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CASE REPORT

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Death due to intravenous application of enteral feed

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Abstract A 6-month-old male infant was treated with intravenous infusions and enteral feed via a naso-gastric tube. Accidentally, enteral feed containing pureed carrots diluted with water was injected intravenously and the child died immediately. Carrot material could be found in the pulmonary blood vessels and in various organs of the systemic circulation.

Keywords Food · Intravenous administration · Medical malpractice

Introduction

There are only a few reports in the literature about the risks from an artificial diet. An extremely rare complication is the infusion of such a nutrient through a intravenous line leading to death. Such a case is described here.

Case report

A 6-month-old male infant was admitted to a children's clinic because of coughing and fever which had started 1 week before and an episode of vomiting which had started 3 days before admittance. On admission he was in a poor nutritional state. Treatment was carried out with infusions which started at 700 ml and were reduced step-wise over the next 4 days. When no infusions were given, the catheter was shut off. Since the child refused to eat or drink, the food was administered via a naso-gastric tube. During administration of pureed carrots by the night nurse on day 4, the child suddenly suffered a respiratory arrest, became cyanotic in the face and had cramp attacks. Resuscitation attempts were carried out for 1 h but were unsuccessful. The nurse later admitted that she may have done something wrong.

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Autopsy results

The autopsy was carried out 11 h post-mortem. The body weight was 7,900 g and the body was 70 cm in length. Injection marks were present at the right anterior neck at a site typical for accessing the external jugular vein. There was a balloon-like distension of the right ventricle and atrium containing 60 ml gas.

Liquid blood was present, as well as dystelectasia of the lungs, acute hyperaemia of the parenchymatous organs, otitis media, bronchitis and a closed foramen ovale.

Histology

Heart. The heart tissue showed slight interstitial oedema and foreign material was found in small arteries and in the coronary arteries (Fig. 1c).

Lungs. Focal emphysema was found in the lungs alternating with dystelectasia and focal oedema. Slight bronchitis and peribronchitis and moderate bronchopneumonia could be seen.

There was a dilatation of arteries, veins and capillaries and foreign material was found in the pulmonary arteries up to the peripheral branches. Such findings were present particularly at the level of the bronchi. Foreign material could also be found in some small bronchial arteries and veins at the same level. In this area and also more peripherally there existed small arteries with a wide inner muscle layer and veins with very thin walls. In both types of blood vessels small amounts of foreign material could also be visualised but the quantity of material was less on the venous side (Fig. 1a).

Kidneys. The kidney tissue showed hyperaemia and signs of shock, foreign material could be seen in arteries (Fig. 1b).

Liver. Mild hyperaemia and hypoxic swelling of liver cells could be found as well as foreign material in the arteries.

Pancreas. The pancreas tissue showed a normal structure and foreign material was found in the arteries.

Brain. Slight oedema and hyperaemia were found but no foreign material could be seen in the arteries.

The foreign material found in most organs consisted partly of an amorphous and filamentous eosinophilic material, and partly of material with clear structures. When structures were illuminated by polarised light the material was hexagonal in transverse sections and in longitudinal cuts it showed a ladder-like structure typical for plant cells. The particles showed a maximum diameter of 50 μm.

