

Diastolic Augmentation with an External Pulsating Device To Treat Cardiogenic Shock

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ABSTRACT

An 80 cc stroke volume pulsatile assist device (PAD) was modified and used in place of an intra-aortic balloon for diastolic augmentation when passage of the balloon proved impossible due to aorto-femoral obstruction. The PAD was attached via the usual 10 mm graft sutured end-to-side to the patient's left common femoral artery. Systemic heparinization prevented coagulation for 72 hours of PAD support after which time the patient had recovered and was discharged. Metabolic blood pressure was augmented 20–30 mm Hg and CVP reduced from 21 to 9 mm Hg. Pulmonary artery wedge pressure was reduced from 26 to 12 mm Hg and normal urine output was restored. Plasma free hemoglobin ranged from 5–41 mg% and platelet count from 92,000 to 188,000. No complications occurred. Timing was performed in the same manner as in surgery when the PAD is used in conjunction with the pump-oxygenator, and similar precautions were taken. The PAD appears to be an effective alternative counterpulsation in patients suffering from obstructive arteriosclerotic disease precluding the insertion of a balloon catheter.

Intra-aortic balloon pumping is an accepted mode of therapy for treatment of complicated myocardial infarction.^{1,2} Some patients who would benefit from intra-aortic balloon pumping cannot have the procedure applied via the femoral artery because of severe arteriosclerotic occlusive disease. This can prevent passage of the balloon or result in complications of insertion.^{3–5} A small group of patients in which intra-aortic balloon pump can be applied, develop varying degrees of ischemic neuropathy in the leg in which the balloon was inserted, because of subliminal occlusion by the balloon catheter of the femoral artery, reducing flow through that leg. Here we describe a patient in which an intra-aortic balloon could not be inserted and a Pulsatile Assist Device (PAD®)* was utilized for diastolic augmentation.^{6,7}

CASE REPORT

A 69-year-old man was referred for intra-aortic balloon pumping for treatment of cardiogenic shock secondary to myocardial infarction. The patient had sustained an acute inferior wall myocardial infarction 16 hours earlier. Eight hours earlier he developed multiple ventricular arrhythmias, hypotension, and required catecholamine support to maintain adequate perfusion pressure. He continued to deteriorate and was transferred

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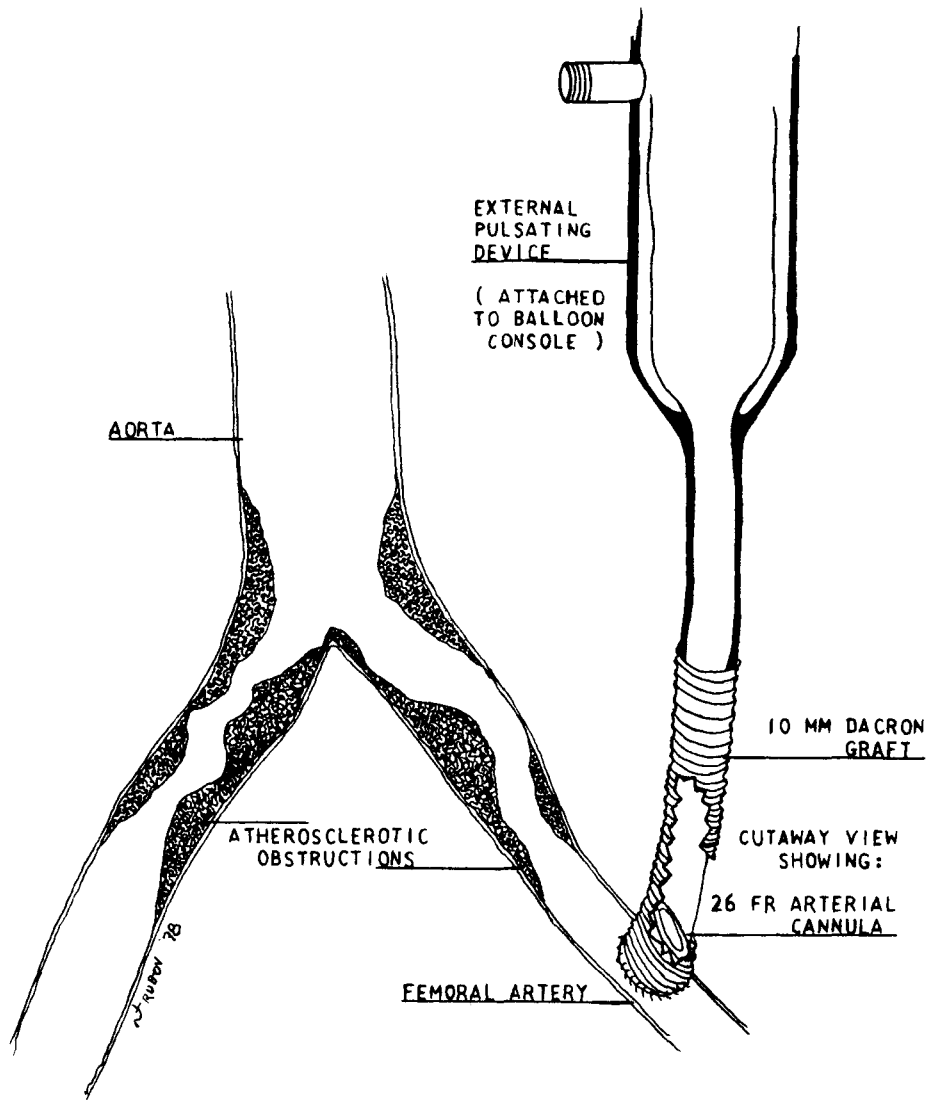


Figure 1. Showing pulsatile assist device in position for long term counterpulsation.

to Mercy Hospital, Des Moines, Iowa, for consideration of intra-aortic balloon pumping.

