Atrioventricular block in coronary artery bypass surgery: perioperative predictors and impact on mortality

Bloqueio atrioventricular pós-cirurgia de revascularização do miocárdio: fatores preditores perioperatórios e impacto na mortalidade

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Abstract

Introduction: **Disturbances of the cardiac conduction system are frequent in the postoperative period of coronary artery bypass surgery. They are mostly reversible and associated with some injury of the conduction tissue, caused by the ischemic heart disease itself or by perioperative factors.**

Objective: **Primary: investigate the association between perioperative factors and the emergence of atrioventricular block in the postoperative period of coronary artery bypass surgery. Secondary: determine the need for temporary pacing and of a permanent pacemaker in the postoperative period of coronary artery bypass surgery and the impact on hospital stay and hospital mortality.**

Methods: **Analysis of a retrospective cohort of patients submitted to coronary artery bypass surgery from the database of the Postoperative Heart Surgery Unit of the Sao Lucas Hospital of the Pontifical Catholic University of Rio Grande do Sul, using the logistic regression method.**

Results: **In the period from January 1996 to December 2012, 3532 coronary artery bypass surgery were carried out. Two hundred and eighty-eight (8.15% of the total sample) patients had atrioventricular block during the postoperative period of coronary artery bypass surgery, requiring temporary pacing. Eight of those who had atrioventricular block progressed to implantation of a permanent pacemaker (0.23% of the total sample). Multivariate analysis revealed a significant association of atrioventricular block with age above 60 years (OR=2.34; CI 95% 1.75-3.12; *P*<0.0001), female gender (OR=1.37; CI 95% 1.06-1.77; *P*=0.015), chronic kidney disease (OR=2.05; CI 95% 1.49-2.81; *P*<0.0001), atrial fibrillation (OR=2.06; CI 95% 1.16-3.66; *P*=0.014), functional class III and IV of the New York Heart Association (OR=1.43; CI 95% 1.03-1.98; *P*=0.031),**

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Abbreviations, acronyms & symbols	
AVB	Atrioventricular block
CABG	Coronary artery bypass surgery
NYHA	New York Heart Association
PO	Postoperative period
POHS	Postoperative Heart Surgery Unit
PPM	Permanent pacemaker
PUCRS	Pontifical Catholic University of Rio Grande do Sul
TP	Temporary pacing

perioperative acute myocardial infarction (OR=1.70; CI 95% 1.26-2.29; *P*<0.0001) and with the use of the intra-aortic balloon in the postoperative period of coronary artery bypass surgery (OR=1.92; CI 95% 1.21-3.05; *P*=0.006). The presence of atrioventricular block resulted in a significant increase in mortality (17.9% vs. 7.3% in those who did not develop atrioventricular block) (OR=2.09; CI 95% 1.46-2.99; *P*<0.0001) and a longer hospital stay (12.75 days x 10.53 days for those who didn't develop atrioventricular block) (OR=1.01; CI 95% 1.00-1.02; *P*=0.01).

***Conclusions:* In most cases, atrioventricular block in the postoperative period of coronary artery bypass surgery is transient and associated with several perioperative factors: age above 60 years, female sex, chronic kidney disease, atrial fibrillation, New York Heart Association functional class III or IV, perioperative acute myocardial infarction and use of an intra-aortic balloon. Its occurrence prolongs hospitalization and, above all, doubles the risk of mortality.**

***Descriptors:* Atrioventricular block. Artificial Pacemaker. Coronary Artery Bypass. Postoperative Complications.**

Resumo

***Introdução:* Os distúrbios do sistema de condução cardíaca são frequentes no pós-operatório de cirurgia de revascularização do miocárdio. Majoritariamente reversíveis, estão associados com alguma injúria do tecido de condução, causada pela própria cardiopatia isquêmica ou por fatores perioperatórios.**

