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The Effect of Coronary Revascularization on New-Onset Complete Atrioventricular Block Due to Acute Coronary Syndrome

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ABSTRACT

Background: Coronary artery disease is one of the most common causes of complete atrioventricular block (AVB) in adults. In this study, we evaluated whether prompt revascularization of the coronary artery occlusion can ameliorate new-onset complete AVB due to acute coronary syndrome (ACS).

Methods: Five patients (4 men and 1 woman) with a mean age of 69.8 ± 7.1 years with diagnosed new-onset complete AVB and proven coronary artery disease were enrolled in the study. At the time of AVB diagnosis, 3 of the patients had acute myocardial infarction, and the other 2 patients had unstable angina pectoris. All patients underwent complete coronary bypass surgery after the diagnosis of complete AVB. A patient who underwent 2 coronary bypasses also underwent aortic valve replacement.

Results: No mortality was observed in the study group. All but one of the patients converted back to sinus rhythm after a mean interval of 30 ± 13.6 hours following revascularization procedures. Complete AVB persisted in 1 patient, and a permanent pacemaker was implanted. All patients were discharged uneventfully. The mean hospital stay was 11.4 ± 4.5 days. All patients are still being followed up after surgery; at a mean follow-up of 27.4 ± 0.9 months, there have been no further problems.

Conclusion: Coronary revascularization may ameliorate ACS-related new-onset complete AVB with an acceptable rate of successful reversion to sinus rhythm. An especially appropriate time for surgery, complete coronary revascularization, and management of myocardial protection during surgery might improve the results of coronary bypass procedures in these patients.

INTRODUCTION

New-onset complete atrioventricular block (AVB) is a rare but serious complication of acute events related to coronary artery disease [Archbold 1998; Nicod 1998]. Complete AVB occurs in almost 7% of cases of acute myocardial infarction (MI) and is associated with a high risk of mortality [Meine 2005]. Among acute coronary syndrome (ACS) patients, there is 40% difference in the 2-year mortality rate between patients with normal conduction and patients with complete AVB [Archbold 1998]. Previous studies showed that complete heart block was more prevalent among patients with inferior MI than among patients with anterior MI [Archbold 1998; Nicod 1998; Rathore 2001]. Mosseri et al [1997] previously documented coronary artery lesions considered to lead to complete AVB because of lack of conduction-tissue perfusion (Table 1).

Revascularization methods have been shown to reduce mortality in ACS by restoring the coronary flow in the ischemia/infarct-related artery and by reducing the extent of myocardial injury [Archbold 1998]; however, it is not certain whether such methods ameliorate the new-onset complete AVB due to ACS. To address this question, we examined the effect of prompt coronary revascularization in patients who experienced sudden onset of complete AVB due to ACS.

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MATERIALS AND METHODS

Patients

The institutional ethics committee approved this study and waived individual consent for this retrospective analysis (approval no. 2008/023). We included in the study 5 patients who were hospitalized for ACS with new-onset complete AVB between September 2005 and August 2006 and who required coronary artery bypass grafting (CABG). Four of the patients were male. The mean patient age was 69.8 ± 7.1 years.

Two patients had ST-segment elevation MI (STEMI), 1 patient had non-STEMI, and 2 patients had unstable angina pectoris. The diagnosis for the 2 patients with STEMI was made in another hospital. Both patients received thrombolytic therapy and were transferred to our hospital because of complete AVB. Medical therapy was administered to the non-STEMI patient because the patient had been admitted to our hospital after the period for effective coronary intervention. Among the MI patients, the mean peak troponin I level was 9.6 ± 4.6 ng/mL. No other etiologies, such as hormonal, metabolic, or degenerative disorders, led to complete AVB in any of the patients.