Admission vital signs and physical examination revealed: blood pressure maintained at 70 mm Hg systolic by a norepinephrine drip, pulse rate was 120 and regular, CVP 21 mm Hg and PA wedge 26 mm Hg. He had had no urine output for the past 7 hours. He was responsive but was very somnolent and confused. His skin was cold and clammy and his extremities cold and mottled. His neck veins were distended to the angle of the jaw at 30 degrees. Chest auscultation revealed bilateral rales throughout and his heart sounds were very distant and could not be evaluated. His abdomen was soft with no masses or

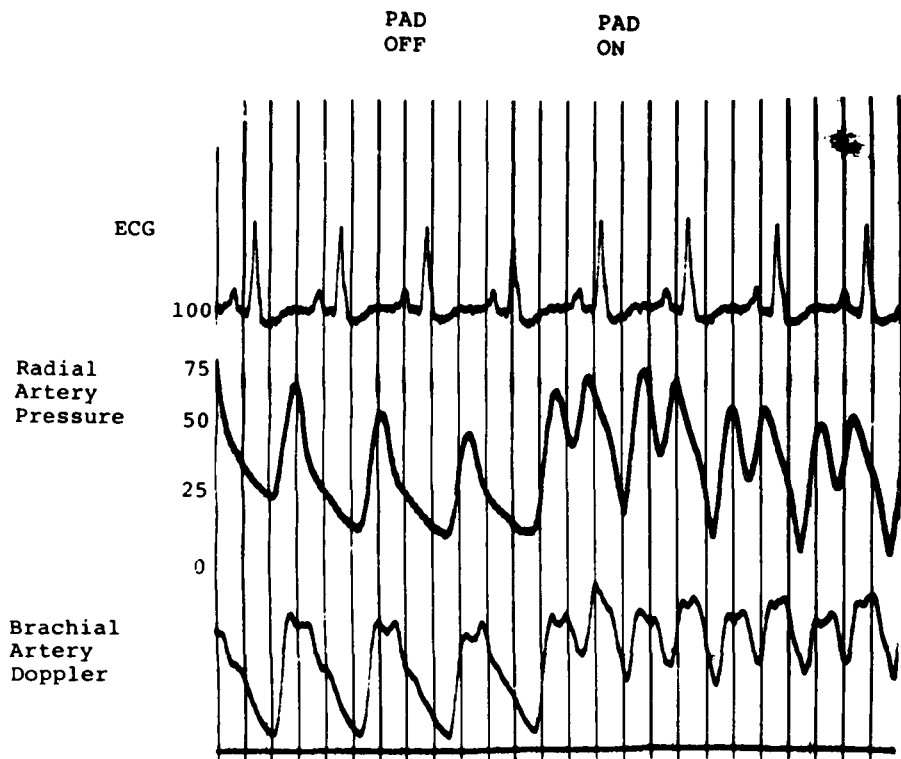


Figure 2. Pulsatile assist device (off-on) providing femoral arterial diastolic augmentation in a patient in cardiogenic shock.

organomegaly. His femoral pulses were palpable bilaterally, but his pedal and radial pulses could not be felt.

The patient was admitted to the coronary care unit where preparation for intra-aortic balloon pump insertion was made. Under sterile conditions, utilizing local anesthesia, a left femoral cutdown was carried out. The common femoral artery above the profunda was isolated with tapes and incised. A 37 cc single chambered intra-aortic balloon** was inserted but could not be passed beyond the level of what was felt to be the aortic bifurcation. Multiple attempts at passage of guide wires and dilators were made, but were unsuccessful. A pulsatile assist device (Figure 1) was prepared as follows: The corporeal connecting tubing of the PAD was clamped. The PAD and tubing were suspended vertically from an I.V. pole and filled with heparinized saline thereby removing all air from the system. The tubing just distal to the PAD was clamped which created a closed-ended pumping chamber with an 80 cc stroke volume.