***Objetivo:* Primário: investigar a associação entre fatores perioperatórios com o surgimento de bloqueio atrioventricular no pós-operatório de cirurgia de revascularização do miocárdio. Secundários: determinar a necessidade de estimulação cardíaca artificial temporária e de marca-passo definitivo no pós-operatório de cirurgia de revascularização do miocárdio e seu impacto na permanência e na mortalidade hospitalar.**

***Métodos:* Análise de Coorte retrospectiva de pacientes submetidos à cirurgia de revascularização do miocárdio, do banco de dados da unidade de Pós-Operatório de Cirurgia Cardíaca do Hospital São Lucas da Pontifícia Universidade Católica do Rio Grande do Sul, pelo método de regressão logística.**

***Resultados:* No período de janeiro de 1996 a dezembro de 2012, foram realizadas 3532 cirurgias de revascularização do miocárdio. Duzentos e oitenta e oito (8,15%) pacientes apresentaram bloqueio atrioventricular durante o pós-operatório de cirurgia de revascularização do miocárdio, necessitando de estimulação cardíaca artificial temporária. Oito dos que apresentaram bloqueio atrioventricular evoluíram para implante de marcapasso definitivo (0,23% do total da amostra). A análise multivariada evidenciou associação significativa de bloqueio atrioventricular com idade acima de 60 anos (OR=2,34; IC 95% 1,75-3,12; *P*<0,0001), sexo feminino (OR=1,37; IC 95% 1,06-1,77; *P*=0,015), doença renal crônica (OR=2,05; IC 95% 1,49-2,81; *P*<0,0001), fibrilação atrial (OR=2,06; IC 95% 1,16-3,66; *P*=0,014), classe funcional III e IV da *New York Heart Association* (OR=1,43; IC 95% 1,03-1,98; *P*=0,031), infarto agudo do miocárdio perioperatório (OR=1,70; IC 95% 1,26-2,29; *P*<0,0001) e com o uso do balão intra-aórtico no pós-operatório de cirurgia de revascularização do miocárdio (OR=1,92; IC 95% 1,21-3,05; *P*=0,006). A presença de bloqueio atrioventricular acarretou um aumento significativo da mortalidade (17,9% vs. 7,3% nos que não desenvolveram bloqueio atrioventricular) (OR=2,09; IC 95% 1,46-2,99; *P*<0,0001) e um tempo mais prolongado de permanência hospitalar (12,75 dias vs. 10,53 dias nos que não desenvolveram bloqueio atrioventricular) (OR=1,01; IC 95% 1,00-1,02; *P*=0,01).**

***Conclusão*: O bloqueio atrioventricular, no pós-operatório de cirurgia de revascularização do miocárdio, é, na maioria dos casos, transitório, sendo associado a diversos fatores perioperatórios: idade acima de 60 anos, sexo feminino, doença renal crônica, fibrilação atrial, classe funcional III e IV da *New York Heart Association*, infarto agudo do miocárdio perioperatório e uso do balão intra-aórtico. Sua ocorrência prolonga a internação hospitalar e, sobretudo, duplica o risco de mortalidade.**

***Descritores:* Bloqueio Atrioventricular. Marcapasso Artificial. Revascularização do Miocárdio. Complicações Pós-Operatórias.**

INTRODUCTION

Disturbances of the cardiac conduction system are relatively frequent in the postoperative period (PO) of coronary artery bypass grafting (CABG), with an incidence ranging from 18 to 55% of cases[1-6]. Atrioventricular block (AVB) is one of these conduction disturbances and its incidence ranges from 0.5 to 16%[3,5-9]. Most patients have transitory and reversible conduction disorders that require temporary pacing (TP). 0.4 to 1.1% of patients, however, when faced with the irreversibility of the condition, will have to undergo a permanent pacemaker (PPM) implant during their hospital stay[10]. This study, which is unprecedented in the national literature, tries to identify the relationship between pre-, intra and postoperative (perioperative) factors associated with the emergence of AVB, the need for TP and, if the case, the implantation of a PPM in the PO of CABG.

METHODS

Population and sample

Between January 1996 and December 2012, 3532 CABGs with cardiopulmonary bypass (CPB) were performed at the Sao Lucas Hospital of the Pontifical Catholic University of Rio Grande do Sul (PUCRS).

