C. Jackowski[1,] N. Schwendener[1], J. Zeyer-Brunner[1], C. Schyma[1]

Body weight estimation based on post mortem CT data – validation of a multiplication factor

[1] Institute of Forensic Medicine, University of Bern, Buehlstrasse 20, 3012 Bern, Switzerland

Corresponding author:

Christian Jackowski, Prof. Dr. med., EMBA

University of Bern

Institute of Forensic Medicine,

Buehlstrasse 20

3012 Bern

Switzerland

Phone: ++ 41 31 631 8412

Fax: ++ 41 31 631 3833

Email: christian.jackowski@irm.unibe.ch

Abstract

Postmortem computed tomography (pmCT) is increasingly applied in forensic medicine as a documentation and diagnostic tool. The present study investigated if pmCT data can be used to estimate the corpse weight.

In 50 forensic cases pmCT examinations were performed prior autopsy and the pmCT data were used to determine the body volume using an automated segmentation tool. PmCT was performed within 48 hours postmortem. The body weights assessed prior autopsy and the body volumes assessed using the pmCT data were used to calculate individual multiplication factors.

The mean postmortem multiplication factor for the study cases was 1.07 g/ml.

Using this factor the body weight may be estimated retrospectively when necessary. Severe artefact causing foreign bodies within the corpses limit the use of pmCT data for body weight estimations.

1. Introduction

Postmortem computed tomography (pmCT) is increasingly applied in forensic medicine as a documentation and diagnostic tool (1-3). PmCT is mostly performed prior autopsy and documents the state of admission of the corpse as it was delivered to the forensic institute. Archived on a Picture Archiving and Communication System (PACS) the pmCT data remain available for a second look, especially when the body was autopsied and has been released afterwards (4, 5).

In 2014 the publication's host institute was involved in a case of a 1.5 year old boy who died from an unknown cause. Prior autopsy a pmCT examination was performed as part of the autopsy routine in our institute. Image reading did not reveal any pathologic findings except from regular postmortem alterations. At autopsy no macromorphological findings explaining the death were found. Histologically a myocardial virus infection was confirmed. Prior to the autopsy the corpse weight was documented as being 8kg.

Three days after the autopsy the forensic pathologist noticed within the clinical records the last documented weight of the living child being 10.7kg and measured 4 days before the child had passed away. At that time the corpse was already released and buried. Based on that information a weight loss of almost 3kg over the last 4 days was assumed, which could not be supported by the autopsy findings. However, a weight loss down to 75% in a few days is life-threatening for children (6). Therefore, the district attorney wanted to know whether the parents or the grandmother as well as the pediatrician have overlooked the relevant weight loss. The question arose whether the weight loss was real and somehow related to the cause of death or if there was a relevant measurement error in one of the two documented weight measurements.

The present publication shows how the problem could be solved using the postmortem CT data of the individual case as well as of a control population. In the literature a soft tissue multiplication factor is descripted as 1.04 g/ml for the living (7). Therefore, the aim of the

present study was to investigate if this factor can also be applied postmortem using pmCT data to estimate the corpse weight when necessary.

2. Methods

2.1 PmCT

50 corpses wrapped in a body bag where CT scanned in supine position. Whole body pmCT examinations where performed using an Emotion 6 CT scanner (n=18) and a Somatom Definition AS CT scanner (n=32) (Siemens Medical Solutions, Erlangen, Germany). Examination time ranged between 10 min (Somatom Definition AS) and 30 min (Emotion 6) and image reconstructions took another 10 to 20 min. *CT parameters*: Emotion 6: 120 kV, care dose mAs, rotation time 0.5s, slice thickness 1.0mm, increment 0.5mm, kernel B30; Somatom Definiton AS: 140 kV, care dose mAs, rotation time 0.5s, slice thickness 0.6mm, increment 0.3mm, kernel I30.

2.2 Volume segmentation

PmCT dicom data where sent from the PACS to a Mac Pro computer equipped with Osirix. A threshold based volume segmentation plugin (Mia lite; free available on http://www.mia-solution.com) was used to segment the whole corpse volumes. The lower threshold was set to -270 and the upper threshold was left as high as possible. After setting seed ROI's (Region of Interest) within the corpse the program segmented the volume automatically. After segmentation the corpse volume was documented in ml.

2.3 Cases and evaluation

PmCT data (postmortem interval < 48 hours) of 50 corpses (20 children, 20 adults and 10 adults who died in a hospital setting, age 0-94 years, 23 female, 27 male, table 1) where used. The segmented volume (ml) and the weight (g) at autopsy were used to calculate an individual multiplication factor (g/ml). The mean multiplication factor was used to verify the weight of the 1.5 year old boy.

