

编者按

辅助生殖技术（ART）的应用和迅速发展，为广大不孕症患者带来福音，但相应地也带来了诸如助孕年龄的界限、多胎妊娠、卵子冷冻、冷冻胚胎归属、胚胎基因筛选和生殖细胞基因编辑等伦理问题。这不仅关乎技术本身的合理应用，更触及人类社会的基本价值观、道德准则以及对生命本质的理解。因此，《中华生殖与避孕杂志》和中华医学会生殖医学分会合作，由黄国宁教授牵头、全松教授和胡琳莉教授负责，共同策划出版“生殖医学伦理专栏”，探讨生殖医学实践中所面临的伦理困境与挑战，旨在为学术界提供一个深度交流与思想碰撞的空间，促使专家们从多学科视角审视生殖医学伦理问题。我们希望通过严谨的学术探讨，为ART的规范应用提供理论支撑，为相关政策的制定提供科学依据，为公众的伦理认知提供引导，从而在推动ART发展的同时，坚守人类社会的伦理底线，确保医学技术始终服务于人类的福祉，而非成为引发新的社会矛盾与伦理危机的源头。让我们携手共进，为在生殖医学领域构建一个既充满创新活力又坚守伦理原则的和谐发展环境而努力。

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ART助孕治疗知情同意书签署中涉及的伦理问题及考量

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【摘要】 知情同意原则是人类辅助生殖技术（assisted reproductive technology, ART）伦理原则中最重要的原则之一，ART必须在夫妻双方自愿同意并签署书面知情同意书后方可实施，这也是保护医患双方利益的重要举措。ART知情同意书的签署中不仅涉及较多的伦理问题，也需要加入很多具体的考量。本文主要对ART知情同意书的历史变迁、涉及的伦理问题及签署时需要进行的一些考量做了具体的分析，旨在促进ART知情同意书的进一步规范和完善，助力人类ART的发展。

【关键词】 生殖技术，辅助； 知情同意； 伦理

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Ethical issues and considerations involved in informed consent for ART therapy

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【Abstract】 The principle of informed consent is one of the most important principles in the ethical principles of human assisted reproductive technology (ART), and ART can only be performed after both spouses have voluntarily agreed and signed a written informed consent form, which is also an important measure to protect the interests of both doctors and patients. The signing of the ART informed consent form not only involves more ethical issues, but also requires the incorporation of a lot of specific considerations. This paper analyzes the development of ART informed consent, the ethical issues involved, and the considerations that need to be taken into account when signing the consent form, with the aim of promoting the further standardization and improvement of ART informed consent, and helping the development of ART.

【Key words】 Reproductive technology, assisted; Informed consent; Ethics

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赠卵与受卵助孕的伦理问题及争议

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【摘要】 赠卵结合体外受精-胚胎移植 (*in vitro* fertilization and embryo transfer, IVF-ET) 技术能够帮助因年龄或各种原因引发卵巢功能衰退而无法获取或使用自身卵子生育的女性实现为人母的心愿。尽管赠卵 IVF-ET 技术成熟且早已应用,但在赠卵来源与卵子捐赠模式、赠/受卵者的条件、赠/受卵子的数目、赠卵补偿额度以及赠/受卵者信息披露等方面,仍存在不少伦理及管理的问题及争议,有必要对此进行深入的探讨和充分的考量,为辅助生殖管理政策的调整和伦理争议的解决提供新思路,从而促进赠卵 IVF-ET 助孕治疗的规范化开展。

【关键词】 体外受精; 胚胎移植; 伦理; 赠卵; 受卵

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Ethical issues and controversies related to egg sharing donation program

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【Abstract】 *In vitro* fertilization and embryo transfer (IVF-ET) with egg donation can help women who are unable to conceive by their own egg due to advanced age or the other various reasons. This technique could fulfill their desire to become mothers. Although this technique is well developed and has been widely used, there are still many ethical issues waiting to address, such as the sources of donor eggs, the criteria for donors and recipients, the number donated and receipted eggs, compensation for donation, disclosure of the information of donor and recipient. It is necessary to thoroughly discuss and carefully consider these issues to provide new insights for adjusting management policies and resolving ethical controversies in reproductive medicine.

【Key words】 Fertilization *in vitro*; Embryo transfer; Ethics; Egg donation; Egg donation reception

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高龄患者在助孕治疗中生育年龄限制的伦理考量

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【摘要】 近年来,随着人们认知观念的改变、女性社会地位的提高,我国女性生育年龄普遍推迟,这一变化使我国女性生育力显著下降。“三孩生育”政策的实施及多地将辅助生殖纳入医保范畴的举措,也进一步加剧了我国高龄女性对辅助生殖需求的急速增长。然而各种高级别循证医学证据证实,年龄是影响辅助生殖技术治疗预后的关键因素,许多高龄助孕女性,尤其是>43岁的女性,在经过多次辅助生殖助孕后,仍无法得到较好的妊娠结局。那么从有利无害原则、保护后代原则及社会公益原则考虑,结合国内外相关指南、共识、政策法规及研究数据,我们是否需要对其进行辅助生殖技术的高龄患者设置年龄限制?这一点值得深入的伦理探讨。

【关键词】 生殖技术, 辅助; 高龄女性; 伦理分析

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Ethical considerations regarding the age limit for fertility in assisted reproductive treatments for elderly patients

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【Abstract】 In recent years, as societal perceptions have evolved and women's social standing has improved, the average age of childbearing for women in China has generally increased. This shift has contributed to a notable decline in fertility rates among Chinese women. The introduction of the "three-child" policy and the inclusion of assisted reproductive technology (ART) in medical insurance coverage across many regions have further fueled the rapid rise in demand for ART among older women. However, numerous high-level evidence-based medical studies have confirmed that age remains a critical factor influencing the success rates of ART treatments. Many older women seeking pregnancy assistance,

particularly than aged 43 years and above, continue to experience unsatisfactory outcomes despite multiple attempts at ART. Therefore, considering the principles of beneficence, protection of offspring, and social welfare, and in light of relevant domestic and international guidelines, consensus, policies, regulations, and research data, should there be an age limit for high-aged patients undergoing ART treatments? This issue warrants a thorough ethical examination.

