Nursing Care of Patients Receiving Intra-aortic Balloon Counterpulsation

Mary Beth Reid, RN, PhD, APRN-BC, CCRN, CEN
Damon Cottrell, RN, MS, APRN-BC, CCNS, CCRN, CEN

Intra-aortic balloon counterpulsation (IABC) was introduced into clinical settings in 1967 for the treatment of cardiogenic shock. IABC is now used for more than 100,000 patients each year in the United States. In the past 3 decades, IABC has assumed a prominent role in the treatment of patients with a failing heart; the intra-aortic balloon catheter is the most widely used left ventricular assist device.

Patients receiving IABC require the same intense and expert nursing care required by all critically ill patients. In addition, specialized management is required to reduce the risk of complications and to minimize the morbidity associated with IABC. These acutely ill patients require nursing care based on specialized knowledge and skill. Prompt recognition and treatment of the sometimes life-threatening complications associated with IABC are essential. In this article, we describe the indications for using IABC, potential complications and the nursing care required, potential risk factors for complications, and education of patients and their families about IABC.

Intra-aortic Balloon Counterpulsation

To initiate IABC, a polyurethane, nonthrombogenic catheter is inserted, most commonly into the femoral artery, and threaded upward so that the distal tip of the catheter is in the thoracic part of the aorta just distal to the origin of the left subclavian artery. The proximal end of the catheter is connected to a balloon pump console that forces helium into and out of the balloon, inflating and deflating the balloon.

Inflation occurs during the diastolic or resting phase of the heart. Displacement of blood, proximally to the aortic root and coronary arteries and distally to the systemic circulation, results in elevation of the diastolic pressure (Figure 1). Deflation occurs at the end of diastole just before the onset of the heart’s isovolumetric contraction (Figure 2). The displacement of the blood that occurs during inflation decreases the workload of the left ventricle by decreasing the systolic and aortic end-diastolic pressure or afterload. Thus, the mean pressures are elevated and tissue perfusion is improved.

Indications for Using IABC

Although IABC was originally designed to assist patients in cardiogenic shock, the indications for IABC have expanded during the past 30 years because of continued research, the ease of catheter insertion, the increased availability of the technology, and a decrease in the size of the pump console. Table 1 lists many indications for IABC.

The most common indication for use of IABC is low cardiac output due to left ventricular dysfunction. Low cardiac output can result from mechanical complications due to...
acute myocardial infarction or from left ventricular failure resulting in congestive heart failure. IABC is commonly used to relieve myocardial ischemia in such conditions as impending or acute myocardial infarction or unstable refractory or postinfarction angina. It has also been indicated for hemodynamic support during and after procedures such as angiography and angioplasty, for weaning from cardiopulmonary bypass, and as a bridge to and after heart transplantation.

Potential Complications and the Nursing Care Required

When monitoring patients receiving IABC, critical care nurses must be alert for the possible occurrence of complications throughout the process. Table 2 lists potential complications attributed to IABC, including the nursing care and treatment for each. Each complication is addressed in more detail in the following sections.

Limb Ischemia

Limb ischemia is the most frequent complication of IABC. The primary causes are obstruction of a small or diseased femoral artery by the catheter, distal formation of a thrombus from direct arterial injury during insertion of the catheter, and thromboembolism.

Critical care nurses must complete an extensive peripheral vascular assessment before the intra-aortic balloon (IAB) catheter is inserted and should continue reassessments throughout the remainder of the patient’s stay in the hospital because long-term complications related to decreased perfusion to the extremity are not unusual. Nurses should start by assessing the skin’s color and temperature, observing for indications of poor perfusion and arterial insufficiency such as cyanosis, mottling, pallor, or coolness of each extremity. Then they should palpate the femoral, popliteal, dorsalis pedis, and posterior tibial pulses while marking the sites bilaterally with a permanent marker before the IAB catheter is inserted. Because 8% to 10% of persons in the general population do not have a palpable dorsalis pedis pulse, the absence of this pulse should be documented before the IAB catheter is inserted. The pulses are recorded on the assessment form by using numerical values to indicate the quality:

- 0 = no pulse,
- 1 = thready pulse,
- 2 = weak pulse,
- 3 = normal pulse, and
- 4 = bounding pulse.

