Air Embolism in Children Undergoing Suboccipital Craniotomy

ROY F. CUCCHIARA, M.D.,* AND BETTY BOWERS, M.D.†

While the use of the sitting position provides surgical advantages for suboccipital craniotomy, the threat of venous air embolism is a serious concern. Sophisticated monitoring devices advocated for the detection of venous air embolism include the Doppler ultrasound unit, right atrial catheters, Swan-Ganz catheters, and capnography. The use of cardiac catheters in patients who are in the sitting position during surgery has received considerable attention. We propose to retrospectively compare the incidence of venous air embolism in children and adults.

METHOD

With approval of our institutional Human Studies Committee, we reviewed the charts of 48 patients, 12 years of age and under, who had suboccipital craniotomy in the sitting position performed during a 6-year period (1975–1980). A control group of 48 adult patients who had undergone a suboccipital craniotomy in the sitting position was randomly selected (8 per year) for the same time period. Halothane or enflurane with 50% nitrous oxide, with or without muscle relaxants, was used for anesthesia. All patients were monitored with a precordial Doppler ultrasound unit. Air embolism was felt to have occurred only if the characteristic Doppler changes were detected by an experienced neuroanesthesiologist.

RESULTS

The occurrence of hypotension, cardiac arrhythmia, initiation of spontaneous ventilation, or murmurs from the esophageal stethoscope could have indicated air embolism, but did not occur in patients without Doppler changes. In the pediatric cases, right atrial (RA) catheterization was successful in 38/48 (79%) patients and arterial catheterization was performed in 27/48 (56%). All adults had successful RA and arterial catheterization.

In the pediatric group, air embolism occurred in 16 patients (fig. 1). Eleven of these 16 patients became hypotensive (decreased systolic blood pressure ≥ 25 mmHg below the blood pressure just before the air embolus), two developed a cardiac arrhythmia, two initiated spontaneous ventilation, and one had a murmur audible on the esophageal stethoscope. Fourteen of the 16 patients with air embolism had a right atrial catheter in place, but air could be aspirated from only six of these patients. The age distribution of air embolism within the pediatric group was scattered (fig. 1). The five patients with air embolism and hypotension, but from whom air could not be aspirated, had transient hypotension which responded readily to vasopressors. In the adult group, air embolism occurred in 22 patients. No arrhythmias or murmurs were detected. One patient initiated spontaneous breathing during an air embolism episode.

DISCUSSION

The incidence of air embolism in children undergoing suboccipital craniotomy (33%) is not significantly different from adults in this study (45%). The incidence of air embolism in the adults in our study is very nearly the same as that reported from this institution with early experience with Doppler monitoring (42%).

The incidence of hypotension with Doppler detected air embolism was much greater in the pediatric group (69%) than in the adult group (36%) (table 1). Perhaps the volume of entrained air in children is larger relative to their cardiac volume, and thus produces more pronounced hypotension. Perhaps the frequent use of PEEP when air embolism occurred could account for the decreases in blood pressure in both groups.

Aspiration of air from the RA catheter was accomplished less frequently in children (38%) than in adults (68%). Because of the simultaneous use of several therapeutic maneuvers, we could not specifically credit any one maneuver as a cause for improvement as in cases of massive air embolism.

The success rate of right atrial catheterization can be expected to be lower in children than in adults, especially if the operator prefers to avoid the internal jugular and subclavian routes. The success rate in children 5 years old or less in this study (11/22 or 50%) is comparable to that (57%) reported from a cardiac unit. The high success rate of RA catheterization in adults in this study is consistent with previously reported results.
Because of the expected physiologic changes from infancy to pre-school years, a special consideration of this group seems worthwhile. In the 22 patients under six years old, the incidence of air embolism was 30% (6/20), not different from the overall pediatric incidence of 33%. Of these six cases of air embolism, five had a RA catheter in place. Air could be aspirated from three of these five children. Notably, half of the children from whom air could be aspirated in this study were under the age of six years. While care must be taken in placing too much emphasis on results from such a small number of cases, air embolism apparently is not rare in the under six-year-old child and associated hypotension is just as frequent (4/6 or 67%) as in the pediatric group as a whole (69%).

Based on this study and that of Klein, a success rate of about 50% for RA catheterization in children under 6 years old can be expected. While the incidence of air embolism is not extremely high (30%), the incidence of associated hypotension is quite high (67%). This study yields no data on the efficacy of aspiration from the heart of embolized air as a useful treatment modality, but there is a strong suggestion that such is the case both in the literature and in our own experience. The risk in this study of central catheterization from a peripheral vein was negligible but may become a factor when subclavian and internal jugular vein catheterization is considered. In the authors' opinion, insertion of a right atrial catheter is not essential for a sitting position suboccipital craniotomy. However, the catheter is a useful adjunct in diagnosis of air embolism and may be very useful in the treatment of rare massive air embolism. Since success in RA catheterization is a reasonable expectation, we feel that an attempt should be made to place a right atrial catheter in every sitting position suboccipital craniotomy.

**Table 1. Incidence of Doppler-detected Venous Air Embolism in 96 Patients**

<table>
<thead>
<tr>
<th>Patient Ages (yr)</th>
<th>Incidence of Air by Doppler</th>
<th>Air Aspirated RA Catheter</th>
<th>Decrease in Systolic BP ≥ 25 mmHg with Doppler Air</th>
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<tbody>
<tr>
<td>12 and under</td>
<td>33% (16/48)</td>
<td>38%* (6/16)</td>
<td>69%* (11/16)</td>
</tr>
<tr>
<td>Over 12</td>
<td>45% (22/48)</td>
<td>68%* (15/22)</td>
<td>36%* (8/22)</td>
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* Pediatric and adult values statistically significantly different (P < 0.05) by chi-square test.

**References**