Original Article

Risk Factors, Morbidity, and Mortality Associated with Atrial Fibrillation in the Postoperative Period of Cardiac Surgery

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Objective

To determine the incidence of atrial fibrillation in the postoperative period of cardiac surgery, its impact on morbidity, mortality, and hospital stay, and to analyze the risk factors in the pre, trans, and postoperative periods.

Method

Contemporary cohort study with 158 adult patients undergoing cardiac surgery, of whom those with atrial fibrillation in the preoperative period were excluded. The patients were assessed with continuous cardiac monitoring and daily electrocardiograms. Any episode of irregular rhythm with the presence of f waves of variable morphology and amplitude was considered atrial fibrillation.

Results

The general incidence of atrial fibrillation was 28.5%, being 21.6% for revascularized patients and 44.3% for those undergoing valvular repair. Factors independently associated with atrial fibrillation were left heart failure in the preoperative period (p=0.05; RC=2.2), total fluid balance (p=0.01; RC=1.0), duration of surgery (p=0.03; RC=1.01) [and other associated factors, age > 70 years, aortic valvular disease, psychomotor agitation, length of installation of the drains, pulmonary congestion and respiratory insufficiency in the postoperative period]. The use of beta-blockers (p=0.01; RC=0.3) was a protective factor. Atrial fibrillation in the postoperative period was associated with an increase in the length of hospital stay (16.9±12.3 days versus 9.2±4.0 days, p<0.001) and a greater incidence of stroke or postoperative death (p=0.02).

Conclusion

The incidence of atrial fibrillation in the postoperative period of cardiac surgery was high and caused a significant increase in morbidity, mortality, and the length of hospital stay. Among the independent risk factors, excessive fluid balance is significant. The use of beta-blockers was identified as a protective factor.

Key words

atrial fibrillation, arrhythmias, cardiac surgery, postoperative care, risk factors

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Atrial arrhythmias are common in the postoperative period of cardiothoracic surgery. They may occur in 11% to 40% of patients after myocardial revascularization surgery and in approximately 50% of those undergoing valvular surgery[1,2]. Atrial fibrillation is the most frequent arrhythmia after cardiac surgery[3]. It is commonly an auto-limited condition, which rarely causes perioperative death, but can extend the length of hospital stay, increasing costs. Sometimes, it may be considered a cause of perioperative acute myocardial infarction and thromboembolic phenomena[3,4]. The following risk factors are associated with atrial fibrillation in the postoperative period of cardiac surgery: left heart failure, systemic inflammatory response syndrome, septicemia or multisystem organ failure[5], suspension of beta-blockers[6], chronic obstructive pulmonary disease[7], and the need for mechanical ventilatory support[8]. Advanced age, however, is the risk factor most frequently associated with postoperative atrial fibrillation[9]. In patients at higher risk, preventive measures should be considered[10].

This prospective and observational study aimed at assessing the incidence of atrial fibrillation in the postoperative period of cardiac surgery and the pre, trans, and postoperative risk factors associated with that arrhythmia in a national cardiology referral center, and at analyzing morbidity, mortality, and the length of hospital stay related to that arrhythmia.

Methods

From January to May 2002, 158 patients undergoing cardiac surgery in a referral institution were selected in the immediate postoperative phase.

The sample comprised patients undergoing cardiac surgery on a systematically selected day, which differed consecutively from week to week, such that if carried out on Monday on a given week, it would be carried out on Tuesday the following week, and so forth. All patients selected during the study were followed up until the discharge day, and no patient or protocol information was lost during follow-up. The mean number of patients selected per month was 31.8.

This is a contemporary cohort study, in which the patients were assessed at 4 distinct times: in the immediate postoperative period; in the intensive care unit (postoperative ICU); on discharge from the postoperative ICU; and on hospital discharge.

This study comprised patients undergoing cardiac surgery, with or without extracorporeal circulation, due to ischemic or valvular heart disease. Those with a history of preoperative atrial fibrillation were excluded.

In each of the 4 phases of assessment, a protocol previously approved by the Committee of Ethics on Research with data to be investigated and written informed consent was used. In the selection phase, the demographic and preoperative data were collected.

