

Experimental Evaluation of Effects of Intra-Aortic Balloon Pumping (IABP) on Ischemic Heart

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The intraaortic balloon pumping (IABP) has been widely employed in the management of ventricular power failure.

The effects of IABP were studied in a large number of reports. However, the efficacy of IABP has not been certified with reference to the severity of myocardial ischemia.

Experimentally augmentation of coronary blood flow were observed on acute ischemic heart by ligation of the anterior descending artery.

It has shown from the view of increased coronary blood flow that excess of 50ml/min/kg of coronary blood flow were obtained in functional reserved myocardium with ischemia. However, the efficacy of IABP on acute ischemic heart can not be precipitated by severe damage of the myocardium.

The usefulness of IABP was elucidated by functional myocardial level of at least 50mmHg of LVP, 40mmHg of LVEDP and 1000mmHg/sec of max dp/dt respectively and it is emphasized that immediate application of IABP for cardiogenic shock allows to improve the further myocardial depression.

INTRODUCTION

Intraaortic balloon pumping (IABP) has been established as an effective mechanical support for left ventricular myocardial power failure, especially its procedure is design to reduce left ventricular afterload and increase cardiac output during systole by deflation of balloon which is inserted into the descending aorta through femoral artery to direct beneath the attachment of left subclavian artery and also to increase aortic diastolic

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pressure and coronary flow during diastole by inflation of balloon.

Based on the experience by many authors, clinical application of IABP is widely accepted in the treatment of patients with cardiogenic shock. However, relatively little information is available on the influence of IABP on coronary blood flow of normal and diseased myocardium.¹⁾²⁾

The present study is to certify the effect of IABP on coronary blood flow of ischemic myocardium following experimentally performed coronary occlusion.

METHOD

Experimental studies were carried out in 25 dogs anesthetized with pentotal sodium (25mg/Kg). Left thoracotomy was performed through the fifth intercostal space.

Pressure in the aortic arch, proximal to the balloon was monitored through a catheter introduced into the left carotid artery and the distal aortic pressure was measured through a catheter introduced from the left femoral artery. In order to estimate left ventricular function, pressure tracing of the left ventricle was done by catheter inserted through the apex of the left ventricle.

A catheter-mounted intraaortic balloon, 20cm in length and 1.1cm in diameter, was inserted through the right femoral artery to descending thoracic aorta immediately distal to the aortic arch at the origin of the left subclavian artery.

Coronary blood flow measured on the left circumflex artery by the probe of electromagnetic flow meter.

Accurate synchronization of balloon inflation and deflation was based on the arterial pressure. Coronary blood flow apparently changed reflecting an accurate or inaccurate synchronization of balloon inflation and deflation. An excellent diastolic augmentation was observed by balloon inflation synchronized during diastolic phase.

Experimental diseased heart was provoked by surgical ligation of anterior descending artery and left ventricular functions were evaluated by tension time index (TTI), left ventricular end-diastolic pressure (LVEDP), and peak diastolic pressure/systolic pressure ratio.

Coronary blood flow was measured by electromagnetic flow meter (Nihon Koden) on the left circumflex coronary artery and changes of coronary blood flow by IABP were evaluated either in normal heart or in ischemic heart with ligation of the anterior descending coronary artery.

Furthermore, an influence of IABP of cardiogenic drug on ischemic heart was observed under administration of adrenaline or protanol.

RESULT

The conditions of intraaortic balloon pumping are of the most influencing factors on changes of coronary blood flow, Furthermore, an inadequate balloon inflation was provoked reduced coronary blood flow.

The inflation of intraaortic balloon was adjusted to synchronize to diastolic phase but synchronization of balloon inflation to beginning of R wave on ECG is superior to that to dicrotic notch of R wave on ECG to increase coronary blood as shown fig 1.

The influences of cardiogenic drug were evaluated under utilization of combined IABP.

