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Brain fragility can be estimated by its putrefactive signs on postmortem computed tomography ☆

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ABSTRACT

Along with time after death, postmortem computed tomography (PMCT) of the brain can reveal sequential changes. In the present study, we investigated the relationship between brain rigidity and advanced postmortem changes such as intravascular gas production, cerebral settling or cerebral liquefaction on PMCT. We then examined the findings of PMCT as an indicator of successful macroscopic examination of arbitrary brain slices at classical autopsy. The association between these advanced postmortem changes and the validity of macroscopic brain examination was investigated in 149 cases that were examined by PMCT at our department prior to autopsy in the period from September 2011 to December 2013. We found that the postmortem changes, classified into four stages, generally reflected the fragility of the brain. Thus, it is likely that PMCT findings of advanced postmortem changes are able to indicate decreased brain rigidity ahead of autopsy. These findings support the idea that PMCT could be used as a guide by forensic pathologists for suitable handling of a fragile brain, thus enhancing the quality of autopsy.

1. Introduction

Recently, postmortem computed tomography (PMCT) has proved to be a useful tool for forensic examination, especially in cases involving trauma [1,2]. Imaging methods such as PMCT have revolutionized not only forensic diagnosis but also the documentation of evidence that can be applicable in court proceedings [3]. Previously, we have reported cases in which PMCT was valid for providing clues as to the causes of death in bodies that were severely decomposed [4–6]. In general, PMCT of the brain shows sequential changes such as blurring or loss of gray-white matter distinction, effacement of cerebral sulci and ventricles, intravascular gas production, cerebral settling or cerebral liquefaction [7]. In the present study, we investigated the relationship between brain rigidity and advanced postmortem changes such as intravascular gas production, cerebral settling or cerebral liquefaction on PMCT. We examined the findings of PMCT as an indicator of brain rigidity of arbitrary slices in classical autopsy, because detailed macroscopic examination of the brain is difficult when autolysis and putrefaction have rendered the tissue fragile with a tendency to fragment upon removal from the skull or when cutting slices.

2. Materials and methods

2.1. PMCT conditions and interpretation

PMCT of the entire body was performed before autopsy. All scans were performed using a four-slice CT scanner (Asteion/TSX-021B/4A, Toshiba, Japan) with a slice thickness of 1 mm and settings of 120 kV and 225 mAs for the head. These PMCT images were interpreted by radiologists, so that any injuries, diseases and other lesions should be detected. To evaluate the postmortem changes on PMCT qualitatively, we classified PMCT findings of the brain into four stages based on the presence of gas production, cerebral settling or cerebral liquefaction: Stage 0 – only general postmortem changes such as blurring or loss of gray-white matter distinction; Stage I – intravascular gas production (Fig. 1A); Stage II – cerebral settling (Fig. 1B); and Stage III – cerebral liquefaction

☆ All procedures of this study were approved by the Ethics Committees at Gunma University Graduate School of Medicine.

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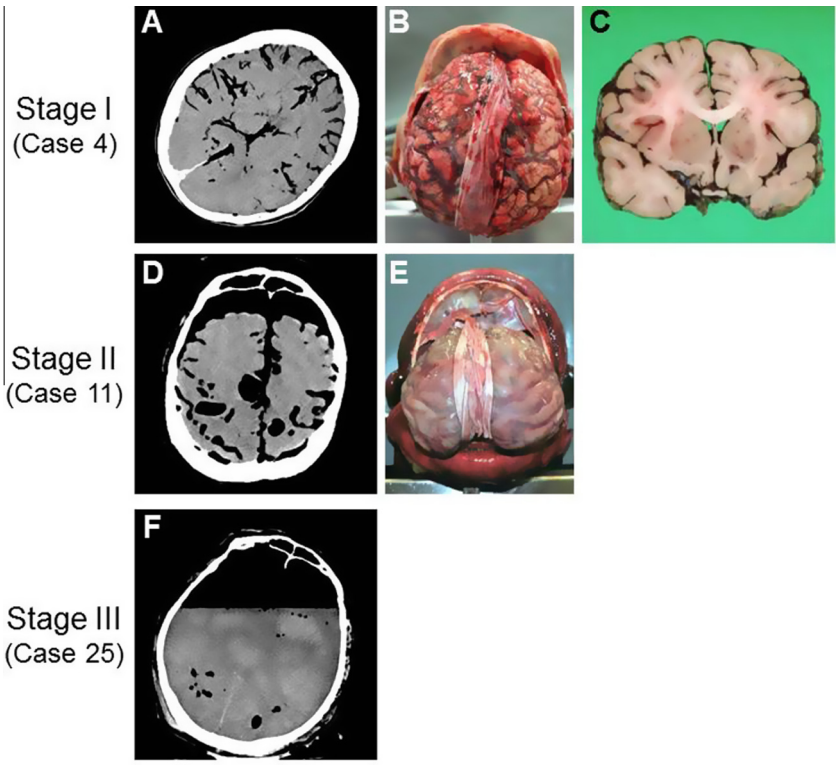

