Relationship between thyroid hormone levels and age in post-mortem cases

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Abstract: Simple and low-cost age estimation methods that produce objective numerical values are required to aid the identification of cadavers. Clinical studies have revealed that thyroid hormone levels decrease in elderly people. However, no previous studies have examined the relationship between thyroid hormone levels and age in corpses in detail. In this study, we evaluated the correlations between the triiodothyronine (T3) or thyroxine (T4) levels of post-mortem blood samples and age and assessed whether these parameters can be used for estimating the ages of corpses.

The subjects’ T3 and T4 levels decreased with age, and negative correlations were detected between age and the T3/T4 level. A correlation was also observed between thyroid weight and age.

It was not possible to estimate age based on thyroid hormone levels alone. However, it might be possible to estimate the ages of unidentified cadavers more accurately by using thyroid level data together with other age estimation methods.

Key Words: Triiodothyronine, T3, thyroxin, T4, thyroid gland, aging, post-mortem blood.

INTRODUCTION

Personal identification is one of the main purposes of forensic medicine. Although personal identification generally tends to be considered important after large-scale disasters or terrorism [1, 2], it is actually a very important daily matter. For example, we sometimes have trouble identifying dead bodies that are found outdoors.

When a body whose identity cannot be ascertained based on its fingerprints or the associated belongings, age and sex estimates become significant clues for identification. While gender is easy to judge from external inspections, age estimation is very difficult. As methods for estimating chronological age, dental attrition-based findings, such as the degree of tooth wear or eruption [3]; macroscopic findings or imaging findings of bone anthropological features [4-6] are often used. However, there are not so many skilled doctors who can estimate age from those features.

In recent years, age estimation methods involving DNA methylation [7], radioactive isotopes [8], or the racemization of aspartic acid [9] have been reported as techniques that produce highly accurate estimates of age based on objective numerical values. However, they require special knowledge, skill, and expensive machinery and reagents.

Due to the low autopsy rate, in Japan causes of death are often determined based solely on external examinations and drug tests of the corpse [10]. Thus, simple and low-cost age estimation methods that produce objective numerical values are required.

In this study, we focused on thyroid hormone levels. Thyroid hormone levels have been shown to decrease in elderly people in clinical studies [11, 12]. This finding is referred to as subclinical hypothyroidism and is clinically recognized [13]. On the other hand, thyroid hormone-related thyroglobulin levels are often measured in forensic medicine as a marker of cervical compression [14-16]. The levels of thyroid hormones; i.e.,

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triiodothyronine (T3) and thyroxin (T4), are frequently measured together and used to differentiate between thyroid diseases. Therefore, if T3/T4 levels could be used to estimate the ages of corpses, it would be possible to estimate age and diagnose cervical compression based on a single blood sample. However, there have not been any reports about detailed examinations of the relationship between thyroid hormone levels and age in corpses. Therefore, we examined the correlations between age and post-mortem T3 or T4 levels, and investigated whether these parameters can be used to estimate the ages of corpses.

**MATERIALS AND METHODS**

Among the patients sent for medico-legal autopsies at Kyoto Prefectural University of Medicine, the whole blood samples of 210 patients who underwent post-mortem examinations within 2 days of death (age: 21 to 98 years old; 141 males, 69 females) were used. Patients that had undergone thyroidectomy were excluded. Right cardiac blood samples that were collected at autopsy were centrifuged, and the obtained serum samples were sent for analysis at an external examination institution (LSI Medience Corporation). The levels of T3 and T4 were measured using chemiluminescent immunoassays.

We performed single regression analyses to examine the relationships between age and the T3 or T4 level, and quadratic polynomial regression analysis was conducted to evaluate the relationship between age and thyroid weight. We then examined whether the T3/T4 level or thyroid weight is a useful variable for predicting age at a probability level of 5%. Microsoft Excel was used for the statistical analyses.

This research was conducted with the permission of the institutional review board of Kyoto Prefectural University Medical University (G-67).

**RESULTS**

The mean T3 level was 200.2 ± 158.7 ng/dL (clinical reference value: 58 to 159 ng/dL), and the mean T4 level was 6.5 ± 2.6 μg/dL (clinical reference value: 4.87 to 11.72 μg/dL). The mean weight of the thyroid gland was 16.1 ± 8.2 g. The subjects’ T3 and T4 levels were both significantly higher than the relevant clinical reference values.

