



Delayed Subarachnoid Hemorrhage after Cardiopulmonary Resuscitation: Case Report and Literature Review

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Abstract

We report here a case of a 54-year-old man who developed subarachnoid hemorrhage following cardiopulmonary resuscitation. Both computed tomography scans performed respectively within 24 h and on day 3 indicated a normal physical condition. The computed tomography scan conducted 7 days after the cardiopulmonary resuscitation revealed diffuse cerebral edema and subarachnoid hemorrhage. The existence of blood in cerebrospinal fluid was confirmed by lumbar puncture. We propose that ischemia/reperfusion response plays an important role in the development of post-resuscitation subarachnoid hemorrhage.

Introduction

Cardiac arrest is one of the leading causes of death.¹ According to previous reports, the hospital mortality rate of cardiac arrest ranges from 50% to 71%.^{2,3} Apart from those immediate pathological changes resulting from cardiac arrest and cardiopulmonary resuscitation (CPR), other complicated pathophysiological changes occur during the post-cardiac arrest period.⁴ This period also comprises some neurological complications as well, such as hypoxic-ischemic encephalopathy. However, subarachnoid hemorrhage (SAH) has been rarely reported as a delayed complication of CPR.^{5,6} We report herein a case of SAH as a complication of CPR and present our analysis of its mechanism.

Case report

A 54-year-old man presented to a local hospital, having a medical history of pulmonary embolism and deep vein thrombosis, and who was currently receiving anticoagulant therapy of rivaroxaban. He complained chest tightness, shortness of breath, and hemoptysis that had occurred for about 3 weeks. On the same day, he developed heart failure and was admitted to the Intensive Care Unit. His hemodynamics collapsed suddenly and the heart rate was

extremely slow the day after his admission. CPR was initiated as soon as the staff identified the abnormal condition and lasted for about 20 m until spontaneous cardiac activities returned and satisfactory hemodynamics were obtained. However, a coma persisted. Computed tomography (CT) scan of the brain was performed 3 h after the CPR and repeated 3 days later. Both of the two pictures obtained indicated a normal physical condition (Fig. 1). The use of rivaroxaban was not interrupted at any time during this period.

The patient was transferred to our institution on the 7th day after his admission to the local hospital. Upon his admission to our institution, the vital signs were as follows: blood pressure of 110/60 mmHg (norepinephrine at 0.4 µg/kg/m); heart rate of 60 min⁻¹; and body temperature of 39 °C. Physical examination showed that the patient was in a deep coma, and the pupillary light reflex was absent. The laboratory results were as follows: international normalized ratio of 1.32; activated partial thromboplastin time of 49.5 s; platelet count of $90 \times 10^9/L$; D-dimer of > 20000 ng/mL; N-terminal B-type natriuretic peptide concentration of 7460 pg/mL; and lactic acid of 10 mmol/L. Liver function and renal function markers indicated slight impairment.

The CT scan conducted in our institution, at 7 days after the CPR, revealed that there was diffuse cerebral edema and hyperdensity in the sulcus and ventriculus quartus cerebri (49–52 Hounsfield units) (Fig. 1). Lumbar puncture indicated the existence of blood in cerebrospinal fluid (Fig. 2). Therefore, the patient was diagnosed with SAH. CT-angiography of the pulmonary arteries revealed small embolisms in the branches of the right pulmonary artery. We suspected that pulmonary embolism might be the cause of the cardiac arrest. On the 8th day after CPR, the patient was in a profound coma. Since the patient's condition was irreversible, his family withdrew his treatment and transferred him back to the local hospital.

Discussion

It is known that hypoxemia, ischemia, and reperfusion are the

Keywords: Subarachnoid hemorrhage; Cardiopulmonary resuscitation; Reperfusion injury; Pseudo-subarachnoid hemorrhage.

Abbreviations: CPR, cardiopulmonary resuscitation; CT, computed tomography; SAH, subarachnoid hemorrhage.

