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IMPACT OF IRON LEVELS ON EMBRYO QUALITY IN IVF: A QUANTITATIVE AND QUALITATIVE ANALYSIS

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Abstract

Iron deficiency is a prevalent condition among women of reproductive age and may negatively impact in vitro fertilization (IVF) outcomes. The role of iron in embryo quality and fertilization rates remains insufficiently studied.

Objective: This study aims to assess the effect of ferritin levels and iron supplementation on embryo quality and fertilization rates in IVF cycles.

Methods: A total of 106 women undergoing IVF were divided into four groups: a control group with normal iron levels (n=21), a low-ferritin group (n=20), and two iron-supplemented groups (n=29 and n=36), with or without a two-month pause before ovarian stimulation. Quantitative and qualitative embryo characteristics were assessed. Statistical analysis was performed using the χ^2 test, with significance set at $p<0.05$.

Results: Iron deficiency significantly reduced fertilization rates and embryo quality. The group that received iron supplementation before ovarian stimulation showed no significant improvement compared to the untreated low-ferritin group. However, the group that received iron supplementation followed by a two-month pause before stimulation demonstrated a significant recovery of embryo parameters, reaching levels comparable to the control group.

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Conclusion: Iron deficiency adversely affects embryo quality and fertilization rates in IVF. Immediate iron supplementation before ovarian stimulation does not improve outcomes, whereas iron therapy followed by a two-month pause significantly restores embryo parameters. These findings emphasize the importance of pre-treatment iron optimization before IVF.

Keywords: IVF, iron deficiency, ferritin, embryo quality, ovarian stimulation.

Introduction

Iron is a crucial micronutrient involved in oxygen transport, cellular metabolism, and DNA synthesis, making it essential for reproductive health. Iron deficiency has been linked to menstrual irregularities, anovulation, and poor endometrial receptivity [2, 4, 6]. However, the direct impact of iron levels on embryo development and IVF success remains underexplored [1, 3, 7].

Previous studies have highlighted the role of oxidative stress and inflammation associated with iron deficiency, which may compromise oocyte and embryo quality [5]. This study aims to determine how ferritin levels and iron supplementation strategies influence embryo quality and fertilization rates in IVF cycles.

Materials and Methods.

2.1 Study Design and Participants

This prospective cohort study was conducted between March 2023 and august 2024 at IVF clinic “Siz ona bulasiz”. The study included 106 women undergoing IVF, divided into four groups:

- Control group (CG) (n=21): Women with normal iron levels.
- Group 1 (n=20): Women with low ferritin levels (11.1±0.98 µg/L).
- Group 2a (n=29): Women with low ferritin levels receiving iron supplementation immediately before ovarian stimulation.
- Group 2b (n=36): Women with low ferritin levels receiving iron therapy followed by a two-month pause before ovarian stimulation.

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2.2 Data Collection and Embryo Assessment

Embryo quality was evaluated based on:

- Number of fertilized oocytes (2pn).
- Total number of embryos.
- Percentage of excellent, good, and poor-quality embryos.
- Number of compacted embryos.
- Embryos not reaching the blastocyst stage.

2.3 Statistical Analysis

Data were analyzed using the χ^2 test to compare categorical variables between groups. A p-value <0.05 was considered statistically significant.

Results

3.1 Quantitative Embryo Parameters

- The control group had the highest fertilization rate, with 261 fertilized oocytes and 236 total embryos.
- Group 1 (iron deficiency) had a significant decline, with only 85 fertilized oocytes and 51 embryos ($p<0.001$).
- Group 2a (iron supplementation without a pause) showed no significant improvement compared to Group 1 ($p>0.05$).
- Group 2b (iron supplementation with a two-month pause) demonstrated recovery, with 317 fertilized oocytes and 261 embryos, comparable to the control group ($p>0.05$).

3.2 Qualitative Embryo Parameters

- Group 1 had a significant reduction in excellent embryos (23.5% vs. 62.3% in CG, $p<0.001$) and an increase in poor-quality embryos (27.5% vs. 7.6% in CG, $p<0.01$).
- Group 2a had similar poor outcomes to Group 1.
- Group 2b restored excellent embryo rates to 60.9% ($p>0.05$ compared to CG) and significantly reduced poor-quality embryos to 8.8% ($p<0.01$).

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- The number of compacted embryos and those failing to reach the blastocyst stage was significantly higher in Group 1 and Group 2a but reduced in Group 2b ($p<0.01$).

Discussion

Our results suggest that iron deficiency negatively impacts embryo quality and fertilization rates in IVF. Direct iron supplementation before ovarian stimulation did not improve outcomes, possibly due to the time required for iron metabolism and utilization. However, iron therapy followed by a two-month pause before IVF led to a significant improvement, indicating that iron storage and metabolic adaptation play a role in reproductive success.

These findings align with previous research suggesting that iron deficiency contributes to oxidative stress, mitochondrial dysfunction, and compromised oocyte quality. The study highlights the need for preconception iron optimization in women undergoing IVF.

Limitations. This study has some limitations:

- The sample size was relatively small.
- Long-term outcomes such as pregnancy and live birth rates were not assessed.
- The study did not account for genetic or environmental factors that might influence embryo quality.

Future research should include larger multi-center studies and evaluate long-term pregnancy outcomes.

Conclusion

Iron deficiency significantly reduces embryo quality and fertilization rates in IVF. Immediate iron supplementation before ovarian stimulation does not improve outcomes. However, iron supplementation followed by a two-month pause restores embryo parameters, emphasizing the importance of pre-treatment iron optimization before IVF.

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