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Does Intermittent Aortic Cross Clamping Decrease the Incidence of Atrial Fibrillation after Coronary Bypass Surgery?

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ABSTRACT

Atrial fibrillation (AF) is the most common arrhythmia after coronary artery bypass grafting (CABG). AF is a vexing problem that causes morbidity, prolongs hospital stay, and increases costs. Numerous factors have been suggested to play a role in the development of AF. The aim of this study was to evaluate the effect of intermittent aortic cross clamping (IACC) compared with hypothermic cardioplegic solution (HCS) in the development of postoperative AF. We evaluated data obtained from 345 patients undergoing CABG with HCS (HCS group, n = 212) and IACC (IACC group, n = 173) between April 2004 and August 2005. Diabetes mellitus was observed more often in the HCS group ($P < .05$), otherwise both groups had similar preoperative characteristics including sex, age, the number of distal anastomoses, left ventricle ejection fraction, history of myocardial infarction, and use of β-blocker medication. The only statistically significant difference between the groups was higher postoperative Ca-antagonist use in the HCS group. Rates of postoperative AF, however, were significantly lower in the IACC group (21.52%) than that in the HCS group (11.05%; $P < .01$). Postoperative Ca-antagonist use in the HCS group and smoking in the IACC group were independent predictors of AF after CABG. The incidence of postoperative AF after CABG with IACC was reduced compared with HCS. IACC with ventricular fibrillation may exert a counteractive effect against AF.

INTRODUCTION

Atrial fibrillation (AF) is one of the most common complications after cardiac surgery, with occurrence rates up to 50% within the first postoperative week and peak incidence between the second and fourth postoperative days [Creswell 1993; Funk 2003].

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AF is a major challenging complication that affects the postoperative outcome after coronary artery bypass grafting (CABG) despite considerable improvements in surgical techniques and perioperative management including pharmacological prevention. AF generally results in a prolonged hospital stay with increased cost and increased morbidity with adverse outcomes such as thromboembolism and hemodynamic complications [Creswell 1993; Funk 2003].

The pathomechanism of postoperative AF remains a mystery despite various histopathological studies of structural changes in the right atrium [Ad 2000; Ak 2005]. Demonstrated risk factors for AF include postoperative withdrawal of β-blockers, postoperative catecholamine discharge, and inadequate protection of right atrial tissue during aortic cross clamping, as occurs with chronic obstructive pulmonary disease (COPD), advanced age, prolonged preoperative P-wave duration, and cardiopulmonary bypass [Hogue 2000].

Numerous cardioplegic techniques are aimed at establishment of the best operative strategy for intraoperative myocardial protection. A respectable minority of surgeons are still using the simple noncardioplegic techniques such as intermittent aortic cross clamping (IACC) with ventricular fibrillation and moderate hypothermia, which are associated with various reports of good results even with severe left ventricular dysfunction [Akins 1987; Antunes 1999; Raco 1999]. There are no reports, however, on the effect of noncardioplegic techniques on AF following CABG surgery. We reviewed our clinical data to compare the incidence of AF after CABG with IACC, an older noncardioplegic myocardial protection technique, to the incidence with the current conventional cardioplegic technique. We also investigated the effect on postoperative AF of IACC with hypothermic fibrillatory arrest.

MATERIALS AND METHODS

For 395 CABG surgeries we performed between April 2004 and August 2005, we compared the incidence of AF after CABG performed with cardioplegia with crystalloid hypothermic cardioplegic solution (HCS group) and intermittent aortic cross clamping (IACC group).

We did not use a particular strategy for the sequence in which we grafted the vessels. We prefer to use the cardioplegic method when more than 4 bypass vessels are anticipated, with

Table 1. Preoperative Patient Variables*

	HCS (n = 223)	IACC (n = 172)	*P*
Male	70.85%	68.02%	.4
Age, y	64.00 ± 7.89	64.83 ± 7.50	.29
Preoperative LVEF <30%	4.93%	4.07%	.78
No. of diseased vessels			
Single	13.0%	13.95%	.92
Double	34.5%	33.14%	.87
Triple	52.9%	53.49%	.99
Preoperative Drugs			
β-blockers	22.42%	21.51%	.83
Ca antagonists†	27.35%	23.84%	.51
LMC disease	11.2%	16.28%	.14
RCA disease	62.3%	72.67%	.03‡
Previous PCI	27.35%	29.07%	.075
Medical history			
Myocardial infarction	21.1%	23.84%	.53
Diabetes mellitus	42.15%	30.23%	.008§
Hypertension	55.61%	56.40%	.9
Hyperlipidemia	41.26%	43.60%	.64
Smoking	48.0%	39.53%	.12
COPD	13.5%	13.95%	.76
Family history	12.11%	19.19%	.052
New York Heart Association Class			
I	12.6%	18.02%	.13
II	45.7%	40.12%	.14
III	28.3%	26.16%	.87
IV	12.1%	18.60%	.07

