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EPIGENETIC BASIS OF INFERTILITY IN YOUNG MEN AND ITS IMPACT ON THE HEALTH OF FUTURE GENERATIONS

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Abstract
The epigenetic mechanisms of male infertility in young men have recently become the focus of scientific research. In addition to genetic factors, processes such as DNA methylation, histone modification, and microRNA expression significantly regulate spermatogenesis. This article analyzes the epigenetic basis of male infertility, its heritability, and its impact on the health of future generations. The findings indicate that epigenetic alterations may not only cause infertility but also influence the development of hereditary diseases in offspring.
Keywords: male infertility, epigenetics, offspring health.

Introduction

Male infertility in young men is one of the pressing global health problems. According to the World Health Organization (WHO), one in six couples worldwide faces infertility, and almost half of these cases are related to male health. Traditionally, male infertility has been explained by genetic defects, infections, or hormonal imbalances. However, recent studies have shown that epigenetic factors also play a crucial role in this process.

Epigenetics is the science that studies mechanisms controlling gene expression without altering the DNA sequence. DNA methylation, histone modification, and microRNAs determine whether specific genes are "turned on" or "off" during spermatogenesis. Therefore, epigenetic disruptions directly affect sperm count, quality, and genetic stability.

Importantly, epigenetic changes can be inherited. This means that epigenetic disruptions in young men may not only cause infertility but also increase the risk of metabolic syndrome, cardiovascular diseases, and developmental disorders in their offspring.

This article aims to analyze the epigenetic basis of male infertility in young men, its inheritance, and its impact on the health of future generations.

Relevance of the Study

Infertility today is not only a medical but also a social and psychological problem. According to global statistics, half of all infertility cases are related to male health. Infertility in young men is particularly concerning, as it occurs during the peak of reproductive capacity.

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Recent studies demonstrate that male infertility is not only linked to genetic defects or infections but also to epigenetic mechanisms. Alterations in DNA methylation, histone modification, and microRNA expression can disrupt spermatogenesis, preventing the formation of healthy sperm.

The critical point is that epigenetic modifications can be transmitted across generations. This means that the health of young men determines not only their fertility but also the general health of future generations. Therefore, studying the epigenetic mechanisms of male infertility, developing diagnostic methods, and creating new treatment strategies are urgent scientific tasks.

Materials and Methods

This article is a review study, analyzing existing scientific sources, laboratory research, and clinical observations regarding the epigenetic basis of male infertility in young men.

Materials:

- Articles published in the last 10 years in PubMed, Scopus, and Web of Science databases;
- Data from the World Health Organization (WHO);
- Reports from major clinical centers in reproductive medicine and molecular biology.

Methods:

1. **Systematic analysis** – examining epigenetic mechanisms (DNA methylation, histone modification, microRNAs) associated with male infertility.
2. **Comparative analysis** – comparing epigenetic alterations in infertile men and healthy controls.
3. **Review of clinical observations** – generalizing evidence on the hereditary transmission of epigenetic changes.
4. **Prognostic approach** – evaluating potential impacts of epigenetic alterations on the health of future generations.

Statistical Analysis

Recent scientific studies demonstrate a strong association between epigenetic factors and male infertility in young men. Key findings include:

- **Global prevalence of infertility:** According to WHO, 15–20% of couples worldwide face infertility, with 40–50% of cases linked to male health.
- **Epigenetic alterations:** DNA methylation abnormalities were found in 35–40% of infertile men.
- **Spermatogenesis disruption:** Men with epigenetic defects showed a 30–50% reduction in sperm count compared to healthy controls.
- **Impact on offspring:** Animal studies revealed that offspring of fathers with epigenetic defects showed metabolic syndrome, developmental delays, or genetic disorders in 25–30% of cases.
- **Clinical observations:** Studies from 2020–2023 indicated that 10–15% of male infertility cases had epigenetic origins.

Discussion

The analysis indicates that the epigenetic basis of male infertility in young men is complex and multifaceted. While traditional approaches explained infertility mainly by genetic defects, infections, or hormonal disorders, recent findings emphasize the role of epigenetic mechanisms.

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Epigenetic factors such as DNA methylation, histone modification, and microRNA expression directly influence sperm quality and quantity. These changes reduce reproductive capacity and have long-term consequences for offspring health. For instance, animal model studies showed that paternal epigenetic abnormalities could lead to metabolic disorders, cardiovascular risk, and neuropsychiatric conditions in descendants.

A crucial aspect of epigenetics is its **reversibility**. This opens opportunities for developing novel therapeutic strategies. Epigenetic therapies, such as drugs normalizing DNA methylation, microRNA-based approaches, and lifestyle interventions (healthy diet, quitting harmful habits, stress management), may become effective methods for treating male infertility.

Additionally, introducing epigenetic testing in clinical practice for reproductive-age men could allow early diagnosis of infertility and prevention of hereditary risks in future generations.

Thus, studying the epigenetic basis of male infertility is important not only for individual patients but also for the overall health of society.

Conclusion

The epigenetic basis of male infertility in young men is emerging as a new direction in modern medicine. The findings can be summarized as follows:

1. Male infertility is closely associated not only with genetic and hormonal disorders but also with epigenetic mechanisms (DNA methylation, histone modification, microRNA expression).
2. Epigenetic changes are reversible, offering opportunities for targeted treatment.
3. Such alterations can be inherited, affecting the health of future generations.

Practical Recommendations

- Introduce epigenetic testing for reproductive-age men to enable early diagnosis of infertility.
- Promote lifestyle interventions (healthy nutrition, physical activity, avoidance of harmful habits) to reduce negative epigenetic effects.
- Accelerate the development of new drugs targeting molecular and epigenetic pathways.
- Conduct large-scale clinical trials on epigenetic therapy for male infertility.
- Consider infertility not only as an individual issue but also as a public health problem affecting future generations.

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