In males, the mean T3 level was 195.7 ± 150.0 ng/dL, the mean T4 level was 6.4 ± 2.7 μg/dL, and the mean weight of the thyroid gland was 16.1 ± 7.5 g. In females, the mean T3 level was 209.7 ± 176.5 ng/dL, the mean T4 level was 6.7 ± 2.4 μg/dL, and the mean weight of the thyroid gland was 16.6 ± 9.7 g.

Single regression analyses were performed to examine the relationships between age and the T3 or T4 level. The subjects’ T3 and T4 levels decreased with age, and negative correlations were found between age and the T3/T4 level (P<0.05) (Fig. 1). The levels of both thyroid hormones exhibited slightly greater reductions in females than in males (Figs 2 and 3). The T3 level displayed a stronger correlation with age than T4. The regression coefficients for the T3 and T4 levels indicated that these parameters could be used to estimate age.

Quadratic polynomial regression analysis of the relationship between age and thyroid weight showed a correlation between them (P<0.05) (Fig. 4). The correlation between these variables was stronger in males than in females. The regression coefficient for thyroid weight suggested that it could be used to estimate age.

**DISCUSSION**

It has been reported that the appearance of autoantibodies is one of the causes of the reductions in thyroid hormone levels seen in the elderly. Progressive fibrosis, reductions in thyroid gland weight, and decreasing follicle size, etc., are 5 to 8 times more common in females than in males [11, 12]. Although a correlation between thyroid gland weight and age was observed in

![Figure 1](image1.png)

*Figure 1. Relationships between the serum T3 or T4 level and chronological age in all cases.*

The relationship between the serum T3 level and age is shown in a) and that between the serum T4 level and age is shown in b). The levels of T3 and T4 gradually decreased with age. P<0.05.
this study, the correlation was weaker in females than in males (Fig. 4). This might have been because the lifetime risk of Grave’s disease, one of the main causes of hyperthyroidism, is much higher in females (3%) than males (0.5%) [17].

Many of the T3/T4 level values obtained in this study greatly exceeded the relevant clinical reference values. It was reported that the thyroglobulin levels in post-mortem blood samples are higher than clinical values, and are particularly high in blood from the right side of the heart. It has been suggested that the thyroglobulin in thyroid follicles flows into the blood after death, although the detailed mechanism underlying this process remains unknown [18]. The thyroid hormones T3 and T4 are produced via the iodination of the tyrosine residues in thyroglobulin, which results in the production and subsequent condensation of monoiodotyrosine and diiodotyrosine. The generated T3 and T4 molecules are stored in thyroid follicles in thyroglobulin-bound forms. T3 and T4 are reabsorbed into the follicular epithelium by endocytosis, hydrolyzed by proteases, and secreted into the blood. In this study, since the post-mortem time was relatively short, no correlation between the post-mortem time and T3 or T4 levels was observed. As has been found for thyroglobulin, the damage caused to the epithelial cells of thyroid follicles by the hypoxic state experienced in the agonal period and post-mortem autolysis might induce the diffusion of stored T3 and T4 into the blood.

Figure 2. Relationships between the serum T3 or T4 level and chronological age in females. The relationship between the serum T3 level and age is shown in a), and that between the serum T4 level and age is shown in b). The levels of T3 and T4 gradually decreased with age. P<0.05.

Figure 3. Relationships between the serum T3 or T4 level and chronological age in males. The relationship between the serum T3 level and age is shown in a), and that between the serum T4 level and age is shown in b). The levels of T3 and T4 gradually decreased with age. P<0.05.

Figure 4. Relationship between the weight of the thyroid gland and chronological age. The data for all cases a), males b), and females c) are shown. The weight of the thyroid gland initially increased and then decreased with age (p<0.05).
T3 exhibited a stronger correlation with age than T4. This is because T4 degradation by outer ring deiodination decreases with age [11].

The aging-induced reductions in T3 and T4 levels were not very large although correlations between age and T3/T4 levels were detected, but they were not strong enough to allow age to be estimated based on T3/4 levels alone. However, it was considered that more accurate estimation of the ages of unidentified cadavers could be possible by using thyroid hormone-based methods together with other age estimation methods.

**Conflict of interest.** This article is the authors’ original work, has not been published previously, and is not under consideration for publication elsewhere.

There are no financial/personal interests or beliefs that could affect our objectivity.

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