Coronary artery disease was documented with coronary angiography in all of the patients. The right coronary system

Table 1. Classification of Pathologic Coronary Anatomy Supplying the Conduction System*

Type I	Lesions not related to septal branches or the AV node
Type II	Lesions compromising blood supply to septal branches emerging from the LAD
Type III	Lesions compromising blood supply to the AV node
Type IV	Lesions compromising blood supply both to septal branches emerging from the LAD and to the AV node

*AV indicates atrioventricular; LAD, left anterior descending coronary artery.

was dominant in all patients. Two patients had 3–coronary vessel disease, and 3 patients had 2–coronary vessel disease. One of the patients who had 2-vessel disease had additional severe aortic insufficiency. The distribution of the pathologic anatomic type with regard to the conduction-system blood supply showed that 3 patients had the type IV pattern and 2 patients had the type II pattern, according to the criteria of Mosseri et al [1997]. Ventriculography examinations showed that the mean ejection fraction was 54% ± 11.4%. The location of MI was inferior in 1 patient and anterior in 2 patients.

Temporary transvenous pacing was inserted through the femoral vein in all of the patients when complete AVB was diagnosed and was actively used in 3 patients until their operations. The patients were planned for CABG as soon as possible in the hope that they would recover from complete AVB. Given this consideration, CABG was performed at a mean of 4.2 ± 1.4 days after the diagnosis of complete AVB, in accordance with American College of Cardiology/American Heart Association guidelines [Eagle 2004] for appropriate timing of revascularization in ACS patients. Table 2 summarizes the preoperative characteristics of the patients.

Patients were informed that implantation of a permanent pacemaker would be necessary in the event that the complete AVB did not improve after CABG. Implantation of a permanent pacemaker was planned if the complete AVB persisted 15 days after the operation.

Surgical Technique

All operations were performed through a median sternotomy with the patient on cardiopulmonary bypass (CPB). The left internal thoracic artery and the saphenous vein were harvested before the institution of CPB. After administration of heparin (300 U/kg), CPB was established through standard aortic and 2-stage venous cannulation by means of a roller-pump membrane oxygenator under mild hypothermia (31ºC to 34ºC). The activated clotting time was maintained at >480 seconds. Combined antegrade and retrograde tepid blood cardioplegia was used at 10- to 20-minute intervals in all patients. Tepid cardioplegia was preferred to avoid excessive cooling of the myocardium, as described by Mustonen et al [2000].

The left internal thoracic artery was anastomosed to the left anterior descending coronary artery in all patients. Individual saphenous veins were used for other coronary artery bypass procedures. Selective antegrade tepid blood cardioplegia was also delivered through the saphenous vein in addition to the combined method following the completion of each distal saphenous vein anastomosis. Three vessels were bypassed in 3 patients, and 4 vessels were bypassed in 1 patient. Concomitant aortic valve replacement with a no. 23 mechanical valve (St. Jude Medical, Minneapolis, MN, USA) was performed in 1 patient who underwent bypass for 2 coronary arteries. Complete revascularization was achieved in all patients. Operative data are shown in Table 3. Because the complete AVB persisted, all patients were weaned from CPB with external pacing provided through the epicardial pacing wire to achieve an appropriate heart rate. Heparinization was reversed with protamine when the extracorporeal circulation was completed.

RESULTS

Postoperative data are provided in Table 3. All patients were transferred to the intensive care unit with temporary epicardial pacemaker support. Neither an intra-aortic balloon pump nor substantial use of inotropic agents was required in

Table 2. Preoperative Characteristics of the Patients*

Patient No.	Age, y/Sex	Symptoms	Diagnosis	CAD Risk Factors	Heart Rate	Active Temporary Pacemaker Usage	Cardiac Pathology	Coronary Anatomy Type	LVEF, %
1	59/F	Epigastric pain, nausea	STEMI (inferior)	HT, HC, DM	41	Yes	3-Vessel disease	IV	45
2	77/M	Chest pain	NSTEMI (anterior)	HC, Sm	45	No	2-Vessel disease	II	40
3	75/M	Chest pain	UAP	HT, HC, DM	44	No	2-Vessel disease + aortic insufficiency	II	65
4	71/M	Dyspnea, sweating	STEMI (anterior)	HT, HC, Sm	42	Yes	3-Vessel disease	IV	55
5	67/M	Chest pain	UAP	HT, HC, DM, Sm	43	Yes	3-Vessel disease	IV	65