Study Design

Historical cohort observation study. Data were collected prospectively and entered into the database of the Postoperative Heart Surgery Unit (POHS) of the São Lucas Hospital of PUCRS.

Inclusion Criteria

Patients with age equal to or greater than 18 years who were submitted to isolated CABG.

Exclusion Criteria

Patients who had been undergo valvular surgery, for left ventricular aneurysmectomy or correction of the interventricular communication associated with CABG.

Study Variables

Age - the mean age was calculated and also divided into groups for analysis: less than 60 years and greater than or equal to 60 years, according to the reference in the literature[11,12]; gender (male and female); left ventricular ejection fraction (EF) - evaluated by echocardiography or radiocardiography, with the values being subdivided for analysis into ≤ 40% and > 40 %; chronic kidney disease (CKD) - diagnosed through serum creatinine level > 1.5 mg/dl, according to the reference in the literature[11,12]; Diabetes Mellitus (DM); atrial fibrillation (AF); previous use of beta-blockers; previous use of statins; previous use of other antiarrhythmics (propafenone and/or amiodarone); acute myocardial infarction (AMI) prior to CABG; New York Heart Association functional (NYHA) class; presence of calcification of the aorta; time of cardiopulmonary bypass (CPB); aortic clamping time; need for the use of intra-aortic balloon (IAB) in the PO of CABG; perioperative AMI; length of hospital stay and hospital death.

Outcome

Development of AVB in the PO of CABG and the need for TP and implantation of a PPM.

Procedures

The CABGs were performed under general anesthesia. In all cases, a hyperkalemic cardiac arrest was induced using a cold cardioplegic blood solution in the anterograde flow, with the infusion being repeated every 20 minutes. A mild systemic hypothermia (32ºC) was used. After surgery, all patients were transferred to the ICU of the POHS with mechanical ventilation.

Statistical Analysis

The data was plotted in a digital Microsoft Access® spreadsheet and analyzed using version 17.0 of the statistical software SPSS. The descriptive analysis was performed through frequency and mean ± standard deviation analysis, according to the case. For the univariate analysis the following tests were performed: chi-square and/or Fisher's Exact Test for ordinal variables and the Student's T-test for quantitative data. The multivariate analysis was performed using logistic regression (*backward conditional* method). The difference was considered as statistically significant for the value of $P<0.05$.

Ethical Considerations

The design of this study was submitted to the Research Ethics Committee of the Faculty of Medicine of the PUCRS, under registration number 060/3478.

RESULTS

Of the 3532 patients undergoing CABG in the period under analysis, 288 (8.15%) presented the clinical and electrocardiographic signs of AVB during the postoperative period, with an indication for temporary pacing (TP).

Table 1 shows the demographic profile of the patients studied. The univariate analysis of the preoperative data revealed a greater need for TP in the PO of CABG in patients above 60 years of age (OR=2.48; CI 95% 1.90-3.24; $P<0.0001$), of the female gender (OR=1.03; CI 95% 1.00-1.05; $P=0.012$), with CKD (OR=2.03; CI 95% 1.55-2.65; $P<0.0001$), the presence of AF (OR=2.38; CI 95% 1.49-3.72; $P<0.0001$) and in patients with NYHA functional class III or IV (OR=1.60; CI 95% 1.21-2.12; $P=0.001$).

Table 2 presents the trans and postoperative data, together with their univariate analysis. Here we can observe the association of AVB with the need of TP in patients who presented calcification of the aorta, perioperative AMI and the need for the use of an IAB. Of statistically significant relevance, the univariate analysis also revealed the association of TP caused by AVB with increased mortality (17.9% vs. 7.3%) and with a longer hospital stay (mean hospitalization time of 12.75 days compared to 10.53 days for those who did not require TP).

