

Enhancing Hemodynamic Effect of Intraaortic Balloon Pumping (IABP) using Cardiac Agents in Canine Myocardial Infarction

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The effectiveness of intraaortic balloon pumping (IABP) with the use of dipyridamole, isoproterenole and norepinephrine was experimentally evaluated on canine ischemic heart produced by ligation of the left anterior descending coronary artery distal to the diagonal branch and ligation of many branches from both the left circumflex and the right coronary artery.

The results were as follows:

- 1) The use of norepinephrine with IABP application resulted in a 20% increase in coronary flow and a 19% increase in cardiac output, a decline of left ventricular work and a slightly raised EVR.
- 3) Isoproterenole did not indicate significant benefits with respect to coronary blood flow and cardiac output including EVR.
- 4) In our conclusion, on the basis of these results, if IABP would not function in the treatment of myocardial infarction, the use of dipyridamole and norepinephrine combined with IABP application is recommended in achieving the better cure rate.

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INTRODUCTION

Since the rationale of intraaortic balloon pumping (IABP) has been introduced by Kantrowitz in 1953, numerous work corroborates its efficiency. Until recently, IABP application was widely indicated for the treatment of low cardiac output syndrome following open heart surgery, for the management of difficulty in weaning from cardiopulmonary bypass, for the relief of severe attack of angina or impending myocardial infarct and for the prevention from complications after coronary angiography. It, however, is noted that the validity of IABP is limited to the application for either widen myocardial infarct or severely depressed left ventricular failure¹⁾²⁾.

On the basis of widely extending application, this study was undertaken to certify whether cardiac stimulants is helpful or not for enhancing the IABP effects.

MATERIAL AND METHOD

Thirty-one mongrel dogs, weighing from 12 kg to 24 kg, were subjected in this study. These dogs were anesthetized with 25mg/kg of sodium pentobarbital, intubated with a cuffed endotracheal tube and ventilated with room air using a volume respirator (Harvard). Left thoracotomy was made at the Vth intercostal space and the pericardium was opened longitudinally. Myocardial infarction was experimentally prepared by means of ligation in the left descending coronary artery just distal to the origin of the diagonal branch and of additional ligations of numerous branches of the right coronary and the left circumflex artery on the free wall of the left ventricle, which was equivalent to a 45% myocardial infarction of the entire free wall of the left ventricle. After heparization intravenously with a 2mg/kg dosis, the single ballon catheter (20 ml volume) was intraluminally introduced from the femoral artery to directly beneath the origin of the left subclavian artery. It was connected with IABP apparatus (AVCO-Model 10) which was driven by He-gas, adjusting to dicrotic notches on the wave curves of the aortic pressure tracing. Hemodynamic changes were observed on ischemic heart in one sequence of a 30 min IABP followed by 15 min of rest and continuous drip administration of 0.3 mg/kg/min of dipyridamol, 0.5 mg/kg/min of isoproterenole and 1.0 mg/kg/min of norepinephrin. Each measurement was made during a 30 min period of hemodynamically stable status. The imposed ventricular fibrillated dogs on the provoked myocardial infarction were excluded from this study.

The changes in systemic hemodynamics were evaluated by the following indicators.

Cardiac output (CO): It was measured by means of electromagnetic flowmeter (Nihonkoden Model MF 27) with the use of the flow probes (13mm to 16mm) placed on the root of the ascending aorta.

Coronary blood flow (CBF): It was depicted at the proximal left coronary artery by the same flow probes of 1.5 to 3.0mm as described above.

Left ventricular Max dp/dt (Max dp/dt). It was calculated with pressure wave

analyzer (Sanei Co.) on the left ventricular pressure waves obtained from No 7 Cournaud catheter inserted into the left ventricle via the apex.

Endocardial viability ratio (EVR) : It was indicated according to Philips' method³⁾ with the use of aortic pressure wave obtained from No 7 Cournaud catheter inserted into the aorta via the left carotid artery.

The above values of CO, CBF, Max dp/dt and EVR were shown as a ratio to 100 of the control on the average.

The area of the visible infarction on the free wall of the left ventricle were calculated and also histologically examined.

RESULT

1) Changes in coronary blood flow and IABP and their influential factors of drugs (Fig 1)

IABP alone did not permit the increased coronary blood flow. Meanwhile, drug administrations of dipyridamole and isoproterenole after IABP application were effective

