

## CASE REPORT

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# Estimation of Caloric Deficit in a Fatal Case of Starvation Resulting from Child Neglect

**ABSTRACT:** We report the case of a 3-year-20-day-old girl who died of starvation as a result of severe neglect. Her body weight had been 12 kg 70 days before her death, but was only 5 kg at the time of autopsy. From information supplied by her parents to police, we calculated her daily caloric intake and estimated the factors for physical activity. The daily recommended dietary allowance for the victim was calculated from 700 kcal/day  $\times$  the appropriate factor for physical activity.

In the absence of enough food, body fat (7.2 kcal/g body fat) and protein (4 kcal/g protein) would have been used to compensate until death. The calculated body weight at the time of death was around 5 kg. The statements of the parents therefore appear to be true.

**KEYWORDS:** forensic science, child abuse, neglect, starvation, caloric deficit

Child abuse and neglect have been recognized as a widespread problem since the early 1960s (1). It is a problem of great public concern, and has gained wide attention among pediatricians, psychiatrists, social workers, forensic pathologists, and others. Most reports concentrate on the physical abuse aspects of this problem; however, there are also several published reports of nutritional neglect in children (2–4).

We performed a judicial autopsy on a 3-year-20-day-old girl who had died of starvation resulting from severe neglect. The victim weighed 5 kg at autopsy, and had lost 7 kg in 70 days. In this report, we describe the autopsy findings and present an estimation of the caloric deficit based on the parents' confession in the interrogation rooms.

### Case Report

A 3-year-20-day-old girl was living with her 21-year-old natural parents and 1-year-6-month-old brother. The parents (perpetrators) had not cared for the victim, had not fed her sufficiently, and had finally put her in a packing case. One day in winter, they went out with their son leaving the victim alone at home. When they returned home that night, they found her dead in the packing case.

### Autopsy Findings

Autopsy revealed an emaciated girl measuring 89 cm in height and weighing 5 kg. She had well-demarcated ribs and a concave ab-

domen (Fig. 1A). Decubitus ulcers were present on the left temporal and left occipital areas of the head and on the left of the back and pelvis. Bilateral contracture of the knee joints and bilateral edema of the feet were observed (Fig. 1A). Dried feces and urine adhered to the waist, hip, anus, vulva and the backs of both thighs (Fig. 1B). Recent subcutaneous hemorrhages were observed on the right temporal area and the face, and a few scars were present on the forehead. The muscles of the head, face, trunk, and lower and upper extremities were flaccid. There was no subcutaneous or omental fat. The orbital adipose tissue was spent and the eyes were open. Because of drying of the eyes, the choroid could be seen through the dried sclera. The stomach and small intestine were contracted and empty, while the large bowel contained hard pellets of fecal material. The weights of most of the victim's organs were markedly less than the normal averages (Table 1). The thymus was extremely atrophic (1.7 g). In addition, there was almost no glycogen in the liver on PAS (para-amino salicylic acid) stain (Fig. 2).

### Background

When the victim was 2 years and 8 months old, her mother had taken her to the hospital. At that time, her body weight was 9 kg and the pediatrician diagnosed her as being malnourished. The pediatrician pressed the mother to have the victim admitted, but the mother rejected this recommendation and took the girl back home. Six days later, the mother brought the victim back to the same hospital. At this time, her body weight had increased to 11 kg (Fig. 3) and the doctor's doubt about possible child abuse was negated.

When the victim was 2 years 9 months old, her grandmother had taken care of her. At this time, her body weight was 10 kg and she could not stand alone. The grandmother cared for her adequately but wondered why her grandchild ate so hungrily. When the victim was 2 years 10 months and 11 days old, she was returned to the parents. Her body weight was 12 kg.