These data were submitted to multivariate analysis (Table 3), which revealed a higher risk of AVB in the PO of CABG in patients with: age > 60 years, female sex, CKD, AF, NYHA functional class III or IV, perioperative AMI and with the use of an IAB. Patients with EF≤40 %, DM, the use of beta-blockers, statins and other antiarrhythmic drugs, prior AMI and CPB and aortic clamping

times didn't prove to be independent risk variables for the development of AVB in the PO of CABG.

In the multivariate analysis, the presence of AVB resulted in a longer hospital stay (12.75 days vs. 10.53 days for those who didn't develop AVB) (OR=1.01; CI 95% 1.00-1.02; *P*=0.01) and in a significant increase in the risk of mortality (17.9% vs. 7.3% for patients without AVB) (OR=2.09; CI 95% 1.46-2.99; *P*<0.0001).

In the subgroup of 288 patients who had AVB and who had undergone TP, 08 (2.78 %) required a PPM implant, corresponding to 0.23% of the total cohort analyzed. The average time elapsed since the surgery until the PPM implant was 12.25 days.

Table 1. Preoperative characteristics of the groups and univariate analysis.

Variable	Total 3532 (100%)	TP 288 (8.15%)	NTP 3244 (91.85%)	OR	CI 95%	*P*
Age						
≥ 60	2030 (57.5%)	222 (10.9%)	1808 (89.1%)	2.48	1.90 – 3.24	<0.0001
<60	1502 (42.5%)	66 (4.4%)	1436 (95.6%)			
Gender						
Male	2393 (67.8%)	176 (7.4%)	2217 (92.6%)	0.75	0.57 – 0.94	0.012
Female	1139 (32.2%)	112 (9.8%)	1027 (90.2%)	1.03	1.00 – 1.05	
EF						
≤ 40	730 (20.7%)	64 (8.8%)	666 (91.2%)	1.11	0.85 – 1.45	0.44
> 40	2802 (79.3%)	224 (8.0%)	2578 (92.0%)			
CKD (Creat>1.5)						
Yes	398 (11.3%)	59 (14.8%)	339 (85.2%)	2.03	1.55 – 2.65	<0.0001
No	3134 (88.7%)	229 (7.3%)	2905 (92.7%)			
DM						
Yes	1129 (32.0%)	98 (8.7%)	1031 (91.3%)	1.09	0.87 – 1.39	0.433
No	2403 (68.0%)	190 (7.9%)	2213 (92.1%)			
AF						
Yes	86 (2.4%)	16 (18.6%)	70 (81.4%)	2.38	1.49 – 3.72	<0.0001
No	3446 (97.6%)	272 (7.9%)	3174 (92.1%)			
Antiarrhythmic Agents						
Yes	90 (2.5%)	12 (13.3%)	78 (86.7%)	1.66	0.97 – 2.85	0.069
No	3442 (97.5%)	276 (8.0%)	3166 (92.2%)			
BB						
Yes	2500 (70.8%)	208 (8.3%)	2292 (91.7%)	1.07	0.84 – 1.37	0.575
No	1032 (29.2%)	80 (7.8%)	952 (92.2%)			
Digoxin						
Yes	204 (5.8%)	23 (11.3%)	181 (88.7%)	1.42	0.95 – 2.12	0.093
No	3328 (94.2%)	265 (8.0%)	3063 (92.0%)			
Previous AMI						
Yes	1600 (45.3%)	117 (7.3%)	1483 (92.7%)	0.826	0.66 – 1.03	0.096
No	1932 (54.7%)	171 (8.9%)	1761 (91.1%)			
NYHA FC						
III and IV	453 (12.8%)	55 (12.1%)	398 (87.9%)	1.604	1.21 – 2.12	0.001
I and II	3079 (87.2%)	233 (7.6%)	2846 (92.4%)			

AF=atrial fibrillation; AMI=acute myocardial infarction; BB=beta-blockers; CI=confidence interval; CKD=chronic kidney disease; DM=diabetes mellitus; EF=left ventricular ejection fraction; FC=functional class; NYHA=New York Heart Association; NTP=no use of temporary pacing; OR=odds ratio; P=statistical significance; TP=temporary pacing

Table 2. Trans and postoperative data of groups and univariate analysis.