The administration of 0.25 ug/kg/min of protanlol produced favorable hemodynamic

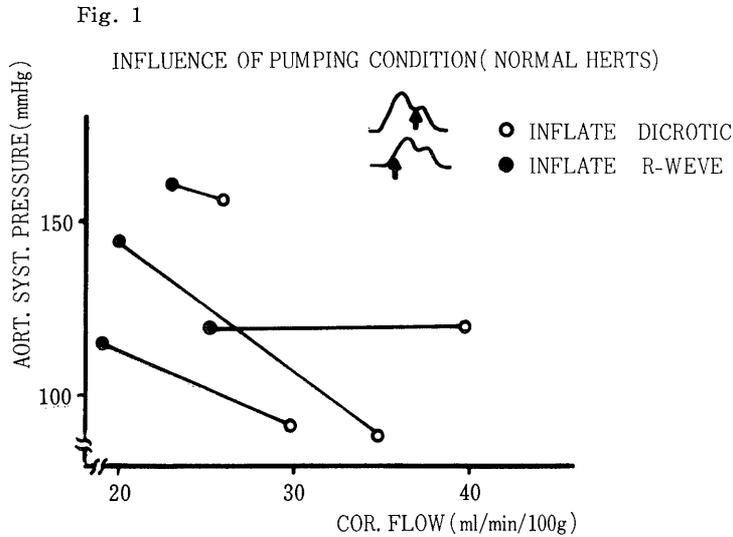
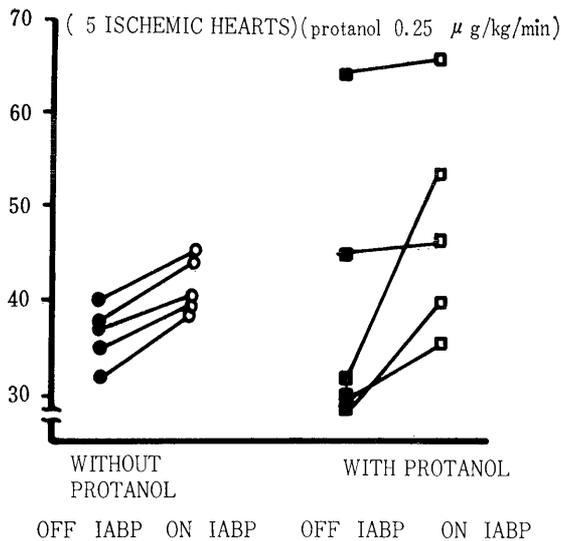


Fig. 2

EFFECT OF IABP ON CF UNDER
PROTANOL ADMINISTRATION



alternation by IABP in which remarkable increased coronary blood flow was presented and the effects of administration of adrenaline combined with IABP was also evaluated as one of factors related to increased coronary blood flow.

As shown in Fig 3, the administration of 2.0 $\mu\text{g}/\text{kg}/\text{min}$ of adrenaline presented obviously increased coronary blood flow and further combination of IABP reproduced

Fig. 3

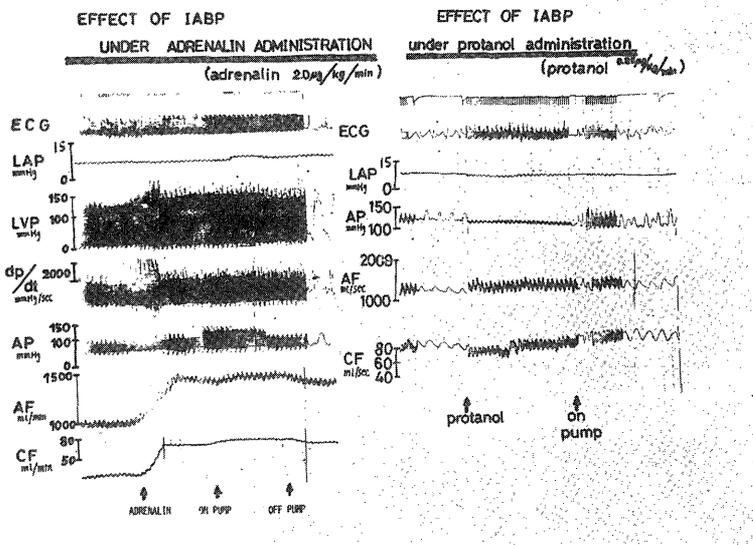
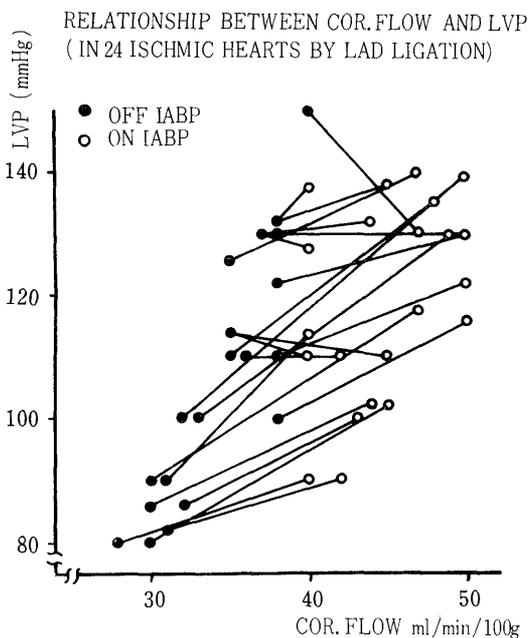


