

## Low Cardiac Output Syndrome During Cardiac Surgery

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### Summary:

To confirm the importance of combination therapy "amrinone, dopamine and Nitroglycerin" in improving the cardiac output and reducing the after load with better results than anyone mono or bitherapy, i.e., Amrinone and Dopamine or Dopamine and Nitroglycerin. Triple therapy as presented by our study including dosage and haemodynamic effects have not been done before. A controlled study was conducted on twenty patients whose cardiac index was  $\geq 1.5L$ . before or after cardiopulmonary pump. Two patients needed intra aortic balloon pump. All were males. The aim was to increase cardiac index above 2.2L. The average increase in cardiac index 55% ranging from 30-260% the average reduction in pulmonary capillary wedge pressure was 34% range 20-55%. The average reduction in systemic vascular resistance was 30% range 30-65%. The average reduction in pulmonary vascular resistance was 37% range 25-76%. Triple therapy produced good cardiac index, less systemic and pulmonary resistance and reduced incidence of dysrhythmias. There is less catecholamine toxicity and better control of blood sugar in the diabetic patients. There is a significant reduction in the dosage of the three drugs to achieve acceptable results. The use of intra aortic balloon pump is reduced by 50% achieving a "pharmacological aortic balloon".

### Introduction:

In 1908 when the symptoms of cardiac output were described, little was known about the case of heart failure. Many pharmacological approaches have been advocated majorly catecholamines<sup>1</sup>, assist devices were introduced later. Anaesthetic medications and the surgical procedure may induce low cardiac output in patients with poor ventricular function. Some patients with good ventricular function can develop low cardiac output after prolonged or difficult surgery. Dysrhythmias may be caused and increase the symptoms of low cardiac output. The classic management with catecholamines alone sometimes deteriorate the patients condition due to down regulation and reduc-

tion of the density of B receptors in the myocardium<sup>16</sup>. Coronary artery spasm<sup>33,34,35,36,37</sup> and ischaemia increased the condition further.

The proper approach would be reduction of the dose of catecholamines alteration of preload and after load with other agents like the phosphodiesterase inhibitors and Nitroglycerin. Amrinone<sup>16,17</sup> was found to be a very useful addition along with nitroglycerine in reducing the after load and maximising the forward ejection of the myocardium.

Haemodynamic measurements before induction of anaesthesia can reveal some patients with low cardiac output examples of such patients are those who are received on urgent or semi urgent basis with unstable angina, segmental wall motion abnormalities and diabetics.

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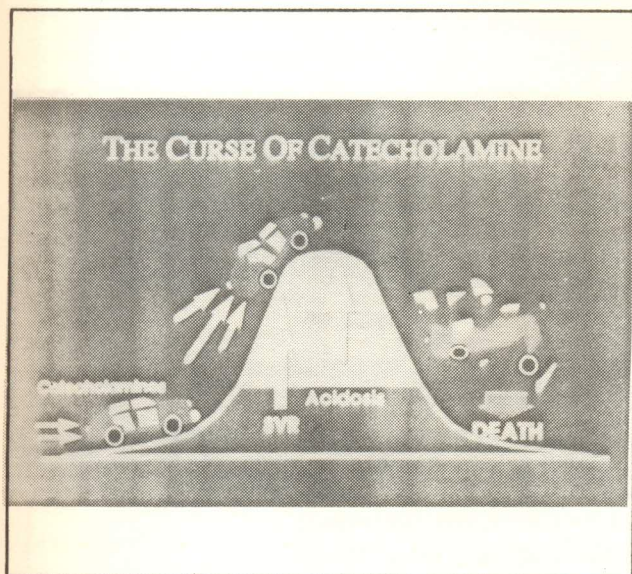


Figure 1

High dose catecholamines can be very damaging to the myocardium, renal, hepatic & mesenteric systems. Endogenous catecholamines are at high level in acute heart failure, less & less B1 & B2 receptors are available and more  $\alpha_1$  receptors are activated causing higher systemic vascular resistance and more tissue acidosis with possible tragic results.

Catecholamines as sole agents for improvement of cardiac output can be very expensive in terms of increased systemic and pulmonary vascular resistance, increased tissue acidosis and increased dysrhythmias. The end result may be failure of a tired myocardium<sup>1,2,3,4,5,6</sup>.

