European Journal of Radiology 84 (2015) 721–725

Contents lists available at ScienceDirect

European Journal of Radiology

journal homepage: www.elsevier.com/locate/ejrad

Post-mortem computed tomography findings of the lungs: Retrospective review and comparison with autopsy results of 30 infant cases

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ARTICLE INFO

Article history:
Received 7 July 2014
Received in revised form 21 October 2014
Accepted 3 December 2014

Keywords:
Post-mortem computed tomography
Forensic medicine
Autopsy
Sudden infant death
Lung

ABSTRACT

Objectives: Infant cases frequently show a diffuse increase in the concentration of lung fields on post-mortem computed tomography (PMCT). However, the lungs often show simply atelectasis at autopsy in the absence of any other abnormal changes. Thus, we retrospectively reviewed the PMCT findings of lungs following sudden infant death and correlated them with the autopsy results.
Materials and methods: We retrospectively reviewed infant cases (0 year) who had undergone PMCT and a forensic autopsy at our institution between May 2009 and June 2013. Lung opacities were classified according to their type; consolidation, ground-glass opacity and mixed, as well as distribution; bilateral diffuse and areas of sparing. Statistical analysis was performed to assess the relationships among lung opacities, causes of death and resuscitation attempt.
Results: Thirty infant cases were selected, which included 22 sudden and unexplained deaths and 8 other causes of death. Resuscitation was attempted in 22 of 30 cases. Bilateral diffuse opacities were observed in 21 of the 30 cases. Of the 21 cases, 18 were sudden and unexplained deaths. Areas of sparing were observed in 4 sudden and unexplained deaths and 5 other causes of death. Distribution of opacities was not significantly associated with causes of death or resuscitation attempt. The 21 cases with bilateral diffuse opacities included 6 consolidations (4 sudden and unexplained deaths, 2 other causes of death), 4 ground-glass opacities (3 sudden and unexplained deaths and 1 other) and 11 mixed (11 sudden and unexplained deaths). Types of opacities were not significantly associated with causes of death or resuscitation attempt.
Conclusion: Atelectasis is very common in sudden and unexplained death of infants. Bilateral diffuse mixed opacity was observed only in sudden and unexplained deaths. Bilateral diffuse pure consolidation or ground-glass opacity was also observed in other causes of death.

Abbreviations: CT, computed tomography; MDCT, multi-detector computed tomography; PMCT, post-mortem computed tomography; DICOM, digital imaging and communication in medicine.

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http://dx.doi.org/10.1016/j.ejrad.2014.12.002
0720-048X/

1. Introduction

Sudden infant death is sometimes determined to be unexplained death even at autopsy [1–4]. This determination is the result of excluding every conceivable cause of death and requires an immensely careful inspection [5,6]. Excluding respiratory diseases such as pneumonia, bronchitis and bronchiolitis plays an important part in the decision [4,7].

The use of post-mortem computed tomography (PMCT) has become common in forensic medicine [8–10]. Although various PMCT finings have been reported, there are still many difficulties interpreting CT because differences exist between PMCT findings and those of clinical CT. Therefore, further direct comparisons of CT findings and autopsy results are necessary to promote the usefulness of PMCT. PMCT of adult cases usually shows peripheral lung opacification as post-mortem hypostasis [11,12]. However, infant cases in our institution frequently show a diffuse lung opacification. It is reasonable to predict the existence of pulmonary disease such as pneumonia, bronchitis or tumour as the reason behind this increase. However, the lungs of infant cases at forensic autopsy have often shown just atelectasis in the absence of respiratory disease. In this study, we retrospectively reviewed the PMCT findings of lungs in cases of sudden infant death and correlated them with autopsy results.

2. Materials and methods

2.1. Study cases

We retrospectively reviewed infant cases (0 year) who had undergone PMCT and a forensic autopsy at our institution between May 2009 and June 2013. This was the only period in which we had performed PMCT. In recent years, approximately 50 infants have died yearly in our region. We perform PMCT and forensic autopsies on 5–10 infants per year in our institution. We excluded patients who died soon after delivery because they never breathed normally. This retrospective study was approved by the Ethics Board of our institution. Informed consent was not required for this study, as it involved a review of previously obtained imaging data.

2.2. Computed tomography and autopsy

An eight-channel multi-detector row CT (MDCT) scanner (Aquilion 8; Toshiba Medical Systems, Tokyo, Japan) was used for all examinations. All subjects were scanned clothed in a body bag. No contrast material was administered. The CT scan was taken from the head to the toes in the helical mode; tube voltage was 120 kVp and tube current was 250 mAs. Collimation was 2.0 mm. Rotation time was 0.75 s per rotation, table speed was 14 mm per rotation and the helical beam pitch was 0.875. For the lungs, the reconstructed slice thickness of the images was 1.0 mm and the reconstruction filter was FC50.