*Values are presented as mean ±SD or percentage of patients. HCS indicates hypothermic cardioplegic solution; IACC, intermittent aortic cross clamping; LVEF, left ventricular ejection fraction; LMC, left main coronary; RCA, right coronary artery; PCI, percutaneous intervention; COPD, chronic obstructive pulmonary disease.

†Includes only dihydropyridines such as diltiazem.

‡$P < .01$.

§$P < .05$.

heavily calcified coronary arteries that may require more time for anastomosis, and with poor left ventricular function when more than 3 bypass vessels are anticipated.

Operative Procedure

The anesthetic techniques, including premedication, induction, and maintenance of anesthesia, were essentially similar in both groups. After the left internal thoracic artery and long saphenous veins were harvested, heparin was given and cardiopulmonary bypass was established. A basket cannula was used to ensure venous drainage through the right atrium. Arterial return to the patient was provided through an arterial cannula placed in the ascending aorta.

A roller pump and a membrane oxygenator were used. Heparin was administrated intravenously to achieve an activated clotting time greater than 450 seconds. The patient's blood temperature was cooled down to 32°C before the aorta was clamped. Moderate systemic hypothermia (32°C) was maintained during bypass in all cases.

Study patients formed 2 subgroups, patients who underwent hypothermic crystalloid St Thomas cardioplegia (HCS group, n = 223) and those who underwent intermittent aortic cross-clamp fibrillation (IACC group, n = 172).

The cardioplegia solution Plegisol, at 4°C, was used in the HCS group. All bottom ends were anastomosed with the aorta cross clamped and cardioplegic arrest of the heart, followed by declamping and performance of proximal anastomosis during partial aortic occlusion while the heart started to beat again.

In the IACC group, ventricular fibrillation was induced using 10 mA alternate current through a fibrillator device. The flow of the pump was reduced, and the heart decompressed after the aorta was cross clamped for the first distal anastomosis to be performed. On completion of each distal anastomosis the aorta was declamped, perfusion of the heart was started, and defibrillation with 5 to 10 J direct current shock was performed. The heart was allowed to beat during partial aortic occlusion for the proximal anastomosis. The flow delivered through the pump was reduced for each manipulation of the aorta that was required during the operation.

Systemic rewarming was instituted during the final left anterior descending distal anastomosis in each group. In both groups weaning was performed during the cardiopulmonary bypass and was first attempted when the nasopharyngeal temperature reached 37°C.

Emergency redo cases and the individuals who required technique conversion were not included in the study. Patient characteristics are presented in Table 1.

Statistical Analysis

Values are presented as mean ± SD or percentage of patients. Proportions were compared with the Pearson ξ^2 test. Quantitative variables were normally distributed and compared with the Student *t* test. Differences were considered to be statistically significant for $P < .05$. SPSS statistical software (version 13.0) was used. The potential independent variables for the development of AF were determined by stepwise logistic regression analysis.

RESULTS

Preoperative variables are shown in Table 1. Only diabetes mellitus was significantly higher (42.15%, $P = .008$) in the HCS group. The other variables were comparable in both groups.

Table 2 shows intraoperative and postoperative variables. The postoperative incidence was statistically lower (21.52% versus 11.05%, $P = .006$) in the IACC group. The mean postoperative onsets of AF in the 2 groups were 74.33 ± 11.69 and 66.78 ± 16.29 h, respectively. The number of grafts in the HCS group and IACC groups were 2.39 ± .79 and 2.41 ± .75, respectively. Postoperative outcomes in both groups were comparable in terms of cardiopulmonary bypass ($P = .35$) and aortic cross-clamp times ($P = .86$), cerebrovascular complications (temporary: $P = .28$, permanent: $P = .87$), β-blocker withdrawal ($P = .89$), re-exploration ($P = .47$), sternal rewiring, total hospital stay, and mortality. Although not statistically significant, higher intra-aortic balloon pump