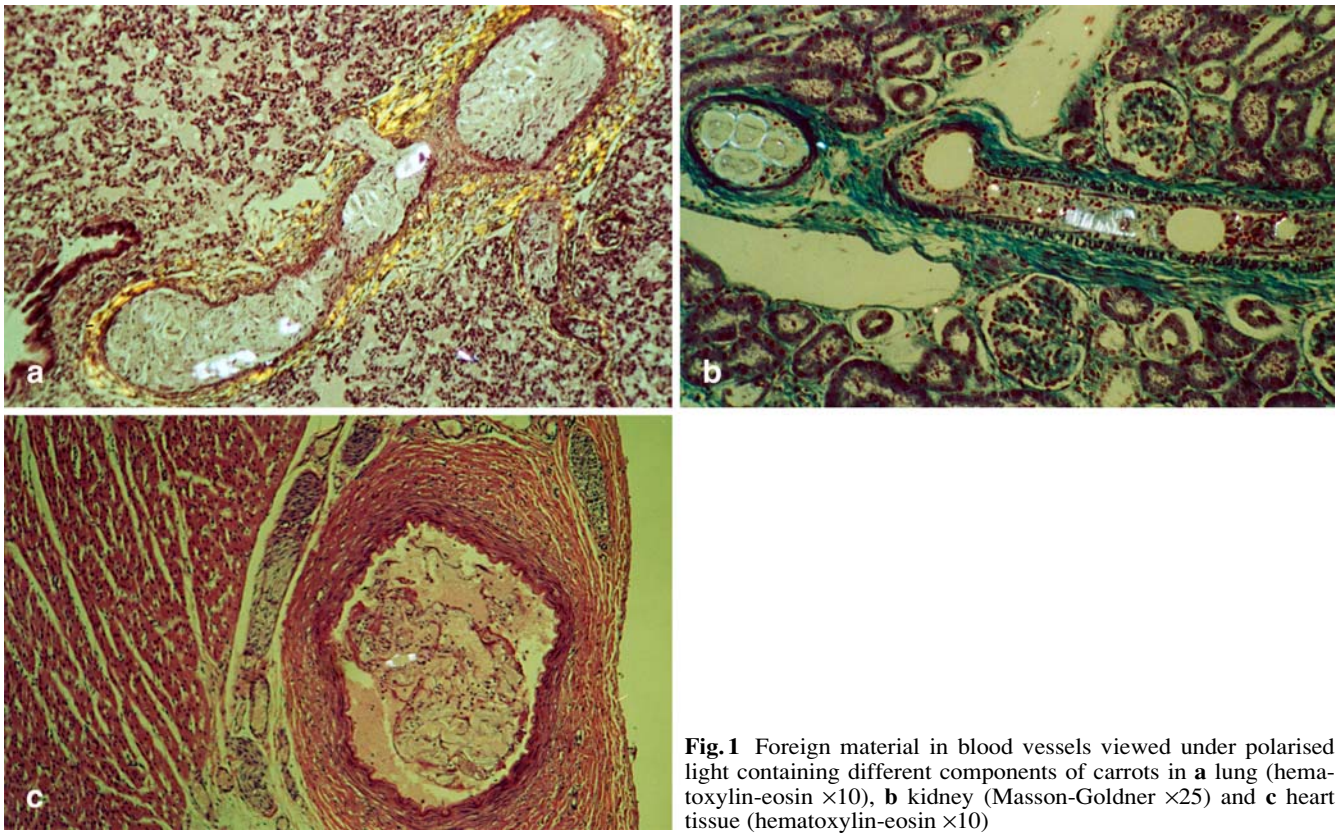

Fig. 1 Foreign material in blood vessels viewed under polarised light containing different components of carrots in **a** lung (hematoxylin-eosin ×10), **b** kidney (Masson-Goldner ×25) and **c** heart tissue (hematoxylin-eosin ×10)

Chemical and toxicological investigations

The gas taken from the right heart at autopsy was analysed by gas chromatography and was found to contain nitrogen (77.5 vol %), oxygen (20.6 vol %), carbon dioxide (1.4 vol %) and methane (less than 0.1 vol %).

Further examinations

The police took custody of the remaining residues of the food material and also of the used syringe and reddish-brown material was found in both. Smears of this substance were made and examined histologically. The foreign material found in the smears had the same morphological features as the foreign material found in the blood vessels. The original material was pureed carrots diluted with water (Fig. 2).

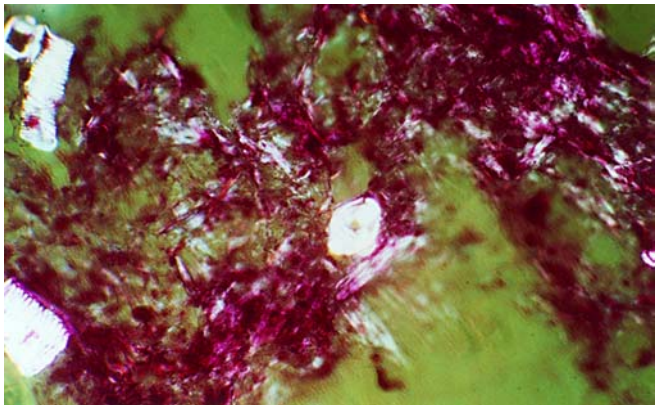

Fig. 2 Smear preparation of the pureed carrots. Amorphous material and ladder-like structures refract when viewed under polarised light (magnification ×25)

Discussion

The cause of death of the infant was cardiac arrest due to lung embolisation with carrot material and air. This foreign material had been injected accidentally into the intravenous catheter. The carrot material in the blood vessels corresponded to the pureed carrots administered and the gas composition from the right heart was very similar to air. The decreased amount of oxygen and the increase of carbon dioxide could be explained by interaction with blood components.

