Swan–Ganz Catheter-Induced Pulmonary Artery Pseudoaneurysm Formation*

Three Case Reports and a Review of the Literature

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The use of Swan-Ganz catheters has increased tremendously since they were first introduced in 1970. Their ability to give vital hemodynamic measurements in critically ill patients makes their use invaluable when providing quality medical care. The formation of pulmonary artery (PA) pseudoaneurysm from a Swan-Ganz catheter-induced perforation of the PA is a rare but potentially fatal complication of Swan-Ganz catheter use. Three case presentations and a review of the literature are presented. (CHEST 2001; 120:2105–2111)

Key words: complications; hemoptysis; pseudoaneurysm; pulmonary artery; pulmonary artery rupture; Swan-Ganz catheter; treatment

Abbreviation: PA = pulmonary artery

In 1970, Swan and colleagues1 were the first to describe the use of a flow-directed, balloon-tipped catheter for cardiac catheterization and cannulation of the pulmonary artery (PA). Since that time, the use of Swan-Ganz catheters has become widely accepted and has proven to be extremely helpful in the management of critically ill patients.2,3 The use of the catheter, however, is not without risk as a wide range of complications has been reported. The complications can be categorized as those of the initial venous cannulation (ie, subclavian or carotid artery laceration, pneumothorax, thoracic duct laceration, phrenic nerve injury, air embolism, and endotracheal tube cuff rupture) and those due to the catheter itself (ie, arrhythmias, infection, valvular damage, thrombosis, pulmonary infarction, and PA perforation).4–12 Of these, PA rupture is the most serious complication, with a reported mortality rate as high as 50%.13–15 We present three cases of PA rupture with pseudoaneurysm formation, all of which were successfully treated percutaneously with coil embolization, that occurred over a 6-month period. A review of the literature also is presented.

Case Reports

Case 1

An 83-year-old woman with a history of hypertension, congestive heart failure, myocardial infarction, end-stage renal disease, abdominal aortic aneurysm rupture and repair, and osteomyelitis presented with congestive heart failure and acute cholangitis, the latter being secondary to choledocholithiasis. A Swan-Ganz catheter was placed to assist in monitoring the patient’s hemodynamic status. Two days after placement, the patient developed hemoptysis immediately following Swan-Ganz catheter manipulation and recording measurements (PA pressure, 45/22 mm Hg; wedge pressure, 25 mm Hg). An emergent portable chest radiograph (Fig 1) then was obtained, and the patient was brought to the angiography suite where a right pulmonary angiogram was performed in the left anterior oblique projection via a right common femoral vein approach, utilizing an 80-cm, 8.2F catheter (Monte 1; Cook; Bloomington, IN). The Swan-Ganz catheter was left in place to help localize the area of injury. Images revealed a faint extravascular collection of contrast arising off the right lower lobe PA adjacent to the Swan-Ganz catheter (Fig 2, top). The catheter then was exchanged for a 4F, 100-cm catheter (Headhunter; Angiodynamics; Queensbury, NY), which then was advanced into the neck of the pseudoaneurysm. The catheter tip position was verified with contrast injection (Fig 2, bottom), and the pseudoaneurysm then was embolized with multiple 8-mm,

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10-mm, and 12-mm coils (Cook). A repeat angiogram revealed complete occlusion of the pseudoaneurysm (Fig 3). The Swan-Ganz catheter then was removed, and the cordis sheath was left in place for venous access. A follow-up chest radiograph (Fig 4, top) and CT of the chest (Fig 4, middle and bottom) performed 1 day after embolization revealed partial right lower lobe atelectasis and an effusion. No further hemoptysis was experienced by the patient, who was discharged from the hospital 2 weeks later to a rehabilitation center. A chest radiograph performed 2 months after embolization showed complete resolution of the atelectasis and the effusion (Fig 5).

