Complications of Intra-aortic Balloon Insertion and Counterpulsation

JOHN C. McCabe, M.D., RONALD M. Abel, M.D., VALAVANUR A. Subramanian, M.D., AND WILLIAM A. Gay, Jr., M.D.

SUMMARY One hundred consecutive patients considered to be candidates for intra-aortic balloon pumping (IABP) are reviewed from a standpoint of complications and difficulties encountered with balloon catheter insertion. A single attempt at positioning the balloon in the descending thoracic aorta proved successful in 73% of these patients, but the standard femoral artery approach proved difficult in 27% and impossible in 21%. Eighty-two patients ultimately underwent counterpulsation using various insertion techniques. The overall complication rate was 23%. The incidence of complications was higher in those who never had IABP than in those who did. Major complications included: iatrogenic dissection (7), free perforation (1), limb ischemia (10) and sepsis (2), and resulted in two deaths.

BROADENED APPLICATIONS OF INTRA-AORTIC BALLOON PUMPING have resulted in increasing numbers of patients being treated by this modality. The standard indications for counterpulsation are cardiogenic shock and low output states related to cardiac operations. Recent reports, however, consider medically refractory ischemia, "left main" coronary stenosis and prophylactic use in the "bad" left ventricle as relative indications for counterpulsation.1-3 The hemodynamic and therapeutic effects of IABP have been well described and will not be considered in this report.4-6 The expected complication rate and the severity of such complications as well as the expected failure rate of balloon catheter passage must be weighed against the advantages of IABP. The purpose of this report is to examine these specific aspects of IABP and report our clinical experience.

Clinical Material

In the 18-month period between April, 1975, and October, 1976, 100 patients were considered to be candidates for counterpulsation. Indications included acute myocardial infarction with cardiogenic shock, refractory myocardial ischemia manifested as pre- and post-infarction angina and intractable ventricular arrhythmias, post-bypass left ventricular failure, prophylactic use in "high risk" patients with poor ventricular function, left main coronary artery lesions or evolving myocardial infarction (table I).

When counterpulsation was performed for myocardial infarction with cardiogenic shock or refractory ischemia, coronary angiography was done as soon as a stable state was attained. No attempt was made to "wean" patients from counterpulsation support prior to study. If the patient was deemed an operative candidate, surgery was undertaken urgently.

Catheter tip injury of an atherosclerotic arterial wall was common to many of these, particularly in the aorto-iliac-femoral artery segment. Successful treatment of these problems necessitates balloon removal and catheter thrombectomy when hemodynamically feasible or a change in the access site. In addition, repair of arterial injury may be necessary. Thrombocytopenia is universal in these patients, although rarely to a significant degree. Three complications relating to the lymphatic system were encountered which resulted in increased morbidity. The number and magnitude of complications demonstrated in this series must be weighed against the expected advantages of IABP, particularly in that group who might be managed effectively without this procedure.

The balloons were inserted via the femoral artery in a retrograde manner when possible. The artery with the stronger femoral pulse was selected or, if recent cardiac catheterization had been performed, the contralateral femoral artery was selected. The lubricated balloon catheter was threaded through a 10 mm woven dacron graft which was subsequently anastomosed to the common femoral artery in end-to-side fashion. Balloon catheter position was checked prior to wound closure in all patients by portable roentgenogram or fluoroscopy. Three balloon catheters in the series were placed via the ascending thoracic aorta through a long dacron sleeve, brought out the inferior margin of the sternotomy wound or the second right intercostal space. Intravenous Heparin was used on all preoperative and nonsurgical patients and low molecular weight Dextran on postoperative patients. Prophylactic antibiotics (Cephalexin) were used throughout the counterpulsation period.

The IABP system exclusively employed at The New York Hospital-Cornell Medical Center during this interval was the Avco IABP console (Model IABP-7) and catheters.*

The capacity of the balloon was determined by patient size and appearance of the exposed femoral artery. A 40 cc balloon was used in most males and a 30 cc balloon in females. If difficulty was encountered in the initial attempt to pass the catheter a 20 cc balloon was attempted. When the catheter could not be passed despite rotational manipulation and size reduction, the second femoral artery was usually attempted. The amount of force imparted to the balloon catheter to negotiate a "difficult" aorto-iliac segment was small; occasionally, in urgent situations greater force was used to pass the catheter, and the increased risk of this maneuver was accepted in light of the patient's grave condition.

Once the patient had been weaned from IABP support, the catheter was removed under sterile conditions. Fogarty embolectomy catheters were passed in both directions as a matter of routine and the excess graft was amputated and the stump oversewn. The wounds were then irrigated with

*Avco Corporation.

From the Department of Surgery, Division of Cardiothoracic Surgery, The New York Hospital-Cornell Medical Center, New York, New York.

