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NEURODEVELOPMENTAL ASPECTS OF PRENATAL CHILD'S LIFE

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Abstract
The prenatal phase of life is a critical period for brain development. It is a crucial period for the formation of structural and functional integrity of the brain with the combination of various factors in the unique environment of the uterus. It is a period of manifold interactions that are essential biological conditions for the continuous development of the human brain and it is also a particularly vulnerable period for the development of potential risk predispositions. Several findings suggest that the formation of the human mind starts as early as the prenatal period.

Key words: *prenatal period; development; brain; mind*

REVIEW

INTRODUCTION

Both traditional and modern knowledge show the unique development of the human brain as early as the prenatal period. It is obvious that already in the early prenatal period there is an important determinant of neuronal processes and regulation, which are stimulated by multiple factors. Prenatal brain development represents a critical time window in which there is unrepeatable interaction of various factors in a unique constellation inside the uterus environment. It is a period in which future neuro-behavioural characteristics and the complex brain capacity of an individual in the postnatal life is being decided. Modern evidence shows that the developing brain before birth has a wide repertoire of expressions, reactions and capacities, which indicate the formation of the complex determinants of the human mind as early as the prenatal period of life.

Prenatal development of the brain and the human mind

The prenatal phase of life is a critical period of development of an individual, which controls the formation of all organs. It is also the most important period for the development of the human brain with critical neurodevelopmental processes and regulations necessary for comprehensive development of the human mind and future personality. The development in the womb is an absolutely crucial period for the development and differentiation of the human brain, which is subject to massive changes in this phase. These are represented by intensive migration, proliferation and differentiation of brain cells with the formation of important brain circuits. Basic brain circuits and connections are organized 24 weeks after fertilization. During the early and intensive differentiation and development of the human brain, its structure is particularly sensitive to different organizing or disorganizing influences of diverse etiology. This plasticity conditioned by susceptibility to various factors is called fetal programming, which is one of the most important mechanisms of structural and functional brain development (Fedor-Freybergh 2013, Hrubý and Fedor-Freybergh 2013).

There is convincing evidence that the child *in utero* already has in place the learning processes and diverse adaptation mechanisms that are essential for its survival. These also serve as a fundamental training and acquisition of adaptive capacity necessary for postnatal life. The ability to learn, whose prerequisite is the presence of functional capacity of the memory, is necessary for the development of adaptive mechanisms. Therefore, it is possible to talk about the initial formation of memory functions already in the prenatal stage of life. The prenatal period is also a time of turbulent changes, wherein the developing brain is exposed to multiple factors (genetic, hormonal, immunological, toxic, etc.) that can significantly affect the development and differentiation of a fetal brain and subsequently lead to various pathological disorders or predispositions (Fedor-Freybergh and Maas 2011). A developing fetus has a complete repertoire of responses to diverse stimuli. Even during the intrauterine development, it acquires the capability of the relative stimulus typical reactivity, corresponding to the so-called neurobehavioral status. The spontaneous motor activity of the fetus can be detected about 8 weeks after fertilization, showing considerable quantitative and qualitative increase with time gradient. This activity is the result of ontogenetic processes that reflect intense structural and functional brain development. In the 10th week after fertilization, a child shall acquire the ability to change its position in the womb, and in the 15th week it can demonstrate up to 16 different kinds of movements (movements of the limbs, yawning, rotary movements, swallowing, etc.). It is also known that the human fetus responds to various sensory stimuli (taste, smell, touch, even tone and pitch of the mother's voice), and later also to the emotional and social signals of the mother. During fetal life, it perceives the whole spectrum of specific incentives bound to this period of life, and it is assumed that their processing leads to major neurodevelopmental regulations that create conditions for the subsequent comprehensive postnatal development of cognitive, emotional and social skills of human beings (Michel and Moore 1999, Hrubý and Fedor-Freybergh 2013).

Paramount importance for the development of the brain belongs to mutual connection and maturation of the neuro-endocrine-immunological system, where all the components interact with each other, create a dynamic and functionally linked and organized unit. In the maturation period, some vital regulations occur. These are provided by various neurotransmitters, hormones, cytokines and other substances that serve as important information and "communication" molecules in the interaction between these systems. In pregnancy, a number of substances cross the placental barrier (e.g. vasopressin, oxytocin, stress hormones, ACTH, cortisol, and the like) and can significantly influence the neuronal structures of the human fetus. Several of these molecules are very important for the right brain development, but in non-physiological concentrations or other pathological constellations, these can act as "endogenous pathogens" inducing risk phenotypes or diseases (Fedor-Freybergh and Maas 2011).

In addition to these traditionally known neuro-developmental factors, there is an ever growing body of knowledge regarding the role of genetic and epigenetic factors in the development of the brain. It is believed that the development of the brain is affected by approximately 2/3 of all the genes on human chromosomes, which is a huge potential for the application of a variety of genes of both large and small effect and different types of inheritance. Recent research suggests an increasing number of identified genes for growth factors, contactins and other specific factors and molecules that are necessary for the adequate development of brain structures in the critical periods. The number of genes involved in brain development also illustrates the extraordinary complexity and potential vulnerability (the emergence of risk phenotypes, predispositions or diseases) in case of disorders with such important biological mechanisms. Another extremely important area of scientific research in this area is epigenetics. It deals with the study of mechanisms in external and internal environments, which affect the function of genes without changing the genetic information. Usually, these are the changes in activity and/or conformation of molecules of nucleic acids/genes caused by multiple mechanisms (in particular the histone modification, DNA methylation, and micro RNA dysregulation). It is known that the epigenetic mechanisms may serve for the transmission of a variety of environmental factors with different effects. It is known that epigenetic mechanisms also apply in the management of embryonic neurogenesis and the formation of neuronal circuits and behavioral patterns. It is also known that epigenetic factors play an important role in the pathogenesis of serious disorders and diseases such as schizophrenia, bipolar disorder, depressive and anxiety disorders, post traumatic stress disorder and even Alzheimer's dementia and Huntington disease (Jankowski et al. 2006, Koukolík 2008, Fagiolini et al. 2009, Jobe et al. 2012, Carbe et al. 2013, Hosák et al. 2013, Mercati et al. 2013).

In summary, it can be stated that the prenatal development of the brain is an extremely complex process, which involves various biological mechanisms. It is also a critical period for the application of critical neuronal processes and regulations that are necessary for adequate structural and functional brain development. Prenatal development is a dynamic period for brain development and a period of turbulent changes, during which enormous amounts of interacting external and internal factors are involved. These are both inevitable and potentially risky variables in the development and maturation of brain structures, and for adequate development of their unique multifunctional capacity.

CONCLUSION

Scientific evidence clearly shows that the degree of development of the human fetal brain allows it to perceive, process and respond to a full spectrum of sensory, but also emotional and social stimuli. It has such a quality of neurobehavioural regulations, that it presents in both quantitative and qualitative terms a human sentient being with regard to the degree of its individual development and functional and structural identity. From this perspective, it is therefore preferable to use the term prenatal child rather than fetus, because already in fetal life, a child has not only somatic but also mental, emotional, cognitive and social capacities (Fedor-Freybergh 2013). These unique competencies of a prenatal child encourage further intensive exploration in the prenatal brain development and prenatal mind. New knowledge in this field can contribute significantly to a better understanding of the pathogenesis, prevention, diagnosis, and development of more effective methods of treatment of various neuropsychiatric disorders. At the same time, a deeper understanding of the unique mechanisms of prenatal human development can significantly contribute to building an inclusive and modern concept of personalized medicine.

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