*CAD indicates coronary artery disease; LVEF, left ventricular ejection fraction; F, female; STEMI, ST-segment elevation myocardial infarction; HT, hypertension; HC, hypercholesterolemia; DM, diabetes mellitus; M, male; NSTEMI, non-STEMI; Sm, smoking; UAP, unstable angina pectoris.

Table 3. Operative and Postoperative Data of the Patients*

Patient No.	Time from AVB to Surgery, d	Operation	CPB/X-Clamp Time, min	Time from Surgery to Obtaining NSR, h	ICU Stay, d	Hospital Stay, d	Permanent Pacemaker
1	4	CABG 3 (LAD, OM2, RCA)	75/52	32	4	8	No
2	3	CABG 3 (LAD, D1, OM1)	60/46	17	3	10	No
3	4	CABG 2 (LAD, OM1) + AVR	92/68	44	4	17	No
4	3	CABG 4 (LAD, D1, OM2, RCAPD)	90/72	28	3	6	No
5	6	CABG 3 (LAD, OM2, RCAPD)	85/45	—	6	15	Yes

*AVB indicates atrioventricular block; CPB, cardiopulmonary bypass; X-clamp, cross-clamp; NSR, normal sinus rhythm; ICU, intensive care unit; CABG, coronary artery bypass grafting; LAD, left anterior descending coronary artery; OM, obtuse margin branch of circumflex artery; RCA, right coronary artery; D, diagonal branch of LAD; AVR, aortic valve replacement; RCAPD, posterior descending branch of the RCA.

any of the patients. Prolonged ventilatory support was not needed, and all patients were extubated within 12 hours without any pulmonary complications. There were no surgical complications, such as excessive drainage, cardiac failure, or renal failure. No in-hospital or late mortality was seen in the study group.

Complete AVB converted to normal sinus rhythm (NSR) in the intensive care unit in 4 patients. The mean duration of NSR observation after the operation in this group was 30.2 ± 11.1 hours (range, 17-44 hours). All patients who attained NSR postoperatively were discharged without any conduction abnormalities. At the mean follow-up of 27.7 ± 0.5 months, all patients were symptom free, and all had NSR. Because complete AVB persisted in 1 patient 15 days after the CABG surgery, he underwent implantation of a permanent pacemaker. At the 26th month of follow-up, this patient was asymptomatic and had a good, functional permanent pacemaker.

DISCUSSION

The results with our series, which consisted of patients with ACS-related new-onset complete AVB, showed that prompt complete surgical revascularization with management of myocardial protection ameliorates conduction abnormalities with an acceptable success rate. Surgery was well tolerated in this group, and heart rhythm recovered in 80% of the patients without any major complications.

Patients presenting with new-onset AVB due to ACS constitute a high-risk group with respect to mortality and morbidity [Archbold 1998; Nicod 1998; Okmen 2003; Meine 2005]. The adverse effects of conduction-system defects on the prognosis for ACS patients are presumably due to their association with extensive myocardial injury [Archbold 1998; Okmen 2003]. Onset of heart block usually occurs within the first day of acute MI and rarely occurs after the fourth day [Lim 1971]. Rathore et al [2001] showed that patients with complete heart block and ACS were slightly older, had a higher Killip class, had a lower heart rate and systolic blood pressure at admission, had a higher prevalence of diabetes, and were more likely to be smokers than patients without this conduction disorder. Heart block is more prevalent among patients with inferior infarctions than among patients with anterior infarctions, but the latter frequently involve disease at the level of the His bundle or bundle branches associated with extensive necrosis and do not readily resolve [Archbold 1998; Rathore 2001]. There is a close relation in patients with coronary artery disease between the conduction disturbance and the specific coronary location for stenosis involving the first septal artery of the left anterior descending artery and the right coronary artery. Hence, conduction disturbances are more prevalent among patients with type IV and type II coronary stenosis, because sinoatrial and atrioventricular node perfusion is compromised in such cases [Mosseri 1997]. In our series, 3 of the patients had a type IV coronary anatomy, and 2 patients had a type II coronary anatomy.