3. Results

The individual multiplication factors (g/ml) of the 50 corpses ranged between 1.0 and 1.17 (table 1, Fig. 1). The average of the 50 corpses was 1.071, of the female corpses 1.061 and of the male corpses 1.077. The corpse with a multiplication factor of 1.0 was one of the ten hospital deaths, which ranged between 1.0 and 1.09. The mean multiplication factor of the corpses from the hospital was slightly lower than the others (1.06). The body with a multiplication factor of 1.17 was one of the children. The average of the 20 children was 1.07.

Comparing the weight of the 1.5 year old boy with the rest of the children showed his weight as an outlier (Fig. 2). Using the mean multiplication factor of children his correct postmortem weight would be estimated with 11.1kg, which was in line with the last documented living weight of 10.7kg. Therefore, the postmortem weight documented prior autopsy could retrospectively be revealed as wrong.

4. Discussion

Based on the presented investigations the case related problem could be solved and it was found out that a decalibration of the autopsy scale was the explanation of the case relevant discrepancy. Thereby any malpractices or mistreatment by neglect could be ruled out definitively. Retrospectively we asked our autopsy technicians if they could explain the decalibration. One then admitted that the scale bumped against a door frame while it was moved within our facility shortly before the child was measured. Until the decalibration was realized three further adult corpses have been measured with that scale. Also these measurements were roughly 3 kg too low as we could show afterwards using the multiplication factor obtained within the study. However, these measurement errors had no consequences for the individual case work in contrast to the child’s case presented within the

study. All this happened in between two regular scale calibrations and these additional three cases did not become part of the study population, of course.

The mean postmortem multiplication factor (1.07 g/ml) obtained within the present study is comparable to the soft tissue multiplication factor (1.04g/ml) described for the living (7) (annotation: the authors of reference 2 wrote 1.04 mg/ml, which obviously was meant to be 1.04 g/ml).

The slightly higher multiplication factor in the deceased as compared to the living may be explained by the first postmortem drying processes. When the bodies lose water having a physical density of 1.00 g/ml the mean multiplication factor of the body is expected to increase. This explanation may also be supported by the finding that the rather edematous hospital death corpses showed a slightly lower mean multiplication factor compared to the control group because in these cases the mean multiplication factor should be lowered by the higher percentage of water. Furthermore, the postmortem multiplication factor is a whole body density factor also including other tissues such as bones, which may also explain the slight discrepancy (8).

The comparison of male and female adults did result in the expected minor difference in favor of the males (Fig. 3). The males showed a slightly higher mean multiplication factor of 0.016 (+ 1.51%). This result can be explained by the BMI's. The study population showed a mean BMI for the females of 26.7 and for the males of 25.6. The females presented with more body fat than the males. Thereby, the expected influence of mean body fat content on the multiplication factor could be shown even within only 50 cases.

Study limitations

The rather small study population limits the value of the presented mean multiplication factor.

Beam hardening artefacts within the pmCT data are a relevant limitation for the use of this technique, because these artifacts can disturb the segmentation using Mia lite distinctively. Bodies with a lot of metal (e.g. endoprosthesis) will cause the segmented volume values to be too high. Applying the multiplication factor will then result in too heavy weights. The same is true for any foreign body that comes along with the corpse on its exterior surface such as e.g. medical casts.

In further studies the influence of a longer postmortem interval may be investigated as well.

5. Conclusion

Volume data of pmCT scans may be used to estimate the weight of the corpses with the use of a multiplication factor of 1.07 g/ml. Artefacts within the images limit the use of pmCT-data for weight estimation.

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Fig.1:

