Pulmonary Artery Rupture Associated With the Swan-Ganz Catheter*

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Objectives: This study was designed to determine the incidence rate, define risk factors, and suggest proper management protocols for pulmonary artery (PA) rupture associated with Swan-Ganz catheters.

Design: This is a retrospective chart-review study.

Setting: This study involved 32,442 inpatients requiring hemodynamic monitoring with Swan-Ganz catheters in the operating rooms and ICUs at a large, private teaching hospital over a 17-year period (1975 to 1991).

Results: Ten patients sustained PA rupture, yielding an observed rupture rate of 0.031% of catheter insertions. All ten patients had hemoptysis and five (50%) had pulmonary hypertension. Two patients (20%) had undergone anticoagulation at the time of rupture. Four of the six surgical patients were still in surgery at the first sign of rupture. A thoracotomy was performed in five patients. We noted a trend toward survival with thoracotomy, but it was not statistically significant. The overall mortality rate was 70%. When data from our 10 patients were combined with 65 patients from the literature, we found that thoracotomy was essential for survival in patients with hemothorax. There were no survivors among seven patients with hemothorax simply observed, compared with eight (50%) survivors in 16 patients undergoing thoracotomy (p=0.026). Thirty-nine (75%) of 52 patients without hemothorax survived, whether or not a thoracotomy was performed.

Conclusions: Our study suggested that the incidence of Swan-Ganz catheter-associated PA rupture is 0.031% and that an urgent thoracotomy should be performed if hemothorax is present at any point.

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OR=operating room; PA=pulmonary artery

Key words: hemothorax; ICUs; physiologic monitoring; pulmonary artery rupture; Swan-Ganz catheterization

Since the pulmonary artery (PA) catheter was introduced in 1970 by Swan et al., numerous authors have documented various complications associated with its use. These include pneumothorax, ventricular arrhythmia, complete heart block, carotid and subclavian arterial puncture, catheter sepsis, endocarditis, thrombosis, pulmonary infarction, balloon rupture, catheter knotting, and cardiac tamponade.

A rare but often lethal complication is rupture of the PA. Numerous authors have described more than 50 cases of catheter-associated PA rupture since the first case described by Chun and Ellestad. More than a dozen cases of pseudoaneurysm formation following catheter-associated PA rupture have also been described. Most authors have published case reports of one or two cases, although Barash et al. described six cases. Published incidence estimates range from 0.001 to 0.47%. This range is due to the small number of control cases included in most reports, although Shah et al. examined 6,245 patients. Our institution has extensive experience with PA catheter placement. We decided to review our experience with PA rupture to further define its incidence, risk factors, and management suggestions.

Materials and Methods

Our medical center is a 1,201-bed tertiary care teaching hospital with more than 70 beds in the adult ICU. Records of all PA catheters placed in the operating room (OR) are maintained by the office of the OR supervisor for resupply and billing purposes. Records of all PA catheters placed in any ICU or special unit are maintained by the section of inpatient cardiology for similar purposes. No other area of the hospital is used for PA catheter placement. These records were reviewed to determine the total number of PA catheter procedures in the hospital during the study period 1975 to 1991. An informal list of unusual complications or events related to PA catheters is maintained by the cardiology section and the department of surgery. Eleven cases of PA rupture related to a Swan-Ganz catheter were identified. Complete records are available for ten of these patients and they form the basis of our report. Actual radiographs were reviewed when possible; otherwise, written reports from the patient chart were used. Patient information from the charts included patient age, patient location (ICU vs OR), presence of PA hypertension, anticoagulant use, presence of hemothysis, chest radiographic findings, operations performed, and patient survival. If a patient survived the rupture and died later from unrelated causes, the patient was considered a survivor. In addition to our hospital records, the literature was reviewed for case reports of catheter-related PA rupture. When available, the same information was recorded for the patients from the literature as for our hospital patients. Sixty-five cases with adequate information were

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found. Information was entered into a computerized database (dBase IV; Ashton-Tate; Torrance, Calif) for analysis with a statistical program (dBase Stats). Categorical data were analyzed with either the χ² test or Fisher's exact test. Statistical significance was defined as p<0.05.

Results

A total of 23,291 PA catheters were placed in patients in the OR during our study and an additional 9,151 were placed in patients in various ICUs for a total of 32,442 PA catheterizations. Ten patients sustained a rupture of the PA. Six of the patients had catheters placed in the OR with the remaining four having ICU placement. The incidence rate of PA rupture is 10/32,442 or 0.00031 (if the 11th case with incomplete data is included the incidence is 0.00034). Therefore, approximately three cases of rupture can be expected for every 10,000 catheterizations.

A number of risk factors have been suggested for PA rupture (Table 1). All of our patients had at least one risk factor present. Our ten patients were all older than age 60, with a range from 66 to 89 years and an average age of 80. Two of the ten (20%) had undergone anticoagulation at the time of rupture and five of ten (50%) had pulmonary hypertension. One patient (10%) was receiving cardiopulmonary bypass. Seven of ten (70%) had rupture associated with difficult placement of the catheter or difficult repositioning of an indwelling catheter. In the 65 patients cases collected from the literature, all but 1 had at least one risk factor, most commonly age above 60 years old.

All ten patients had hemoptysis. Seven (70%) patients died. In five of the ten patients a thoracotomy was performed in an attempt to repair the rupture. Two of the five patients who received a thoracotomy survived. The third survivor was treated without surgery. There is a trend toward thoracotomy being associated with survival, but it is not statistically significant (Fisher's exact test, p=0.50). All seven patients who had a chest radiograph immediately after the rupture demonstrated an abnormality such as a hemothorax, infiltrate, or pulmonary hematoma.

