Suicide by air embolism introduced by means of a bicycle pump

Introduction

Gas embolisms have a wide variety of etiologies. They are potentially life-threatening but rarely the cause of death. Fatal venous air embolisms can be caused by acute pathological alterations, diagnostic and surgical procedures [1–3]. Some cases of air entering the venous blood system subsequent to incorrectly applied medical measures or in connection with defective intravenous infusion systems have been described [4–8]. In medicolegal cases air embolisms can be found principally after blunt chest trauma and in connection with penetrating injuries, such as cuts and stab wounds especially to the head, neck and chest and even more rarely gunshot wounds.

Most of the cases observed, gas embolism was accidental. According to the literature [9], premeditated homicides through injection of air into the venous system are extremely rare, whereas a few cases of forced air injection in suicidal intention have been described. This article describes a case of suicide through air embolism induced by a bicycle pump.

Case history

Previous history

A 64-year-old man was found by his wife. He was lying motionless on his back, undressed in the bed in their flat. A commercially available bicycle pump with a volume of ca. 100 ml was found in

his right hand. A cannula as used for the injection of insulin was attached to the valve of the pump (■ Fig. 1). There were no indications where the cannula came from. Macroscopically visible traces of blood were detected in the cannula and two puncture wounds were found on the back of the left hand (■ Fig. 2). The wife began resuscitation, which was continued by the emergency physician who had been summoned to the site, but without positive outcome.

With respect to pre-existing conditions, there was only mild arterial hypertension. Aside from that, the deceased had recently consulted an urologist. A concrete diagnosis was unknown. According to relatives, the deceased—who worked as a carpenter before his retirement—had not suffered from depression and had not spoken of suicide in the days prior to his death. No suicide note was found. The handedness of the deceased remained unknown to us as it was not mentioned in the police report. The po-

lice investigations led to the conclusion that the man had committed suicide.

Radiography

Prior to autopsy a thorax radiograph was taken in the anteroposterior (AP) view and assessed by the physicians who carried out the autopsy. The gas embolism which was discovered later during autopsy could not be reliably seen in the radiograph.

Results of autopsy

The autopsy was performed 22 h after death. The body was in a fresh state and showed no signs of putrefaction besides a slight greenish discoloration of 2 cm in diameter in the right side of the lower abdomen. Body height: 177 cm, body weight: 68.9 kg, body mass index (BMI): 21.7 kg/m².

The external examination of the corpse revealed two small, fresh puncture wounds with minimal bleeding into the

Fig. 1 ◀ Cannula (with a slightly curved tip) as used for insulin injection, set into the valve of the bicycle pump

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Fig. 2 ▲ Small puncture wounds on the back of the left hand

Fig. 3 ▲ Postmortem thoracic X-ray without a sure indication of gas in the right ventricle

Fig. 4 ▲ Aspirometer for proving air/gas embolisms in autopsies, used according to Bajonowski et al. 1998 [10]

surrounding tissue located centrally on the back of the left hand. While preparing the back of the hand it was discovered that a superficial vein had been punctured several times. There were no other signs of external application of force.

The autopsy began with the opening of the chest cavity. After the sternum had been removed, the pericardium was opened and filled with water until the heart was submerged. The right ventricle was then punctured under water with the heart cannula of the aspirometer (■ Fig. 4), and in total ca. 50 ml of gas was obtained. Usage of the aspirometer followed the method described in Bajonowski et al. [10]. The foramen ovale was closed.

Other findings of acute pathological alterations were a slight swelling of the brain, a pronounced lung edema, erosive bleeding in the stomach lining and a low-grade aspiration of stomach contents into the peripheral bronchial tubes. Pre-existing pathological organ alterations were not found, there were neither pathological changes to the urinary organs, the sex organs, nor the rectum.

Toxicological analysis

In toxicological analysis portions of the stomach contents, femoral blood samples and urine were tested using immunochemistry, UV-spectrometry as well as HPLC. In the contents of the stomach

and in the femoral blood only caffeine (3.5 mg/l) was found; a trace of bisoprolol was detected in the urine. The deceased was not under the influence of alcohol at the time of death.

Discussion

Gas embolism usually occurs through the blockage of a blood vessel by a gas aggregation. It can affect the arterial as well as the venous branch of circulation. Circulatory arrest as a result of gas embolism can be caused by a massive embolism in previously healthy persons or in cases of pre-existing cardiac or pulmonary insufficiency, by decompensation and several smaller embolisms. The right ventricle is adapted to low pressures and has only limited ability to react to an acute increase of resistance in pulmonary vessels. As widely known the Italian anatomist Morgagni postulated even in the late eighteenth century that an increasing afterload of the right ventricle threatens the circulatory system by a lower ejection fraction, as well as a certain amount of gas in the right ventricle [44]. In addition, humorally and/or reflexively elicited vasoconstriction plays an important role. Lung segments affected by embolic obstruction are still ventilated but the alveoli do not participate in gas exchange, resulting in an increased dead space. The functionally disturbed balance between ventilation and perfusion leads to dysp-

nea and arterial hypoxemia. This hypoxemia can be partially explained through the opening of additional arteriovenous anastomoses [2, 10–13].

Information on the quantity of gas in a fatal gas embolism varies in the literature. Most frequently, quantities of 70–130 ml are given to be fatal [10, 12, 13]. Some authors cite quantities of 10 ml and 70 ml gas as being fatal [14, 15], others described a rapidly injected gas volume of 100–300 ml or 3–5 ml/kg body weight as a fatal volume [16]. Acute amounts of 0.5–2 ml/kg body weight are attributed to cause inter alia myocardial and cerebral ischemia, hypotension and pulmonary hypertension [2]. Because no pathological alterations of the organs or evidence for an intoxication were found, the 50 ml of gas in the right ventricle was considered to be the cause of death.