Table 2. Intraoperative and Postoperative Variables*

	HCS (n = 223)	IACC (n = 172)	*P*
Number of distal anastomoses	2.39 ± .79	2.41 ± .75	.38
LIMA	96.86%	98.26%	.38
Operation time, min			
Total	157.03 ± 28.69	159.92 ± 32.03	.35
Cardiopulmonary bypass	58.97 ± 16.34	59.94 ± 15.12	.54
Aortic cross clamping	30.86 ± 12.75	31.09 ± 12.89	.86
Inotropic support	16.7%	18.8%	.76
Postoperative drugs			
β-blockers	5.83%	4.07%	.72
Ca antogonists	39.91%	30.23%	.002‡
β-blocker withdrawal	20.85%	21.04%	.89
Incidence of postoperative atrial fibrillation	21.52%	11.05%	.006‡
Initial atrial fibrillation, h postsurgery	74.33 ± 11.69	66.78 ± 16.29	.08
Re-exploration	3.14%	2.33%	.47
Sternal rewiring	0.45%	2.33%	.098
Temporary CVA	1.35%	2.91%	.28
Permanent CVA	1.35%	1.16%	.87
IABP	4.93%	6.40%	.67
Mortality	3.59%	5.23%	.57
Hospital stay, d postsurgery	8.39 ± 4.79	7.3 ± 4.71	.62

*Values are presented as mean ± SD or percentage of patients. LIMA indicates left internal mammary artery; CVA, cerebrovascular accident, IABP, intra-aortic balloon pump.

†Includes only dihydropyridines such as diltiazem.

‡$P < .01$.

usage ($P = .67$), mortality ($P = .57$), and hospital stay ($P = .62$) were detected in the IACC group.

Multivariate logistic regression analysis identified postoperative Ca-antagonist use in the HCS group and smoking in the IACC group as the independent predictors ($P < .05$) of AF after CABG. However, those predictors were not significant in the opposite groups.

The rest of the variables were not considered as independent predictors of AF after CABG in the HCS and IACC groups, including age ($P = .76$, $P = .30$), right coronary artery disease ($P = .15$, $P = .29$), COPD ($P = .09$, $P = .14$), cross-clamp time ($P = .83$, $P = 31$), inotropic support ($P = .66$, $P = .49$), β-blocker withdrawal ($P = .47$, $P = .46$), intra-aortic balloon pump support ($P = 91$, $P = .84$), and re-exploration ($P = .43$, $P = .561$) (Table 3).

DISCUSSION

The main purpose of cardioplegic arrest for myocardial protection is to minimize cardiac metabolism and maximize cellular energy to avoid myocardial injury as much as possible.

There are many different variations in the route of delivery, temperature, and composition of cardioplegia to maximize myocardial protection in the current practice of cardiac surgery [Cohen 1999; Vinten-Johansen 2000]. During the early years of myocardial revascularization, the technique of IACC with fibrillation and moderate hypothermia was routinely used by many surgeons with satisfactory results. In the last decade, however, there has been a widespread conversion to the use of hypothermic potassium and blood cardioplegia solutions, and many surgeons might be unaware of the

Table 3. Multivariate Logistic Regression Analysis for the Predictors of Atrial Fibrillation in Both Groups.

	P for HCS (n = 223)	*P* for IACC (n = 172)
Male	.92	.88
Age, y	.76	.30
Preoperative LVEF < 30%	.69	.29
Number of diseased vessels		
Single	.80	0,88
Double	.92	.57
Triple	.88	.63
Preoperative Drugs		
β-blockers	.42	.24
Ca antogonists	.35	.40
LMC Disease	.41	.07
RCA Disease	.15	.29
Previous PCI	.78	.60
History		
Myocardial infarction	.34	.48
Diabetes mellitus	.55	.35
Hypertension	.89	.05
Hyperlipidemia	.41	.46
Smoking	.11	.004†
COPD	.09	.14
Family history	.70	.71
NYHA class		
I	.82	.74
II	.04	.64
III	.17	.94
IV	.27	.56
No. of distal anastomoses	.33	.45
LIMA	.43	.66
Operation time, min		
Total	.98	.77
Cardiopulmonary bypass	.99	.11
Aortic cross clamping	.83	.31
Inotropic support	.66	.49
Postoperative drugs		
β-blockers	.38	.50
Ca antogonists	.00	.60
β-blocker withdrawal	.47	.46
Re-exploration	.43	.56
Sternal rewiring	.45	.38
Temporary CVA	.51	.40
Permanent CVA	.68	.55
IABP	.91	.84
Hospital stay, d postsurgery	.50	.52

*See legends to Tables 1 and 2 for abbreviation definitions.

