Air Embolism Arising from Burr Holes

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Venous air embolism is a well-recognized complication of posterior fossa exploration of a patient in the sitting position.1–5 The usual sources of air entry are the open venous channels from the suboccipital craniotomy. The following two cases demonstrate that burr holes should also be considered possible sources of air.

Report of Two Cases

Patient 1. A 6-year-old boy was scheduled for a posterior fossa craniotomy in the sitting position for a cerebellar astrocytoma. Catheters were inserted into the right atrium and dorsalis pedis artery and heart sounds monitored with the ultrasonic doppler. A right parietal burr hole was made to facilitate cannulation of the lateral ventricle. The burr hole was sealed with bone wax and a wet cotton plug. Approximately 45 min later, a suboccipital incision was made. As the tumor was being excised, we heard changes in the sounds of the doppler; small amounts of air were then aspirated from the right atrial catheter. The wound was flooded with saline solution, positive airway pressure applied, and the nitrous oxide turned off. Because no further sign of air entrainment occurred and no source of air entrainment was found, the operation was continued. Shortly after this, air was again detected by changes in the sounds of the doppler and confirmed by right atrial aspiration. Arterial blood pressure was unobtainable and heart sounds disappeared. Cardiopulmonary resuscitation was instituted and the patient was returned to the supine position. Phenylephrine, 0.1 mg, was given twice intravenously, 1 min apart, resulting in an arterial blood pressure of 100 torr. The vital signs stabilized without further impairment of cardiovascular function. The patient was again placed in the sitting position and the operation was continued. Again no venous bleeding could be identified by the surgeon. Thirty minutes later, air was detected by changes in the sounds of the doppler and confirmed by right atrial aspiration. The wound was flooded with saline solution, and no venous bleeding could be identified when the venous pressure was increased. At this point the burr hole was considered as a possible site of air entrainment. The ventriculostomy catheter was removed and the skin over the burr hole closed. No further episode of air entry occurred, and the rest of the operation and recovery were uneventful.

Patient 2. A 57-year-old man had a posterior fossa exploration in the sitting position for excision of a right acoustic neuroma. Catheters were inserted into the right atrium and right radial artery and heart sounds were monitored with the ultrasonic doppler. A parietal burr hole was placed for a lateral ventriculostomy catheter. The bone edges were not sealed with bone wax but the hole was plugged with wet cotton. Approximately 45 min later, the suboccipital craniotomy was performed. The tumor was being excised when changes in the doppler were heard; 5–10 ml air were aspirated from the right atrium. The arterial systolic pressure dropped from 120 to 75 torr, but quickly returned to baseline after positive airway and jugular pressures were applied and the nitrous oxide turned off. No venous bleeding site was identified. Changes in the doppler sounds occurred repeatedly over the next 3 hours, and a total of 150 ml air was aspirated from the right atrial catheter. Each time air was aspirated from the right atrial catheter, positive pressure was applied and the source of air sought, but none was found. The arterial pressure was maintained, so the operation was continued. After considerable discussion that the burr hole might be the source of the air because there was no temporal relationship between the doppler sound changes and the manipulation of the tumor, the ventriculostomy tube was removed and the skin over the burr hole was closed. About 15 min after the burr hole was closed, a small amount of air was aspirated from the right atrial catheter following doppler sound changes during manipulation of the tumor. After that, no more air was detected. The rest of the procedure progressed without difficulty, and recovery was uneventful.

Discussion

The potential for venous air embolization9 or paradoxical arterial embolization9 exists any time the surgical wound is above the level of the heart, producing a subatmospheric pressure in the open veins. The usual sources of air are the suboccipital plexus of veins with branches held open by fascial attachments to the cervical muscles, occipital emissary veins, dural sinuses, diploic veins, and veins in the tumor itself.9,10 In both of our patients, air was assumed to be entrained in the area of the suboccipital incision. The burr hole was not considered

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Received from the Department of Anesthesiology, University of Nebraska Medical Center, 42nd and Dewey Avenue, Omaha, Nebraska 68105. Accepted for publication February 5, 1980.

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Key words: Anesthesia, neurosurgical, Embolism, air, Measurement techniques: Doppler ultrasound, Equipment: catheters, right atrial.
the source of air because in each case the burr hole had been made some time before the detection of air in the right atrium. The burr hole as the source of air was considered after we were relatively certain that the source was not the suboccipital incision or the tumor mass. Other sources of air, such as the pin holes from the skeletal fixation device used to stabilize the head, could have been considered. In the first operation, the burr hole was considered a likely source when air entrainment stopped after the burr hole was closed. In the second operation, the burr hole was suspected when the bulk of the air entrainment stopped after closure of the burr hole, with only a small amount of air aspirated after the Doppler sounds changed with surgical manipulation of the tumor bed. Jackson recently challenged the need for right atrial catheters by concluding that effective treatment can be instituted without such catheters. Our cases illustrate the value of the right atrial catheter for aspirating air. Since the source of air was not immediately identified and the quantity was large, the ability to aspirate the air from the right atrium may have prevented a catastrophe.

The entry of air from the burr holes may have been delayed because 1) the bone wax and wet saline cotton plug seal may have failed after a certain period of time, 2) opening the suboccipital area may have provided a bellows-like pump, allowing air entrainment from veins where previously there had been none, or 3) changing intracranial blood volume, cerebrospinal fluid volume, and brain water volume may allow the brain to shift in a more caudal direction and, in the process, hold open the dural veins, which had previously been closed.

We believe these cases illustrate the need to suspect all of the potential sources of air, including burr holes performed for ventriculostomies. They also emphasize the value of a right atrial catheter for aspiration of air, which, in the case of the second patient, was therapeutic as well as diagnostic.

**References**


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**Fentanyl-associated Delirium in Man**

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Berryhill et al. recently reported a case in which a patient experienced a dramatic stimulatory effect after the intravenous administration of morphine sulfate. We recently observed a patient who showed hyper-excitability after intravenous administration of fentanyl.

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Received from the Anesthesia and Operative Service, Walter Reed Army Medical Center, Washington, D.C. 20012. Accepted for publication February 6, 1980.

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Key words: Analgesics, narcotic; fentanyl. Complications: delirium.

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**Report of a Case**

A 23-year-old, 65-kg man was scheduled for arthrodesis of the index finger of his left hand. Medical history included two previous orthopedic procedures for stabilization of this same digit, performed with local anesthesia. He was taking no medication and denied drug abuse. Preoperative laboratory data were normal.

The patient received no medication preoperatively. A digital nerve blockade was performed with lidocaine, 1 per cent. The patient appeared apprehensive, for which diazepam, 5 mg, iv, was given. Because this was ineffective, fentanyl, 0.1 mg, iv, was given. He then became increasingly agitated, and was unaffected by an additional dose of diazepam, 5 mg, iv. Because this agitation interfered with the operation, thiopental, 250 mg, iv, was given to induce general anesthesia, which was then maintained with nitrous oxide, 70 per cent, for the duration of the surgical procedure. The operation and anesthesia lasted 15 min and proceeded without further difficulty.