Predictive Factors of In-Hospital Mortality and of Severe Perioperative Complications in Myocardial Revascularization Surgery

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Objective *- To investigate preoperative predictive factors of severe perioperative intercurrent events and in-hospital mortality in coronary artery bypass graft (CABG) surgery and to develop specific models of risk prediction for these events, mainly those that can undergo changes in the preoperative period.*

Methods *- We prospectively studied 453 patients who had undergone CABG. Factors independently associated with the events of interest were determined with multiple logistic regression and Cox proportional hazards regression model.*

Results *- The mortality rate was 11.3% (51/453), and 21.2% of the patients had 1 or more perioperative intercurrent events. In the final model, the following variables remained associated with the risk of intercurrent events: age ≥ 70 years, female sex, hospitalization via SUS (Sistema Único de Saúde - the Brazilian public health system), cardiogenic shock, ischemia, and dependence on dialysis. Using multiple logistic regression for in-hospital mortality, the following variables participated in the model of risk prediction: age ≥ 70 years, female sex, hospitalization via SUS, diabetes, renal dysfunction, and cardiogenic shock. According to the Cox regression model for death within the 7 days following surgery, the following variables remained associated with mortality: age ≥ 70 years, female sex, cardiogenic shock, and hospitalization via SUS.*

Conclusion *- The aspects linked to the structure of the Brazilian health system, such as factors of great impact on the results obtained, indicate that the events investigated also depend on factors that do not relate to the patient's intrinsic condition.*

Key words: myocardial revascularization surgery, in-hospital mortality, perioperative complications

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At the beginning of the 20th century, cardiovascular diseases accounted for less than 10% of the deaths in the world. At the end of that century, that group of diseases accounted for approximately half of the deaths in the developed countries and 25% of the deaths in developing countries. In 2020, cardiovascular diseases are estimated to ount for 25 million deaths per year, and ischemic heart diseases will surpass infectious diseases as the first cause of death in the world [1].

In Brazil, cardiovascular diseases lead the causes of death and hospitalization, accounting for 32.6% of the deaths with a determined cause. From 1996 to 1999, cardiovascular diseases accounted for 9% of the hospitalizations via SUS (Sistema Único de Saúde - the Brazilian public health system), being the major cause of hospitalization in the population aged 40 to 59 years (17%) and in the population aged 60 or above (29%). Ischemic cardiac diseases accounted for 29.6% of the deaths due to cardiovascular diseases, the mean mortality rate of this group of diseases being 46.4 deaths per 100,000 inhabitants/year in the period [2].

Mortality due to ischemic heart diseases varies widely among countries and among regions in the same country. Recent data from the MONICA Project [3] relative to a 10-year period of study with 37 different populations indicate a reduction in ischemic cardiac events and related mortality rates in most countries. Multiple aspects have contributed to this favorable tendency, including the reduction in the prevalence of risk factors, the improvement in health care and the increase in access to it, and new methods of diagnosis and treatment [4,5].

The number of myocardial revascularization surgeries increased 227% in the United States from 1979 to 1997, and, in 1997, approximately 366,000 patients underwent this surgical procedure. In that country, approximately 1 in every 1,000 individuals undergoes myocardial revascularization surgery per year, which results in costs of $ 50 billion an-

nually [6]. The introduction of percutaneous coronary intervention slowed down the progression of myocardial revascularization surgery [7], which, however, remained as 1 of the most frequently performed surgeries. In-hospital mortality after isolated myocardial revascularization surgery declined over the period from 1967 to the 1980s. From the 1990s onwards, the morbidity and mortality rates have been constant or shown a mild increase [8]. In Brazil, the hospitalizations via SUS related to myocardial revascularization surgeries comprised a total of 1,465 in 2001, representing a 27% increase as compared with data from 1996 (1,157). The mean in-hospital mortality rate during this period was 7.4% [9].

The tendency towards stabilization or mild increase in the mortality indices after myocardial revascularization surgery worldwide may reflect alterations in the type of patient undergoing myocardial revascularization surgery over time, particularly with the appearance of the percutaneous revascularization procedures. Compared with patients from the 1970s, the current population undergoing surgery is characterized by older people, a high percentage of females, presence of poor cardiac condition (unstable angina, three-vessel disease, previous revascularization, left ventricular dysfunction) and association with other diseases (hypertension, diabetes, and peripheral vascular disease), comprising a more severely ill population [10,11].

Raw (overall) rates of mortality and of complications, however, do not allow a precise evaluation of the institutional results related to the surgical procedures for cardiovascular diseases. Assessment of the severity of the illness of the population undergoing cardiac surgery and the use of this information to stratify the risk is fundamental to adjust the indicators of mortality and complications according to the degree of compromise of the patients, and, consequently, to allow valid comparisons of the results in the same institution over time and among institutions [12-14].

In Brazil, punctual initiatives for quantifying the results related to myocardial revascularization surgery are limited to overall indicators, particularly mortality, ignoring the characterization of the severity of the surgical population. The lack of epidemiological studies to predict the risk of mortality in myocardial revascularization surgery in our country hinders valid comparisons with the mortality rates reported by different institutions.

