thrombosis and not readily explained by pannus ingrowth. In a series of surgically removed prosthetic heart valves, Schoen (6) reported that tissue ingrowth was not a cause of valve failure in any of 112 bioprosthetic valves, but accounted for 20% of the failures in 45 mechanical prosthetic valves. Nonetheless, tissue ingrowth is a differential diagnostic consideration.

Prosthetic mitral valves, particularly mechanical valves, have a high rate of thrombotic complications. Current practice is to anticoagulate all mechanical and most mitral bioprosthesis patients (7). Patients with thrombosis of a mitral prosthesis generally have 1 to 3 days of orthopnea followed by congestive heart failure (8). Rapid clinical deterioration requires urgent valve debridement and atrial thrombectomy (9). Fibrinolytic therapy can be effective for treatment of late thromboses of prosthetic valves, but risk of systemic embolization is reportedly as high as 18% (10). The superior ability of transesophageal echocardiography to clarify prosthetic morphologic changes and to detect thrombus in the left atrial appendage may ultimately allow safer use of such therapy. However, a clinical element to the echo diagnosis of prosthetic thrombus is necessary. Transesophageal echocardiography should be used early in the assessment of suspected prosthetic valve

abnormalities to identify the cause and allow possible intervention directed toward prevention of additional sequelae.

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Cerebral air embolism during removal of a pulmonary artery catheter

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Monitoring of cardiovascular function by pulmonary artery catheter provides an important source of information to assist in the proper management of critically ill patients (1). There are a number of reported complications, both immediate and late, associated with the use of the pulmonary artery catheter (2). The most important complications are

cardiac dysrhythmias, pulmonary artery rupture, pulmonary infarction, and infection. Complications can occur during removal of the pulmonary artery catheter. These complications include: inability to remove the catheter, cardiac dysrhythmias, and venous air embolism. The following case illustrates the occurrence of venous air embolism leading to paradoxical air embolism during the removal of a pulmonary artery catheter.

venous air embolism, carotid artery puncture,

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CASE REPORT

A 66-yr-old, 65-kg male with diabetes mellitus, occlusive peripheral vascular disease, coronary artery disease, left renal artery stenosis, hypertension, and crescendo claudication of the lower extremities underwent a

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Key Words: embolism; catheterization, pulmonary artery; foramen ovale; ventilation, mechanical; tachycardia; hemiplegia; air embolism; echocardiography; critical care; cerebrovascular accident

left femoral to posterior tibial artery saphenous vein bypass graft procedure. A general anesthetic was performed with the administration of isoflurane, nitrous oxide, and fentanyl. Intraoperative monitors included a continuous ECG, radial arterial catheter, capnograph, pulse oximeter, and pulmonary artery catheter inserted via the right internal jugular vein. Anesthesia and surgery were uneventful. After surgery, the patient was mechanically ventilated in the surgical ICU. Over the next 48 hrs, the patient was weaned from mechanical ventilation and the endotracheal tube was removed after it was determined that normal arterial blood gas values could be maintained with room air. After extubation, the patient was alert with normal neurologic function. The pulmonary artery catheter was removed with the patient in a 15° headup position. During obturator placement after catheter removal from the insertion sheath, there was bleeding from the junction of the side-port valve and the sheath. In an attempt to seal the leak, the port assembly was tightened and an obturator inserted into the sheath. During this procedure the patient became agitated, confused, hypertensive, and developed ventricular tachycardia that resolved within 1 min. The patient became unresponsive with conjugate movement of the eyes to the right and seizures involving the left side of the body. Diazepam (5 mg) iv, supplemental oxygen, and an iv nitroprusside infusion were administered. Fifty minutes after this event, a CT scan of the brain showed air bubbles in the cerebral circulation (Fig. 1). The patient improved over the next 48 hrs with increased responsiveness and a more alert sensorium, including proper verbal response. However, he continued to have periods of confusion and a persistent left hemiplegia. A contrast echocardiogram was performed, but no right-to-left intracardiac shunt could be demonstrated. Although he continued to improve clinically, he still has residual left hemiparesis. Four months after the episode, the patient is able to talk and walk with support.

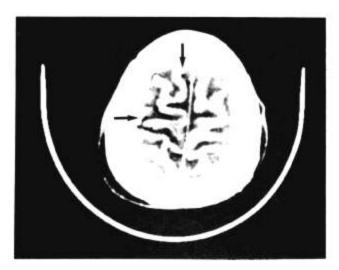


Figure 1. CT scan of the brain showing multiple air bubbles in the cerebral circulation (*arrows*) 50 mins after removal of the pulmonary artery catheter and development of acute neurologic signs.

