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Does Combination of Antegrade and Retrograde Cardioplegia Reduce Coronary Artery Bypass Grafting–Related Conduction Defects?

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ABSTRACT

Background. Conduction disorders appearing after coronary artery bypass surgery (CABG) may have many different causes. In this study, we evaluated the postoperative conduction disorders after CABG with respect to the antegrade blood cardioplegia and antegrade plus continuous retrograde cardioplegia delivery methods.

Materials and Methods. This retrospective study included 1824 patients undergoing CABG between January 2001 and December 2005. There were 694 female patients (38%) and 1130 male patients (62%). Myocardial protection was done by isothermic hyperkalemic blood cardioplegia. Patents in Group 1 (n = 704) were operated on using only intermittent antegrade cardioplegia and those in group 2 (n = 1120) were operated on using the antegrade plus retrograde continuous cardioplegia. The postoperative occurrences of a new right bundle branch block, left anterior hemiblock, left posterior hemiblock, left bundle branch block, or third-degree atrioventricular block were evaluated and compared.

Results. Total mortality rate was 1.6% (29 patients) without significant difference between the groups. The preoperative and perioperative characteristics were statistically similar in the groups. The occurrence of conduction disorders was significantly higher in group 1 (P = .006, 55 versus 52 patients). The analysis of the patients with conduction disorders showed a significantly increased mortality rate (P < .001) in addition to a significantly increased period of intensive care unit follow-up and duration of postoperative hospitalization (P < .001).

Conclusion. The present study demonstrated that the perioperative occurrence of conduction disorders after CABG was decreased by antegrade controlled and retrograde continuous combination cardioplegia.

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INTRODUCTION

The conduction disorders (CDs) associated with coronary artery bypass grafting (CABG) have been reported to occur with an incidence up to 43% [Gundry 1989; Caretta 1991; Pattison 1991; Flack 1992; Mustonen 1995]. These conduction abnormalities, particularly left bundle branch block and third-degree atrioventricular block, are associated with adverse immediate postoperative prognosis and with higher mortality and morbidity rates [Caspi 1989; Mustonen 1995]. However, there is a limited number of studies concerning the CDs associated with the method of cardioplegia administration. This retrospective study mainly focused on the CDs associated with the method of cardioplegia administration.

PATIENTS AND METHODS

Patients

The study was approved by the local ethics committee. The study included the patients undergoing CABG operation between January 2001 and December 2005. A total of 1824 patients were included in the study. There were 694 female patients (38%) and 1130 male patients (62%). All of the patients underwent CABG operation with the diagnosis of coronary artery disease. The preoperative characteristics of the groups are provided in Table 1.

The exclusion criteria were off-pump coronary artery surgery, emergency operation, elevated cardiac enzymes, recent myocardial infarction, redo coronary artery surgery, and additional cardiac operation other than coronary artery surgery.

The patients were studied in 2 groups. Group 1 included 704 patients who were operated on using the intermittent antegrade cardioplegia administration protocol, and group 2 included 1120 patients who were operated on using the antegrade controlled plus retrograde continuous cardioplegia protocol.

Surgical Technique

Anesthetic technique was standard for all patients. General anesthesia and intratracheal intubation was done. The chest was opened by median sternotomy. The left internal

Table 1. Preoperative Characteristics of the Groups

	Group 1, n = 704	Group 2, n = 1120	P
Age, y	56.3 ± 8.4	56.4 ± 8.5	.743
Sex, male:female	434:270	696:424	.843
Hypertension	193	333	.313
Diabetes	157	264	.568
Peripheral arterial disease	114	165	.423
Chronic obstructive pulmonary disease	85	156	.287
Reoperation	11	16	.844
Smoking	415	659	1.000

mammarian artery was harvested before the pericardiotomy. The left internal mammarian artery was used as a routine graft for all of the patients. Moderate degree systemic hypothermia was used during the cardiopulmonary bypass (CPB). Alpha stat acid-base management was adopted, and systemic anticoagulation with an activated clotting time more than 450 seconds was accomplished. Heparin was neutralized by protamine sulphate at the end of the operation. The chest was closed in a standard fashion.

