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Therapeutic and prognostic implications of subarachnoid hemorrhage in patients who suffered cardiopulmonary arrest and underwent cardiopulmonary resuscitation during an emergency room stay

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ABSTRACT

Objective: Aneurysmal subarachnoid hemorrhage (SAH) is a well-known cause of sudden cardio-pulmonary arrest (CPA). Even after successful cardio-pulmonary resuscitation (CPR), the prognosis of patients following an aneurysmal SAH presenting with CPA remains dismal. However, there have been anecdotal reports of good outcomes with appropriate interventions. Pseudo-SAH resulting from marked elevation of intracranial pressure (ICP) after CPR, can mimic SAH in head computed tomographic (CT) scan. Such manifestations hamper resuscitation or delay appropriate neurosurgical management. This study assessed incidence and clinical characteristics of SAH–CPR or pseudo-SAH–CPR patients among non-traumatic CPA–CPR patients, and investigated their therapeutic and prognostic implication.

Methods: During the 5-year observation period, 63 non-traumatic coma patients with CT evidence of high attenuation areas in the basal cistern who suffered arrest and underwent CPR during initial resuscitation in the emergency room, were reviewed retrospectively. They were divided into two groups according to the imaging pattern: true-SAH vs. pseudo-SAH, and then true-SAH group were further divided into two groups according to the CT acquisition time: brain CT before arrest vs. brain CT after arrest. Demographic, clinical, and CT data were assessed, and the primary outcome was measured using the 30-day Glasgow Outcome Scale (GOS) score, and the final outcome was evaluated at the end of 3 months post-ictus.

Results: When compared with pseudo-SAH ($n = 28$) patients, true-SAH ($n = 35$) patients showed a higher Hounsfield unit values in the affected area, earlier CT acquisition time before CPR, more survivors beyond 3 months (all $p < 0.05$); however, the 30-day survival rate was not significantly different. Of the true-SAH patients, ruptured intracranial aneurysms were found in eight patients, and definite intervention was administered in four patients. When SAH patients were categorized according to the temporal relationship with CPR, the group of 24 patients undergoing CT scan before CPR showed a lower frequency of intraventricular hemorrhage, but showed a higher chance of surgical treatment and survival at 30 days and 3 months compared to the group undergoing CT scan after CPR.

Conclusion: The overall survival between true-SAH and pseudo-SAH group was different significantly. Administering definite treatment for a ruptured aneurysm in instances of true SAH could save patients, albeit infrequently. A Prompt CT scan could guarantee recognition of high-density area, blood in the ventricle, and subsequent identification of the ruptured aneurysm, altogether preventing re-bleeding and warranting further systemic resuscitation.

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1. Introduction

Spontaneous subarachnoid hemorrhage (SAH) has been shown to be a common cause of sudden cardiopulmonary arrest (CPA) [1,2]. Sudden increase of intracranial pressure, release of catecholamine, direct mechanical compression of the brainstem seems to be the probable causes of CPA [3–5]. Even after successful cardiopulmonary resuscitation (CPR), the prognosis of patients following an aneurysmal SAH presenting with CPA remains dismal, but there have been reports of good outcomes with appropriate interventions [4,6,7].

High attenuation of the basal cisterns or subarachnoid spaces on computed tomographic (CT) scans is a characteristic finding of acute subarachnoid hemorrhage (SAH). In patients with hypoxic ischemic encephalopathy after cardiopulmonary resuscitation (CPR) post-CPA or in patients with severe brain injury, marked brain edema may occur acutely. Significant portions of patients might exhibit so called, pseudo-SAH resulting from marked elevation of intracranial pressure (ICP) after CPR, can mimic SAH in head computed tomographic (CT) scan. Spiegel et al. proposed the term pseudo-SAH to describe conditions in which SAH-like high-density areas (HDAs) are seen along the cisterns or cortical sulci in the aforementioned clinical setting [8].

In patients undergoing CPR, such radiographic manifestations may preclude on-going resuscitation or delay appropriate neurosurgical intervention, unless discrimination between SAH and pseudo-SAH is made that is often difficult to distinguish promptly. To enable prompt and appropriate therapeutic intervention with early identification of SAH, this study assessed incidence and clinicoradiological characteristics of true-SAH-CPR or pseudo-SAH–CPR patients among non-traumatic CPA–CPR patients, and investigated their therapeutic and prognostic implication.

