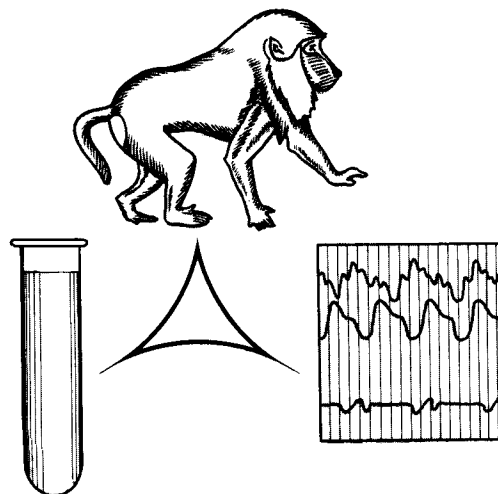


Experimental Intraaortic Balloon Pumping Prior to Acute Myocardial Infarction



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Introduction

Intraaortic phase-shift balloon pumping, a method of circulatory support based on diastolic augmentation, has been studied extensively in the laboratory and clinically. These studies indicated that balloon pumping adequately supports the failing circulatory system, improves survival,^{1,2,4-7} and imposes minimal discomfort to the patient.

To date, no studies of the effects of balloon pumping just prior to or simultaneous with a myocardial infarction have been reported. The protective effect of balloon pumping on experimental myocardial infarction³ is the subject of this report.

Materials and Method

Twenty 15-32 Kg mongrel dogs were divided into two groups. Group I consisted of 10 control dogs in which myocardial infarction alone was created. Group II consisted of 10 dogs that underwent balloon pumping for one hour immediately prior to creation of a myocardial infarction.

Similar myocardial infarctions were created in both groups in the following manner. Dogs were anesthetized with sodium pentobarbital (50 mgm per Kg). Endotracheal intubation and ventilatory control with a Mark VII Bird respirator was instituted. A postero-lateral thoractomy through the left 4th intercostal space was performed. The pericardium was opened and the left circumflex coronary artery was exposed. Direct injection of 0.015 cc mercury/Kg flushed with 0.035 cc of saline/Kg into the proximal left circumflex coronary artery was done. A chest tube was inserted and the thorax was closed in a standard manner.

Group II dogs underwent one hour of closed chest balloon pumping just prior to experimental myocardial infarction. Through a femoral arteriotomy, a single chambered 15 cc polyurethane balloon was inserted into the thoracic aorta just distal to the brachiocephalic vessels. The pumping chamber was pulsed with helium during the diastolic phase of the cardiac cycle. Synchronization was accomplished by R-wave coupling with a Kantrowitz driving unit. Anticoagulants were not used. Central aortic pressure and the electrocardiogram were measured and recorded directly on a Sanborn recorder.

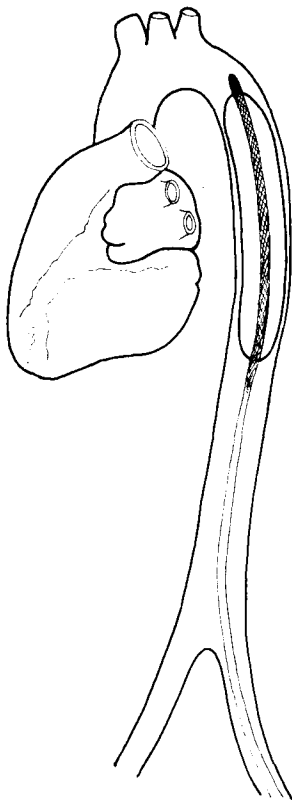
Twenty-four hours post infarct, measurements of serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT) and lactic acid dehydrogenase (LDH), were made in all surviving dogs from both groups. Hearts of all dogs that died or were sacrificed were X-rayed to ascertain the distribution of mercury and then subjected to gross and electron-microscopic examination.

Survivors were those dogs that lived a minimum of 48 hours following infarction. No attempts were made to treat arrhythmias or resuscitate any of the animals. Any dog that died during surgery was excluded from the study.

Comparison of Group I and Group II as to survival time, enzyme changes, infarct location and size, radiographic distribution of mercury and electron microscopic findings were made.

Survival

Immediate operative mortality was 1 of 10 dogs in the control group and 3 of 10 dogs in the pre-pumped



Infarct Location

The location of the infarcts in the control group were similar to those in the pre-pumped group. All infarcts were posterolateral in position and of the same approximate size by gross inspection.