Variable	Total 3532 (100%)	TAHP 288 (8.15%)	N TAHP 3244 (91.85%)	OR	CI 95%	*P*
CPBT						
≥ 90 min	1567 (44.4%)	136 (8.7%)	1430 (91.3%)	1.08	0.86 – 1.35	0.494
< 90 min	1965 (55.6%)	157 (8.0%)	1807 (92%)			
Tclamping						
≥ 40 min	2512 (71.1%)	208 (8.3%)	2304 (91.7%)	0.978	0.77 – 1.25	0.86
< 40 min	1020 (28.9%)	87 (8.5%)	933 (91.5%)			
Calcification Ao						
Yes	350 (9.9%)	44 (12.6%)	306 (87.4%)	1.639	1.21 – 2.22	0.001
No	3182 (90.1%)	244 (7.7%)	2938 (92.3%)			
Peri AMI						
Yes	555 (15.7%)	78 (14.1%)	477 (85.9%)	2.155	1.63 – 2.84	<0.0001
No	2977 (84.3%)	210 (7.1%)	2767 (92.9%)			
IAB						
Yes	141 (4.0%)	29 (20.6%)	112 (79.4%)	2.69	1.90 – 3.80	<0.0001
No	3391 (96.0%)	259 (7.6%)	3132 (92.4%)			
Death						
Yes	285 (8.1%)	51 (17.9%)	234 (82.1%)	2.452	1.86 – 3.23	<0.0001
No	3247 (91.9%)	237 (7.3%)	3010 (92.7%)			

Calcification Ao=calcification of the aorta; CPBT=cardiopulmonary bypass time; IAB=intra-aortic balloon; Peri AMI=perioperative acute myocardial infarction; Tclamping=aortic clamping time; Others: see Table 1

Table 3. Multivariate analysis of the risk factors and outcomes of AVB in the PO of CABG.

Variable	OR	CI 95%	*P*
Age > 60 years	2.34	1.75 – 3.12	< 0.0001
Female Gender	1.37	1.06 – 1.77	0.015
Atrial Fibrillation	2.06	1.16 – 3.66	0.014
Previous CKD	2.05	1.49 – 2.81	< 0.0001
FC III and IV	1.43	1.03 – 1.98	0.031
Perioperative AMI	1.70	1.26 – 2.29	< 0.0001
IAB	1.92	1.21 – 3.05	0.006
Hospitalization Time	1.01	1.00 – 1.02	0.01
Death	2.09	1.46 – 2.99	< 0.0001

AMI=acute myocardial infarction; AVB=atrioventricular block; CABG=coronary artery bypass grafting; CKD=chronic kidney disease; FC=functional class; IAB=intra-aortic balloon; PO=postoperative

DISCUSSION

CABG is a proven therapeutic strategy for the treatment of Coronary Artery Disease (CAD). Although it is well tolerated by most patients, perioperative complications can occur, among which we find disturbances in the cardiac conduction system in varying degrees, including AVB.

Previous studies have reported an incidence of conduction disturbances (CD) after CABG that varies from 18 to 55% of cases[1-6], with the right bundle branch block being the most common[4]. Atrioventricular block (AVB) is one of these conduction disturbances and its incidence ranges from 0.5 to 16%[3,5-9]. Our incidence of AVB is in line with this data, since 8.15% of our patients developed AVB in the PO of CABG.

The etiology of AVB seems to be multifactorial. The patient's age (>60 years), hypertension, number of revascularized vessels, aortic clamping time, total time of CPB, use of digitalis and beta-blockers, type of cardioplegia and previously existing left bundle branch block may be related to its appearance[1-4,8,9,13,14].

Myocardial ischemia seems to be the factor that is most implicated in the emergence of AVB, since there is a correlation with coronary artery disease (CAD) and preoperative AMI[4]. Studies[3,10] have demonstrated that perioperative AMI also increases the incidence of AVB in the PO of CABG. Caspi et al.[7] reported a higher occurrence of AVB in patients with AMI in the PO of CABG (12% vs. 2 %, $P<0.05$).

