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Postmortem Angiography of Catheter-Induced Pulmonary Artery Perforation

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ABSTRACT: A case of pulmonary artery perforation by the placement of a balloon-tipped, flow-directed (Swan-Ganz) catheter, as demonstrated postmortem by angiography and confirmed by conventional autopsy method, is reported. Angiography is an effective adjunctive modality in the postmortem diagnosis and localization of pulmonary artery perforation. In cases of suspected catheter-induced pulmonary artery perforation and death, postmortem angiography may prove useful to the forensic pathologist.

KEYWORDS: pathology and biology, pulmonary artery perforation, catheter-induced pulmonary artery perforation

Since its invention in 1970, the flow-directed balloon-tipped (Swan-Ganz) pulmonary artery catheter has gained widespread use in the bedside evaluation and management of the hemodynamic status in patients who are in shock or severe pulmonary edema [1,2]. Such invasive hemodynamic monitoring has been associated with several complications involving the pulmonary arterial tree, including local thrombosis, pulmonary infarction, and perforation. The incidence of pulmonary artery perforation with hemorrhage has been reported to range from 0.1 to 0.2% of catheterized patients [3]. Risk factors for rupture include pulmonary hypertension, anticoagulation, hypothermia, advanced age, and sustained use of corticosteroids [4,5]. Proposed mechanisms of rupture include perforation by the catheter tip, eccentric balloon inflation, and inflation of the balloon in an inappropriately small ramification of the pulmonary artery [4]. Kelly et al. report a 53% fatality rate among the 15 cases reviewed from the literature [6].

At autopsy, a clinical history of hemoptysis or sudden localized air-space opacification in the region of the catheter tip strongly suggests pulmonary artery perforation. However, if a localized thrombus or hematoma is not identified, the actual site of perforation may not be found by conventional methods [7]. Since the question of interventional mishap arises when sudden death occurs during an invasive procedure, such as Swan-Ganz catheterization, the detection of a possible pulmonary artery perforation becomes the central task of the forensic pathologist.

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This article presents a case of fatal pulmonary artery perforation by Swan-Ganz catheterization, the diagnosis of which was established by postmortem angiography and confirmed by conventional pathologic techniques.

Report of a Case

A 71-year-old man was admitted to the Veterans Administration Hospital with sepsis secondary to diverticulitis with perforation. His clinical course was characterized by recurrent bouts of congestive heart failure complicated by hypotensive episodes. The patient's hemodynamic status was monitored with the Swan-Ganz catheter and managed with antiarrhythmic, pressor, and afterload reduction agents.