All patients were examined personally by the author, who also analyzed the pre and postoperative examinations. In the postoperative ICU stay phase and in the discharge from the ICU phase, the patients were assessed daily from the clinical and laboratory points of view.

Cardiac rhythm was assessed through continuous cardiac monitoring in all patients during a minimum period of 72 hours (postoperative ICU stay phase) and through daily electrocardiographic examinations until hospital discharge. Additional electrocardiographies were performed when patients reported palpitations, tachycardia, or angina, and postoperative biochemical, hematological, and radiological examinations were performed according to the routine of the postoperative service at our institution.

Any episode of supraventricular arrhythmia, whose electrocardiographic tracing had f waves of variable morphology and amplitude with irregular ventricular rhythm, was considered atrial fibrillation (primary outcome).

Episodes of atrial fibrillation that had a minimum duration of 15 minutes or required treatment due to symptoms or hemodynamic instability were included in the study. The use of a vasopressor, when administered at a dosage greater than 5μg/kg/min longer than the first 2 hours of the postoperative period, was considered.

Postoperative anemia was defined as a hematocrit lower than 30% or hemoglobin below 10 mg/dL, or both, or in case of transfusion of at least 1 unit of red blood cell concentrate and hypokalemia, as a serum potassium level below 3.5 mmol/L.

Initially, frequency tables for all variables contained in the database were generated. Then, the mean ± standard deviation for quantitative variables and the percentage for qualitative variables were calculated. The strength of the association of each factor for postoperative atrial fibrillation was measured through the estimates of the relative risk with 95% confidence intervals. The significance of these associations was determined by the chi-square test, and, when necessary, by the Fischer exact test. Comparisons of quantitative data between the groups were performed by using the Student *t* test for independent samples.

A mathematical model based on multivariate logistic regression was used for establishing the best model for predicting and controlling the potential effect of confusion between the factors analyzed and the occurrence of postoperative atrial fibrillation. Variables reported as relevant in the literature and those showing a strong association with the outcome in the bivariate analysis performed were selected to be included in the logistic model. The significance level adopted was 0.05. The analysis of data was performed by using the SPSS software program, version 8.0.

Results

In our sample, males (64%) and coronary artery disease (70%) predominated. In regard to the patients, 61% were hypertensive, 60% smokers, 58% had unstable angina, and 54% used beta-blockers. The mean age of the patients was 60.9±11.2 years.

The general incidence of postoperative atrial fibrillation was 28.5% (45 cases). Of the 158 patients followed up, the mean number of atrial fibrillation per month was 9 cases.

Table I shows the preoperative categorical variables, the demographic characteristics of the patients, which underwent bivariate analysis in regard to the occurrence of atrial fibrillation. The following 4 risk factors significantly related to the greater incidence of postoperative atrial fibrillation were identified: aortic valvular disease (p=0.02); preoperative left heart failure (p=0.006); no previous use of beta-blockers (p=0.02); and age > 70 years (p=0.03). Of the 20 cases with mitral valvular disease, 9 had atrial fibrillation (45%; p=0.07). Previous acute myocardial infarction, enlargement of the P wave on electrocardiography, emergency surgery, reoperation, and unstable angina were not related to postoperative atrial fibrillation. Coronary artery disease showed an inverse relation with postoperative atrial fibrillation.

Comparing patients undergoing myocardial revascularization with those undergoing valvular heart surgeries, a greater incidence of postoperative atrial fibrillation was found among the latter (p=0.008; RR=2.18; CI: 1.28-3.70).

The bivariate analysis for postoperative categorical variables (tab. II) identified 3 factors associated with atrial fibrillation. The most significant factor was psychomotor agitation (p=0.008), in which atrial fibrillation occurred in 9 out of 15 patients. Respiratory insufficiency and pulmonary congestion were also significant findings in our study. Pericardial friction, perioperative acute myocardial infarction, and use of dopamine were factors not related to postoperative atrial fibrillation.

