

## Cranial Computed Tomograms of Arterial and Venous Cerebral Air Embolism

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## Case Report

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# Cranial Computed Tomograms of Arterial and Venous Cerebral Air Embolism

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**Abstract** We had the opportunity to give our expert opinion on two cases, in which the physician did not make the appropriate diagnosis of cerebral air embolism. One case was a cerebral arterial air embolism, which had occurred due to a simple error made by a physician following coronary angiography. The other case was a cerebral venous air embolism, which was deliberately induced by venous injection of 340 ml of air. In both cases, cranial CT was performed but an accurate diagnosis was not made; nevertheless the manner of death was recorded as natural death on both death certificates. We suggest that a physician cannot easily describe the manner of death on a death certificate when the cause of death is not certain, and that a medico-legal autopsy should definitely be performed for investigation into the cause of death in such case.

**Key words:** Cerebral air embolism, Cranial computed tomogram, Medical malpractice, Homicide

### Introduction

It is said that an air embolism, which is the entry of air into a vascular structure, is mainly an iatrogenic problem<sup>1)~5)</sup>. Air embolisms can generally be divided into two types; arterial air embolism and venous air embolism<sup>1)~3)</sup>.

Arterial air embolism is caused by the entry of air into the pulmonary veins or directly into arteries which provide systemic circulation. Once air bubbles invade the arterial circulation, they are distributed to practically all the organs. The symptoms of embolization depend upon the amount of air, however embolization to the cerebral and coronary circulation may result in severe morbidity and even death, even if the amount of air is small<sup>1)~3)6)</sup>. In particular, it is generally accepted that a cerebral arterial air embolism can be in-

duced by cardiac surgery during cardiopulmonary bypass, by hip replacement, by craniotomy performed in the seated position and by caesarean section<sup>1)~4)</sup>.

On the other hand, venous air embolism may often occur in patients when a central venous catheter is inserted, maintained or removed<sup>2)</sup>. In addition, it is said that hyperventilation, abortion and oral sex may also be the cause of venous air embolism<sup>2)3)</sup>. Furthermore, there have been some reports of cerebral venous air embolism associated with meningitis, lumbar spondylitis and subarachnoid hemorrhage<sup>7)8)</sup>.

We had the opportunity to give an expert opinion on two cases occurred in other hospitals, in which the physician did not make the appropriate diagnosis of cerebral air embolism. We herein present the two cases of cerebral arterial and venous air embolism, in which both the amount of air

and its route of travel are described.

### Case History

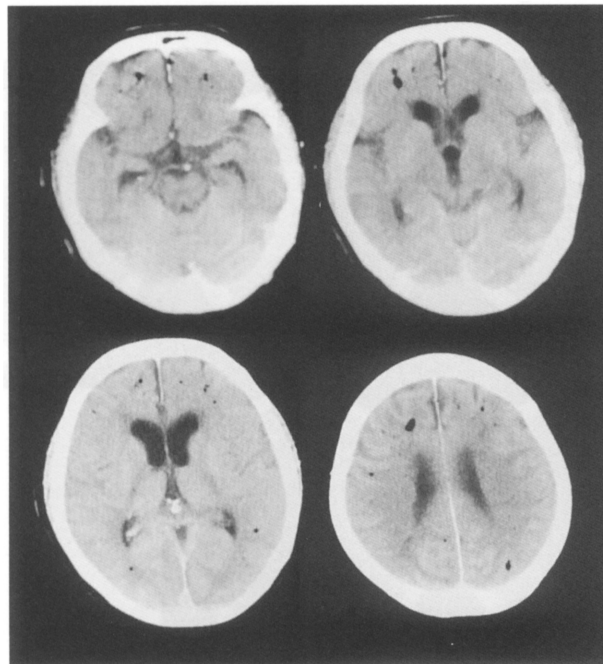
#### Case 1

An 83-year-old woman who had been suspected of suffering from angina pectoris was hospitalized for an examination using coronary angiography (CAG). A sheath was catheterized in her left brachial artery, through which the CAG was performed. Before the sheath catheter was extracted after the CAG, the physician wound a manchette around her arm which should have been ballooned by air because of pressure hemostasis at the point of puncture. The physician should then have injected air into the manchette through the port of the manchette, however, 40 ml of air were actually injected into the left brachial artery through the port of the sheath, by mistake. The patient lost consciousness immediately after that, and a cranial computed-tomogram (CT) was taken. Many small circular-shaped low-density areas could be seen in

the parenchyma of her cerebrum (Fig. 1). Three days after the incident, she died without recovering consciousness. The physician described the cause of death as cerebral infarction and recorded death due to natural causes on the death certificate. He did not notify the police of the incident. Subsequently, the incident was revealed by whistle blowing by someone from within the hospital.

#### Case 2

A 39-year-old man, whose motor function and intelligence were normal, was given a eutrophic drink mixed with a hypnotic and he was then injected with 50 mg of diazepam into his peripheral vein whilst he slept, by his wife, who was a nurse. He thus had no response to the stimulus of pain. His wife and her colleagues then inserted a winged needle into his right cubital vein and injected 340 ml of air using a disposable syringe, which resulted in his falling into a deep coma. He was then intentionally car-



**Fig. 1** Cranial computed tomograms of a cerebral arterial air embolism. Many circular-shaped low-density areas can be seen in the parenchyma of the cerebrum.