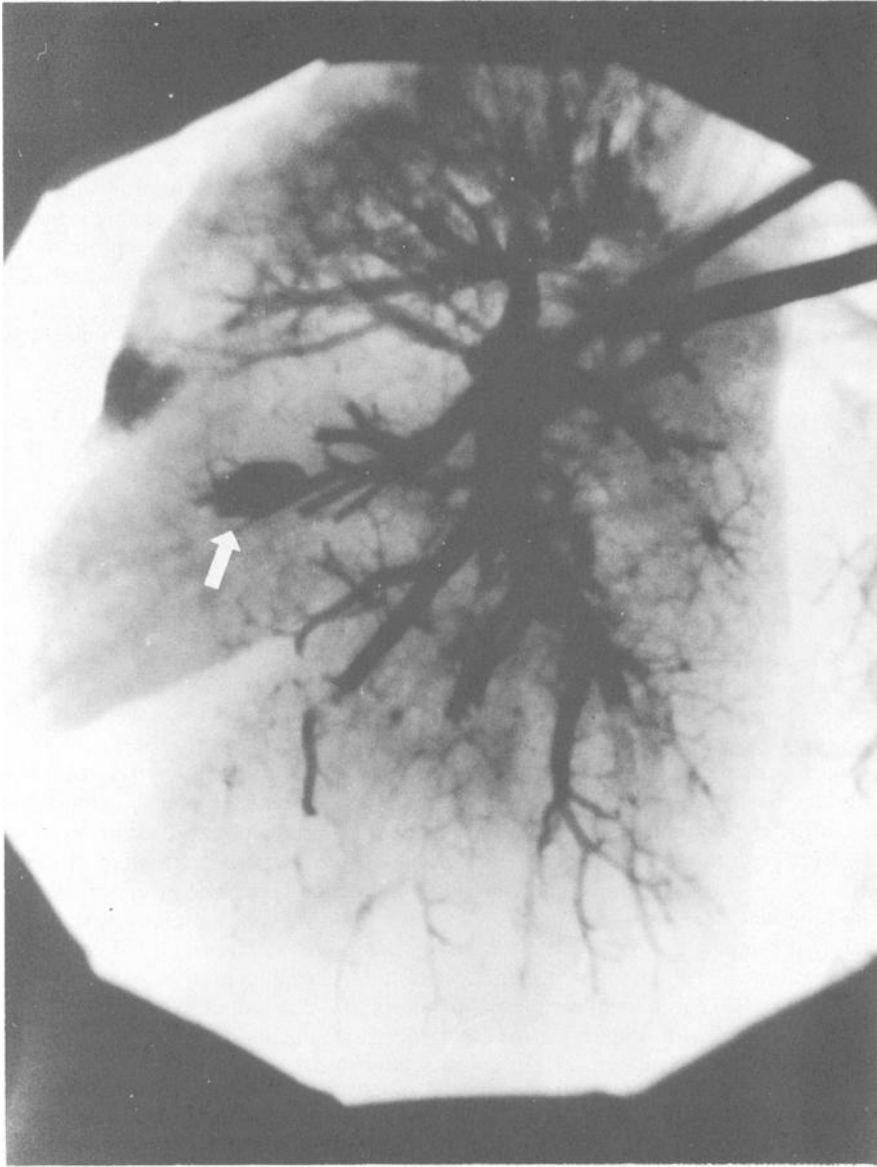
On the 19th day after admission, a Swan-Ganz catheter (7.5 French) was placed via the right internal jugular vein. At this time, the patient had a platelet count of 36 000/mm³, a prothrombin time of 13 s (11 to 13 s), and a partial thromboplastin time of 39 s (21 to 35 s). An elevated pulmonary capillary wedge pressure of 22 mm. Hg was obtained, accompanied by prominent V waves (pulmonary artery pressure 41/29 mm Hg). In an effort to confirm these findings, the clinician deflated the 1.5 cm diameter balloon and withdrew the catheter approximately 10 cm. The balloon was reinflated without sensing any resistance, and the catheter readvanced approximately 5 cm. The patient then coughed and expectorated approximately 5 mL of fresh blood. Rapid cardiorespiratory deterioration followed. No extraordinary attempts at resuscitation were made, as had been the patient's wish. A chest radiograph at this time demonstrated new, patchy air-space consolidation of the entire right lung and no evidence of congestive failure in the clear left lung. Although the Hennepin County Medical Examiner accepted jurisdiction of the case, the autopsy was performed at the Veterans Administration Hospital.

On autopsy, the lungs were obtained en bloc with mainstem bronchi and trachea. Gross examination revealed diffuse right lung hemorrhage. A Councill catheter was inserted into the trachea, and the lungs were inflated with air. A second Councill catheter was placed in the right pulmonary artery, and iodinated water-soluble contrast material was injected for postmortem angiography. Serial digital subtraction images were obtained. A false aneurysm with perforation of the proximal medial segmental artery of the right middle lobe was demonstrated (Fig. 1A,B). Dissection of the pulmonary vasculature, guided by the angiogram, revealed a 1.2 cm linear longitudinal laceration, 3 cm beyond the bifurcation of the right pulmonary artery. Histologic examination of a section of the involved artery (prepared with Verhoeff-Van Gieson stain) revealed an abrupt disruption in the arterial wall with underlying fibrinoid debris, fragments of collagen and elastin, hemorrhage, and inflammation (Fig. 2). Cut sections of the right lung revealed diffuse hemorrhage, with no localized hematoma, thrombus, or cavity. The medical examiner classified the death as a therapeutic accident resulting from pulmonary artery perforation during the Swan-Ganz catheterization.

Comment

The documented morbidity and mortality associated with pulmonary artery perforation is significant enough to have elicited suggestions as to how the Swan-Ganz catheter as well as insertion techniques might be modified [4,8]. Of the known complications, pulmonary-artery perforation is probably the most disastrous. Massive hemorrhage is considered typical and may be acute or delayed [6,9,10]. The extent of hemorrhage varies from localized parenchymal involvement to hemothorax. As might be expected, the clinical sequelae vary significantly as well.

In rare cases, *in vivo* pulmonary angiography has led to the treatment of contained false aneurysms by transcatheter embolization [9]. Typically, the clinician is alerted to

