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Case report

Delayed cerebral enhancement on post-mortem computed tomography due to residual contrast medium administered shortly before death ☆,☆☆,★,★★

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ABSTRACT

Postmortem computed tomography (CT) is currently a well-known procedure and helps in postmortem investigations. In this case report, we report a unique postmortem CT finding: delayed cerebral enhancement associated with the antemortem infusion of contrast medium. A 72-year-old female lost consciousness at a restaurant and was taken to a hospital in an ambulance. Despite resuscitation efforts, she died of hypoxic–ischemic encephalopathy caused by cardiac arrest. About 6 h before her death, she underwent enhanced antemortem CT of the head. No abnormal enhancement was observed in the cerebral parenchyma. Then, 11 h after her death, she underwent unenhanced postmortem CT, which showed bilateral hyperdense caudate nucleus and putamina, due to residual iodinated contrast medium, in addition to other characteristic findings of hypoxic–ischemic encephalopathy. The mechanism underlying this phenomenon could be the destruction of the blood–brain barrier, and/or selective vulnerability, due to hypoxic–ischemic changes in the gray matter. Enhancement of basal ganglia on postmortem CT due to antemortem infusion of iodinated contrast medium might suggest hypoxic–ischemic encephalopathy, which should be noted in postmortem CT interpretations.

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Introduction

Postmortem CT is currently a well-known method for investigating postmortem situations. Postmortem CT before an autopsy can provide useful information for a consecutive autopsy. Postmortem CT may also be used as an alternative to autopsy in some cases. Additionally, postmortem CT is less expensive to perform than autopsy [1] and represents a reduced mental burden that a bereaved family may be more comfortable providing consent for.

Postmortem CT can sometimes reveal antemortem pathologies that autopsy cannot find. A previous report showed major discrepancies in the rates at which cause of death was identified between CT and autopsy (32%) and between MRI and autopsy (43%) [2]. However, another study reported that unenhanced postmortem CT and enhanced postmortem CT detected 76.0% and 89.9%, respectively, of all findings categorized by anatomic structure, including bone, organ parenchyma, soft tissue, and vascular systems, whereas autopsies only identified 61.3% of these results [3]. The combined diagnosis of postmortem CT, together with antemortem CT, in cases where antemortem CT is available, is considered preferable [4-6].

According to previous studies examining brain postmortem CT, the loss of gray and white matter differentiation, diffuse brain swelling, and pseudo-subarachnoid hemorrhages were often observed in nonpathological brains and hypoxic–ischemic encephalopathy [7-11]. Another study examining voxel-based analyses reported a rapid decrease in cortical gray matter density combined with a delayed increase in white matter density [12]. A study on enhanced postmortem CT observed enhancement of the cerebral cortex [13]. However, the reports of postmortem CT with even postmortem contrast medium referring to brain findings hypoxic–ischemic injury are still rare. We report a unique case of postmortem CT, in which we observed delayed cerebral enhancement, due to the antemortem infusion of iodinated contrast medium. To the best of our knowledge, no similar case has been previously reported.

Case report

A 72-year-old female was found sitting in front of the lavatory at a restaurant, losing consciousness. When the ambulance arrived, she experienced cardiopulmonary arrest, and an electrocardiogram showed pulseless electrical activity. Her medical history was unknown. Cardiopulmonary resuscitation was immediately started. She was bought to the hospital 30 min after she was found. At the hospital, she achieved spontaneous circulation following the infusion of noradrenaline and defibrillation. A blood test revealed elevated serum aspartate aminotransferase (122 U/L; normal range, 13–30 U/L), alanine aminotransferase (139 U/L; normal range, 7–23 U/L), and creatine kinase myocardial band 27 U/L (normal range, ≤12 U/L) levels and decreased estimated glomerular filtration rate (41.9 mL/min/1.73 m^2); the blood test was otherwise unremarkable. Echocardiogram and electrocardiogram were performed, and she was diagnosed with acute myocardial infarction. About 2 h after the first discovery, an unenhanced whole-body CT scan including the head was performed. The head CT revealed diffuse brain swelling and the loss of gray and white matter differentiation, suggesting hypoxic–ischemic encephalopathy (Fig. 1A and B). However, no sulcal effacement in the cerebral hemisphere was observed at this time. Subsequently, an enhanced whole-body CT scan was performed, following the administration of 100 mL iomeprol, with an iodine concentration of 350 mg I/mL (Iomeron; Eisai, Tokyo, Japan). We were unable to detect the cause of cardiopulmonary arrest based on CT findings; no abnormal enhancement in the cerebrum was observed at the time of this CT (Fig. 1C and D). Percutaneous coronary intervention was performed 5.5 h after the first discovery of the patient, during which 140 mL iomeprol was administered. She was moved to an intensive care unit; her condition worsened due to low blood pressure. Next, 7 h after the first discovery, enhanced whole-body CT was performed again to exclude intrathoracic or intraabdominal bleeding, following the administration of 100 mL iomeprol. CT showed multiple liver hemorrhages, hemoperitoneum, and mediastinal hemorrhage, considered to be due to cardiopulmonary resuscitation. Despite cardiopulmonary resuscitation efforts, the patient died 8 h after the first discovery.