We report the results of a prospective study with patients who had undergone myocardial revascularization surgery to identify predictive factors of in-hospital mortality and of severe perioperative intercurrent events. A $p < 0.05$ was considered significant.

Methods

This study was carried out in a medium-sized (250 beds) tertiary care general hospital and referral center for cardiac surgery in the city of Belo Horizonte, in the state of Minas Gerais, from March 1996 to March 1999. At that hospital, a mean of 30 cardiac surgeries is performed per month. The population studied comprised all patients who underwent myocardial revascularization surgery. The surgical procedures without extracorporeal circulation or aortic clamp were also included in this study.

Based on a literature review, 4 models of mortality risk prediction in cardiac surgery were selected [15-18] as a basis for structuring the assessment protocol of the patients. All risk factors included in the final models of risk prediction in those studies were included in our final protocol in addition to other factors considered pertinent by the authors that were available in the patient's medical record. The final protocol comprised 5 groups of variables as follows: demographic variables and those related to lifestyle, concomitant clinical problems, assessment of the cardiovascular system, priority degree of the surgery, and data referring to the surgical procedure itself. The variable "team" was structured aiming at grouping the surgeons of the institution considering the following working similarities: technical approach, type of patients, and work routine. Chart I shows the list of variables included in the protocol.

Data collection was performed by the major investigator, the major source of data being the medical records. The patients who met the inclusion criteria were followed up from their admission to the surgical block onwards, and their data referring to the pre-, peri-, and postoperative periods were recorded in a specific form. The periodicity of data collection varied, being daily in the intensive care unit and 3 times a week in the other hospitalization units. Peri- and postoperative complications were recorded in open field. Periodical assessment of the records of the surgical cardiac procedures performed enabled the identification of all patients who died during surgery, avoiding loosing information of this specific group, and also enabled checking occasional losses of patients due to changes in data collection flow. The database was structured with EPI-INFO software. Data input was performed on a monthly basis with parallel consistency analysis and correction of occasional errors.

The following dependent variables were considered: in-hospital death due to all causes during or after myocardial revascularization surgery, and severe intercurrent events during the procedure (acute myocardial infarction, low cardiac output, arrhythmias, increased bleeding, cardiopulmonary arrest, and hemodynamic instability).

We chose to include "death due to all causes" in the place of "death due to cardiac cause" because of the difficulty in establishing the cause of death in patients undergoing myocardial revascularization surgery with a complicated clinical evolution.

The analysis of severe intercurrent events was limited to the perioperative period, because the immediate postoperative (24 hours) complications are strongly influenced by the factors related to surgery, therefore not fulfilling the objectives of this study.

All patients were followed up from the day of the surgery until their hospital discharge or death. The sociode-

Chart I – Independent variables included in the protocol and their relation with the models of risk prediction chosen

Variable	Models of risk prediction			
	Parsonnet[15] 1989	Tuman[17] 1992	Iggins[16] 1992	Tu[18] 1995
Demographic and anthropometric aspects and lifestyle				
Age	x	x	x	x
Sex	x	x		x
Weight			x	
Smoking *				
Assessment of the cardiovascular system				
Stenosis of the left main coronary artery*				
Number of coronary arteries impaired*				
Left ventricular ejection fraction	x	x	x	x
Left ventricular aneurysm	x			
Surgical aortic stenosis			x	
Transaortic pressure gradient >120 mm Hg	x			
Mitral valve insufficiency			x	
Pulmonary artery systolic pressure ≥ 60 mm Hg	x			
Pulmonary hypertension		x		
Preoperative intra-aortic balloon	x			
Preoperative AMI		x		
Unstable angina *				
Systemic arterial hypertension	x			
Congestive heart failure		x		
Cardiogenic shock	x			
Acute mechanical complication	x			
Dependence on pacemaker	x			
Adult congenital heart disease	x			
Endocarditis*				
Previous cerebral stroke		x	x	
Previous peripheral vascular surgery			x	
IV Nitrate /IV inotropic *				
Previous anti-platelet therapy*				
Coexisting clinical problems				
Acute renal failure	x			
Serum creatinine		x	x	
Dialysis	x			
Hematocrit			x	
Diabetes	x		x	
Chronic obstructive bronchopulmonary disease			x	
Morbid obesity	x			
Paraplegia	x			
Severe asthma	x			
Dyslipidemia*				
Preoperative ICU*				
Priority of surgery				
Elective, urgent, emergency surgery				x
Emergency surgery		x	x	
Postangioplasty emergency	x			
Postcatheterization emergency	x			
Data referring to surgery				
Reoperation	x	x	x	x
Valve				x
Mitral valve surgery	x	x		
Aortic valve surgery	x	x		
MRVS				x
MRVS + valve	x			
Multivalve or MRVS + valve		x		x

* Other variables included in the protocol.

mographic variables and the preoperative conditions contained in the protocol were investigated as potential predictors of death and of severe complications. The following preoperative risk factors were excluded from the study because they had a frequency below 3%: emergency surgery after angioplasty (0.9%), emergency surgery after catheterization (0.2%), left ventricular aneurysm (2.9%), preoperative intra-aortic balloon (0.7%), and acute renal failure (0.2%).