Therapeutic approach of the low cardiac output<sup>7,8,9,10,11</sup> should be on basis of multiple therapy of catecholamines, phosphodiesterase inhibitors and vasodilators, to reduce the side effects of each agent alone, to reduce the dosage and get the additive effects of the three agents<sup>13</sup>, low dose dopamine "dose range 3-10 micrograms/kg/minute will produce its beneficial effects on the renal circulation and increasing the urine output. At lower dosage it produces gentle inotropy.

Phosphodiesterase III inhibitors will cause inotropy through phosphodiesterase inhibition, availing more intracellular C AMP in a different route than that of catecholamines<sup>14,15,16,17</sup>. The advantageous stimulation of B<sub>2</sub> receptors on the peripheral vasculature causing dilatation and improves the mesenteric circulation. "An important part which is usually forgotten during the storm of low cardiac output with resultant reduction of liver, gut

and pancreatic blood flow.

The reduction of systemic and pulmonary vascular resistance with amrinone<sup>6,18,19</sup> improves forward ejection of right and left ventricles.

Nitroglycerin reduces the incidence of coronary artery spasm<sup>33,34,35,36,37</sup> reduces the incidence of dysrhythmia "which is usually due to coronary ischaemia in coronary artery disease", and reduces the systemic and pulmonary vascular resistance an additive action to that of amrinone<sup>20,21,22,23,24,25</sup>.

### Material & Method:

This study did not need the approval by the human ethics committee, because the study was observations and collection of data with methods and drugs already approved in cardiac anaesthesia and intensive care.

Twenty patients were selected randomly, on basis of a cardiac index  $\geq 1.5$  L/sq meter. All the patients were males. Number of grafts ranged from three to five vessels, all the twenty patients were on betablockers and nitrates up to the morning of surgery. Six of these patients were on heparin drip. Ejection fraction (E.F) ranged from 25-71%,

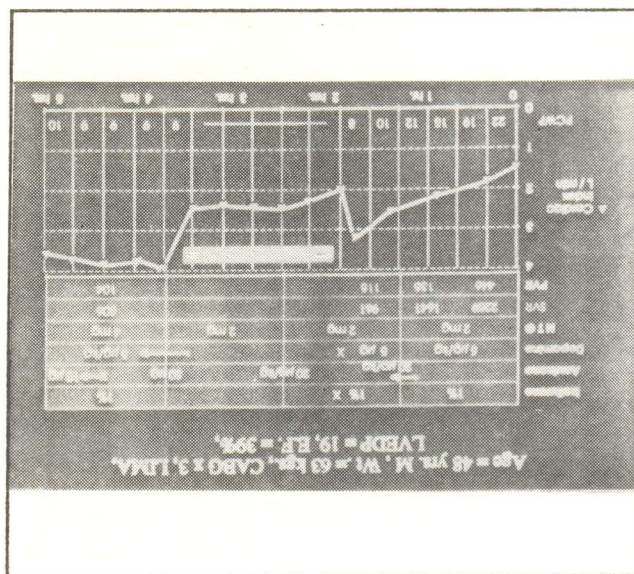


Figure 2

48 years old patient coronary artery bypass graft 3 veins and left internal mammary artery. CI was 1.4 at the start. Triple therapy improved the CI upto 3.9 Litres reduced SVR from 2259 dynes down to 806 dynes and PVR from 446 down to 104 dynes. PCWP from 22 down to 10mm Hg.



average E.F. 43%. Left ventricular end diastolic pressure (LVEDP) ranged from 7-36 mm Hg, average 17 mm Hg. The age ranged from 31-73 yrs. One of the twenty patients had twelve years old renal transplant. Eleven of the patients were diabetic, six of them insulin dependent. Thirteen of the patients had a history of hypertension. One patient was received with universal ST segment depression on all leads, he was on Nitroglycerin and heparin drip.

Under local anaesthesia right radial artery cannulation was selected to avoid pressure damping during harvesting of left internal mammary artery. Gauge 14 intravenous cannulae on the dorsum of the hand. Pulmonary artery thermodilution catheter was introduced through right internal jugular vein. Femoral artery was cannulated in patients with E.F. below 40% as well.