The nurse confirmed her error when confronted with the results. Because of insufficient lighting in the room she had confused the naso-gastric tube with a venous cannula. The nurse had used a 50 ml syringe to inject the 20 ml volume of pureed carrots. The excess amount of air in the heart was explained by the nurse in that she had found it difficult to inject the nutrition and refilled the syringe with air perhaps several times to re-inject. The structures seen under polarised light were the typical conduction vessel structures of carrots.

The distribution pattern of the carrot fibre micro-emboli is very interesting from a pathology and anatomical point of view. It was surprising that carrot material was found not only in the pulmonary circulation but also in the systemic circulation and could be seen in the arteries of many organs. The foramen ovale was closed; because of the air embolism found and recovered at autopsy this had been thoroughly checked for and therefore other connec-

tions between both circulations must have existed. The most probable explanation is intrapulmonary anastomoses (Liebow et al. 1949; Verloop 1948; von Hayek 1940, 1970). Such anastomoses exist, for example between branches of the A. pulmonalis and A. bronchialis and between the A. pulmonalis and V. pulmonalis. At the bronchial level, arterial blood vessels branch from the A. pulmonalis and because they have a thick inner longitudinal muscle layer and a relatively thin outer muscle layer, under normal conditions the lumen is very narrow. These vessels are known as contractile arteries and on the venous side the vessels are veins with thin walls and almost no muscle layers. These vessels anastomose with the peribronchial venous complex, then to the V. pulmonalis and 3–5 anastomoses are reported to exist in each lung lobule (Lapp 1959).

Furthermore, similar arteriovenous anastomoses could be demonstrated in the subpleural region. Investigations of human lung tissue showed that anastomoses can have a diameter in the range of 20–65 μm and in experiments with different animals, glass beads with a diameter of 100–250 μm were found to pass through anastomoses. Proof of such anastomoses could be seen in cases of fat or bone marrow embolism. Cain (1958) and Wehner (1968) found a transition of such material through contractile arteries and anastomoses into pulmonary veins in cases with severe narrowing of terminal pulmonary arteries due to fat or bone marrow embolism. Adebahr (1979) could demonstrate histologically fatty material in these arteries and anastomoses. In order for this passage to occur, abormal blood pressure conditions must exist. The pressure at the pulmonary artery must be higher than that in the bronchial artery and veins. In the case described here, the amount of foreign material and air in the right heart and pulmonary artery in connection with resuscitation could have changed the pressure conditions. The occurrence of small carrot fibre components in the veins of the lungs and in arteries of the systemic circulation could be further evidence of the existence of such anastomoses.

However, the existence of such anastomoses still remains controversial and Weibel (1959) found no evidence of such anastomoses in his study. He could however, demonstrate another possible pathway in the lungs and described ectatic capillaries inside the network of alveolar capillaries which connected arterioles with venoles. The diameter of this form of capillary is assumed to be between 20 and 50 μm and because of low pressure in the surrounding lung tissue, the diameter of these capillaries could undergo extreme expansion.

There can obviously exist situations such as embolisation in this case where the pulmonary autoregulation is extremely stimulated and it is possible that such autoregulation mechanisms could be more expressed in children than in adults. We tentatively suggest that these mechanisms could be important in other dysregulations as well, e.g. in sudden infant death (Bajanowski and Brinkmann 2000; Kuono et al. 2000).

Another possibility for foreign material to pass over to the systemic circulation could be present in the heart, where transseptal anastomoses have been reported (Hort 1999), but because of the large quantity of carrot material in the systemic circulation, this is only a theoretical possibility.

The results of intravenous application of enteral feed could be different depending on a variety of factors such as the consistency, amount and solubility of particles, osmolarity, contamination with bacteria and the amount of foreign material. The ingredients of enteral feed differ between products from different manufacturers. One fatal case was reported by Takeshita et al. 2002 and in two fatal cases the cause of death was septicaemia (Donovan 1979; Casewell and Philpott-Howard 1983). In non-fatal cases patients received 15–400 ml but most of these cases required intensive care treatment (Ulicny and Korelitz 1998; Kenelly and Barnes 1989; Stellato et al. 1984). In all these cases elderly patients were affected and this is the first report of an accidental application of enteral feed in a intravenous line in a child.

In the subsequent court trial the nurse was found guilty of involuntary manslaughter.

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