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Comparison of the cardiothoracic ratio between postmortem and antemortem computed tomography

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ABSTRACT

As postmortem imaging has gained prominence as a supplement to traditional autopsy, it is important to understand the normal postmortem changes to enable the accurate evaluation of postmortem imaging. No studies have evaluated the postmortem changes in cardiothoracic ratio (CTR) compared with antemortem images in the same subjects. We studied 147 consecutive subjects who underwent antemortem and postmortem CT, and autopsy. Postmortem CT was performed <23 h after death and was followed by autopsy. The subjects were divided into three groups: normal heart, old myocardial infarction, and CPR-treated hearts. CTR was compared between antemortem and postmortem CT using paired t tests, which revealed that the CTR was greater on postmortem CT than on antemortem CT in all groups (mean CTR: 0.53 ± 0.06 vs. 0.50 ± 0.06, respectively; $P < 0.01$). Sex, age, time elapsed since death, and the causes of death were examined as potential confounding factors for the postmortem changes in CTR, but no significant associations were found. Receiver-operating characteristic (ROC) curves were used to determine CTR values for cardiomegaly, which was defined according to the autopsy weight of the heart. The area under the ROC curve was 0.71 (95% confidence interval 0.63–0.79). The CTR threshold of 0.54 identified cardiomegaly with the greatest accuracy, compared with the general threshold of 0.50. In conclusion, the CT-determined CTR increases after death, irrespective of the heart's condition. We should be cautious of overdiagnosis of cardiomegaly on postmortem CT, and new criteria for interpreting cardiomegaly on postmortem CTR are needed.

1. Introduction

High-resolution imaging modalities such as computed tomography (CT) and magnetic resonance imaging are increasingly being used as adjuncts to traditional forensic methods in postmortem studies [1–5]. However, clinical radiologists may find it difficult to interpret postmortem images because of specific and nonspecific postmortem signs on CT [6]. Now that guidelines for the diagnosis of postmortem images are being established worldwide [7–9], it is important to understand the normal changes that occur on postmortem CT [10]. The postmortem CT features of several organs, including the cardiovascular system [11–14], brain [15], thyroid [16], adrenal gland [17], spleen [18], muscle [19], airway [20], and lung [21], have already been described. The normal postmortem features of the cardiovascular system have attracted particular interest, because postmortem findings allow us to diagnose the causes of death related to cardiovascular diseases or to heart failure, which is one of the most common causes of death.

The cardiothoracic ratio (CTR) is very simple to measure and is frequently used in clinical practice as a radiographic index of heart size. A CTR >0.50 is generally defined as cardiomegaly. Some studies have assessed the cardiothoracic ratio on antemortem CT [22,23] or on postmortem CT [24,25]. To our knowledge, however, no studies have compared the changes in CTR between antemortem and postmortem images in the same subjects. Because we often encounter radiological cardiomegaly on postmortem CT in patients with a pathologically normal heart, we hypothesized that the threshold CTR to detect cardiomegaly on postmortem CT may differ from the CTR on antemortem CT. Therefore, the objectives of this study were to describe the normal changes in CTR on postmortem CT in comparison with antemortem CT, and to compare the postmortem changes in CTR between different heart conditions. To achieve these objectives, we conducted a

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quantitative study in which we determined the changes in CTR between postmortem and antemortem CT scans obtained in the same subjects.

2. Materials and methods

The Institutional Review Board of the University of Tokyo Hospital approved this study. Written informed consent was obtained from the next of kin to use the clinical, pathological, and radiographic data in this study.

2.1. Study design and subjects

We retrospectively enrolled all consecutive subjects who died from nontraumatic causes in our academic tertiary care hospital and who underwent chest antemortem CT, postmortem CT, and autopsy between April 2009 and December 2011. A total of 167 consecutive subjects were initially included in this study. Subjects aged <20 years and those with a history of congenital heart disease or cardiovascular surgery were excluded. After applying the exclusion criteria, 147 adults (100 males, 47 females) were included in this study. The mean age at death was 67 years (range, 21–92 years; median, 72 years). The subject disposition is shown in Fig. 1. Antemortem CT scanning was performed at a median of 14 days before death (range, 1–71 days). Postmortem CT scanning was performed at a median of 5.8 h after death (range, 1.2–23 h) and was immediately followed by autopsy.

