Case Report

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A Case Report on Traumatic Head Injury Leading to Air Embolism

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ABSTRACT

A 15-year-old male was assaulted by several people living near his home. He had a few abrasions, contusions, and minor fractures of the skull bone. The patient survived for approximately 22 hours while undergoing conservative treatment. On post-mortem examination, frothy blood was seen coming out from the right ventricle, along with numerous air bubbles in the jugular veins and heart, eliciting the diagnosis of air embolism. The case presented here draws attention to the fact that a simple head injury, augmented by lapses in treatment due to a lack of suspicion, can lead to fatal degrees of air embolism.

Introduction

Gas embolism, also known as air embolism, occurs when air or gas bubbles enter the blood vessels. This condition can manifest as either an arterial or venous embolism. Venous air embolism (VAE), a specific type of gas embolism, poses significant risks of severe health complications and death. VAE is primarily an iatrogenic issue resulting from the introduction of atmospheric gas into the venous circulatory system[1-3]. Historically, this health issue was primarily linked to neurosurgical operations performed while the patients were in a seated position[4-5]. Recently, venous air embolism has been linked to various medical procedures and conditions. These include central venous catheterization, [3,6,7]chest injuries (both penetrating and blunt), [8, 9] ventilation using high-pressure machines, [3] thoracocentesis, [1] hemodialysis, [3,7] and numerous other invasive procedures involving the blood vessels.Numerous instances of venous air embolism (VAE) are asymptomatic and do not result in negative consequences, leading to underreporting. Typically, when symptoms manifest, they lack specificity, necessitating a high degree of clinical suspicion for prompt further investigation and appropriate treatment. The occurrence of VAE requires two essential conditions: [1] a direct pathway between an air source and blood vessels, and [2] a pressure differential that facilitates the entry of air into the circulatory system[4].

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The severity of venous air embolism-related morbidity and mortality is primarily influenced by three factors: the quantity of gas introduced, the speed at which it accumulates, and the patient's body position during the incident[1,6]. Typically, minor quantities of air are dispersed within the capillary network and absorbed by the circulatory system without causing any noticeable effects. Historically, it has been believed that a volume exceeding 5 mL/kg of air introduced into the intravenous system is necessary to trigger substantial adverse reactions, such as shock or cardiac arrest[1]. Adverse events have been documented with the intravenous introduction of as little as 20 mL of air[7] (equivalent to the volume in an unprimed IV line). Cerebral circulation can be fatally affected by 2 or 3 mL of air. When air enters the systemic venous system rapidly or in large quantities, it places considerable stress on the right ventricle, particularly if it causes a notable increase in pulmonary artery (PA) pressure. This elevated PA pressure may obstruct right ventricular outflow and further impede pulmonary venous return to the left heart. Consequently, the reduced pulmonary venous return leads to decreased left ventricular preload, resulting in diminished cardiac output and ultimately systemic cardiovascular collapse.[1,4,6]

Venous air embolism (VAE) commonly results in rapid heart rhythms, although slow heart rates can also occu[2,4]. The activation of complement and release of mediators and free radicals can trigger secondary effects, leading to fluid leakage from capillaries and subsequent non-heart-related lung swelling[1,7,3]. The severity of VAE's potentially fatal and disastrous outcomes is directly linked to its impact on the organ system in which the air bubble becomes lodged. VAE often causes significant neurological, respiratory, and cardiovascular complications and can be lethal. The mortality rate for catheter-related VAE has been reported to reach 30%. (2) In a study involving 61 patients with severe lung injuries, the death rate associated with concurrent VAE was 80% for those with blunt trauma and 48% for those with penetrating trauma[8,14,15]. The severity and fatality rates linked to traumatic VAE, similar to nontraumatic VAE, are influenced by several factors. These include concurrent injuries, as well as the quantity and speed of air infiltration, the patient's existing heart condition, and their physical orientation.

Case report

The dead body of a 15-year-old male was brought to a tertiary care hospital for a post-mortem examination. According to police papers, this was a case of assault, involving a head injury inflicted on the deceased and his father on the night of the previous day. The father of the deceased died immediately, whereas his son survived for approximately 22 hours after the injury. During this time, investigations, including CT scans, were conducted, and supportive treatment was given for the head injury – including a "head-up position" and mannitol infusion.

CT reports showed fractures of the left ethmoid air cells, right mastoid air cells, and anterior wall of the right external auditory canal, which extended to the petrous part of the temporal bone along with a thin strip of subdural hemorrhage in the fronto-parieto-temporal region, subarachnoid hemorrhage, and cerebral edema.