Heart rate, blood pressure, central venous pressure, pulmonary artery pressure, pulmonary capillary wedge pressure (PCWP), cardiac output, cardiac index, systemic vascular resistance (SVR) and pulmonary vascular resistance (PVR) were recorded in the induction room before induction of anaesthesia, oximetry was also recorded.

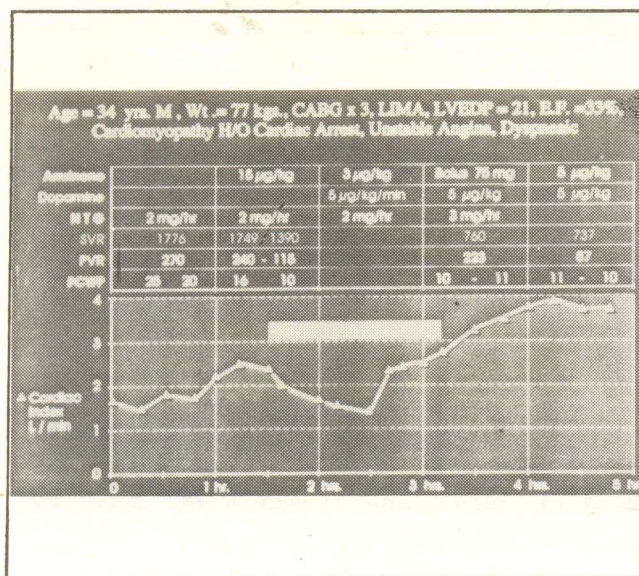


Figure 3

34 years old patient coronary artery bypass graft 3 veins & one Lt. internal mammary artery, with cardiomyopathy & history of cardiac arrest, unstable angina, dyspnoea. LVEDP 21 EF=33%. CI went down to 1.5 litres. CI improvement was upto 3.9L. PCWP went down from 25 down to 10 mm Hg. SVR went down from 1776 dynes to 737. PVR went down from 270 to 87 dynes.

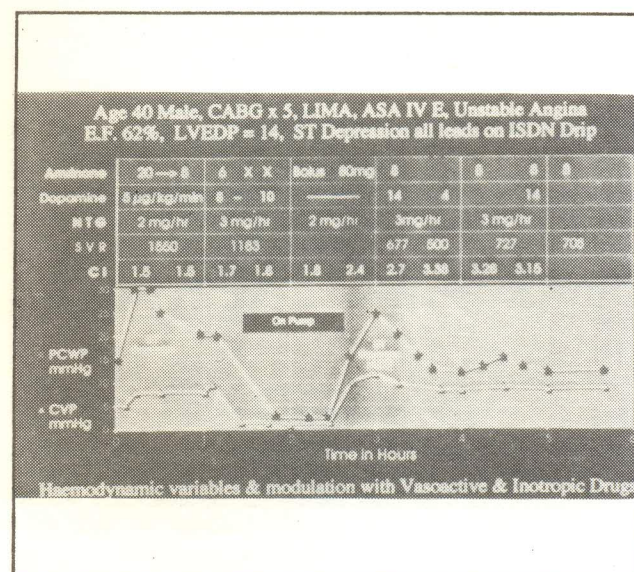


Figure 4

40 years old patient unstable angina, ST segment depression all leads when he was received in theatre. Angiographic results were before deterioration, notice there is no relation what so ever between central venous pressure (CVP) & PCWP. He was put on aortic balloon pump improved but later died after cardiac tamponade from bleeding.

Nitroglycerin (NTG) drip is routinely put to all coronary artery surgery patients at the rate of 1-1.5 micrograms/kg/minute before induction of anaesthesia.

Anaesthesia was induced with 5-10mg diazepam (Diazemul), 10-20 micrograms/kg Fentanyl and 0.1mg/kg pancuronium. Nitrous oxide (N2O), O2 50:50 plus isoflurane 0.5-1.5% were given after induction and before intubation to reduce the hypertensive reflex to laryngoscopy and intubation. Isoflurane was not given to start with when the cardiac index was below 2 L. Isoflurane use was varied from 0-1.5% according to haemodynamic responses.

All the haemodynamic measurements done before induction were repeated every 15 minutes, before pump and after pump, and in the intensive care area every 3-6 hours according to need up to 24 hours.

