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# Pulmonary Artery Rupture Management with a Single Lumen Endotracheal Tube: Old Tricks that Should be Revisited

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**Conflict of interest:** None declared

**Patient:** Female, 67  
**Final Diagnosis:** Pulmonary artery rupture  
**Symptoms:** Hemoptysis • shortness of breath  
**Medication:** —  
**Clinical Procedure:** Ventricular assist device  
**Specialty:** Cardiac Surgery

**Objective:** Unusual clinical course

**Background:** Pulmonary artery rupture can be a lethal complication of a pulmonary artery catheter (PAC). Different techniques have been used to manage PAC-induced pulmonary artery rupture, including double lumen endotracheal tube (DLT), bronchial blockers, pulmonary artery embolization, thoracotomy with hematoma evacuation, and extracorporeal life support for ventilation (ECLS). Single lumen endotracheal tube (ETT) is not frequently reported in the literature despite its advantages.

**Case Report:** The authors present a case of PAC-induced pulmonary artery rupture successfully managed with a single lumen ETT. Although single lumen ETT is more labor intensive and requires constant critical care attention, the advantages of this technique are reported in this case in comparison to other well-documented therapies.

**Conclusions:** With on-going pulmonary bleeding, a single lumen ETT intubation offers advantages to the commonly advocated methods of treating a PAC-induced pulmonary artery rupture.

**MeSH Keywords:** Bronchoscopes • Catheterization, Swan-Ganz • Critical Care • Hemoptysis

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## Background

Although, the incidence of pulmonary artery rupture due to pulmonary artery catheterization (PAC) is low at 0.031% [1], it has the potential to be a devastating complication. The mortality rate of pulmonary artery rupture averages 50% but can be as high as 75% in anticoagulated patients [2].

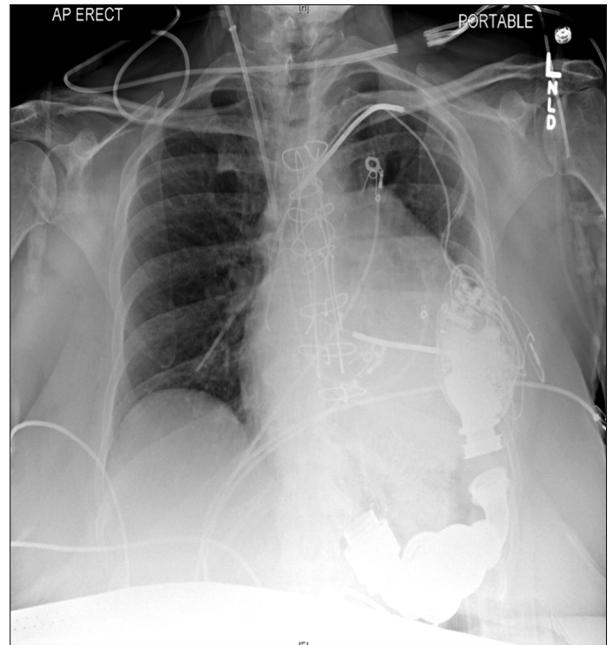
Risk factors for pulmonary artery rupture due to a PAC include pulmonary hypertension, anticoagulation, and hypothermia [3]. The incidence of pulmonary artery rupture due to PAC is probably underestimated. They most likely resolve spontaneously after a small hemoptysis episode and therefore are under investigated [4]. However, ruptures of the pulmonary artery can lead to rapid and life-threatening intrapulmonary bleeding that should be addressed emergently and thoroughly.

Commonly accepted management of a pulmonary artery rupture include placement of a double lumen endotracheal tube (DLT), bronchial blockers, inflating the PAC balloon in hopes of tamponading the bleed [5], pulmonary artery embolization in interventional radiology, performing a thoracotomy for hematoma evacuation and/or extracorporeal life support (ECLS). Literature lends little discussion to utilizing a single lumen endotracheal tube (ETT) and serial bronchoscopy evaluation for the management of pulmonary artery rupture. The present case details the advantages of a single lumen ETT in a complex patient to provide optimal and timely management of ongoing pulmonary bleeding secondary to a PAC-induced pulmonary artery rupture.

## Case Report

A 67-year-old African American woman with a history of chronic kidney disease, pulmonary hypertension, hypothyroidism, and non-ischemic dilated cardiomyopathy status post Heartmate II LVAD (Thoratec, Pleasanton, CA, USA) was admitted to the hospital for melanotic stools. Her international normalized ratio (INR) on admission was 2.8. She was found to have gastrointestinal arteriovenous malformations requiring no intervention. After cessation of her gastrointestinal bleeding, she was maintained on intravenous heparin for therapeutic anticoagulation. To further evaluate her cardiac function, a PAC was placed demonstrating pulmonary artery pressure of 29/7 mm Hg, central venous pressure of 8 mm Hg, pulmonary artery occlusion pressure of 5 mm Hg and cardiac index of 2.69.