【Key words】 Reproductive technology, assisted; Advanced maternal age; Ethics

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人类配子与体外胚胎用于科研的伦理考量及监督

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【摘要】 将人类胚胎视为主体和客体的折中说是当前人们对胚胎伦理地位的主要认知。胚胎人格是胚胎发育过程中逐渐获得的。从伦理角度看, 胚胎在受精后2周原条出现视为具备“人”属性或人格的开始, 科研中应遵循这一时间界限, 具备“人”属性的体外胚胎用于研究令人难以接受。以出生子代为目的的研究, 须遵循辅助生殖技术的伦理准则, 生殖基因编辑和生殖克隆不被接受。出于对人的尊重, 人类配子与异种配子结合、构建不同个体、不同物种的嵌合胚胎则有违对人类尊重的原则。胚胎在体外培养期限不应超过胚龄2周。伦理监督是保障胚胎科学研究中遵循伦理行为规范的重要措施, 包括自我监督、公众和舆论监督、伦理委员会的伦理审查和督察、法规与制度监督等形式。本文拟从人类配子与体外胚胎用于科研的伦理考量及监督进行综述。

【关键词】 配子; 人格; 伦理; 体外胚胎

Ethical considerations and oversight of the use of human gametes and *in vitro* embryos for scientific research

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【Abstract】 Human embryo is regarded as the middle body between subject and object, which is the main cognition of the ethical status of embryo. It is considered that personhood of an embryo is gradually acquired in the process of its development. From an ethical point of view, when the primitive streak of an embryo is generated at 2 weeks after fertilization, the "human" property is considered to be generated, and this time limit should be followed in scientific research. It is unacceptable that *in vitro* research uses embryos which have "human" property. Research for the purpose of obtaining offspring must be in accordance with the ethical guidelines of assisted reproductive technology. Reproductive gene editing and reproductive cloning are forbidden. Construction of chimeric embryos between individuals and species violates the principle of respect for human beings. Embryos should not be cultured *in vitro* for more than 2 weeks of embryo age. Ethical supervision is an important way to ensure the observance of ethical norms in embryology research, including self-supervision, supervision by public opinions, ethical review and supervision of ethics committee, regulation and system supervision. This article reviews the ethical considerations and supervision of the use of human gametes and *in vitro* embryos for scientific research.

【Key words】 Gamete; Personhood; Ethics; Embryo *in vitro*

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基因检测技术在辅助生殖中应用的若干伦理问题思考

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【摘要】 基因检测技术在辅助生殖领域的应用,如植入前遗传学检测和携带者筛查,为不孕不育夫妇提供了更多生育选择,并在遗传病防控方面发挥了重要作用,显著提升了生殖健康水平。然而,这些技术的广泛应用也带来了诸多伦理挑战,包括嵌合体胚胎移植的不确定性与生育权的平衡、检测染色体倒位携带者的成本效益争议、多基因遗传病筛查的预测准确性及伦理边界问题,以及携带者筛查的广泛应用带来的信息过载、知情选择权受限、筛查范围争议及医疗资源不均等伦理挑战。生殖医学伦理委员会在这一过程中发挥着核心作用,负责技术应用的伦理审查、保障患者的知情同意权、平衡技术创新与伦理责任,并促进社会公平性。本文通过探讨胚胎植入前遗传学检测、携带者筛查等技术应用于辅助生殖时带来的伦理挑战,并基于伦理原则框架提出相应的建议,以期推动基因检测技术在生殖医学中的规范化应用。

【关键词】 基因检测; 生殖技术, 辅助; 伦理学, 医学

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Reflections on the ethical implications of genetic testing in assisted reproduction

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【Abstract】 The application of genetic testing technologies in assisted reproduction, such as preimplantation genetic testing (PGT) and carrier screening for monogenic diseases, has provided infertile couples with more reproductive options and played a crucial role in the prevention of genetic disorders, significantly improving reproductive health. However, the widespread use of these technologies has also raised various ethical challenges, including the uncertainty of mosaic embryo transfer and its implications for reproductive rights, the cost-effectiveness debate surrounding PGT for structural rearrangement for chromosomal inversion carriers, the predictive accuracy and ethical boundaries of polygenic embryo screening, and the ethical concerns related to extensive carrier screening, such as information overload, restricted informed choice, disputes over screening scope, and disparities in healthcare access. The reproductive medicine

ethics committee plays a central role in addressing these challenges by overseeing ethical reviews of technological applications, ensuring patients' informed consent, balancing technological innovation with ethical responsibility, and promoting social equity. This article explores the ethical challenges brought by the application of technologies such as PGT and carrier screening in assisted reproduction, and proposes corresponding suggestions based on ethical principles framework, in order to promote the standardized application of genetic testing technology in reproductive medicine.

【Key words】 Genetic testing; Reproductive techniques, assisted; Ethics, medical

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胚胎归属案例涉及的伦理问题

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【摘要】 辅助生殖技术管理的重要目标之一是子代安全, 当患方的需求与辅助生殖技术管理发生冲突时, 产生了生殖伦理难题。冻存胚胎的保管和使用是辅助生殖技术管理的一部分, 当患方在冻存胚胎的保管和使用发生冲突时, 少部分的法院判决与国家管理办法一致, 但绝大多数的法院判决都将冷冻胚胎归属权判决给患方, 裁决患方享有保管和处置权, 医院将难以按照国家法律法规实施胚胎冷冻保存和管理。本文围绕胚胎归属案例涉及的伦理问题予以综述, 以期为辅助生殖技术中胚胎管理提供有益的借鉴。

【关键词】 胚胎研究； 所有权； 胚胎处置； 生殖技术，辅助； 伦理学

Ethical considerations in embryo disposition cases

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【Abstract】 One of the important goals of assisted reproductive technology management is the safety of offspring. When the needs of patients conflict with the management of assisted reproductive technology, reproductive ethical problems arise. The storage and use of frozen embryos is a part of the management of assisted reproductive technology. When the patient has a conflict in the storage and use of frozen embryos, a small number of court decisions are consistent with the national management measures, but the vast majority of court decisions give the patient the right to ownership of frozen embryos, ruling that the patient has the right to custody and disposal, and the hospital will be difficult to implement embryo cryopreservation and management by national laws and regulations. In this paper, we review the ethical considerations in embryos, in order to provide beneficial references for embryo management in assisted reproductive technology.