Fig. 4



definitive increase of coronary blood flow. And also the administration of 0.2 $\mu\text{g}/\text{kg}/\text{min}$ of protanol allowed increased coronary blood flow and further combined IABP accelerated more increased coronary blood flow.

From a practical point of view, various factors for increased coronary flow were evaluated on ischemic heart with ligation of anterior descending coronary artery experimentally.

From relationship of left ventricular pressure (LVP), it showed over 50 to 80mmHg of LVP was necessary to obtain 40ml/min/100gr of an adequate coronary flow on experimental ischemic heart and it certified that the high level of LVP produced increased coronary flow.

From relationship of left ventricular end-diastolic pressure (LVEDP), marked increased coronary blood flow by IABP was observed in those which showed under 20mmHg of LVEDP (fig 5).

Fig. 5

RELATIONSHIP BETWEEN COR.FLOW AND LVEDP
(IN 24 ISCHEMIC HEARTS BY LAD LIGATION)

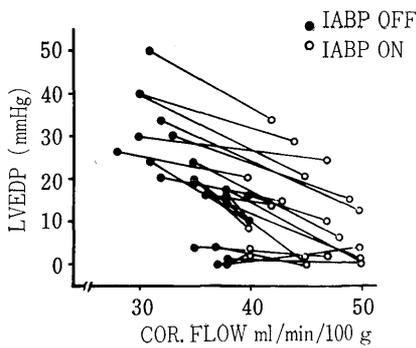


Fig. 6

RELATIONSHIP BETWEEN COR.FLOW AND MAX dp/dt (LV)
(IN 24 ISCHEMIC HEARTS BY LAD LIGATION)

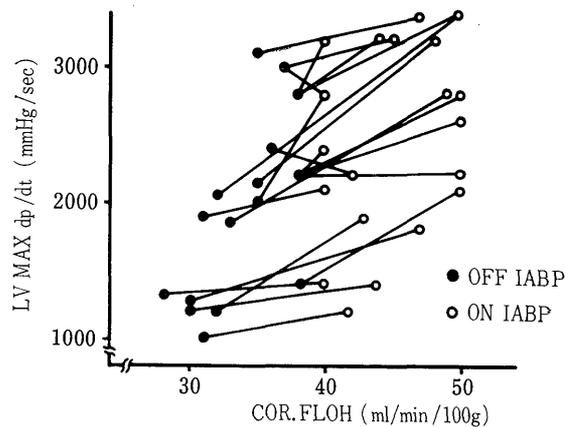
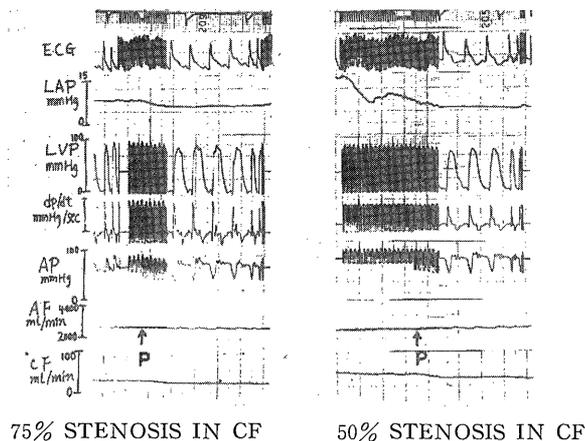