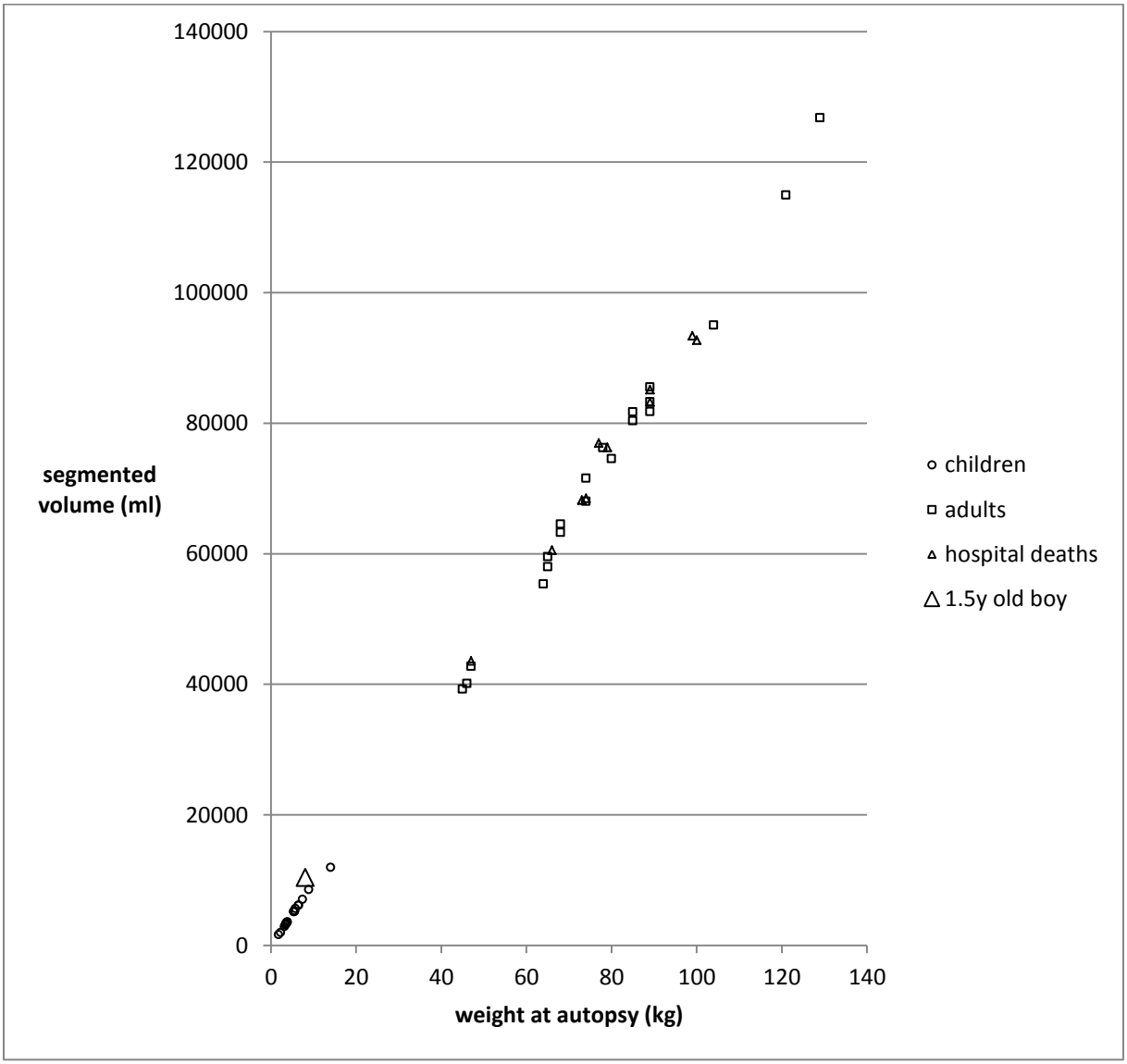

Fig.1: PmCT volumes compared to the weights at autopsy in all study cases.