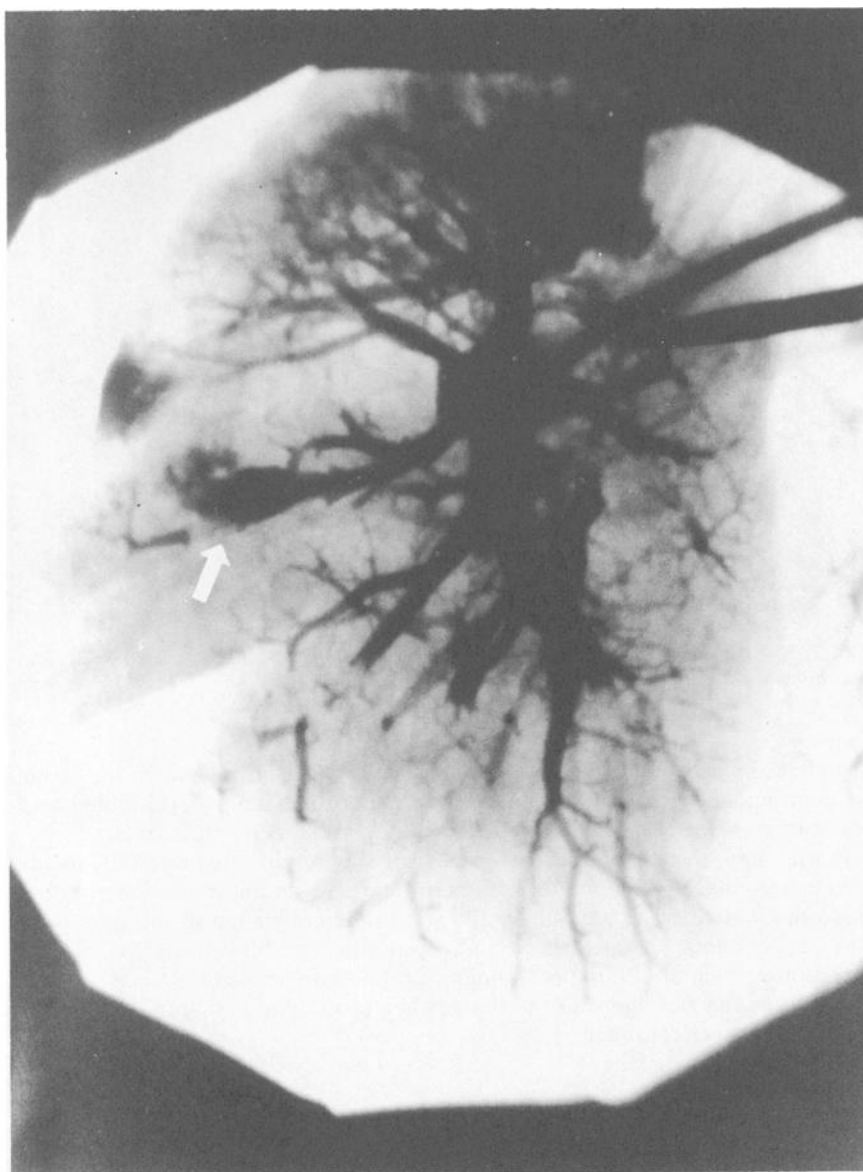


A

FIG. 1 (A)—Serial digital subtraction angiograms showing extravasation of dye from the site of perforation (medial segmental artery of the right middle lobe).

the possibility of this complication by massive and sometimes recurrent hemoptysis, a new focal area of pulmonary consolidation surrounding the catheter tip on chest radiograph, or a new pleural fluid collection.

The case reported here is unusual in two respects: (1) the small amount of blood perceived externally and (2) the consolidation of the entire right lung demonstrated radiographically. Documented cases of angiographic diagnosis and successful transcatheter embolization without need for thoracotomy challenge us to diagnose those cases of



B

FIG. 1 (B)—Serial digital subtraction angiograms showing extravasation of dye from the site of perforation (medial segmental artery of the right middle lobe).

perforation that do not appear with classic signs, as well as those with massive hemoptysis or sudden cardiorespiratory failure [9].

The value of postmortem angiography lies in the diagnosis and localization of iatrogenic pulmonary artery perforation. Even when pulmonary artery rupture is strongly suspected, the actual site of injury is rarely identified on gross examination alone [7]. If the patient has died without demonstrating the classic signs, a thorough search may not be made. We therefore agree with Fraser that the incidence of pulmonary arterial rupture



FIG. 2—Disruption of pulmonary arterial wall, with underlying fibrin, fragments of collagen and elastin, hemorrhage, and inflammation (Verhoeff-Van Gieson, $\times 100$).

is underestimated. To our knowledge, this case is the third in which the technique of postmortem angiography has supplemented the routine autopsy [10]. Pulmonary-artery perforation is demonstrated effectively by digital subtraction angiography.

In summary, the use of postmortem angiography fulfills three roles: (1) the diagnosis of catheter-induced pulmonary artery perforation, (2) localization of the perforation to guide the search for a tissue diagnosis, and (3) determination of the true incidence of perforation among patients who recently were monitored invasively. By facilitating the detection of such an arterial perforation, postmortem angiography may assist in documenting the manner and cause of death when procedural mishap is a concern and the medical examiner consulted.

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