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Morphological Characteristics of Thymus in the Newborns in Different Climatic and Geographical Conditions of Kyrgyzstan

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Abstract

This paper is describing a detailed study of morphological structures and characteristics newborns thymus in different climatic and geographical conditions of Kara-Balta, Cholpon-Ata, and Bishkek in Kyrgyzstan. Anatomical structure research done on 26 thymuses of newborn corpses. Research results showed that a significant amount of thymuses consisted of lobes with very thin connective tissues between them. It is observed that the Hassall cells were usually located in the medulla part of the thymus after using the coloring by Van-Gieson's stain visible clear elastic and collagen fibers. In addition, cell population dynamics in a unit of conditional area of cortical substance thymus lobes in newborns determined.

Keywords

Thymus, Newborns, Hassall Cells, Climatic Conditions, Histological Methods

1. Introduction

The thymus gland [1] [2] [3] belongs to the central organs of the immune system responsible for the formation and maintenance of the body's biological defenses. The thymus is an important organ regulating the immune system with immunologic function closely dependent on the presence of normal thymic structures

[4]. Histologically, the thymus can be divided into two subcompartments such as the: cortex and the medulla each of which contains distinct populations of thymic epithelial cells (TECs), as well as mesenchymal cells, endothelial cells, and dendritic cells [5]. The thymus reaches its maximum weight during the puberty period and subsequently undergoes involution [6]. Thymus functions are important in providing a suitable microenvironment for the proliferation, differentiation, TCR gene rearrangement, and selection of T cells as shown in the **Figure 1** [7] [8] [9] [10] [11].

Experts in the field of immunomorphology [12] define the immune system as a set of organs, tissues, and cells, whose work aimed directly at protecting the body from various diseases and at destroying foreign substances that have already entered the body. The immune system is an obstacle to infections (bacterial, viral, fungal). When the immune system malfunctions, the likelihood of infection increases, it also leads to the development of autoimmune diseases by activation of autoimmunity [13] as represented in the **Figure 2**, knowledge of the age characteristics of structure and functions of the immune system organs, in particular, the thymus gland is relevant for determining periods of immunogenesis at critical moments during the postnatal period. The neonatal period characterized by the impairment of the major components of both innate and adaptive immunity; however, there is a lack of information about the neonatal condition of the thymus gland, a key organ for efficient immune system maturation [14]. These data are in demand in clinical medicine for the proper organiz1ation of

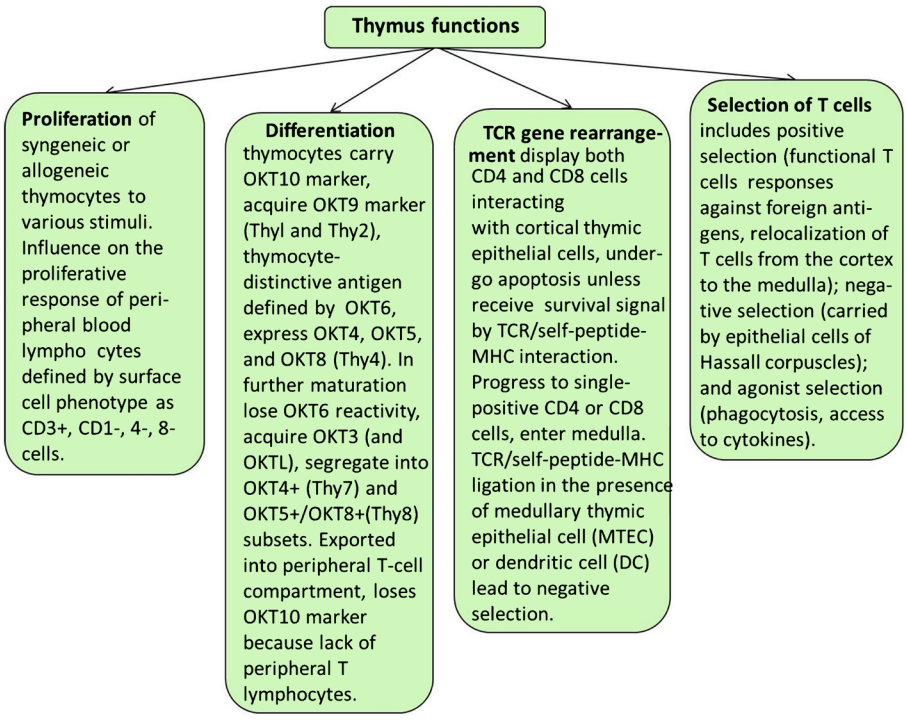

Figure 1. Example of the thymus and its functions as an important organ providing microenvironment for thymocytes proliferation, differentiation, TCR gene rearrangement, and various selections (adapted from ref. [7] [8] [9] [10] [11]).

