# Benefits of ambulatory axillary intra-aortic balloon pump for circulatory support as bridge to heart transplant

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**Objective:** Axillary intra-aortic balloon pump therapy has been described as a bridge to transplant. Advantages over femoral intra-aortic balloon pump therapy include reduced incidence of infection and enhanced patient mobility. We identified the patients who would benefit most from this therapy while awaiting heart transplantation.

**Methods:** We conducted a single-center, retrospective observational study to evaluate outcomes from axillary intra-aortic balloon pump therapy. These included hemodynamic parameters, duration of support, and success in bridging to transplant. We selected patients on the basis of history of sternotomy, elevated panel-reactive antibody, and small body habitus. Patients were made to ambulate aggressively beginning on postoperative day 1.

**Results:** Between September 2007 and September 2010, 18 patients underwent axillary intra-aortic balloon pump therapy. All patients had the devices placed through the left axillary artery with a Hemashield side graft (Boston Scientific, Natick, Mass). Before axillary placement, patients underwent femoral placement to demonstrate hemodynamic benefit. Duration of support ranged from 5 to 63 days (median = 19 days). There was marked improvement in ambulatory potential and hemodynamic parameters, with minimal blood transfusion requirements. There were no device-related infections. Some 72% of the patients (13/18) were successfully bridged to transplantation.

**Conclusions:** Axillary intra-aortic balloon pump therapy provides excellent support for selected patients as a bridge to transplant. The majority of the patients were successfully bridged to transplant and discharged. Although this therapy has been described in previous studies, this is the largest series to incorporate a regimen of aggressive ambulation with daily measurements of distances walked. (J Thorac Cardiovasc Surg 2012;143:1193-7)

Cardiac transplantation is currently the definitive therapy for patients with end-stage heart failure. However, the availability of donor hearts to perform transplantation remains a major limiting factor. The United Network for Organ Sharing Registry data show the number of available hearts to range from 3000 to 3500 over the last several years.[1] With an increasing number of patients developing end-stage heart failure each year, the number awaiting cardiac transplantation far exceeds the number of available donor hearts.

As a result, mechanical support devices have been used increasingly as a bridge-to-transplant strategy to sustain patients' hemodynamics and organ function while they are on the heart transplant waiting list. Specific hemodynamic criteria are applied when the use of mechanical support is considered. These criteria include a cardiac index of less than 2.2 L/min/m$^2$, systolic blood pressure of less than 90 mm Hg, mean pulmonary capillary wedge pressure or central venous pressure of greater than 20 mm Hg, and concomitant use of high doses of at least 2 inotropic agents.[1] A patient's initial decline in hemodynamic status may first be managed pharmacologically with inotropes and an intra-aortic balloon pump (IABP), which is usually percutaneously inserted via the femoral artery. Although a femoral IABP can be inserted with relatively low risk and ease, major disadvantages include risk of infection, limited duration of support (3–7 days), and severe restriction of a patient's mobility. This constraint further deconditions a patient's musculoskeletal system. Insertion of an IABP via the axillary artery overcomes these disadvantages, and patients are able to ambulate.

Although there are a multitude of intermediate and long-term circulatory support devices available, the implantation of these devices can be costly financially and physiologically. In certain patients, the surgical risk may be high because of multiple previous cardiac surgeries. Some patients may also present with issues that render the use of these devices difficult, including the inability to tolerate higher levels of anticoagulation, history of sternotomies, elevated panel-reactive antibody (PRA) levels, or small

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**Abbreviations and Acronyms**
BTT = bridge to transplant
IABP = intra-aortic balloon pump
LVAD = left ventricular assist device
PRA = panel-reactive antibody

body habitus, which could make implantation difficult. The patient may have psychosocial issues that preclude the use of a left ventricular assist device (LVAD). Axillary IABP counterpulsation therapy is an alternate strategy in these scenarios, providing a feasible bridge-to-transplant option while maintaining patient mobility. In addition to containing cost, axillary IABP therapy also provides several other advantages compared with standard LVAD therapy. It is a less complicated surgical procedure with shorter extubation times and reduced blood transfusion requirements, and does not require specialized infrastructure and personnel for care as LVAD therapy does. Other distinct advantages with axillary IABP therapy include a low incidence of device-related infections, postoperative bleeding, stroke, and thrombosis.

We report our experience over a 2-year period in which axillary IABP support was used in 18 patients as a bridge to transplant (BTT). The patients underwent axillary IABP placement in our hybrid operating room, which combines the facilities of a cardiac surgery operating room with a cardiac catheterization laboratory.