Myocardial Protection Methods

The myocardial protection method was selected according to the preference of the surgeon. Myocardial protection was done by isothermic hyperkalemic blood cardioplegia in both groups. In group 1, the heart was arrested by antegrade infusion of cardioplegic solution with a flow rate of 200 mL per minute and the arrest was maintained by intermittent antegrade infusion of maintenance cardioplegic solution every 20 minutes. In group 2, the heart was arrested by antegrade infusion of cardioplegic solution with a flow rate of 200 mL per minute and the arrest was maintained by continuous retrograde infusion of maintenance cardioplegic solution with a perfusion pressure of 20 to 30 mmHg during the distal anastomosis. Each anastomosed vessel was perfused for 1 minute through the bypass graft after each anastomosis in group 2. Retrograde infusion was continued after antegrade perfusion of the grafts. The temperature of the blood collected for cardioplegia was the same as that of the perfusate (25-28°C), and the hematocrit level was the same as the perfusate level (20%-25%). Blood cardioplegia was prepared by mixing 4 parts oxygenated blood with each part of St. Thomas no. 2 solution. St. Thomas solution was at room temperature. The final mixture of induction cardioplegic solution contained 30 mEq/L potassium, 10 mEq/L sodium bicarbonate, and 6 mEq/L magnesium sulphate, whereas the final mixture of maintenance cardioplegic solution contained 12 mEq/L potassium and 5 mEq/L sodium bicarbonate.

Table 2. Operative and Postoperative Data of the Groups *

	Group 1, n = 704	Group 2, n = 1120	P
CPB time, min	55.51 ± 13.92	55.68 ± 13.93	.530
Cross-clamp time, min	31.50 ± 7.36	32.51 ± 8.31	.055
Number of distal anastomosis	2.79 ± 0.69	2.80 ± 0.70	.908
Intensive care unit follow-up, d	1.97 ± 0.53	1.99 ± 0.64	.827
Postoperative hospitalization, d	5.26 ± 0.97	5.33 ± 1.26	.223
Inotropic support	136	230	.548
IABP	15	17	.362
CD	55	52	.006†
Mortality	11	18	1.000
Low cardiac output syndrome	5	8	
Respiratory problem	4	4	
Multiorgan failure	1	3	
Gastrointestinal system complication		2	
Ventricular fibrillation	1	1	

*CPB indicates cardiopulmonary bypass; IABP, intra-aortic balloon pump; CD, conduction disorder.

†Significant.

Table 3. Data of the Patients with Respect to the Presence of Conduction Disorder (CD)*

	Patients with CD, n = 107	Patients without CD, n = 1717	P
Age, y	56.4 ± 8.5	56.4 ± 8.4	.905
Sex, male:female	73:34	1057:660	.183
Hypertension	37	489	.187
Diabetes	24	397	1.000
Peripheral arterial disease	22	257	.127
Chronic obstructive pulmonary disease	18	223	.242
Smoking	66	1008	.613
Reoperation	4	23	.069
CPB time, min	55.61 ± 13.71	55.61 ± 13.94	.730
Cross-clamp time, min	32.27 ± 8.51	32.11 ± 7.93	.879
Number of distal anastomosis	2.80 ± 0.70	2.80 ± 0.70	.810
Intensive care unit follow-up, d	2.49 ± 1.31	1.96 ± 0.53	<.001†
Postoperative hospitalization, d	6.59 ± 2.79	5.22 ± 0.91	<.001†
IABP	14	18	<.001†
Inotropic support	49	317	<.001†
Mortality	9	22	<.001†

*CPB indicates cardiopulmonary bypass; IABP, intra-aortic balloon pump.

†Significant.