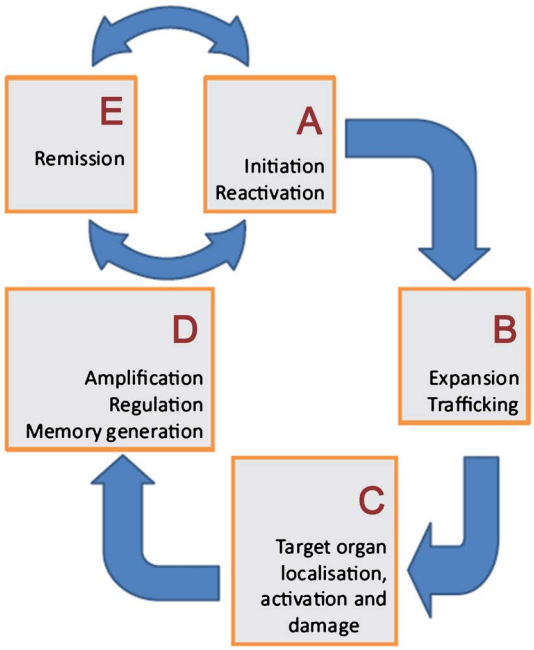

Figure 2. Overview of autoimmunity. An autoimmune episode starts (A) with the initiation or reactivation of an immune attack directed against self. The T-cells expand and traffic (B) to the site where the antigen is found, are activated and damage the tissue (C). With time, the response is regulated and subsides, although the immune memory remains (D). Future infection may then trigger a relapse of the remission (E) (reproduced from [13]).

preventive and therapeutic measures [15]. It was reported that the number and size of Hassall's corpuscles of different maturity invertebrate animals and humans depend on age and the environmental conditions [16].

The Hassall's corpuscles (HC) usually have dimensions ranging from 20 to 150 microns in bovines, from 10 to 1000 microns in other species, and located in the medulla of the mammalian thymus [17]. Small Hassall's corpuscles consisted of type-6 epithelial cells, while in larger corpuscles many nuclei of type-6 cells ("large-medullary" cells) [18].

2. Research Methods

The following research methods used in the course of this study: 1) *Anatomical methods* used including preparation on cadaver, sample isolation, mass weighing and size measurement; 2) *Histological methods* applied such as cleaning in the ethanol and xylol coloring by hemotoxylin-eosin, according to Van-Gieson's stain, and observations under microscope. *Materials and objects:* The anatomy of the thymus gland was studied on 26 corpses of newborns who were died in the neonatal period from causes not associated with immune-deficient conditions. Microscope (MBS), camera (Canon), and computer software program. *Methods:* Student's t-test used based on the mean of the comparison values. Peculiarities of using the Student's t-test include multiple comparisons such as: pairwise differences of more than two samples, multiple pairwise comparisons, the probability of error

differences [19].

3. Results and Discussions

The thymus gland is a small organ of pinkish-gray color and with a soft consistency. The thymus develops from a paired epithelial anlage in the neck [20]. Although the thymus has enormous regenerative capacity during fetal development, the regenerative capacity of the human postnatal thymus decreases over time [21]. Morphometric proportions of the thymus individual lobes analyzed as represented in **Table 1**, where the left thymus lobe is longer and thicker compared to the right lobe [22].

