Volume 4, Issue 4, April 2026 ISSN (E): 2938-3765

CONGENITAL TOXOPLASMOSIS: PATHOGENESIS, ITS IMPACT ON FETAL DEVELOPMENT, AND PERINATAL COMPLICATIONS

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Abstract
Congenital toxoplasmosis is a complex infectious-pathological condition caused by the vertical transmission of the Toxoplasma gondii parasite from mother to fetus, characterized by significant morphofunctional alterations and long-term complications during the perinatal period. This article provides an in-depth analysis of the pathogenesis of toxoplasmosis, with particular emphasis on the mechanisms by which the parasite crosses the fetoplacental barrier, its interaction with the immune system, and its tropism for fetal tissues. Primary maternal infection represents the highest risk factor for fetal involvement, with clinical outcomes varying depending on the gestational stage: early infection may result in spontaneous abortion or severe developmental anomalies, while later stages are often associated with subclinical progression followed by delayed neurological and ophthalmological complications. The parasite's tropism for the central nervous system contributes to the development of the classical triad, including hydrocephalus, intracranial calcifications, and chorioretinitis. Furthermore, immunopathological processes, inflammatory mediators, and intracellular persistence of the parasite play a critical role in disrupting normal fetal development. The article also highlights the importance of modern diagnostic approaches, including serological markers and molecular genetic testing, as well as the effectiveness of early detection and preventive treatment strategies. Prevention of congenital toxoplasmosis relies on screening of pregnant women, enhancement of hygienic measures, and identification of high-risk groups [1,2].

Keywords: Congenital toxoplasmosis, Toxoplasma gondii, vertical transmission, intrauterine infection, pathogenesis, fetoplacental system, fetal development, perinatal complications, hydrocephalus, intracranial calcifications, chorioretinitis, serological diagnostics, IgM, IgG avidity, PCR, screening, prevention.

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Introduction

Annotatsiya

Tug‘ma toksoplazmoz — Toxoplasma gondii parazitining homilaga vertikal yo‘l bilan yuqishi natijasida yuzaga keladigan murakkab infeksion-patologik holat bo‘lib, u perinatal davrda jiddiy morfofunksional o‘zgarishlar va uzoq muddatli asoratlar bilan tavsiflanadi. Ushbu maqolada toksoplazmozning patogenezi, ayniqsa parazitning fetoplatsentar to‘siqni bosib o‘tish mexanizmlari, immun tizim bilan o‘zaro ta’siri va homila to‘qimalariga tropizmi chuqur tahlil qilinadi. Onaning birlamchi infeksiyalanishi homila uchun eng yuqori xavf omili hisoblanib, infeksiya gestatsion davrning turli bosqichlarida turlicha klinik oqibatlarga olib keladi: erta bosqichlarda spontan abort yoki og‘ir rivojlanish nuqsonlari, kechki bosqichlarda esa subklinik kechuvchi, ammo keyinchalik namoyon bo‘ladigan nevrologik va oftalmologik asoratlar kuzatiladi. Parazitning markaziy asab tizimiga tropizmi gidrotsefaliya, intrakranial kalsifikatsiyalar va xorioretinit kabi klassik triada shakllanishiga olib keladi. Bundan tashqari, immunopatologik jarayonlar, yallig‘lanish mediatorlari va hujayra ichidagi parazitning persistensiyasi homila rivojlanishining buzilishiga zamin yaratadi. Maqolada zamonaviy diagnostika usullari, jumladan serologik markerlar va molekulyar-genetik tekshiruvlarning ahamiyati, shuningdek, erta aniqlash va profilaktik davolash strategiyalarining samaradorligi yoritilgan. Tug‘ma toksoplazmozning oldini olishda homilador ayollarni skrining qilish, gigiyenik choralarni kuchaytirish va xavf guruhlarini aniqlash muhim ahamiyat kasb etadi [1,2].

Kalit so‘zlar: Tug‘ma toksoplazmoz, Toxoplasma gondii, vertikal transmissiya, intrauterin infeksiya, patogenez, fetoplatsentar tizim, homila rivojlanishi, perinatal asoratlar, gidrotsefaliya, intrakranial kalsifikatsiyalar, xorioretinit, serologik diagnostika, IgM, IgG avidlik, PZR, skrining, profilaktika.

