



Evaluation of thymic volume by postmortem computed tomography



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ABSTRACT

The thymus is exceedingly sensitive to stress and undergoes abrupt involution as a result of exposure to strong stress in early childhood. Therefore, thymic involution is often utilized to assess the presence of a stressful environment, such as an environment involving child abuse, in forensic medicine. In recent years, computed tomography (CT) has been commonly used in the daily practice of forensic medicine. We have focused on the thymic volume in postmortem CT images to evaluate the presence of a stressful antemortem environment. We calculated the thymus volume from postmortem CT images of children under six years old and demonstrated that the volume showed a positive correlation with the real weight obtained from an autopsy. The evaluation of thymic volume by CT may make it possible for us to identify child maltreatment. The most useful feature of this application of CT is to be able to demonstrate thymic involution less invasively in a surviving victim.

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1. Introduction

The thymus is located in the anterior mediastinum. It is a primary lymphoid organ that is critical for the differentiation of T-cells and for the development of T-cell-mediated immunity in childhood. The thymus markedly increases in volume in early childhood and is physiologically involuted after puberty. The thymus exhibits acute involution as a result of exposure to strong and/or long-term stress in childhood [1,2]. A large amount of serum glucocorticoid may induce naïve T-cell apoptosis in the thymic cortex [3], resulting in acute thymic involution. Therefore, thymic involution has been utilized in forensic autopsies to evaluate the degree and duration of child abuse/neglect [2,4].

Diagnostic imaging, especially computed tomography (CT), is now commonly used in forensic medicine. CT provides whole body imaging and is a quick and convenient method of organ volume measurement. Few reports on the evaluation of thymic volume on CT are available, however. In the present study, we determined the thymic volume in children using postmortem CT (PMCT) imaging and compared this volume with that determined in autopsy

findings. This is the first report describing autopsy findings and PMCT findings regarding the thymus.

2. Materials and methods

Thymic volume and weight were compared in 27 cases (0–6 years old) autopsied in the Department of Legal Medicine at the University Medical Center Hamburg-Eppendorf (Table 1). Among these cases, a single case (No. 17) was suspected to involve child abuse.

Whole body CT scans were performed using a PHILIPS MX8000 Quad CT scanner. Image data were handled using OsiriX imaging software run on a Macintosh computer (Version 3.9.4. <http://www.osirix-viewer.com/>, version 6.0 is now available on the website).

The thymic volume was calculated in each case from the region of interest (ROI). The thymic region was bordered by a green line as shown in Fig. 1a and b. Images were displayed using brain settings; window width = 100 Hounsfield units (HU); window level = 50 HU. All cases examined in the present study showed good resolution, and the postmortem periods were four days or less. ROIs were placed on the thymus images using the “mouse button function” tool at 10-mm intervals. Missing ROIs among the manually placed ROIs were filled in using the “create missing ROI” command. The ROIs were placed under the supervision of a radiologist. Finally,

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Table 1
Overview of cases.

No.	Age in days	Sex	Cause of death	Group	Body weight (g)	Height (cm)	Volume of thymus (cm ³)	CT attenuation value (HU)	Weight of thymus (g)
1	18	M	Suspicion of SIDS	SIDS	4048	54.5	11.2	76.3	13
2	41	F	Suspicion of SIDS	SIDS	4092	57.0	9.0	66.4	17
3	44	M	Inflammatory heart disease	Disease	3520	52.0	18.8	59.7	25
4	48	F	Unclear	Unclear	5000	54.0	14.9	59.2	21
5	51	W	Unclear	Unclear	4226	58.0	13.9	52.8	18
6	69	F	Suspicion of SIDS	SIDS	5136	62.0	35.6	71.1	43
7	88	F	Unclear	Unclear	6100	56.0	15.1	53.1	18
8	89	F	Unclear	Unclear	6300	63.0	20.5	61.9	25
9	96	M	Suspicion of SIDS	SIDS	5600	60.0	30.4	60.9	40
10	128	M	Congenital heart disease	Disease	6400	64.0	23.6	68.5	29
11	129	M	Unclear	Unclear	5490	60.0	20.0	65.1	25
12	136	M	Respiratory infection	Disease	7000	70.0	10.9	57.2	18
13	139	M	Suspicion of SIDS	SIDS	7400	66.0	24.9	71.5	34
14	176	F	Suspicion of SIDS	SIDS	4900	70.0	54.6	56.9	68
15	210	M	Unclear	Unclear	6500	61.0	46.7	59.9	48
16	261	M	Suspicion of SIDS	SIDS	9900	71.0	18.8	70.4	31
17	299	F	Suspicion of child abuse	Abuse	4802	66.0	5.3	60.8	7
18	351	M	Suspicion of SIDS	SIDS	9300	78.0	40.7	61.3	55
19	374	M	Respiratory infection	Disease	9600	78.0	25.6	69.5	35
20	398	M	Head injury	Accident	12,100	82.0	17.6	78.8	30
21	556	F	Intestinal volvulus	Disease	9900	79.0	22.6	68.1	23
22	563	M	Unclear	Unclear	10,200	75.0	17.8	73.7	24
23	570	M	Foreign body aspiration	Accident	15,400	82.0	24.0	72.7	25
24	705	M	Drowning	Accident	13,700	87.0	27.8	67.4	36
25	795	M	Head injury	Accident	15,000	83.0	18.8	72.2	17
26	1509	M	Unclear	Unclear	18,000	108.0	17.8	73.7	29
27	1881	F	Unclear	Unclear	22,500	119.0	36.0	64.7	54