Gas embolisms are more frequently described in connection to medical procedures like the use of rapid infusion systems, invasive vascular procedures and neurosurgical procedures [17] as with, for example, cuts or stab wounds [18, 19], gunshot wounds to the head [20, 21] or open craniocerebral injuries [22–24]; however, gas embolism is not inevitable in these cases [25, 26]. Furthermore, gas embolism can occur in connection

with medical malpractice [4–8]. Most frequently, gas embolism is found in connection with inappropriate infusion therapies [4, 6, 8], endoscopic operations with air insufflation [18], surgery on large blood vessels, neurosurgery and orthopedic surgery [27] but also in faulty operation of dialysis equipment or during legal abortions [28, 29]. Furthermore, there are reports of sexual orogenital insufflation in pregnancy and also autoerotic practices that caused a fatal air embolism [30, 31].

Traditionally, a thorax radiograph is used as a non-invasive proof of gas embolism of the right ventricle. A transesophageal echocardiography is the most sensitive invasive monitoring device, the precordial Doppler ultrasound is the most sensitive noninvasive monitoring device [2, 32] and helical computed tomography (CT) [33] is also applied. In the present case, the gas embolism of the right ventricle was not reliably detected by radiography, probably because the volume of 50 ml air found using the spirometer was too small. In addition, the small amount of blood was foamy, which might further have complicated radiological confirmation. There are various methods for detecting a gas embolism during autopsy: the test according to Richter [34] can be used as qualitative proof as bubbles would emerge after inserting the submerged right ventricle. An appropriate method for the quantification and collection of the gas is the method according to Bajonowski et al. using an spirometer [10] as used in this case. Gas samples obtained by this method can be chemically analyzed [10, 35]. In the present case no analysis of the gas sample was performed because the autopsy was conducted just 22 h after the death and there were no signs of internal putrefaction. Moreover, it was assumed that the gas within the right ventricle was ambient air out of the bicycle pump.

Suicides through insufflation of air into the venous system have seldom been reported. There are a few cases described in which people connected an oxygen supply with tubes to a venous cannula to commit suicide [36–38].

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Abstract

A 64-year-old man was found dead in bed in his flat. In his right hand he held a bicycle pump to which a small-gauge cannula was attached and two fresh puncture wounds were found on his left hand. During the autopsy an air embolism of ca. 50 ml air was detected in the right ventricle of the heart by means of an spirometer. The air embolism could not be reliably detected in a thorax radiograph taken prior to autopsy. Blood in

the right ventricle was foamy. Pathological changes to organs were not found. Aside from the puncture wounds, there were no signs of externally applied mechanical force. The results of the toxicological analyses were negative.

Keywords

Bicycle pump · Gas embolism · Air embolism · Suicide · Spirometer

Suizid durch Luftembolie unter Verwendung einer Luftpumpe

Zusammenfassung

Ein 64 Jahre alt gewordener Mann wurde tot im Bett liegend in seiner Wohnung aufgefunden. In seiner rechten Hand hielt er eine Fahrradluftpumpe, auf der eine kleine Injektionsnadel befestigt war. An der linken Hand des Mannes konnten zwei frische Punktionsmale festgestellt werden. Unter der Obduktion wurden mit Hilfe eines Spirometers etwa 50 ml Luft im rechten Ventrikel detektiert. Die Luftembolie wurde in der vorausgegangenen Röntgenuntersuchung des Thorax nicht sicher festgestellt.

Das Blut im rechten Ventrikel war schaumig. Pathologische Organveränderungen wurden nicht gefunden. Abgesehen von den Punktionsmalen zeigten sich keine Zeichen einer externen mechanischen Gewalteinwirkung. Die Ergebnisse der chemisch-toxikologischen Untersuchungen waren negativ.

Schlüsselwörter

Luftpumpe · Gasembolie · Luftembolie · Suizid · Spirometer

In one suicide case a man blew air through a system of tubes and a cannula into a vein in one arm [39], in another case an oral air insufflation is assumed in a patient in hospital after suicidal cutting of the veins of the wrist [40]. Another case describes a fatal air embolism of a man after cutting his varicose saphenous vein in apparently suicidal intention [41]. Moreover, one case is presented in which a man committed suicide by compressing a 2000 mL plastic bottle containing air linked to a system of tubes and a venous cannula with his body weight [42]. With respect to forensic cases, bicycle pumps in connection with air embolisms have usually been used in cases of illegal abortion [43]. To our knowledge, our case is the first in which a bicycle pump has been used to commit suicide by intentionally inflicted air embolism. The two puncture wounds on the back of the left

hand were suitable as an entry point for air into the circulatory system.

The homemade system, an insulin cannula set into the valve of the bicycle pump, is capable of insufflating air into the venous system. The insulin cannula was slightly curved, maybe for an easier insertion of the needle. Apparently, the man had placed the bicycle pump on the back of the hand at a right angle, punctured the vein, and then pressed the plunger down. By reconstructing the case this procedure was possible if the man had pulled up the plunger before inserting the cannula into the vein. The existence of two puncture wounds indicated that he was not successful at the first attempt.

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Compliance with ethical guidelines

Conflict of interest. J. Falk, V. Fischer, T. Riepert and M.A. Rothschild declare that they have no competing interests.

For this article no studies with human participants or animals were performed by any of the authors. All studies performed were in accordance with the ethical standards indicated in each case. The studies were performed in accordance with the guidelines of the central ethics committee and the German Medical Association.

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