However, AMI before CABG was not a significant factor for the appearance of AVB in our study, which is consistent with the world literature[3,7,8,15,16]. This shows there is no difference in the incidence of AVB between patients who had preoperative AMI and those who didn't, regardless of its electrocardiographic location.

Caspi et al.[7] have shown that the combination of left main disease and proximal obstruction of a dominant right coronary artery was more frequent in patients who exhibited AVB (32%) than in those who without it (12%, $P<0.05$). The explanation for this effect is the fact that the cardioplegic solution is not properly distributed to the coronary beds because of

their high degree of obstruction, which compromises myocardial protection and, in some cases, because of the impossibility of bypassing the right coronary artery.

The impairment of myocardial irrigation gets worse with age, just as the frequency of degenerative diseases of the conduction system, increasing the probability of AVB[9,11,15,17-19]. In this scenario, our patients above 60 years of age presented a significant risk (OR=2.34; CI 95% 1.75-3.12; *P*<0.0001) for the development of AVB in the PO of CABG, corroborating the findings of other studies[7,8,13,14].

The electrical cardiac conduction tissue differs from cardiac myocytes by being less tolerant to the effects of ischemia, hyperkalemia and hypothermia (whether these are systemic or, mostly, induced by a cardioplegic solution that is cold and rich in potassium). This may cause a transient block of the conduction system[11]. The advent of cold cardioplegia as a method of myocardial protection has increased the incidence of CD from 20 to 58%[13]. The more significant incidence of conduction disturbances occurred in patients who received cold cardioplegia, as opposed to warm (19.6% vs. 1.7 %, respectively)[13], a finding that has also been described by Sirlak et al.[20]. Specifically with respect to AVB, the incidence was of 3.8% in the hypothermia group and zero in the normothermal group[13]. All patients in our study underwent surgery with the myocardial protection performed by infusion of a cold cardioplegic blood solution at the root of the aorta every 20 minutes, which contributed to the genesis of AVB cases.

As such, the perfusion injury determined by the myocardial ischemia and the hypothermic injury caused by the cardioplegic solution are the mechanisms that are most involved in the genesis of AVB, acting on the proximal portions of the bundle of His, which are more sensitive to this type of aggression than the more distal conduction tissue, determining the emergence of bundle branch blocks and increasing the risk of AVB[4].

In this scenario, the extent of the CAD, the duration of CPB and the aortic clamping time could compromise myocardial protection during surgery, increasing the risk of an ischemic injury and of metabolic damage to the conduction tissue[11]. However, our CPB time of ≥ 90 min and aortic clamping time of ≥ 40 min showed no influence on the development of AVB, which is supported by the literature[5-7,16,19]. Baerman et al.[1], however, demonstrated that patients with lower CPB (101±32min x 121±34min; *P*<0,01) and aortic clamping (44±19min x 53±17min; *P*<0.05) times didn't show evidence of AVB in the PO of CABG.

Our study has shown that the female gender is a risk factor for the occurrence of AVB (OR=1.37, CI 95% 1.06-1.77; *P*=0.015), which contrasts with the results of Gordon et al.[19] who observed a higher need for PPM implants in men (*P*=0.041). Other studies[3,8,15,20], however, didn't point to any of the genders as risk factor. Cadore et al.[12] had already pointed to the female gender as a risk predictor for mortality in CABG, which can be an expression of the greater severity of the ischemic impairment in this gender and explain their greater tendency for developing the block, as seen in our study.

The presence of CKD was also verified to be a risk factor for the development of AVB (OR = 2.05; CI 95% 1.49-2.81; *P*<0.0001). A previous study[19] indicated the presence of CKD as more significant among those patients who required PPM implantation in the PO of CABG. Like the female gender variable, CKD was also found to be a predictor of mortality in patients underwent CABG according to the score by Cadore et al.[12], expressing its potential for increasing the risk of complications in the PO of CABG.

