Legal Medicine 17 (2015) 65–69

Contents lists available at ScienceDirect

Legal Medicine

journal homepage: www.elsevier.com/locate/legalmed

Brief Communication

Appropriate blood sampling sites for measuring Tg concentrations for forensic diagnosis

Akira Hayakawa, Kotaro Matoba *, Kie Horioka, Manabu Murakami, Koichi Terazawa

Department of Forensic Medicine, Hokkaido University Graduate School of Medicine, Sapporo, Japan

ARTICLE INFO

Article history:
Received 26 June 2014
Received in revised form 18 August 2014
Accepted 12 September 2014
Available online 28 September 2014

Keywords:
Thyroglobulin
Forensic biochemistry
Postmortem change
Forensic diagnosis
Postmortem diffusion

ABSTRACT

Previous studies have reported that thyroglobulin (Tg) concentrations in heart blood are high in cases of asphyxia caused by neck compression such as hanging, strangulation, and throttling and in those with fatal traumatic brain injuries. However, even in cases without these findings presumed to increase the Tg concentration in the previous studies, we previously reported that in some cases the Tg concentration in right heart blood (RHB) and left heart blood (LHB) exceeded the standard value for diagnosis (200 ng/mL) defined in previous studies and the Tg concentration in RHB was significantly higher than that in LHB. In the present study, in our 46 forensic autopsy cases without findings presumed to increase Tg concentration, we separately collected external iliac venous blood (IVB) and external iliac arterial blood (IAB) in addition to RHB and LHB, measured Tg concentrations in RHB, LHB, IVB, and LAB (TRHB, TLHB, TIVB, and TIAB, respectively), and investigated the appropriate blood sampling site for measuring Tg concentrations for forensic diagnosis. TRHB, TLHB, TIVB, and TIAB were 386.3 ± 674.1, 105.8 ± 179.0, 109.2 ± 166.8, and 43.7 ± 90.9 ng/mL, respectively. There were statistically significant differences between TRHB and TLHB, TIVB and TIAB, TRHB and TIVB, and TLHB and TIAB. Tg is more readily diffused by the venous system (RHB, IVB) than by the arterial system (LHB, IAB) because the venous system retains more blood volume after death. Tg is more readily diffused to heart blood (RHB, LHB) than to peripheral blood (IVB, IAB) because of the proximity of the heart to the thyroid gland. Therefore, we conclude that Tg leaks into the vessels around the thyroid gland because of the influences of postmortem changes and subsequently diffuses through the blood after death, and therefore the Tg concentration increases after death. When Tg concentration values are used for forensic diagnosis, it is appropriate to measure them using peripheral arterial blood situated distant from the thyroid gland.

1. Introduction

Thyroglobulin (Tg) is the precursor for thyroid hormone, which is secreted into the bloodstream, and it is produced only in the thyroid follicular cells, and most Tg is stored in the thyroid follicular lumen [1]. Tg concentrations are known to be high in cases with hyperthyroidism or differentiated thyroid cancer, whereas Tg is rarely secreted into the circulation in healthy individuals [1].

Previous studies have reported that Tg concentrations in heart blood are high in cases of asphyxia caused by neck compression such as hanging, strangulation, and throttling, because a large quantity of Tg can leak from the thyroid gland by the damage of neck compression and enter the circulation [2–5]. Tamaki et al. collected right heart blood (RHB) and left heart blood (LHB) separately and measured Tg concentrations in each blood sample [3]. They found that the Tg concentration in RHB was significantly higher than that in LHB in cases both with and without neck compression [3]. They proposed that a difference in the Tg concentrations in RHB and LHB was likely to arise in cases with neck compression because the cardiovascular system is arrested before the Tg concentration was equalized throughout the body at the agonal stage [3]. However, to our knowledge, they did not explain why the Tg concentration in RHB is higher than that in LHB even in cases without neck compression.

Tg concentrations in heart blood are also reported to be high in cases with fatal traumatic brain injuries because these injuries are presumed to generate acute and excessive Tg release at the agonal stage [6].

In previous studies [2–6], in cases without findings presumed to increase Tg concentration (control group), Tg concentrations

* Corresponding author at: Department of Forensic Medicine, Hokkaido University, Graduate School of Medicine, N15 W7, Kita-ku, Sapporo, Hokkaido 060-8638, Japan. Tel.: +81 11 706 5063; fax: +81 11 706 7860.
E-mail address: k-matoba@med.hokudai.ac.jp (K. Matoba).

http://dx.doi.org/10.1016/j.legalmed.2014.09.003
1344-6223/

in heart blood were below the standard value for diagnosis (200 ng/mL). In these studies, forensic autopsies were performed within 24 h of death [2–5] or approximately 1–2 days after death [6].

In our previous study [7], we collected RHB and LHB separately in cases without the findings presumed to increase the Tg concentration in the previous studies [2–6], and measured the Tg concentration in each blood sample. We observed that in many cases the Tg concentrations in RHB and LHB exceeded the previously defined standard value (200 ng/mL) [7]. We have also reported that the Tg concentration in RHB was significantly higher than that in LHB and that there were large differences in the Tg concentrations in RHB and LHB [7].

In our cases without the findings presumed to increase the Tg concentration in the previous studies [2–6], we separately collected external iliac venous blood (IVB) and external iliac arterial blood (IAB), in addition to RHB and LHB and measured the Tg concentrations in RHB, LHB, IVB, and IAB (TRHB, TLHB, TIVB, and TIAB, respectively). We then investigated the appropriate blood sampling site for measuring Tg concentrations for forensic diagnosis.