The following morning, the patient's pulmonary artery waveform appeared to be spontaneously wedged and her chest x-ray supported migration of the catheter (Figure 1). With minimal manipulation of the catheter, she began having copious bright red hemoptysis. The PAC was removed, and she was



**Figure 1.** Chest radiograph showing patient's pulmonary artery catheter wedged the morning following the day of pulmonary artery catheter placement.

emergently intubated with a single lumen ETT. She became acutely hemodynamically unstable and therefore was resuscitated with two 1-mg epinephrine boluses and increases in her inotropic medications consisting of dobutamine and epinephrine.

All anticoagulation was held, and an initial bronchoscopy was performed which did not identify a bleeding source. However, her chest x-ray revealed complete opacification of the left hemithorax prompting a repeat bronchoscopy. This bronchoscopy revealed the bleeding originating from her proximal left main stem bronchus. Irrigation and evacuation of the blood was accomplished; however, cessation of bleeding could not be verified. Therefore, her single lumen endotracheal tube (ETT) was advanced into the right main stem bronchus under bronchoscopic guidance to protect her right lung. This was continued until repeat bronchoscopy was warranted (Figure 2). The ventilator settings were adjusted accordingly for one-lung ventilation with decreased tidal volume of 350-mL and a slightly higher respiratory rate of 16 breaths per minute.

A few hours later, by withdrawing ETT into the trachea, a repeat bronchoscopy was performed. This examination identified a large fibrin clot originating from the left main stem bronchus with partial carinal occlusion. This could not be evacuated with lavage and suction and required biopsy forceps to be partially removed. A more friable clot was noted beneath it, which was gently lavaged and suctioned but not completely removed. The single lumen ETT was again advanced under bronchoscopic guidance into the right main stem bronchus.



**Figure 2.** Chest radiograph showing endotracheal tube advanced to right main bronchus.

Over the course of the next few days, pullback of the single lumen ETT and repeat bronchoscopies were performed for evaluation of bleeding and evacuation of blood and friable clots. The right lung remained clear of blood spill-over and appeared healthy during this time. Her blood gases, laboratory values, and ventilation parameters remained stable throughout, thus more invasive investigation or intervention was not warranted. She also weaned successfully from her inotropic medications.

On post-bleed day 3, her bronchoscopy revealed no further bleeding and it was felt safe to attempt 2-lung ventilation. She tolerated this well and was successfully extubated. Her anticoagulation continued to be held until she was successfully discharged from the intensive care unit without further bleeding sequelae.

## Discussion

Primary management of PAC-induced pulmonary artery rupture needs to focus on the prevention of asphyxia in a rapid manner. Hypoxia secondary to bleeding is the main factor leading to death. When signs of any pulmonary bleeding during catheter placement and/or manipulation occur, preventing contamination of the unaffected lung is essential to prevent complete lack of oxygenation and ventilation [4].

The incidence of spontaneous bleeding resolution when a PAC induces a pulmonary artery bleed is unknown, but likely occurs often and is under reported. This is because the pulmonary system is a low-pressure system and blood loss is rarely massive enough to cause a great threat to the hemodynamic status. Patients may require hemodynamic support which

should be done concomitantly while obtaining lung protection of the non-bleeding lung. This is different from massive hemoptysis secondary to bronchial systemic high-pressure bleeding which has a higher propensity of rapid hemodynamic decline and asphyxia [4].

The standard and recommended therapies for pulmonary artery rupture include: placement of a DLT [6], placement of bronchial blocker [7], thoracotomy with hematoma evacuation [8], pulmonary artery embolization [6,9,10], and ECLS [10]. Single lumen ETT placement with purposeful main stem position remains a less utilized treatment modality. This is likely due to the vigilance and skill required not only in bronchoscopic evaluation and careful hematoma evacuation, but also in intensive care unit monitoring and ventilation management required for this technique.

Each of the previously stated therapies has substantial shortcomings that can be overcome with use of a single lumen ETT. Due diligence must be paid to proper placement within the main stem, timely and frequent bronchoscopic investigations, and prudent adjustment of the ventilator settings. In our case, the bleeding lung was the left and thus the right lung needed protection with a right main stem intubation. If the left lung needed protection, the left main stem would have needed intubation. This may have presented a challenge but can be easily achieved with skilled bronchoscopic visualization. Overall, the authors believe that in stable patients with pulmonary artery bleeding, utilization of a single lumen ETT is advantageous for immediate management, better lavage and evacuation of blood and ultimately results in earlier extubation.

However, DLT intubation is the most commonly recommended therapy for cases of massive hemoptysis including those due to pulmonary artery rupture. While this modality does serve the purpose of lung protection from blood spillage into the healthy lung, it does not allow bronchoscopic evacuation of clots due to the small caliber of the DLT. Only small caliber bronchoscopes can fit through a DLT, which severely limits the blood evacuation. This would lead to severe alveolar damage from blood sitting in the injured lung. This lung damage could prove irreversible [11].