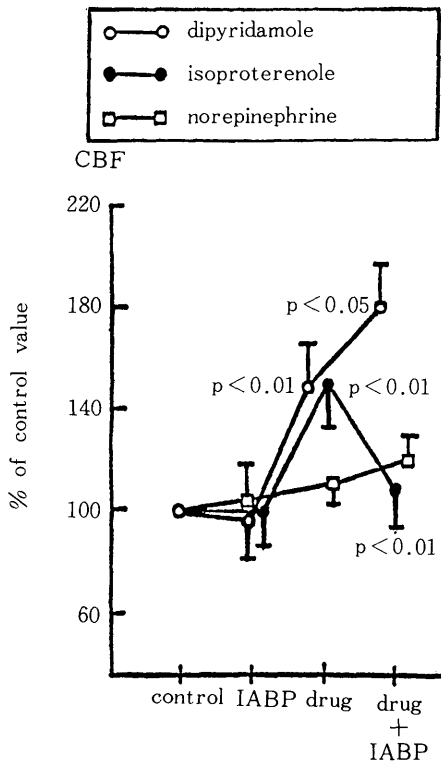


Fig 1. Changes in coronary blood flow (CBF) among IABP, cardiogenic agents (dipyridamole, isoproterenole, norepinephrine) and in combination

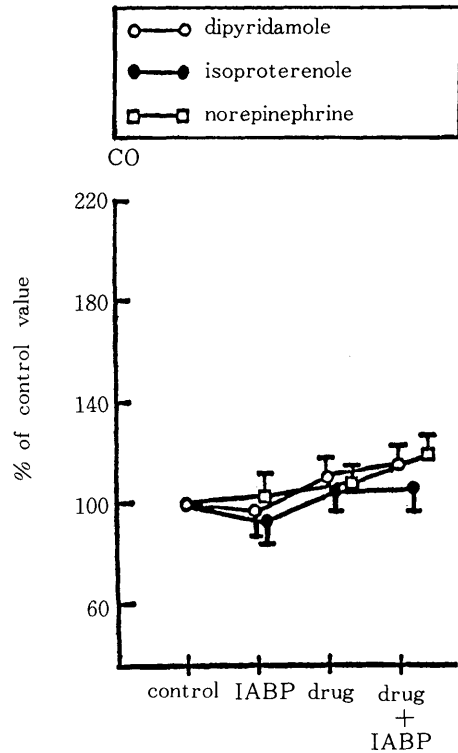


Fig 2. Changes in cardiac output (CO) among IABP, cardiogenic agents (dipyridamole, isoproterenole, norepinephrine) and in combination

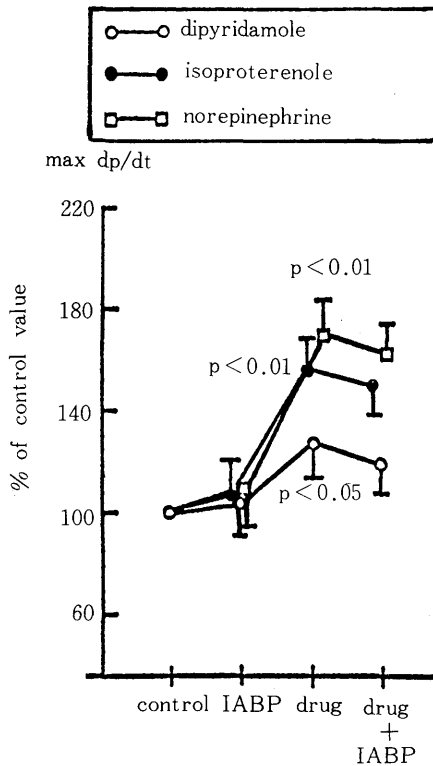


Fig 3. Changes in max dp/dt among IABP, cardiogenic agents (dipyridamole, isoproterenole, norepinephrine) and in combination

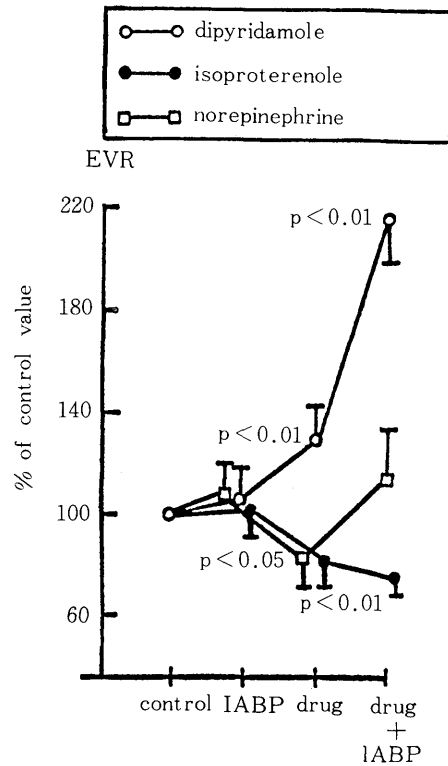


Fig 4. Changes in endocardial viability ratio (EVR) among IABP, cardiogenic agents (dipyridamole, isoproterenole, norepinephrine) and in combination

in the increasing coronary blood flow. In dipyridamole and isoproterenole administrations, these increased an average of 148% and 150% respectively with significant difference. ($p < 0.01$) In norepinephrine, it remained a 110% increase, showing no significant difference.

