Quantitative analysis of brain edema and swelling on early postmortem computed tomography: comparison with antemortem computed tomography

Naoya Takahashi · Chihiro Satou · Takeshi Higuchi · Motoi Shiotani · Haruo Maeda · Yasuo Hirose

Abstract

Purpose. The aim of this study was quantitatively to analyze brain edema and swelling due to early postmortem changes using computed tomography (CT) scans of the head.

Materials and methods. Review board approval was obtained, and informed consent was waived. A total of 41 patients who underwent head CT before and shortly after death were enrolled. Hounsfield units (HUs) of gray matter (GM) and white matter (WM) were measured at the levels of the basal ganglia, centrum semiovale, and high convexity area on both antemortem and postmortem CT. The length of the minor axis of the third ventricle at the level of the basal ganglia and the width of the central sulcus at the level of high convexity were measured.

Results. At each level tested, the HUs of GM and the GM/WM ratios on postmortem CT were significantly lower than those on antemortem CT ($P < 0.001$). HUs of WM on postmortem CT were slightly higher than those on antemortem CT but without significant difference ($P > 0.1$). Postmortem CT showed subtle loss of distinction between GM and WM. The size of the third ventricle and the width of the central sulcus did not vary before and after death ($P > 0.1$).

Conclusion. Early postmortem CT shows mild brain edema but does not show brain swelling.

Key words. Postmortem CT · Brain edema · Forensic radiology · Postmortem change · Autopsy imaging (Ai)

Introduction

Because of advances in medical imaging technologies, postmortem computed tomography (CT) has been introduced into autopsies and forensic investigations. In Japan, postmortem imaging using CT or magnetic resonance imaging (MRI) is called “autopsy imaging.” Postmortem CT is widely performed to determine the cause of death, particularly in the emergency department, and it plays an important role in hospital risk management.

One needs to understand normal postmortem features before making a confident diagnosis. Although brain edema has been reported as a postmortem change, to our knowledge, quantitative analysis of brain edema on postmortem CT has never been previously reported. Therefore, to investigate the imaging of brain edema in the early postmortem head, we compared postmortem head CT with antemortem CT in the same patients using state-of-the-art CT scanners.
Materials and methods

Study group

The institutional review board of our hospital approved this study and did not require informed consent from the relatives of the deceased. Between January 2006 and June 2009, a total of 578 postmortem CT scans were performed in our hospital. Of these, 42 patients underwent conventional nonhelical CT of the head before and after death. We excluded a 6 year-old girl because the patient had had severe hypoxic-anoxic encephalopathy with hypotension for 20 h before being revived after cardiopulmonary resuscitation. A total of 41 patients (29 males, 12 females; aged 16–89 years, mean 71 years) were enrolled in the study.

Altogether, 33 patients had presented to our emergency room and died in the emergency department, and 8 patients died in the hospital in other departments. The cause of death was classified as nontraumatic in 39 cases and traumatic in 2 cases, the latter consisting of one hanging and one multiple trauma caused by a fall.

Traditional autopsies were performed in three nontraumatic cases involving acute cardiac failure due to cardiac amyloidosis, chronic brain hemorrhage due to cerebral dural arteriovenous fistula, and meningitis, respectively. The cause of death in the rest of the nontraumatic cases was determined on the basis of available clinical information and included 14 cases of cardiac sudden death, 4 thoracic aortic ruptures due to 3 acute aortic dissections and 1 aortic aneurysm, 4 drownings, 4 sudden deaths due to unknown origin, 3 respiratory failures, 3 malignant neoplasms (lung carcinoma, urinary bladder carcinoma, and renal cell carcinoma, respectively), 2 chokings, and 1 case each of brain stem hemorrhage and poisoning. Cardiopulmonary resuscitation involving chest compression and artificial respiration were performed in all cases except for three patients who died in the hospital.

CT technique

All subjects were imaged with multislice CT scanners (SOMATOM Sensation 16 scanners, SOMATOM Emotion 6 scanners, and SOMATOM Sensation 64 scanners; Siemens; Erlangen, Germany). Postmortem CT examinations were done within 70 min of determination of death. Antemortem CT examinations were performed within 0–1357 days (median 201 days) before death. In all cases, there were no severe brain events during the period between the last antemortem and postmortem CT scans; therefore, remarkable changes, such as hemorrhages, infarctions, and tumors were not observed between the two examinations. Both postmortem and antemortem examinations were performed in the natural supine position within the following parameters recommended by the manufacturer (Table 1). No contrast material was administered. Images were obtained of a 5 mm slice thickness with a 200 mm field of view and a 512 × 512 imaging matrix using the sequence mode from the level of the foramen magnum to the skull vertex parallel to the orbitomeatal plane.

Imaging and clinical analysis

Postmortem CT scans were compared with the latest antemortem CT scans. Brain density was measured according to the method of Torbey et al. Three regions of interests (ROIs) were defined through axial imaging (Fig. 1a–c): (1) basal ganglia level, defined as the image in which the caudate nucleus, internal capsule, third ventricle, and sylvian fissures were visualized; (2) centrum semiovale level, defined as the image 5 mm above the lateral ventricular system; and (3) high convexity level, defined as the next image 5 mm above the centrum semiovale level. Hounsfield units (HUs) were measured by placing a 15-mm² elliptical surface ROI in gray matter (GM) and white matter (WM) obtained from axial images at the same levels of the basal ganglia, centrum

<table>
<thead>
<tr>
<th>CT scanner</th>
<th>Tube voltage (kV)</th>
<th>Tube current (mAs)</th>
<th>No. of subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-Row detector</td>
<td>120</td>
<td>320</td>
<td>16 32</td>
</tr>
<tr>
<td>6-Row detector</td>
<td>130</td>
<td>186–240</td>
<td>16 9</td>
</tr>
<tr>
<td>64-Row detector</td>
<td>120</td>
<td>250</td>
<td>9 0</td>
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<tr>
<td>CT, computed tomography</td>
<td></td>
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</tbody>
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Table 1. Acquisition protocol of each CT scanner