Management of Massive Hemoptysis Secondary to Catheter-induced Perforation of the Pulmonary Artery during Cardiopulmonary Bypass*

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Pulmonary artery perforation by flow-directed catheters is associated with high mortality, particularly in heparinized patients. We report a recent case and discuss recognition and management. (Chest 1999;115:1340-41)

Pulmonary artery (PA) perforation is an uncommon complication of Swan-Ganz catheterization. It has a particularly high mortality in heparinized cardiopulmonary bypass patients. The purpose of this report is to increase awareness of this complication, outline a systematic approach when it occurs, and suggest methods to avoid it.

Case Report
A 65-year-old dentist presented with incapacitating angina, cardiac cachexia, and signs of pericardial constriction seven years after initial aortocoronary bypass surgery. Therapy with long-acting nitrates, calcium blockers, beta-blockers and afterload reduction was largely ineffective and associated with many side effects. Weight loss was 15 pounds over the previous few months, 30 pounds over two years. The ECG showed first degree and left anterior hemiblock. Catheterization showed critical three-veil stenosis with no patent grafts. Ejection fraction was diffusely reduced to 37 percent. An extensive workup for malignancy was negative.

The patient was admitted for coronary bypass surgery, and after premedication with nitroglycerin paste and antibiotics, and induction of Fentanyl, isoflurane and O₂ anesthesia, a PA catheter (Oximetric, Mountainview, CA) was inserted through the right internal jugular vein to 62 cm for an initial and only wedge pressure of 13 mm Hg. The catheter was then withdrawn to 54 cm and the diastolic pressure was 12 mm Hg. The previous sternotomy was opened, revealing dense adhesions.

Following heparinization, aortic and two-stage right atrial cannulation, the patient was placed on cardiopulmonary bypass. Using hypothermic cardioplegic arrest, grafts were placed from the aorta to the anterior descending, diagonal, distal circumflex and posterior descending coronary arteries.

Prior to weaning from bypass, the right lung did not move well with ventilation, and a small amount of blood was aspirated from the endotracheal tube. As flows were reduced, bleeding increased and a tentative diagnosis of PA perforation was made. The right PA was encircled between the aorta and superior vena cava, the catheter palpated within its lumen, and a tourniquet placed and tightened. Fiberoptic bronchoscopy revealed bleeding from the posterior segment of the right lower lobe. With the tourniquet released, bleeding increased markedly when attempting to wean from bypass. A chest x-ray film confirmed catheter tip location (Fig 1).

With the PA snare tightened, endobronchial bleeding fell to a few ml/min on partial bypass. A Fogarty balloon (American Edwards, Irvine, CA) inflated in the segmental bronchus reduced bleeding to a trickle. The catheter tip was pulled back into the main PA and the patient weaned from bypass over 20 minutes with satisfactory hemodynamics, mixed venous oxygen saturation, arterial blood gases and pH, although dopamine, 6 μg/kg/min, and adrenaline, 5 μg/min, were required. Pulmonary artery diastolic pressure was 15 mm Hg and nitroglycerin infusion was maintained at 0.2 to 0.5 μg/kg/min. Because of the catecholamine requirement, an intra-aortic balloon was inserted with excellent unloading of the left ventricle.

Protamine sulfate was given and a decision made to do a lobectomy through the median sternotomy rather than persist with endobronchial tamponade and right PA tourniquet. After completion, cardiopulmonary status restabilized, although an air leak persisted. The wounds were closed and the patient transferred to the intensive care unit in stable condition. Seven hours later he died suddenly following a bradycardiac arrest.

The posterior basilar segment of the resected lobe was replaced by a large hematoma (Fig 2). A major segmental arterial branch entered the hematoma, but fine sectioning could not demonstrate the point of rupture. Post-mortem examination showed main left coronary artery stenosis, diffuse distal disease, and four patent grafts with good runoff. The kidneys, heart and lungs showed extensive deposits of stiff proteinaceous material (amyloid) with involvement of pulmonary connective tissue and small vessels.

Discussion
This patient had one of 852 open-heart procedures performed at the Vancouver General Hospital during 1986. Pulmonary artery catheters were placed in 85 percent of patients; 88 percent were urgent or emergent, and 87 percent in NYHA class 3 or 4. Over the last seven years,

Figure 1. Intraoperative chest x-ray film showing (1) PA catheter in the right lower lobe, (2) umbilical tape snare encircling the pulmonary artery, (3) fiberoptic bronchoscope in the right lower lobe bronchus, and (4) one of the markers for proximal anastomoses.