The patient received a heparinizing dose of 300 units/kg. Heparinization was maintained at 3000 units/hr. by continuous infusion. A 10 mm low porosity dacron graft was sutured end-to-side to the common femoral artery. The graft was tunneled out through a separate stab wound in the skin lateral to the arteriotomy incision. A 26 French

** Datascope Corporation, Paramus, New Jersey.

arterial perfusion cannula*** was then inserted into the lumen of the graft and positioned approximately 1 cm from the arteriotomy. The graft was then tied to the body of the cannula to prevent leakage. The cannula was filled with blood to remove air and connected to the PAD tubing. Air was then removed from the chamber of the PAD by removing the distal clamp and re-filling it with normal saline. PAD support was then initiated. Excellent diastolic augmentation was achieved as indicated by the radial arterial pressure tracing. In order to more accurately time the device, a brachial artery doppler wave form was utilized to define the dicrotic notch. (Figure 2)

Over the next 24 hours, the patient's pulmonary artery wedge and central venous pressure normalized. The urine output increased, blood pressure stabilized, catecholamines were weaned and the peripheral signs of shock abated. After 72 hours of PAD support, hemodynamic stabilization occurred and the PAD was removed.

The continuous heparin infusion was regulated by keeping the partial thromboplastin time at 30 minutes. During the period of PAD support no overt hematologic deficits were noted. The platelet count ranged between 92,000 and 188,000 and averaged 147,000. The highest free hemoglobin which occurred after 6 hours of PAD support was 41 mg %.

DISCUSSION

Intra-aortic balloon pumping continues to be our first choice of therapy for patients with complications of myocardial infarction.¹ Alternates to intra-aortic balloon pumping, though numerous, have not proven efficacious for the treatment of left ventricular power failure and have not gained wide clinical application. Such assist devices as arterial counterpulsator, body acceleration synchronous with the heart beat (BASH), left heart bypass, whole body counterpulsation,⁸⁻¹² etc., have been investigated experimentally and applied clinically but have not gained popularity for a variety of reasons.

The PAD, a device described by Bregman,⁷ et al., was designed to convert the continuous flow of cardiopulmonary bypass into pulsatile flow. It can also be utilized intra-operatively for diastolic augmentation prior to, during weaning, and following cardiopulmonary bypass. This device was modified and applied successfully in a patient in cardiogenic shock in which an intraaortic balloon could not be inserted. Though we were concerned about the possibility of retrograde aortic dissection with this device, no clinical complications were noted due to the application of the PAD in the manner described. The PAD appears to be safe and efficacious when applied in a patient in whom an intra-aortic balloon pump can not be safely inserted.

REFERENCES

1. Kantrowitz, A., Tjonneland, S., Freed, P. S., Phillips, S. J., Butner, A. N., and Sherman, J. L., Jr.: Initial Clinical Experience With Intra-aortic Balloon Pumping In Cardiogenic Shock, *JAMA* 203:113, 1968.
2. Kantrowitz, A., Phillips, S. J., Butner, A. N., Tjonneland, G. S., and Haller, J. D.: Technique of Femoral Artery Cannulation for Phase Shift Balloon Pumping, *J. Thorac. Cardiovasc. Surg.* 56:219, 1968.
3. Bregman, D., Bolooki, H., and Malm, J. F.: A Simple Method to Facilitate Difficult Intra-aortic Balloon Counterpulsation, *Ann. Thorac. Surg.* 15:636, 1973.
4. Lamberti, J. J., Cohn, L. H., and Collins, J. J. Jr.: Iliac Artery Cannulation for Intra-Aortic Balloon Counterpulsation, *Ann. Thorac. Surg.* 67:976, 1974.
5. Phillips, S. J. and Zeff, R. H.: Balloon Insertion via Ascending Aorta, *Ann. Thorac. Surg.*, 20:376, 1975.
6. Bergman, D., et al: Counterpulsation With A New Pulsatile Assist Device (PAD) in Open-Heart Surgery, *Med. Inst.*, 10:232, 1976.

*** U.S. Catheter Corporation.

7. Kaplitt, M. J. and Tamari, Y.: Clinical Experience With the Tamari-Kaplitt Pulsator: A New Device to Create Pulsatile Flow or Counterpulsation During Open-Heart Surgery, *Amer. Coll. Cardiol.*, Las Vegas, March, 1977.
8. Cooper, T. and Dempsey, P. J.: Assisted Circulation, *Mod. Conc. Cardiovasc. Dis.*, I.37:95, 1968, II.37:101, 1968.
9. Arntzenius, A. C., Koops, J., and Hungenholtz, P. G.: Cardiovascular Responses in Piglets to Body Acceleration Given Synchronously with the Heartbeat, *Circulation*, 40:Suppl. 3, 38, 1969 (abs.)
10. Zwart, H. H., Kralios, A. C., Kwan-Get, C. S., Backman, D. K., Foote, J. L., Andrade, J. D. and Kolff, W. L.: Transarterial Closed Chest Left Ventricular Bypass for Desperate Heart Failure, *J.A.A.M.I.*, 5:44, 1971.
11. Laird, J. D., Arntzenius, A. C.: The Effect of Body Acceleration Synchronous with the Heartbeat (BASH) or Aortic Root Pressures—An Inquiry to the Physical Basis, *Trans. Amer. Soc. Artif. Int. Organs*, 18:28, 1972.
14. Bregman, David: Mechanical Support Of The Failing Heart, *Current Problems in Surg.*, 13:12 Dec., 1976.