A portable Doppler ultrasound device should be used to determine the presence or absence of distal pulses that are difficult to palpate.
especially the dorsalis pedis and posterior tibial pulses. In addition, any neurological deficits or impairments of the lower extremities should be documented before the IAB catheter is inserted.

Acute ischemia of the limb may produce the “6 P’s”: pain, pallor, pulselessness, poikilothermia (cold), paresthesia, and paralysis. Circulation checks of the femoral, popliteal, dorsalis pedis, and posterior tibial pulses should be completed every 15 minutes for the first hour after the catheter is inserted, every 30 minutes for the second hour, then every hour for 2 hours, and then every 4 hours thereafter until the catheter is removed. Bilateral capillary refill should be recorded in seconds.

Circulation checks include using Doppler imaging to locate an impalpable pulse; comparing both lower extremities to detect differences or changes in color, temperature, and sensation; and using an ankle-brachial index to provide a more quantitative measurement of circulation. The ankle-brachial index is a noninvasive examination that provides objective baseline data for later comparison with subsequent measurements. It is a simple, painless, and objective method of detecting vascular changes in the lower limb associated with the patient’s subjective complaints.

In order to measure the ankle-brachial index, the blood pressure cuff is put around the ankle above the malleolus. When the dorsalis pedis pulse has been located via Doppler imaging, the cuff is inflated in the usual manner until the Doppler signal is no longer heard. As the cuff is slowly deflated, the systolic pressure is recorded when the signal returns. The brachial systolic pressure is measured in the same manner and divided into the ankle systolic pressure to obtain the index (Table 3). Ideally, the IAB catheter is inserted into the leg that has the higher ankle-brachial index. Measurements of the ankle-brachial index can be useful in monitoring changes in blood flow to the limb, detecting the presence of acute ischemic changes, and monitoring progression of peripheral vascular disease.

Maintaining body temperature, cardiac index, and systemic vascular resistance near normal levels is essential to promote maximum perfusion of the affected limb. Nitroglycerin can be applied topically to the limb in an attempt to increase blood flow if the limb becomes ischemic.4 In most cases, removal of the IAB catheter resolves the ischemia; rarely a partial or full amputation is necessary when irreversible, massive necrosis due to prolonged ischemia occurs.

### Table 1: Indications for use of intra-aortic balloon counterpulsation

| Low cardiac output states due to left ventricular dysfunction, such as |
| Right ventricular failure |
| Refractory left ventricular failure |
| Ventricular septal defect |
| Ventricular aneurysm |
| Papillary muscle rupture with mitral valve regurgitation |
| Mechanical complications due to acute myocardial infarction |
| Relief of myocardial ischemia in |
| Impending or acute myocardial infarction |
| Unstable refractory angina or angina after a myocardial infarction |
| Ischemia related to intractable ventricular dysrhythmias after myocardial infarction |
| Hemodynamic support during and after procedures, such as |
| Support and stabilization during coronary angiography and angioplasty |
| Prevention of acute restenosis in percutaneous transluminal coronary angioplasty |
| Weaning from cardiopulmonary bypass |
| Cardiac support for high-risk general noncardiac surgical patients |

As a bridge to heart transplantation and after transplantation because of cardiovascular deterioration from rejection

Acute ischemia of the limb may produce the “6 P’s”: pain, pallor, pulselessness, poikilothermia (cold), paresthesia, and paralysis.

**Compartment Syndrome**

Critical care nurses must be alert for changes that can lead to compartment syndrome. Compartment syndrome is a condition in which increased pressure within a closed, unyielding fascial space reduces capillary blood flow to the point that the viability and function of the tissues enclosed in the fascia are at risk. The increase in pressure is due to increases in fluid pressure plus the contribution of cells, fibers, gels, and matrices. Compartment syndrome can be triggered by any con-
dition that reduces capillary blood flow, such as difficulty of insertion of the catheter further reducing blood flow within small vessels, preexisting peripheral vascular disease, vasopres-
sive drugs, lengthy periods of immobilization, and thrombosis. When an event occurs that affects the microvasculature, the result is diffuse ischemia within the compartment. Deep throbbing pain or pressure, paresthesia, and paralysis localized in the involved compartment are common complaints. The earliest objective findings of compartment
syndrome are a swollen, palpably tense compartment, reflecting increased intracompartmental pressure. The compartment pressure may be high enough to cause nerve and muscle damage but not so high as to occlude the artery and obliterate peripheral pulses.