†$P < .05$.

benefits of the older technique and may have slight prejudices against it.

IACC with fibrillation and moderate hypothermia to decrease oxygen demand, which limits the effects of myocardial ischemia to <15 minutes, is associated with rapid and adequate reperfusion with normal blood in a decompressed ventricle. Surgeons who currently use IACC are in the minority, but they have shown that this technique provides a simple and safe protective method for myocardial revascularization [Alex 2003]. Some reported studies have shown remarkable benefits and protective effects of IACC for myocardial protection at the cellular level. In particular, Yellon [1993] and Abd-Elfattah [1995] reported some new insights into the ischemic preconditioning phenomenon regarding the protective effect of intermittent ischemic arrest. In addition, Taggart [1994] and Cohen [1997] also showed that IACC provides a similar degree of myocardial protection by determining troponin T release and free radical activity. Nevertheless, the controversy concerning the cardioplegic and noncardioplegic techniques for myocardial protection in CABG continues, as evidenced by prospective, randomized studies comparing both techniques [Anderson 1994; Cohen 1997; Alhan 1999].

According to the results obtained from our study, AF was significantly lower ($P < .01$) in the IACC group. The previously reported predictors for AF, including COPD, right coronary artery disease, and age, were not determined. However, postoperative Ca-antagonist use in the HCS group and smoking in the IACC group were independent predictors ($P < .05$) of AF after CABG. The rate of postoperative Ca-antagonist use may be attributable to the higher rate of Ca-antagonist use in the same group preoperatively. Those findings in our study were not similar to those reported for previously published studies of AF after CABG. We found that in the HCS and IACC group, right coronary artery disease ($P = .15$ versus $P = .29$) and COPD ($P = .09$ versus $P = .14$) were closely related to postoperative AF, but the relationship was not significant.

The mechanism of IACC against postoperative AF following CABG may involve continuous electrical activity throughout the heart chambers, which increases the threshold for AF, or myocardial protection resulting from preconditioning, a role strongly supported by data from Fuji and coworkers [2005]. It is obvious that the unidentified counteracting mechanism of IACC against postoperative AF requires further investigation.

The neurologic complication rate with the IACC technique is a concern because repeated aortic clamping is considered a major risk factor for a perioperative cerebrovascular accident (CVA), especially in cases of severely diseased atherosclerotic aorta. In a study of a very high number of patients, Bonchek et al [1992] observed a relatively lower incidence of transient and permanent neurologic events (1.1% and 1.8%, respectively). Antunes et al [2003] suggested that conversion of IACC without aortic clamping decreases the chance of cerebrovascular complications [Antunes 2003], but Musumeci and coworkers [1998] showed that repeated clamping of the aorta in IACC does not result in a higher rate of neurological complications compared with the single-clamp technique. In our study, temporary CVA was observed more frequently in the HCS group but this finding was not statistically significant ($P = .28$), although rates of permanent CVA were similar in both groups. These findings do not suggest that manipulation of the aorta during IACC increases the risk CVA.

The use of cardioplegic techniques rather than IACC in cases of diffuse atherosclerotic plaques seems advisable, but even the single cross clamp used in conventional cardioplegic arrest may not be safe and reliable in patients with a heavily atherosclerotic ascending aorta. We do not advocate dogmatic use of IACC in our own practice; we prefer the conventional cardioplegic method when we expect more and heavily diseased coronary arteries that will definitely require more time for dissection and anastomosis. For experienced surgeons, IACC offers greater versatility and flexibility with good results, but intermittent cross clamping is not the method of choice for young surgeons because longer periods of ischemia could contribute to unfavorable results.

Cardioplegia provides efficient protection to the myocardium, but noncardioplegic techniques do not necessarily result in poorer myocardial protection. In regard to other possible consequences of IACC, such as the effect on postoperative AF, our clinical data revealed a significantly lower incidence of AF. Other data are limited, however, because IACC is preferred by a minority of surgeons. Therefore we can only theorize as to the mechanism of IACC for reducing the risk of AF, but we believe that the noncardioplegic techniques deserve more credit than they now receive. Although it is an old-fashioned method that some individuals are reluctant to use [Vaage 2005], IACC seems to decrease the incidence of postoperative AF through an unidentified counteractive mechanism that warrants further investigation.

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