In regard to the continuous variables associated with postoperative atrial fibrillation, the bivariate analysis showed that the increased length of installation of the drains is a significant factor (p=0.04). Patients with a greater incidence of atrial fibrillation showed crystalloid, colloid, and total fluid balances significantly more positive than those who did not have that arrhythmia (p=0.03, 0.04, and 0.04, respectively). The durations of extracorporeal circulation and ischemia were not significant in the present study. The preoperative potassium level determined no difference (p=0.07). The other postoperative biochemical and hematological measurements were not statistically significant (serum levels of potassium, creatinine, and sodium; glycemia; hematocrit; and hemoglobin) (tab. III).

Multivariate logistic regression identified 4 statistically independent predictors of postoperative atrial fibrillation. Left heart failure was identified as a preoperative variable, whilst an exceedingly long time of surgery was recognized as a significantly independent transoperative variable. In regard to the postoperative variables, respiratory insufficiency with a borderline statistical significance (p=0.07) showed a clinically important association with a greater incidence of atrial fibrillation. The excessively positive total fluid balance was a significant risk factor for triggering that arrhythmia (1% of additional risk for each milliliter accumulated above the mean fluid balance). The use of beta-blockers was a protective factor for the development of postoperative atrial fibrillation. Respiratory insufficiency (p=0.07) showed no clinically important association with a greater incidence of that arrhythmia (tab. IV).

Figure 1 depicts the postoperative incidence of atrial fibrillation as follows: most patients (63%) had arrhythmia on the second (13 cases) and third (16 cases) postoperative days; 11% of the patients had atrial fibrillation on the forth postoperative day; and

8% had that arrhythmia on the fifth postoperative day. Atrial fibrillation was observed in 39 (86.7%) patients during their stay in the intensive care unit (ICU), and 79% had the arrhythmia up to the third day in the ICU.

All 45 patients with postoperative atrial fibrillation were discharged with sinus rhythm. Of the others, 18 (40%) spontaneously reverted to sinus rhythm before any therapeutic measures were taken. Most patients analyzed in this study were treated and the arrhythmia was reverted with the intravenous administration of amiodarone (40%). Eight patients with spontaneous reversion received intravenous digitalis for controlling ventricular response. Nine patients underwent electrical cardioversion as follows: 4 due to hemodynamic instability and the other 5 treated with amiodarone prior to electric cardioversion.

Of the patients receiving beta-blockers, those receiving the medication in the pre and postoperative periods had a lower incidence of atrial fibrillation (12.5%). Sixty-one patients with a 23% incidence of atrial fibrillation discontinued the use of beta-blockers in the postoperative period. Patients who did not receive beta-blockers in the pre- and postoperative periods had a greater incidence of atrial fibrillation (39.7%; p=0.017) (fig. 2).

The use of beta-blockers in the pre and postoperative periods (p=0.028; RC=0.22; CI: 0.05-0.88) provided protection against atrial fibrillation as compared with those who did not use the drug. Prevention of atrial fibrillation was also observed in patients who received the drug only in the preoperative period, with a borderline statistical significance, as compared with those who did not receive it (p=0.06; RC=0.45; CI: 0.19-1.04). Suspension of the beta-blockers in the postoperative period caused an increase in the incidence of atrial fibrillation in our study, but with no statistical difference (p=0.37; RC=0.48; CI: 0.10-2.07). Usually, the use of beta-blockers at any moment (pre or postoperative periods, or both periods) represented a protective factor against the development of atrial fibrillation as compared with the nonuse of them (p=0.01; RC=0.38; CI: 0.17-0.83).

The increase in the length of hospital stay had a direct relation with postoperative atrial fibrillation, the mean stay being 16.9 ± 12.3 days for patients with atrial fibrillation versus 9.2 ± 4.0 days for those with no atrial fibrillation (p < 0.001) (fig.3).

Nine patients, 6 with aortic valvular disease and 3 with ischemic heart disease, had stroke or died (combined outcome) in the postoperative period, 7 of whom had atrial fibrillation (p=0.02). Of the 45 patients with atrial fibrillation, 11.1% developed stroke, and among those with no atrial fibrillation, only 1.9% had stroke (p=0.02) (fig. 4). Atrial fibrillation was related to neither pulmonary thromboembolism (p=0.72) nor perioperative acute myocardial infarction (p=0.54).

