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Non-specific post-mortem modifications on whole-body post-mortem computed tomography in sudden unexpected death in infancy

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ABSTRACT

Objectives: To provide an overview of non-specific modifications on whole-body post-mortem computed tomography (PMCT) images of infants and children.
Materials and methods: 69 infants and children underwent a whole-body PMCT scan at our institution following sudden unexpected death. Two paediatric radiologists reviewed the PMCT images, specifically focusing on non-specific postmortem modifications unrelated to the presumed cause of death.
Results: Iatrogenic post-mortem modifications included focal infiltration of the legs ($n=15$) and hemopericardium ($n=2$). Vascular postmortem modifications included hypostasis (density in the posterior sagittal sinus was correlated with density in the dependent portion of the heart ($p<0.001$)), portal vein thrombosis ($n=56$, 75.3%), hyperattenuating aortic wall and reduced abdominal aortic diameter ($n=69$, 100%). Intravascular gas was detected in 40 subjects (57.9%). Ligamentum arteriosum calcification was seen in 42 children and was not correlated with age ($p=0.68$). Umbilical artery calcification was found in 30 children and was correlated with age ($p<0.005$). Gaseous distension of the stomach ($n=45$, 65.2%) and bowels ($n=44$, 63.7%) was a frequent finding. Mean liver density was 49.6 ± 7.5 HU and mean spleen density was 43.2 ± 5.9 HU. Ground-glass opacity was observed in 63 cases (91.3%) and mild bilateral consolidation in 16 cases (23.1%).
Conclusion: Non-specific post-mortem signs are rare and new to clinical paediatric radiologists. They should be aware of these signs when interpreting whole-body PMCT images in cases of sudden unexpected death in infancy or childhood in order to avoid pitfalls that may have a critical impact.

1. Introduction

Non-specific post-mortem modifications are now well known to forensic radiologists. However, post-mortem imaging has mostly been described in adult populations [1]. Vascular post-mortem modifications are described in adult population, such as hypostasis [2], hyperattenuating aortic wall [3], clotting in the heart and great vessels [4]. Presence of cardiovascular gas bubbles is also a common finding even if physiopathology is unclear. Only one study has focused on non-specific post-mortem signs in paediatric population, regarding normal cranial post-mortem CT findings [5].

SUDI is the most common cause of post-neonatal death. Infection represents the most common cause of explained SUDI. Almost two thirds of SUDI cases remain unexplained even after meticulous post-mortem examination including a detailed autopsy with full histological examination [6]. About 10% of all SUDI cases are related to non-accidental injuries (NAI). One of the main purposes of post-mortem imaging in SUDI is to identify findings related to child abuse. Few studies focus on whole-body

Abbreviations: CPR, cardiopulmonary resuscitation; GGO, ground-glass opacity; IVG, intravascular gas; LAC, ligamentum arteriosum calcification; PMCT, post-mortem computed tomography; SUDI, sudden unexpected death in infancy; UAC, umbilical artery calcification

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PMCT in infants and children [7–9]. Paediatric radiologists need to become more familiar with post-mortem imaging and non-specific post-mortem modifications in order to distinguish them from pathological modifications that may be relevant to the cause of death. The purpose of this paper is to provide an overview of non-specific modifications on whole-body post-mortem CT in infants and children.

2. Materials and methods

Between March 2005 and May 2014, 69 sudden unexpected deaths of infants and children with no known pre-existing disease were investigated in our institution. All cadavers underwent a whole-body PMCT scan. There were 21 girls and 48 boys. The mean age was 9.7 ± 17.0 months. The group included 65 children younger than 2 years (mean age 5.9 ± 5.3 months) and 4 children older than 2 years (4, 5, 7 and 8 years). All CT examinations were performed using a 16-slice multidetector CT scanner (Philips Brilliance, Cleveland, Ohio, USA) with the same protocol. The imaging parameters used were as follows: 120 kV, 300 mAs, collimation 16 × 0.75 mm, pitch 0.688, rotation time 0.5 s, slice thickness 2 mm, and increment 1 mm. The cadavers were imaged in the supine position with arms parallel to the body. Volumetric CT data were acquired from the vertex to the feet. No contrast material was administered. The median interval between certification of death and PMCT acquisition was 2 h and never exceeded 6 h.

Two paediatric radiologists experienced in post-mortem imaging retrospectively interpreted the whole-body PMCT images. The circumstances of death and autopsy findings were unknown at the time of image interpretation. They used a standardised checklist to evaluate non-specific post-mortem modifications unrelated to the cause of death. As prior studies on describing normal findings in children are scarce, we selected the items based on our own experiences [7] and paper regarding normal post-mortem modifications in adults [1–4,10,11].