Case 2

An 81-year-old woman with a history of hypertension was a front seat passenger in a head-on motor vehicle accident. She sustained multiple serious injuries including bowel perforations requiring small bowel resection and sigmoid colostomy, pelvic fractures with hemorrhage requiring emergent percutaneous embolization of branches of the internal iliac arteries, and multiple long-bone fractures. The patient had a prolonged hospital course with multiple complicating factors including a myocardial infarction, ARDS, and sepsis. Multiple Swan-Ganz catheters had been placed during the patient’s prolonged hospital stay to help monitor the hemodynamic status. The existing catheter had been present for 10 days when, immediately following the retrieval of hemodynamic parameters (PA pressure, 40/18 mm Hg; wedge pressure, 20 mm Hg), bright red blood was noted in the tracheostomy tube and ventilator tubing. The Swan-Ganz catheter was quickly pulled back several centimeters by the house staff. An emergent portable chest radiograph revealed a new, focal round infiltrate in the right upper lobe (Fig 6). The patient was sent for an emergent pulmonary arteriogram, which was performed through a right common femoral vein approach using an 8.2F, 80-cm Monte 1 catheter. It revealed a pseudoaneurysm arising off the right upper lobe PA (Fig 7, top) and a new right pleural effusion (Fig 7, bottom). The feeding artery of the pseudoaneurysm then was selected using a 4F, 100-cm Berenstein catheter (Angiodynamics) [Fig 8], and the pseudoaneurysm was embolized using multiple 8-mm coils (Cook) with the catheter positioned at the neck of the aneurysm. A repeat angiogram showed complete occlusion of the pseudoaneurysm and the small feeding artery (Fig 9). As the patient still required close hemodynamic monitoring, the Swan-Ganz catheter then was directed into the opposite PA. A chest radiograph performed 1 day after embolization showed the coils to be present within the infiltrate (Fig 10). The patient did not experience any further episodes of bleeding but succumbed to complications of her injuries 4 weeks later.

Case 3

A 78-year-old woman with a history of moderate aortic stenosis was transferred to our institution after an anterior-wall myocardial infarction and cardiac arrest. The patient was resuscitated successfully and underwent a cardiac catheterization and Swan-Ganz catheter placement. Forty-eight hours after the Swan-Ganz catheter placement and immediately following balloon deflation
to determine the pulmonary wedge pressure (25 mm Hg), bright red blood was noticed coming from the endotracheal tube. The Swan-Ganz catheter then was removed by the house staff, and the patient was sent for an emergent pulmonary angiogram. Via a right common femoral vein approach, an 8.2F, 80-cm Monte 1 catheter was manipulated into the right PA, and an angiogram was performed, revealing a pseudoaneurysm arising off the medial-segment branch of the right middle-lobe PA (Fig 11, top). The flush catheter was exchanged for a 100-cm, 4F Headhunter catheter, which then was advanced into the PA pseudoaneurysm where 10-mm and a 3-mm coils (Cook) were deployed. A repeat pulmonary arteriogram revealed persistent filling of a portion of the pseudoaneurysm with sluggish flow (Fig 11, bottom). Multiple attempts to recatheterize the pseudoaneurysm were unsuccessful, and the procedure then was terminated. It was believed that the remainder of the pseudoaneurysm would spontaneously thrombose off, so the feeding artery was not embolized. The patient underwent aortic valve replacement and three-vessel coronary artery bypass grafting and was discharged to a rehabilitation center 15 days later without any further episodes of hemoptysis.

**DISCUSSION**

Major complications associated with Swan-Ganz catheter insertion have been reported to occur in up to 17% of cases. The most serious complication that can occur is PA rupture with hemorrhage and/or pseudoaneurysm formation. In a prospective study involving 528 consecutive Swan-Ganz catheter placements, Boyd et al found the rate of PA rupture with hemorrhage to be 0.2%. Other retrospective studies involving thousands of Swan-Ganz catheter placements have shown rates ranging from 0.001 to 0.47%. The mortality rate associated with pulmonary rupture is as high as 50%, secondary to aspiration and asphyxia following intrapulmonary hemorrhage.