【 Key words 】 Embryo research; Ownership; Embryo disposition; Reproductive techniques, assisted; Ethics

·生殖医学伦理专栏·

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智力障碍患者的助孕伦理思考：1 例男女双方 轻度智力障碍申请辅助生殖技术助孕案例的伦 理分析

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【摘要】 智力障碍患者享有生育权。智力障碍临床表现多样、病因复杂,生殖临床医师在面临智力障碍患者辅助生殖技术助孕申请时,如何在遵守我国法律法规及伦理原则的同时,保障智力障碍患者的生育权及子代权益,仍面临诸多争议和挑战。本文以1例男女双方轻度智力障碍患者申请辅助生殖技术助孕案例入手,结合智力障碍不同病因及相应生殖策略,对患者申请实施辅助生殖技术的伦理冲突和原则依据进行阐述和分析,以帮助临床医师更好地平衡患者需求、子代权益和社会风险之间的矛盾,同时推动我国进一步健全相关伦理指南和法律法规。

【关键词】 智力障碍; 生殖技术,辅助; 法律法规; 伦理原则
基金项目: 国家自然科学基金面上项目 (32370917)

Application for assisted pregnancy in patients with intellectual disabilities and ethical considerations: ethical analysis of a case of mild intellectual disability in both men and women applying for assisted reproductive technology for pregnancy assistance

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【Abstract】 Patients with intellectual disabilities have the reproductive rights. The clinical manifestations of intellectual disabilities are diverse and the causes are complex. When faced with the application of assisted reproductive technology (ART) for pregnancy in patients with intellectual disabilities, reproductive physicians still face many controversies and challenges on how to protect the reproductive rights and offspring rights of patients with intellectual disabilities while complying with Chinese laws, regulations, and ethical principles. This article starts with a case of a male and female patient with mild intellectual disabilities applying for assisted pregnancy by ART. Combining different causes of intellectual disabilities and corresponding reproductive strategies, it elaborates and analyzes the ethical conflicts and principle basis of the patient's application for ART, in order to help clinical physicians better balance the contradiction among patients' needs, offspring rights and social risks, and promote the further improvement of relevant ethical guidelines and laws and regulations in China.

【Key words】 Intellectual disability; Reproductive techniques, assisted;
Laws and regulations; Ethical principles

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配子与胚胎实验室差错防范策略——“配子安全核查表”的建立与使用

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【摘要】 自1988年中国大陆首例“试管婴儿”诞生至今, 我国辅助生殖技术 (assisted reproductive technology, ART) 日趋成熟。开展 ART 的周期数已超过百万, 辅助生殖机构及从业人员数量亦达一定规模, 为建设生育友好型社会贡献力量。然而, 由于 ART 过程的复杂性, 人员背景多样性及一旦发生错误影响的深远性, 迫切需要建立高效且有效的应对差错防范的安全管理模式。本文旨在梳理 ART 实施的关键过程与步骤, 探寻关键过程的控制措施, 通过“配子安全核查表”的建立和使用, 探讨配子与胚胎实验室差错防范策略。

【关键词】 生殖技术, 辅助; 安全管理; 配子/胚胎实验室; 差错防范

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Error prevention strategies in gamete and embryo laboratories: establishment and implementation of the "Gamete Safety Checklist"

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【Abstract】 Since the birth of the first "test-tube baby" in Chinese mainland in 1988, assisted reproductive technology (ART) in China has matured significantly. The number of ART cycles has surpassed one million, and the number of assisted reproductive institutions and practitioners has attained a significant scale, contributing to the establishment of a fertility-friendly society. However, due to the complexity of the ART process, the diversity of personnel backgrounds, and the profound impact of any error that may occur, there is an urgent need to establish an efficient and effective safety management model for error prevention. This paper aims to outline the key processes and steps involved in the implementation of ART, explore control measures for these critical processes, and delve into error prevention strategies for gamete and embryo laboratories through the creation and utilization of a "gamete safety checklist".

【Key words】 Reproductive technology, assisted; Safety management; Gamete/embryo laboratory; Error prevention

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基于多模型机器学习算法预测体外受精累积活产率的研究

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【摘要】 目的 开发和验证体外受精累积活产率 (cumulative live birth rate, CLBR) 的机器学习预测模型, 并通过 SHAP 值分析模型的重要特征。**方法** 本研究基于 2017 年 1 月至 2022 年 12 月在保定市妇幼保健院生殖医学科接受体外受精-胚胎移植治疗患者的回顾性数据, 共 1 792 个周期。根据活产结局分为活产组 ($n=1 036$) 和非活产组 ($n=756$)。数据集被随机分割为训练集和验证集 (比例 7:3)。模型开发采用 5 种算法: 逻辑回归、随机森林、极端梯度提升树 (extreme gradient boosting, XGBoost)、支持向量机和神经网络。通过受试者工作特征曲线下面积 (area under the curve, AUC)、F1 分数和校准曲线评估模型性能, 并使用临床决策曲线 (decision curve analysis, DCA) 分析评估模型的临床应用价值。采用 SHAP 值分析 XGBoost 模型的特征重要性, 以提升模型解释性。结果 XGBoost 模型在预测 CLBR 方面表现最佳, 测试集数据的准确率为 72.44%, AUC 达到 0.775, F1 分数为 0.654, 准确率和 F1 分数均优于逻辑回归 (准确率为 70.02%, F1 分数为 0.585)、随机森林 (准确率为 71.69%, F1 分数为 0.606)、支持向量机 (准确率为 70.20%, F1 分数为 0.607) 和神经网络 (准确率为 68.72%, F1 分数为 0.560)。XGBoost 的校准曲线接近对角线, 表明它们的预测概率与实际结果非常接近, 具有良好的预测校准度。DCA 分析结果表明, 在大多数临床决策阈值范围内, XGBoost 模型均提供了较高的净获益。SHAP 值分析显示, 体外受精失败次数、窦卵泡计数、抗苗勒管激素水平、精子正常形态率和精子 DNA 碎片指数是预测 CLBR 的关键特征。**结论** XGBoost 模型在预测 CLBR 方面具有良好的预测能力和校准度, 并通过 SHAP 值提供重要特征的解释性, 可为临床制定个性化治疗策略提供有力支持。然而, 模型的泛化能力尚需通过外部数据验证, 以确保其在不同人群中的适用性。

【关键词】 体外受精; 累积活产率; 预测模型; 极端梯度提升树; SHAP
基金项目: 河北省医学科学研究项目 (20232036)

Prediction of cumulative live birth rate in *in vitro* fertilization using multi-model machine learning algorithms

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【Abstract】 Objective To develop and validate machine learning models for predicting the cumulative live birth rate (CLBR) following *in vitro* fertilization