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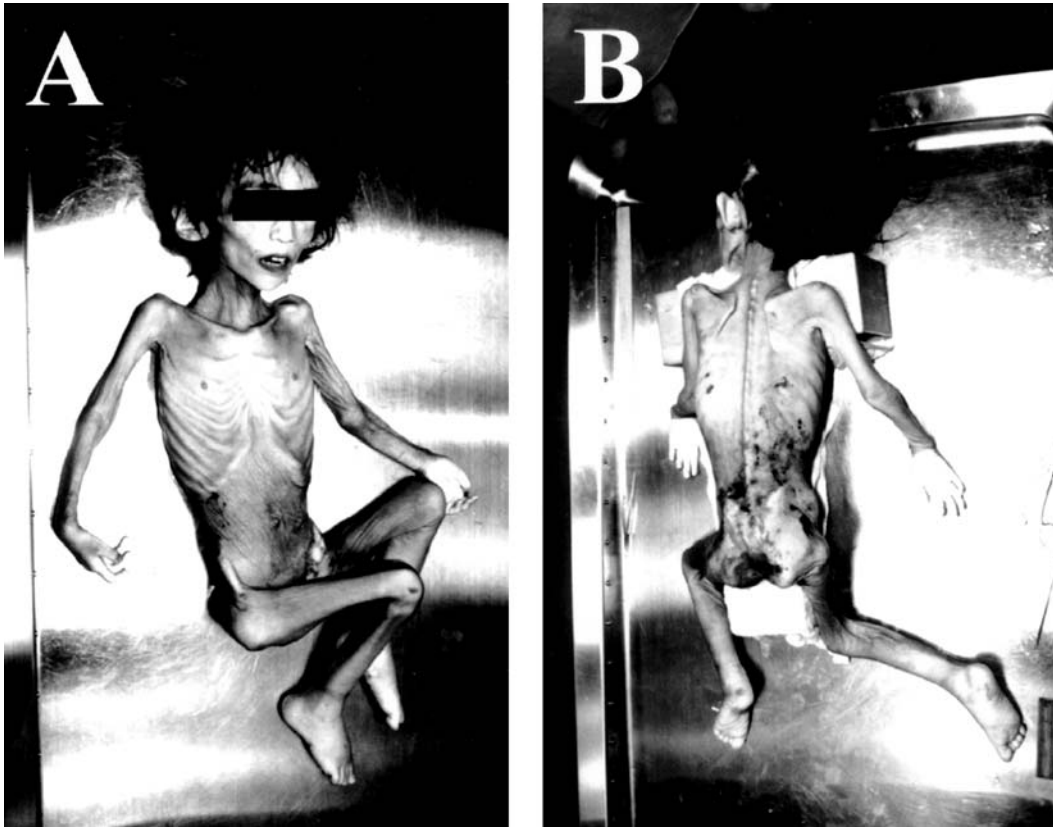


FIG. 1—A. View of the victim in the supine position. Bilateral contracture of the knee joints and bilateral edema of the feet can be seen. B. View of the victim in the prone position. Dried feces and urine adhering to the waist, hip, anus, vulva, and the backs of both thighs are apparent.

TABLE 1—Weights of the victim's organs at autopsy.

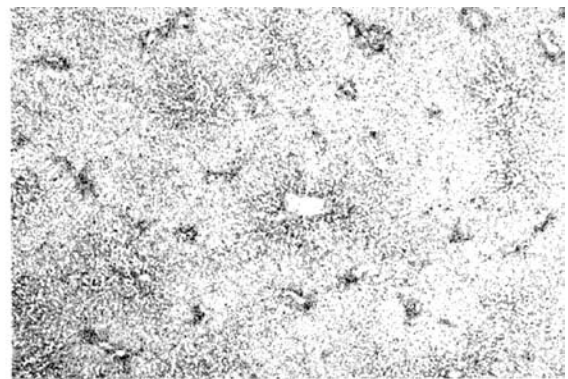
Organ	Victim (g)	Average $\pm$ S.D.* 2 year/old (female)	Average $\pm$ S.D.* 3 year/old (female)
Brain	980	1180 $\pm$ 96	1234 $\pm$ 110
Heart	40	62 $\pm$ 8.1	72 $\pm$ 10.2
Left lung	35	95 $\pm$ 26.6	114 $\pm$ 23.8
Right lung	40	106 $\pm$ 30.2	133 $\pm$ 33.2
Liver	210	440 $\pm$ 85	475 $\pm$ 72
Spleen	10	41 $\pm$ 14.1	45 $\pm$ 8.8
Pancreas	6.8	23 $\pm$ 6.1	30 $\pm$ 9.3
Left kidney	20	40 $\pm$ 6.5	43 $\pm$ 6.6
Right kidney	25	37 $\pm$ 5.6	42 $\pm$ 7.3
Left adrenal gland	1.7	2.2 $\pm$ 0.95	2.4 $\pm$ 0.87
Right adrenal gland	1.4	1.9 $\pm$ 0.89	2.2 $\pm$ 0.72
Thymus	1.7	25.1 $\pm$ 10.2	30.9 $\pm$ 10.9

\* Jpn J Legal Med 1992;46(3):225–35.

