), the risk of cardiogenic shock or death in the hospital phase of AMI[3]. Zapata *et al.*[3] argue that the values 0, 1 and 2 showed a shock or in-hospital death rate of 2.7%, 15.5% and 59.4%, with a good model calibration and area under the ROC curve of 0.80, which corresponds to a good discrimination for sensitivity and specificity in the group of patients included in this study, which does not coincide with our results. Contrary to what was stated by this author[3], ICR score was not effective in predicting MACE and in-hospital death risk in specific populations, for we find a "C" index with very poor predictive power, which shows poor prediction of the event, due to low sensitivity and specificity.

It should be noted that although excellent clinical trials have been developed, the results are subject to differing interpretations, and that the purpose of these trials is to give rise to early interventions, and provide treatment options to patients who are determined directly by the individual risk of each one and,

in part, by the resources available in the center where they are being treated.

We realize that diagnostic tests and treatment options may not be available in all countries or institutions; even in the richest countries the issues of cost-effectiveness are increasingly important when deciding on treatment strategies. As up to now, the clinical practice guidelines are not prescriptive, there are many differences between one patient and another, so individual attention is paramount, and clinical judgment, experience and common sense are very important.

The prognostic value of ventricular function in patients with acute or chronic cardiovascular disease is well proven, as well as the usefulness of its assessment through clinical means or imaging (echocardiography) to stratify risk and facilitate decision making. Some of the proposed prediction scores do not include measurements of ventricular function, either through clinical means or imaging. This has surely limited its usefulness and may partly justify the low "C" index values observed with some proposed models[49].

For several years the determination of intracellular proteins and inflammatory markers such as troponin, C-reactive protein and brain natriuretic peptide (BNP or NT-pro BNP) has gained great boom in randomized clinical trials, which is a reason for great enthusiasm in the medical community, because they are useful to stratify prognosis by identifying patients at increased risk of fatal complications that could not be detected by usual means[24,54]. Probably, their inclusion in risk prediction models might increase the predictive power of these, however, although the results obtained to date are encouraging, before including these markers in risk scores, other studies are needed to adjust the actual predictive value of each in different populations[11-13,55,56]. It is also needed to analyze the cost-benefit, cost-effectiveness and cost-utility[57,58], for although some of the more effective treatments (intra-aortic balloon pump, angioplasty, urgent bypass surgery) can only be performed in tertiary health care centers, those centers of scarce resources will be able to quickly identify high-risk patients to refer them to institutions of higher development.

Although only some of the most common factors are commented, one should not forget that the ACS is a condition in which there are, from the pathophysiological point of view, multiple factors affecting various body systems to a greater or lesser extent, hence the risk stratification models should be continuously nurtured because advances in therapeutic strategies in recent decades can offer different treatment options to patients, depending on the severity of the disease and its prognosis.

CONCLUSIONS

Of the three risk stratification models in STEMI patients, the GRACE risk score showed higher sensitivity and specificity to predict the onset of serious complications and in-hospital death. The Prognostic Index stratified and defined properly the probability of death for patients found in extreme values, but not to those included in intermediate ranges, and ICR score did not achieve good predictive indexes.

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