A number of risk factors, some of which have been brought into question, have been attributed to the development of PA rupture and pseudoaneurysm formation. These include pulmonary hypertension, systemic anticoagulation, long-term steroid use, surgically induced hypothermia, age > 60 years, female gender (69% preponderance), cardiac decompression, and cardiac manipulation during surgery.

**Figure 3.** Postembolization digital subtraction angiography demonstrates complete occlusion of the pseudoaneurysm with sparing of the feeding vessel. The subtracted images of the coils within the pseudoaneurysm are easily seen (arrow).

**Figure 4.** Chest radiograph (top) and CT scan of the chest (middle and bottom) performed after embolization demonstrate an effusion (open arrow) and atelectasis (arrow heads) of the right lower lobe. The coils in the pseudoaneurysm are easily identified (curved arrows).
In the presence of pulmonary hypertension, it was postulated that the catheter and balloon could be propelled into the smaller, more fragile arterioles, thereby increasing the likelihood of rupture. This postulate was found to be erroneous by Hardy et al,9 whose experimental studies performed on human cadaveric lungs failed to verify this, suggesting that pulmonary hypertension poses no additional risk of pulmonary rupture and may be merely a coincidental finding. Furthermore, small PA branches were found to withstand higher pressures without rupture than the larger PA branches. These same cadaveric studies of PA pressures have demonstrated that the pulmonary arteries in patients who are > 60 years of age were more likely to rupture at a given pressure than similar arteries in younger patients.9

Chronic steroid use is believed to increase the fragility of the vascular system by its negative effect on collagen formation and connective tissue strength and healing, making vascular rupture more likely.19 While not increas-
ing the risk of vascular injury directly, anticoagulation inhibits the body’s ability to seal any vascular injury caused by a Swan-Ganz catheter, leading to pseudoaneurysm formation.

In a retrospective study involving 32,442 Swan-Ganz catheter placements, Kearney and Shabot\(^5\) have shown that in 7 of 10 patients who sustained ruptures of the PA, difficulty was experienced either as the balloon was inflated or as the catheter was advanced or withdrawn. Fletcher and colleagues\(^8\) proposed five potential mechanisms for the etiology of PA rupture secondary to Swan-Ganz catheter manipulation. They concluded that the most plausible etiology was that the pressure in the expanded Swan-Ganz balloon exceeded the tensile strength of the vessel wall with subsequent rupture. Hardy et al\(^9\) further expanded on this when they demonstrated on cadaveric models that the distal PA ruptured at 1,875 mm Hg and the mid-PA ruptured at 975 mm Hg. When the pressure in the balloon exceeded these pressures, rupture occurred in an all-or-none phenomenon.

“Spearing” or penetration of the PA by the Swan-Ganz catheter tip is another proposed mechanism of PA injury. Shin and colleagues\(^10\) demonstrated that eccentric balloon inflation, particularly in smaller vessels, could leave the catheter tip exposed, allowing it to act as a spear and to penetrate the wall of the PA. In another study, Johnson and colleagues\(^11\) showed that during balloon deflation, the catheter tip migrates distally, which could also spear the vessel wall, causing injury. Lastly, cardiac motion transmitted to the arterial wall through the catheter tip also can induce trauma to the PA by spearing. Other causes of injury that have been reported include retraction of a wedged balloon and the flushing of a wedged catheter.\(^5\)

The probability of Swan-Ganz catheter-induced injury to the PA may be diminished by proper catheter placement and management. First, balloon inflation should be performed in a large, proximal PA. The catheter then is advanced or “floated” to its wedged position to obtain the necessary hemodynamic parameters. Second, the time spent with the catheter in a wedged position should be minimized. Third, the balloon should be deflated while traction is applied on the catheter and then should be withdrawn when completely deflated to avoid the spearing.