Considering the equivalence of some variables indicating similar dysfunctions, they were grouped into the 5 following categories for multivariate analysis: type of surgery (reoperation or nonelective surgery, or both), renal dysfunction (dependence on dialysis or creatinine ≥ 1.9 mg/dL, or both), cardiac failure (congestive heart failure or acute pulmonary edema or pulmonary hypertension, or any combination of these), myocardial ischemia (unstable angina or acute myocardial infarction in the 3 weeks preceding surgery), and degree of impairment (stenosis > 50% in 3 coronary arteries or stenosis of the left main coronary artery, or both).

The factors associated with mortality and with severe complications in the perioperative period were determined with multiple logistic regression. Initially, each variable grouped according to affinities, demographic aspects and lifestyle, concomitant clinical problems, assessment of the cardiovascular system, priority of the surgery, and data referring to the surgical procedure was investigated. Later, the colinearity between the variables in each group and between variables of different groups was investigated. The final model included all variables that showed a statistical association with the event at the level of 0.10 in addition to sex and age, considered, a priori, confounding variables in this study. When 2 or more variables had colinearity, only the one showing the strongest association with the event of interest or with the most plausible clinical significance was included in the final model.

Survival after myocardial revascularization surgery was analyzed to determine the factors associated with mortality within the first 8 days after surgery. The patients who were discharged or died prior to that period contributed to the study only with the time until the occurrence of 1 of these facts. Kaplan-Meier curves for the time elapsed until death were calculated for the cohort and subgroups according to age and sex. The heterogeneity of the curves was tested using the log-rank test. The multivariate analysis of deaths after surgery was performed with the Cox proportional hazards regression model to assess the predictive effect of each variable on the risk of death.

Results

In the period studied, 453 patients underwent myocardial revascularization surgery, of whom only 12 (2.6%) underwent another concomitant surgical cardiac procedure (9 aortic valve replacements and 3 mitral valve replacements). Tables I and II show the characteristics of the patients studied in regard to length of stay (overall, stratified for periods, and at the intensive care unit), the preoperative variables investigated, and data about the surgical procedure.

The mean age was 61.1 years (± 10.4 years), 22.5% of the patients being 70 years or older. Males represented

Table I – Length of stay, duration of the surgery, and time of extracorporeal circulation in myocardial revascularization surgery.

Variable	Mean ± SD	Median	Variation
Length of stay (days)			
Preoperative	6.6 ± 6.4	5	0 - 37
Postoperative	11.2 ± 12.6	8	0 - 138
Preoperative ICU	3.8 ± 3.6	3	0 - 23
Postoperative ICU	4.1 ± 5.8	2	0 - 63
Surgery			
Duration of the procedure (hs)*	5.2	5	0.8 - 11.7

SD- standard deviation; * information available for 98.0% of the patients; ** information available for 82.3% of the patients; duration of aortic clamp available in only 33% (151) of the procedures.

67.5% of the patients. The age distribution of the female population differed from that of the male population, with a greater concentration of females older than 59 years ($X^2 = 6.24$; $p = 0.04$). In regard to medical insurance coverage, 71.3% of the patients were covered only by the SUS. An increase in the proportion of individuals with other types of coverage (private patients or patients covered by private health plans) was observed as age increased (fig. 1).

Elective surgeries corresponded to 71.7% of the procedures performed. No difference was observed in the distribution of the surgeries grouped by categories in regard to the type of patient's medical insurance coverage at the time of hospitalization.

Ventricular ejection fraction was determined only in 153 (33.8%) patients, in whom the median of the ventricular ejection fraction was 55%, and 10.5% of the patients showed severe left ventricular dysfunction (ventricular ejection fraction ≤ 35%).

Although 38.9% of the patients had acute myocardial infarction prior to surgery, only 3.1% experienced it within 7 days from surgery, 4.4% between 7 and 21 days, and 27.6% experienced it more than 21 days before surgery.

During the procedure, 21.2% of the patients (96/453) had 1 or more severe perioperative intercurrent events (tab. III). Six risk factors showed a statistically significant association

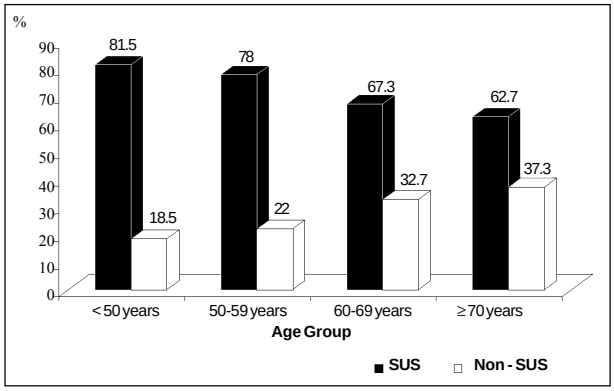

Fig. 1 - Distribution of the population studied according to age group and the type of health care coverage at the time of hospital admission.

Table II – Distribution of the patients who underwent myocardial revascularization surgery according to the preoperative characteristics and conditions.