2. Materials and methods

Of the 326 forensic autopsies conducted in our institution between July 2012 and July 2014, we analyzed 46 cases for which the postmortem intervals were within 48 h, excluding cases in which an external force was applied to the neck such as in cases of hanging, throttling, or strangulation; cases that involved fatal traumatic brain injuries; cases with thyroid lesions or thyroid disease; cases in which a sufficient volume of blood could not be collected to measure the Tg concentrations in each sample (TRHB, TLHB, TIVB, and TIAB); cases of burned bodies for which it was difficult to obtain detailed autopsy findings of the head and neck area because of burn injuries; cases in which the patient died after prolonged treatment in the hospital; and cases of infants that were not included in the previous studies [2–7]. Of the 46 cases, there were 24 with cardiopulmonary resuscitation and 22 without cardiopulmonary resuscitation.

The mean and standard deviation of the ages of the cases were 62.9 ± 15.7 (23–89) years. The study group comprised 30 males and 16 females.

At forensic autopsies, we collected RHB, LHB, IVB, and IAB separately by syringe needle and measured the Tg concentrations in each sample. In addition to the samples collected at the forensic autopsy, we were able to collect RHB from the body surface by puncture with a spinal needle at external medical examinations before forensic autopsy in 5 of the 46 cases (cases 10, 15, 21, 24, and 45). After confirming that the punctures were in the right ventricle at the forensic autopsies, we also measured TRHB at external medical examinations.

The Tg concentration measurements were performed by electrochemical luminescence immunoassay (ECLIA) at SRL Inc. (Sapporo, Japan).

JMP®10 (SAS Institute, USA) was used for all statistical analyses. Differences in the Tg concentrations in each sample were evaluated using the Wilcoxon signed-rank test. The correlation between the postmortem interval and Tg concentration was investigated by simple regression. P values < 0.05 were considered to represent statistical significance.

Sample collection and analysis were practiced as a routine part of our forensic work, following the autopsy guidelines (2009) and ethical guidelines (1997 and 2003) of the Japanese Society of Legal Medicine, and approved by our institutional ethics committee.

3. Results

Table 1 shows the Tg concentrations in each sample (TRHB, TLHB, TIVB, and TIAB), postmortem intervals, and causes of death in the 46 cases. The differences between the maximum and minimum values of TRHB, TLHB, TIVB, and TIAB in each case (Max−Min) are also shown in Table 1. Table 2 shows the mean and standard deviation of the Tg concentrations in each sample. The differences between TRHB and TLHB, TIVB and TIAB, TRHB and TIVB, and TLHB and TIAB were statistically significant. This result indicates that the Tg concentration in venous blood was significantly higher than that in arterial blood in both the heart and peripheral blood (TRHB > TLHB, TIVB > TIAB), and that the Tg concentration in heart blood was significantly higher than that in peripheral blood in both venous and arterial blood (TRHB > TIVB, TLHB > TIAB). No correlation was observed between the postmortem interval and Tg concentrations in each sample.

Among 11 cases of drowning (cases 8, 15, 20, 21, 22, 29, 30, 31, 42, 44, and 45), 5 of hypothermia (cases 14, 27, 34, 36, and 37), 13 of ischemic heart disease (cases 1, 2, 4, 9, 13, 18, 24, 28, 33, 35, 39, 40, and 46), and 7 of poisoning (cases 7, 10, 12, 16, 26, 38, and 41), there were no statistically significant differences in TRHB, TLHB, TIVB, and TIAB among the groups.

There were 18 cases (cases 1, 3, 5, 9, 10, 16, 19, 22, 23, 25, 26, 30, 32, 39, 41, 43, 45, and 46) in which TRHB exceeded the previously defined standard value (200 ng/mL), 7 cases (cases 1, 5, 22, 26, 32, 43, and 45) in which TLHB exceeded the standard value, 9 cases (cases 1, 5, 16, 22, 25, 30, 43, 45, and 46) in which TIVB exceeded the standard value, and 1 case (case 43) in which TIAB exceeded the standard value.

Table 3 shows TRHB and the postmortem intervals at the external medical examination and the forensic autopsy in 5 cases (cases 10, 15, 21, 24, and 45) in which RHB was collected both at the external medical examinations and at the forensic autopsies. In all 5 cases, Tg concentration at the forensic autopsies was higher than that at the external medical examinations.

Regardless of cardiopulmonary resuscitation, the differences between TRHB and TLHB, TIVB and TIAB, TRHB and TIVB, and TLHB and TIAB were statistically significant. There were no significant differences in TRHB, TLHB, TIVB, and TIAB between the groups.

4. Discussion

Our results show that the Tg concentrations are higher than the previously defined standard value (200 ng/mL) in some cases, although we examined only cases without findings presumed to increase Tg concentration in the previous studies [2–6]. This phenomenon suggests that a leakage of Tg into the circulation occurs at the agonal stage or after death. In addition, the presence or absence of cardiopulmonary resuscitation is unlikely to be involved in the increase in the postmortem Tg concentrations, because there were no statistically significant differences in TRHB, TLHB, TIVB, and TIAB between case with and without cardiopulmonary resuscitation.

If the leakage of Tg into the circulation occurs at the agonal stage, Tg in the thyroid follicular lumen leaks into the vessels around the thyroid gland and circulates first through the right ventricle, then to the left ventricle through the lungs, and thereafter to the peripheral arteries, systemic tissues and organs, and peripheral veins. The equilibrium of the Tg concentration in the whole body does not appear to be readily completed, because the efficiency of circulation is markedly decreased at the agonal stage. Based on this hypothesis, the Tg concentration in peripheral arterial blood is predicted to be higher than that in peripheral venous blood. If this rule is applied to this study, the predicted order would