Some patients with PA rupture secondary to Swan-Ganz catheter manipulation remain asymptomatic and present with a new nodule or infiltrate on chest radiographs, while others present with the classic symptom of hemoptysis. In patients who survive the initial hemoptysis from a PA rupture, the formation of a pseudoaneurysm has been reported to occur anywhere between minutes to 7 months later.\(^16\) Thrombus formation and compressed lung parenchyma usually contain the pseudoaneurysm, preventing extravasation. The rate of recurrent hemor-
Rhage associated with the identification of a pseudoaneurysm is approximately 30 to 40%, with an attendant mortality rate of 40 to 70%. A review article described 92 cases of PA rupture induced by pulmonary catheterization that led to the formation of 28 false aneurysms. All patients who were treated prior to rupture of the pseudoaneurysm (12 of 28 patients) survived, whereas a 100% mortality rate was found in those patients whose false aneurysm ruptured prior to treatment. The 100% mortality rate reported in this study is somewhat misleading as not all untreated pulmonary pseudoaneurysms rupture. In a case report by You and Whatley, a 2.2-cm pseudoaneurysm was described that resolved spontaneously over a 4-month period. Despite this single reference, most authors emphasize the importance of prompt treatment of the pseudoaneurysm once the diagnosis is established. In fact, Yellin and colleagues recommend that all survivors of an initial episode of hemoptysis associated with PA catheter manipulation undergo emergent contrast-enhanced spiral CT scanning or angiography of the chest for diagnosis and possible treatment.

The radiographic diagnosis of PA pseudoaneurysm usually begins with a chest radiograph. Findings vary according to the pathophysiology and chronicity of the lesion. Occasionally, the chest radiograph may appear normal. This nonvisualization can be due to several factors, including the small size of the lesion, its location within the lung, its proximity to the mediastinum, or the radiographic technique used to expose the radiograph. When changes are noted on a radiograph, they follow a fairly characteristic pattern. Early films may show a dense pulmonary infiltrate with hazy margins. However, within 1 to 3 weeks, a round, well-circumscribed, persistent nodule or mass with a diameter of 2 to 8 cm often can be visualized. The right PA is involved in 93% of cases, usually affecting the right lower or middle-lobe branches. This is consistent with the usual location of Swan-Ganz catheter tips as seen on chest radiographs.

Contrast-enhanced spiral CT scanning has been advocated by many as the noninvasive procedure of choice to diagnose a PA pseudoaneurysm. The pseudoaneurysm appears as an enhancing mass with an adjacent vessel. Occasionally, a partially thrombosed lumen can be seen. Guttentag and colleagues have described two cases in which CT scans demonstrated a sharply circumscribed nodule surrounded by a halo of faint density. While
contrast-enhanced CT scanning is an excellent diagnostic modality for detecting PA pseudoaneurysms, angiography remains the “gold standard.” Angiographically, it appears as an extravascular collection of contrast in continuity with a vessel. Angiography is not only diagnostic, but it can also be used as a treatment option (i.e., transcatheter embolization).

Several different therapeutic options are available to treat PA pseudoaneurysms. Transcatheter embolization has become the treatment of choice for most Swan-Ganz catheter-induced PA pseudoaneurysms.22-25 It is a relatively simple procedure that can be performed at the same time as the diagnostic angiogram and carries a lower rate of morbidity and mortality than surgical resection. In all three of the cases presented, the time from hemoptysis to embolization was within 3 h. Steel coils are usually used, which are preferentially placed in the pseudoaneurysm sac itself, thrombosing the pseudoaneurysm and preserving pulmonary blood flow. Alternatively, the feeding vessel of the pseudoaneurysm can be embolized to occlusion. Surgical options include lobectomy, pneumonectomy, hilar clamping with direct arterial repair, and PA ligation.26-28 Parenchymal resection remains the treatment of choice by some,29-32 when an acute rupture of the PA occurs during cardiac surgery, because the procedure is relatively quick and easy as the patient’s thorax is already exposed.

Swan-Ganz catheters have become an indispensable part of intraoperative and critical-care patient management. PA rupture with subsequent pseudoaneurysm formation is a rare but potentially fatal complication. Confirmation of the diagnosis can be made using dynamic CT scanning with IV contrast or with pulmonary arteriography. Because of the potential risk of rupture, early diagnosis and treatment is essential. Transcatheter embolization has become the treatment of choice for PA pseudoaneurysms as it is relatively safe, easy, and provides good long-term results.

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