Table I - Bivariate analysis of preoperative categorical variables and atrial fibrillation

Categorical variable	With AF N= 45 (%)	No AF N=113 (%)	p
Male sex	28 (68)	73 (64)	0.46[a]
Age > 70y	15 (33)	20 (17)	0.03[a]
CAD	24 (53)	87 (76)	0.004[a]
Previous AMI	13 (28.8)	38 (33)	0.35[a]
AVD	17 (37)	22 (19)	0.02[a]
MVD	09 (20)	11 (9.7)	0.07[a]
COPD	09 (20)	17 (15)	0.29[a]
Nonuse of BB	27 (61)	45 (39)	0.02[a]
Unstable angina	22 (49)	69 (61)	0.11[a]
LHF	27 (60)	41 (36)	0.006[a]
P wave amplitude	14 (31)	24 (22)	0.14[a]
Reoperation	05 (11)	09 (7)	0.36[a]
Emergency surgery	02 (4.5)	06 (5.3)	0.59[a]

CAD - coronary artery disease; AMI - acute myocardial infarction; AVD - aortic valvular disease; MVD - mitral valvular disease; COPD - chronic obstructive pulmonary disease; BB - beta-blockers; LHF - left heart failure. [a] Fisher exact test.

Table II - Bivariate analysis of postoperative categorical variables and atrial fibrillation

Categorical variables	With AF	No AF	p
Psychomotor agitation	09	06	0.008[a]
Respiratory failure	14	15	0.01[a]
Pulmonary congestion	14	19	0.04[a]
Dopamine use	18	39	0.32[a]
Pericardial friction	12	33	0.46[a]
AMI	03	09	0.54[a]

AMI - acute myocardial infarction. [a] Fisher exact test.

Table III - Continuous variables in bivariate analysis associated with atrial fibrillation

Continuous variables	With AF	No AF	p
Ejection fraction (%)	63.7 ± 17.3	58.4 ± 15.4	0.23
LA dimension (mm)	42.7 ± 6.9	39.1 ± 10.9	0.23
Preoperative K (mEq/L)	4.0 ± 0.3	3.9 ± 0.41	0.07
Duration of ECC (min)	85.0 ± 29.4	83.3 ± 31.2	0.75
Duration of ischemia (min)	56.3 ± 21.8	53.6 ± 19.2	0.48
Duration of surgery (min)	279 ± 62.2	260 ± 70.2	0.09
Length of drain installation (min)	53.7 ± 25.9	44.9 ± 16.2	0.04
Crystalloid balance (mL)	2941 ± 1809	2246 ± 1517	0.03
Colloid balance (mL)	-252 ± 964	-530 ± 878	0.04
Total balance (mL)	2688 ± 1945	1716 ± 1542	0.04
Length of hospital stay (days)	16.9 ± 12.3	9.2 ± 4.0	<0.001
PO Hg (mg/dL)	10.0 ± 1.6	10.4 ± 1.4	0.22
PO Ht (%)	30 ± 4.1	30.7 ± 3.3	0.32
PO creatinine (mg/dL)	1.1 ± 0.7	1.1 ± 0.5	0.98
PO K (mEq/L)	4.2 ± 0.4	4.1 ± 0.4	0.69
PO Na (mg/dL)	137 ± 3.5	137 ± 3.6	0.99
PO glycemia (mg/dL)	156 ± 50	187 ± 202	0.14

ECC - extracorporeal circulation; LA - left atrium; Hg - hemoglobin; PO - postoperative; Ht - hematocrit; Student *t* test.

Table IV - Variables associated with atrial fibrillation in logistic regression

Variables	Odds ratio	95% CI	p
Use of BB	0.34	0.2 - 0.8	0.01
Preoperative			
LHF	2.24	1.0 - 5.0	0.05
Transoperative			
Exceedingly long surgery (min)	1.01	1.001 - 1.015	0.03
Postoperative			
Positive total FB (mL)	1.01	0.99 - 1.02	0.01
Respiratory insufficiency	2.6	0.90 - 7.3	0.07

BB - beta-blocker; LHF - left heart failure; FB - fluid balance.