Direct measurement of the pressure in the compartment is a more sophisticated method of quantifying the increase in compartmental pressure. A needle or catheter is inserted into the compartment, allowing direct measurement of the pressure. Normal capillary perfusion pressure is 25 mm Hg. Normal muscle tissue pressure is 0 to 12 mm Hg. When tissue pressure exceeds capillary perfusion pressure, the capillaries collapse. A compartment pressure of greater than 30 mm Hg is an indication of compartment syndrome that requires quick intervention, whereas a pressure of 70 mm Hg or higher requires acute surgical fasciotomy to avoid contractures or rhabdomyolysis with acute renal failure.12

The anterior and lateral compartments are most often affected by chronic exertional compartment syndrome.12 The posterior compartment is deeper and does not respond as well or as quickly to fasciotomy as the other compartments. Elevation in the level of creatine phosphokinase is also used as an indicator of muscle ischemia in acute compartment syndrome. Early detection and surgical decompression of the affected area are crucial to avoid permanent damage of muscles and nerves and to increase the chances for functional recovery of the limb. The limb should be kept elevated at the level of the heart, and the patient’s hydration should be maintained at adequate levels. Mannitol has been used in some cases of compartment syndrome.12

Dissection of the Aorta

Dissection of the aorta is a serious complication of IABC that can be caused by trauma due to difficulty...
inserting, repositioning, or moving the catheter. Dissection occurs when the catheter causes a tear in the intimal wall of the aorta. The pressure within the aorta forces blood between the vascular layers. This forceful lengthwise channel of blood can strip the intimal layer from the adventitial layer along the aorta, resulting in obstruction of arterial branches along the path of the dissection or rupture of the aorta leading to catastrophic hemorrhage.

Signs and symptoms of aortic dissection (Table 2) include patients’ reports of a ripping or tearing pain in the back or in the abdomen radiating to the back or chest. The peripheral pulses may be unequal, or blood pressure may vary between the right and left extremities. Peripheral pulses may decrease on one or both sides. Once the IAB catheter is inserted, cardiac output and renal function may decrease. Other indications of aortic dissection include decreases in blood pressure and hematocrit, signs and symptoms of shock, and an increase in abdominal girth. A chest radiograph will show mediastinal enlargement. Aortic dissection is an emergency complication commonly managed by surgical intervention.

Dislodgment of Plaque or Emboli

Complications arising from dislodgment of plaque or emboli in the femoral artery or aorta can occur at any point during IABC and result in an obstruction somewhere in the vasculature. Emboli that decrease capillary blood flow to the extremities could result in compartment syndrome, which has many of the same signs and symptoms as limb ischemia with symptoms of nerve compression. Emboli making their way to the cerebral circulation may cause an occlusion that evolves into neurological signs and symptoms of a cerebrovascular accident. Emboli that become lodged in the coronary arteries can lead to an acute myocardial infarction. Respiratory failure can occur if the emboli travel to the pulmonary artery. Prevention of this complication is key. Treatment generally consists of supportive care. Maintenance of ventilation, oxygenation, and anticoagulation with close monitoring are extremely important.

Catheter Migration

After the IAB catheter is inserted, interventions to monitor for and prevent migration of the catheter are undertaken. The IAB catheter is positioned high in the aorta so that the lower end of the balloon does not compromise perfusion to the celiac, superior mesenteric, or renal arteries (Figure 1). On a chest radiograph, the proper position of the catheter is 2 cm below the origin of the left subclavian artery, or between the second and third ribs and above the renal arteries. If the carotid artery becomes occluded, changes will be apparent in the patient’s level of consciousness, mental alertness, and orientation, or the patient may have unilateral neurological deficits. Outward migration of the IAB catheter may result in occlusion of the renal artery. Indicators of renal artery occlusion include the patient’s report of abdominal, back, or flank pain, fever, nausea, vomiting, or anorexia, followed by a decrease in renal output. The treatment for balloon migration is for the physician to reposition the catheter if possible or to remove the catheter and insert a new one.

Bleeding

Another potential complication that can occur during any part of IABC is systemic or local bleeding. Thrombocytopenia from the use of anticoagulants in patients requiring IABC reduces the risk for thromboembolic complications but can increase the risk of bleeding. Thrombocytopenia also can be a result of platelet destruction due to the mechanical trauma that occurs during the inflation of the IAB catheter against the wall of the aorta. Hemoglobin level, hematocrit, platelet
count, prothrombin time, and partial thromboplastin time must be monitored closely for changes that could indicate bleeding or the potential for bleeding.