DISCUSSION

We are reporting this case because of the neurologic symptoms associated with the radiologically proved cerebral air embolism that occurred after removal of the pulmonary artery catheter, despite the lack of demonstrable intracardiac shunt. Venous air embolism has been reported to occur via a malfunctioning valve on the side-port assembly (3). Venous air embolism is a potentially important complication during central venous cannulation. The signs and symptoms of venous air embolism depend on the amount of air entering the circulation. Small quantities of air may produce no signs while large quantities of air may produce increased central venous and pulmonary artery pressures, right ventricular failure, hypotension, and death.

Paradoxical air embolism can occur from venous air embolism, although there is usually an intracardiac defect or a patent foramen ovale. A probe patent foramen ovale can be present in nearly 25% to 30% of the population with no history of cardiac disease (4). A patent foramen ovale can open or close depending on the pressure differential between right and left atria. When the right atrial pressure exceeds the left atrial pressure, as in pulmonary embolism, pulmonary hypertension, and right ventricular failure, a right-to-left shunt can result through a patent foramen ovale. Consequently, demonstration of a patent foramen ovale will depend on the dynamic conditions present at the time of the study. The absence of a demonstrable shunt in our patient does not exclude the possibility of a patent foramen ovale. transesophageal echocardiogram can also help detect paradoxical air embolism (5). Paradoxical air embolism can occur without an intracardiac shunt (6, 7). The air can pass through the pulmonary arterial system to the systemic arterial system through congenital (8) or acquired (e.g., hepatic disease) (9, 10) arteriovenous communications in the lungs. However, in most of these reports, the air bubbles associated with the neurologic signs were not seen, but autopsy studies concluded that the pathologic changes were secondary to air embolism. Generally, pulmonary arteriovenous communications produce hypoxemia with resultant cyanosis and finger clubbing. Our patient did not show any evidence of pulmonary arteriovenous communication or hepatic disease.

The amount of time required for clearance of air bubbles from the cerebral circulation is not known. Air bubbles were seen within 50 mins of the event in our patient. Autopsy studies in a report (9) demonstrated air in the cerebral vessels 2 days after occurrence in a patient after liver transplantation. Air can also localize in the pulmonary circulation and serve

as a reservoir for repeated systemic air embolism over a long period of time.

The ventricular tachycardia in our patient could have been secondary to coronary artery air embolism, although there were no detectable ST-T wave changes.

In conclusion, we report a patient who developed paradoxical air embolism with neurologic dysfunction during removal of a pulmonary artery catheter. We were able to demonstrate air in the cerebral circulation by CT scan. We recommend meticulous care when removing pulmonary artery catheters, including checking for duckbill valve competence, loose connection of the side port to the sheath, and open ports. The head-up position should be avoided when removing pulmonary artery catheters.

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Aminophylline antagonizes the neuromuscular blockade of pancuronium but not vecuronium

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Theophylline antagonizes nondepolarizing neuromuscular blockade in animals (1, 2) and has been anecdotally noted to do so in man (3, 4). However, the two patients reported (3, 4) had both received hydrocortisone, which has also been implicated in the antagonism of neuromuscular blockade (5). Herein, we report a patient not receiving other potentially antagonistic drugs in whom aminophylline caused resistance to neuromuscular blockade by pancuronium. Subsequently, successful blockade was achieved with the administration of vecuronium.

CASE REPORT

A 48-year-old white male weighing 82.3 kg was admitted for exploratory thoracotomy and pneumonectomy after the discovery of a mediastinal mass on a routine chest radiograph in July 1989. Before admission, a biopsy taken at mediastinoscopy demonstrated undifferentiated largecell cancer. A metastatic "work-up" was negative. Two months before hospitalization, the patient received chemotherapy consisting of cisplatin and VP-16 with chest and brain irradiation (45 Gy in 25 treatments over 35 days). Throughout his treatment course, the patient did not have any constitutional symptoms. Past medical history was not contributory. Family history was important only for several family members with other types of cancer. The patient was a 30 "pack-yr" cigarette smoker but had stopped for several years. He had no allergies and was taking no medications at the time of admission. Physical examination was exceptional only for a BP of 98/80 mm Hg.

Preoperative laboratory studies showed a hematocrit of 34% and room air arterial blood gases of pH 7.42, Paco₂ 40.5 torr (5.4 kPa), Pao₂ 77.0 torr (10.2 kPa), ionized bicarbonate 26.5 mmol/L, and a hemoglobin saturation of 93.8%.

The patient underwent a right posterolateral thoracotomy and pneumonectomy with mediastinal node

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