(IVF) and to analyze key predictive features using SHAP values. **Methods** This retrospective study included data from patients who underwent IVF-embryo transfer at the Department of Reproductive Medicine, Baoding Maternal and Child Health Hospital, between January 2017 and December 2022. Patients were categorized into two groups based on live birth outcome: the live birth group ($n=1036$) and the non-live birth group ($n=756$). The dataset was randomly divided into a training set and a validation set in a ratio of 7 : 3. Five algorithms were utilized for model development: logistic regression, random forest, extreme gradient boosting (XGBoost), support vector machine, and neural networks. Model performance was assessed using the area under the receiver operating characteristic (AUC) curve, F1 score, and calibration curves. Clinical decision curve analysis (DCA) was employed to evaluate the clinical utility of the models. SHAP values were used to interpret feature importance in the XGBoost model and enhance its explainability. **Results** The XGBoost model demonstrated the best performance in predicting CLBR, with accuracy of 72.44%, AUC of 0.775, and F1 score of 0.654, accuracy and F1 score outperforming logistic regression (accuracy was 70.02%, F1 score was 0.585), random forest (accuracy was 71.69%, F1 score was 0.606), support vector machine (accuracy was 70.20%, F1 score was 0.607), and neural network (accuracy was 68.72%, F1 score was 0.560). The calibration curve of XGBoost closely aligned with the diagonal line, indicating that the predicted probabilities were very close to the actual outcomes, demonstrating good calibration. DCA indicated that the XGBoost model provided higher net benefits across a wide range of clinical decision thresholds. SHAP value analysis identified number of previous IVF failures, antral follicle count, anti-Müllerian hormone level, percentage of normal sperm morphology, and sperm DNA fragmentation index as key predictors of CLBR. **Conclusion** The XGBoost model exhibits excellent predictive performance and calibration for CLBR, with SHAP values providing important insights into feature importance. This model has the potential to support the development of personalized treatment strategies in clinical practice. However, its generalizability needs to be validated using external datasets to ensure its applicability to diverse populations.

【Key words】 Fertilization *in vitro*; Cumulative live birth rate; Predictive model; Extreme gradient boosting; SHAP

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恶性肿瘤患者辅助生殖助孕实验室结局分析

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【摘要】 目的 探讨罹患恶性肿瘤是否影响患者在首次控制性超促排卵 (controlled ovarian hyperstimulation, COH) 周期中的实验室结局。方法 采用回顾性病例对照研究, 分析 2020 年 1 月至 2024 年 5 月于郑州大学第三附属医院生殖健康医院因恶性肿瘤在放化疗前进行生育力保存患者以及因输卵管因素不孕首次行体外受精/卵胞质内单精子注射 (*in vitro* fertilization/intracytoplasmic sperm injection, IVF/ICSI) 患者的临床及实验室资料。将进行生育力保存的患者记为研究组, 同期因输卵管因素助孕的患者记为对照组。经 1:3 倾向性评分匹配 (propensity score matching, PSM), 研究组纳入患者 40 例, 对照组纳入患者 118 例, 比较两组患者首次 COH 周期中的卵巢反应、获卵结局以及受精后的胚胎发育等实验室结局。结果 PSM 后, 在首次 COH 周期中, 研究组的促性腺激素 (gonadotropins, Gn) 启动剂量 [225.00 (162.50, 300.00) U]、Gn 使用时间 [10.00 (8.00, 11.00) d]、扳机日雌二醇水平 [2487.00 (1461.25, 4090.25) pmol/L] 与对照组 [193.75 (150.00, 225.00) U, $P=0.002$; 12.00 (10.00, 13.00) d, $P<0.001$; 10738.50 (8400.00, 16507.25) pmol/L, $P<0.001$] 相比差异均具有统计学意义; 两组间 Gn 使用总量差异无统计学意义 ($P>0.05$)。两组间获卵数、MII 卵数、正常双原核 (two pronuclei, 2PN) 率、2PN 卵裂率、可利用胚胎率、优质胚胎率、囊胚形成率、可利用囊胚形成率差异均无统计学意义 (均 $P>0.05$)。结论 与输卵管因素助孕患者相比, 恶性肿瘤患者在放化疗前进行 COH 以进行生育力保存的实验室结局无明显差异。

【关键词】 生育力保存; 恶性肿瘤; 控制性超促排卵; 体外受精; 精子注射, 细胞质内

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Analysis of laboratory outcomes in assisted reproductive technology for malignant tumor patients

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【Abstract】 Objective To investigate whether malignant tumors affect the laboratory outcomes of patients in their first controlled ovarian hyperstimulation (COH) cycle. **Methods** This study was a retrospective case-control study that analyzed the clinical and laboratory data of patients who underwent fertility preservation before chemotherapy and radiotherapy due to malignant tumors, as well as patients with infertility caused by tubal factors who first underwent *in vitro* fertilization/intracytoplasmic sperm injection (IVF/ICSI) at the Reproductive Health Hospital of the Third Affiliated Hospital of Zhengzhou University from January 2020 to May 2024. Patients who underwent fertility preservation were designated as the research group, while patients who underwent assisted reproduction due to tubal factors during the same period were designated as control group. After 1 : 3 propensity score matching (PSM), 40 patients were included in the research group and 118 patients were included in control group. The ovarian response, oocyte retrieval outcomes, and embryonic development after fertilization in the first COH cycle were compared between the two groups. **Results** After PSM, the research group and control group showed statistically significant differences in the gonadotropin (Gn) starting dosage [225.00 (162.50, 300.00) U vs. 193.75 (150.00, 225.00) U, $P=0.002$], duration of Gn used [10.00 (8.00, 11.00) d vs. 12.00 (10.00, 13.00) d, $P<0.001$], and average estradiol levels on human chorionic gonadotropin trigger day [2 487.00 (1 461.25, 4 090.25) pmol/L vs. 10 738.50 (8 400.00, 16 507.25) pmol/L, $P<0.001$]. However, no statistically significant difference was found in the total dosages of Gn used between the two groups ($P>0.05$). There were no significant differences between the groups in terms of the number of oocytes retrieved, the number of metaphase II oocytes, two pronuclei (2PN) rate, 2PN cleavage rate, available embryo rate, high-quality embryo rate, blastocyst formation rate, and available blastocyst formation rate (all $P>0.05$). **Conclusion** Compared with infertility patients with tubal factors, there is no significant difference in the laboratory outcomes of malignant tumor patients undergoing COH for fertility preservation prior to chemotherapy and radiation.

【Key words】 Fertility preservation; Malignant tumor; Controlled ovarian hyperstimulation; Fertilization *in vitro*; Sperm injections, intracytoplasmic

Fund program: National Key R&D Program of China (2022YFC2703500); 2023 The Second Batch of Innovative Research and Development Projects in Henan Province (GZS2023002); Henan Young and Middle-aged Health Science and Technology Innovation Leading Talent Training Project (YXKC2021020)

·临床研究·

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血清 AMH 对非嵌合型克氏综合征患者睾丸显微取精结局的预测价值