Electrocardiograhy

All patients underwent electrocardiographic assessment before surgery, immediately after the surgery, and daily after the surgery. Standard 12-lead electrocardiography recordings

Table 4. Logistic Regression Analysis for Conduction Disorders*

	Unadjusted OR	95% CI	*P*	Adjusted OR	95% CI	*P*
Sex†	1.341	0.882-2.037	.170	1.363	0.895-2.075	.148
Peripheral vascular disease	1.470	0.903-2.393	.121	1.458	0.894-2.379	.131
Hypertension	1.327	0.879-2.004	.178	1.355	0.894-2.054	.152
Reoperation	2.860	0.971-8.425	.057	2.845	0.961-8.423	.059
Group‡	0.575	0.388-.850	.006	0.575	0.389-0.851	.006

*OR indicates odds ration; CI, confidence interval.

†Reference category is male sex.

‡Reference category is inclusion in Group 2.

immediately after the operation and every postoperative day were evaluated. A new right bundle branch block, left anterior hemiblock, left posterior hemiblock, left bundle branch block, or third-degree atrioventricular block occurring after CABG was considered to be a CD [Willems 1985].

Statistical Analysis

The significance of observed differences in discrete variables was calculated with the chi-square test or the Fisher exact test. Continuous variables were expressed as the mean ±1 standard deviation. Continuous variables were compared by the Mann-Whitney *U* test. *P* values less than .05 were considered to be statistically significant. The effects of the preoperative and operative variables on CDs were analyzed by calculating odds ratios in univariate analyses for all patients. Variables for which the unadjusted *P* value was ≤.20 in logistic regression analysis were identified as potential risk markers and included in the full model.

We conducted multivariate analyses using logistic regression. We reduced the model by using backward elimination and we eliminated potential risk markers by using likelihood ratio tests.

RESULTS

Total mortality rate was 1.6% (29 patients) due to low cardiac output syndrome in 13 patients, respiratory problems in 8 patients, multiorgan failure in 4 patients, gastrointestinal system complications in 2 patients, and ventricular fibrillation in 2 patients. The mortality rates of the groups did not show significant difference ($P = 1.000$). The CPB times, cross-clamp times, number of distal anastomosis, intensive care unit follow-up times, and hospitalization times were statistically similar in the groups. Intra-aortic balloon pump support and inotropic support were also similar in the groups (Table 2).

When the groups were analyzed according to the incidence of CD, the occurrence of CD was significantly higher in group 1 ($P = .006$). Independent from the groups, the analysis of the patients with CD showed that CD significantly increased the mortality rate; 9 of the patients with CD died ($P < .001$). In addition, mean intensive care unit follow-up time and mean hospitalization time of the patients with CDs were 2.49 ± 1.31 and 6.59 ± 2.79 days, and without CDs were 1.94 ± 0.51 and 5.22 ± 0.91 days, respectively. A CD significantly increased the intensive care unit follow-up time and duration of postoperative hospitalization ($P < .001$). The preoperative risk factors did not have a significant effect on the occurrence of CD. Age, number of distal anastomosis, CPB time, and cross-clamp time did not affect the occurrence of CD either (Table 3). Multivariate analysis confirmed the significance of cardioplegia delivery method as a predictor of CD ($P = .006$). The results from the logistic regression analysis for risk factor analysis of CDs are provided in Table 4. Four of the patients were pacemaker dependent at the time of discharge. The distribution of the CDs according to the groups is provided in Table 5.

DISCUSSION

CABG with proper myocardial preservation during aortic cross clamping has substantially improved and reduced operative mortality and morbidity. Myocardial preservation during aortic cross clamping is of critical importance for the postoperative outcome. There are reports emphasizing the possible diagnostic significance of the new occurrence of conduction disturbances such as right bundle branch block or left bundle branch block in postoperative complications of myocardial ischemia [Wexelman 1986; Caspi 1987; Hake 1990; Tuzcu 1990; Mustonen 1998]. Left bundle branch block is widely accepted as an indicator of perioperative myocardial ischemia [Caspi 1987; Hake 1990], but the occurrence of a new right bundle branch block after CABG remains controversial in the