About 12 h after her death, unenhanced head and whole-body postmortem CT was performed, followed by subsequent body autopsy. The head postmortem CT showed diffuse edema, sulcal effacement of the cerebral hemisphere, decreased cortical gray matter attenuation, and the loss of normal gray and white matter differentiation (Fig. 1E and F). These findings were compatible with the diagnosis of hypoxic–ischemic encephalopathy. Additionally, bilateral hyperdense caudate nuclei and putamina were observed (Fig. 1E and F). These findings are thought to have resulted from the administration of contrast medium for the percutaneous coronary intervention and antemortem CTs shortly before death because postmortem CT was performed without contrast medium. Whole-body postmortem CT also showed mediastinal hematoma and hemorrhagic ascites, which were also observed on antemortem CT. Rib fractures and hypostasis, which are associated with cardiopulmonary resuscitation and postmortem changes, respectively, were observed. Contrast medium was also observed in the vessels and organs. The timeline is shown in Fig. 2.

★ Competing Interest: The authors declare that they have no competing interests.
★★ Patient consent: Informed consent for the use of cadaver in our study was obtained from the family of the deceased subject.
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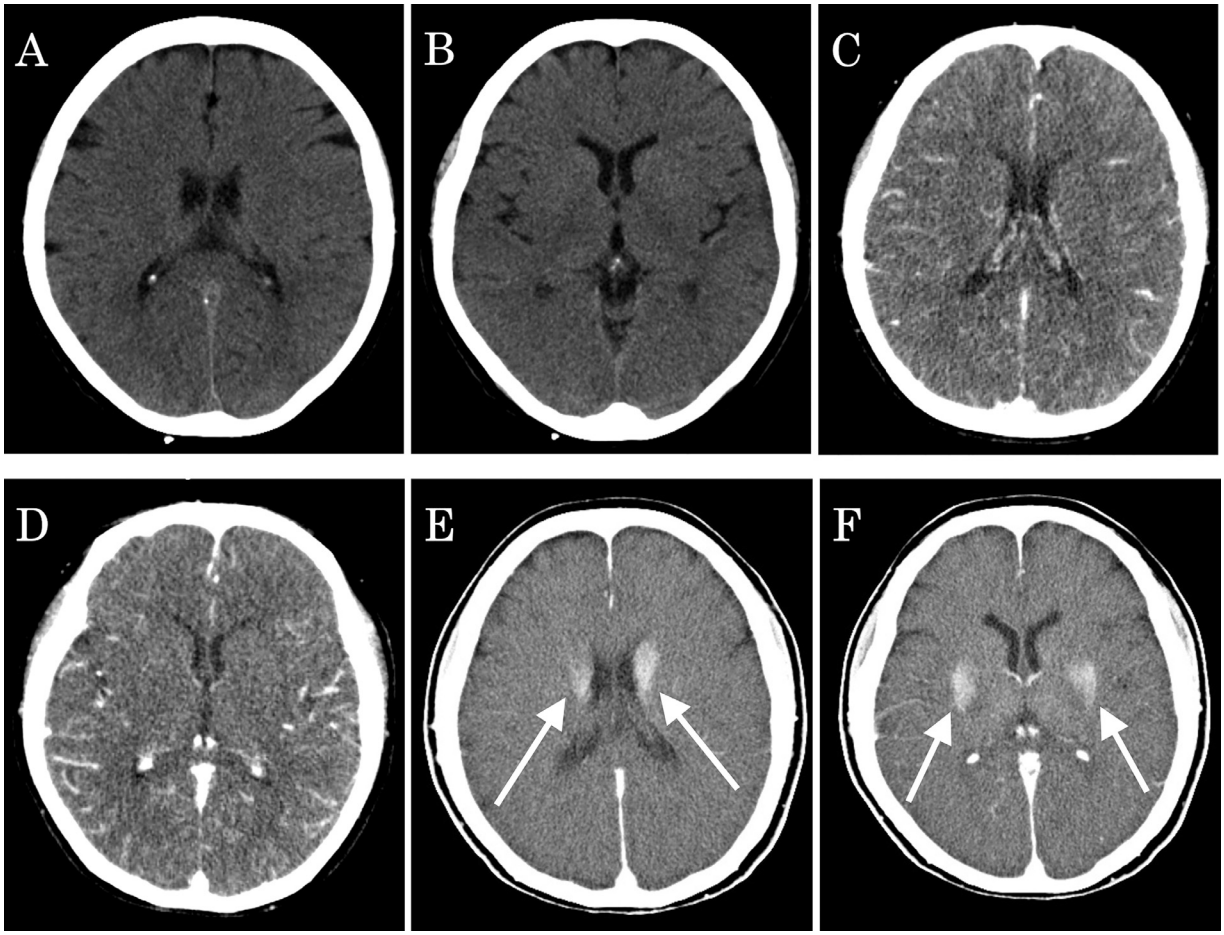