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【摘要】 目的 探讨抗苗勒管激素 (anti-Müllerian hormone, AMH) 对非嵌合型克氏综合征 (Klinefelter syndrome, KS) 患者显微镜下睾丸切开取精术 (microscopic testicular sperm extraction, micro-TESE) 结局的预测价值, 并寻找 micro-TESE 结局的有效预测因素。方法 采用回顾性病例对照研究, 分析 2018 年 5 月至 2023 年 9 月在郑州大学第一附属医院生殖医学中心就诊的 118 例非嵌合型 KS 患者的临床资料。患者根据 micro-TESE 是否取到精子分为取到精子组 (45 例) 和未取到精子组 (73 例), 比较两组临床资料的差异, 多因素 logistic 回归分析取精结局的影响因素。比较术后睾丸体积和性激素的变化。结果 非嵌合型 KS 患者取精率为 38.1% (45/118)。取到精子组患者的年龄 [(26.93±3.80) 岁] 显著低于未取到精子组 [(28.27±3.92) 岁, $P=0.029$], 而 AMH 水平 [0.44 (0.18, 1.13) $\mu\text{g/L}$] 显著高于未取到精子组 [0.10 (0.03, 0.22) $\mu\text{g/L}$, $P<0.001$]。AMH 是非嵌合型 KS 患者 micro-TESE 结局的独立影响因素 ($OR=7.867$, 95% CI : 2.727~27.242, $P=0.001$), 受试者工作特征曲线下面积为 0.802 (95% CI : 0.722~0.883), 最佳参考阈值范围为 $\geq 0.265 \mu\text{g/L}$ 。所有患者术后睾酮水平中位数降低 0.27 $\mu\text{g/L}$ ($P=0.019$), 黄体生成素水平中位数升高 2.08 U/L ($P=0.049$), 未取到精子组睾酮水平中位数降低 0.29 $\mu\text{g/L}$ ($P=0.022$)。结论 AMH 可以作为非嵌合型 KS 患者 micro-TESE 取精结局的预测因子, 高 AMH 水平提示更高的取精率。

【关键词】 抗苗勒管激素; 无精子症; 克氏综合征; 睾酮; 显微镜下睾丸切开取精术

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Predictive value of serum AMH for micro-TESE outcomes in patients with non-mosaic Klinefelter syndrome

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【 Abstract 】 Objective To investigate the predictive value of anti-Müllerian hormone (AMH) on the outcome of microscopic testicular sperm extraction (micro-TESE) in patients with non-mosaic Klinefelter syndrome (KS) of the clinical data and to identify effective predictors for successful micro-TESE. **Methods** A retrospective case-control study was conducted on the clinical data of 118 non-mosaic KS patients treated at the Center for Reproductive Medicine of the First Affiliated Hospital of Zhengzhou University between May 2018 and September 2023. Patients were divided into two groups based on whether sperm were successfully retrieved via micro-TESE: the sperm retrieved group ($n=45$) and the no sperm retrieved group ($n=73$). Differences between the two groups were compared, and multivariate logistic regression analysis was used to identify factors influencing sperm retrieval. Changes in testicular volume and sex hormone levels before and after surgery were also assessed. **Results** The sperm retrieval rate was 38.1% (45/118). Patients in the sperm retrieved group were significantly younger $[(26.93\pm3.80)$ years] than those in the no sperm retrieved group $[(28.27\pm3.92)$ years, $P=0.029$], and the AMH level was significantly higher $[0.44$ (0.18, 1.13) $\mu\text{g/L}]$ than that in the no sperm retrieved group $[0.10$ (0.03, 0.22) $\mu\text{g/L}$, $P<0.001$]. AMH was identified as an independent predictor of micro-TESE outcome in non-mosaic KS patients ($OR=7.867$, 95% CI : 2.727-27.242, $P=0.001$). The area under the receiver operating characteristic curve was 0.802 (95% CI : 0.722-0.883), and the optimal reference threshold for AMH was ≥ 0.265 $\mu\text{g/L}$. Postoperatively, testosterone levels decreased significantly by a median of 0.27 $\mu\text{g/L}$ ($P=0.019$), while luteinizing hormone levels increased by a median of 2.08 U/L ($P=0.049$), with a more significant decline in testosterone levels observed in the no sperm retrieved group by a median of 0.29 $\mu\text{g/L}$ ($P=0.022$). **Conclusion** AMH can predict successful micro-TESE in non-mosaic KS patients, with higher AMH levels indicating a higher likelihood of success.

【Key words】 Anti-Müllerian hormone; Azoospermia; Klinefelter syndrome; Testosterone; Microscopic testicular sperm extraction

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实验研究

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第3天胚胎培养液代谢组学分析预测早期胚胎发育潜能的初步研究

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【摘要】 目的 探讨不同发育潜能胚胎第3天 (day 3, D3) 培养液代谢图谱的差异, 以为代谢组学筛选胚胎技术平台的建立提供理论基础。方法 选取2023年11月13日至2023年12月5日在广西壮族自治区妇幼保健院生殖医学中心行体外受精-胚胎移植 (*in vitro* fertilization and embryo transfer, IVF-ET) 治疗的8例患者为研究对象, 收集患者胚胎的D3培养液, 依据D5囊胚形成情况, 将其分为优质囊胚组 ($n=42$)、非优质囊胚组 ($n=33$) 和未形成囊胚组 ($n=43$), 应用高效液相色谱-质谱技术对3组胚胎的D3培养液进行非靶向代谢组学检测与分析。结果 ①不同发育潜能胚胎的D3培养液代谢物差异显著, 其中囊胚形成组与未形成囊胚组之间存在79个差异代谢物 (均 $P<0.05$); 优质囊胚组与非优质囊胚组之间鉴定出73个差异代谢物 (均 $P<0.05$)。②显著差异代谢物预测D3囊胚形成及优质囊胚形成潜能的受试者工作特征曲线下面积均 >0.9 , 预测性能良好。③KEGG通路富集分析显示, 与囊胚形成能力相关的差异代谢物主要富集在D-氨基酸代谢、甘氨酸-丝氨酸-苏氨酸代谢、精氨酸生物合成、组氨酸代谢等通路 ($P<0.05$); 与优质囊胚形成能力相关的差异代谢物主要富集在色氨酸代谢、D-氨基酸代谢、5-羟色胺能突触和蛋白质的消化和吸收等通路 ($P<0.05$)。结论 不同发育潜能的胚胎具有显著差异的代谢图谱, 利用代谢组学分析预测D3胚胎发育潜能具有可行性。

【关键词】 代谢组学; 生殖技术, 辅助; 胚胎发育潜能; 胚胎培养液; 液相色谱-质谱联用

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Preliminary study on predicting early embryonic developmental potential by metabolomics analysis of day 3 embryo culture medium

