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MORPHOMETRIC CHARACTERISTICS OF THE ADRENAL GLANDS IN NEWBORNS WITH BIRTH-RELATED BRAIN INJURY

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Abstract. The aim of this study was to comparatively assess the time-dependent morphometric parameters of adrenal gland tissue in newborns who died within the first 24 hours of life (up to 8 hours, up to 16 hours, and up to 24 hours) as a result of birth-related brain injury. The study included adrenal tissue samples obtained during autopsy from preterm newborns who died with a diagnosis of birth-related brain injury. Histological specimens were prepared, and their digital images were obtained using a NanoZoomer histoscanner. Morphometric analysis was performed on digital images of tangential tissue sections. The area of a single field of view was standardized to 32,000 μm², 64,000 μm², and 128,000 μm². Morphometric parameters were measured along the X and Y axes within each predefined field of view, and the obtained data were comparatively analyzed according to the time from birth to death.

The findings of the study allow the identification and assessment of time-dependent morphometric changes in adrenal gland tissue in newborns with birth-related brain injury.

Keywords: adrenal gland injury assessment, morphometric method, birth-related brain injury, necrosis, dystrophy.

Relevance of the Problem. Birth-related injuries in newborns, particularly birth-related brain injuries, are among the important causes of perinatal morbidity and mortality and remain a significant challenge in modern neonatology. According to various epidemiological studies, the incidence of birth-related injuries ranges from 0.2 to 41.2 cases per 1,000 deliveries, with considerable variation depending on the region, gestational age, characteristics of labor and delivery, and the clinical condition of the newborn.

Birth-related brain injury may cause secondary morphofunctional changes not only in the central nervous system but also in vital organs and systems. In particular, hypoxia, impaired blood circulation, hemodynamic disturbances, and stress responses may affect the morphological state of endocrine organs, including the adrenal glands.

Globally, severe neurological complications and fatal outcomes associated with perinatal asphyxia and mechanical birth injuries continue to occur in newborns. These consequences may be particularly pronounced in preterm newborns due to the

morphological and functional immaturity of the central nervous system and endocrine organs, which may contribute to the severity of birth-related injuries.

In this context, the study of morphological and morphometric changes occurring in adrenal gland tissue in newborns with birth-related brain injury is of considerable scientific and practical importance. In particular, determining the dynamics of these changes according to the time from birth to death, their comparative morphometric assessment, and the characterization of the development of pathological processes are important aspects of research in this field. The assessment of time-dependent morphometric changes in the adrenal glands may provide valuable information for morphological evaluation of stress-adaptive responses in newborns with birth-related brain injury and contribute to a better understanding of the pathomorphological characteristics of fatal outcomes.

Materials and Methods. The study material consisted of adrenal gland tissue samples obtained from 69 full-term newborns who died as a result of birth-related brain injury. Morphometric parameters of the adrenal gland tissue were analyzed according to the time from birth to death.

Discussion and Results. The results of the study demonstrated that the morphometric parameters of adrenal gland tissue in newborns with birth-related brain injury changed progressively depending on the time from birth to death. The findings indicate that compensatory-adaptive responses predominated during the initial hours, whereas dystrophic and decompensatory changes became more pronounced at later stages.

Total thickness of the adrenal gland. In the control group, the total adrenal gland thickness was 2.15±0.08 mm. During the 0–8-hour period after birth, this parameter increased to 2.32±0.09 mm, showing a statistically significant difference compared with the control group ($P<0.05$). At 8–16 hours, the thickness was 2.24±0.07 mm, approaching the control value. During the 16–24-hour period, the total thickness decreased to 1.98±0.06 mm, representing a significant reduction compared with the control group ($P<0.01$).

The increase in adrenal gland thickness during the initial hours may be associated with acute hemodynamic changes, vascular congestion, and interstitial edema. At later stages, persistent hypoxia and impaired circulation may lead to deterioration of tissue trophism, reduction in cellular mass, and dystrophic changes, resulting in a decrease in organ thickness.

Total thickness of the adrenal cortex. The mean cortical thickness in the control group was 1.82±0.07 mm. During the 0–8-hour period, this parameter increased to 1.97±0.08 mm, whereas by 16–24 hours it decreased to 1.62±0.05 mm ($P<0.01$). These changes reflect the influence of hypoxic-ischemic and stress responses associated with birth-related brain injury on the adrenal cortex.

The relative increase in cortical thickness during the early period may be related to hemodynamic alterations and interstitial edema. As the pathological process progresses, impaired tissue trophism and increasing dystrophic changes in cortical cells contribute to a reduction in cortical thickness.