Another risk predictor for the occurrence of AVB was the more advanced functional class of the NYHA (III and IV) (OR = 1.43; CI 95% 1.03-1.98; *P*=0.031). Studies[18,19] have corroborated this finding, indicating that patients who underwent heart surgery and needing a PPM implant were in the more severe functional class of the NYHA (III and IV) when compared to patients who did not require such an implant (57% vs. 35%, respectively, *P*<0.0001)[18]. Bateman et al.[6] showed that of those patients who passed away within the first 30 days of the PO of CABG and who had developed some degree of blockage, 90% were into class IV of the NYHA in the preoperative period.

The patients in this study who had EF≤40% did not present a significant risk for the appearance of AVB in the PO of CABG (OR=1.11; CI 95% 0.85-1.45; *P*=0.44), a finding supported by Gordon et al.[19] who didn't observe any significant impact of EF on the need for PPM implantation in the PO of isolated CABG. Caspi et al.[7], however, found a greater susceptibility to the development of atrioventricular block in patients submitted to CABG with a lower EF.

Although Merin et al.[18] mention that the use of antiarrhythmic agents is more frequent in the group of patients that develops blockage after heart surgery (CABG, valve or combined), our data does not reflect this influence. Regarding the use of beta-blockers, we also didn't find any association with the development of AVB, which has already been described by other authors[2,3,16].

The need for the use of an IAB in the PO of CABG occurred in 141 patients (4%) of the total sample of 3532 patients, of which 20.6% developed AVB, leading to the need for TP (OR=1.92; CI 95% 1.21-3.05; *P*=0.006). The need for the use of the IAB has been associated with a greater probability of developing blocking and has been indicated as a predictor of its occurrence and of the need for a PPM implant[6,17,19]. Probably because its use is an expression of a more significant ischemic cardiopathy, i.e., of patients with more severe compromising. This finding is important because the patients did not have AVB in the preoperative period, presumably reflecting a greater perioperative myocardial injury[6].

Perioperative AMI was a risk factor for the emergence of AVB (OR=1.70; CI 95% 1.26-2.29; *P*<0.0001), and this was

corroborated by the study of Caspi et al.[7] who identified the occurrence of low cardiac output (34% vs. 3%) and perioperative AMI (12% x 2%) as risk factors for AVB in the PO of CABG. Perioperative AMI also increases the need for a PPM implant[10], reflecting acute ischemic damage of the conduction tissue.

The need for TP showed a significant association with mortality (OR=2.09; CI 95% 1.46-2.99; *P*<0.0001), which was 17.7% for patients with AVB and 7.2% for those who didn't develop it. Zeldis et al.[3] had already reported a mortality of 19.2% in the group of patients who developed block of the left conduction system (left bundle branch block or left anterior hemiblock or both), compared with a 7% mortality rate in the group of patients without such block. Specifically with respect to AVB, Caspi et al.[7] observed a significantly higher mortality in the group of patients who developed AVB (7% vs. 0.6%). On the other hand, patients who develop right bundle branch block or fascicular block have a more favorable prognosis, because these are more transient disorders and because they do not increase mortality[6,21].

The patients who developed AVB had a significantly longer hospital stay (mean hospitalization time of 12.75 days compared to 10.53 days for those who did not need TP for AVB (OR=1.01 CI 95% 1.00-1.02; *P*=0.01). Gordon et al.[19] have shown that the need for a PPM implant significantly increased hospital stay (23.3±18.7 days vs. 9.6±9.0 days for patients without need of implant, *P*=0.0001) and ICU stay (5.6±10.5 days vs. 2.2±3.3 days, *P*=0.0258). Other studies[11,18] also corroborate this finding of a longer hospital stay in the presence of AVB and the need of TP.

