A definite perioperative myocardial infarction (PMI) was diagnosed when a patient showed following criteria; 1) ECG changes defined as the appearance and persistence of a new Q wave of at least 4mm in depth and 40 msec or more in duration in pattern from two or more leads, 2) a peak postoperative serum enzyme elevation of CPK$>$1300 IU/l (22 IU/ml/min), GOT$>$300 Ku (5$>$Ku/min), LDH$>$1200 WU/ml (20$>$WU/ml/min). The peak activity levels of enzyme in the patients with PMI revealed a remarkable increase in comparison with that of patients without PMI as above described.

**Discussion and Conclusion**

The goal of intraoperative myocardial protection is to provide excellent cardiac function after surgery as well as relaxation of the heart during operation. Chemically induced cardioplegia and topical cardiac cooling are convenient to reduce oxygen demand and to maintain a quiet, bloodless fields as well as relaxation of the heart.

Nowadays, St. Thomas Hospital solution was used in our clinic in stead of cold blood cardioplegia, of which characteristics have been already experimentally or clinically evaluated. On the basis of our clinical experiences using multidose cold St. Thomas Hospital solution, there was no evidence of myocardial injury associated with arrest periods of up to 200 minutes. That is, upper limits of safety for ischemic arrest was 200 minutes. There was no abnormal increase in serum enzyme activity and only minimal increase in the administration either inotropic or pressor agents in group III compared with that of other two groups.

In conclusion, on the basis of these findings, it was proposed that the method of group III using cold cardioplegic solution and topical cardiac cooling by ice slush was the best method among three types of myocardial protection. Thereafter, the means of group III have been widely employed for cardiac surgery with satisfactory operative results in the recent years. It was considered that proper reduction of myocardial temperature by using of multidose cold cardioplegia was essential for optimal myocardial protection.


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**Current Technique of Myocardial Protection in Coronary Artery Bypass Surgery**

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*Toshifumi Suzuki and Akio Suzuki*

**Introduction**

Cardioplegia has contributed to improve the operative result in open heart surgery, particularly in coronary artery bypass surgery (CABG). Intraoperative myocardial protection can be achieved by cold cardioplegia, however, it is known that the myocardium distal to severe stenosis of the coronary artery may be less protected from ischemia because of maldistribution of cardioplegic solution.

We have elucidated that pretreatment of the myocardium with lidocaine, aprotinin and coenzyme Q10 provides additive myocardial protection from ischemia to cardioplegia.

In this communication, we describe the current technique of myocardial protection in CABG, and we evaluate
the operative results by different modality in cardioplegic solution reviewing our clinical experience.

**Methods**

419 patients who underwent CABG were selected in this study. Operations were conducted under cardioscopic bypass associated with systemic hypothermia. CABG was performed using reversed saphenous veins. Cardiac arrest was achieved by ischemic arrest technique using cross-clamping the aorta in the early cases, by K+-cardioplegia in the mid-series and by K+-Mg2+-cardioplegia in the latest series in our clinical history.

The current technique of the myocardial protection in CABG is following procedures;

1) Precise anesthesia has been recommended to avoid hypotension, tachycardia and dysrhythmia since perioperative myocardial damage is not uncommon during induction of anesthesia in the cases with severe coronary artery stenosis or the left main trunk lesion.

2) Pretreatment of the myocardium is an adjunct method to intraoperative myocardial protection. Aprotinin is used by drip infusion with 10,000 IU/kg coenzyme Q10 is also applied in each case by drip infusion with 5 mg/kg, a night before surgery and an additional 5 mg/kg after induction of anesthesia. Lidocaine hydrochloride is continuously dripped during induction of anesthesia throughout operation and next day.

3) Main intraoperative myocardial protection depends upon cold K+-Mg2+-cardioplegia. This solution contains following ingredient in one liter of solution; K+, 20mEq, Mg2+, 16mmoles, Ca2+, 2mEq, mannitol 100 mmoles, glucose 247 mmoles, pH 7.5 adjusted by bicarbonate and osmolarity 420 mOsm. This solution is infused using a pump with an initial dose of 10-15 ml/kg, then the additional dose is half of the initial dose every 30 to 45 minutes. Perfusion pressure ranges within physiological pressure.

4) We rely on strong, homogeneous and stable protective effect of hypothermia on the heart. Therefore, we use both systemic and topical hypothermia. Systemic hypothermia is kept between 22 and 26 °C in rectal temperature. Topical cooling is employed using cold saline solution.