Аннотация

Врожденный токсоплазмоз представляет собой сложное инфекционно-патологическое состояние, обусловленное вертикальной передачей паразита Toxoplasma gondii от матери к плоду, и характеризуется выраженными морфофункциональными изменениями и долгосрочными осложнениями в перинатальном периоде. В данной статье подробно анализируется патогенез токсоплазмоза, с особым акцентом на механизмы преодоления паразитом фетоплацентарного барьера, его взаимодействие с иммунной системой и тропизм к тканям плода. Первичное инфицирование матери является наиболее значимым фактором риска для плода, при этом клинические исходы зависят от срока гестации: на ранних этапах инфекция может приводить к самопроизвольному аборту или тяжелым врожденным аномалиям, тогда как на поздних сроках чаще наблюдается субклиническое течение с последующим развитием отсроченных неврологических и офтальмологических осложнений. Тропизм паразита к центральной нервной системе способствует формированию классической триады, включающей гидроцефалию, внутричерепные кальцификации и хориоретинит. Кроме того, иммунопатологические процессы, воспалительные медиаторы и внутриклеточная персистенция паразита играют важную роль в нарушении нормального развития плода. В статье также освещена значимость современных методов диагностики, включая серологические маркеры и молекулярно-генетические исследования, а также эффективность

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раннего выявления и профилактических лечебных стратегий. Профилактика врожденного токсоплазмоза основана на скрининге беременных женщин, соблюдении гигиенических мер и выявлении групп высокого риска [1,2].

Ключевые слова: Врожденный токсоплазмоз, Toxoplasma gondii, вертикальная передача, внутриутробная инфекция, патогенез, фетоплацентарная система, развитие плода, перинатальные осложнения, гидроцефалия, внутричерепные кальцификации, хориоретинит, серологическая диагностика, IgM, авидность IgG, ПЦР, скрининг, профилактика.

Congenital toxoplasmosis is considered one of the pressing problems in modern perinatal medicine and infectious pathology, as it significantly negatively affects fetal development and is often accompanied by severe neurological and ophthalmological complications. The etiological agent of this disease, Toxoplasma gondii, is широко распространён как облигатный внутриклеточный паразит, enters the human body mainly through the alimentary route and manifests in various clinical forms depending on the state of the immune system [6]. Primary infection in pregnant women is particularly dangerous, as the parasite can cross the placenta and lead to intrauterine infection of the fetus. According to epidemiological data, the seroprevalence of toxoplasmosis varies significantly depending on the region, which is directly related to socio-hygienic conditions, dietary habits, and sanitary culture. The clinical significance of the disease is further complicated by its often asymptomatic course, resulting in delayed diagnosis and an increased risk of fetal damage. At the same time, the severity of fetal involvement depends on gestational age: infection in early stages may lead to severe developmental anomalies or fetal death, whereas in later stages it often presents as a latent infection with subsequent clinical manifestations [3,7]. The pathogenesis of congenital toxoplasmosis is complex and is closely associated with the invasive properties of the parasite, the functional state of the placental barrier, and the maternal immune response. Therefore, in-depth study of this problem, early diagnosis, and the development of effective preventive strategies are of great importance for medical practice [9,14].

Congenital toxoplasmosis remains one of the important challenges for the global healthcare system today, as this infection causes severe and often irreversible pathological changes in the fetus and newborns. The widespread prevalence of Toxoplasma gondii infection, its frequently latent course, and the lack of timely diagnosis in pregnant women further increase its clinical and social significance [19]. Particularly in cases of primary infection, vertical transmission of the parasite occurs with a high risk, leading to serious damage to the fetal central nervous system, visual organs, and other vital systems. The relevance of this problem lies in the fact that congenital toxoplasmosis often initially proceeds without clinical symptoms, but later manifests with severe complications such as delayed psychoneurological development, epileptic syndromes, decreased vision, or complete loss of vision [11,20]. This not only significantly reduces the patient's quality of life but also imposes a considerable economic burden on society and the healthcare system. At the same time, insufficient implementation of screening programs in many regions and low public awareness regarding preventive measures contribute to the continued spread of this disease. Moreover, despite advances in modern diagnostic methods, a number of challenges remain in the early detection of toxoplasmosis and the application of effective treatment strategies. Therefore, in-depth study of the pathogenesis of congenital

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toxoplasmosis, identification of risk factors, and improvement of prevention and early diagnostic systems are considered priority directions in modern medical science [10].

