Thermographic Demonstration of Uneven Myocardial Cooling in Patients with Coronary Lesions

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ABSTRACT Low temperature is an important factor in protecting the myocardium during an operation on the heart. This can be difficult to accomplish if the cold cardioplegic solution is hindered by occlusions or stenosis of the coronary arteries. We used thermography to study myocardial temperature during infusion of cold cardioplegic solution. Slow cooling was recorded distal to coronary stenosis or occlusions, thereby indicating insufficient protection of the myocardium in these areas.

Cooling the myocardium by infusion of cold cardioplegic solution into the aortic root has improved the results of cardiac operations. Coronary occlusions or stenosis can cause an uneven distribution of the cold solution and thereby produce areas of insufficient protection in the myocardium. We used thermography to demonstrate the course of events during infusion of the cardioplegic solution.

Material and Methods
Ten patients were investigated. Two had aortic stenosis and no coronary lesions, 1 had aortic stenosis and stenosis of the left anterior descending coronary artery and the left circumflex artery, and 7 had coronary stenosis of varying degree.

After the institution of extracorporeal circulation, the aorta was cross-clamped and 1 liter of cold (4°C) cardioplegic solution was infused by gravity through a 3 mm cannula into the aortic root from a height of 1 meter above the aortic root. Infusion time was kept within 8 to 10 minutes. In 6 patients in whom the effect of the infusion on myocardial temperature was insufficient as judged by the thermographic appearance, additional cold solution was infused.

In order to obtain a frontal view of the heart with maximal exposure of the left ventricle, gauze pads were placed in the pericardium behind the ventricles and the operating table was tilted laterally toward the thermocamera (AGA thermovision 680°). The pictures recorded showed lowering temperatures as represented by increasingly darkening areas. Black areas in these studies indicated temperatures below 20°C. Thermographic pictures were taken at 60 second intervals beginning just before the start of infusion of the cardioplegic solution. To control the accuracy of the thermography, needle thermistors were used to measure myocardial temperatures at different points.

Results
In the 2 patients without coronary lesions, the myocardial temperature was less than 20°C after approximately 4 minutes. All 8 patients with coronary lesions had various degrees of uneven and delayed cooling of the myocardium. In 2 of them, the myocardium was cooled to less than 20°C after about 8 minutes. In 6 patients, an additional 500 ml of cardioplegic solution was infused in an attempt to lower the temperature below 20°C. This was accomplished in 3 patients, but in the other 3, a regional insufficient cooling of the myocardium prevailed (Figs 1 through 4).

Eight patients had an uneventful postoperative course. Two of the patients with insufficient myocardial cooling had moderate to severe arrhythmias postoperatively.

Comment
It is important to achieve a uniform and sufficiently low temperature of the myocardium in

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Fig 1. (A) Thermographic picture of a heart with two stenoses in the left anterior descending coronary artery (LAD) after 1 minute of cardioplegic infusion shows that most parts of both ventricles are cold. The area around the LAD is still warm. Notice especially the apical part of the heart. The 1 corresponds to the left ventricle, 2 to the pericardium, and 3 to venous can- nulas. (B) After 5 minutes, there is almost complete cooling of the heart except for a small apical area. Here, 1 corresponds to a small warm apical area, and 2 and 3 are the same as in 1A.
Fig 2. (A) Thermographic picture of a heart with proximal stenoses of the left anterior descending coronary artery and an obtuse marginal artery. After 3 minutes, the right ventricle is sufficiently cold while most of the left ventricle is still more than 20°C. (B) After 9½ minutes, there is complete cooling of the heart’s exposed surface. The 1 corresponds to the right ventricle, 2 to the pericardium, 3 to venous cannulas, 4 to the retractor, and 5 to an artifact.
order to assure a maximal protection during ischemic cardiac arrest following aortic cross-clamping. Factors that can jeopardize this are myocardial hypertrophy, which makes the standard amount of cold cardioplegic solution inadequate, or stenotic lesions of the coronary arteries, which prevent a rapid and even distribution of the perfusate.

Needle thermistors have been used to control the effect of the cold cardioplegic infusion [1, 2]. However, this technique gives information only from local areas. In nonmonitored parts of the myocardium, hazardous insufficient cooling can occur.

The thermographic method reveals not only the temperatures over the total exposed surface of the heart [3] but also the sequential events during cooling. The temperatures at the surface should be representative of the temperature of the whole myocardium since cold cardioplegia has a protective effect throughout the myocardium. Furthermore, in our study, the thermographic appearance correlated well with the temperatures recorded by intramyocardially located thermistors.

The two hearts with aortic stenosis and myocardial hypertrophy rapidly and evenly decreased in temperature. Hypertrophy alone did not appear to cause insufficient cooling when our cold cardioplegia technique was used.

Coronary lesions caused a slow cooling of the myocardium, and the findings in patients with...
such lesions revealed the insufficiency of using our standardized technique for cold cardioplegia. To overcome this drawback, a larger amount of cold cardioplegic solution should be used along with topical cooling. Also, injections of cold solution into the bypass graft as soon as an anastomosis is completed will help to achieve better and more reliable myocardial protection.

References