Variable	Distribution N (%)
Demographic aspects and lifestyle	
Age < 50 years	65 (14.4)
Age 50-59 years	127 (28)
Age 60-69 years	159 (35.1)
Age ≥ 70 years	102 (22.5)
Female sex	147 (32.5)
Male sex	306 (67.5)
Smoking	130 (28.7)
Type of health care coverage on admission	
Public (SUS)	323 (71.3)
Private (non-SUS)	130 (28.7)
Data concerning the cardiovascular system	
Stenosis of left main coronary artery	42 (9.3)
One-vessel disease	94 (20.9)
Two-vessel disease	217 (48.3)
Three-vessel disease	138 (30.7)
Left ventricular aneurysm	13 (2.9)
Previous AMI < 7 days	14 (3.2)
Previous AMI 7-21 days	20 (4.6)
Previous AMI > 21 days	125 (28.7)
Previous cerebral stroke	22 (4.9)
Systemic arterial hypertension	301 (66)
Congestive heart failure	64 (14.1)
Unstable angina	191 (42.2)
Cardiogenic shock	10 (2.2)
Acute pulmonary edema	17 (3.8)
Pulmonary hypertension	20 (4.4)
Preoperative intra-aortic balloon	3 (0.7)
Use of an anti-platelet drug 7 days	19 (4.2)
Coexisting clinical problems	
Creatinine ≥ 1.9 mg/dL	14 (3.6)
Dependence on dialysis	6 (1.3)
Diabetes mellitus	88 (19.4)
Chronic obstructive pulmonary disease	76 (16.8)
Dyslipidemia	80 (17.7)
Anemia (hematocrit < 34%)	39 (10.1)
Surgical team	
Team A	98 (21.6)
Team B	250 (55.2)
TeamC	105 (23.2)
Type of surgery	
Elective surgery	325 (71.7)
Non-elective surgery	128 (28.3)
Reoperation	30 (6.6)
Postangioplasty emergency surgery	4 (0.9)
Postcatheterization emergency surgery	1 (0.2)
Characterization of the procedure	
Use of the saphenous vein	389 (86.1)
Use of the internal thoracic artery	327 (72.3)
Concomitant aortic replacement	9 (2)
Concomitant mitral replacement	3 (0.7)
Surgery without extracorporeal circulation	24 (5.4)

with the occurrence of an event: age ≥ 70 years, dependence on dialysis, serum creatinine ≥ 1.9 mg/dL, cardiogenic shock, unstable angina, and pulmonary hypertension.

The incidence of severe postoperative intercurrent event in myocardial revascularization surgery was higher in the extreme age groups: < 50 years (24.6%) and ≥ 70 years (30.4%) (fig. 2). The incidence was also greater in patients hospitalized via SUS in all age groups and in all surgical categories, except in the elective surgery/reoperation group (fig. 3).

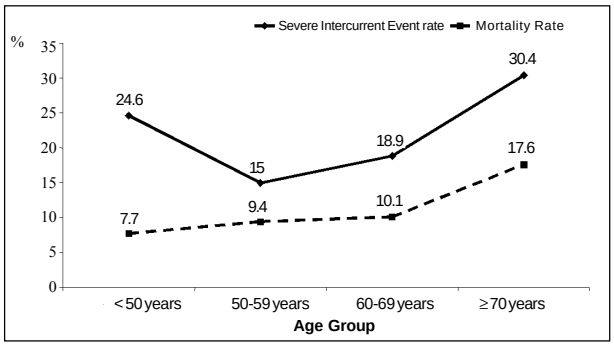

Fig. 2 - Mortality rate and severe perioperative intercurrent event rate in myocardial revascularization surgery according to age group.

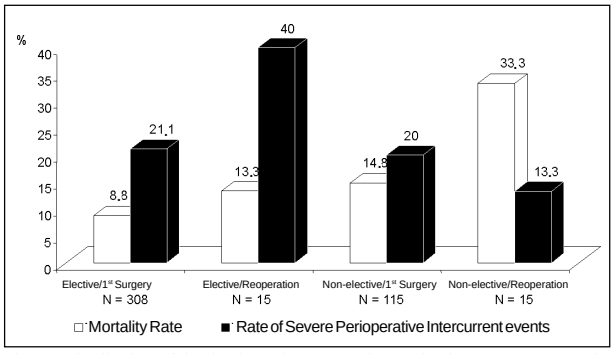

Fig. 3 - Distribution of the deaths and severe perioperative intercurrent events in regard to the characteristics of the surgeries.

Severe perioperative intercurrent events predominated in female patients in all age groups, except in the 60- to 69-year group (fig. 4).

In the final model, the following preoperative variables remained statistically associated with a high risk of intercurrent events: age ≥ 70 years, hospitalization via SUS, cardiogenic shock, ischemia, and dependence on dialysis. The variable ischemia (OR = 0.45; 95% CI: 0.27 – 0.75) showed a protective effect in regard to the event assessed (tab. IV).

The overall mortality rate observed was 11.3% (51/453). In the period referring to the day of the surgery (perioperative and immediate postoperative periods), the mortality rate was 3.3% (15/453). Eight (1.8%) patients died in the surgical block, and, in the postoperative period, the mortality rate was 9.7%.

The results of the univariate analysis of the preoperative risk factors for mortality are shown in table III, where the following 11 risk factors showed a significant association with mortality: age ≥ 70 years, hospitalization via SUS, reoperation, nonelective surgery, dependence on dialysis, diabetes, serum creatinine ≥ 1.9 mg/dL, congestive heart failure, cardiogenic shock, acute pulmonary edema, and pulmonary hypertension.

