Prostaglandin E_1 Increased Cardiac Contractility in Cardiac Arrest during Open-heart Surgery

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(Key words: Prostaglandin E_1, Cardiac Arrest, Open-Heart surgery)

In recent years, weaning from the cardiopulmonary bypass in open heart surgery has been made easy by the development of myocardial protection, and postoperative cardiac failure has decreased as well[1]. However, weaning from the cardiopulmonary bypass has continued to be difficult in patients with decreased cardiac function or myocardial damage before surgery[2].

Prostaglandin E_1 (PGE_1) has a number of potent biological actions including direct relaxing effects on vascular smooth muscles[3–5]. PGE_1 is applied in the neonate to maintain the patency of the ductus arteriosus[6], and also beneficial effect of PGE_1 has been reported in patients with congestive heart failure[7]. However, the exact mechanism of the latter effect remains unknown as the potent vasodilating property. PGE_1 would likely change the cardiac loading conditions and mask an eventual positive inotropic effect.

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We report a case cardiac arrest in which cardiac contractility recovered by the administration of PGE_1 during surgery of a descending thoracic aortic aneurysm and coronary artery bypass graft surgery (CABG).

Case Report

A 64-yr-old man, height 162cm, weight 51kg, was scheduled for reconstruction of a descending thoracic aortic aneurysm. This patient had been diagnosed as having had an obsolete myocardial infarction as of around 1965. Preoperative coronary angiography revealed complete occlusion of the right coronary artery and 50% stenosis of the left anterior descending artery and left circumflex artery, but CABG was not scheduled at this time.

Upon arrival in the operating room, standard monitoring including radial artery and flow-directed pulmonary artery catheter was started. Anesthesia was induced with fentanyl 0.3mg, diazepam 2.5mg and thiopental 100mg, and the trachea was intubated after the administration of vecuronium bromide 15mg (fig. 1). Anesthesia was maintained with oxygen-air (F_{IO_2}=0.5) and sevoflurane at 0.5 ~ 1.5% inspired concentration with fentanyl and diazepam as needed. A left atrial-common femoral artery bypass with

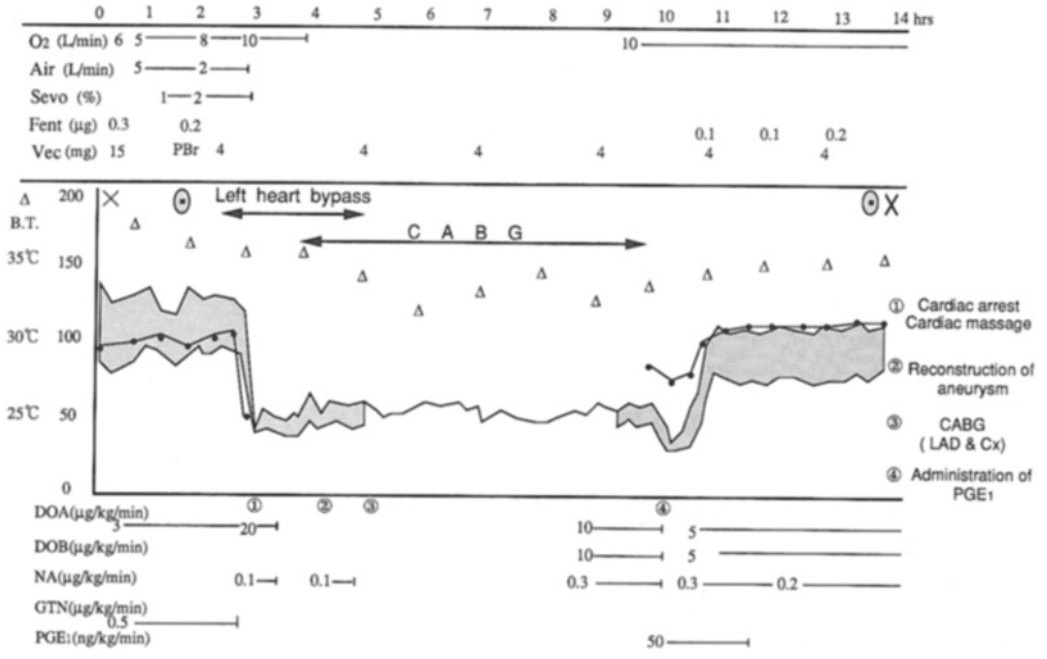

Fig. 1. Anaesthetic course of the case.
Sevo: Sevoflurane, Fent: Fentanest, Vec: Vecuronium bromide, PBr: Pancuronium bromide, B.T.: Body Temperature, DOA: Dopamine, DOB: Dobutamine, NA: Noradrenaline, GTN: Glyceryl trinitrate, CABG: Coronary artery bypass graft surgery