Fig. 1 – Unenhanced antemortem CT about 6 h before her death (A and B) showing the loss of gray and white matter differentiation and diffuse brain swelling, which suggested hypoxic–ischemic encephalopathy. Subsequent enhanced antemortem CT (C and D) showed no abnormal enhancement of the brain parenchyma. Postmortem CT (E and F) 12 h after the patient's death showed unexpected and symmetrical hyperdense lesions of the bilateral caudate nuclei and putamina (arrows). The loss of gray and white matter differentiation and diffuse brain swelling was continued to be observed.

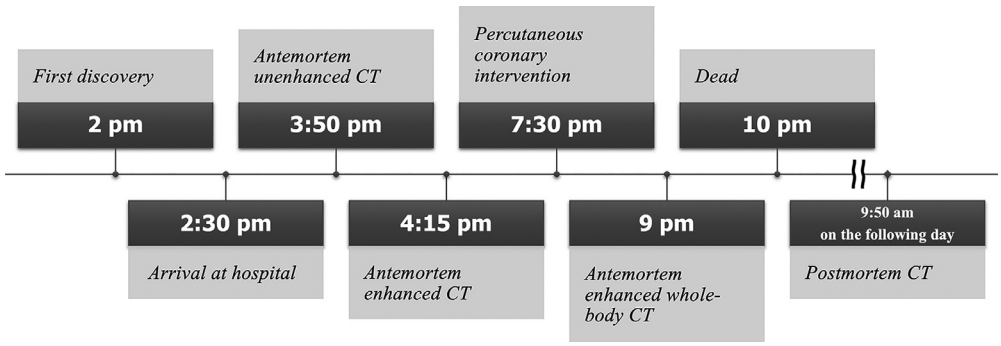

Fig. 2 – Timeline of events for this case.

Discussion

In this case report, we presented a case that showed a unique postmortem CT finding: hyperdense basal ganglia, which was considered to be the result of delayed enhancement due to the antemortem infusion of contrast medium. The antemortem CT findings of loss of gray and white matter differentiation and symmetrical, low-density cerebral edema have typically been reported for hypoxic–ischemic encephalopathy on ante-

mortem CT [14], consistent with the present case. The postmortem CT findings of sulcal effacement of the cerebral hemisphere and the loss of contrast at the basal ganglia are characteristic findings of hypoxic–ischemic encephalopathy on postmortem CT [7-11], which were also consistent with the present case. Furthermore, in the present case, we observed delayed enhancement of deep gray matter, such as the caudate nucleus and putamina, on postmortem CT. To the best of our knowledge, this is the first report on these postmortem CT findings.