Fifty-nine children (85.5%) underwent an autopsy. Fifty conventional autopsies and 9 forensic autopsies were performed using a standardised protocol.

The study population, imaging results and autopsy finding variables were represented as numbers plus or minus a percentage for qualitative variables. Quantitative variables were described by a mean ± standard deviation. The Spearman correlation test was used to compare two quantitative variables and Student's test to compare means.

3. Results

Non-specific findings on whole-body post-mortem CT detected in our cohort ($n=69$) are listed in Table 1. Fifteen children (21.7%) had focal infiltration of the legs with gas bubbles due to intraosseous adrenaline administration during cardiopulmonary resuscitation (CPR) (Fig. 1A). Two children had haemopericardium due to cardiac puncture for blood sampling performed before PMCT acquisition (Fig. 1B).

Blood sedimentation in the heart and major vessels (Fig. 2A and B) was visible in all cases. The mean density in the posterior sagittal sinus (54.9 HU ± 9.6 HU) was significantly correlated with the mean density in the dependent portion of the heart (52.1 HU ± 10.3 HU). The Pearson correlation coefficient was 0.77 ($p<0.001$). Intravascular clotting (Fig. 3A–C) was frequently seen. Postmortem clotting in the portal vein occurred in 56 cases (81.1%). Periportal oedema was seen in 52 cases (75.3%) (Fig. 3D). Hyperattenuating aortic wall and reduced abdominal aortic diameter were seen in all children (100%) (Fig. 4). Intravascular gas (IVG) bubbles (Fig. 5) were seen in 40 subjects (57.9%). IVG was seen in the heart chamber ($n=40$, 57.9%), intracranial arteries ($n=3$, 4.3%), veins ($n=24$, 34.7%), liver veins ($n=31$, 44.9%) and other abdominal vessels ($n=15$, 21.7%). For all subjects with IVG detected in the brain, liver or abdomen, IVG was also seen in the heart chamber.

Calcification of the ligamentum arteriosum (Fig. 6A and B) was seen in 42 children (60.9%) and was not correlated with age ($p=0.68$). The mean age was 8.9 months (± 11.8) if present and 10.9 months (± 23.2) if absent. Prevalence of umbilical artery calcification (UAC) visualisation ($n=30$, 43.5%) was significantly correlated with age ($p=0.0035$) (Fig. 6C and D). The mean age was 3.6 months (± 2.9) if present and 14.4 months (± 21.5) if absent.

Stomach distension was observed in 45 children (65.2%) as mild ($n=10$), moderate ($n=22$) or severe ($n=13$). Gas and fluid distension was seen in 11 of the 45 cases. Bowel gaseous distension was observed in 44 children (63.7%) as mild ($n=23$), moderate ($n=14$) or severe ($n=7$) (Fig. 7).

Mean liver density was 49.6 ± 7.5 HU and mean spleen density was 43.2 ± 5.9 HU. Two children with a liver density of 15 HU and 22 HU and a spleen density of 38 HU and 42 HU respectively had hepatic steatosis that was confirmed by autopsy.

Non-specific pulmonary post-mortem modifications (Fig. 8A and B) such as ground-glass opacity (GGO) were observed in 63 subjects (91.3%) as mild ($n=24$), moderate ($n=34$) or severe ($n=5$). Mild bilateral and symmetric consolidation was observed in 16 children (23.1%).

4. Discussion

4.1. Iatrogenic modifications

Post-mortem blood samples may be taken from the heart chambers. In our institution cardiac sampling is usually done after

Table 1
Nonspecific post-mortem modifications on whole body PMCT in infants and children.

	Number (n)	Percentage (%)
Iatrogenic post-mortem modifications		
Focal infiltration of the legs	15	21.7
Haemopericardium	2	2.9
Vascular post-mortem modifications		
Blood sedimentation	69	100
Post-mortem clotting in the portal vein	56	81.1
Periportal oedema	52	75.3
Hyperattenuating aortic wall	69	100
Reduced abdominal aortic diameter	69	100
Intravascular gas		
Total	40	57.9
Heart chamber	40	57.9
Intracranial arteries	3	4.3
Intracranial veins	24	34.7
Liver veins	31	44.9
Calcification		
Ligamentum arteriosum	42	60.9
Umbilical artery	30	43.5
Gaseous distension		
Stomach	45	65.2
Bowel	44	63.7
Pulmonary post-mortem modifications		
Ground-glass opacity	63	91.3
Mild	24	36.3
Moderate	34	50.7
Severe	5	7.2
Mild bilateral and symmetric consolidation	16	23.1