To further examine the trend toward survival with thoracotomy, our ten cases were combined with 65 cases from the literature. We found a difference in survival when we looked at the subgroup of 23 patients who had a documented hemothorax. All seven patients with a hemothorax who did not have a thoracotomy died. Eight (50%) of the 16 patients with a hemothorax who had a thoracotomy survived. A thoracotomy was absolutely essential for survival. This trend was statistically significant (Fisher’s exact test, p=0.026). Among the 52 patients without a hemothorax, we could not show an effect of thoracotomy on survival. Survival was exactly the same (75%) in both subgroups.

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<th>Risk Factors</th>
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<td>Age above 60 years old</td>
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Discussion

Rupture of the PA is a rare but often fatal complication of Swan-Ganz catheterization. Our incidence rate of 0.031% is in concordance with other published rates and is probably close to the true rate, given the size of our sample. It is quite possible that centers which perform few PA catheterizations may never experience a case of PA rupture.

Various authors have proposed risk factors for catheter-induced rupture. Older age appears to be a consistent risk factor and all of our patients met this criteria. Pulmonary hypertension was mentioned by several authors. Barash et al believed that the sclerotic pulmonary vessels seen with this condition are less compliant and more fragile than normal vessels. It was also suggested that the higher pressure gradient across the lung would provide a higher driving pressure of the catheter against the arterial wall. Five of our ten patients had pulmonary hypertension.

Anticoagulation was considered a risk factor by Hanan et al. This seems intuitively correct, but anticoagulation may be more of a risk factor for continued bleeding after rupture rather than for rupture itself. Only two of our ten patients had undergone anticoagulation. Many of the patients in the literature were receiving cardiopulmonary bypass at the time of rupture. This may explain the apparent correlation with anticoagulation. In addition, the hypothermia associated with bypass may affect the fragility of the vessel wall.

A number of mechanisms have been proposed for catheter-induced rupture. Shin et al demonstrated eccentric balloon inflation, particularly in smaller vessels, which would leave the catheter tip exposed like a spear. Others have confirmed his findings in humans and in animal models and in vitro. Johnston et al showed that the most distal tip migration occurred during balloon deflation, which could also spear the vessel wall. In the report of Farber et al, the catheter was firmly wedged in position with the balloon inflated and required a gentle tug for removal. This was followed immediately by 300 mL of hemoptysis. Presumably the vessel was torn by the wedged balloon. Meltzer et al reported two cases of rupture caused by
flushing the catheter while it was wedged. Hardy et al.64 showed that balloon inflation with fluid creates enough pressure to rupture the artery by overdistention. All of these mechanisms can be avoided by inflating the balloon in a large artery with air before advancing it, minimizing the time spent in the wedge position, and then deflating the balloon before withdrawing the catheter tip back to the main PA. It is significant that in seven of our ten patients who sustained ruptures, there was some difficulty experienced either as the tip was placed into the distal PA, the balloon was inflated, or the catheter was withdrawn.

Numerous nonsurgical methods of treating a rupture have been reported. Kelly et al.48 suggested flexible bronchoscopy and Fogarty catheter tamponade if the bleeding site can be localized in the pulmonary tree. Barash et al.44 and Stein and Lisbon17 suggested double-lumen endotracheal intubation to protect the uninjured lung if hemoptysis is massive. Rubin and Puckett34 injected autologous blood clot through the catheter to seal the puncture in their patient. Scuderi et al.66 and Rice et al.49 applied 20 cm of positive end-expiratory pressure in their patients.

Surgical options have all required thoracotomy. Techniques have included lobectomy,37 pneumonectomy,44,52 hilar clamping with direct arterial repair,48 and occlusion of the hilum with subsequent removal of the band or vessel loop.17,25

Our cases and literature review support an aggressive policy of management of catheter-associated PA rupture. Hemoptysis in a patient with a Swan-Ganz catheter should be considered evidence of a PA rupture. Evidence of hemothorax, either clinical or radiographic, demands immediate thoracotomy with direct surgical repair or resection. We have shown that patients with hemothorax will not survive if treated nonoperatively. It is less clear that patients without a hemothorax need surgery. Patients without a hemothorax have been treated both surgically and nonsurgically with similar results. Their survival is 75%. A study able to detect a 20% increase in this survival (from 75 to 90%) with a statistical power of 90% would require more than 150 patients in each treatment arm. This would require a study enrolling more than 1.4 million patients requiring PA catheters. Obviously this will never occur and it will never be definitely known if surgical intervention improves survival in patients without hemothorax. Therefore, we make the following recommendations. The first step in nonoperative treatment is to alert the OR and thoracic surgeon of the possibility of immediate thoracotomy if hemothorax should develop. Anticoagulation should be reversed and the catheter should be pulled back into the main PA. If hemoptysis continues, the patient should be intubated with a double-lumen endotracheal tube and treated with positive end-expiratory pressure. Flexible bronchoscopy can be considered. The threshold for taking the patient to surgery should be low and should be prompted by the development of hemothorax, continued hemoptysis, or hemodynamic instability. It would be helpful to be able to predict which patients without hemothorax will subsequently develop a hemothorax. Unfortunately our data could not answer this question.

In summary, catheter-associated PA rupture is a rare but often lethal complication. Patients with a hemothorax must undergo thoracotomy to survive. Patients without a hemothorax should initially be treated without surgery, but the threshold for operating should be low.

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