The effects combined with drug administration on coronary blood flow were variable. Dipyridamole led to a maximal increase of 180% ($p < 0.05$) but isoproterenole brought a inverse relation, which reduced to 110% ($p < 0.01$) and norepinephrine allowed a small increase of 120% on the average.

2) Changes in cardiac output and IABP, and their influential factors of drugs

Cardiac output under the administration of drugs of dipyridamole, norepinephrine and isoproterenol increased an average of 110%, 108% and 105% respectively.

In IABP application with drugs, dipyridamole apparently increased CO to 117% and norepinephrine to 119% whereas those in isoproterenol were similar to in drug alone.

3) Changes in Max dp/dt and IABP, and their influential factors of drugs

Max dp/dt in drug alone of dipyridamole, isoproterenol and norepinephrine increased

to an average of 129% ($p < 0.05$), 155% ($p < 0.01$) and 168% ($p < 0.01$) with statistically significant differences.

When combined with IABP, these slightly reduced to 120% in dipyridamole, 150% in isoproterenol and 160% in norepinephrine respectively, reflecting the relief of left ventricular workload.

4) Changes in EVR and IABP, and their influential factors of drugs

In drug alone, EVR increased to an average of 130% only in dipyridamole and decreased to 81% ($p < 0.05$) and 82% ($p < 0.01$) in isoproterenol and norepinephrine.

When combined with IABP, dipyridamole greatly raised EVR to 210% ($p < 0.01$) although EVR increased to 116% in norepinephrine and decreased to 77% in isoproterenol.

DISCUSSION

It has become apparent that the effect of IABP depends upon the severity of myocardial damages at the start of its application. Great clinical work has proved its efficacy on improving a compromised hemodynamics³⁾.

It is well known that IABP does not function well when myocardial damages are severe¹⁾²⁾. In this study we evaluated the relation of IABP efficiency to the inherent factors to various drugs in anticipation of enhancing the IABP effects.

Roy et al⁴⁾ reported that if IABP was used for sustained shock status, its effect remained obscure due to loss of both the driving pressure and the critical opening pressure for the coronary artery. It is considered that the driving pressure by IABP application becomes absorbed in compliance of the vessels in shock status and it allows the critical opening pressure to reduce. Brief et al⁵⁾ also identified that IABP was not valuable in dealing with low cardiac output syndrome.

Buckley et al⁶⁾ described that hypotension led to a low degree of success in IABP application due to decrease of blood volume between the aortic valve and the balloon catheter. Clinical experiences indicate that IABP in combination with use of sympathicomimetic drugs afford a good recovery rate rather than IABP alone in either hypotensive or hypovolemic status. Considerable emphasis with respect to cooperative sympathicomimetic action has been placed on the basis of increased diastolic pressure following the sufficient blood filling in the vascular beds. It is also reported that the disadvantages of sympathicomimetic drugs exist in an increasing afterload as a α -adrenergic action but it is offset by the effect of IABP application on the relief of systolic unloading when used in combination. Krakauer⁷⁾ emphasized that IABP should be used in combination with the sympathicomimetic agents in hypotensive status below 50 mmHg of systemic pressure.

Our results showed that IABP combined with use of norepinephrine offered a 20% increase in coronary flow, a 19% increase in cardiac output, a 16% increase in EVR and a 16% increase in Max dp/dt respectively but these were not statistically significant to increase both coronary blood flow and cardiac output, reflecting the fact that IABP was

insufficiently weaning from shock. Kerber et al⁹⁾ reported on the basis of the findings from echocardiography that B-C amplitude in isometric contraction time when used IABP combined with use of norepinephrine was in accord with the control and also m-pwv had become improved in comparison with those of IABP alone. The effect of IABP with use of norepinephrine was also certified by means of echocardiographic evaluation on hemodynamic changes. Greater emphasis has been focused upon the use of dipyridamole which rendered the coronary artery distensible with an aid of adenosin. When dipyridamol was used with IABP, a copious increase in cardiac output and EVR was allowed in our study.

The use of nitroprusside with IABP was also beneficial in improving the depressed heart action on the basis of the facts of increasing cardiac index and enhancing diastolic augmentation⁹⁾¹⁰⁾¹¹⁾ and the effect of phenylephrine was documented by Feola¹²⁾ and Matloff et al¹³⁾. Meanwhile, it is noted that vasodilator such as isoproterenole also enhances the effect of diastolic augmentation when used with IABP although it is considered that it alone may cause ischemia in the endocardium, followed by enlargement of the extent of myocardial infarction. It is well known that EVR indicates a ratio of the endocardial blood flow to the endocardial one in relation to oxygen demand and its supply in the myocardium.

Based on our experimental study, it was confirmed that isoproterenole resulted in a 81% decline of EVR and in a 77% decline with IABP combination. It seems that it is based on increased heart work, enhanced oxygen consumption in the myocardium and reduced blood flow in the endocardium in consequence of induced tachycardia. It is suggestive of the inhibitive use of isoproterenole in the management of acute myocardial infarction and of effective use of catecholamine.

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