Thickness of the zona glomerulosa. In the control group, the thickness of the zona glomerulosa was 125.4±4.2 μm. During the 0–8-hour period, this parameter increased to 134.2±4.8 μm, with a statistically significant difference (P<0.05). At 8–16 hours, it was 128.6±3.9 μm, while during the 16–24-hour period it decreased to 115.2±3.5 μm (P<0.01).

The early increase in zona glomerulosa thickness may be associated with edema and functional stress occurring in response to acute stress and hemodynamic disturbances. At later stages, hypoxia, impaired microcirculation, and tissue dystrophy contribute to a reduction in the morphometric parameters of this zone.

Thickness of the zona fasciculata. In the control group, the thickness of the zona fasciculata was 1.35±0.05 mm. During the 0–8-hour period, it increased to 1.48±0.06 mm (P<0.05), whereas during the 16–24-hour period it decreased significantly to 1.18±0.04 mm (P<0.01).

The zona fasciculata constitutes the major portion of the adrenal cortex and plays an important role in glucocorticoid synthesis. The stress response associated with birth-related brain injury may initially induce functional activation and interstitial edema in this zone. With persistence of the pathological process, depletion of intracellular lipid reserves, cytoplasmic alterations, and progressive dystrophic changes may lead to a reduction in the thickness of the zona fasciculata.

Thickness of the zona reticularis. The thickness of the zona reticularis in the control group was 340.5±12.1 μm. During the 0–8-hour period, the parameter was 358.2±14.0 μm, and at 8–16 hours it was 345.1±11.2 μm. During the 16–24-hour period, the thickness decreased significantly to 302.4±9.8 μm (P<0.01).

The morphometric changes in the zona reticularis also reflect the time-dependent progression of the pathological process. During the early period, alterations in blood circulation and tissue edema may cause a slight increase in zone thickness. At later stages, increasing hypoxia and microcirculatory disturbances may result in dystrophic and destructive changes in the cells, leading to a significant reduction in the thickness of the zona reticularis.

Thickness of the adrenal medulla. In the control group, the thickness of the adrenal medulla was 0.33±0.03 mm. It was 0.35±0.03 mm during the 0–8-hour period, 0.36±0.04 mm at 8–16 hours, and 0.31±0.02 mm during the 16–24-hour period. No statistically significant differences were observed between the groups (P>0.05).

The relative stability of medullary thickness may be associated with the structural characteristics of the medulla and the relative resistance of chromaffin tissue. However, despite the absence of significant morphometric changes, alterations in microcirculation and the functional state of chromaffin cells may still develop within the adrenal medulla.

Nuclear-cytoplasmic ratio of spongiocytes in the zona fasciculata. In the control group, the nuclear-cytoplasmic ratio was 0.22±0.01. This parameter increased to 0.25±0.01

during the 0–8-hour period (P<0.05), to 0.29±0.02 at 8–16 hours (P<0.01), and to 0.34±0.02 during the 16–24-hour period (P<0.01).

The progressive increase in the nuclear-cytoplasmic ratio indicates intensification of intracellular morphological remodeling in spongiocytes of the zona fasciculata. A reduction in cytoplasmic lipid components, changes in cell volume, and relative nuclear condensation may contribute to this increase. These morphometric changes may reflect a decline in cellular adaptive capacity and progression of dystrophic processes associated with prolonged hypoxic-ischemic exposure in newborns with birth-related brain injury.

Overall, the findings demonstrate that morphometric changes in adrenal gland tissue in newborns with birth-related brain injury develop in a time-dependent manner. While relative increases in most parameters were observed during the first 8 hours, significant reductions in the thickness of the adrenal cortex and its functional zones, accompanied by an increase in the nuclear-cytoplasmic ratio, predominated during the 16–24-hour period. These findings indicate a transition from early compensatory-adaptive responses to more pronounced dystrophic and decompensatory morphological changes.

Conclusions

1. The morphometric parameters of the adrenal glands in newborns with birth-related brain injury change dynamically depending on the time from birth to death, with compensatory changes predominating during the early period and dystrophic changes becoming more pronounced at later stages.
2. An increase in the total adrenal gland thickness to 2.32±0.09 mm during the first 0–8 hours, followed by a decrease to 1.98±0.06 mm at 16–24 hours, reflects tissue edema, hypoxia, and impaired tissue trophism.
3. The increase in the nuclear-cytoplasmic ratio (NCR) of spongiocytes in the zona fasciculata from 0.22±0.01 to 0.34±0.02 indicates an intensification of hypoxic-dystrophic changes at the cellular level.
4. During the 16–24-hour period, an increase in capillary diameter to 12.8±0.6 μm and in the vascular congestion coefficient to 38.9±1.8% indicates an intensification of microcirculatory disturbances.
5. An increase in the area of focal diapedetic hemorrhages to 2850.4±142.1 μm² indicates that hemorrhagic changes in the adrenal gland tissue become particularly pronounced during the 16–24-hour period.

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