5) Great cares are taken to prevent distension of the ventricles and to avoid hemodynamic stress during operating extracorporeal circulation. We prefer the venting from the main pulmonary artery. Extracorporeal circulation is terminated gradually taking approximately 15 to 30 minutes to ensure the being completely recovered from ischemia.

In reviewing the cases of CABG with respect to the methods of myocardial protection, operative, hospital and late mortality were compared between the current technique and previous technique for myocardial protection.

**Result**

Overall operative mortality was 3.3% under ischemic arrest, 3% under K+-cardioplegia and 0% under K+-Mg2+-cardioplegia. Requirement of intraaortic balloon pumping (IABP) was 13% in K+-cardioplegia while 9% in K+-Mg2+-cardioplegia, which was significantly different ($p<0.05$).

Hospital mortality was 3.3% in the group of ischemic arrest, 1.25% in the group of K+-cardioplegia and 2.2% in the group of K+-Mg2+-cardioplegia.

Late mortality was 4.4% in the group of ischemic arrest, 0.4% in the group of K+-cardioplegia and 1.1% in the group of K+-Mg2+-cardioplegia.

**Discussion**

It is well known that cardioplegia has contributed to improve operative results in CABG. However, cardioplegia itself has limitation of protecting the myocardium from either prolonged global ischemia or severe coronary artery stenosis. Thus, we depend upon strong and stable protective effect of hypothermia on the myocardium, and pretreatment of the myocardium by combination of myocardial protective agents.

It is still controversial whether different methods of cardioplegia influence on operative results in CABG. Our experience suggests that operative mortality may be related to the modality of cardioplegic technique, however, hospital or late mortality may be linked to cardiac function and severity of coronary artery disease, which are known to be the major determinants for prognosis.
of coronary artery revascularization.

In summary, current technique of myocardial protection in CABG was described. K+-Mg2+ cardioplegia associated with hypothermia and pretreatment of the myocardium with aprotinin, coenzyme Q10 and lidocaine appear to be beneficial to improve operative result in CABG.

A - II - 36 Cold Blood Cardioplegia による心筋保護法の臨床経験

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岡 田 行 功 福 山 守 岡 本 交 二 蔵 潤
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庄 村 東 洋

Follette ら 43 的報告以来，blood cardioplegia はその簡便さと優れた心筋保護効果により広く臨床に使われている。著者らは cooling coil を作製し，blood cardioplegia を臨床に用いたので本法の心筋保護効果を成人の開心術症例について検討し報告する。

対象および方法

対象は弁膜症 83 例（A 例群）と虚血性心疾患 42 例（B 例群）の計 125 例である。年令および性別は A 例群平均 49.3 才，男 51 例，女 32 例。群平均 56.2 才，男 33 例，女 9 例であった。体外循環は各例平均 25% とし，最低圧頭温の中等度低体温 24～28℃ を用いた。体外循環の組成（37℃）は pH 7.43±0.07, Pco2 34.3±7.7 mmHg, Po2 417±113 mmHg, BE 0.8±2.6 mEq/l, Ht 24.4±3.4%, Hb 8.6±0.7 g/dl, 症状圧は 304±2.9 mOsm/l であった。cold blood cardioplegia（以下 CBC）の作製は体外循環血液を動脈路より充填量 50 ml の cooling coil を通じて採取し，これに KCl（初回 30 mEq/l, 追加 20 mEq/l）を添加した。CBC は 30 分間隔で大動脈根部あるいは選択的に左右冠動脈へ手動的に圧入した。B 例群の A-C bypass では初回注入量を増加させ，末梢側吻合を先に行い，末梢側吻合終了後に graft および大動脈根部より圧入することを原則とした。しかし最近では心筋温の均一化を計るのと再灌流時の冠動脈狭帯に対す虚血を防ぐ目的で以下の方法を取った。

(1)体外循環による中心冷却で咽頭温 30～31℃ まで大動脈圧降下させ，その間に中樞吻合を行う。 (2)その後大動脈圧降下し，CBC の大動脈根部注入および ice slush による周所心冷却を行う。 (3)末梢側吻合終了ごとに大動脈根部および graft から CBC を圧入する。 (4)再灌流の血液

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<tr>
<th>表 1 再灌流における Cold Blood Cardioplegia の臨床結果</th>
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<td>Procedure</td>
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A: AVR, M: MVR or OMC, T: TAP or TVR, CPB: cardiopulmonary Bypass LOS: low cardiac output syndrome, POD1: first post operative day, Value: mean±S.D.