Address for reprints: John C. McCabe, M.D., Department of Surgery, Division of Cardiothoracic Surgery, The New York Hospital-Cornell Medical Center, 525 East 68th Street, New York, New York 10021.

Received August 22, 1977; revision accepted November 7, 1977.
antibiotic solution and carefully closed in layers using chromic catgut. Attention was given to ligating any potential source of lymphatic leakage.

The catheter-bearing extremity was examined several times daily for evidence of ischemia. When this occurred every effort was made to rapidly determine hemodynamic dependence of IABP and to remove the device if possible. If this proved impossible because of hemodynamic instability, the balloon catheter was changed to the opposite femoral artery. An unexplained fever also prompted an early removal of the balloon, and the accompaniment of positive blood cultures was an absolute indication for removal. Serial platelet counts were obtained on all patients who were assisted for long periods.

Results

Forty-seven of the 100 patients considered survived (table 1). Patients with refractory ischemia states did noticeably better than those with cardiogenic shock and those with post bypass left ventricular failure. Cardiogenic shock was initially reversed in 23 of 35 patients with counterpulsation, and 11 survived. Six patients did not respond and the remaining six could not be assisted due to access problems. Only five of 23 patients with post bypass left ventricular failure were saved with counterpulsation, but the balloon could not be passed in six. Ten complications were encountered in those two groups and were attributable to forceful balloon insertion or the low flow state.

The inability to insert the balloon catheter via a femoral artery approach is not specifically a complication, but rather a reflection on the diffuse atherosclerosis present in these patients. This situation frequently leads to localized vessel injury. One hundred patients underwent attempted IABP insertion (table 2). Of this group, successful counterpulsation was established at the first attempt in 73 patients. Difficulty inserting the catheter was encountered in the remaining 27 patients. An attempt at the opposite femoral artery was successful in six patients and unsuccessful in eight. Due to absence of a pulse in the opposite femoral artery, only one side was tried in 12 patients with unsuccessful attempts. The most common point of obstruction was the aorto-iliac segment where stenosis and/or tortuosity precluded catheter passage. Three of the patients with failed groin approaches were subsequently counterpulsated via the ascending aorta. Establishment of IABP by way of the usual retrograde femoral artery technique proved impossible in 21% of the patients, and seven complications resulted in this group. Eighty-two of 100 were ultimately assisted with IABP (three via ascending aorta).

There were 113 femoral artery approaches, considering the bilateral attempts, of which 34 (30%) were unsuccessful. The average age of the group with a successful first attempt was 57 years compared to an average age of 64 years in the group in which difficulty passing the balloon catheter was encountered.

Twenty-three patients developed 29 complications related to either insertion of the balloon catheter or counterpulsation itself (table 3). No correlation between duration of counterpulsation and the development of complications was noted. The mean duration of pumping in the complication group was 53.3 hours, compared to 54.6 hours in the group without complications. There were two complications which played a contributory part in the death of the patient. These complications were categorized as follows: 1) lower extremity ischemia, 2) arterial injury during insertion, 3) wound problems, and 4) hematologic abnormalities.

---

**Table 1. Indication for Counterpulsation and Survival**

<table>
<thead>
<tr>
<th>Indication</th>
<th>N</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>MI with cardiogenic shock with MR</td>
<td>35</td>
<td>11</td>
</tr>
<tr>
<td>MI with VSD</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>MI with ventricular aneurysm</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MI with free rupture</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>MI with no mechanical defect</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>not studied</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Post bypass LV failure</td>
<td>23</td>
<td>5</td>
</tr>
<tr>
<td>Refractory angina pectoris</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>&quot;High Risk&quot; and left main lesion</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>MI with impending extension</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Intractable ventricular arrhythmia</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Evolving MI</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>47</td>
</tr>
</tbody>
</table>

**Table 2. Success of Attempted IABP**

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total studied</td>
<td>100</td>
</tr>
<tr>
<td>Successfully ballooned at first attempt</td>
<td>73</td>
</tr>
<tr>
<td>(average age: 57 years)</td>
<td></td>
</tr>
<tr>
<td>Difficulty inserting balloon</td>
<td>27</td>
</tr>
<tr>
<td>(average age: 64 years)</td>
<td></td>
</tr>
<tr>
<td>Both CFA failed</td>
<td>8</td>
</tr>
<tr>
<td>One of two successful</td>
<td>6</td>
</tr>
<tr>
<td>Only one attempted unsuccessfully</td>
<td>12</td>
</tr>
<tr>
<td>No femoral pulses</td>
<td>1</td>
</tr>
<tr>
<td>Eventually successful (3 via ascending aorta)</td>
<td>9</td>
</tr>
<tr>
<td>Total patients balloon pumped</td>
<td>82</td>
</tr>
<tr>
<td>Unable to insert via femoral artery</td>
<td>21</td>
</tr>
</tbody>
</table>