In all cases, a conventional autopsy was performed shortly after forensic CT. All autopsies were performed by a forensic pathologist who had >30 years' experience in forensic autopsies. The lungs were sectioned axially. One histology section was taken from each lobe (5 sections per case). CT images were available online in the autopsy room shortly after CT scans and radiology reports were faxed to the autopsy room during the autopsy. At least one of the radiologists participated in the autopsy and discussed the location of the samples in reference to the CT images and reports. The sections were fixed with formalin and haematoxylin and eosin (H&E) stain was performed. After receiving the autopsy reports from the forensic pathologist, we reviewed the CT images and discussed the association between the CT findings and the autopsy results.

2.3. Image assessment

All CT image data were sent to a digital imaging and communication in medicine (DICOM) server (POP-Net Server; ImageONE, Tokyo, Japan), which was observed with a two-dimensional DICOM viewer (POP-Net Essential; ImageONE) and a three-dimensional DICOM workstation (Ziostation ver. 2.0.0.1; Ziosoft, Tokyo, Japan).

A radiologist retrospectively interpreted the CT images in the axial plane. The radiologist was a board-certified diagnostic radiologist with 13 years of experience in general radiology as well as subspecialties in thoracic and gastrointestinal radiology. The radiologist also had approximately 5 years' experience interpreting post-mortem forensic CT. The radiologist assessed axial images in the lung window which is used for lung pathology evaluation. Lung opacities were classified according to their type; consolidation: opacity obscures adjacent vessels, ground-glass opacity: opacity does not obscure adjacent vessels, mixed: both consolidation and ground-glass opacity are present, as well as distribution; bilateral diffuse: all lung parenchymas are opacified, areas of sparing: some focal or multifocal regions of aerated lung are identifiable.

2.4. Statistical analysis

Fisher's exact test was used to assess the relationship between opacity distributions and causes of death and between opacity distributions and resuscitation attempt. Additionally, Pearson's chi-square test was used to assess the relationship between opacity types and causes of death and between opacity types and resuscitation attempt.

3. Results

We retrospectively reviewed 33 infant cases. We excluded three patients who died soon after delivery, and selected 30 cases (18 males and 12 females) for final analysis. The interval between death and CT was more than half a day and less than 2 days in all cases. According to the autopsy results, 22 cases were sudden and unexplained deaths. The other causes of death were acute bronchiolitis ($n = 1$), pneumonia ($n = 1$), asphyxia ($n = 2$), myocarditis ($n = 1$), cardiac anomaly ($n = 1$), cardiac hypertrophy ($n = 1$) and head trauma ($n = 1$). Resuscitation was attempted in 22 of 30 cases.

Bilateral diffuse opacities were observed in 21 of the 30 cases. Of the 21 cases, 18 were sudden and unexplained deaths and 3 were other causes of death. Areas of sparing were observed in 9 of 30 cases. Of the 9 cases, 4 were sudden and unexplained deaths and 5 were other causes of death. Fisher's exact test demonstrated the opacity distribution was not significantly associated with whether the death was sudden and unexplained ($p = 0.0318$; $\alpha = 0.01$). Resuscitation was attempted in 15 of 21 infants with bilateral diffuse opacities and 7 of 9 infants with areas of sparing. Fisher's exact test demonstrated the opacity distribution was not significantly associated with whether resuscitation was attempted ($p = 1.0000$; $\alpha = 0.01$).

Of the 21 cases with bilateral diffuse opacities, 6 were consolidations (4 sudden and unexplained deaths, 1 myocarditis and 1 cardiac anomaly), 4 were ground-glass opacities (3 sudden and unexplained deaths and 1 head trauma) and 11 were mixed (11 sudden and unexplained deaths; Table 1). The CT and autopsy findings of typical cases are shown in Figs. 1–3. Fig. 1 shows a case of sudden and unexplained death. Almost all lung fields were occupied by consolidation on CT (Fig. 1a). The lungs showed atelectasis at autopsy (Fig. 1b). Fig. 2 shows another case of sudden and unexplained death. All lung fields were consolidated with ground-glass opacity on CT (Fig. 2a). No abnormal findings were detected at autopsy, with the exception of atelectasis (Fig. 2b). Fig. 3 shows