If the CI was > 1.5L / sq meter before induction or after induction amrinone at the rate of 40 micrograms/kg/minute were started for a period of 25 minutes to load the patient with one mg/kg



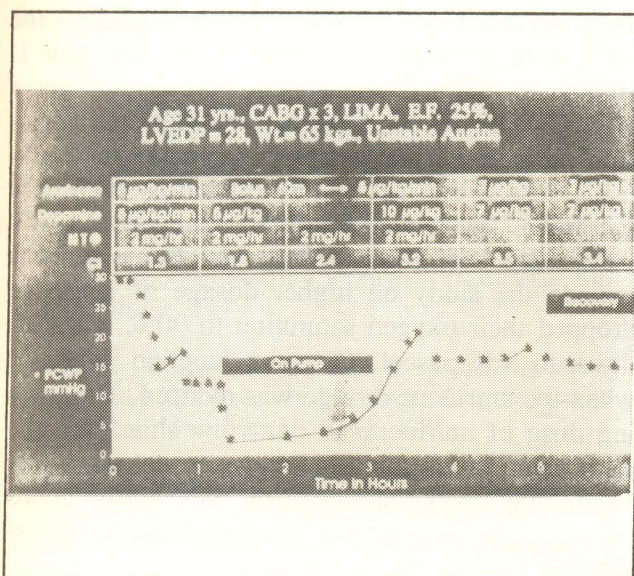


Figure 5

31 years old patient. Unstable angina, LVEDP=28mm Hg E.F. 25%. Cardiac index went up from 1.3L to 3.4L. PCWP went down from 30 to 15mm Hg, on triple therapy.

body weight after that the dose is continued on 3-10 micrograms/kg/minute according to haemodynamic response. Dopamine at rate of 3-10 micrograms/kg/minute was started along with amrinone to prevent drop in blood pressure and to augment the cardiotonic action of amrinone.

According to the need of the patient if amrinone is not infused before pump (By pass) it is given during the pump after removal of aortic cross clamp 1mg/kg at rate of 5mg/minute<sup>26</sup>. If CI was low at the weaning from pump, and amrinone was not given before, then the same method was adopted as before pump.

Hewlett Packard haemodynamic monitor was used to record and calculate all the needed haemodynamic variables and their calculations.

### Results:

Four examples of results on haemodynamic variables and dosage variation of triple therapy are shown in Figure 2, 3, 4 and 5.

The average infusion rate of NTG was 1.2 micrograms/kg/minute (Range 1-1.5). The average infusion rate of dopamine was 5.7 micrograms/kg/minute (range 3-10). The average infusion rate of

amrinone was 7.8 micrograms/kg/minute (range 3-10). The average increase in CI was 55% (range 30-260%)<sup>27</sup>. PCWP reduction, average 34% (range 20-55%)<sup>24,25</sup>. Average reduction in SVR 39% (range 30-65%), average reduction in PVR 37% (range 25-76%)<sup>28,29</sup>.

Aortic balloon pump was used in two patients, their CI remained at 1.7 & 1.8L. Aortic balloon pump improved their index to 2.3 & 2.5 litres. The patient who was received with universal ST segment depression exhibited ST segment depression in the anterior leads and his index was 1.8L. Aortic balloon pump reduced ST segment depression to normal isoelectric, and the depression disappeared. In the intensive care area the patient started bleeding and had cardiac tamponade, he was rushed again to theatre, his CI went down to 1.1L and died four hours later in the intensive care area.

One patient developed thrombocytopenia 18 hours after surgery, his platelets went down to 20,000. Amrinone drip was discontinued and a day later the count was 120,000<sup>30</sup>.

