Fibrin glue is used to control diffuse surgical bleeding. Apart from occasional allergic reactions caused by co-administered apritin, haemodynamic disturbances or systemic reactions appear rare. We describe near fatal air and fibrin glue embolism after spraying of aerosolized fibrin glue to the liver surface during partial hepatectomy.

Case description
A 45-yr-old female (body weight: 59 kg, ASA II) underwent segmental (segments 4 and 6) liver resection for a liver metastasis. A neuroendocrine pancreatic tumour had been treated previously by surgery and chemotherapy of the hepatic metastasis. Otherwise, past medical history and cardiopulmonary status were unremarkable.

Before induction of general anaesthesia, an epidural catheter was placed at the T7/8 interspace and bupivacaine 0.5% was injected to achieve an appropriate level of sensory block. General anaesthesia was induced i.v. with thiopental (7.5 mg kg\(^{-1}\)), fentanyl (4 \(\mu\)g kg\(^{-1}\)), and rocuronium (0.6 mg kg\(^{-1}\)), and maintained with isoflurane (1.0% end-tidal) in 50% oxygen/air and with further doses of fentanyl, rocuronium, and bupivacaine, as required. Mechanical ventilation with an end-expiratory pressure of 5 mbar was adjusted to keep end-tidal CO\(_2\) within the range of 4.65–5.32 kPa.

Arterial pressure was monitored electromanometrically at the left radial artery. Central venous pressure was measured continuously with a catheter placed in the right internal jugular vein, with its position close to the right atrium as confirmed by an intravascular ECG. Surgery was performed in the supine position with a 20° head up. Anaesthesia proceeded uneventfully and after some bleeding, the patient was kept in a stable haemodynamic condition by transfusion of 4 units of packed red blood cells, in addition to crystalloid and colloid infusions.

As there was persistent diffuse bleeding, the surgeon decided to use a fibrin glue aerosol (Quixil\textsuperscript{®}, OMRIX Bio-pharmaceuticals Inc. Rhode-st-Genèse, Belgium) on the liver resection site before closing the abdomen. This aerosol device uses pressurized air (2–3 bar) to nebulize the fibrin aerosol. A few seconds later, heart rate decreased from 80 to 25 beats min\(^{-1}\) and systolic arterial pressure decreased from 110 to 30 mm Hg. Simultaneously, central venous pressure increased from 2 to 28 mm Hg, and end-tidal CO\(_2\) decreased from 4.65 to 2.26 kPa. To restore circulation, epinephrine (1 mg i.v.) was given twice. Venous air embolism was suspected and the central venous catheter was advanced by 5 cm, but no air could be aspirated. Repeated injections of epinephrine (total 15 mg) and norepinephrine (total 30 mg) and cardiopulmonary resuscitation were necessary for the next 25 min, followed by continuous infusion of both drugs (both at 4 mg h\(^{-1}\)).

Eventually, this restored a systolic arterial pressure of 80 mm Hg and a heart rate of 130 beats min\(^{-1}\). Arterial blood gas analysis showed a Pa\(_{O_2}\) of 49.87 kPa and a Pa\(_{CO_2}\) of 6.25 kPa with an inspired oxygen fraction (Fi\(_{O_2}\)) of 1.0 and a minute ventilation of 10 litre min\(^{-1}\). Transoesophageal echocardiography (TOE) showed bubbles in both ventricles, deriving from the inferior vena cava (Fig. 1A).
Right and left ventricular contraction was markedly impaired in all wall areas. Furthermore, a low-density floating thrombus (≏3 cm diameter) was observed in the right ventricle (Fig. 1A).

Cardiac performance was improved by milrinone administration (4 mg h⁻¹) and over the next 60 min epinephrine dosage could be decreased to 0.2 mg h⁻¹ and norepinephrine infusion was stopped. Over the following 2 h, central venous pressure and end-tidal CO₂ tension returned to their pre-event values, and the abdomen was closed.

Left ventricular function was still severely impaired on admission to ICU, but it gradually improved to normal within 24 h and the patient was discharged from the hospital 2 weeks later without sequelae.

**Discussion**

In this case, pressurized administration of fibrin glue to the resection surface of the liver produced life-threatening venous air and fibrin embolism. Topical application of fibrin glue can achieve haemostasis, especially where the use of electrocautery, sutures, or metal clips is not feasible, and this method has gained popularity in hepatic surgery. In our case, fibrin glue was sprayed onto the hepatic resection surface using pressurized air. The device used consists of two components, a biological active component (BAC) and human thrombin (1000 IU ml⁻¹). The BAC solution is a mixture of human clotting proteins, predominantly fibrinogen and fibronectin (70 mg ml⁻¹), and the antifibrinolytic drug tranexamic acid (95 mg). It does not contain any animal-derived protein or aprotinin. It can be applied to tissue either with a syringe or a special spray applicator. The manufacturer’s guidelines recommend that glue should be delivered to the surface from a distance of 10–15 cm using small bursts (0.1–0.2 ml).

In general, the use of fibrin glue is believed to be safe. However, a fatal reaction to the use of fibrin glue administered topically by a syringe to a deep hepatic wound has been reported. This resulted in hypotension which responded only slowly to fluid administration and α-adrenergic stimulation, and was thought to be a systemic reaction to bovine thrombin. Air embolism during liver surgery caused by the use of an ultrasonic aspirator, electro-cauterization, and a water jet dissector has been described. To our knowledge, combined venous air and fibrin glue embolism after the use of a pressurized aerosol has not been described previously. It would appear that air and fibrin glue either entered an open venous vessel or created a vascular opening, although the distance between the spray gun and liver surface was as recommended by the manufacturer.

TOE is the gold standard for detection of intracardiac emboli and we clearly visualized air originating from the inferior vena cava, and a low-density floating thrombus was detected in the right ventricle, which was presumably induced by the fibrinogen and thrombin-containing glue. Clinically, the embolism presented with cardiac failure, consistent with an increase in central venous pressure, a profound decrease in arterial pressure and heart rate, and also a decrease in end-tidal CO₂ tension. It is of note that, in addition to right heart failure, fulminant left ventricular failure was seen soon after initial resuscitation, as shown by hypokinesia of all left ventricular areas. A possible explanation might be coronary air embolism, as numerous air bubbles were also demonstrated in the left ventricular cavity. However, a patent foramen ovale, which has an incidence of 27.3%, was not detected by TOE despite attempts for echocardiographic visualization using colour duplex sonography. It is more likely, therefore, that the paradoxical air embolism can be explained by transpulmonary passage of air, as increased pulmonary artery pressure can open anatomical shunts facilitating gas passage.

In summary, the use of a fibrin glue aerosol spray device produced a sudden massive venous embolism of air and an intracardiac thrombus.

**Conflict of interest**

None declared.
References


