LETHAL AIR EMBOLISM DURING ARTHROSCOPY
A CASE REPORT

R. HABEGGER, R. SIEBENMANN, CH. KIESER

From the Stadtpital Triemli, Zurich

We report a case of lethal air embolism during diagnostic arthroscopy using air to distend an acutely injured knee. Air had escaped from the joint through an intra-articular fracture and entered the venous system. During arthroscopy, pressure within the joint may be 5 to 10 times higher than venous pressure, so any medium may escape. We advise that the use of air, especially in freshly injured joints, should be abandoned in favour of saline or carbon dioxide.

Lethal complications of arthroscopy and arthroscopic surgery are uncommon and rarely reported (Dick et al. 1978; Mulhollan 1982; Saillant, Benazet and Roy-Camille 1986; DeLee 1985). A national survey on 118,000 arthroscopic procedures in North America found four deaths from pulmonary embolism; a similar survey in France reported one anaesthetic death in 22,000 arthroscopies. One case of lethal toxic shock syndrome from staphylococcal infection was reported by Farber, Broome and Hopkins (1984) and deaths from gas gangrene and from gram-negative sepsis were mentioned by Jackson (1983) and by Glinz (1987). Thus the mortality rate may be about one in 20,000 to 30,000, but is probably higher since all deaths may not be reported.

In the autumn of 1986, a 27-year-old man died in our hospital from massive air embolism during diagnostic arthroscopy. A similar case occurred three months before in Vienna (Grünwald, Bauer and Wruhs 1987); it seems that air embolism is a dangerous complication of gas arthroscopy. We report our case and the autopsy findings and discuss its pathogenesis.

CASE REPORT

A 27-year-old man had a severe blow on the medial side of his left knee in a sleigh accident and the next day required aspiration of a haemarthrosis. Radiographs appeared to be normal and there was no obvious instability. Three days after the accident, arthroscopy was performed under general anaesthesia with pentothal, nitrous oxide and halothane using spontaneous breathing with a mask. No tourniquet was used. Residual haemarthrosis was washed out with Ringer's solution and the joint was slowly filled with air, injecting 50 ml at a time from a 100 ml syringe to a total of about 300 ml.

At arthroscopy a fresh lamellar fracture of the anteromedial edge of the medial femoral condyle was detected; this was not visible on the radiographs. No other pathology was found in the joint, but during examination the knee was flexed and adducted to open the lateral joint space, and more air had to be injected.

At this time, about 10 minutes from the start of the arthroscopy, the patient began to cough and then suddenly developed severe bradycardia, cyanosis, congestion of the neck veins and signs of cardiac shock. Gas analysis showed a rapid drop of end expiratory CO₂ level, a sign of massive impairment of pulmonary circulation. The diagnosis of pulmonary thromboembolism was obvious, and resuscitation by intubation, positive pressure respiration with oxygen and external cardiac massage was started, but had no effect. Because of lack of awareness of the danger of air embolism, no specific effort was made to aspirate from the heart and the patient died.

At autopsy on the same day, massive air embolism into the right atrium and ventricle of the heart and into the pulmonary artery was found. Smaller and fewer air bubbles were observed in the left atrium, left ventricle and the coronary arteries as well as in some cerebral arteries. The medial condyle of the left femur showed a slightly depressed area measuring 3.5 × 2.0 cm at the margin of the patellar surface with a fissure fracture near
the articular border extending 2 cm into trabecular bone (Fig. 1). A few bubbles of air of 0.5 to 1.0 cm diameter were demonstrated in the distal femoral diaphysis by radiography after the bone had been removed and fixed in formalin and histological examination of the fractured area showed large empty spaces consistent with air within the sinusoids and disrupting adjacent marrow tissue (Fig. 2). Further air bubbles were found in the femoral and iliac veins and the inferior vena cava.

DISCUSSION

Air or other gases (carbon dioxide, nitrous oxide and oxygen) have been used at arthroscopy since the first description of the method by Bircher in 1921, who filled the knee with O₂ or N₂O by means of a pneumothorax apparatus. This technique of gas arthroscopy became widespread, especially in Europe. Wrubs (1970) in Vienna advocated the use of air, Henche (1978) in Basel the use of carbon dioxide. Many cases of emphysema of soft tissue were reported (Henderson and Hopson 1982; Shupak, Shuster and Funch 1984; Amsalem et al. 1985), but the danger of gas embolism was not reported until Grünwald et al. (1987) published the case of a 17-year-old girl with a fresh fracture of the intercondylar eminence who died during an arthroscopy using air as the medium.

Our case was very similar, and as Grünwald suggests, it seems that gas may enter an intra-articular fracture and enter the venous system. Intra-articular pressure during arthroscopy is usually between 80 and 150 mmHg and may reach peak values of 300 mmHg, especially in sudden flexion of the knee (Noyes and Spievack 1982). The pressure in the venous sinusoids averages between 15 and 30 mmHg (Ficat and Arlet 1977), so any medium (saline, air or carbon dioxide) may enter the venous circulation where an opening exists between the joint space and the bone marrow.

The risk of gas embolism depends on the type and amount of the gas (Panning 1987). The injection of carbon dioxide into the circulatory system of experimental animals is less dangerous than injection of air (Moore and Braselton 1940; Graff et al. 1959; Kunkler and King 1959). Graff found intravenous air five times more dangerous than carbon dioxide. Moore injected both gases into the left side of the heart of cats; though both caused death, carbon dioxide was six times better tolerated.

Air was replaced by carbon dioxide for retroperitoneum, perturbation, laparoscopy and open heart surgery, but for arthrography many radiologists still use air (Rüttimann 1957; Newberg, Munn and Robbins 1985). Small amounts (30 to 50 ml) seem safe, only one case of air embolism having been reported (Kleinberg 1927). However, air embolism has been reported during hip arthrography in small infants and the use of carbon dioxide is advised (Saha 1976; McCauley, Wunderlich and Zimbl 1981).

![Fig. 1](image1)

An oblique cross-section showing a haemorrhagic fracture at the margin of the medial femoral condyle.

![Fig. 2](image2)

Bone marrow from the femoral metaphysis adjacent to the fracture, showing round empty spaces corresponding to air bubbles which had compressed the surrounding marrow (Haematoxylin and eosin × 25).

Larger volumes of air are needed to fill joints for arthroscopy because of leakage along the instrument. The two deaths now reported lead us to advise that air be abandoned and replaced by saline or carbon dioxide, especially for the examination of a freshly injured joint.

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REFERENCES


Kleinberg S. Pulmonary embolism following oxygen injection of a knee. *JAMA* 1927;89:172-3.