The mortality rate was greater in the population aged 70 years or more (17.6%) as compared with that of the patients aged less than 70 years (9.4%; p=0.02) (fig. 2). Differences in the mortality rates between the sexes were only

Table III - Factors associated with severe perioperative intercurrent event and in-hospital mortality in myocardial revascularization surgery on univariate analysis (logistic regression).

Severe perioperative intercurrent event		
Variable	Odds ratio	P value
Age ≥ 70 years	1.80	0.02
Dependence on dialysis	7.72	0.02
Serum creatinine ≥ 1.9 mg/dL	3.06	0.03
Unstable angina	0.62	0.048
Cardiogenic shock	3.87	0.03
Pulmonary hypertension	2.61	0.03
In-hospital mortality		
Variable	Odds ratio	P value
Age ≥ 70 years	2.006	0.02
SUS coverage on admission	3.35	0.005
Non-elective surgery	2.06	0.02
Reoperation	2.62	0.03
Dependence on dialysis	8.31	0.02
Serum creatinine ≥ 1.9 mg/dL	6.69	<0.001
Diabetes mellitus	2.33	0.008
Congestive heart failure	2.35	0.01
Acute pulmonary edema	3.53	0.03
Cardiogenic shock	8.53	0.002
Pulmonary hypertension	3.70	0.007

observed when stratification by age group occurred. In the group aged ≥ 70 years, the risk of death in females was 2.7 times greater than that in males (p= 0.02) (fig. 4).

The mortality rate among individuals hospitalized via SUS was 13.9%, and the risk of death among them was 3.4 times greater than that among individuals covered by private health plans or private patients (p=0.05). All deaths on the day of the surgery occurred in patients hospitalized via SUS (X^2 = 6.2; p=0.01). After that period, no difference was observed in the distribution of deaths in regard to the type of health care coverage at the time of hospitalization (X^2 = 0.64; p=0.42). Among individuals hospitalized via SUS, deaths occurred in all age groups, while in the category of private medical insurance or private patients, deaths were limited to the population aged 60 years or more.

Nonelective surgeries associated with reoperation had a mortality rate of 33.3%, 5 times greater than that in the reference group (elective/first surgery) (X^2 = 7.93; p= 0.005) (fig. 3).

The patients who developed cardiogenic shock in the preoperative period had an 8.6-time greater risk of death than those without that risk factor (p=0.002). In the population assessed, 10 patients with that condition were identified, and 50% evolved to death. Analyzing death on the day of surgery, this risk became 15 times greater (p=0.003) and it increased to 36 times when, in addition to shock, the patient had been hospitalized via SUS (p=0.0006).

The final model of mortality risk prediction in myocardial revascularization surgery obtained with multiple logistic regression is shown in table IV. The following variables comprise the model: age ≥ 70 years, female sex, hospitalization via SUS, diabetes, renal dysfunction, and cardiogenic shock.

Table IV – Final models of risk prediction of severe perioperative intercurrent event and in-hospital mortality in myocardial revascularization surgery.

Severe perioperative intercurrent event (logistic regression)				
	Coefficient	OR	95% CI	P
Age ≥ 70 years	+ 1.97	1.71	[1.00 - 2.90]	0.049
Female sex*	+ 1.36	1.41	[0.85 - 2.30]	0.17
SUS coverage	+ 2.22	1.90	[1.08 - 3.35]	0.03
Cardiogenic shock	+ 2.66	6.39	[1.62 - 25.09]	0.008
Dependence on dialysis	+ 2.69	11.37	[1.94 - 66.62]	0.007
Ischemia	- 3.04	0.45	[0.27 - 0.75]	0.002
Mortality (logistic regression)				
	Coefficient	OR	95% CI	P
Age ≥ 70 years	+ 2.15	2.10	[1.07 - 4.15]	0.03
Female sex*	+ 0.61	1.23	[0.63 - 2.40]	0.54
SUS coverage	+ 2.89	3.89	[1.55 - 9.78]	0.004
Diabetes	+ 2.27	2.25	[1.12 - 4.53]	0.02
Renal dysfunction	+ 2.95	6.04	[1.83 - 19.93]	0.003
Cardiogenic shock	+ 3.05	10.58	[2.33 - 48.18]	0.002
Mortality (cox proportional hazards regression model)				
	Coefficient	HR	95% CI	P
Age ≥ 70 years	+ 1.36	1.64	[0.80 - 3.36]	0.17
Female sex*	+ 1.12	1.45	[0.75 - 2.80]	0.26
SUS coverage	+ 2.47	3.72	[1.31 - 10.55]	0.01
Cardiogenic shock	+ 4.24	8.79	[3.22 - 23.99]	<0.01

OR- odds ratio; HR- hazard-ratio; 95% CI- 95% confidence interval; * sex was maintained as an adjusting factor in the final model, although not statistically associated with the risk of severe intercurrent events and mortality.