Indications of bleeding may be manifested as bruising or a hematoma at the insertion site or by an increase in the girth of the thigh. The patient may not initially be hypotensive, but becomes tachycardic and has a decrease in hemoglobin level and hematocrit. Retroperitoneal bleeding may be manifested by the patient becoming hypotensive and complaining of back, flank, or abdominal pain unrelieved by changes in position. The pulse distal to the catheter may be absent because of blood loss, a situation that requires immediate surgical intervention.

Several factors can be checked in an effort to avoid bleeding complications when the IAB catheter is removed. Prothrombin and partial thromboplastin times should be less than 1.5 times the control; the activated clotting time should be greater than 200 seconds; and administration of anticoagulants should be stopped 1 to 4 hours before the catheter is removed. The physician should apply pressure above and below the site of insertion while removing the sheath and the catheter simultaneously, usually allowing the insertion site to bleed vigorously for 1 to 2 seconds to remove any clots at the site. The physician may choose to deploy a vascular hemostasis device.13

The extremity must be evaluated closely for signs of ischemia for 24 hours after the catheter is removed. Once the IAB catheter is removed, pressure should be applied to the puncture site for 20 to 30 minutes continuously, or until hemostasis is achieved. Then a 4.5-kg (10-lb) sandbag and a compression bandage can be applied for 2 hours. The patient should be instructed to remain on bed rest for a minimum of 8 hours after removal of the catheter and to avoid exercising the extremity so as to prevent bleeding. Treatment for bleeding includes administration of platelets, packed red blood cells, and other blood products as needed.

**Balloon Rupture**

Blood or brown flakes in the IAB catheter are indications of balloon rupture. When the catheter balloon ruptures, immediate recognition of the rupture and removal of the IAB catheter are crucial. If the gas leak is only a small pinhole, the catheter may not contain any blood. The balloon pump may indicate a “gas leak” or augmentation with inflation of the catheter may be poor. Whether blood appears in the catheter, the same grievous potential exists for a gas embolus or for entrapment of the IAB catheter. When the balloon ruptures, it fills with blood that forms a clot and the balloon cannot deflate completely. As a result, the catheter cannot simply be pulled out. Treatment for an entrapped balloon is usually surgical removal; however, the clot can be dissolved with a fibrinolytic agent, allowing the physician to aspirate the liquid blood and remove the catheter by femoral artery cutdown.14

**Infection**

The second most frequent complication of IABC is infection at the catheter insertion site, which is manifested by fever, local infection, and bacteremia.15 Indications of infection are the same as with any invasive catheter: elevation of body temperature; elevation of white blood cell count; warmth at the site, with redness, swelling, and drainage; blood cultures that show growth of microorganisms; and indications of sepsis.

The primary goal of critical care nurses is prevention of infection. Scrupulous aseptic technique must be exercised throughout the insertion procedure, during manipulation of the catheter, and when redressing the insertion site.

**Skin Breakdown**

Because of their restricted mobility, chronic disease, impaired sensory perception, and altered tissue perfusion, patients receiving IABC are prime candidates for development of pressure ulcers. These patients generally have limited mobility because of mechanical ventilation, deep sedation, chemical or physical restraints, immobilizing devices, and hemodynamic instability. The mere presence of the IAB catheter in the femoral artery exposes patients to a decrease in tissue perfusion to the affected extremity.

Pressure-reducing or pressure-relieving devices such as low-air-loss beds that are designed to maintain low interface tissue pressure would reduce or eliminate interface pressure to a level below that of capillary closing pressure. Patients should be repositioned every 1 to 2 hours to promote skin integrity. Ensuring adequate nutrition and hydration also assists in protecting the skin’s integrity.

**Risk Factors for Complications**

Thorroughness when obtaining a patient’s medical history is essential
for recognizing factors that can pre-
dispose patients to the development of complications related to IABC. Information from patients’ medical histories can assist critical care nurses in determining which patients are more likely to have complications related to IABC. Table 4 lists factors that put patients at greatest risk for development of such complications.