X-ray

No consistent differences in the distribution of mercury was noted in the control vs. the pre-pumped group. Figure 3 is a typical post-mortem x-ray of a heart in which mercury was injected into the left circumflex coronary artery.



Figure 1. Electron micrograph (x10,000) of non-balloon pumped infarcted myocardium. The Z lines are fragmented. The sarcoplasm is vacuolated and the sarcomeres degenerated.

group. All operative deaths resulted from ventricular fibrillation immediately after the injection of mercury into the left circumflex coronary artery.

Of the remaining dogs, 85.7% (6 of 7) of the pre-pumped animals survived 48 hours or more as compared to 44.5% (4 of 9) dogs of the control group. Survival in the pre-pumped group was 41.3% greater than the control.

Enzyme Changes

The enzymes (SGOT, SGPT, LDH) were generally higher in the control as compared to the pre-pumped group. In the control group the SGPT was 88%, the SGOT 76%, and the LDH was 36% greater than the pre-pumped group.

Electron Microscopic Studies

Dogs from both the control and pre-pumped groups were sacrificed 6 days post infarct and equivalent portions of heart muscle just adjacent to the myocardial infarction were studied by electron microscopy.

Several differences were evident between the control (Fig. 1) and the pre-pumped (Fig. 2) groups. The myofibrils from the pre-pumped group remained parallel and evenly distributed within the myocyte. The Z-lines were well defined and extended evenly across the cell. The sarcosomes and mitochondria were generally more intact as compared to the control group.

In the non-pumped (control) group the following changes were noted: the myofibrils were fragmented and the myocytes were less organized as compared to the pre-pumped group. The Z-lines were disorganized and ill defined across the cell. The sarcosomes were partially or completely degenerated.

Discussion

Intraaortic phase shift balloon pumping has proven efficacious for the treatment of experimental and clinical myocardial infarction.^{1,2,4-7}

This study was undertaken to determine whether balloon pumping prior to creating a myocardial infarction had any effect on the overall outcome of survival, enzyme levels, area of infarction, x-ray appearance of the mercury induced infarct, and the electron microscopic appearance of the peripheral zone of infarct.