Analyzing survival, 72.5% (37/51) of the deaths occurred within 8 days after the procedure, including the day of surgery. The Kaplan-Meier curves indicated the following risk factors for shorter survival in myocardial revascularization surgery: health care coverage via SUS (p=0.01), perioperative cardiogenic shock (p<0.001), and diabetes (p=0.04). Overall survival and that stratified by age, sex, and type of health care coverage are shown in figure 5. Table IV shows the Cox regression model for the risk of death. The variables age ≥ 70 years, female sex, preoperative cardiogenic shock, and hospitalization via SUS remained in the model significantly interfering with the risk of death.

Discussion

This study attempted to clarify the impact of factors intrinsic to the patient and the aspects regarding health care assistance on 2 events related to myocardial revascularization surgery: severe perioperative intercurrent events and in-hospital mortality.

The following preoperative conditions were identified as important predictors of both mortality and severe perioperative intercurrent events: cardiogenic shock, renal dysfunction, and type of health care coverage at the time of hospitalization.

Our results significantly differ from most of the models of risk prediction in cardiac surgery [15-24], because we identified a more restricted number of variables. This difference may be partially due to the smaller number of patients included in our study and to the fact of not following the patients after hospital discharge.

Age ≥ 70 years was a risk factor for both mortality and severe perioperative intercurrent events, although its statistical significance was borderline for the latter. Age is a critical determinant of complications and mortality after cardiac surgery in most studies, although the importance attributed to age varies widely [15-18,22]. Loss of physiological reserve with aging, which affects the various systems in different degrees, contributes to the elevated morbidity in the elderly population, especially regarding noncardiac complications, such as renal dysfunction, neurological dysfunction, or multiple organ failure [17,25].

The increased risk for complications and mortality after cardiac surgery among females [15,17-22,24] has been attributed to several factors, such as the reduced body surface [15,16], the smaller diameter of the arteries in the female sex [26], and the diagnosis and treatment of ischemic heart diseases in more advanced stages among females, because of the inappropriate approach of female chest pain [17,27,28]. Factors, such as the reduction in estrogen with age, may influence the differences in risk found between the sexes. Although in our study no statistical association of the female sex with the events assessed has been found, this variable was maintained in the final models, because of the potential confounding effect attributed to it.

Some elements (priority of surgery and reopera-

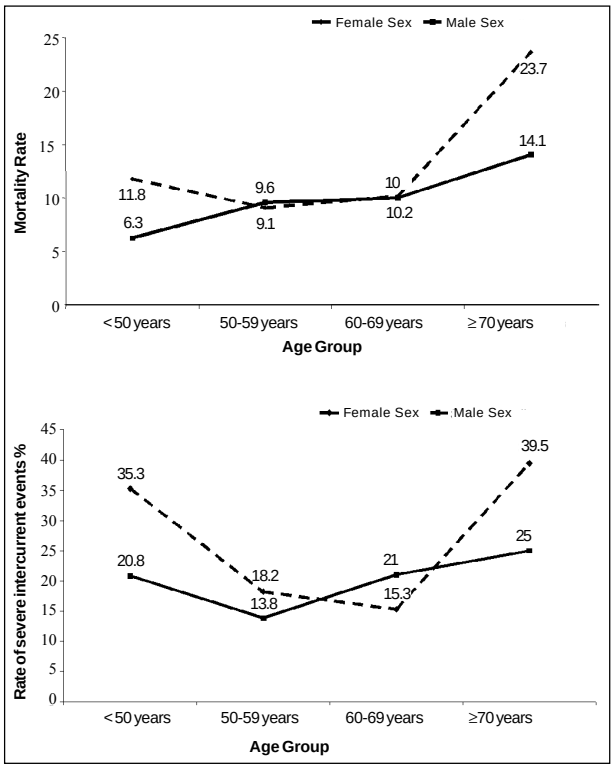

Fig. 4 – Distribution of the mortality rate and rate of severe perioperative intercurrent events in myocardial revascularization surgery according to age group and sex.

tion), although important predictors of mortality in other studies [18-20,22], have a degree of subjectivity that makes their use difficult. The classification of the surgery as urgent or emergency, for example, is extremely subjective. In the present study, even classifying the surgeries as elective and nonelective, that variable was significant only for mortality in the univariate analysis and was not maintained in the final model. Colinearity was observed in the combined variable "category of surgery", which aggregates priority of surgery and reoperation with preoperative cardiogenic shock in predicting mortality, and maintenance of the last variable in the final model was chosen due to its strongest association with the response event.

One of the important aspects of this study is the presence of the variable hospitalization via SUS as a predictor of perioperative intercurrent event and mortality in myocardial revascularization surgery. This aspect leads us to the question of inequality that characterizes our society, permeating all the spheres of Brazilian life, including health care [29-31]. Hospitalization via SUS may be interpreted in this context as a marker of the patient's specific conditions (worse economic and life conditions) and of the structure of health care assistance (access to diagnosis and time elapsed until health care assistance) [29]. This structure is characterized by a greater difficulty in accessing specific medical actions, especially for patients living in the countryside, which may lead to worsening of the clinical findings and a delay in scheduling surgery. This is very clear when the risk of death on the day of surgery and in the following period is stratified. The impact of hospitalization via SUS concentrates in mortality in the perioperative period and in the immediate postoperative period (on the same day of surgery): all patients who evolved to death were covered by SUS at the time of hospitalization. The severity of the clinical findings of these patients is well characterized by the presence of preoperative cardiogenic shock: of the 6 patients covered by SUS who developed that condition, 67% died, 50% on the day of surgery. A contrary situation was observed with the other 4 patients who had cardiogenic shock and were not covered by SUS: only 1 patient died in the postoperative period. In the preoperative period, the mean length of stay in the intensive care unit was 9.5 days for the patients covered by SUS (0 – 23 days) and 2.3 days for the other patients (0 - 4 days). Although not significant, this difference is 1 more indicator of the severity of this group of patients.

