
Case Report

Fatal Paradoxical Air Embolism to the Brain: Complication of Central Venous Catherization

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ABSTRACT. A case of paradoxical air embolism to the brain via a patent foramen ovale after placement of a central venous catheter is reported. Diagnosis was facilitated by seeing punctate areas of lucency in the brain after computed tomography

of the head. Presence of a right-to-left shunt was confirmed by radionuclide study of the brain after intravenous injection of ^{99m}Tc -labeled albumin microspheres.

In the 10 years since introduction of total parenteral nutrition, 19 cases of venous air embolism occurring as a direct complication of central venous catherization have been reported, seven of them fatal (37%).¹⁻⁴ We now report death following cerebral arterial air embolism occurring via a patent foramen ovale as a complication of central venous catherization.

CASE REPORT

A 72-year-old man was admitted for evaluation of obstructive jaundice and severe weight loss. He had both a mass in the head of the pancreas and dilated bile ducts. To help prepare him for surgery, a right internal jugular catheter was placed for parenteral nutrition. Three hours later, the patient was found in decerebrate coma; 5 min earlier he had appeared normal. The central venous catheter was leaking blood because the intravenous (IV) administration set was detached from the hub of the catheter, despite the fact that the connection had been secured with adhesive tape.

Computed tomography of the head showed punctate areas of lucency in the middle cerebral artery and anterior cerebral artery territories, suggesting presence of gas within the cerebral vascular system (Fig 1). Because of the likelihood of a right-to-left shunt to explain the transfer of air from the venous circulation to the cerebral circulation, a radionuclide study of the brain was done following the IV injection of 20,000 human albumin microspheres (mean diameter: 30 μm) labeled with 3 mCi ^{99m}Tc .⁵ Multiple focal regions were present within the brain (Fig 2); these findings were diagnostic for the

presence of a right-to-left shunt because normally over 95% of the microspheres should be trapped by the lung capillary network, with less than a 4% right to left loss via the Thebesian, bronchial, and pleural veins and intrapulmonary capillary shunts. Six days later, the patient died from hepatic failure and upper gastrointestinal bleeding.

At autopsy examination, a patent foramen ovale was found, and the presence of a carcinoma of the head of the pancreas was confirmed. Multiple areas of recent infarction were present in the right cerebral hemisphere and the superior aspect of the left hemisphere. No occlusive vascular lesions were identified. Air bubbles could not be identified in the cerebral vessels, probably because the gas had been absorbed. There were no cerebral metastases from the pancreatic carcinoma.

DISCUSSION

Air embolism from peripheral veins to the lungs has been recorded following a variety of surgical, therapeutic, and diagnostic procedures. The rate at which air enters the venous circulation and subsequently the pulmonary artery circulation appears to be more important than the volume.^{1,6,7} In this respect, air embolism during catherization of a central vein appears to be more harmful than air embolism via a peripheral vein, because 100 ml air/sec can traverse a 14-gauge needle that is 5 to 6 cm long if there is a 5-cm H_2O pressure difference across the needle.⁷

If the air embolism occurs in a patient who has a right-to-left shunt, the air can pass into the systemic arterial circulation (paradoxical air embolism). When it occludes cerebral vessels, even 2 or 3 ml air is likely to cause cerebral damage and eventually death. Three patients having sustained paradoxical air embolism during neurosurgical procedures in the presence of a foramen ovale

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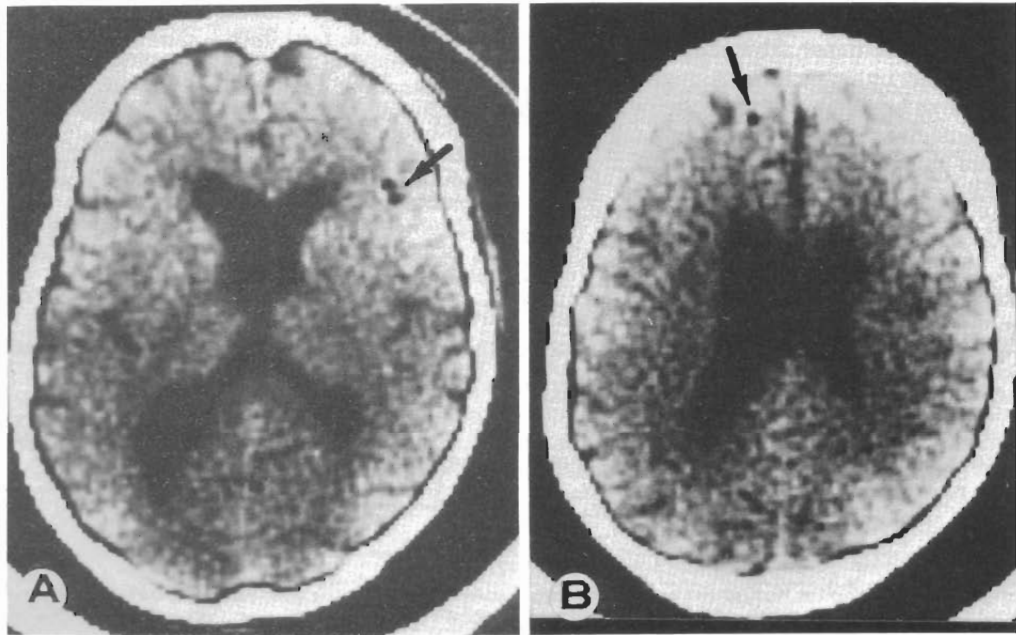


FIG. 1. Computed tomographic scan of the head after paradoxical air embolism shows punctate areas of lucency in (A) the middle cerebral artery territory, and (B) the anterior artery territory.