Lower limb ischemia is more likely to develop in women than in men when the IAB catheter is inserted via the femoral artery.3,16 This increased risk for peripheral vascular complications is often attributed to the differences between men and women in the diameter of the femoral artery. The smaller diameter in women increases the chance for compromised blood flow and the risk of thrombosis.16

Preexisting peripheral vascular disease is a major, if not the main, risk factor for the development of vascular complications associated with IABC.9 Predisposing factors to peripheral vascular disease include diabetes mellitus, cigarette smoking, hypertension, hypercholesterolemia, advanced age, and obesity.3,16 Because of the peripheral vascular disease associated with diabetes mellitus, the incidence of lower limb ischemia is as much as 6 times higher in diabetic patients than in nondiabetic patients when an IAB catheter is inserted in the femoral artery.16 The patient’s lower extremities should be assessed for signs of poor perfusion such as loss of leg hair, thickened toenails, pallor, and shiny skin.

Major ischemia of the lower limb in patients receiving IABC is 3 times more likely in cigarette smokers than in nonsmokers.16 Hypertensive patients have a higher incidence of vascular complications than do normotensive patients.16 Other established risk factors such as obesity, low cardiac index, elevated systemic vascular resistance, and the use of vasopressors are related to the development of lower limb ischemia.16

### Education of Patients and Their Families About IABC

Educating patients and patients’ families about IABC is important to prepare them for the limitations the patients will experience and to reduce anxiety. Helping patients and their families understand the basics of IABC and why the patients’ mobility is limited increases compliance.

The limitations that patients will experience while receiving IABC should be explained. If the catheter is inserted via the femoral artery, the patient will be on complete bed rest with the head of bed raised to no more than 30°. Patients should be taught how to apply an immobilizer to maintain extension of the limb that has the catheter insertion site. Patients must be turned at least every 2 hours to prevent skin breakdown and promote comfort.

Nurses should explain to patients and patients’ families that bleeding may occur at the catheter insertion site. Patients should be told to put pressure on the insertion site when coughing or sneezing and to notify the nurse immediately if they experience pain in the lower back or a sudden burning, pain, or wetness at the insertion site.

Patients and their families should be instructed to immediately report symptoms indicative of peripheral circulatory changes (eg, tingling, numbness, coldness, pallor, and pain) to a nurse while in the hospital and to a physician after discharge from the hospital.

Once home, patients should know that if any pain in the extremity occurs when walking (claudication) or while at rest, especially at night, a physician should be notified. Patients and their families must understand that such a change is serious and requires immediate evaluation and treatment to prevent possible tissue damage. Patients and their families must be taught how to inspect the patients’ feet daily for redness or ulcers, especially on the toes or around any pressure points, and patients should be instructed to wear shoes loose enough to avoid pressure points on the feet. Patients and their families should understand that any of the preceding changes, even if seemingly insignificant, must be brought to the attention of a physician immediately.

### Conclusion

Since the initial introduction of IABC in 1967 for the treatment of cardiogenic shock, the IAB catheter has become the most widely used left ventricular assist device. IABC is not accomplished without risk to patients; therefore, practitioners must weigh the risks against the benefits before using IABC. Nurses

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<th>Table 4</th>
<th>Risk factors for complications of intra-aortic balloon counter-pulsation</th>
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<tr>
<td>Female sex</td>
<td>Preexisting peripheral vascular disease</td>
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<td>Advanced age</td>
<td>Diabetes mellitus</td>
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<td>Cigarette smoking</td>
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caring for these critically ill patients must be aware of potential problems and, through assessment, recognize those patients who are at high risk for possible complications of IABC.

Critical care nurses must be vigilant and skilled in assessing circulation in the lower extremity. Frequent and thorough assessment of the extremities is essential before, during, and after IABC. Because of the potential for long-term vascular complications related to the use of IABC, the peripheral vascular assessment should continue for at least several days after the IAB catheter is removed. It should become a part of each patient’s annual physical examination, especially if the patient has preexisting peripheral vascular disease.

With the broadened use of IABC, prevention, recognition, and management of complications must be the focus of care. The importance of the nursing assessment and appropriate interventions to minimize morbidity associated with IABC cannot be overemphasized. Because of the high mortality rate, the acuity of these cases, and the complexity of their management, critical care nurses must fully understand the nursing care and potential complications related to caring for patients receiving IABC. As more research is performed and outcomes evaluated, the data will accumulate and practice can be adjusted to prevent complications related to IABC.

References