The overall and postoperative lengths of stay in the intensive care unit were similar for the patients covered by SUS and the others. The difference observed in the preoperative length of stay may reflect social problems of the patients covered by SUS, who are many times referred from other municipalities, and, not rarely, with no condition to undergo preoperative examinations at an ambulatory level. In addition, delay in performing the procedure with several episodes of surgery suspension during hospitalization was observed.

Although certain noncardiac diseases have been intuitively considered important predictors of severe perioperative intercurrent events and mortality in myocardial revascularization surgery, in the present study only diabetes and renal dysfunction remained in the final model. These findings are in accordance with the results of several other studies [15-17,20,22,24] and favor a causal association between these variables and in-hospital mortality and perioperative intercurrent events.

The definitions for renal dysfunction vary among the studies, some of which consider high levels of serum creatinine [16,17,21,24] and others value the dependence on dialysis [22]. In this study, these 2 definitions were maintained as separate variables. In the analysis, an additional variable, renal dysfunction, was created and defined as the presence of at least 1 of the 2 alterations. This additional variable was included in the model of mortality prediction. In the predicting model of severe perioperative intercurrent event, dependence on dialysis was more significant than elevated levels of serum creatinine or the combination of the 2 variables. The prevalence of the dependence on dialysis was low in the cardiac surgical population, which was evident in the population assessed, and that association should be seen with caution.

The importance of the variable "cardiogenic shock" was verified in all models developed. As a predictor of mortality, it is related to the perioperative period and the immediate postoperative period. As a severe clinical expression of left ventricular failure, shock has been associated with extensive myocardial lesion of that ventricle in 40% of the ca-

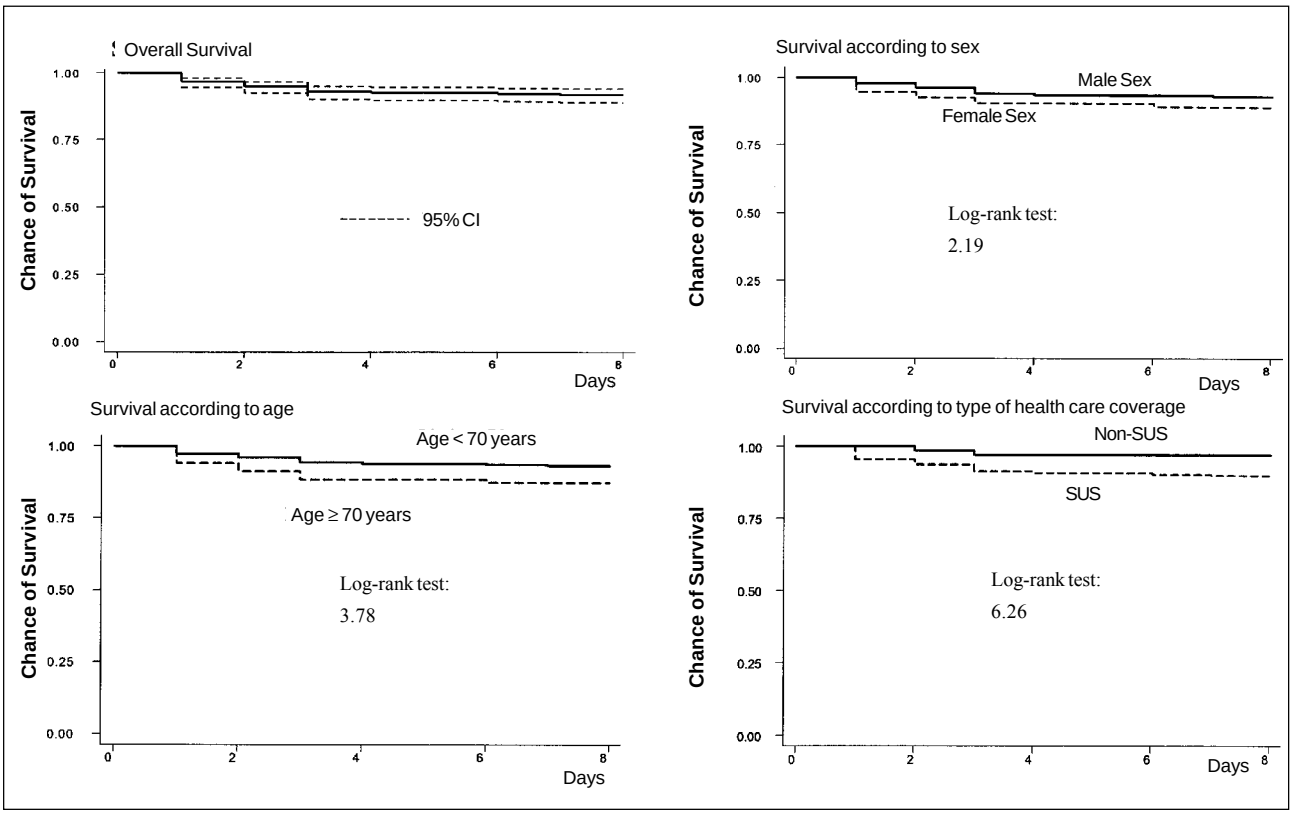

Fig. 5 - Overall survival and survival stratified for age, sex, and type of health care coverage during and after myocardial revascularization surgery.