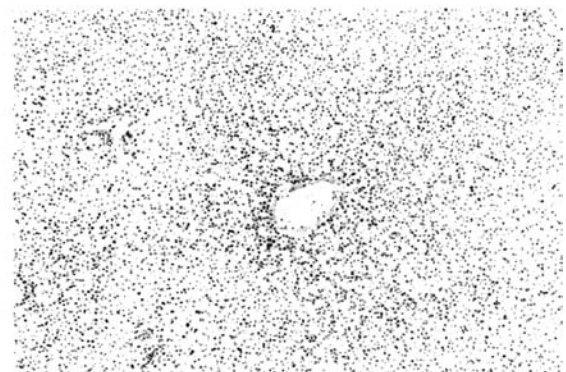
The parents confessed that they kept the victim in a small room for about 50 days, and then in a packing case. The amount of food served to her was decreased with time (Fig. 4). When she was 3 years and 20 days old, she was found dead in the packing case. Her body weight was 5 kg at death, having decreased by 7 kg (58.3% of her previous body weight) in 70 days.

#### Calculation of Caloric Deficit

The recommended dietary allowance for Japanese, 6th version (Public Health Council, Ministry of Health and Welfare, Japan.),



x10



x25

FIG. 2—PAS staining of the victim's liver.

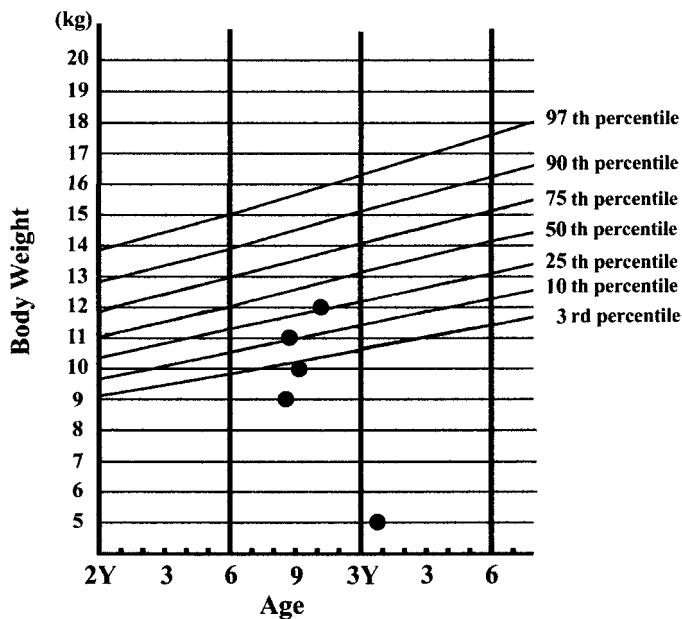


FIG. 3—Changes in the victim's body weight (solid circles), on a standard growth curve for Japanese girls.

indicates that the requirement for basal metabolism in a 2-year-old Japanese girl is 700 kcal/day (5). Activity factors are given as 1.3 for low physical activity (I), 1.5 for moderate (II), 1.7 for light-heavy (III) and 1.9 for heavy (IV). Therefore, the daily recommended dietary allowance for a 2-year-old Japanese girl is 700 kcal/day × the appropriate factor for physical activity plus 16 kcal/day, which is the number of calories needed for weight gain. Because this child had been neglected, and had not been fed enough food as described below, we omitted the calorie allowance for weight gain. The daily caloric requirement of the victim was therefore calculated as 700 kcal/day, times the factor for physical activity.

According to statements from the parents, we calculated the daily caloric intake and estimated the activity factor (Fig. 4). The victim stayed in her house for first 2 weeks without playing outside. The parents then locked her in a small room for next about 2 weeks. From this information, the factors for physical activity were estimated to be 1.5 and 1.3, respectively. After that, she lay in a package

box until death. We assumed the daily caloric requirement should be 700 kcal/day (basal metabolism), and, her factor in this period was decided to be 1.0. The daily caloric deficit was calculated from the difference between the calculated daily caloric intake and the estimated daily caloric requirement, based on the estimated activity factor for the victim. The range of percentage body fat at the age of 1 year is 28%–30%, and that at ages 4–6 years is 22% (6). We assumed the range at ages 2–3 years to be 24%–26%. As the victim was a thin girl, her percentage body fat was assumed to be 20%, leading to calculated fat content of 2.4 kg (12 kg × 0.2). The internal autopsy findings revealed that the victim had no subcutaneous or omental fat. Therefore, assuming that 2.4 kg of the weight deficit was attributable to loss of fat and the rest to loss of protein, we calculated the caloric deficit. Fat reserves of 2.4 kg would be sufficient to compensate for a caloric deficit of 2400 g × 7.2 kcal/g body fat (7). We assumed that, after the fat reserves were exhausted, protein would be used to compensate for the caloric deficit (4 kcal/g protein) until death. On the basis of these assumptions, the calculated body weight at the time of death was 4.988 kg (Fig. 5). When we assumed the percentage body fat to be 25%, the calculated body weight was 5.468 kg.