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【Abstract】 Objective To explore the differences of metabolomic profiles in day 3 (D3) culture medium of embryos with varying developmental potentials, in order to provide a theoretical foundation for the establishment of embryo selection technology platform using metabolomics. **Methods** Eight patients who received *in vitro* fertilization and embryo transfer (IVF-ET) treatment at Reproductive Medicine Center of Guangxi Zhuang Autonomous Region Maternal and Child Health Hospital between November 13 and December 5, 2023 were selected as the study subjects. The D3 culture medium from patient embryos was collected and divided into high-quality blastocysts ($n=42$), non-high-quality blastocysts ($n=33$), and embryos that failed to form blastocysts (non-formation group, $n=43$) according to the formation of day 5 blastocysts. High-performance liquid chromatography-mass spectrometry was employed to perform non-targeted metabolomic analysis in the D3 culture medium from three distinct groups. **Results** 1) The metabolites in D3 culture medium of embryos with varying developmental potentials exhibit significant differences. Specifically, 79 differential metabolites were identified between the blastocyst formation group and the non-blastocyst formation group (all $P<0.05$); additionally, 73 differential metabolites were found between the high-quality blastocyst group and the non-high-quality blastocyst group (all $P<0.05$). 2) The area under the receiver operating characteristic curve of significantly differential metabolites for predicting potential of D3 embryo blastocyst formation and high-quality blastocyst formation were both greater than 0.9, demonstrating excellent predictive performance. 3) KEGG pathway enrichment analysis revealed that differential metabolites associated with blastocyst formation potential were primarily enriched in pathways including D-amino acid metabolism, glycine-serine-threonine metabolism, arginine biosynthesis, and histidine metabolism ($P<0.05$). For high-quality blastocyst formation, the differential metabolites were predominantly enriched in pathways related to tryptophan metabolism, D-amino acid metabolism, serotonergic synapses, and protein digestion and absorption ($P<0.05$). **Conclusion** Embryos with different developmental potentials have significantly different metabolic profiles, and it is feasible to predict the developmental potential of D3 embryos by metabolomics analysis.

【Key words】 Metabolomics; Reproductive technology, assisted; Embryo development potential; Embryo culture medium; Liquid chromatograph-mass spectrometer

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数据非依赖采集蛋白组学技术筛选 多囊卵巢综合征患者血清蛋白标志 物的研究

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【摘要】 目的 探索利用高通量的数据非依赖采集 (data independent acquisition, DIA) 蛋白质组学技术筛选多囊卵巢综合征 (polycystic ovary syndrome, PCOS) 患者血清生物标志物。方法 采用病例对照研究, 收集 2021 年 3~11 月在江西省妇幼保健院辅助生殖医学中心诊断为 PCOS 患者的外周血样本 20 例, 同期收集因男方因素导致不孕行辅助生殖的 19 例女性外周血样本作为对照组。DIA 组学结合生物信息学分析, 筛选 PCOS 患者血清差异蛋白质表达谱, 选取典型差异表达蛋白进行表达分析、受试者工作特征 (receiver operating characteristic, ROC) 曲线分析及酶联免疫吸附法 (enzyme-linked immunosorbent assay, ELISA) 验证。结果 DIA 组学结合生物信息学分析结果显示, 与对照组相比, 在 PCOS 患者外周血中筛选到显著性差异表达蛋白 194 个, 其中表达上调蛋白 64 个, 表达下调蛋白 130 个。ROC 曲线分析结果显示 PSMD8、RPS15A、NDUFB1、GM2A 及 TOP2A 的曲线下面积值均为 0.9 以上, 表明这些蛋白质具有良好的诊断价值。ELISA 验证结果表明, PCOS 患者外周血中 TOP2A 的含量显著高于对照组 ($P=0.046$), GM2A 的含量显著低于对照组 ($P=0.021$), 与 DIA 结果一致。结论 利用 DIA 蛋白组学可筛选出 PCOS 患者外周血差异表达蛋白谱, 其中

PSMD8、RPS15A、NDUFB1、GM2A 及 TOP2A 可作为 PCOS 诊断和治疗的血清生物标志物。

【关键词】 多囊卵巢综合征； 数据非依赖采集蛋白质组学； 外周血； 生物标志物

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Study on data independent acquisition proteomics technology for screening serum protein markers in patients with polycystic ovary syndrome

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【Abstract】 Objective To screen serum biomarkers of polycystic ovary syndrome (PCOS) patients by high throughput data independent acquisition (DIA) proteomics technology. **Methods** This was a case-control study. A total of 39 peripheral blood samples were collected at Reproductive Medical Center of Jiangxi Maternal and Child Health Hospital from March to November 2021. Among which, 20 cases were from PCOS patients, and 19 cases were from women who underwent assisted reproduction due to male factors causing infertility. DIA proteomics technology combined with bioinformatics analysis were performed to screen for differential protein expression profiles in the serum of PCOS patients. Typical differentially expressed proteins were selected for expression analysis and receiver operating characteristic (ROC) curve analysis, followed by enzyme-linked immunosorbent assay (ELISA) validation. **Results** The results of DIA proteomics combined with bioinformatics analysis showed that compared with control group, 194 significantly differentially expressed proteins were screened in the peripheral blood of PCOS patients, including 64 upregulated proteins and 130 downregulated proteins. The ROC curve analysis results showed that the area under curve values of PSMD8, RPS15A, NDUFB1, GM2A, and TOP2A were all above 0.9, indicating that these proteins have good diagnostic value. The ELISA validation results showed that the content of TOP2A in peripheral blood of PCOS patients was significantly upregulated ($P=0.046$), while the content of GM2A was significantly downregulated ($P=0.021$), when compared with control group, which consistent with the DIA results. **Conclusion** DIA proteomics can be used to screen the differential expression of peripheral blood proteins in PCOS patients, among which, PSMD8, RPS15A, NDUFB1, GM2A and TOP2A can be used as serum biomarkers for PCOS diagnosis and treatment.

【Key words】 Polycystic ovary syndrome; Biomarkers data independent acquisition proteomics; Peripheral blood; Biomarker

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·现场调查·

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中国 16 610 例普通育龄女性 *FMR1* 基因 CGG 重复数的分布情况研究

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【摘要】 目的 调查我国普通育龄女性中 *FMR1* 基因 CGG 重复数的分布情况, 为脆性 X 综合症的携带者筛查及遗传咨询提供数据参考。方法 本课题采用横断面研究, 于 2022 年 7 月至 2023 年 10 月在 12 家医疗机构招募 16 610 例育龄女性, 抽取外周静脉血 3 mL, 提取 DNA, 采用三重引物聚合酶链式反应加毛细管电泳技术, 检测 *FMR1* 基因 CGG 重复次数, 并对检测结果进行统计分析。结果 16 610 例育龄女性中, 5 684 例 (34.220%) 女性 *FMR1* 两个等位基因 CGG 重复次数相同, 10 926 例 (65.780%) 女性两个等位基因重复次数不同。在 16 610 例普通育龄女性的 33 220 个 *FMR1* 等位基因中, 最常见的 CGG 重复数为 29 [48.645% (16 160/33 220)] 和 30 [26.276% (8 729/33 220)], 最常见的等位基因型为 CGG 29/29 [24.726% (4 107/16 610)]。16 498 例 (99.326%) 女性 *FMR1* 基因 CGG 重复数在正常范围, 112 例 (0.674%) 女性 *FMR1* 基因 CGG 重复数异常。其中 96 例为中间型携带者 (0.578%), 15 例为前突变携带者 (0.090%), 1 例为全突变携带者 (0.006%), 其 *FMR1* 基因 CGG 重复数为 (36, >200)。结论 我国普通育龄女性的 *FMR1* 基因 CGG 重复数正常型为 99.326%, 中间型携带率为 0.578%, 前突变型和全突变型的总体携带率为 0.096%。