The phenomenon of enhanced gray matter on CT or MRI in the living body has been previously reported. Previous studies have reported abnormal enhancement in laminar cortical regions, cortical–subcortical areas, cerebellar tonsil, hippocampus, and basal ganglia on enhanced CT scans performed in living patients with cerebral cortical necrosis [15,16]. However, reports of postmortem brain imaging using contrast medium remain rare. According to a previous report examining postmortem CT angiography, the enhancement of the cerebral cortex was observed [17]. In antemortem settings, the mechanism through which cerebral gray matter becomes enhanced is thought to be associated with the breakdown of the blood–brain barrier (BBB) and subsequent neovascularity [18]. BBB destruction under hypoxic conditions has been studied both anatomically and biochemically. Many factors are thought to play important roles in BBB destruction, including hypoxia-inducible factor-one, vascular endothelial growth factor, erythropoietin, inducible nitric oxide synthase, and aquaporin-4 [19,20]. Moreover, BBB breakdown begins early under hypoxic conditions [19]. In animal models, BBB permeability has been measured, and the earliest peaks of BBB permeability were reported to be seen 2, 4, and, 6 h after hypoxic–ischemic injury in mouse, sheep, and rat, respectively [20]. In one study examining six living adult patients who received unenhanced and enhanced MRIs multiple times and sequentially, abnormal contrast enhancement was first observed during the early subacute stage (11–19 days after hypoxic–ischemic events) [15]. Abnormal contrast enhancement was observed 16–20 days after hypoxic–ischemic events in another study [16]. As reported by unenhanced MRI studies, diffusion-weighted imaging is the most sensitive modality for the detection of early hypoxic–ischemic encephalopathy change; however, even diffusion-weighted imaging does not reveal hypoxic–ischemic injury-associated abnormalities until several hours after the induction of hypoxia [21,22]. These studies suggested that after hypoxic–ischemic events, cerebral enhancement can take a few hours to days to appear on enhanced images.

In our case, the first enhanced antemortem CT was performed 2 h after cardiopulmonary arrest and showed no abnormal enhancement in the brain, whereas the unenhanced postmortem CT did show abnormal enhancement. The interval between the onset of hypoxic–ischemic injury and the last enhanced antemortem CT may have been too short to establish basal ganglia enhancement on the head CT. A total of 340 mL iomeprol was administered shortly before death, which could have promoted the basal ganglia enhancement of the region where BBB was damaged on postmortem CT. If another antemortem CT had been performed before death, basal ganglia enhancement may also have been observed, similar to the postmortem CT. However, changes in the agonal state or postmortem changes might also promote BBB destruction, strengthening the enhancement of the damaged area on postmortem CT.

Table 1 – The mean CT value (Hounsfield unit) of the putamen, caudate nucleus, cortical gray matter, and white matter on antemortem and postmortem CT.

	Unenhanced antemortem CT (Fig. 1 A and B)	Enhanced antemortem CT (Fig. 1 C and D)	Postmortem CT (Fig. 1 E and F)
Putamen	28	47	66
Caudate nucleus	31	43	63
Cortical gray matter	30	40	37
White matter	28	47	38

Additionally, we hypothesize that selective vulnerability can explain the hyperdense gray matter observed on postmortem CT. This selective vulnerability in the gray matter is induced by the quantity of neuronal cell bodies. Gray matter consumes much more energy than white matter. Therefore, gray matter is considered to be sensitive to energy depletion [23,24].

The mean CT value of the putamen, caudate nucleus, cortical gray matter, and white matter on antemortem and postmortem CT are shown in Table 1. The putamen and caudate nucleus were selectively enhanced only on postmortem CT. In the present case, only the basal ganglia were enhanced, whereas the cerebral cortex was not. According to unenhanced MRI studies, cases with injury to isolated deep gray nuclei injury group had better neurological outcomes than cases with injury to both cortex and deep gray nuclei [25,26]. In a study examining hypoxic–ischemic injuries in adults, although cortex lesions were not universally observed, deep gray matter lesions were observed in all patients on unenhanced MRI [26]. The basal ganglia may be easily damaged due to the vascular supply. If our case had experienced a more severe injury, the cortex may also have been enhanced.

Some researchers may criticize that the hyperdense areas might be hemorrhages rather than contrast medium. The presence of contrast medium could not be directly revealed in the brain since brain autopsy was not performed. On the contrary, antemortem CT showed no abnormal hyperdense lesion in the brain. Additionally, the hyperdense areas were symmetrical. Edema surrounding them was unclear on postmortem CT. Therefore, we considered the hyperdense areas were contrast medium. Few studies have mentioned the findings of hypoxic encephalopathy on enhanced postmortem CT, with no reports referring to the basal ganglia. The present report is the first to report on the enhancement of the basal ganglia on postmortem CT.

In conclusion, we described the unexpected enhancement of basal ganglia, which was observed on unenhanced postmortem CT when contrast medium was administered shortly before death. These findings might suggest hypoxic–ischemic encephalopathy.

Ethics approval and consent to participate

This study was approved by the Ethical Committee of the participating institution [Ethical Committee no. 2076-(12), June 9, 2008]. The protocol complied with the 1964 Declaration of Helsinki and its later amendments (or comparable ethical standards).

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to cadaver's privacy but are available from the corresponding author on reasonable request.

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