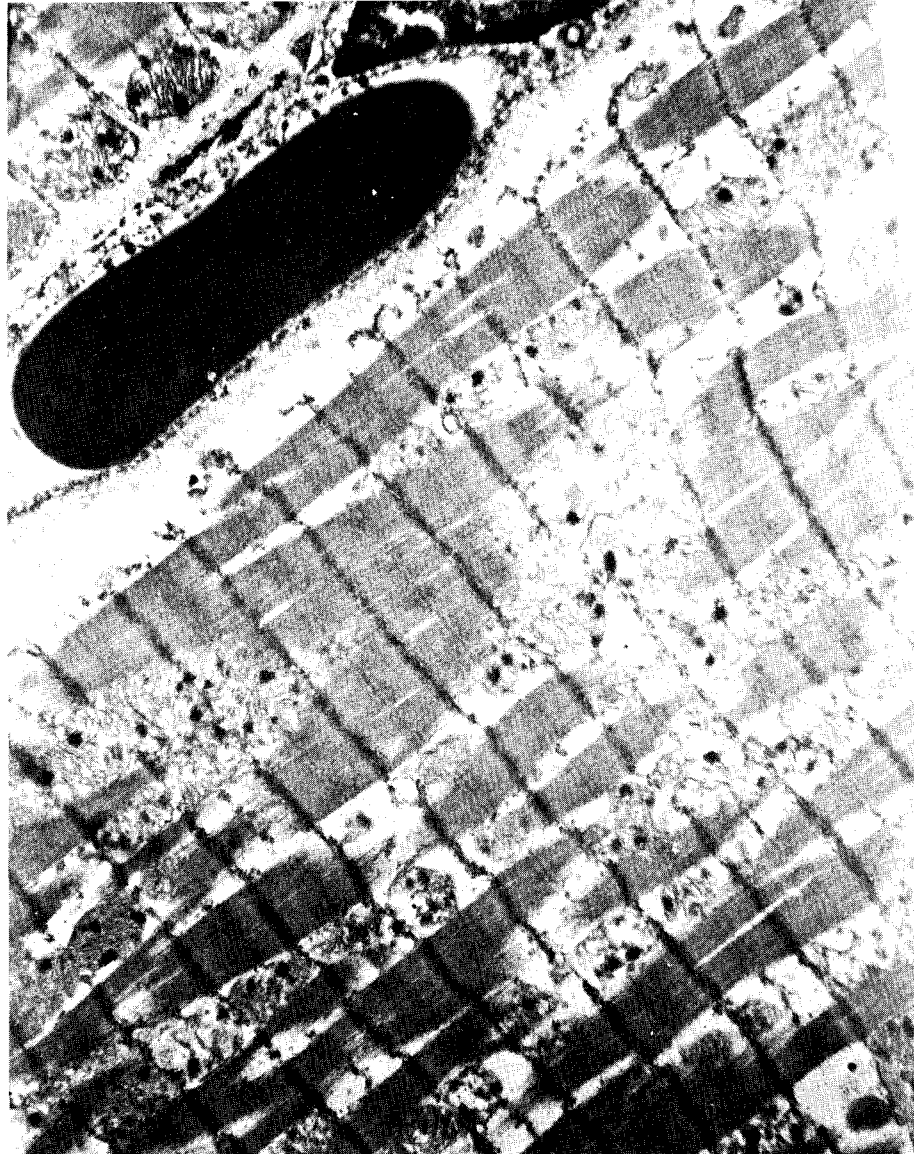


Figure 2. Electron micrograph (x10,000) of preballoon-pumped infarcted myocardium. The Z lines are contiguous and parallel. The sarcoplasm and sarcosomes are generally more intact as compared to Figure 1.

The area of infarction and the x-ray distribution of myocardial mercury was similar in the control and pre-pumped groups. The pre-pumped group survival was 41.2% greater than the non-pumped dogs. The enzyme levels in the pre-pumped group were consistently lower 24 hours post infarction than the non-pumped group. We were able to demonstrate a favorable difference in the electron microscopic picture of the pre-pumped vs. the control dogs.

Increase in long term survival, lower levels of serum enzymes, and the favorable electron microscopic findings in the pre-pumped group suggests that early institution of balloon pumping in patients with acute myocardial infarction or premyocardial infarction angina may possibly improve the overall morbidity and mortality in these patients.

Summary

Myocardial infarction by the injection of mercury into the left circumflex coronary artery was created in 10 control dogs. Similar myocardial infarctions were created in 10 other dogs that were balloon pumped for one hour prior to creation of the infarct.

Increased survival, lower enzyme levels, and a favorable electron microscopic picture was demonstrated in the pre-pumped group as compared to the control group.



Figure 3. Post mortem X-ray in which mercury was injected into the proximal left circumflex coronary artery of a dog.

REFERENCES

1. Chatlerjee, S., Rosenweig, J. Evaluation of intraaortic balloon counter-pulsation. *J. Thorac. & Cardio. Surg.* 51:3 405, 1971.
2. Kantrowitz, A., Tjonneland, S., Krakauer, J., Butner, A. N., Phillips, S. J., Yahr, W. Z., Shapiro, M., Freed, P. S., Jaron, D., and Sherman, J. L., Jr. Clinical experience with cardiac assistance by means of intraaortic phase-shift balloon pumping. *Trans. Amer. Soc. Artif. Int. Organs* 14:344, 1968.
3. Kezdi, P., Misra, S. N., and Kordenat, R. K. Studies of cardiogenic shock model. Abstracts of the National Conference on Research Animals in Medicine. Jan. 1972, Wash. D.C.
4. Krakauer, J. S., Rosenbaum, A., Freed, P. S., Jaron, D., and Kantrowitz, A. Clinical management ancillary to phase-shift balloon pumping in cardiogenic shock. *Amer. J. Cardiol.* 27:2 123, 1971.
5. Mueller, H., Ayres, S. M., Conklin, F. E., Gianneli, S., Jr., Mazzara, J. T., Grace, W. T., Nealon, T. F., Jr. The effects of intraaortic counter-pulsation on cardiac performance and metabolism in shock associated with acute myocardial infarction. *J. Clin. Invest.* (in press)
6. Tanaka, S., Russman, W., Lange, A., Kaster, R., and Lillehi, C. W. Cardiovascular response of the failing dog heart to counter pulsation. *J. Thorac. Cardio. Surg.* 58:112, 1969.
7. Yahr, W. Z., Butner, A. N., Krakauer, J. S., et al. Cardiogenic shock: Dynamics of coronary blood flow with intraaortic phase-shift balloon pumping. *Surg. Forum* 19:142, 1968.