Fig. 1. Classification of postmortem changes evident on PMCT and representation of the states of brain preservation. (A)–(C) Stage I case. The PMCT image shows intravascular gas (A). The brain retained its structure without the calvaria (B), and slicing was possible (C). (D) and (E) Stage II case. The PMCT image shows cerebral settling (D). The brain was barely retained in the skull without the calvaria (E), but was too fragile for slicing. (F) Stage III case. The PMCT image shows cerebral liquefaction, and the brain tissue flowed out immediately after removal of the calvaria at autopsy.

Table 1
Relationship between advanced postmortem changes evident on PMCT and validity of brain macroscopic examination.

Advanced postmortem changes on PMCT	Macroscopic examination on slice	
	Valid	Invalid
Presence: 26*	4	22
Absence: 123	123	0

* Advanced postmortem changes evident on PMCT images include intravascular gas production, cerebral settling and cerebral liquefaction.

(Fig. 1C). This classification was adopted through consensus among radiologists and forensic pathologists.

2.2. Selection of cases for investigation

We investigated all autopsy cases for which PMCT had been undertaken at our department prior to autopsy during the period from September 2011 to December 2013 (total 250 cases). Of these cases, those involving bleached bones, charring of the body, those with penetrating head injuries or injuries to the great vessels, and infants less than 4 years old were excluded. Finally, 149 cases were examined, as shown in Table 1. Details of the cases showing advanced postmortem changes on PMCT are shown in Table 2.

2.3. Assessment of validity for macroscopic examination

Brain fragility was determined from the viewpoint of whether or not the brain texture would allow effective macroscopic examination at autopsy. In valid cases, the brain would retain its structure when removed from the skull and subsequently cut into arbitrary slices (Fig. 1B and C). In contrast, in invalid cases, the brain would not tolerate those procedures (Fig. 1E). These assessments were confirmed by two or more forensic pathologists.

3. Results and discussion

We investigated the relationship between advanced postmortem changes evident on PMCT and the ability to perform macroscopic brain examination in 149 cases (Table 1). All the brains without advanced postmortem changes on PMCT, classified as Stage 0, were able to be cut into slices, allowing macroscopic examination, while those at Stage I showed no relationship between PMCT findings and the feasibility of macroscopic examination (chi-square test, $p = 0.65$) (Tables 1 and 2). On the other hand, all of the brains at Stages II and III were too fragile for slicing, and thus hardly amenable to detailed macroscopic examination, except for one case ($p = 0.03$ for Stage II and $p < 0.01$ for Stage III) (Table 2). With regard to this exceptional case (case 6), although we classified the PMCT image as Stage II, the degree of cerebral settling was very mild, allowing the brain to be subjected to effective macroscopic examination (Fig. 2). Consequently, these results suggested that advanced postmortem changes evident on PMCT corresponding to Stage II or III are sufficient to indicate brain fragility ahead of autopsy. Notably, because we examined PMCT findings qualitatively, and not quantitatively, it cannot be denied that future use of highly efficient analytical software would reveal more clearly the relationship between PMCT findings and brain fragility.

Previously, we reported case 9 in which PMCT demonstrated cerebral hemorrhage in the left putamen, a midline shift, and