In our study, the need for a PPM implant occurred in 08 of the 3532 patients studied (0.23%), which is lower than the rate found in the literature, which points to the need for PPM implants in 0.49% of AVB cases[8]. Gordon et al.[19] implanted PPMs in 50 of their 6859 patients submitted to CABG (0.73%). When other types of post-CABG conduction blocks are considered, the incidence of implants rises and ranges from 0.4 to 1.1%[10]. The calculated risk for need of a PPM implant in the PO of non-complicated CABG is 0.9%[19].

Nascimento et al.[22] couldn't identify any prognosis criterion for the reversibility of AVB in the PO of heart surgery. The ideal moment for the implantation of a PPM in the PO of CABG hasn't yet been properly established. According to the Brazilian Guidelines for Implantable Electronic Heart Devices[23], patients with asymptomatic AVB with wide QRS after cardiac surgery that persists after 15 days, are indicated for a PPM implantation (Class I, level of evidence C). In the cases of asymptomatic AVB persisting after 15 days, resulting from cardiac surgery, with narrow QRS or nodal escape rhythm and good chronotropic response, and in those cases without the prospect of reversal (< 15 days) PPM implantation is also indicated (Class IIa, level C).

According to the criteria of the *American College of Cardiology* and the *American Heart Association*, a PPM implant is indicated in 3rd and advanced 2nd degree AVB in the postoperative period of heart surgery, in addition to cases without expectation of resolution. The decision regarding the time of the implant should be taken by the physician[24].

The European Society of Cardiology recommends a waiting period of 5 to 7 days for the resolution of transient bradyarrhythmias after cardiac surgery, before the decision for the implant is made[25].

According to Pires et al.[13] and Merin et al.[18], the decision to perform the implant should be taken between the 4th and 5th day of the PO, because if the AVB or dysfunction of the sinus node are still present up to this moment, then they tend to be permanent. This would facilitate the early mobilization of patients and shorten their hospitalization time.

Of the 288 patients in our study who had AVB, 08 received a PPM implant after an average of 12.25 days into the PO, which is in line with the Brazilian (Class IIa, level of evidence C), American and European (Class I, level C) guidelines. Emlein et al.[8] described a series of 8 patients who underwent a PPM implant after developing AVB with an average of 10.5±6.5 days into the PO.

Limitations of the Study

The limitations of this study are those inherent to a retrospective database analysis, but they reflect the significant years of experience of an academic institution. Within these limitations we can cite the relative difficulty of accessing the full data, which causes a potential risk of not measuring some random variables. The fact that the results come from the sample of a single center can also represent some degree of bias in the treatment. Another limitation of this study is the absence of more precise information regarding the height of the atrioventricular conduction disorder and the existence or not of any escape rhythm.

Regarding the PPM implants performed in our study, they followed the recommendations of Brazilian, American and European guidelines almost strictly. In this small group of patients a more thorough analysis was compromised, but this could be the target of a more detailed study to be developed in the future.

CONCLUSION

This work sheds light on the risk factors associated with the development of AVB in the PO of CABG and the consequent need for TP and a definitive pacemaker. Based on this we could establish that female patients, 60 years of age or more, with the diagnosis of AF and CKD, in stages III and IV of the functional class, who had perioperative AMI and required the use of an IAB, have a higher risk of developing AVB in the PO of CABG. AVB determines a more prolonged hospitalization and, what is more important, doubles the risk of mortality.

Authors' roles & responsibilities	
RMP	Analysis and/or interpretation of data; final approval of the manuscript; study design; conduct of operations and/or experiments; writing of the manuscript or critical review of its content
ADLF	Analysis and/or interpretation of data; study design; conduct of operations and/or experiments; writing of the manuscript or critical review of its content
AAH	Analysis and/or interpretation of data; actual operations and/or experiments; writing of the manuscript or critical review of its content
DKF	Analysis and/or interpretation of the data
JCEP	Analysis and/or interpretation of the data; statistical analysis
LCA	Final approval of the manuscript; conduct of operations and/or experiments; writing of the manuscript or critical review of its content
JCVCG	Final approval of the manuscript; writing of the manuscript or critical review of its content
JBP	Conduct of operations and/or experiments; writing of the manuscript or critical review of its content

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