air embolism during liver transplantation, despite adequate perfusion of the donor organ prior to unclamping of the inferior vena cava. The case is presented to alert anesthesiologists to prepare for this potentially fatal problem at the time of vascular unclamping.

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Venous Air Embolism during Surgical Manipulation of a Femoral Bone Cyst

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Venous air embolism has been reported as a complication of many types of surgery, but is perhaps best known as a complication of the sitting position for posterior fossa neurosurgery. We report here an unusual case of air embolism in a child occurring as a result of surgical manipulations of a femoral bone cyst.

Case Report

The patient is a 3-yr-old male who was in his normal state of good health until 2 days prior to admission when he jumped from a step of a bus and subsequently was unable to walk because of left leg pain. Physical examination on admission to the hospital revealed: BP 92/50 mmHg, HR 88/min, RR 20/min, T 97.0° F, height 98.1 cm, and weight 13.4 kg. The remainder of the physical exam and laboratory tests were normal. X-ray of the left lower extremity revealed lucency of the proximal femur with a questionable nondisplaced fracture.

The patient was admitted for the treatment of a proximal left femur cyst and to rule out a pathological fracture. Plans were made by the orthopedic service to aspirate the cyst and to inject a steroid into the cyst, followed by treatment with a hip spica cast.

In the operating room, monitors initially consisted of a pulse oximeter, precordial stethoscope, BP cuff, and ECG. Anesthesia was induced with halothane, nitrous oxide, and oxygen *via* mask, after which the trachea was intubated. An iv infusion of D5 in 1/4 normal saline was administered. End-tidal CO_2 (ET_{CO_2}), esophageal temperature, and breath sounds were also monitored. Maintenance of anesthesia consisted of halothane 1% and N_2O (60%) in O_2 *via* a semiclosed circle system, supplemented with iv atracurium for relaxation. Thirty-five minutes after surgery began, ET_{CO_2} suddenly decreased from 30 mmHg to 17 mmHg, then to 4 mmHg. Although breath sounds were still equal bilaterally, auscultation revealed a mill-wheel murmur. Oxyhemoglobin saturation (Sp_{O_2}) which had been 100% decreased to 69%. Blood pressure decreased from 110/52 to 80/40 mmHg and the heart rate decreased from 148 to 102 per min.

The above changes coincided with the injection of air into an 18-G spinal needle that had been inserted into the proximal left femur through a direct lateral approach. A second 18-G needle was also placed distally to the first. In an effort to collect a fluid specimen from the cyst, the surgeons had aspirated one needle or the other. At one point, they injected air of unknown quantity into one needle in an attempt to aspirate fluid from the other. A total of 3 cc of serosanguinous fluid was finally aspirated from the cyst.

Venous air embolism from the left femur was suspected and the surgeons were so informed. Nitrous oxide and halothane were discontinued, and the patient was given atropine 0.2 mg iv. The Sp_{O_2} increased from 69 to 95%, then to 100% within 5 min. No additional air was injected by the surgeons. The ET_{CO_2} increased from 4 to 35 mmHg, the heart rate from 102 to 162 per min, and the blood pressure from 80/40 to 115/45 mmHg. After the patient regained hemodynamic stability, anesthesia was changed to isoflurane 0.5–1% in O_2, supplemented with alfentanil totalling 100 μg.

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Renograffin injected into the bony cyst demonstrated a communication between the needles. The surgeon also injected 60 mg of methylprednisone in 1½ ml of normal saline into the cyst through the distal needle and removed the needles. The remainder of the surgical course was unremarkable. There were no neurological or other sequelae postoperatively.

Discussion

Drinker, *et al.*[1] in 1922 first described the circulation in the mammalian bone marrow. Blood from the bone marrow passes to the noncollapsible medullary venous channels, to emissary veins, and then into the general circulation. In 1934, Josefson[2] described intraosseal injections as a new technique for injections of liver preparations as treatment for pernicious anemia. Currently intraosseous infusion is limited mostly to pediatric emergency situations. We believe that in this patient air passed from the needle(s) to the systemic circulation in a pathway similar to that taken by intraosseously injected fluid. It resulted from positive pressure injection rather than from negative pressure aspiration, thus accounting for its brief self-limiting episode as soon as the cause was removed.

At the onset of surgery, there was no reason to believe that this patient was at risk for venous air embolism. The most sensitive monitor to detect venous air embolism appears to be the Doppler ultrasonic monitor. It may be capable of detecting air bubbles as small as 0.12 ml.[3] However, our case illustrates that even less sensitive monitors can be of great help in the intraoperative diagnosis of air embolism. The capnograph will show a decrease in the end tidal CO_2. The heart sounds will become metallic, resonant, and then drum-like. A systolic murmur may precede the grinding mill-wheel murmur.

As soon as air embolism is suspected or detected the surgeon must be informed. In our case, the outcome might have been disastrous without an early response. Much more air could have been forced in the circulation. While further air entry is being stopped, additional measures should include discontinuation of N_2O, ventilation with oxygen, and use of vasopressors or antiarrhythmic drugs, if necessary, to maintain hemodynamic stability. Positive intrathoracic pressure, position change of the patient, and aspiration from the central venous catheter, if present, should also be considered.

In summary, this case describes venous air embolism in a child caused by intraoperative placement of needles into a femoral bone cyst and injection of air into the cyst in an effort to aspirate fluid from the cyst. The occurrence of this unlikely intraoperative complication was diagnosed by routine monitoring alone, using capnography, pulse oximetry, ECG, blood pressure cuff, and auscultation of the heart and breath sounds.

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Juvenile Hyaline Fibromatosis: Anesthetic Management

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Juvenile hyaline fibromatosis (JHF) is a rare autosomal recessive disease with incomplete penetrance.[1] Clinical characteristics of affected individuals include multiple subcutaneous nodules, flexion contractures of large and small joints, hypertrophic gingiva, and radiolucent destruction of the humerus and femur.[1–3] Difficulty with intubation of the trachea may be caused by gingival hypertrophy and tempromandibular joint and cervical spine contractures.

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Key words: Anesthesia, pediatric: pediatric airway. Fiberoptic bronchoscopy. Juvenile hyaline fibromatosis.

Case Report

A 13-month-old 7-kg female with JHF was scheduled to have a Nissen fundoplication performed. The prenatal course was uneventful and her birthweight was 6 lb 7 oz. She appeared normal until early in her fifth month when flexion contractures of her upper and lower extremities and gingival hypertrophy were noted. Six months later she was hospitalized with failure to thrive and postprandial vomiting of several