Experimental Systemic-Coronary Anastomosis Using Extracorporeal Circulation

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The systemic-coronary artery anastomosis was studied experimentally using extracorporeal circulation.

The left subclavian artery was anastomosed with the left main coronary artery in 6 dogs, and the left internal mammary artery with the right coronary artery in 8 dogs.

The method and technique were discussed, and by this technique the systemic-coronary artery anastomosis will be performed more easily and successfully.

In the coronary artery diseases, changes are most frequently located in the main coronary arteries and its primary branches. Both left and right coronary arteries are involved in many cases. Besides, there is the coronary insufficiency due to the changes of aorta and aortic valve. And, the diseases of ascending aorta and aortic valve will be more easily operable if the origins of both coronary arteries are translocated anywhere. To operate on such cases, the systemic arteries are expected to be anastomosed with more than 2 coronary arteries. Many reports have been published about the systemic-coronary artery anastomosis, but these are limited in only one part. Our purpose is making of this anastomosis in 2 parts, though we tried to make a unilateral anastomosis every instance in this report.

These experiments were performed under the extracorporeal circulation.

Material and Method

Fourteen mongrel dogs, weighing 13.0 to 30.0 Kg., were anesthetized with pentobarbital sodium. Thoracotomy was performed in the left fourth intercostal space.

A disc oxygenator was primed with 1,500 ml. of homologous blood, and driven with a flow rate of 70 ml./Kg./min. Hypothermia was obtained by the electronic heat exchanger, which was placed in the arterial line. Heart beats were abolished by lowering the esophageal temperature to 20°C, and changed into either severe bradycardia or ventricular fibrillation. At this stage, the systemic-coronary artery anastomosis was performed. Following the completion of the suture, all the hearts
were warmed up to 37°C and resuscitated from the hypothermic arrest. The periods of the total perfusion were 44 to 180 min. and those of the coronary arterial occlusion were 17 to 50 min. This experiments were divided into 2 groups.

In 6 dogs, the first group, the left subclavian artery was freed of all its branches up to the apex of the thorax and divided there. The lengths were 5.5 to 9.5 cm., enough to anastomose with the left coronary trunk. And the diameters of the former were 2.5 to 4.5 mm., which were similar to that of the latter. The left main coronary artery was mobilized for about 2 cm. from the ostium to its branches. The important 3 branches, which were the anterior descending, the left circumflex artery and the septal branch, were carefully confirmed.

Following the heart beats were abolished, the main coronary artery was ligated near the ostium, and its trunk was cut longitudinally for about 5 mm. In most cases, the end-to-side vascular anastomosis between the left subclavian and left main coronary artery was performed by using No. 7-0 arterial silk as a continuous suture (Fig. 1).

In 2 experiments of them, the end-to-end anastomosis was tried after the complete repair of the tear in the aorta and coronary trunk. When the trunk was very short, the ligation was placed at the aortic wall near the coronary ostium to

Fig. 1. The left subclavian artery was anastomosed with left main coronary artery under the extracorporeal circulation and moderate hypothermia. In almost all cases, the end-to-side anastomosis was performed by the continuous suture.
occlude the coronary blood flow temporarily, and the subclavian artery was sutured to that portion from the main coronary artery to the proximal part of circumflex branch.

The bleeding from the site of anastomosis was tried to be controlled by the using of several suture and plastic adhesive.

In 8 experiments, the second group, the left subclavian artery was mobilized and divided beyond the origin of the left internal mammary artery, which was freed of all its branches for about 7 cm. and cut off. The diameters of the left internal mammary arteries were 2.0 to 2.5 mm., which were nearly equal to those of the right coronary arteries.

This coronary artery was mobilized for about 2 cm. and incised longitudinally about 3 mm. The end-to-side anastomosis was performed between this vessel and the left internal mammary artery by the continuous horizontal mattress suture (Fig. 2).

**RESULTS**

All the 14 hearts were resuscitated from the hypothermic cardiac arrest. Almost all of the dogs died on the first day after operation. Three dogs died of the coronary insufficiency resulting from stenosis of the anastomosis. Six died of bleeding from the anastomosis, one of which was complicated with air embolism. Two died of other intrapleural bleeding. Two other dogs
died of poor perfusion. Only one died of pyothorax 9 months after anastomosis.

Electrocardiograms and angiograms were studied in the long term survivor. Electrocardiogram in the postoperative period showed the transient elongation of QRS segment, probably due to hypothermia. The right axis deviation was found after 1 week, when the postoperative pneumothorax happened, but there was no sign of the coronary insufficiency (Fig. 3).