All cadavers were carefully transported on a stretcher and were kept in the supine position at room temperature from the time of death until postmortem CT.

2.2. Antemortem CT imaging

All antemortem chest CT scans were obtained using either of the three 64-slice helical CT scanners (Aquilion 64, Toshiba Medical Systems Corporation, Ohtawara, Japan; Discovery CT750 HD and LightSpeed VCT, GE Healthcare, Buckinghamshire, UK) or a 320-detector-row helical CT scanner (Aquilion ONE, Toshiba Medical Systems Corporation, Ohtawara, Japan) without contrast medium. CT images were obtained in the craniocaudal direction with the subject in the supine position with both arms raised. The scan parameters which were routinely used for the chest CT in our hospital, were as follows: slice thickness, 5 mm; slice interval, 5 mm; rotation time, 0.5 s; and tube voltage, 120 kVp. Automatic tube current modulation was performed using Volume EC (Toshiba) and AutomA (GE). Images were reconstructed at 0.5 mm intervals with a 350 mm field of view and a 512 × 512 image matrix.

2.3. Postmortem CT imaging

Whole-body postmortem CT studies were obtained in the craniocaudal direction without contrast medium using a four-detector-row CT scanner (Robusto, Hitachi Medical Corporation, Tokyo, Japan) in the helical mode. For all scans, the cadaver was laid in the supine position with arms placed on either side of the body. The scan parameters were as follows: slice thickness, 2.5 mm; slice interval, 1.25 mm; rotation time, 0.5 s; tube voltage, 120 kVp; and tube current, 250 mA. Images were reconstructed at 1.25 mm intervals with a 350 mm field of view and a 512 × 512 image matrix.

2.4. Image interpretation

All images were interpreted by a board-certified radiologist (8 years of experience) who was not provided with clinical information. The postmortem and most recent antemortem chest CT images were compared. CT images were reviewed on a two-dimensional workstation (OsiriX, Pixmeo Inc., Bernex, Switzerland). We measured the CTR on the scout view and axial slices of each antemortem and postmortem CT by using the workstation caliper tool. The thoracic diameter was delineated by the inner borders of the thoracic cavity and the cardiac diameter was delineated by the outer borders of the heart. The two measurements were not necessarily made at the same level but were made parallel to each other (Fig. 2).

2.5. Pathological analysis

In order to study the influence of morphological and functional changes in the heart on the postmortem changes in CTR caused by antemortem myocardial infarction and perimortem CPR, the subjects were divided into three groups based on the following pathological findings and clinical information: normal hearts, hearts with old myocardial infarction, and CPR-treated hearts. Normal

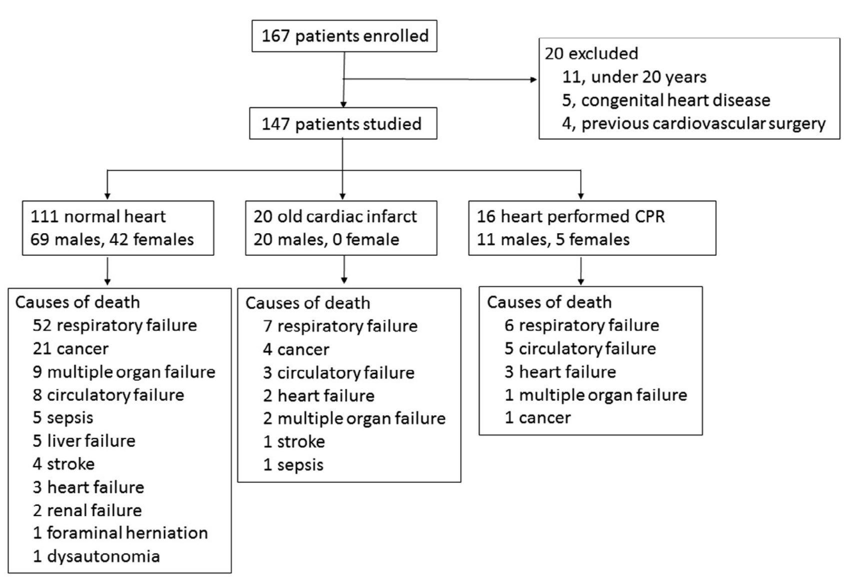

Fig. 1. Subject disposition.