Fig. 2

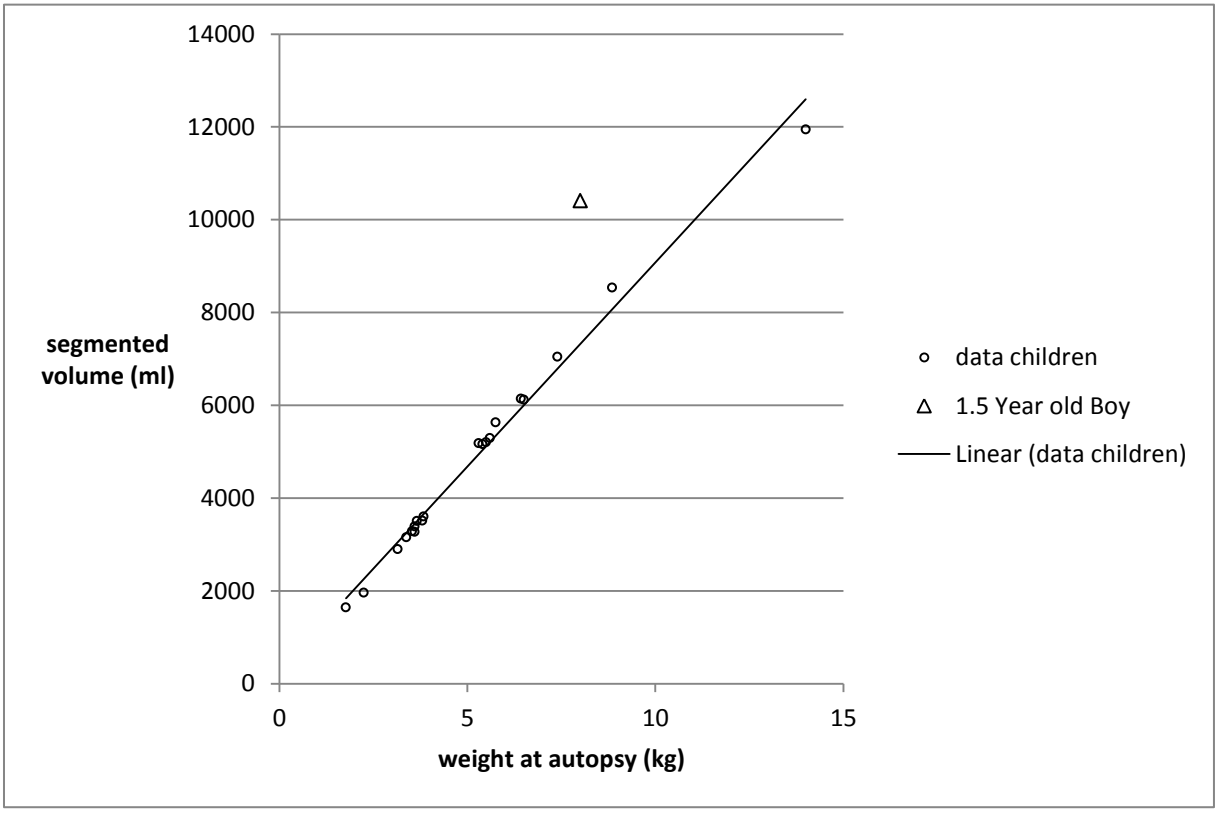

Fig.2: PmCT volume of children compared to the weight at autopsy. The triangle shows the 1.5 year old boy as a destinct outlier.

Fig.3:

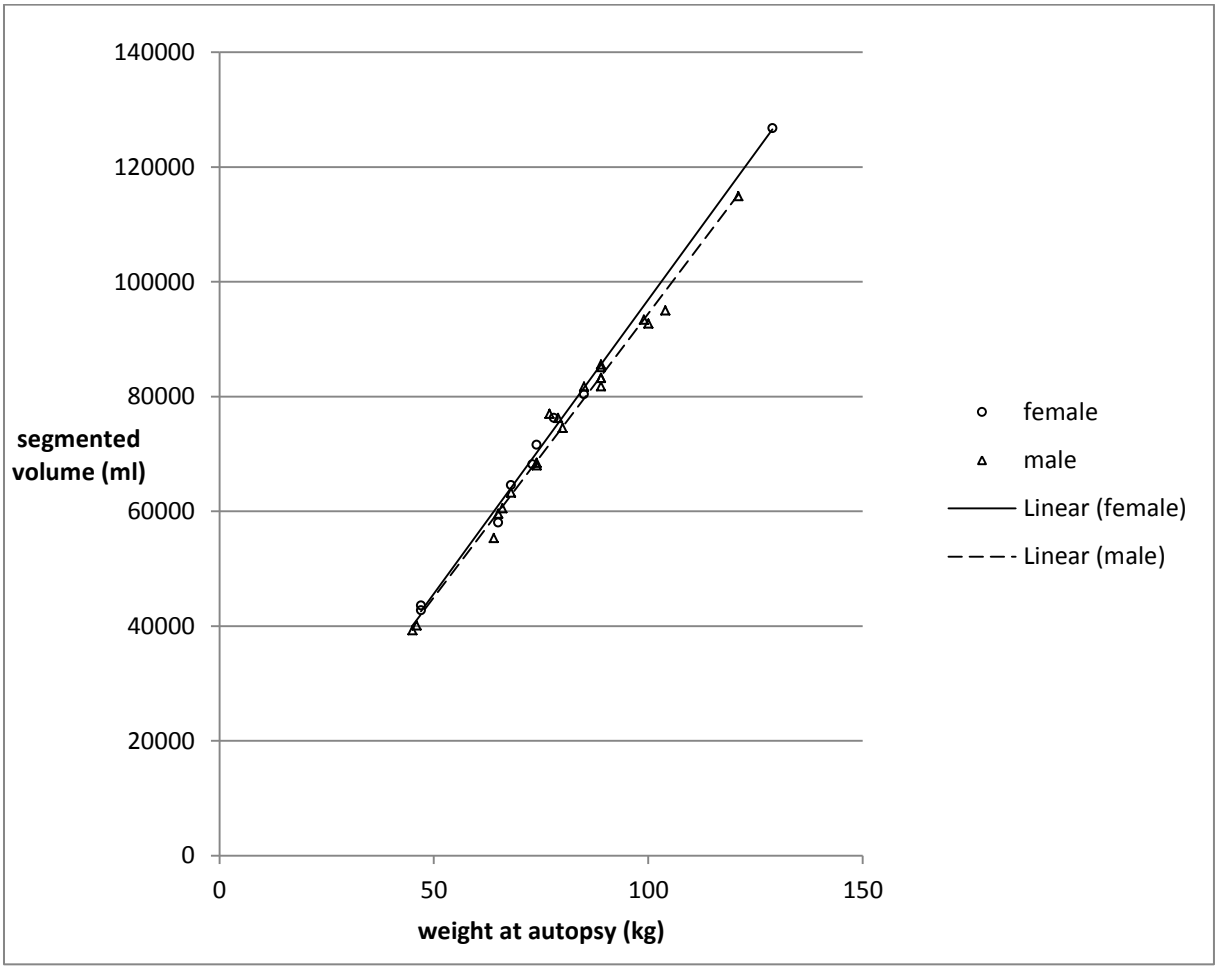

Fig.3: PmCT volume of male and female adult corpses compared to the weight at autopsy.

Note that the females within the study have a slightly higher volume per weight.

Table 1:

	age (y)	sex	segmented volume (ml)	weight at autopsy (kg)	multiplicationfactor (g/ml)	multiplicationfactor in groups
children	2d	f	1643	1.77	1.077297626	
	9d	m	1961	2.247	1.145843957	
	3m	f	2896	3.15	1.087707182	
	1d	f	3154	3.38	1.071655041	
	2d	f	3287	3.53	1.073927594	
	4m	m	3274	3.6	1.099572389	
	1d	f	3386	3.6	1.063201418	
	1.5m	f	3503	3.66	1.044818727	
	12d	f	3514	3.8	1.081388731	
	1m	m	3599	3.84	1.066963045	
	3m	m	5184	5.3	1.022376543	
	6m	f	5160	5.4	1.046511628	
	4m	f	5200	5.5	1.057692308	
	2.5m	m	5296	5.6	1.057401813	
	3m	f	5632	5.75	1.020951705	
	4m	m	6139	6.425	1.046587392	
	11m	f	6124	6.5	1.061397779	
	8m	f	7044	7.4	1.050539466	
	8m	f	8534	8.85	1.037028357	
	3	f	11944	14	1.172136638	1.069249967
1.5y old boy	1.5	m	10414	8	0.768196658	
adultes	26	m	39282	45	1.145562853	
	15	m	40129	46	1.146303172	
	56	f	42771	47	1.098875406	
	67	m	55376	64	1.155735337	
	28	f	58005	65	1.120593052	
	52	m	59569	65	1.091171583	
	61	m	63269	68	1.074775957	
	51	f	64551	68	1.053430621	
	68	m	68037	74	1.087643488	
	44	f	71594	74	1.033606168	
	86	f	76268	78	1.022709393	
	48	m	74559	80	1.072975764	
	83	f	80397	85	1.05725338	
	61	m	81732	85	1.039984339	
	44	m	85569	89	1.040096297	
	42	m	81779	89	1.088298952	
	81	m	83280	89	1.068683958	
	69	m	95039	104	1.094287608	
	69	m	114954	121	1.052594951	
	57	f	126795	129	1.017390276	1.078098628
hospital deaths	90	f	43565	47	1.078847699	
adultes	69	m	60560	66	1.089828269	
	91	f	68200	73	1.070381232	
	58	m	68470	74	1.080765299	
	75	m	76983	77	1.000220828	
	78	m	76277	79	1.035698835	
	61	m	85157	89	1.04512841	
	61	m	83246	89	1.069120438	
	83	m	93394	99	1.060025269	
	79	m	92719	100	1.078527594	1.060854387
mean all (without 1.5y old boy)						1.071110315

Tab 1: All segmented study cases and their individual multiplication factors.