a centrifugal pump (Bio-Medicus, Inc., Minn, U.S.A.) was used before cross-clamping of the descending thoracic aorta, and the mean distal perfusion pressure was maintained at 50 mmHg. When graft replacement was carried out, blood pressure was decreased by compression of the heart by the surgeon's hands. The blood pressure was rapidly recovered by release of the compression, nevertheless, cardiac arrest occurred followed by bradycardia. The cardiac arrest did not recover by cardiac massage and administration of catecholamines. The cardiopulmonary bypass (CPB) was prepared during uninterrupted cardiac massage, and the bypass was started after cannulation of the superior and inferior venae cavae and ascending aorta. Blood flow to the lower limb was maintained by the left atrial-femoral artery bypass. The time required from the start of cardiac arrest until the initiation of the CPB was about 45 minutes, and the blood pressure was about 40 mmHg during the preparation of the CPB. Reconstruction of the aneurysm was carried out under ventricular fibrillation. Cardiac contractility was poor after defibrillation, and the weaning from the CPB was difficult. The CABG for the left anterior descending artery and the circumflex artery was carried out because the shortage of the coronary blood flow was suspected. However, the CABG did not increase cardiac contractility, and weaning from the cardiopulmonary bypass was impossible by the use of high-dose inotropic support (dopamine 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$, dobutamine 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$, and noradrenaline 0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$). We interrupted the administration of all catecholamines because discontinuation of the surgery was proposed by the car-

diac surgeon. We administered PGE_1 0.05 $\mu g \cdot kg^{-1} \cdot min^{-1}$ to expect a direct relaxing effect on the coronary artery at approximately 5 minutes after discontinuation of the administration of catecholamines. Five minutes later (at approximately 10 minutes after the discontinuation of catecholamines), augumentation of the cardiac contractility and gradual increase of the blood pressure were observed. Catecholamines were again administered, and blood pressure was stabilized by the administration of dopamine 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$, dobutamine 10 $\mu g \cdot kg^{-1} \cdot min^{-1}$ and noradrenaline 0.3 $\mu g \cdot kg^{-1} \cdot min^{-1}$. Thereafter weaning from the CPB was successfully accomplished and the surgery was safely completed.

Discussion

In this case, PGE_1 0.05 $\mu g \cdot kg^{-1} \cdot min^{-1}$ increased the myocardial contractility and elevated the blood pressure after 5 minutes from the start of administration, in spite of the discontinuation of catecholamines. Kamiyama et al.[8] reported that the administration of PGE_1 re-started the heart beat during cardiac arrest in emergency open heart surgery of a newborn, and suggested that a decrease of Ca^{2+} in the myocardial cells was a factor in the re-starting of the heart beat. PGE_1 reduces intracellular Ca^{2+} secondary to the increases of cyclic AMP and protein-kinase in the myocardial cells, and also increases the uptake of Ca^{2+} in the isolated myocardium and reduces the relaxation time of the cardiac contractility. In this case the myocardial damage during CPB and the inhibition of mitochondrial function were likely to be caused by an elevation of intracellular Ca^{2+} at re-perfusion after weaning from the CPB. Moreover, the administration of dopamine and calcium gluconate might have increased intracellular Ca^{2+}. The decrease of the function of mitochondria, the protection of ATP, and the inhibition of the relaxation of myocardial contractility are shown by the elevation of intracellular Ca^{2+} [9–12], which particularly decreases the left ventricular dilatation ability and makes rigidity of the left ventricle[10,11]. Then left ventricular compliance decreases[13]. As a result, left ventricular end-diastolic volume, stroke volume and blood pressure decrease.

The decrease of after-load by the administration of PGE_1 also may have been effective for the improvement of myocardial contractility. Particularly, PGE_1 dilates the arteriole, decreases the after-load and increases the left ventricular stroke volume. The increase of the left ventricular stroke volume decreases the left ventricular end-diastolic volume and pre-load. The decrease of the pre-load elevates the coronary perfusion pressure, and cardiac output is increased by vasodilation of PGE_1[14–16].

In this patient with poor myocardial contractility due to cardiac arrest during surgery and whose weaning from the CPB was difficult, the administration of PGE_1 was effective for the recovery of myocardial contractility. The effects of PGE_1 *in vivo* have not yet been sufficiently clarified, further detailed study is necessary.

(Received Aug. 6, 1992, accepted for publication Dec. 1, 1992)

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