## MATERIALS AND METHODS

We conducted a retrospective review of the first 18 patients in whom left axillary IABPs were placed between September 2007 and 2010 at the Vanderbilt Heart Institute after obtaining institutional review board approval. All patients undergoing axillary IABP insertion had end-stage heart failure and failed ongoing inotropic support or could not tolerate inotropic therapy because of arrhythmias from the inotropes. We specifically identified patients with a history of sternotomy, elevated PRA (>20%), or small body habitus (body mass index < 25). Before selection for axillary IABP placement, patients underwent femoral balloon placement to establish hemodynamic benefit from counterpulsation therapy ranging from improved cardiac output and reduced pulmonary artery pressures.

Our management plan was to wean the femoral IABP, and if this was tolerated, the femoral IABP was taken out the same day before axillary IABP insertion. If the wean was not tolerated, then the wire was already in place for the axillary IABP before taking out the femoral IABP in the operating room. We were cautious in ascertaining that the hemodynamic benefit from the axillary IABP was similar to the femoral test insertion.

All patients were brought to the operating room, and monitoring lines were placed. Preoperative intravenous prophylactic antibiotics were given. After induction, the patient was prepped and draped in the standard fashion. An incision was made below the left clavicle. The fibers of pectoralis major and minor were split. The fascia was then incised with Metz scissors. Vessel loops were placed around the axillary vein and artery. Heparin was given, and the axillary artery was clamped proximally and distally. An appropriate arteriotomy was made, and a 6-mm Hemashield graft (Boston Scientific, Natick, Mass) was sewn with 5-0 running Prolene. The graft was allowed to back-bleed, and good hemostasis was achieved.

**TABLE 1. Patient characteristics**

| Variables | Patients (n = 18) |
|---|---|
| Median age (y) | 56 (20–64) |
| Gender | |
| Male | 15/18 (93%) |
| Female | 3/18 (17%) |
| BMI ($m^2$/kg) | 25.55 (19.66–33.22) |
| Diabetes | 7/18 (39%) |
| Hypertension | 7/18 (39%) |
| COPD (moderate to severe) | 3/18 (16.7%) |
| Creatinine ≥1.5 mg/dL at the time of IABP insertion | 7/18 (39%) |
| Chronic renal failure on hemodialysis | 1/18 (5.6%) |
| Inotropic support | 18/18 (100%) |
| Median ejection fraction (%) | 15 (5–25) |
| Congestive heart failure | 18/18 (100%) |
| Mean NYHA class | Class IV |
| Carotid artery disease with >75% stenosis | 3/18 (16.7%) |
| Prior myocardial infarction | 3/18 (16.7%) |
| Atrial fibrillation | 7/18 (39%) |
| Previous sternotomy or elevated PRA (>20%) or small body habitus (BMI < 25) | 10/18 (56%) |
| Ischemic cardiomyopathy | 9/18 (50%) |
| Dilated cardiomyopathy | 9/18 (50%) |
| Mitral insufficiency (moderate to severe) | 7/18 (39%) |
| Tricuspid insufficiency (moderate to severe) | 5/18 (27.8%) |

Values presented as mean, median (range), or number (percent). *BMI,* Body mass index; *COPD,* chronic obstructive pulmonary disease; *IABP*, intra-aortic balloon pump; *NYHA,* New York Heart Association; *PRA*, panel-reactive antibody.

The free end of the graft was shortened and oversewn with running 5-0 Prolene suture.

A pledgeted purse-string with 5-0 Prolene was placed on the anterior surface of the graft. A needle was placed in the center of the purse-string, and the balloon wire was advanced. This was done using fluoroscopy.

The entry site was successively dilated. Once the wire was confirmed to be in the descending aorta, the IABP was advanced over the wire into the descending aorta. Care was taken to flush and de-air the lines. The IABP was initiated, and positioning was reconfirmed by transesophageal echocardiography.

After confirmation of hemostasis, the axillary incision was closed in layers. The stump of the graft was placed superficial to the pectoralis major fascia. The skin was approximated with running Monocryl suture. The IABP was secured to the skin.

Patients were returned to the cardiovascular intensive care unit in stable condition. Aggressive ambulatory therapy was initiated from the first postoperative day. Parameters such as cardiac index, mean and systolic pulmonary artery pressures, central venous pressure, and maximum distance ambulated daily were recorded and compared with their respective values pre-IABP placement. Time to extubation, blood transfusion requirements, and changes in creatinine were also recorded. The duration of support on the IABP and time to cardiac transplant (as appropriate) were recorded. A 2-tailed paired *t* test was used for statistical comparison of pre- and post-IABP parameters.

## RESULTS

Between September 2007 and 2010, 18 patients were managed with axillary IABP therapy at the Vanderbilt Heart