Thymus index as represented in **Figure 3** obtained by measuring the width of the thymus in a transverse image while the area of the largest lobe assessed in a longitudinal image [23]. In newborns we have observed, the longitudinal dimensions of the thymus were ranged from 4.7 to 7.6 cm (average is 6 cm), the left lobe, from 5 to 5.7 cm (average is 5 cm). The transverse dimensions of the right lobe vary from 1.8 to 2.4 cm (average is 2 cm), the left one from 1.5 to 3.3 cm (average is 2 cm). The thickness of the right lobe varies from 0.7 to 1.3 cm (average is 1 cm). The upper border of the thymus gland is located on the cuttings of

Table 1. Morphometry of thymus in a group of 212 full-term newborns [22].

n = 212		Right lobe of thymus	Left lobe of thymus
Length of the lobe (mm)	Mean	34.64	36.19
P = 0.117	SD	4.51	4.20
Width of the lobe (mm)	Mean	13.79	12.76
P = 0.035	SD	2.68	2.53
The thickness of lobe (mm)	Mean	13.57	14.01
P = 0.004	SD	1.78	1.77
The volume of the lobe (cm^3)	Mean	6.66	6.65
P = 0.194	SD	2.34	2.20
The volume of two lobes together (cm^3)	Mean	13.22	-

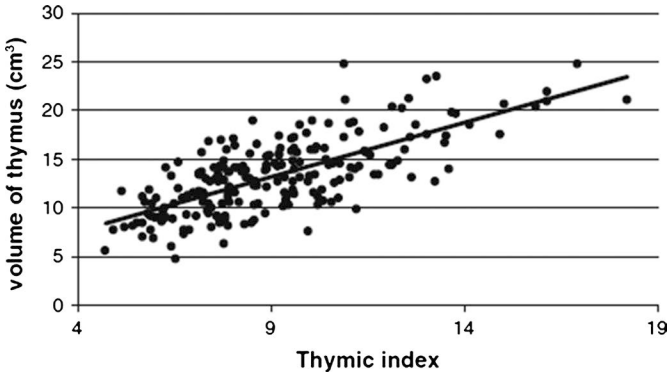

Figure 3. Example ofScatter plot of the volume of thymus against the value of Thymus index (Spearmans' r = 0.675; P/0.001) [23].

the sternum handle or 1.5 to 2.5 cm above it. The border of the right lobe is usually somewhat higher than the left.

The lower border of the gland extends beyond the body and the handle of the sternum to the right from 0.6 to 2.0 cm (average is 1 cm), to the left from 1 to 1.25 cm (average is 1 cm).

The thymus gland has a delicate thin connective tissue capsule, consisting predominantly of elastic fibers, among the fibers, are revealed collagen fibers (when stained according to Van-Gieson's stain) as shown in the Figure 4(A). The cortical layer contains a large number of lymphocytes located compactly. On the periphery of the cortical layer, lymphoblasts are found under the capsule (20%). Lymphoblasts are also found in the medulla (30%), but significantly less than in the cortical (50%). Hassall corpuscles found in the medulla (65%), Hassall's large corpuscles found in the center of the lobules (10%) as shown in Figure 4(B). The interlobular interlayers contain the plexus of the lymphatic vessels. The vascular wall in 2% of cases, was thickened and sclerosed as it can be seen in Figure 4 and Figure 5.

The dynamics of cell populations in the unit of the conditional area of the cortical substance of the thymus lobules in newborns (Table 2) are shown. In Bishkek city, lymphoblasts are 26.6 ± 3.0, the city of Cholpon-Ata 24.7 ± 0.5, and

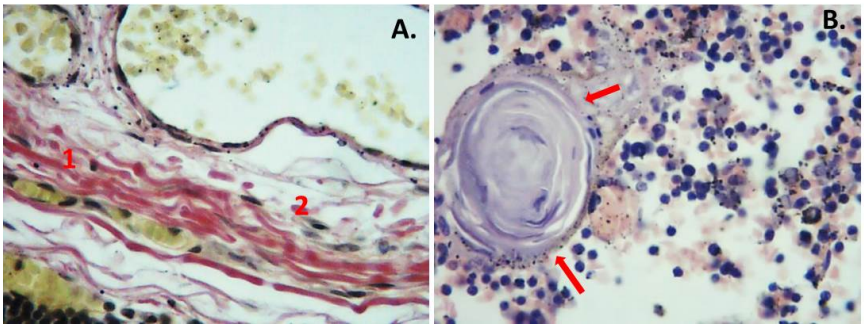

Figure 4. (A) Photomicrograph of collagen (1), and reticular fibers (2) in the cortical layer of the thymus of the 2 days old newborn (40 × 20). (B) Photomicrograph of the medulla (shown by arrows), surrounded by Hassall's corpuscles keratinized formations with mature epithelial cells (original magnification 40; H-E stain).