Restoring sinus rhythm and preventing myocardial damage via revascularization in ACS patients have led to better early and late results with respect to morbidity and mortality [Moreyra 1988; Archbold 1998; Escosteguy 2001; Rathore 2001]; however, there have been limited numbers of published reports regarding the effect of revascularization methods such as thrombolytic therapy [Archbold 1998; Harpaz 1999; Kimura 1999; Meine 2005] and percutaneous coronary intervention (PCI) [Moreyra 1988; Kimura 1999; Ramamurthy 2007] on new-onset complete AVB following ACS. Many authors have emphasized that reperfusion of an artery supplying conduction-tissue perfusion related to the infarction can lower the incidence of conduction disturbances by decreasing the size of the involved area of the myocardium [Archbold 1998; Escosteguy 2001; Rathore 2001]. Kimura et al [1999] described 21 patients with complete AVB following inferior MI, and NSR was restored after reperfusion (thrombolysis or PCI) within 6 hours of the infarction in the vast majority of patients. Ramamurthy et al [2007] described a patient who had a complete AVB that persisted for 2 weeks after an inferior MI and who had undergone a PCI. After PCI of the proximal occlusion of the right coronary artery, the rhythm recovered to NSR. The authors concluded that PCI is superior to thrombolytic treatment for accomplishing complete revascularization in these patients. They also claimed that conducting fibers are less dependent on oxidative phosphorylation than the contractile elements; hence, there may be a possibility for recovery of conductive function even with late revascularization [Ramamurthy 2007]. In our series, although the patients underwent operation at a mean of 4.2 ± 1.4 days following the ACS and the occurrence of complete AVB, NSR was achieved with an 80% success rate, a result that can be explained with the same mechanism. The main reason for the waiting period for revascularization in this group was to avoid the high risk of early surgery, as indicated by American College of Cardiology/American Heart Association guidelines. The patient whose complete AVB did not recover underwent CABG 6 days after the ACS because of the patient's unstable hemodynamics. Prolonging the waiting period for revascularization might have led to irreversible damage to the patient's conduction tissue. Furthermore, a prolonged waiting time for revascularization in this patient, who had a type IV coronary pathology, could have made the conduction tissue more vulnerable compared with the patients with the other types of coronary pathology.

Omeroglu et al [2005] evaluated the effect of CABG in 8 patients who had acute onset of complete AVB and documented coronary artery disease. In this study, none of the patients converted to NSR, and a permanent pacemaker was implanted in all of the patients. In their series, the main symptoms, such as syncope and presyncope, were found to be related to the complete AVB. None of these investigators' patients showed any symptoms related to their coronary artery disease on admission to the hospital, and they showed no ischemic electrocardiographic changes or cardiac enzyme abnormalities. Therefore, it is plausible that CABG might not be effective in restoring NSR to patients with acute onset of complete AVB unrelated to acute coronary events, even though angiographic results may indicate coronary revascularization. In our study, all patients had symptoms of coronary artery disease, and all had ACS. Documented infarction or severe ischemia is known to jeopardize a large part of the myocardium, including the vulnerable conduction system, by decreasing the blood flow and leading to complete AVB [Okmen 2003]. Infarction size has also been reported to be correlated to the incidence of conduction disturbances [Opolski 1986; Archbold 1998; Meine 2005]. Even a mild decrease in blood flow in unstable angina without major myocardial damage could accelerate the degeneration of the susceptible conduction system in older patients and could contribute to the development of conduction defects [Okmen 2003]. This description may explain the occurrence of complete AVB in 2 of our patients, who were older than 65 years and had unstable angina pectoris. One of these patients, a 67-year-old man, remained in complete AVB, even after he had undergone complete CABG and implantation of a permanent pacemaker.