Table 5. Distribution of the Conduction Disorders

	Group 1, n = 704	Group 2, n = 1120
RBBB	36	36
RBBB + LAHB	5	4
LPHB	5	5
LBBB	5	5
TDAVB	3	1
RBBB + TDAVB	1	1

*RBBB indicates right bundle branch block; LAHB, left anterior hemiblock; LPHB, left posterior hemiblock; LBBB, left bundle branch block; TDAVB, third-degree atrioventricular block.

diagnosis of myocardial ischemia [Wexelman 1986; Hake 1990; Tuzcu 1990; Mustonen 1998]. Some studies found a clear association between a new transient and/or permanent right bundle branch block and perioperative CK-MB levels [Seitelberger 2000]. The transient bundle branch blocks following the use of hypothermic cardioplegia do not usually indicate myocardial damage or have any adverse effects on immediate postoperative recovery. The large number of CDs in the study of Mustonen and associates was thought to be due to cold-related injury to the myocardium [Mustonen 1998]. The comparatively low rate of CD in the present study may therefore be due to the avoidance of hypothermia.

The use of antegrade and retrograde blood cardioplegia was reported to provide more effective intraoperative myocardial protection than crystalloid cardioplegic solutions. Moreover, blood cardioplegia prevented the right bundle branch block from becoming permanent [Ueyama 1997]. Pehkonen et al in their study found no correlation between the cardioplegia technique and CDs, but they found reduced left-side CD with improved myocardial protection [Pehkonen 1996]. In the present study, we evaluated the perioperative occurrence of CD on the basis of antegrade and retrograde cardioplegia administration protocols.

The perioperative right bundle branch block occurs predominantly in patients who have a critical stenosis in an artery that supplies the conduction system and in those undergoing more extensive procedures. The large number of bypasses and stenoses of the right coronary artery was found to be strongly associated with a new right bundle branch block [Ueyama 1997]. In our study, we did not find a correlation between the number of vessels bypassed and CDs. In addition, some preoperative factors and intraoperative data such as aortic cross-clamp time, CPB time, and number of grafts were compared between patients with and without CDs. The data revealed no correlation of these to the factors and CDs. The cross-clamp time of group 2 was longer but the difference was not significant. The amount of cardioplegia given to the patients may be different between the groups but we did not have data concerning the amount of total cardioplegia. The cardioplegia delivery techniques in these groups are different and therefore the amount of cardioplegia may show some difference. This may be a limitation in the study.

Mosseri and associates found a clear association between CDs and the first septal perforator branch of the left anterior descending artery and concluded that the lesions in the left anterior descending coronary artery that compromised flow in the first perforator produced localized damage and conduction disturbances after CABG [Mosseri 1991]. In the present study we did not evaluate which vessels were bypassed but found a significant difference according to the cardioplegia administration technique and CDs. This may be because antegrade and retrograde combination cardioplegia might provide better perfusion of the septal branches of the left anterior descending artery. The blood supply to the atrioventricular node in patients with right dominant circulation arises from the mid portion of the right coronary artery. Controlled antegrade perfusion of the grafts in the second group might have yielded a better perfusion of the nodal artery that appeared as a lower rate of CD.

Tepid blood cardioplegia was reported to produce less myocardial injury and better left ventricular function when compared with cold blood cardioplegia [Badak 2005]. Hayashida and colleagues demonstrated that tepid cardioplegia produced similar myocardial oxygen consumption to warm cardioplegia during cardioplegic arrest, suggesting preservation of mitochondrial function. Tepid cardioplegia reduced anaerobic lactate release compared with warm cardioplegia. Lactate and acid washout were least after tepid cardioplegia and greatest after warm cardioplegia at the time of cross-clamp release. They suggested that the combination of intermittent antegrade and continuous retrograde tepid cardioplegia provided superior myocardial protection when coronary obstruction or interruptions limited cardioplegia delivery [Hayashida 1995]. In our study population we did not have data to make such comparisons.

In conclusion, this study on patients undergoing CABG demonstrated that the perioperative occurrence of CD was significantly decreased by antegrade and retrograde combination cardioplegia.

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