Abbreviation: SIDS, sudden infant death syndrome.

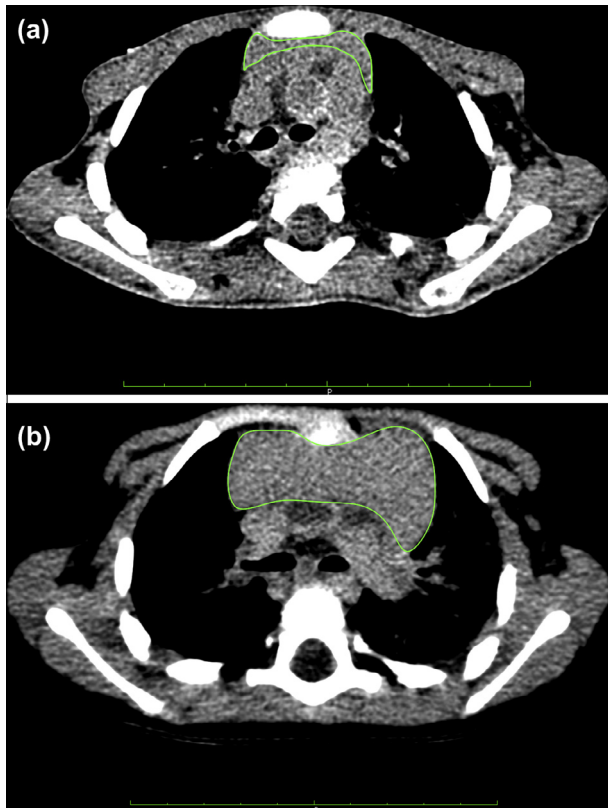


Fig. 1. Horizontal sections of the thymus on CT images taken at the level of the carina. The green line indicates the thymic border and a region of interest. (a) A 10-month-old female with thymic involution (Case No. 17 in Table 1). (b) A 12-month-old male without thymic involution (Case No. 18).

the volume and mean CT attenuation values were obtained using the “compute volume” command.

Each subject’s age in days, height (cm), body weight (g), thymic weight (g) and cause of death were obtained from the autopsy records.

This study was performed in accordance with the laws of the city of the Hamburg and the data production and ethical guidelines of the University Medical Center Hamburg-Eppendorf. The authors have no conflict of interest directly relevant to the content of this article.

3. Results

The thymic volume and CT attenuation values in all cases examined are summarized in Table 1.

The relation between thymic weight and volume was investigated using Pearson’s correlation coefficient test. A statistically significant ($p < 0.001$) strong correlation ($r = 0.95$) was observed between thymic weight and volume (Fig. 2).

Case No. 17, who was suspected to be a victim of child abuse, presented obvious thymic involution, e.g., thinning of the thickness in a horizontal section on the CT image (Fig. 1a). On the other hand, case No. 18, in which the cause of death seemed to be sudden infant death syndrome (SIDS), did not show thymic involution. A non-involved thymus shows its thickest slice thickness on the horizontal section at the level of the carina. The involuted thymus in case No. 17 shows thinning but exhibits a roughly rectangular structure on the horizontal section, as in the non-involved thymus in case No. 18.

Fig. 3 shows three-dimensional (3D) images of the thymuses of cases No. 17 (a–c) and No. 18 (d–f). These figures visualize the thickness of the thymus well.

The CT attenuation value did not correlate with body height, body weight, thymic volume, thymic weight, or postmortem period.

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