Angiograms of the aortic root showed no evidence of aortic regurgitation and no shadow of the left coronary artery. But, the aortic arch and its branches were showed with the fine figure of the left coronary artery by angiography at 3 months after the operation. There was no narrowing of the anastomosis (Fig. 4).

In autopsy, all the anastomosis was patent and no thrombus was found there, and it was endothelialized in the long term survivor (Fig. 5). Three cases showed the stenosis at the anastomosis. Myocardial damage was not so remarkable.

**COMMENTS**

Though the idea of the bilateral systemic-coronary artery anastomosis has once been found in the report of Mamiya,1) the experimental report was not published yet. As the first step to this procedure, we tried the left subclavian-
Fig. 3. Electrocardiogram of long term survivor showed the transient elongation of QRS segment in the early postoperative period (a), which may be due to hypothermia. Right axis deviation was found after pneumothorax, which happened in the first postoperative one week (b).

left main coronary artery anastomosis in 6 dogs, and the left internal mammary-right coronary artery anastomosis in 8 dogs. In this experiment, the problems are the using of extracorporeal circulation, the coronary arterial occlusion, the technique of small vessel anastomosis and the control of the bleeding.

The tube insertion methods, which have been reported by many authors, seem to be useful to make experimentally the anastomosis between the systemic and coronary artery. But, this clinical use has the anxiety that the beats of
the damaged heart would easily turn to the ventricular fibrillation by the brief period of coronary occlusion, and the resuscitation from the cardiac arrest would be difficult. Therefore, hypothermia with or without extracorporeal circulation is preferable for such operative procedures requiring the temporary occlusion.

In this experiment, the periods of the total perfusion were 44 to 180 min., and in the long term survivor it was 113 min. During the perfusion, the blood in the left ventricle was drawn out to the blood reservoir by the cannule, which was inserted through left atrium, to keep the lung from dangerous congestion.

The longest period of the coronary occlusion was 50 min. under the hypothermia of 20°C as esophageal temperature. All the hearts returned to the good action, whereas those with the stenosis of the anastomosis changed
Fig. 6. The variation in the origin of the septal branches of dogs is shown. It disturbed the end-to-end anastomosis between the systemic and coronary artery.

to the ventricular fibrillation. The myocardial damage was not remarkable in autopsy. Then, the hypothermia of 20°C will be useful to elongate the occlusion time of the coronary artery until 50 min. without any myocardial damage.

The origins of the septal branches are usually located in the anterior descending artery or left circumflex artery. Sometimes, this branches comes out from the left main coronary artery, and one case of this experiment has 2 septal branches, each of which from both anterior descending and circumflex artery (Fig. 6). This vessel will be prevented from a dangerous obstruction of its origin by using the end-to-side anastomosis between systemic and its origin by using the end-to-side anastomosis between systemic and coronary artery, even it is located very close to the coronary ostium at the under surface of the main coronary artery. Moreover, this procedure seems to easily get a large orifice enough to supply an adequate blood volume, though the end-to-end anastomosis usually makes the narrowing of the part. But, the utilization of the plastic adhesive often makes the end-to-side anastomosis more narrow, especially in the small right coronary artery, of which many cases died in this experiment.

The coronary artery has very thin wall and many small branches, which disturb to make this vessel mobile for a few distance enough to prepare for the suture apparatus. In the end-to-side anastomosis of the vessels involved by the slight atheromatous change, this technique is less suitable than the manual.

Two mg. of Heparin per Kg. was given intravenously before perfusion, and 3.0 mg. of Protamin Zink Insulin per Kg. was administered after perfusion. In many cases the bleeding from the anastomosis was severe, and the additional suture and plastic adhesive were not so helpful to control the bleeding. The most important procedure to control bleeding was the suture technique, which was taken at first.

The coronary angiography in the clinical cases with the coronary insufficiency is becoming to show the fine figure of the coronary arterial changes. As far as surgical treatment of coronary heart disease is concerned, both degree
and localization of those pathologic alterations are important. When this method is completed, many cases will be found to be curable by the vascular anastomosis.

**Summary**

The left subclavian artery was anastomosed with the left main coronary artery in 6 dogs, and the left internal mammary artery with the right coronary artery in 8 dogs, by the left thoracotomy. The procedures were performed using the extracorporeal circulation and hypothermia to 20°C, which made the occlusion of coronary blood flow possible for 50 min. without remarkable myocardial damage. The most difficulty in these operations was bleeding from the anastomosis, which had to be controlled by the careful suture technique.

**References**