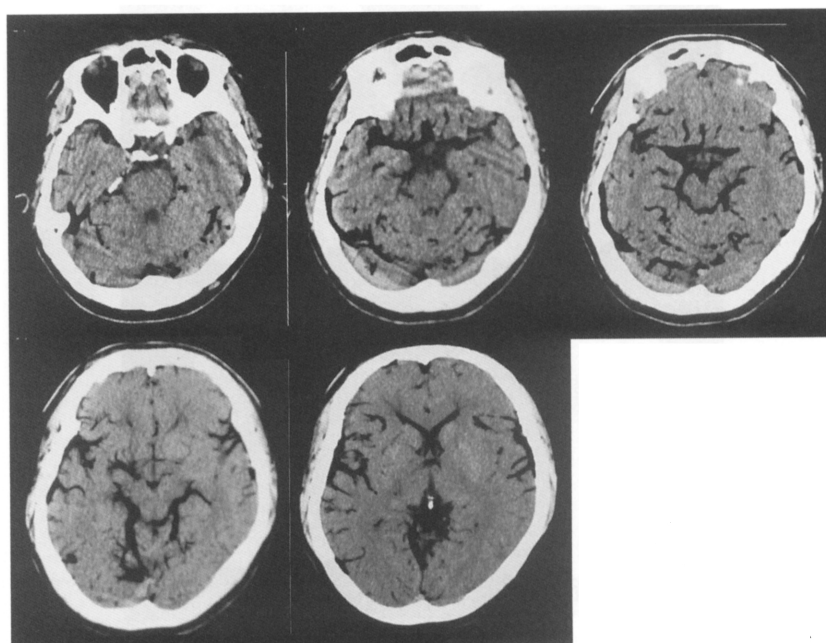
ried to an emergency hospital where a cranial CT was taken. Extensive irregular low-density areas could be seen on the surface of the cerebrum (Fig. 2); however, his wife stated that he had been lying ill in bed due to heart disease. Accordingly, the physician diagnosed his cause of death as a heart attack and recorded death due to natural causes on the death certificate. The incident was not notified to the police. Afterward, the incident was declared to be one of a continuous set of homicides.

### Discussion

In the former case, the patient had complete consciousness prior to the injection and she lost consciousness immediately after the injection of 40 ml of air into her left brachial artery. Moreover, a cranial CT taken after she fell unconsciousness clearly revealed the cerebral gas embolism. Thus, the air injected into the left brachial artery was immediately carried to the cerebral arteries where it caused a cerebral arterial air embolism. In Knight's Forensic

Pathology<sup>9)</sup>, it is described that air injected into a limb artery would do no harm at all and that most of the gas would likely be absorbed very rapidly by the tissues. However, our case would seem to suggest that rapid injection of a large amount of air can cause a cerebral arterial air embolism, even if it is injected into a limb artery.

The symptoms of cerebral arterial air embolism develop suddenly and are various. A mild case of cerebral arterial air embolism involves dizziness, headache and minor motor weakness, whereas a severe case results in convulsions, loss of consciousness and death<sup>1)2)</sup>. Accordingly, the physician should have noticed that the cranial CT presented in Fig. 1 showed the typical findings of cerebral arterial air embolism and he should have doubted whether air had been correctly infused into the port of the manchette, and suspected that it had instead been infused into the port of the sheath. However, the physician recorded the cause of death of the woman as natural death on the death certificate, with the obvious inten-



**Fig. 2** Cranial computed tomograms of a cerebral venous air embolism. Extensive and irregular low-density areas can be seen on the surface of the cerebrum.



sion of concealing an act of medical malpractice.

The latter case was a homicide planned and executed by the victim's wife and her friends who all were nurses. They injected 340 ml of air to his right cubital vein. Once air enters the venous vascular system, the air rapidly reaches the right ventricle and then embolizes within the pulmonary circulation, resulting in diminished cardiac output and systemic cardiovascular collapse<sup>1)</sup>. We thus consider that injection of a large amount of air into a vein led to acute cor pulmonale and/or asystole and we conclude that the man died immediately after the injection. The mechanism behind the development of low-density areas on the surface of the cerebrum is as follows: air which is injected into vein first flows into the right ventricle and then the pulmonary arteries, leading to acute cor pulmonale and/or asystole. After that, any air, which was still being injected, flows into the right ventricle, so that the superior caval vein overflowed and the air was then regurgitated into the cervical and cranial veins. Accordingly, the cranial CT taken in our latter case showed the typical findings of cerebral venous air embolism. It has been reported that the descriptions and photographs of cerebral venous air embolism are probably artifacts<sup>10)</sup>, however, our case would seem to suggest that a cerebral venous air embolism can actually be caused by the injection of air into a vein. It is likely that the fact of his homicidal death would have been detected if the cranial CT had been appropriately diagnosed and if a medico-legal autopsy had then been performed on the basis of the cranial CT.

In conclusion, we suggest that a physician cannot easily describe the manner of death

on a death certificate when the cause of death is not certain, and that a medico-legal autopsy should definitely be performed for investigation into the cause of death in such cases.

### Acknowledgments

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(和文抄録)

## 動脈性および静脈性脳空気塞栓の頭部 CT 画像

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我々は、臨床医が診断なし得なかった脳空気塞栓の頭部 CT 画像について法医学的鑑定を行った。1例は冠動脈造影中に生じた動脈性脳空気塞栓で、施術医の単純なミスであった。もう1例は静脈に340 mlの空気を注入されたことによって生じた静脈性脳空気塞栓であった。いずれも適切な診断が行われなかったにもか

かわらず、死亡診断書の「死因の種類」の欄には「病死」と記載されていた。死因が不明である死体については、その原因を安易に「病死」とすることは避けなければならない。正確な死因を決定するには積極的に解剖を行うべきである。