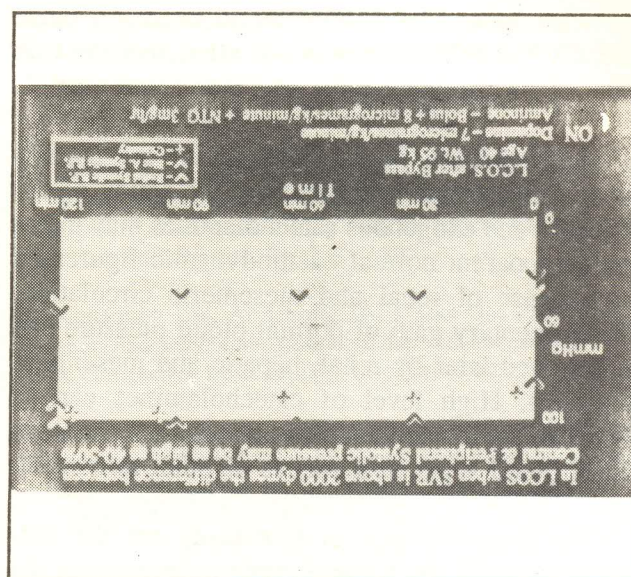


Figure 6

During low cardiac output state the SVR is high, it was observed when SVR is more than 2000 dynes, & C.I. is > 1.7 L, there is a clear difference between central & peripheral blood pressure, there is as well reduction in peripheral oximetry due to intense catecholamine action causing peripheral vasoconstriction. Triple therapy as shown in the diagrams, improves the difference in pressure & when SVR is below 900 dynes the peripheral pressure becomes higher than central.

**Caution:** Same can happen after bypass without any reduction in CI or increase in SVR for unknown reasons.



**Discussion:**

In this study triple therapy (Amrinone, dopamine and nitroglycerin) have been applied to improve the CI,<sup>31,32</sup> reduce SVR and PVR<sup>28,29</sup> and reduce the incidence of coronary ischaemia and spasm<sup>33,34,35,36,37</sup>.

The study was observed in twenty male patients requiring intervention to improve their cardiac output and reducing their high SVR and PVR<sup>4,22,23,25,38,39,40</sup>.

In this clinical study it was with advantage to observe the additive effects of the triple therapy, with reduction of the dosage of each one of the three drugs to reduce the toxic effects of higher dosage<sup>41</sup>. This applies more clearly in the case of dopamine, where a higher dosage can be arrhythmogenic with increase in SVR and PVR. Achievement of what looks like "Normal blood pressure" with tachycardia and increased after load can be very damaging to the sick myocardium and to the mesenteric circulation<sup>6,18,19,42,43</sup>.

What looks like normal blood pressure, pulse rate, CVP & PCWP, may not at all reflect the true state of the cardiac output and blood volume<sup>44,45</sup>.

The reduction in the diameter of the capacitance and resistance vessels from the action of endogenous and exogenous catecholamines may maintain an apparent normal haemodynamic figures on the expense of renal and mesenteric circulation. The momentary gain of normal blood pressure can be followed later by renal, hepatic and mesenteric ischaemia. High level of catecholamines can as well increase tissue acidosis and renders the control of blood sugar in diabetics difficult to control.

The main findings of this study are the balanced action of the triple therapy in improving the forward flow of blood by its cardiotoxic action and reduction of the SVR and PVR. The combined inotropy of amrinone and dopamine and the increase in CI by the addition as well of NTG with its protective effects on the coronary circulation<sup>23,46</sup>.

Use of higher doses of amrinone as observed in other patients outside this study caused a more

steep decrease in SVR where in some patients the SVR went down to 450 dynes<sup>47,48,49,50</sup>. The state is similar to anaphylactic shock were by we get a high CI, but the shunting is very high and perfusion pressure very low. The capacitance and resistance vessels can get widely dilated by high dose amrinone. The reduction in PVR can cause as well pulmonary shunting and hypoxia. Some patients outside the study on higher dosage of amrinone dropped their oxygen saturation to 90%, and PaO<sub>2</sub> down to 8 K pascal. The lung function improved when the amrinone dosage was reduced. The loading dose of amrinone in our view should not be more than 1mg/kg and maintenance not more than 10 micrograms/kg/minute. The same observations on amrinone were noticed on high dose nitroprusside<sup>51,52</sup>.

NTG alone when it was started before induction of anaesthesia reduced the PCWP and improved the CI on a dose of 1.5 micrograms/kg/minute.

The use of double therapy, i.e. Amrinone and dopamine or dopamine and NTG have been mentioned in literature. The triple therapy used by us points clearly on the reduction of dosage of each of them. The incidence of the use of IABP was reduced by 50% from 8% to 4% over two years period.

None of the twenty patients showed signs of right ventricular failure.

The study as shown in the figure (4) show no relations between CVP and PCWP. The measurements of PCWP, CI, CO, SVR and PVR are of extreme advantage in evaluating and manipulating the haemodynamics for the advantage of the patient. Proponents of simple monitoring in these critical cases are using their clinical judgement which can be far away from an adequate circulatory state.

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