Some authors report success with bronchial blockers placed in a single lumen ETT both for lung isolation and for possible tamponade of the bleeding source [7]. This technique is limited by the inability to lavage blood from the airways via bronchoscopy. Without frequent bronchoscopy, it also cannot be ascertained when the bleeding has subsided, and 2-lung ventilation can be attempted. In order to perform bronchoscopy, the blocker must be removed and then replaced after the airways are lavaged. While this technique could be effective, the safety is questionable. Lung protection during the blocker

withdrawal is concerning as it cannot be done under guidance. There may also be leakage of blood around the blocker as depending on the specific blocker, the seal is questionable. Also, balloon over-inflation may have dire consequences such as ventilation problems or cardiac arrest. Bronchial blockers notoriously become dislodged or migrate with significant implications in a bleeding patient [12].

Some authors have suggested tamponading the site with a blocker. However, this would be extremely difficult and may in fact cause further injury to friable tissue. For this reason, hopeful and usually blind attempts of tamponading with a bronchial blocker or the PAC which caused the injury does not seem prudent.

While pulmonary artery embolization may provide definitive treatment for a PAC-induced pulmonary artery rupture, identifying the exact source of bleeding is extremely difficult when there is active bleeding in the acute period. Furthermore, it is even more difficult if there is no bleeding. In fact, locating small sources of bleeding, seen often with PAC-induced pulmonary artery ruptures, complicates the success rate of this procedure [6]. During the time of intervention attempts, the patient may continue to have lung damage due to sanguineous secretions spilling into the healthy lung. Additionally, embolization is a procedure that is typically performed in a remote location requiring transport of a potentially unstable patient who should be monitored in an intensive care unit. Lastly, there are several complications associated with coil embolization of vessels, including infarctions, the exact etiology being treated in this scenario [13,14].

Thoracotomy procedures may be necessary for large ruptures. However, the majority of pulmonary artery ruptures due to PAC are small. Also, quite often the tissues will repair without surgical intervention if protection to the lung is guaranteed and anticoagulation is held. A thoracotomy is a large procedure and may not be well tolerated by critically ill patients. Additionally, the thoracotomy itself will not provide lung protection. Thus, an airway device for this purpose is still required. In one report, 5 patients had a thoracotomy in an attempt to repair a PAC-induced pulmonary artery rupture. Only 3 of the 5 patients survived; the third survivor required further surgery [8].

With severe pulmonary artery ruptures, ECLS can provide life-saving oxygenation and ventilation, but does not offer lung protection by itself. Because of potential significant injury to the healthy lung, the additional step of lung isolation is still necessary even if the blood gases and hemodynamics may appear to stabilize while on ECLS. The use of ECLS for pulmonary artery bleeding is most troublesome in that life-threatening bleeding due to the necessary ECLS anticoagulation will likely

occur. When providing adequate oxygenation and ventilation without serial bronchoscopy evaluations, continued bleeding and lung injury may go unrecognized with ECLS [15,16]. If a DLT or a bronchial blocker is placed for lung isolation during ECLS, bronchoscopy with lavage options are limited as discussed.

While all patients with pulmonary artery ruptures due to PACs cannot be treated identically, we feel that much of the current practice recommendations can be simplified with benefit to the patient. First and foremost, asphyxia, hypoxia, and lung injury need to be monitored and managed. A single lumen ETT is likely the fastest way to do this. Being able to investigate the bleeding source and further gently lavage and evacuate copious amounts of blood and clot debris with a large caliber bronchoscope is necessary to quell injury to the bleeding lung and to protect the healthy lung. Frequent monitoring for bleeding cessation with bronchoscopy may expedite extubation. Frequent examinations for bleeding may also aid decision-making regarding resumption of anticoagulation in patients who need it, such as those with VADs, as in our patient's case.

A single lumen ETT allowing for frequent bronchoscopic assessment and lavage was a frugal yet superior management for PAC rupture in our patient. There are several caveats to be appreciated when utilizing this process. First, it is important to acknowledge that many PAC-induced ruptures, especially if anticoagulation is held, can self-resolve. Second, intensive care unit monitoring is required to ensure safety and stability during this process. Bleeding cessation may take hours to days and can only be recognized with examination via bronchoscopy. Third, minimization of lung injury to the bleeding lung and avoidance of lung injury to the healthy lung needs to be accomplished quickly and can further be life-saving. This protection needs to be adhered to, without question of misplacement, until bleeding stops. Finally, formation of a pulmonary artery pseudoaneurysm may result in bleeding several days after the initial insult. Thus, the authors would advise obtaining a contrast CT scan once the patient is stable to evaluate for a pseudoaneurysm as bleeding could recur at this site [17,18].

## Conclusions

In summary, a single lumen ETT has potent merits when managing a pulmonary artery rupture. This technique is not only superior in numerous ways, but also provides the least invasive mechanism of treatment for these patients.

## Declarations of interest

None.

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