In this study, clinical, laboratory, and analytical approaches were used to comprehensively assess the pathogenesis of congenital toxoplasmosis, its impact on fetal development, and perinatal complications. The research materials were based on clinical observations of toxoplasmosis cases identified in pregnant women and newborns, laboratory test results, and the analysis of modern scientific sources. The study included both retrospective and prospective observation elements, examining the clinical parameters of patients infected with Toxoplasma gondii at different stages of gestation. Serological methods played a key role in the diagnostic process, particularly through the determination of immunoglobulin (IgM and IgG) levels, which allowed for the differential assessment of primary and past infections [4,13]. In addition, an avidity test was used to determine the activity of the infection. Within the framework of molecular genetic investigations, polymerase chain reaction (PCR) was applied to detect parasite DNA in biological fluids, thereby confirming cases of intrauterine infection. Among instrumental methods, ultrasound examination was used to identify morphological changes in the fetus, including hydrocephalus, intracranial calcifications, and other developmental anomalies. The obtained results were statistically processed, and their reliability and correlations were evaluated. During the analysis, correlations between clinical and laboratory indicators were identified, allowing for a comprehensive assessment of the impact of toxoplasmosis on fetal development. This methodological approach ensured the accuracy and scientific validity of the study results [12,16].

The results of the conducted study confirmed that congenital toxoplasmosis has a significantly negative impact on fetal development. Analysis of clinical and laboratory data showed that in cases of primary Toxoplasma gondii infection identified in pregnant women, the risk of vertical transmission increases depending on the gestational age; however, infections occurring in the early stages are characterized by a more severe course [8,15]. In fetuses infected during the first trimester, a high incidence of spontaneous abortions, arrested embryonic development, and severe congenital anomalies was observed, whereas in the second and third trimesters the infection often proceeded in a latent or subclinical form, later manifesting with clinical complications. Laboratory findings indicated that the presence of IgM antibodies reflected active infection, while low-avidity IgG levels confirmed a recent primary infection. Using PCR, parasite DNA was detected in amniotic fluid and other biological samples, reliably confirming cases of intrauterine infection [17]. Instrumental examinations, particularly ultrasound diagnostics, revealed pathological changes in the fetal central nervous system, including hydrocephalus, intracranial calcifications, ventriculomegaly, and hepatosplenomegaly. Observations of newborns demonstrated that in many cases the classical clinical triad—chorioretinitis, intracranial calcifications, and hydrocephalus—was present, while some patients additionally exhibited delayed psychomotor development, epileptic seizures, and reduced visual function. At the same time, in certain cases congenital toxoplasmosis initially proceeded asymptomatically but later developed delayed neurological and ophthalmological complications. The obtained results once again confirm that toxoplasmosis leads to serious clinical consequences during the fetal and neonatal periods [5,18].

The results of the conducted study scientifically confirmed that congenital toxoplasmosis is a high-risk infectious pathology that has a significantly negative impact on fetal development. Vertical

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transmission of Toxoplasma gondii, especially in cases of primary infection during pregnancy, leads to intrauterine fetal damage manifested by severe morphological and functional disorders. The clinical outcomes of the infection are directly dependent on gestational age: in early stages, it is associated with severe developmental abnormalities and fetal death, whereas in later stages it is characterized by a latent course with subsequent long-term neurological and ophthalmological complications. The findings of the study also demonstrated that the pathogenesis of congenital toxoplasmosis is complex and multifactorial, involving the invasive properties of the parasite, the functional state of the placental barrier, and the maternal immune response. Modern diagnostic methods—including serological tests, avidity analysis, and molecular genetic techniques—have proven to be highly effective for early detection of the infection. At the same time, instrumental examinations play an important diagnostic role in identifying structural abnormalities in the fetus. In conclusion, early screening of pregnant women, strengthening hygienic preventive measures, and identifying high-risk groups are essential for the prevention of congenital toxoplasmosis. Timely diagnosis and the implementation of adequate treatment strategies can prevent the development of severe perinatal complications.

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