Computed Tomographic Features of Circulatory Arrest

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Although computed tomography (CT) is used widely in evaluating injuries from various kinds of trauma, the CT features of circulatory events are rarely reported. Recognizing these features is crucial to proper emergency management of patients when circulatory events occur during CT examination. We report two trauma patients who developed circulatory arrest during CT. Both patients had similar CT features of contrast distribution over the dependent portion of the right-sided venous system, a finding that has been previously reported only in patients with cardiac arrest. The quick paddle look feature may be useful to identify the condition and initiate proper resuscitation of patients without electrocardiographic monitoring in CT rooms. [J Formos Med Assoc 2006;105(4):359–362]

Key Words: cardiac arrest, computed tomography, shock, trauma, ventricular fibrillation

In general, contrast-enhanced computed tomography (CT) should not be used as a diagnostic tool for circulatory arrest. Nevertheless, CT is valuable in assessing trauma patients.1,2 Although hemodynamic stability is a prerequisite for CT examination, patients with poorly compensated shock occasionally undergo CT as they appear to be relatively stable. The condition of some initially stable patients may also deteriorate dramatically during CT. Knowledge of the characteristic CT features of circulatory arrest, such as cardiac arrest and ventricular fibrillation (VF), is necessary for the management of this catastrophic event, which has a narrow therapeutic window.

Case Reports

Case 1

A 44-year-old man with major depression was admitted to our emergency room about 2 hours after jumping from a fourth floor height. Radiographs at the referring hospital showed fractures of the pelvis and left malleolus. On admission, blood transfusion was performed under the impression of internal bleeding; Glasgow Coma Scale (GCS) score was 15, blood pressure was 110/75 mmHg, heart rate was 102/min, and hemoglobin was 15.6 g/dL. Abdominal CT was characteristic of internal bleeding.

An intermittent automatic blood pressure monitoring device was installed, and the patient was transferred to the CT room, which was equipped with essential resuscitation equipment including an electroshock defibrillator. In addition to the pelvic fracture, non-contrast scans revealed high-density fluid accumulation in the perisplenic space and pelvis, indicating splenic laceration. CT scans obtained after manual injection of 100 mL of contrast agent (Ultravist 300, 300 mg iodine/mL) through the right antecubital vein unexpectedly showed no enhancement of the left ventricle,
aorta or abdominal visceral organs. Instead, the high-density contrast agent was distributed over the right ventricle and atrium, coronary sinus, inferior vena cava, and posterior aspects of the hepatic and right renal veins (Figure 1). The examination was halted immediately and a check of the patient found no identifiable pulse. Quick paddle look showed cardiac arrest. Subsequent vigorous cardiopulmonary resuscitation temporarily revived the patient. Emergency laparotomy was performed, but the patient died after another cardiac arrest occurred during the operation. **Case 2**

A 75-year-old intubated man was referred to our emergency room about 4 hours after falling from stairs at a height of 1.5 m. He had a history of diabetes, hypertension and coronary artery disease, for which he had received medical care for more than 20 years. On arrival, GCS score was 5, blood pressure was 150/70 mmHg, heart rate was 80/min, and hemoglobin was 9.6 g/dL. Chest radiography revealed cardiomegaly and fracture of the left clavicle. Emergency brain CT showed a fracture of the skull base with intracranial hematoma. Abdominal ultrasonography demonstrated fluid collection in Morison’s pouch. The patient then underwent abdominal CT, which revealed high-density contrast agent distributed over the right ventricle and atrium, inferior vena cava, posterior aspects of the hepatic and right renal veins, and, to a lesser extent, the left ventricle and aorta (Figure 2). The examination was terminated immediately, and the patient was found to be pulseless. Quick paddle look identified VF, and electrocardioversion was performed successfully. However, the patient died 1 day later due to severe brain damage despite aggressive intensive care.

**Discussion**

Circulatory arrest is a life-threatening medical emergency in which all blood flow stops. It can result from cardiac arrest, VF, pulseless ventricular tachycardia (PVT), or pulseless electrical activity (PEA) having a variety of causes, including ischemic heart disease and hypovolemic shock in trauma patients. Cardiac arrest is caused by cessation of all rhythmic impulses to the heart, whereas VF results from rapid, chaotic cardiac impulses within the ventricular muscle mass so that no coordinated contraction occurs. Both PVT and PEA are characterized by loss of palpable pulses in the presence of recordable cardiac electrical activity. In these four cardiac catastrophes, either no blood or only a negligible amount can be pumped from the heart.
In trauma patients, either external or internal hemorrhage may lead to inadequate tissue perfusion. The clinical presentation is shock syndrome, which may evolve through the following three successive stages: (1) non-progressive, in which several mechanisms maintain the arterial pressure at a near normal level; (2) progressive, in which clinical manifestations appear after the compensatory mechanisms begin to fail; and (3) irreversible, in which end-organ damage results. The fundamental approach to management is to recognize overt and impending shock in a timely fashion and to intervene immediately to restore perfusion.

If traumatic hemorrhage leads to shock in progressive stages, cardiac depression, loss of vascular tone, and altered metabolic function will ensue. In Case 1, the cardiac arrest was precipitated by a profound hemodynamic event. In Case 2, VF may have been induced by the deteriorating effect of traumatic stress on the underlying condition of ischemic heart disease. Although adverse reaction to contrast agent can be a cause of cardiac arrest during CT examination, this rare situation probably did not play a role in our patients. Both patients had a characteristic CT feature, namely high-density contrast enhancement of the dependent portion of the right-sided venous system with no enhancement of any visceral organ.

The principal reason for why contrast agent sinks to the dependent portion of the right-sided venous system is the loss of the normal pressure gradient in the vascular system. Hence, under manually-induced pressure, the contrast agent flows through the right side of the heart and regurgitates into the coronary sinus, inferior vena cava and dependent venous system of the right-sided abdominal organs, including the hepatic and renal veins. Furthermore, absence of flowing blood in the vascular system makes the contrast agent appear to have a very high density. The variance of contrast enhancement in our two patients presumably resulted from differences in timing between the cardiac events and the contrast injections. The cardiac arrest in Case 1 may have occurred just before contrast injection, whereas VF in Case 2 occurred right after contrast injection. Enhancement of the abdominal visceral organs was absent because of the lack of sufficient arterial flow. Thus, all circumstances that lead to circulatory arrest during CT examination may result in the CT appearance of contrast distribution over the dependent portion of the right-sided venous system.

Our review of the literature found no report of VF as the cause of this CT manifestation. The use of a quick paddle look to discriminate cardiac arrest from VF, PVT or PEA may be valuable in this acute setting and allow immediate appropriate
treatment. Cardiac arrest requires cardiopulmonary resuscitation to restore normal cardiac rhythm, whereas VT, PVT and PEA can only be stopped by electroshock of the heart.

In conclusion, a distribution of contrast in the dependent portion of the right-sided venous system indicates circulatory arrest, which may include cardiac arrest, VF, PVT and PEA. Identification of the CT features of cardiac arrest can have immediate and important survival implications for the patient.

References