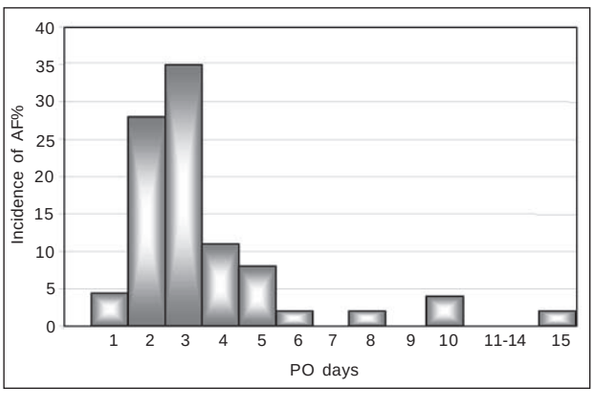

Fig. 1 - Incidence of atrial fibrillation per postoperative day.

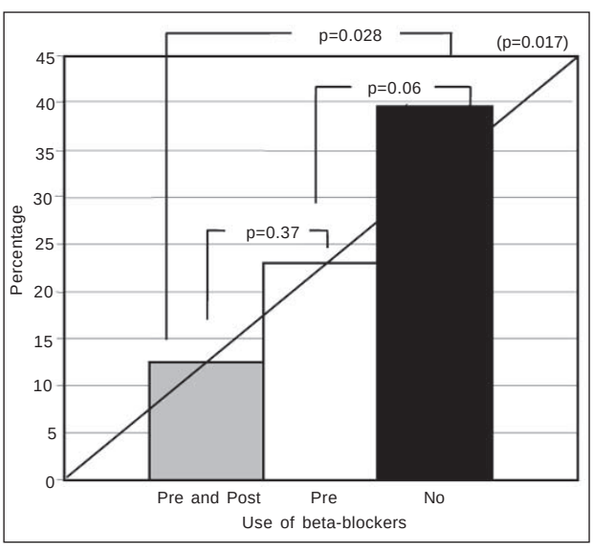

Fig. 2 - Incidence of atrial fibrillation versus use of beta-blockers.

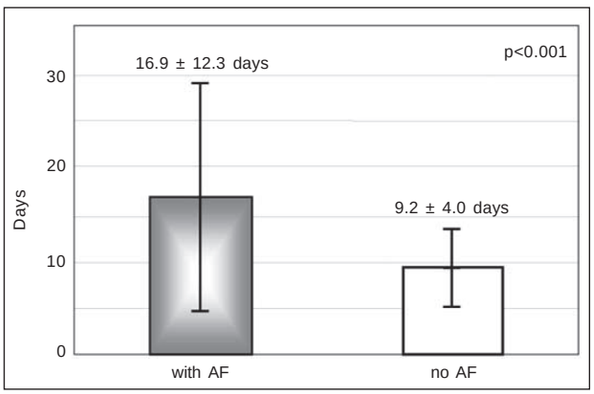

Fig. 3 - Atrial fibrillation versus an increase in the length of hospital stay.