Received: January 22, 2019; Revised: April 14, 2019; Accepted: April 24, 2019

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How to cite this article: Ou Q, Wen M. Delayed Subarachnoid Hemorrhage after Cardiopulmonary Resuscitation: Case Report and Literature Review. *Exploratory Research and Hypothesis in Medicine* 2019;4(2):39–42. doi: 10.14218/ERHM.2019.00003.

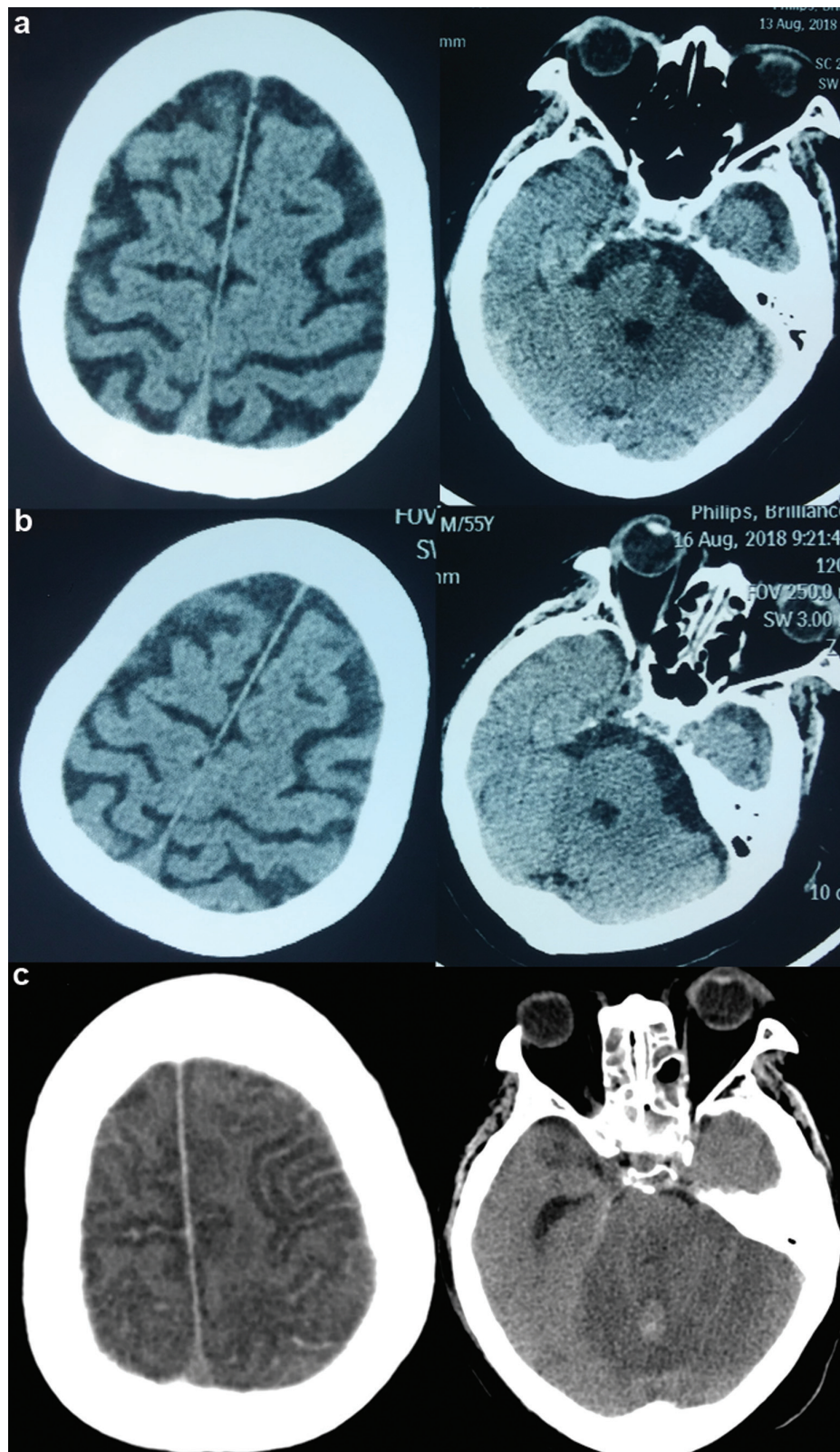


Fig. 1. Exemplary images of matching slice plains in the non-enhanced CT scan. CT scan of the head performed 3 h (a) and 3 days (b) after the CPR indicated a normal physical condition, while the scan conducted 7 days after the CPR (c) revealed diffuse cerebral edema and hyperdensity in the sulcus and ventriculus quartus cerebri (49–52 Hounsfield units). Abbreviations: CPR, cardiopulmonary resuscitation; CT, computed tomography.

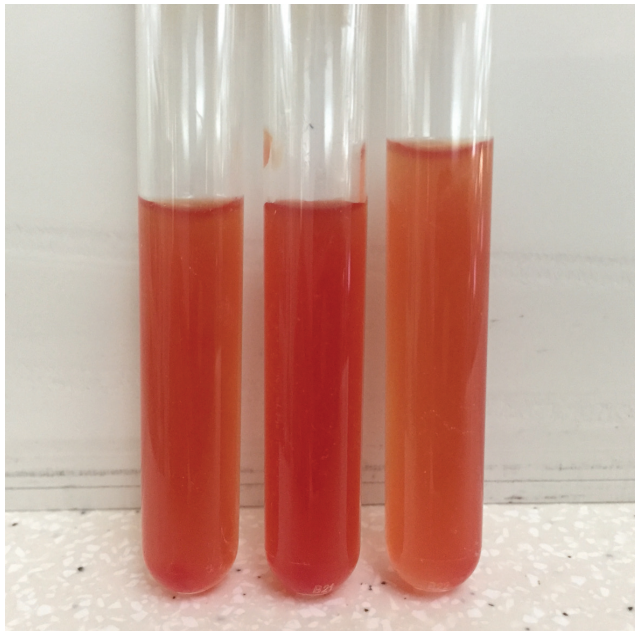


Fig. 2. Cerebrospinal fluid obtained 7 days after CPR. From left to right: the 1st, 2nd and the 3rd tube of cerebrospinal fluid. Abbreviation: CPR, cardiopulmonary resuscitation.

main pathophysiological processes that occur during cardiac arrest and resuscitation, and can cause damage to multiple organs (circu). Brain injury, myocardial dysfunction, and the systemic ischemia/reperfusion response are the major symptoms that present during the post-arrest period. Among them, brain injury is a cause of death after resuscitation. Neurological complications of CPR mainly include hypoxic-ischemic encephalopathy, infarcts, and brain edema.⁴ SAH as a complication of CPR has been rarely reported (Table 1^{5,6}).

Spontaneous SAH is usually caused by aneurysms and arteriovenous malformations. Major pathophysiological changes secondary to SAH include increased intracranial pressure, cerebrovascular spasm, and hydrocephalus.⁷ CT scan is highly sensitive in detecting hemorrhage at the early stage, with an accuracy of more than 90%.⁷ Blood in the cerebrospinal fluid revealed by lumbar puncture helped us to make the diagnosis of SAH for the patient

reported on herein.

Pulmonary embolism and heart failure were considered the causes of the patient’s cardiac arrest. However, absence of symptoms of SAH, such as headache and syncope, and the normal condition indicated by CT brain scan films can lead doctors to rule out the possibility of SAH, though it is a common cause of cardiac arrest. CT scan and lumbar puncture actually established the diagnosis of SAH in our case, which occurred between the 3rd and the 7th day after CPR.

