Correspondence

Intracardiac Catheters in Neurosurgical Anesthesia

To the Editor: — I agree with Dr. Jackson that the routine use of the pulmonary-artery catheter is not necessary for the detection and treatment of venous air embolism. Dr. Jackson advocates abandoning the intracardiac catheter in patients undergoing posterior-fossa craniotomy. However, this recommendation is based on clinical management that included neither the use of a precordial Doppler monitor nor the measurement of end-tidal CO₂ concentrations. Therefore, it is not surprising that this retrospective report showed a relatively low incidence (<1 per cent) of "clinically important" venous air embolism. However, it is very likely that silent showers of embolized air would have gone undetected in some of his patients. In those instances in which venous air embolism was detected using the esophageal stethoscope, changes in vital signs, including decreases in systolic blood pressure of 20 to 30 mm Hg, did occur. In our experience, the incidence of venous air embolism discovered by detectors such as the Doppler monitor and by measurements of end-tidal CO₂ concentration is 27 per cent. Use of these monitors results in early detection and, therefore, early treatment. Such episodes of embolism usually do not affect changes in heart rate and systolic blood pressure. They usually are self-limiting, and aspiration of gas by an intracardiac catheter is not possible, since the gas bubbles pass through the heart and lodge in the distal pulmonary vessels. Although most embolic episodes are of this nature, I feel it would be a mistake to abandon the use of the right atrial catheter, since gas aspiration would be extremely important in those rare occasions when massive venous air embolism occurs.

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To the Editor: — Jackson recently reported that since the incidence of clinically important air embolism was very low in his experience, the routine use of central venous or pulmonary-artery catheters was not necessary.1 Jackson also mentioned the serious risks involved in right atrial and pulmonary arterial catheterization and the fact that catheter placement may be "time consuming and troublesome" as other reasons for not employing these catheters. Unfortunately, the medical literature is replete with neurosurgical cases in which venous air embolism has been shown to be a cause of neurosurgical mortality and morbidity,2-10 and this has been described for posterior cranial fossa explorations as well as cervical laminectomies with the patients in the sitting position. The critical factor in venous air embolism is the gradient that develops between the open vessel and the right heart. Thus, it is possible to entrain air with a very small gradient in the lateral,11 supine,12,13 or prone position.7

Dr. Jackson is indeed fortunate to be able to report such a low incidence of clinical venous air embolism (0.7 per cent—three patients) in a five-year review of 461 patients at his institution. Retrospective studies are often difficult to evaluate because critical data may not always be present. Michenfelder and co-workers6 reported an incidence of 2.2 per cent of patients with clinical signs of air embolism (nine of 418 posterior cranial fossa procedures during 1961–1964) and noted that some cases were probably missed because the study was retrospective. Recently, Davis and co-workers14 reported an air embolism incidence of 60 per cent (94 of 156 patients) during cerebellar stimulator implants with the patients in the sitting position; in 15 per cent, hypotension and ventricular arrhythmias developed, but subsided after aspiration of air from a right atrial catheter, irrigation, covering the wound, and changing to oxygen breathing. Similarly, Wilkins and Jannetta11 found venous air embolism in 57 per cent of their patients operated on in the semi-sitting position, with an average of 21 ml of air aspirated via the right atrial catheter. It was not stated which of the three patients with air embolism in Dr. Jackson's retrospective study were...
from the laminectomy group and which were from the very small series comprising the posterior fossa craniotomy group.

It is also unfortunate that the Neuroanesthesia Service at the Methodist Hospital abandoned right atrial catheterization after a brief trial. There is no question that catheter placement brings with it a potential morbidity that has to be balanced against the complication of venous air embolism. As with any new technique, morbidity usually decreases with experience. Complications of catheter insertion will be less when the subclavian-vein route is avoided. Although there are times when catheter placement may be time-consuming and even troublesome, it is infinitely more rewarding to be able to aspirate air from the right heart quickly during an episode where the source of entrainment cannot be rapidly localized than to be faced with consequences of being unable to remove the entering air.

Maroon and Edmonds-Seal and their co-workers have made an important diagnostic advance in pioneering the development of the Doppler ultrasonic air bubble detector, which can now recognize intravascular air in as small a quantity as 0.1 ml flowing past the externally placed chest probe. The use of this innovative technology has allowed us to appreciate the true incidence of detectable air embolism, ranging from 8 to 60 per cent.\footnote{12,14,16-18} We regard the Doppler to be more sensitive in detecting venous air embolism than either changes in end-expiratory CO₂ concentration or pulmonary arterial pressures.

The incidences of venous air embolism at our institution, as detected by ultrasonic Doppler probe and verified by aspiration of the right atrial catheter, range from 8 to 25 per cent (table 1). In 25 of the 100 patients operated on in the sitting position who had detectable air embolism, more than 50 ml of air were aspirated, and this group showed the greatest incidence of tachyarrhythmias and bradycardias, and included two cases of pulmonary edema. Clinical symptoms were also found during operations done with the patients in the lateral, supine, and (in one case) prone positions.\footnote{21}

There was no death, and in this series of 520 cases, cardiac arrest with successful resuscitation occurred in one patient during cervical laminectomy in the sitting position, where more than 500 ml of air were aspirated after a probable tear in the cervical vertebral sinuses.

Contrary to Dr. Jackson's statement, we believe that even with proper management, venous air embolism is the great hazard that some believe it to be. Our group has found postoperative pulmonary perfusion deficits taking place after air embolism (more than 25 ml aspirated), as demonstrated by positive lung scans (technetium–macroaggregated albumin) persisting for more than two weeks.\footnote{13,20,21}

We feel that proper treatment of venous air embolism consists of early detection (Doppler); preoperative placement of a right atrial catheter; identification and sealing off of open vessels and sinuses; not using N₂O concentrations greater than 50 per cent, and using 100 per cent oxygen during an episode of air embolism; aspiration from the catheter; and in the face of uncontrolled entrance of air, increasing the intrathoracic pressure by cautious increments of PEEP or jugular compression.

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Causes of Induced Hyperthermia

To the Editor:—In his article, Dr. Fraser has reported an effective, if inadvertent, method of inducing hyperthermia. The temperature increases, however, can probably be more correctly attributed to the prevention of evaporative heat loss than to a decrease in convection or radiation. Presently at our institution we are conducting a phase I trial of whole-body hyperthermia to 41.8 °C as an adjuvant mode of therapy in the treatment of metastatic cancer. The technique employed depends primarily on the confinement of endogenous metabolic heat by restricting evaporative heat loss.

In our protocol patients wear a disposable, non-permeable paper "jump suit" over cotton pajamas. The suit, which is made of material similar to the implicated surgical drapes, prevents evaporative heat loss by confining water vapor. The suit is then surrounded by several heated-water perfusion blankets that both further insulate and provide additional exogenous heat in the initial phase to increase the rate of heating. With this combination vapor barrier-insulation system, core temperature can be increased 5 degrees C/hour. The system is so effective that when the patient's temperature is 41.8 °C, the temperature of the water perfusing the blankets often needs to be several degrees cooler to prevent "thermal runaway." Were an anesthetized child, dressed in pajamas and also possibly placed on a conventional heated-water mattress in the operating room, to then be enveloped by a nonpermeable drape, hyperthermia might well ensue.

Under conditions of increased endogenous heat production (malignant hyperthermia or pyrexia infections), oxygen consumption must show correspondingly large increases. Our recent work, however, has shown that in anesthetized adult subjects, where core temperatures are increased by retarding heat dissipation, oxygen consumption does not increase dramatically. When pulmonary arterial blood tem-