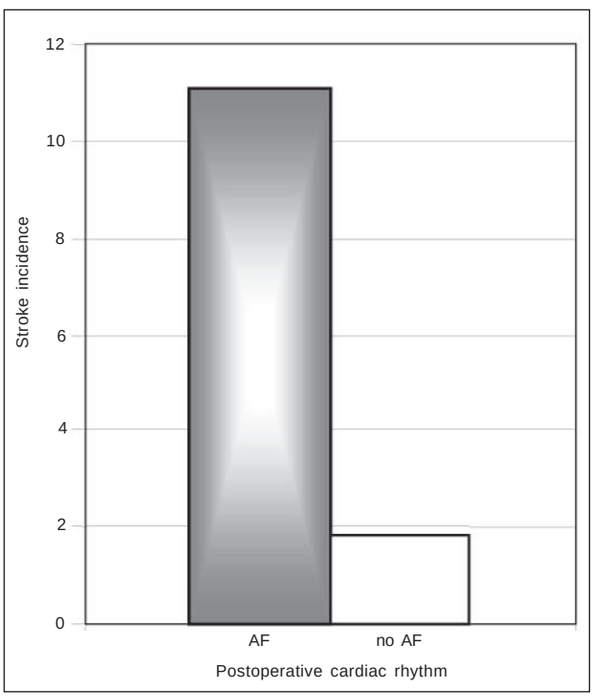

Fig. 4 - Atrial fibrillation versus stroke.

Discussion

This study comprised 158 patients in the postoperative period of cardiac surgery, and aimed at assessing the pre, trans, and postoperative risk factors related to atrial fibrillation, and also the morbidity and mortality associated with that arrhythmia.

In the literature, the incidence of atrial fibrillation ranges from 17% to 33% in myocardial revascularization surgeries, and from 38% to 64% in the postoperative period of valvular heart surgeries [3]. For cardiac surgeries in general, the incidence ranges from 20% to 40% [11]. These values are similar to those of our study.

According to Maisel et al [12], the peak incidence of atrial fibrillation occurred on the second and third postoperative days. This is in accordance with our data, in which 63% of the patients had that arrhythmia in the same period.

Loubani et al [13] reported that 50% of the patients who developed atrial fibrillation in the postoperative period of cardiac surgery remained with the arrhythmia on the day of hospital discharge. All 45 patients with atrial fibrillation in our study were discharged from the hospital with sinus rhythm, indicating that the approach in our institution prioritizes reversion to sinus rhythm.

Knowledge about the risk factors for postoperative atrial fibrillation seems to have a fundamental importance in the elaboration of prophylactic and therapeutical measures for that arrhythmia [14-16]. Age is the most cited risk factor in the literature [1,3,9,17], probably due to the higher content of atrial collagen in elderly patients [18]. Other factors reported in the literature include chronic obstructive pulmonary disease [7,10], mitral valvular disease [10,19], use of inotropic agents [19], previous history of atrial fibrillation [10], and pericarditis [20]. In the present study, age > 70 years proved to be a risk factor for atrial fibrillation.

The nonuse of beta-blockers during hospital stay was also strongly associated with postoperative atrial fibrillation in our study. In the literature, the suspension of beta-blockers is a very important factor for triggering postoperative arrhythmia [21]. In our study, the comparison of the suspension of beta-blockers with their maintenance in the postoperative period caused a decrease in the incidence of atrial fibrillation, although no significant difference occurred, probably due to the small number of patients in the sample. In the multivariate analysis, the use of beta-blockers in the preoperative period proved to be a protective factor of postoperative atrial fibrillation.

In regard to the etiology of the surgical disease, aortic valvular disease proved to be a factor associated with a great incidence of postoperative atrial fibrillation, reaching a value similar to that of mitral etiology. Factors associated with aortic valvular replacement that may explain this result are as follows: advanced age, left atrial enlargement, administration of inotropic agents, prolonged ventilatory support, postoperative acidosis, electrolyte imbalance, and disorders in atrioventricular and intraventricular conduction [22].

Another important factor is preoperative hypokalemia. Wahr et al [23] reported that potassium levels < 3.5 mmol/L were associated with a greater incidence of arrhythmias. In our study, hypokalemia showed no correlation with postoperative atrial fibrillation (p=0.07).

In our study, a very significant postoperative risk factor assessed through logistic regression was an excessive total fluid balance in the first 24 hours. The patients who developed postoperative atrial fibrillation had a greater fluid balance than those who did not develop it. A 1% additional risk of atrial fibrillation was observed for each milliliter accumulated above the mean fluid balance. In this case, arrhythmia may have been triggered by atrial distension [24].