As for the causes of SAH, we believe that ischemia/reperfusion response played an important role in the development of post-resuscitation SAH in our patient. The persistent coma after resuscitation suggested the existence of cerebral hypoxia and ischemia. Cerebrovascular endothelial function and autoregulation were impaired in the hypoxic and ischemic phase. During the initial reperfusion, excessive oxygen could have exacerbated endothelial injuries by producing more free radicals and mitochondrial injury. Delayed brain edema that had occurred days after the cardiac arrest was revealed in the CT scan, and it seems to be the consequence of severe ischemic neurodegeneration.⁴ Impaired endothelium and delayed brain hyperemia played a role in establishment of a bleeding cascade, and finally led to SAH. In addition, the use of rivaroxaban might have been a contributing factor in the bleeding cascade. Cerebral aneurysm might be another potential cause of SAH. However, the patient’s relatives refused another CT angiography. Therefore, we are not sure whether cerebral aneurysm played a role.

Pierre *et al.*⁵ reported a case of early-onset SAH which happened immediately after CPR, but the authors could not convincingly rule out the possibility that the cardiac arrest had resulted from SAH. Whether increased intracranial pressure and central venous pressure during CPR can lead to SAH remains unknown.

The phenomenon of “pseudo-SAH” has been recognized.⁸⁻¹⁶ Non-enhanced CT scan performed on patients with “pseudo-SAH” reveals high-attenuation areas along the sulci and/or basal cisterns, which indicate SAH, but lumbar puncture or autopsy results indicate no blood.⁹ Pseudo-SAH usually occurs in patients with severe cerebral edema.^{9,11} Explanations for this phenomenon include narrowing or complete collapse of the hypodense cerebrospinal fluid spaces, increased hypodensity of the adjacent brain, and vessel congestion.⁸ The CT values of high-attenuation areas in patients with pseudo-SAH are usually lower than 42.0 Hounsfield units¹¹ and are well below the expected attenuation values of SAH, typically ranging from 60 to 70 Hounsfield units.⁹ However, in some particular types of pseudo-SAH, a relatively high HU value of

Table 1. Prior cases/reports about subarachnoid hemorrhage after cardiopulmonary resuscitation

Authors	Year of publication	Brief summary	Similarities	Differences
Gueugniaud PY, <i>et al.</i> ⁵	1987	A 40-year-old man with no previous record of cardiac disease suddenly collapsed. A profound coma persisted after CPR, and SAH was then confirmed by lumbar puncture.	The diagnosis of SAH was made according to lumbar puncture.	The clinical picture was clear in this case. SAH occurred immediately after the CPR. The patient had good neurologic outcome.
Lowenthal A, <i>et al.</i> ⁶	2004	A case of a 20-year-old man who developed cardiac arrest and received CPR. A lumbar puncture performed 24 h later was normal. The contrast-enhanced CT scan repeated 5 days after the initial collapse demonstrated SAH.	SAH occurred several days after the CPR. Severe brain edema was revealed on the final CT scan, in addition to hyperdensity in the sulcus.	The patient was previously healthy and not treated with thromboembolism prophylaxis. The diagnosis of SAH was made according to contrast-enhanced CT instead of lumbar puncture.

Abbreviations: CPR, cardiopulmonary resuscitation; CT, computed tomography; SAH, subarachnoid hemorrhage.

52–62 has been reported.¹⁰ In our case, the CT values of the hyperdensity in the sulcus and ventriculus quartus cerebri were lower than those of fresh blood in typical SAH. Brain edema existence and CT scan reminded us that pseudo-SAH should not be ruled out, though it was proved to be a true SAH ultimately. CT values of high-attenuation areas may be less reliable in differentiating SAH from pseudo-SAH. Lumbar puncture should be performed, especially on patients with SAH signs and cerebral edema.

Conflict of interest

The authors declare there are no conflicts of interest regarding the publication of this paper.

Author contributions

Conception/design of the research and critical revising of the manuscript (MW), acquisition and analysis of the clinical data, and manuscript drafting (QO).

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