Postmortem examination

An averagely built body of the deceased lay in the PM room, wearing a white-colored full-sleeve shirt, dark grey-colored jeans pants with a black leather belt, a white metallic buckle, and blue-colored underwear. Multiple rounds of black thread were present around the right wrist, and one white thread was present around the waist. A blood-soaked white cotton plug was present in the right ear. Rigor mortis was found in the developing stage, and PM lividity was present on the back and dependent parts, except over pressure areas. Conjunctivae were congested, and blood was found coming out of the nose. Two grazed abrasions of sizes 3 cm × 2 cm and 1 cm × 1 cm were found 2.5 cm apart over the right posterior auricular and occipital regions, respectively, with an underlying contusion of size 7 cm × 4 cm. No palpable fractures were externally observed. On internal examination, both temporalis muscles were found to be contused, with diffuse scalp hematoma and extravasation of blood. A fracture of the right petrous temporal bone consistent with the CT findings was found, along with a comminuted and depressed fracture at the base of the skull in the right middle cranial fossa, involving the greater wing of the sphenoid bone. Corresponding to these fractures, the dura was torn, and the petrous temporal venous sinus was lacerated (Fig. 1). Subdural and subarachnoid hemorrhages, as described on CT, were also observed. Upon opening of the neck, extensive air bubbles were observed bilaterally in the external jugular veins (Fig. 2). The body of the sternum was removed along with the ribs while the manubrium was kept in place. The pericardium was opened, the heart was lifted, and an incision was made on the anterior surface, which revealed large bubbles of air and frothy blood exiting the right ventricle (Fig. 3). The cause of death was revealed to be "air embolism due to head injury."

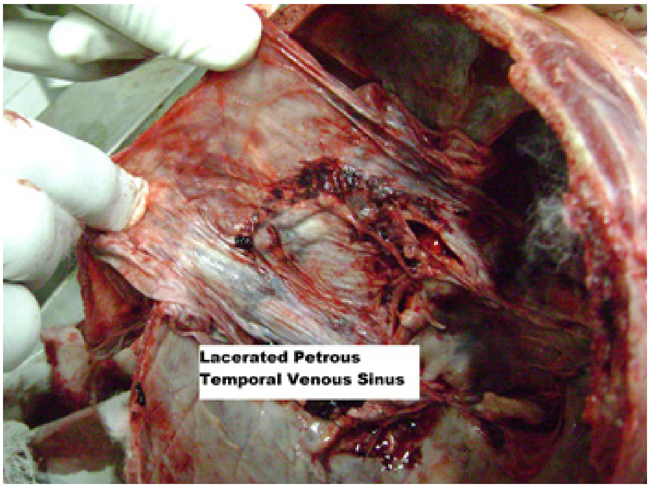

Fig. 1: Lacerated petrous temporal venous sinus

Fig. 2: Air bubbles in the left external jugular vein

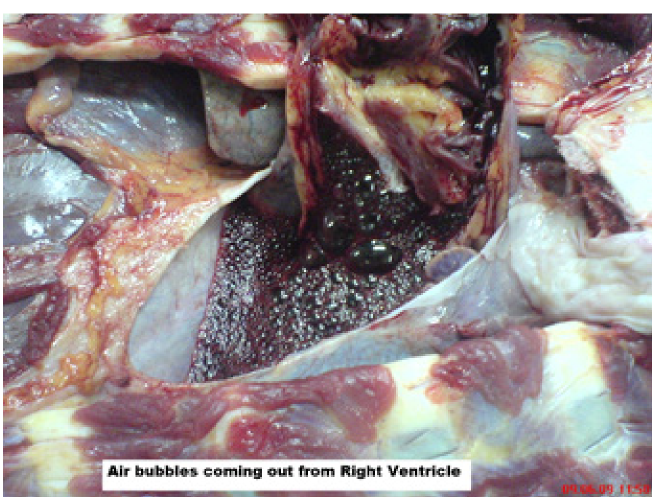

Fig. 3: Air bubbles coming out from the right ventricle

Discussion

Air embolisms typically occur under two main scenarios. The first involves a swift transition from a high-pressure to a lower-pressure environment. (16) The alternative scenario occurs when air enters an exposed blood vessel, usually a vein, owing to pressure differentials. During medical procedures, air embolism (AE) or gas embolism (GE) can occur via several pathways, mainly involving the introduction of air or gas into the vascular system. Specific mechanisms often vary depending on the particular medical procedure or condition. In the case of operative laparoscopy, AE or GE may arise from an air lock (AL) or gas lock (GL) forming in the heart's right side, creating an obstruction (TJ) for blood circulation in the pulmonary vasculature (PT). (17) In the latter case, the majority of incidents are iatrogenic, meaning that medical procedures cause them. These can include certain cranial surgeries performed with the patient in a sitting position, the use of central lines or venous catheters, air insufflation in the uterus, or positive pressure ventilation where the applied pressure exceeds the resistance of the lungs. In this case, the second factor played an important role; that is, the pressure gradient favored the entry of air into an open vascular channel, the petrous temporal sinus. The condition was aggravated by the prescription of "the head-up position of the patient, probably to control cerebral edema." This, along with sufficient time for air to enter the venous circulation through the fracture in the air cells and temporal bone, resulted in the accumulation of air in the right ventricle, ultimately leading to right-sided heart failure.

Conclusion

Thorough scientific examination and interpretation during autopsy enable the surgeon to determine the precise cause of death in ambiguous cases. A comprehensive study and understanding of the circumstances surrounding death may also reveal significant indicators regarding the mode and cause of death; therefore, rigorous efforts should be made to examine the variables associated with death, including the location and magnitude of injury, potential complications, administered treatment, and possible adverse effects. A heightened level of vigilance is necessary to diagnose air embolisms and consequently prevent complications.

Author contributions

Al The authors contributed to the study design and conception, manuscript drafting, and approved the final draft of the manuscript.

Conflict of interest

The authors have no conflicts of interest to declare.

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None.

Ethical Clearance

Not applicable.

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