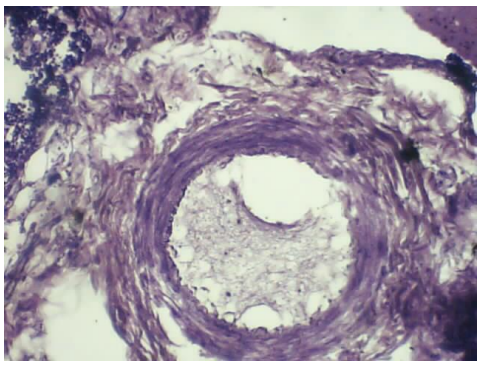

Figure 5. Atrophy, thickened vessel walls, and the collagen fibers around the vessel (objective 40, ocular 20).

Table 2. Cell population dynamics in a unit of conditional area of cortical substance thymus lobes in newborns.

Cell populations	Bishkek	Kara-Balta	Cholpon-Ata
		M ± m	
Lymphoblasts	26.4 ± 0.3	28.9 ± 0.5*	27.7 ± 0.7
Medium lymphocytes	44.2 ± 0.4	51.5 ± 0.6*	63.7 ± 0.7*
Small lymphocytes	285.2 ± 0.7	297.0 ± 1.5*	301.7 ± 2.3*
Apoptotic body	63.5 ± 0.4	69.5 ± 1.5*	61.1 ± 0.4*
Mitosis	18.1 ± 0.5	23.9 ± 0.5*	23.9 ± 0.5*
Macrophages	6.2 ± 0.3	7.7 ± 0.3*	6.6 ± 0.3
Hassall's bodies	4.5 ± 0.3	6.1 ± 0.3*	6.2 ± 0.3*
Total number of cells	451.52.6	471.8 ± 1.8*	489.1 ± 3.3*

Table 3. The stereometric characteristic of the thymus of the newborn (M ± m) in %.

Cortical substance	64.5 ± 0.4	72.7 ± 0.5*	78.6 ± 0.5*
Brain substance	28.0 ± 0.5	29.5 ± 0.7	26.6 ± 0.4*
VPP	4.5 ± 0.4	5.8 ± 0.3*	3.7 ± 0.2
Interlobular septa	-	2.9 ± 0.2	2.5 ± 0.1*

in the city of Kara-Balta, 28.9 ± 0.5. The small lymphocytes of Bishkek city are 285.2 ± 0.7, the city of Kara-Balta 297.0 ± 1, the city of Cholpon-Ata 301.7 ± 2.3.

The stereometric characteristics of the neonatal thymus (Table 3) show a cortical substance in Bishkek 64.5 ± 0.4, Kara-Balta 72.7 ± 0.5, Cholpon-Ata 78.6 ± 0.5. The brain substance in Bishkek was 28.0 ± 0.5, in Kara-Balta 29.5 ± 0.7, and Cholpon-Ata 26.6 ± 0.4.

The thymus body has a lobed structure, with different sizes of the lobules. Between the lobes tender connective tissue, consisting mainly of elastic fibers.

4. Conclusion

Stereometric characteristics of neonatal thymus in Bishkek show a cortical substance 64.5 ± 0.4, in Karabalta was 72.7 ± 0.5, and in Cholponata was 78.6 ± 0.5. The brain substance in Bishkek was 28.0 ± 0.5, in Karabalta 29.5 ± 0.7, and Cholponata 26.6 ± 0.4. Hassall's tissue found within normal limits. Lymphoblasts were located in places form significant clusters. The walls of individual vessels were infiltrated with lymphoblasts.

Ethical Statement

The authors declare that the research conducted in the absence of any commercial or financial relationships that construed as a potential conflict of interest.

Ethical Approval

All procedures performed in studies involving human participants were follow-

ing the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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