**Discussion**

There was no evidence that her filthy diaper had been changed. The autopsy findings of the victim revealed that muscle and organ proteins had been consumed and the stores of glycogen in the liver had been burned up. These findings suggest that the malnutrition was due to marasmus (the lack of both calories and protein), not kwashiorkor (dietary protein deficiency with a still substantial intake of energy) (8). The victim had gained 2 kg in 6 days at the age of 2 years and 6 months (Fig. 3). These facts indicate that she did not suffer from intestinal absorption disorders and was maltreated by her parents.

The presence of decubitus ulcers on the victim's left side, and contracture of both knee joints, and edema of both feet indicates that the victim had been lying on her left side for a long time. Conversely, recent subcutaneous hemorrhages on the right side of her face indicated that her parents had hit her on the head and face several days before her death. Scars on the forehead suggested that the victim had suffered recurrent physical abuse.

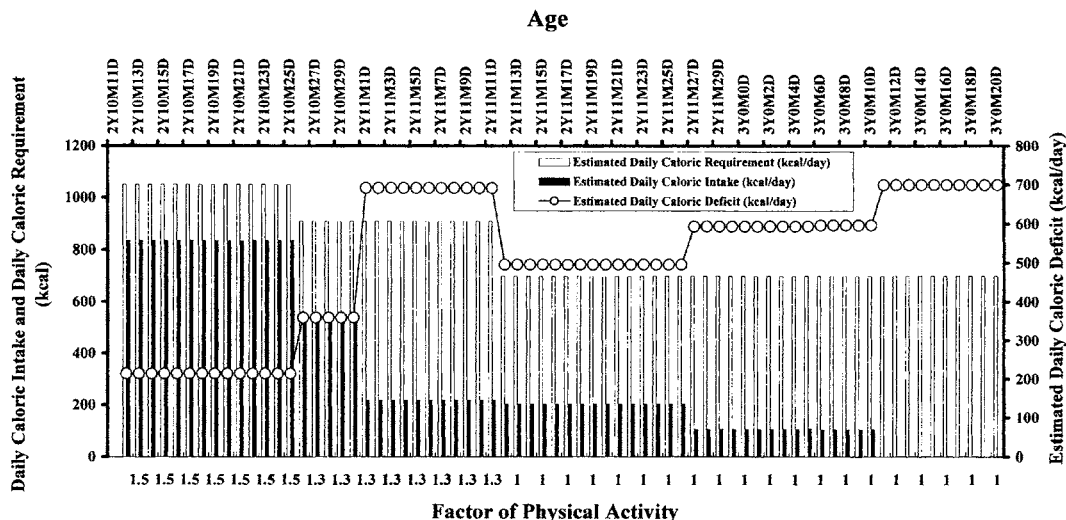


FIG. 4—Changes in the estimated daily caloric requirement, intake, and deficit of the victim.

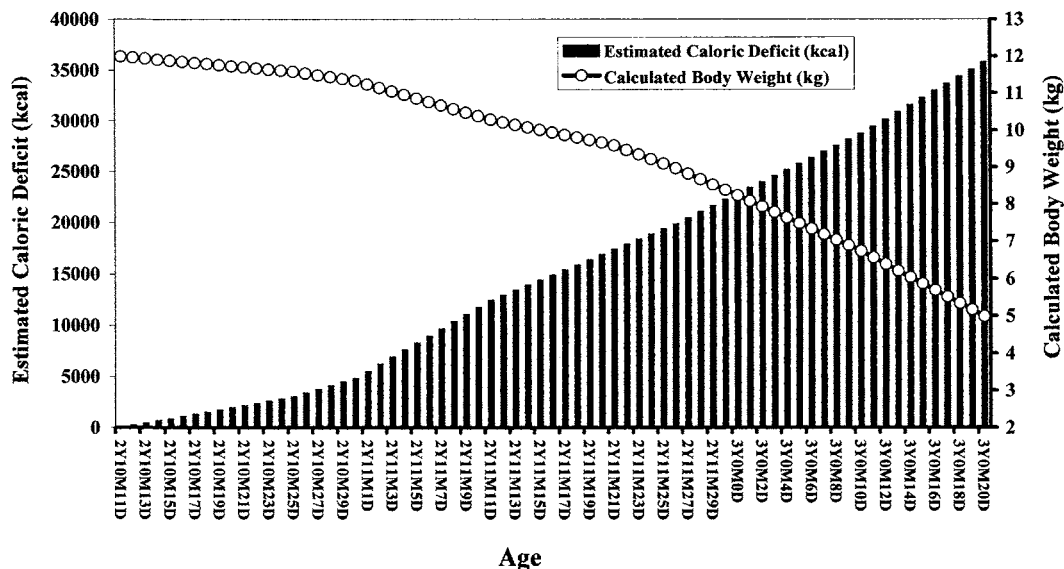


FIG. 5—Changes in the calculated body weight of the victim and the estimated caloric deficit.