【关键词】 脆性 X 综合征; *FMR1*; 单基因病携带者筛查; 产前诊断; 遗传咨询

基金项目: 国家重点研发计划 (2021YFC1005300); 军队后勤科研项目计划生育专项课题 (23JSZ17)

Study on the distribution of *FMR1* CGG repeat numbers among 16 610 women of childbearing age in China

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【Abstract】 Objective To investigate the distribution of CGG repeat numbers in the *FMR1* gene among reproductive-age women in China, providing data reference for carrier screening and genetic counseling of Fragile X syndrome. **Methods** This cross-sectional study recruited 16 610 reproductive-age women from 12 medical institutions between July 2022 and October 2023. Peripheral venous blood samples (3 mL) were collected, and genomic DNA was extracted. The number of CGG repeats in the *FMR1* gene was determined using the triplet-primed polymerase chain reaction (TP-PCR) combined with capillary electrophoresis technology. Statistical analyses were performed to assess the prevalence and distribution of CGG repeat expansions. **Results** Among 16 610 women of childbearing age, 5 684 (34.220%) women had the same number of CGG repeats in the two alleles of *FMR1* gene, and 10 926 (65.780%) women had different numbers of repeats in the two alleles. Among the 33 220 *FMR1* alleles in 16 610 women of reproductive age, the most common CGG repeat numbers were 29 [48.645% (16 160/33 220)] and 30 [26.276% (8 729/33 220)], while the most frequent CGG genotype was CGG 29/29 [24.726% (4 107/16 610)]. The CGG repeat numbers of *FMR1* gene were normal in 16 498 women (99.326%). Among the 112 women (0.674%) with CGG repeat abnormalities, 96 (0.578%) women were classified as intermediate carriers, 15 (0.090%) as premutation carriers, and 1 (0.006%) as a full mutation carrier, whose CGG genotype was (36, >200). **Conclusion** In the general reproductive-age female population in China, the normal CGG repeat numbers of the *FMR1* gene account for 99.326%, while the intermediate carrier

rate is 0.578%, and the combined carrier rate of the premutation and full mutation types is 0.096%.

【Key words】 Fragile X syndrome; *FMR1*; Monogenic disease carrier screening; Prenatal diagnosis; Genetic counselling

Fund program: National Key Research and Development Program of China (2021YFC1005300); Military Logistics Research Project Family Planning Project (23JSZ17)

专家视角

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辅助生殖子代青春期健康风险: 机制与研究现状

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【摘要】 辅助生殖技术 (assisted reproductive technology, ART) 的广泛应用为全球范围内的不孕不育夫妇带来了生育的希望。然而, 随着 ART 的应用逐渐普及, ART 子代的长期健康状况越来越受到社会广泛关注。青春期是个体从儿童过渡到成人的关键发育时期, 伴随着生理和心理的重大变化, 因此 ART 子代在这一时期的健康状况对其未来的整体健康具有深远影响。本文对现有研究进行综述, 重点分析了 ART 对子代在青春期阶段多个健康领域的影响, 特别是生长发育、心血管健康、内分泌功能、生育力、癌症风险以及特应性疾病、心理健康、表观遗传改变等多个方面; 并探讨了导致这些健康问题的可能机制, 包括遗传因素、环境暴露以

及生命早期干预的长期效应。未来研究应继续探索 ART 对子代健康的长期影响，并进一步明确这些影响的发生机制，从而为制定有效的预防和干预措施提供科学依据。

【关键词】 生殖技术，辅助； 青春期； 生育力； 内分泌系统； 子代健康

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Adolescent health risks in offspring conceived through assisted reproductive technology: mechanisms and research status

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【Abstract】 The wide application of assisted reproductive technology (ART) has brought the hope of fertility to infertile couples worldwide. However, with the gradual popularization of ART, the long-term health status of ART children has attracted extensive attention from society. Adolescence is a critical developmental period for individuals to transition from childhood to adulthood, with significant physical and psychological changes, so the health status of ART offspring during this period has a profound impact on their overall future health. This article reviews the existing studies, focusing on the effects of ART on multiple aspects of adolescent health, especially growth and development, cardiovascular health, endocrine function, fertility, cancer risk, atopic diseases, mental health, epigenetic changes and other aspects. The possible mechanisms leading to these health problems, including genetic factors, environmental exposures, and the long-term effects of early life interventions, were explored. Future research should continue to explore the long-term effects of ART on the health of offspring and further clarify the mechanisms of these effects, so as to provide a scientific basis for the development of effective prevention and intervention measures.

【 Key words 】 Reproductive techniques, assisted; Puberty; Fertility; Endocrine system; Offspring health

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综述

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卵巢微环境与多囊卵巢综合征关系的研究进展

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【摘要】 多囊卵巢综合征 (polycystic ovary syndrome, PCOS) 是导致女性不孕的主要内分泌生殖疾病。卵泡发育障碍作为稀发排卵的主因, 是影响 PCOS 患者生育力的关键, 其中卵巢微环境紊乱是造成卵泡发育障碍的重要诱因。近年来, 研究显示卵巢微环境通过卵巢内细胞成分、细胞外基质、血管供给、激素和生长因子等多个方面的协同作用精细调控卵泡发育与成熟, 为女性的生殖健康提供重要保障。PCOS 患者卵巢微环境异常, 导致细胞外基质沉积和纤维化、血管结构和功能异常、免疫炎症反应、代谢紊乱进而影响卵泡生长发育, 从而导致排卵障碍。文章就以上几方面展开综述。

【关键词】 多囊卵巢综合征; 卵巢微环境; 卵泡发育障碍

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Research progress on the relationship between ovarian microenvironment and polycystic ovary syndrome

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【Abstract】 Polycystic ovary syndrome (PCOS) is a prevalent endocrine disorder in women that is a leading cause of infertility. Follicular development disorder, as the main cause of oligoovulation, is the key factor affecting the fertility of PCOS patients. Among them, the disorder of the ovarian microenvironment is an important inducement for follicular development disorder. Emerging research highlights that the ovarian microenvironment plays a sophisticated role in follicular development and maturation through various mechanisms, including the cellular constituents within the ovary, the extracellular matrix's structural support,

adequate vascular supply, and the regulation of hormonal and growth factor signaling. These factors collectively ensure the normal growth and ovulation of follicles, thereby safeguarding female reproductive health. In women with PCOS, however, the ovarian microenvironment is compromised, leading to excessive extracellular matrix deposition and fibrosis, abnormalities in vascular architecture and function, immune-inflammatory reactions, and metabolic disturbances. These anomalies collectively hinder follicular growth and development, resulting in ovulation disorders. This comprehensive review will delve into the intricacies of these disruptions and their implications for fertility in PCOS patients.