2. Materials and methods

2.1. Patients

From July 2004 to June 2009, a total of 1135 patients with non-traumatic CPA were admitted at our institution. The comatose patients and the patients who obtained return of spontaneous circulation (ROSC) with sustained hemodynamically stable condition, underwent head CT scan as the protocol of our institution. We retrospectively analyzed a subtotal of 63 non-traumatic patients with CT evidence of high attenuation areas in the basal cistern, who had been in a comatose state or who had rapidly collapsed during initial resuscitation in the emergency room were provided CPR. As mentioned above, the following patients were excluded: patients who did not undergo CT scan, patients who did not regain ROSC. The data from out-of-hospital cardiac arrest survivors were not included in this study because of insufficient data collection from emergency medical services (EMS).

This study was approved by institutional review board at our hospital. All these patients received treatment at intensive care unit with mechanical ventilation. CT angiography or Digital subtraction angiography for detection of ruptured cerebral aneurysm, and microsurgical clipping or endovascular coil embolization was considered if the true-SAH patients were recovered after intensive treatment.

We analyzed emergency room notes, CT and other radiographic findings, and hospital admission notes. Demographic variables were documented as age, sex, and the estimated time until ROSC. Head CT Scan time in relative to the CPR time, and cause of death were all retrieved when possible. The primary outcome was measured at the 30-day according to the Glasgow Outcome Scale (GOS) score (I, death; II, persistent vegetative state; III, severe disability; IV, moderate disability; V, good recovery), and the final outcome was evaluated at the end of 3 months post-ictus by same method.

These 63 patients were classified into 2 groups. Group A ($n = 35$) showed true-SAH, as evidenced by CT scan, whereas Group B ($n = 28$) exhibited pseudo-SAH. The true-SAH group was divided into two groups according to the CT acquisition time: brain CT before arrest vs. brain CT after arrest. Pseudo-SAH was defined as following criteria: high density in the cerebral sulci and cisterns that not suggesting hemorrhage confirmed by measurement of CT values (the CT attenuation is lower than that of SAH); contrast enhancement with the same location of already established higher densities with effacement of the basal cisterns and cortical sulci; the absence of hemorrhage in the ventricles, sulci or parenchyma on CT; mass effect on the fourth ventricle; poor gray matter–white matter differentiation; presentation not typical of SAH; no blood detected on the cerebrospinal fluid (CSF) analysis, if lumbar puncture was performed to distinguish pseudo- from true-SAH when existing argument for the confirmative diagnosis.

2.2. Measurement of CT values

Radiographic data were independently confirmed by one radiologist (Y.J.L.) and one neurosurgeon (H.J.Y.) in blind fashion, and then inter-observer disagreements were corrected in consensus fashion at the conference. The inter-observer consistency was evaluated with the kappa coefficient.

Fresh blood was identified by Hounsfield unit measurement (H.U.). For patients in the true-SAH and pseudo-SAH groups, the H.U. values of HDAs in the Sylvian vallecula were measured, and the cerebral parenchyma (white matter) just ventral to the Sylvian vallecula was also measured by elliptic regions of interest (ROI) (Fig. 1) [9].

The amount of hemorrhage was assessed by using the simplified van Gijn and Hijdra method [10]. This method consists of grading each of the 10 basal cisterns and fissures separately on a semiquantitative scale according to the amount of extravasated blood on the initial head CT scan (0, no blood; 1, small amount of blood; 2, moderately filled with blood; 3, completely filled with blood). The 10 basal cisterns and fissures are composed of 1 frontal interhemispheric fissure, 2 lateral sylvian fissures, 2 basal sylvian fissures, 2 suprasellar cisterns, 2 ambient cisterns, and 1 quadrigeminal cistern. Originally, the total amount of SAH calculated was ranged from 0 to 30, but we simplified this with multiplying counting of the total number of bloody basal cisterns and fissures by the number obtained from presence or absence of blood (0, absent; 1, present). And, this was adjusted ranging 0–10. A grading scale for the amount of blood in the four ventricles was applied in a comparable fashion (0, no blood; 1, sedimentation of blood in the posterior part; 2, partly filled with blood; 3, completely filled with blood). The total amount of intraventricular blood was computed as the sum total of the four scores and ranged from 0 to 12, but we also simplified by identifying the mere presence or absence of intraventricular blood (0, absent; 1, present).

2.3. Statistical analysis

According to the nature of given variables, Fisher's exact test and analysis of variance (ANOVA) were utilized to compare the true-SAH and pseudo-SAH groups using commercially available software SPSS 21.0 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p < 0.05$.

3. Results

During the 5-year period, 194 of the 1135 non-traumatic CPR patients were survivors as proven by obtained ROSC and sustained

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