ses, and in more than 80% of the patients with acute myocardial infarction, when present. The remaining cases correspond to mechanical defects, such as rupture of the ventricular septum or the papillary muscle, or right ventricular infarction [32,33]. Recent estimates point to an incidence of approximately 7% of cardiogenic shock in patients with acute myocardial infarction, 10% of whom have this condition on hospital admission, while the remaining 90% develop that complication during hospitalization [34]. The same authors showed a drop in the early mortality rate from 70%-80% in the 1970s to 50%- 60% in the 1990s in the group of patients with this condition associated with acute myocardial infarction. In this study, the mortality rate of patients with cardiogenic shock undergoing myocardial revascularization surgery was 50% in the perioperative period, 30% in the immediate postoperative period, and 20% in the middle and late postoperative periods.

An aspect that draws attention in the model of risk prediction for severe perioperative intercurrent events is the presence of the variable ischemia with a protective effect (OR = 0.47). Considering that this variable results from gathering the individuals with a history of acute myocardial infarction or unstable angina in the 3 weeks preceding surgery, or both, a possible explanation for this finding may be the difference in the patients' assistance, in regard to more intensive care and more strict preoperative clinical control. This aspect, however, deserves further investigation.

The Cox proportional hazards regression model allowed analyzing data from the study considering the time elapsed until death, adjusting with covariables. We chose the 7-day follow-up because of the greater frequency of deaths in this period (73%) and to reduce follow-up losses, and, consequently, the bias potential. In the final model, the permanence of the variable "cardiogenic shock" reflects its impact on early mortality, because all deaths with this condition occurred up to the first postoperative day. The presence of diabetes, although significant in the univariate analysis, did not remain in the final model of survival. Colinearity was observed between this condition and the type of health care coverage as follows: of the 12 patients with diabetes who evolved to death, 11 were under the SUS coverage. The renal dysfunction variable, both in univariate and multivariate analyses, did not show a significant association with death. The colinearity with sex may explain this behavior as follows: of the 15 patients with renal dysfunction analyzed, 13 were males and 3 died.

The need to characterize the surgical population in regard to the risk of death or complications resulted in several studies conducted in developed countries and proposals of predicting models of peri- and postoperative risk [15-24]. The major objective of stratifying the population in regard to risk is to estimate the preoperative surgical risk and the variables that may undergo intervention in this phase. In addition, stratification of the patients in regard to surgical risk allows studying the effect of technical alterations, of the dynamics of the medical assistance, and of the working process on the variations and trends of the indicators of

mortality and morbidity, independent of the nature and severity of the cases.

Several discussions have been carried out involving the question of impact of the models of risk prediction on the evaluation and improvement of the quality of health. For many medical professionals, the major question is how, regarding the patients, a system of risk prediction can help in individual decisions. The question is: does statistics apply to the individual? An aspect to be considered is that the models of risk prediction do not accurately estimate the risk of intercurrent events or death for all patients, because they derive from a group of commonly found variables, not considering the infrequent characteristics occurring in the population, and can be decisive for the result of a particular individual. Variables that tend not to be identified as important in studies with small populations due to its rarity can be important in the individual risk expression of the patient. Although patients have some unique characteristics, they also have many other characteristics in common, and the consideration of the similarities allows anticipating risks and foretelling results for the group. Another important aspect is the possibility of interfering with the results expected, optimizing the condition of the surgical patient, ensuring maximum control upon the modifiable variables.

However, it is worth noting that this study has some limitations. The most important one refers to the small size of the population studied, which limits the detection power of the study. Some practical questions made the patients' follow-up for a period of 30 days, as in some studies [15,16,21,23,24], difficult after hospital discharge. Longer follow-up of patients undergoing myocardial revascularization surgery at the institution and the conduction of multicenter studies are required to refine and validate the variables identified in this study. Another important aspect is the lack of some pieces of information for some patients, such as ejection fraction, which were identified in several studies as predictors of in-hospital death after myocardial revascularization surgery. This lack reinforces the need for standardizing comprehensive and well-structured protocols at all hospitals performing this type of surgery.

Finally, it is worth noting that the quality of health care assistance depends on a series of factors, not only on the patient's intrinsic condition, even in more risky procedures, such as myocardial revascularization surgeries. The models of risk prediction developed in this study draw attention to aspects regarding the structure of the health care system as factors of great impact on the results obtained. These results are particularly important because these conditions may be modified by measures and policies of general and specific planning that aim at eliminating the inequalities in health care assistance and at improving in-hospital assistance performance.

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