**Table 3. Overall Complications of Insertion and Counterpulsation**

<table>
<thead>
<tr>
<th>Complication</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dissection</td>
<td>7</td>
</tr>
<tr>
<td>Free perforation</td>
<td>1</td>
</tr>
<tr>
<td>Ischemic extremity</td>
<td>10</td>
</tr>
<tr>
<td>Wound infection</td>
<td>5</td>
</tr>
<tr>
<td>Septicemia</td>
<td>2</td>
</tr>
<tr>
<td>Peripheral neuralgia</td>
<td>1</td>
</tr>
<tr>
<td>Lymphedema</td>
<td>1</td>
</tr>
<tr>
<td>Lymphocele</td>
<td>1</td>
</tr>
<tr>
<td>Lymph fistula</td>
<td>1</td>
</tr>
<tr>
<td>Thrombocytopenia leading to hemorrhagic state</td>
<td>0</td>
</tr>
<tr>
<td>Balloon rupture</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
</tr>
<tr>
<td>Patients with complications</td>
<td>23</td>
</tr>
<tr>
<td>(six patients with 2)</td>
<td></td>
</tr>
<tr>
<td>Related deaths</td>
<td>2</td>
</tr>
</tbody>
</table>
Lower extremity ischemia, the most frequent complication, was related to cardiac output, vessel-catheter diameter discrepancy, intimal injury and thromboembolic phenomena in the ten patients in which it occurred. Although most of the ischemia occurred acutely, one patient required rehospitalization for treatment of chronic limb ischemia. Five patients were successfully treated by balloon removal and catheter thrombectomy. Two patients required the addition of patch angioplasty, and one patient required fasciotomy in addition to balloon removal and thrombectomy. Two patients with ischemic limbs required graft replacement of the injured vessel. No extremity was lost in the entire series.

Of the arterial injuries encountered, there were seven dissections and one free perforation. The point of intimal injury was usually localized to the distal aorto-iliac segment and occurred more often in the shock group where there was a tendency to “push harder” to obtain counterpulsation. Five of the seven dissections were unsuspected, since counterpulsation was accomplished despite the fact that the balloon catheter had passed through or lay in a false lumen (fig. 1).

Three of these were discovered at cardiac catheterization and two at autopsy, although the deaths were not attributable to the iatrogenic dissection (fig. 2). The remaining two were suspected when the catheter could not be passed and vessel occlusion resulted. The single free perforation occurred in a patient who had undergone aortic valve replacement and could not be removed from cardiopulmonary bypass. Perforation of the left common iliac artery resulted in massive retroperitoneal hemorrhage which contributed to the death of the patient. Repair of the perforated artery was accomplished by end-to-end anastomosis using a woven dacron graft but the patient died several days later of complications of a low cardiac output state.

Treatment of the remaining dissections consisted of balloon removal with thrombectomy as soon after recognition as was hemodynamically feasible in four patients, and the addition of patch angioplasty in the remaining patient.

Four of the patients previously included in the ischemia category had arterial injury as the initial event and required bypass grafts or angioplasty to repair vessel injury. The elevation of intimal plaques resulted in stasis and thrombosis.

The wound problems include infection, septicemia, neuralgia, lymphedema, lymphocele and lymph fistula. There were four groin wound infections, two of which were superficial and responded to local wound care and antibiotics. The other two required removal of the remnant of dacron graft to enable wound healing. One of the latter had developed septicemia from the infected dacron.

Another patient had an intra-aortic balloon inserted through a long woven dacron graft from the subcostal region to the ascending aorta when she could not be removed from cardiopulmonary bypass following a mitral valve replacement and coronary bypass surgery. The patient initially did well and was discharged four weeks after surgery. However, she was re-admitted four and one-half months after the original procedure with septicemia and a purulent exposed graft (fig. 3). The graft was removed, but the patient exsanguinated two weeks later from the infected aortotomy closure site.

All three problems related to damage to the lymphatic system responded to conservative measures. The lymph fistula resulted in the greatest morbidity prolonging hospitalization by 21 days. A single case of lymphedema of the operated extremity subsided with a compression stocking; the lymphocele responded to repeated aspiration and compression.

One patient developed neuralgia over the distribution of the medial cutaneous nerve of the thigh. This subsided without treatment but was undoubtedly secondary to injury sustained to the nerve during balloon insertion.