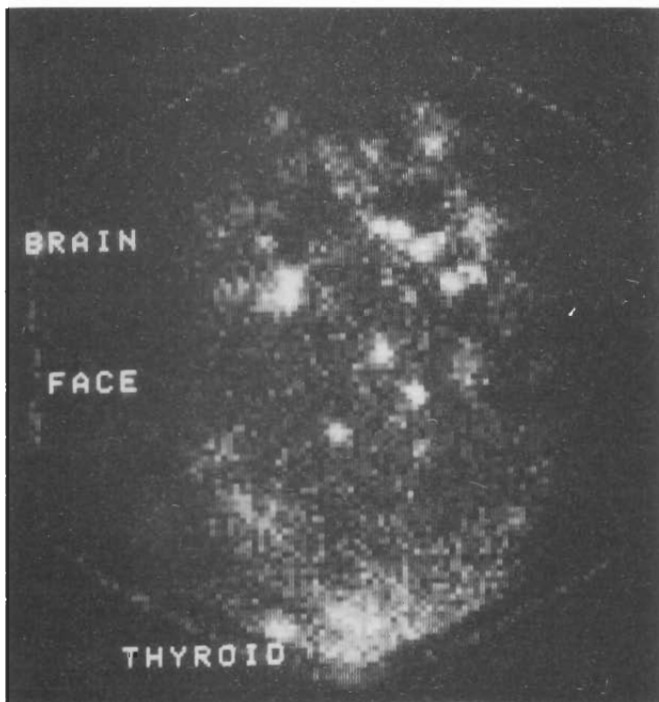


FIG. 2. Radionuclide study following IV injection of ^{99m}Tc -labeled human albumin microspheres. Abnormal focal regions are present within the brain and the face.

have been described.⁸ Another report concerned paradoxical embolism of a catheter, which **lodged in a branch** of the renal artery.⁹

Our patient sustained paradoxical air embolism to the brain via a foramen ovale as a complication of accidental disconnection of a central venous catheter. The presence of his patent foramen ovale was unknown. In fact, the majority of patent foramina ovals (present in 20–25% of

normal people) have no clinical importance, because the higher pressure in the left atrium keeps the foramen ovale closed.¹⁰ In this patient, a right-to-left shunt surely occurred through the foramen ovale, because of venous air embolism to the pulmonary artery via the disconnected central catheter, causing a sudden increase of the pressure in the right ventricle and the right atrium and passage of air into the left atrium. At the time of the radionuclide study, the patient was being ventilated with continuous positive pressure ventilation, no doubt further increasing the right-to-left shunt and explaining the massive entrapment of intravenously injected microspheres in the brain.

Prevention of paradoxical air embolism and prevention of venous air embolism related to central venous catheterization are similar because the ports of entry of air are identical. To prevent air embolism during insertion of catheters into the neck vein or subclavian vein, the patient should be placed in the Trendelenburg position. Hypovolemic patients should be rehydrated before central venous catheterization when placement of the catheter is an elective procedure (eg, parenteral nutrition). When the catheter is in place, every junction should be secured with adhesive tape, and an occlusive dressing should be placed over the catheter insertion site. Single-thread Luer lock mechanisms alone are not proof against disconnection since they can be fractured when grasped with a forceps during tubing changes.¹ When pump-assisted IV infusions are used, all injection and "piggy-back" entry sites should enter the infusion system before the air detection device of the pump.¹¹ Antiseptic ointment should be placed over the site of entry of the catheter into the skin.

When venous air embolism occurs, the patient should be placed immediately into the left lateral position with the head tilted downward (Durant's maneuver)⁶ to decrease the amount of air entering the outflow tract of the

right ventricle. Subsequently, an attempt can be made to aspirate air through the catheter advanced into the superior vena cava or the right atrium. A recent recommendation is to perform aspiration through a Swan-Ganz catheter while it is withdrawn from the pulmonary artery to the superior vena cava.¹²

REFERENCES

1. Peters JL, Armstrong R: Air embolism occurring as a complication of central venous catheterization. *Ann Surg* 187:375-378, 1978
2. Ross SM, Freedman PS, Farman JV: Air embolism after accidental removal of intravenous catheter. *Br J Med* 1:987, 1979
3. Colquhoun BP: Air embolism and intravenous catheters. *Br J Med* 1:1489, 1979
4. Paskin DL, Hoffman WS, Tuddenham WJ: A new complication of subclavian vein catheterization. *Ann Surg* 179:266-268, 1974
5. Strauss HC, Hurley PJ, Rhodes BA: Quantification of right-to-left transpulmonary shunts in man. *J Clin Lab Med* 74:597-607, 1979
6. Durant TM, Long J, Oppenheimer MJ: Pulmonary (venous) air embolism. *Am Heart J* 33:269-281, 1947
7. Flanagan JP, Gradisar IA, Gross RJ, Kelly TR: Air embolus: a lethal complication of subclavian venipuncture. *N Engl J Med* 281:388-389, 1969
8. Groner GA, Messick JM, Cucchiara RF, Michenfelder JD: Paradoxical air embolism from a patent foramen ovale. *Anesthesiology* 50:548-549, 1979
9. Nash G, Moylan JS: Paradoxical catheter embolism. *Arch Surg* 102:213, 1971
10. Edwards JE: Inter-arterial communication. IN *Pathology of the Heart*, Gould SE (ed), Springfield, Charles C Thomas, 1960, pp 260-261
11. Abernathy CM, Dickinson TC: Massive air emboli from intravenous infusion pump: etiology and prevention. *Am J Surg* 69:274-275, 1979
12. Marshall WK, Bedford RF: Use of a pulmonary artery catheter for detection and treatment of venous air embolism. *Anesthesiology* 52:131-134, 1980