A preoperative low left ventricular ejection fraction in patients with coronary artery disease has been associated with high conduction disturbances after CABG [Mustonen 1998]. As an indicator of left ventricular dysfunction, an intraoperative need for intra-aortic balloon pump use corresponded to the greatest likelihood of the development of a new-onset conduction defect after CABG [Cook 2005]. These indicators of left ventricular systolic dysfunction in such patients may reflect severe myocardial damage to consequently affected conduction tissue. In our series, the mean preoperative ejection fraction was 54% ± 11.4%, and neither an intra-aortic balloon pump nor pronounced use of an inotropic agent was needed.

Cook et al [2005] compared patients who underwent CABG in 1991 with those who underwent their operations in 2001 with regard to the incidence of new conduction-system defects after CABG. These investigators determined that the incidence of new conduction-system defects was lower in 2001 than in 1991, even with increased use of beta-blockade. They claimed that current medical and surgical management of CABG patients has decreased the possibility of developing a postoperative conduction defect.

The management of myocardial protection during CABG in patients with conduction disturbances has been well defined in the literature [Partington 1989; Flack 1992; Hippeläinen 1994; Ceviz 1995; Mustonen 1998, 2000]. Some authors have emphasized the use of combined cardioplegia (ie, antegrade and retrograde cardioplegia), which provides better myocardial protection than either technique alone, ensures good cardioplegic distribution to the left and right ventricles, and allows regional delivery of cardioplegic flow to segments supplied by occluded arteries [Partington 1989; Ceviz 1995]. Thus, conduction-tissue perfusion can be warranted, and further conduction disturbances can be prevented. Some authors have mentioned that low myocardial temperatures due to cold cardioplegia may cause conduction disturbances during CABG [Hippeläinen 1994; Mustonen 1998, 2000]. Therefore, many authors have used warm or tepid cardioplegia during revascularization procedures, and conduction disturbances have been reported to be less with this method [Flack 1992]. In our series, mild hypothermia (31°C to 34°C) was used during CPB to prevent further cooling of the patient. Combined antegrade and retrograde tepid blood cardioplegia was delivered at 10- to 20-minute intervals to all patients. Tepid cardioplegia was preferred to avoid excessive cooling of the myocardium. In addition to providing better distribution of cardioplegia to the myocardium and conductive tissue with the combined method, we also delivered selective antegrade tepid blood cardioplegia through the saphenous vein following completion of each distal saphenous vein anastomosis. We speculate that mild body hypothermia and combined tepid cardioplegia have a high myocardial-protection effect.

Our study has several limitations. First, the study was not designed as a prospective evaluation. We were therefore unable to determine the precise onset of complete AVB and its relation with the ACS. Second, the number of patients in our series was small, and therefore a statistical analysis of the effect of different methods on conduction disturbance could not be performed. Third, because 3 patients had MI and 2 patients had unstable angina pectoris, the study group was not homogeneous, even though all of the patients had the diagnosis of ACS. Fourth, preoperative and postoperative imaging studies of myocardial perfusion, such as scintigraphy or positron emission tomography, were not carried out. Thus, we were not able to delineate which myocardial or conduction area undergoing revascularization was most effective for obtaining NSR.

In conclusion, complete coronary revascularization might ameliorate ACS-related new-onset complete AVB and restore sinus rhythm with an acceptable success rate. An especially appropriate timing of the surgery and management of myocardial protection, such as avoidance of excessive cooling of the body and myocardium and combined tepid cardioplegia, might improve the results of a coronary bypass procedure to restore sinus rhythm in patients with new-onset complete AVB due to ACS. Further studies in these patients are needed to reveal the effect of coronary revascularization on the cellular mechanisms of the myocardium and the conductive system.

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