The only significant hematologic problem associated with IABP was thrombocytopenia. Serial platelet counts were performed in 50 patients surviving periods of counterpulsation ranging from a few hours to 14 days (fig. 4). Among those measured, most patients’ platelet counts (17) fell to between 50,000 and 100,000; however, eleven of 50 had counts below 50,000 and four patients were given platelet transfusions when bleeding was accompanied by a count below 30,000. Thirteen patients fell to a low between
100–150,000 and the remaining nine sustained a count above 150,000. Generally, depression of the platelet count correlated with duration of counterpulsation. Recovery toward normal platelet counts followed balloon removal quickly (fig. 5). Although most of these patients were subjected to cardiopulmonary bypass in addition to counterpulsation, thrombocytopenia was demonstrated in three patients who had counterpulsation alone. Hemolysis related to IABP was not observed in this series. Examination of the balloon catheters revealed no evidence of platelet aggregates or thrombi adherent to the Avcothane surface.

Discussion

Much of the clinical information on counterpulsation has outlined indications, hemodynamic response and results, which is increasingly impressive as an efficacious, simple, and relatively uncomplicated system of circulatory support. The overall incidence of complications has been cited as 4 to 36%, with most in the 10 to 16% range. These statistics are generally calculated on the basis of total successful insertions, which would seem to understate the problem, as: 1) many patients with unsuccessful attempts develop complications, and 2) some patients expire soon after counterpulsation is established with little opportunity to develop complications. In our experience, using the standard techniques of insertion, 23% of 100 patients undergoing attempted balloon insertion developed complications.

Once the decision to use IABP has been reached, the first hurdle encountered is placement of the balloon catheter tip in the proximal thoracic aorta. This all too often proves a formidable problem. The balloon catheter could not be adequately positioned from the femoral artery in 21% of the patients, yet one-third of them developed vascular complications. The problem of inability to pass the catheter takes on greater significance with advancing patient age and is presumably related to progressive atherosclerosis in the aorto-iliac segment. This problem is also reflected by a lower success rate in the second femoral artery, when the first attempt has been unsuccessful. The use of guide wires through a central lumen catheter, fluoroscopy and angiography have been suggested as a solution to this problem and may prove helpful when time permits.

Most complications of IABP are related to insertion of the catheter, more specifically to vessel injury. Intimal injury can occur anywhere from the femoral arteriotomy to the aortic arch. More severe injury, dissection and perforation,
Catheter-bearing limb ischemia, in the absence of intimal injury, was attributed to combinations of low cardiac output, thromboembolic occlusion, catheter encroachment of the artery in the presence of underlying atherosclerotic stenosis. Ischemia responded to catheter removal and catheter thrombectomy in the majority of cases, the remainder required a plastic repair or bypass graft. When a patient was hemodynamically dependent on counterpulsation with ischemia, the contralateral femoral artery was used, although a femoro-femoral crossover graft has been suggested by others as a means to alleviate ischemia in the patient who still requires IABP. No amputations resulted in this series, but limb loss has been reported by others. It seems clear that IABP results in thrombocytopenia; however, it is difficult to isolate the effect of counterpulsation from that of cardiopulmonary bypass. Most patients demonstrate a moderate reduction in platelets after a few days of IABP. Those patients who demonstrated counts below 30,000 were usually post-bypass with multisystem failure. No bleeding disorders developed which were directly attributable to an absolute drop in platelet count alone. The usual thrombocytopenia is not a problem and reverses soon after balloon removal.

Complications not encountered in this series have been reported by others. Weber, in a collective review, documents balloon rupture and gas embolus, visceral embolic phenomena, red cell destruction and dissecting aneurysm without intimal injury due to lateral and shearing forces of balloon inflation on the aortic wall. Vascular insufficiency of the catheterized limb followed by iatrogenic dissection are consistently the most common serious complications reported.

Intra-aortic balloon pumping is not without risk. The significant number and magnitude of complications seen in this series, as well as the inability to insert the catheter in some, must be weighed against the indication for the use of this device. There is no question that the benefit of counterpulsation in cardiogenic shock and post-cardiopulmonary bypass low output states justifies the risk. However, the routine use of counterpulsation in patients with left main coronary artery stenosis and in those with marginal ventricular function is questionable and the procedure should be done on a case-by-case basis. The role of IABP in medically refractory ischemia is also not well defined but generally it should be considered only when beta-adrenergic blocking agents and pharmacologic left ventricular afterload reduction have failed to control angina.

References
Complications of intra-aortic balloon insertion and counterpulsation.
J C McCabe, R M Abel, V A Subramanian and W A Guy, Jr

Circulation. 1978;57:769-773
doi: 10.1161/01.CIR.57.4.769

Circulation is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 1978 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/57/4/769.citation

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in Circulation can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to Circulation is online at:
http://circ.ahajournals.org//subscriptions/