Nontraumatic postmortem computed tomographic demonstration of cerebral gas embolism following cardiopulmonary resuscitation

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Abstract

Purpose. The aim of this study was to investigate cerebral gas embolism (GE) on nontraumatic postmortem CT (PMCT), regarding its frequency, location (arterial or venous), and causes.

Materials and methods. Our subjects were 404 nontraumatically deceased patients who had been in a state of cardiopulmonary arrest on arrival at our emergency room. PMCT was performed within 2 h of the confirmation of death.

Results. Cardiopulmonary resuscitation (CPR) was performed on 387 of the 404 subjects; and of these, cerebral GE was detected in 29 (7.5%) subjects (3 arterial, 25 venous, 1 undeterminable). Cerebral GE was not noted in the other 17 of the 404 subjects who did not undergo CPR. However, there was no significant difference in the incidence of cerebral GE between the subjects who underwent CPR and those who did not. The mechanism of cerebral arterial GE was presumed due to pulmonary barotrauma and/or paradoxical embolism, while the thoracic pump theory was suggested to explain the cerebral venous GE.

Conclusion. Cerebral arterial/venous GE is found in CPR cases on nontraumatic PMCT.

Key words Postmortem computed tomography · Cerebral gas embolism · Cardiopulmonary resuscitation

Introduction

In light of the number of autopsies currently being performed, postmortem examination using imaging modalities such as computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography, and angiography has been proposed as an alternative to or a concomitant method for autopsy.1–13 In Japan, as the medical examiner system does not extend nationwide, about 80% of major facilities with emergency rooms (ERs) use postmortem CT (PMCT) to detect the cause of death in patients arriving at the ER in a state of cardiopulmonary arrest (CPA).14–18 As the need for and frequency of PMCT increase worldwide for the purpose of determining the cause of death, diagnostic methods that aid the interpretation of PMCT findings such as intravascular gas in the heart, great vessels, and liver need to be established.19,20

Cerebral gas embolism (GE) is thought to occur accidentally,21–23 iatrogenically,24,25 and as a result of cardio-
pulmonary resuscitation (CPR) after CPA. On PMCT imaged immediately before or after death in traumatically deceased cases, only arterial findings of cerebral GE due to CPR have been reported. In contrast, both arterial and venous GE findings have been reported in nontraumatically deceased cases. Any analysis of cerebral GE induced by CPR should exclude the possible effects of trauma. However, the published literature on the subject is limited, and the nature of GE remains unclear with regard to its frequency of occurrence and whether it occurs more commonly in arteries or veins. In this study, we investigated cerebral GE on PMCT in nontraumatically deceased subjects and discussed its possible mechanisms.

Materials and methods

Our subjects were 404 nontraumatically deceased patients for whom death was confirmed after arriving at our ER in a state of CPA between January 2000 and December 2007. They included 274 men and 130 women, ranging in age from 0 to 101 years (mean 67 years). CPR was performed on 387 of the 404 subjects during transport and in our ER by artificial respiration with bag-valve masking and intratracheal intubation, continuous chest compression, and infusion. CPR was not performed on 17 of the 404 subjects because they had already exhibited early signs of death (postmortem hypostasis is usually apparent within 30 min to 2 h following death, as is rigor mortis at about 4 h after death), although there was no indication of putrefaction.

Causes of death were diagnosed based on a comprehensive understanding of the patient’s present illness, clinical history, and PMCT findings. A fatal hemorrhagic lesion was defined when PMCT detected a subarachnoid hemorrhage, cerebral hemorrhage, aortic dissection, or rupture of abdominal aortic aneurysm. For diagnosis of acute heart failure, a frequent cause of death, PMCT cannot detect direct findings, such as thromboembolism of the coronary artery or ischemic myocardium. Therefore, we diagnosed acute heart failure when pulmonary edema was seen on PMCT, which is an indirect finding that results from cardiac pump failure. Autopsy findings were also obtained in 29 cases for which we were able to secure family consent.

PMCT was performed within 2 h of the confirmation of death in the Radiology Department of our institution with the prior approval of the institutional review board. Two clinical CT scanners were used for PMCT. Until April 2004, PMCT was performed with a single-detector CT scanner (Accel Proceed; GE-Yokogawa Medical Systems, Tokyo, Japan) in conventional scan mode without using the helical scan technique. The scan parameters for the head were as follows: 120 kV, 160 mA, 2.0 s/rotation, contiguous 5-mm sections from the orbitomeatal line to the pentagon level, and 10-mm sections in the upper area. The scan parameters for the thorax, abdomen, and pelvis were 120 kV, 250 mA, 1.0 s/rotation, and 15-mm intervals with 10 mm collimation. A neck CT scan was omitted because the attending emergency physician, who performed CPR on the patient, thought that the cervical spine was not injured based on a comprehensive understanding of the patient’s present illness, clinical history, and physical examination; thus, the cause was categorized as a nontraumatic death.

From April 2004, PMCT was performed with a 16-channel multidetector row CT (MDCT) scanner (Aquanion 16; Toshiba Medical Systems, Tokyo, Japan). The scan parameters for the head were conventional scan mode 120 kV, 200 mA, 2.0 s/rotation, 1 mm collimation, and contiguous 4-mm sections. The scan parameters for the thorax, abdomen, and pelvis were helical scan mode, 120 kV, 300 mA, 0.7 s/rotation, 1 mm collimation, pitch 15, and contiguous 10-mm sections. The neck region was not scanned for the same reason as described above. All images were observed on a 21-inch monochrome monitor with 1600 × 1200 pixels at appropriate window settings for each region.

A board-certified radiologist and board-certified emergency medicine physicians retrospectively reviewed PMCT findings of the brain, thorax, abdomen, and pelvis. We determined whether cerebral GE was present by means of consensus. Cerebral arterial GE26–33 was defined as when one or more of the following arteries contained gas: the internal carotid artery (cavernous and supraclinoid segments) or the anterior, middle, or posterior cerebral artery. Cerebral venous GE34,35,38,39 was defined as when the posterior cranial fossa or venous sinuses contained gas. Cardiovascular gas and other abnormal findings associated with cerebral GE were also recorded if present.

The chi-squared test for independence was used to determine whether differences between the incidence of cerebral GE in patients who received CPR and that in those who did not were statistically significant. A two-tailed probability value of \( P < 0.05 \) was considered statistically significant.

Results

Cerebral GE was detected in 29 (7.5%) of the 387 subjects who underwent CPR. No cerebral GE was detected in the 17 subjects who did not receive CPR. The differ-