Abused or neglected children suffer serious stress. Stressors trigger physiological responses, including activation of the hypothalamic-pituitary-adrenal axis, which releases glucocorticoids. An increase in endogenous glucocorticoid levels induces apoptosis of the thymocytes in the cortex of the thymus, resulting in thymic involution (9,10). Thymic involution is an important factor in determining child abuse, and has been reported to be an important parameter for estimating the degree and duration of child abuse (11). The thymus from the victim was severely affected, showing that she had been suffering serious stress and severe malnutrition for a long time.

To verify that the parents had maltreated the victim, we developed the theoretical calculation model of the caloric deficit based on the parents' statements. Although the victim had no access to water, the parents gave her 100 to 150 mL milk once every few days. The degree of dehydration was unclear. A previous study (3) classified dehydration as mild (5%), moderate (10%) and severe (15%). Thus, the hydrated death weights were supposed to be 5.263 kg ( $5 \text{ kg} \div 0.95$ ) to 5.882 kg ( $5 \text{ kg} \div 0.85$ ). The model assumed a body fat content of 20% and 25%. It also assumed that protein would be used for energy only after the fat reserves had been exhausted. In reality, both fat and protein are broken down at the same time. However, in this case, almost all the body fat was spent on compensating for the caloric deficit. The calculated body weight of 4.988–5.468 kg at death was close to the hydrated actual weight. Therefore, this theoretical model verified the parents' statements.

Madea and Brissie reported the starvation of a 6-week-old baby and calculated the number of days of total food and liquid deprivation (3). The daily physical activity for a 6-week-old is stable and the daily caloric requirement can be calculated reliably. However, the daily physical activity for young children varies. Estimating the caloric deficit in starved young children should be more difficult than estimating that in the starved infants. Our calculation method is more applicable to cases of nutritional neglect than that described in the previous report (3). To verify the reliability of the

statements of perpetrators, it might be useful to calculate the caloric deficit on the basis of their statements, as described here.

## References

1. Kempe H, Silverman FN, Steele BF, Droegemueller W, Silver HK. The battered child syndrome. *JAMA* 1962;181:17–24. [\[PubMed\]](#)
2. Davis JH, Valerie JR, Valdes-Dapena M. A forensic science approach to a starved child. *J Forensic Sci* 1984;29:663–9. [\[PubMed\]](#)
3. Meade JL, Brissie M. Infanticide by starvation: calculation of caloric deficit to determine degree of deprivation. *J Forensic Sci* 1985;30:1263–68. [\[PubMed\]](#)
4. Sarvesvaran ER. Homicide by starvation. *Am J Forensic Med Pathol* 1992;13:264–67. [\[PubMed\]](#)
5. Society of informatics for health and nutrition. Recommended dietary allowance. Dietary reference intakes. [in Japanese] Tokyo: Dai-Ichi Shuppan Publishing Co. Ltd., 1999.
6. Nakamura H, editor. Growth disorders and nutrition of children. [in Japanese] Osaka: Nagai Shoten Co., Ltd., 1998.
7. Iwamatsu S, Haccho Y, editors. Nutrition education. 3rd ed. Rev. [in Japanese] Tokyo: Ishiyaku Publishers, Inc., 1995.
8. Graham GG. Starvation in the modern world. *N Engl J Med* 1993; 328:1058–61. [\[PubMed\]](#)
9. Gruber J, Sgonc R, Hu YH, Beug H, Wick G. Thymocyte apoptosis inducing by elevated endogeneous corticosterone levels. *Eur J Immunol* 1994;24:1115–21. [\[PubMed\]](#)
10. Tarcic N, Ovardia H, Weiss DW, Weidenfeld J. Restraint stress-induced thymic involution and cell apoptosis are dependent on endogeneous glucocorticoids. *J Neuroimmunol* 1998;82:40–6. [\[PubMed\]](#)
11. Fukunaga T, Mizoi Y, Yamashita A, Yamada M, Yamamoto Y, Tatsuno Y, et al. Thymus of abused/neglected children. *Forensic Sci Int* 1992;53:69–79. [\[PubMed\]](#)

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