【Key words】 Polycystic ovary syndrome; Ovarian microenvironment; Follicular development disorder

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环境金属元素暴露与女性生殖健康及辅助生殖助孕结局的相关研究进展

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【摘要】 金属元素广泛存在于人们所处的日常环境中。随着工业活动的增加, 人们面临着比以往更多的金属暴露, 甚至在卵泡液中已检测出多种金属元素。大多数人生活在环境背景量的金属暴露下, 而非职业性长期暴露。因此, 本文中的“环境金属元素”特指人们日常背景环境中的金属元素。研究环境金属元素暴露对女性生育能力的潜在影响具有重要意义。本文就环境金属元素暴露对女性生殖健康影响的最新研究进展进行综述, 探讨金属元素的毒性机制, 并提出可能的解毒和干预策略, 为保护女性生殖健康提供科学依据。

【关键词】 生殖技术, 辅助; 女性生殖健康; 卵巢功能; 金属元素暴露

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Advances in research related to environmental metal element exposure and female reproductive health and outcomes of assisted reproductive technology

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【 Abstract 】 Metal elements are widely present in people's daily environment. With the increase of industrial activities, people are facing more metal exposures than ever before, and even several metal elements have been detected in follicular fluid. Most people live with environmental background levels of metal exposure rather than occupational long-term exposure. Therefore, the term "environmental metals" in this paper refers specifically to the metals in people's daily background environment. It is important to investigate the potential effects of environmental metal exposure on female fertility. In this paper, we summarize the latest research progress on the effects of environmental metal element exposure on women's reproductive health, discuss the toxicity mechanisms of metal elements, and propose possible detoxification and intervention strategies to provide scientific evidence for the protection of women's reproductive health.

【 Key words 】 Reproductive technology, assisted; Female reproductive health; Ovarian function; Exposure of metallic elements

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$PM_{2.5}$ 暴露对胎儿生长受限的影响及机制研究进展

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【摘要】 大气细颗粒物 (fine particulate matter, PM_{2.5}) 对人类健康的不良影响已经成为全球范围内广泛关注的重大公共卫生问题。孕妇和胎儿作为易感人群, 更容易受到 PM_{2.5} 污染的威胁。越来越多的研究显示, PM_{2.5} 暴露是导致胎儿生长受限 (fetal growth restriction, FGR) 的重要危险因素, 并可能是通过氧化应激、炎症反应、内分泌紊乱、表观遗传学修饰、自噬异常和肠道菌群紊乱等作用途径而导致 FGR 的发生。本文对 PM_{2.5} 暴露所致 FGR 的研究进展作一综述, 以期对相关病理机制和干预技术的研究提供线索和参考。

【关键词】 空气污染; 妊娠并发症; 分子机制; 炎症反应; 表观遗传修饰

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Research progress on the effects and mechanisms of fetal growth restriction induced by PM_{2.5} exposure

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【Abstract】 The adverse effects of fine particulate matter (PM_{2.5}) on human health have become a major global public health concern. Pregnant women and fetuses, as susceptible populations, are more vulnerable to the threat of PM_{2.5} pollution. Increasing studies indicate that PM_{2.5} exposure is an important risk factor of fetal growth restriction (FGR), and oxidative stress, inflammatory response, endocrine disorders, epigenetic modifications, autophagic abnormalities, and gut microbiota dysbiosis may be the biological mechanisms underlying PM_{2.5}-induced FGR. This study offers insights for the development of targeted preventive and therapeutic methods for FGR caused by PM_{2.5}.

【 Key words 】 Air pollution; Pregnancy complications; Molecular mechanisms; Inflammatory response; Epigenetic modifications

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着床前胚胎发育过程中细胞凋亡的研究进展

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【摘要】 细胞程序性死亡或凋亡是一种普遍存在的生物学现象。胚胎早期发育虽然以细胞分裂、增殖为主,但是也存在细胞凋亡。细胞凋亡紊乱可能导致胚胎发育异常或停滞,甚至胚胎死亡。细胞凋亡以典型的细胞改变为特征,如膜起泡、染色质凝集和 DNA 断裂。它涉及许多膜受体(例如 Fas、TNFR)和一系列信号转导步骤,并导致许多半胱氨酸蛋白酶的激活。着床前胚胎的凋亡可以由各种内外部因素诱发,内部因素如:DNA 损伤、内质网应激、线粒体功能障碍;外部因素如:细胞凋亡相关受体的激活、各种细胞外因素刺激等。了解细胞凋亡对早期胚胎发育的影响及其机制,有助于深入了解胚胎发育机制,同时可以优化胚胎培养条件、减少细胞凋亡导致的负面影响,从而为临床实践带来指导。因此,本文就细胞凋亡及其在早期着床前胚胎发育中的作用进行综述。

【关键词】 凋亡; 凋亡诱导因子; 凋亡调节蛋白质类; 早期胚胎发育

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Research progress of apoptotic events during preimplantation embryonic development

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【Abstract】 Programmed cell death or apoptosis is a common biological phenomenon. Although early embryonic development is dominated by cell division and proliferation, there are also apoptotic events. The disturbance of apoptosis may lead to abnormal or stagnant embryo development, or even embryo death. Apoptosis is characterized by typical cell changes such as membrane blistering, chromatin clotting, and DNA breakage. It involves many membrane receptors (e.g., Fas, TNFR) and a series of signal transduction steps, and leads to the activation of many cysteine proteases. Preimplantation embryo apoptosis can be induced by various internal and external factors. Internal factors such as DNA damage, endoplasmic reticulum stress, mitochondrial dysfunction; external factors such as activation of apoptosis-related receptors, stimulation of various extracellular factors, etc. Understanding the influence of apoptosis on early embryonic development and its mechanism is helpful to further understand the embryonic development mechanism, and can optimize the embryo culture conditions and reduce the negative effects of apoptosis, so as to provide guidance for clinical practice. Therefore, this article reviews the apoptotic events and their role in early preimplantation embryonic development.

【Key words】 Apoptosis; Apoptosis-inducing factors; Apoptosis-regulating proteins; Early embryonic development

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