The durations of ischemia and extracorporeal circulation showed no significant differences in the patients who developed atrial fibrillation and those who maintained sinus rhythm. These data confirm that of previous studies [3,25,26], which compared the incidence of atrial fibrillation in patients who underwent conventional cardiac surgery and surgery without extracorporeal circulation, and could not emphasize the role played by extracorporeal circulation as a predisposing factor.

Left atrial enlargement has also been reported as a factor associated with postoperative atrial fibrillation [10]. In a study [27] using transesophageal echocardiography, left atrial enlargement did not predict that arrhythmia. In our case series, left atrial enlargement assessed through transthoracic echocardiography in the preoperative period showed no correlation with postoperative atrial fibrillation. The analysis of the P wave by use of 12-lead conventional electrocardiography showed no significant association between postoperative atrial fibrillation and left atrial enlargement [28].

In this study, preoperative left heart failure proved to be associated with postoperative atrial fibrillation, confirming the previous results reported by Mayr et al [5]. In multivariate analysis, the excessive duration of surgery was a factor that proved to be related to postoperative atrial fibrillation. This factor in combination with other significant factors related to postoperative atrial fibrillation in bivariate analysis, such as length of installation of the drains, psychomotor agitation, respiratory insufficiency, and pulmonary congestion in the postoperative period, may indicate that the patient who develops postoperative atrial fibrillation is the one with the greatest systemic impairment. Therefore, atrial fibrillation can be considered a marker of severity in the postoperative period of cardiac surgery.

We found a significant association between postoperative atrial fibrillation and a greater incidence of stroke. Creswell et al [29] reported that patients with postoperative atrial fibrillation had a 3.3% incidence of stroke, while those who did not develop it had an incidence of only 1.4% (p < 0.005). Our study showed an incidence of stroke in patients with atrial fibrillation greater than that reported in the literature. A study [30] assessing the risk factors for the occurrence of stroke and transient ischemic attack in the postoperative period of myocardial revascularization surgery reported that atrial fibrillation and low cardiac output were significantly related to those complications.

Kim et al [31], comparing the length of hospital stay and costs in patients with and without atrial fibrillation after cardiac surgery, reported that the impact of that arrhythmia on the length of hospital stay was not very important. However, an observational study[19] with 3,855 patients undergoing cardiac surgery reported significant differences in the mean length of hospital stay for patients with and without atrial fibrillation. In our study, the length of hospital stay in patients with atrial fibrillation was almost two times greater than that in patients who sustained sinus rhythm. Multivariate analysis showed a direct relation between atrial fibrillation and the increase in the length of hospital stay.

Our data are in accordance with previous recommendations for the use of beta-blockers in the preoperative period of cardiac surgery, provided no contraindications exist, and their maintenance in the postoperative period, mainly in patients > 70 years and those with mitral-aortic valve diseases. Our data also suggest that a strict fluid balance is necessary to decrease the incidence of that arrhythmia in the postoperative period.

The major limitation of this study, similarly to that reported in other publications, was the lack of telemetry monitoring during the patients' recovery period, which may have underestimated the actual incidence of atrial fibrillation. However, during the stay in the ICU, when patients are more susceptible to arrhythmias, most patients were monitored and under permanent surveillance of the nurse team. In addition, only the clinically relevant episodes of arrhythmia were considered. As the incidence of atrial fibrillation found in our study is in accordance with that reported in the literature, this limitation may not have been of great magnitude.

In conclusion, the general incidence of atrial fibrillation in the postoperative period of cardiac surgery was 28.5%. Preoperative risk factors associated with a greater incidence of atrial fibrillation were as follows: age > 70 years, aortic valvular disease, and nonuse of beta-blockers. Postoperative risk factors associated with a greater incidence of atrial fibrillation were as follows: psychomotor agitation, length of installation of the drains, respiratory insufficiency, and pulmonary congestion. In multivariate analysis, the following 4 factors had an independent association with the development of postoperative atrial fibrillation: preoperative left heart failure, total fluid balance, and excessive duration of surgery, in addition to the use of beta-blockers, which was a protective factor against postoperative atrial fibrillation. Atrial fibrillation was associated with an increase in the length of hospital stay and with a greater incidence of stroke or death in the postoperative period (combined outcome).

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