Fig 7. EFFECT OF IABP IN LEFT MAIN CORONARY STENOSIS



From relationship of max dp/dt of left ventricle, the values of max dp/dt were apparently improved according to increased coronary blood flow of over 40ml/min/100gr by IABP suggesting to be strong contractile strength by an adequate increased coronary blood flow, when coronary flow increased to more than level of 40ml/min/100gr, the values of max dp/dt documented to be high level more than 1000mmHg/sce (fig 6).

From the observation with regard to changes of coronary blood flow in stenotic coronary artery by IABP, it showed there were no evidences that IABP promote remarkable increased coronary blood flow in stenotic anterior descending artery.

In anterior descending artery with experimental stenosis of 50% and 75% segmentally, mechanical support of IABP did not present increased coronary blood flow. However, ventricular overload was alleviated showing decreased left atrial pressure (LAP) and increased dp/dt, (fig 7).

It was worthy of notice that IABP provides increased coronary blood flow on ischemic heart although no changes of coronary blood flow were observed in coronary artery with stenosis of one half and three fourth in diameter respectively.

DISCUSSION

IABP produces favorable hemodynamics on acute ischemic heart and its application was widely accepted in patients with cardiogenic shock¹⁾²⁾³⁾ at coronary care units.

The theoretical advantage for its application consist in relieving overload of the left ventricle and increasing coronary blood flow on ischemic heart.

From an analysis with regard to influence on changes of coronary blood flow, the pumping conditions in which deflation is balloon is synchronized to ventricular systole and inflation is also synchronized to ventricular diastole accurately are of the most importance to develop the effect of IABP on ischemic heart.

The factors of increasing coronary blood flow were evaluated experimentally on ischemic heart with a ligation of anterior descending artery.

It was ascertained that cardiogenic drugs such as adrenalin and protanol produced marked increase of coronary blood flow and also further increasing coronary blood flow were observed by combined IABP. The increased ratio of coronary blood flow by IABP was less than that by administration of cardiogenic drugs.

The practical and clinical reliability of IABP has been substantiated by experimental measurement of coronary blood flow and the experimental results showed obviously the benefit of increasing coronary blood flow.

The finding of this investigation documented that the effect of IABP influencing on increase of coronary blood flow was dominated by level of pressure of left ventricle end-diastolic pressure of left ventricle and LV max dp/dt. It suggested that the pressure of left ventricle accounted for over 50mmHg at least, end-diastolic pressure of left ventricle for less than 40mmHg and LV max dp/dt for more than 1000mmHg/sec respectively to expect

an adequate increasing coronary blood flow on ischemic heart.

Therefore, these data imply that the potential benefits of IABP is to demonstrate the augmentation of the myocardial function in which the degrees of damage and injury on the myocardium are not necessarily severe even though cardiogenic shock.⁴⁾⁵⁾⁶⁾

Furthermore, its effect was accelerated by administration of cardiogenic drugs as shown numerous experiment.

However, the reliable limitations for indication of IABP have not been fully elucidated.

The results in this series documented that efficacy of IABP develops in proportion to functional reserve of the myocardium, the augmentation of cardiac pump action were apparently observed in functional preserved myocardium in which the level of LVP was more than 50mmHg, that of LVEDP was less than 40mmHg and that of max dp/dt was 1000mmHg/sec respectively.

From the view of measurement of coronary blood flow, the usefulness of IABP documented on ischemic heart, However its efficacy was accelerated by using inotropic agent. At least in attempt to augmantation of coronary blood flow functional myocardial reserve demands in minimal limit of functional reservation of the myocardium.

The elective use of IABP was beneficial in treatment of myocardial depression which increased coronary blood flow and reduced progressive myocardial damage. The application of IABP, therefore, is to be an indispensable part of surgical management.

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