Figure 2. Right lower lobectomy specimen showing intrapulmonary hemorrhage.

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3,900 PA catheters have been placed prior to open heart surgery, with two perforations of clinical significance. The previous patient was also cachectic and, in addition, had chronic mitral regurgitation and PA hypertension. Our incidence of serious perforation is 0.05 percent, with previous reports ranging from 0.06 to 0.125 percent.1,2

The mortality rate following Swan-Ganz catheter injury is over 50 percent and much higher in heparinized patients.1,4 Associated factors include PA hypertension, advanced age, fragility of tissues, and peripheral catheter tip locations.5 Retraction of the heart, especially to expose distal circumflex vessels, may push the catheter peripherally5 and hypothermia stiffens the catheter, increasing the risk of perforation. In addition, we suspect that inflation of the balloon and wedging of the catheter while the patient was heparinized played a role in the previous fatal case in our institution.

Methods reported for control of hemoptysis after PA injury include positive end-expiratory pressure,7 double lumen endotracheal tube placement,8 endobronchial tamponade,9 unilateral PA occlusion,10 lobectomy,11 and pneumonectomy.7 When perforation is suspected during cardiopulmonary bypass, encircling and palpation of the right PA will delineate the side of rupture if the catheter has not been pulled back. A radiograph will confirm catheter position. Bleeding can be controlled almost completely with unilateral PA occlusion and fiberoptic bronchoscopy for toilet, localization of bleeding and selective bronchial blockade. The patient is then weaned from bypass and anticoagulation reversed. Release of the PA tourniquet at this point may be associated with improved gas exchange while the bleeding remains controlled by the inflated endobronchial balloon.

Lobectomy may then be performed under relatively controlled conditions. In favor of early lobectomy is the risk of persistent bleeding into the lung or fatal perforation into the pleural space.12 In addition, in our patient there was continued trivial bleeding around the Fogarty balloon with the possibility of airway obstruction and soilage of the other lung. A double lumen endotracheal tube was not used, as placement in a draped patient with an endobronchial catheter can be technically difficult and ventilation may be compromised. In spite of our patient's high preoperative risk and unsatisfactory end result, the approach used could lead to improved survival following PA injury. In other series, the only survivors have followed resection.

However, lower lobectomy through a sternotomy requires destabilizing mediastinal retraction in a critically ill patient. Subsequent communications with experienced surgeons raise alternate therapeutic possibilities. Patient salvage has been achieved by prolonged balloon occlusion of the segmental bronchus and leaving the PA catheter in place with gentle inflation of the balloon to obstruct the artery into the injured segment. The trivial anatomic extent of this functionally catastrophic injury is confirmed by our inability to locate the perforation, as previously reported by Connors et al.14 Patients surviving without resection show resolution of the hematoma on followup x-ray film, with the potential for return of normal pulmonary function preferable to pulmonary resection, if an equal or lower risk can be demonstrated. More experience and reports of survival with nonresective approaches are required before they can be recommended, but a temporizing trial in stable patients with excellent control of bleeding with the preliminary measures described may be considered.

To avoid PA rupture and hemorrhage, special attention should be given to catheter management. While pullback to 30 cm has been suggested,3 Shah et al2 note it may then be difficult to differentiate right atrial from ventricular pressure tracings during bypass. If the catheter tip retracts into the atrium, balloon inflation may obstruct a single right atrial cannula with emptying of the oxygenator, as occurred in their experience. Even though he was tall, with cardiomegaly, the 62 cm insertion required in our patient to get an initial wedge pressure must have been associated with curling of the catheter and the withdrawal to 54 cm was inadequate. We now practice withdrawal to 40-50 cm, depending upon patient and cardiac size, with confirmation of nonwedging by continual PA pressure monitoring. In addition, prior to heparinization, the surgeon may palpate the tip of the catheter to be certain it is not beyond the main PA. The balloon should never be inflated while the patient is heparinized, and reduction of elevated PA pressures should be attempted. Prevention remains the best method of eliminating mortality from this catastrophic complication.

REFERENCES
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