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人工智能在辅助生殖技术领域的应用进展

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【摘要】 人工智能 (artificial intelligence, AI) 在人类辅助生殖技术 (assisted reproductive technology, ART) 领域的应用日益受到关注, 一些 AI 技术已经应用于 ART 临床实践, 协助医生进行精液分析、胚胎选择以及子宫内膜容受性评估等工作, 并在改善患者预后、提高医生工作效率方面展现了巨大的潜力。然而, 目前大多数研究仍处于探索阶段。规范 AI 的开发流程、增进医患双方对 AI 的认知并促进其与临床实践融合, 有助于推动 AI 技术的进步。本文对 AI 在 ART 领域各环节中的研究应用进展进行综述, 并探讨该技术面临的挑战和发展方向。

【关键词】 人工智能; 机器学习; 生殖医学; 生殖技术, 辅助; 不孕

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Progress of artificial intelligence in assisted reproductive technology

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【Abstract】 Artificial intelligence (AI) in human assisted reproductive technology (ART) is gaining attention. AI technologies have been applied in ART clinical practice to assist doctors in performing semen analysis, embryo selection, and endometrial receptivity assessment, improving patient's outcomes and physician efficiency. However, most researches are experimental. Standardizing AI development, enhancing understanding among physicians and patients, and integrating AI with clinical practice are crucial. This review summarizes AI

researches and applications in ART, discusses challenges, and explores future directions.

【Key words】 Artificial intelligence; Machine learning; Reproductive medicine; Reproductive techniques, assisted; Infertility

Fund program: National Natural Science Foundation of China (82360308); Natural Science Foundation of Guangxi Zhuang Autonomous Region (2019GXNSFFA24501); Outstanding Young Scholars Training Program of Guangxi Medical University (2020-2025); Special Fund for Women's Fertility Protection and Improvement Innovation Team of the First Affiliated Hospital of Guangxi Medical University (YYZS2021001)

ART 与 AI 专栏

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人工智能在子宫内膜异位症诊疗中的应用进展

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【摘要】 子宫内膜异位症 (endometriosis, EMS) 是在育龄女性中普遍存在的一种慢性全身性疾病。这种疾病的体征和症状并不特异, 病情严重程度各异, 导致了临床上的异质性, 这增加了诊断的难度, 严重影响患者的生活质量, 还占用大量社会卫生资源。人工智能 (artificial intelligence, AI) 是指利用计算机技术使机器具备模拟人类智能的能力, 包括感知、学习、推理、决策和语言理解等。AI 作为一个强大的数据挖掘工具, 能够处理大量的医疗数据, 并根据患者的具体情况进行诊断、管理和治疗。特别是在 EMS 的诊断过程中, 利用 AI 可以提高检出率, 缩短诊断时间, 同时增加诊断灵敏度和特异度。本文就医疗大数据和 AI 对 EMS 的诊断、治疗等方面的应用进行综述, 为进一步提高诊断效率和治疗效果提供新的辅助工具。

【关键词】 子宫内膜异位症; 人工智能; 诊断; 治疗

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Advances in the use of artificial intelligence in the diagnosis and treatment of endometriosis

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【Abstract】 Endometriosis (EMS) is a chronic systemic disease prevalent in women of reproductive age. The signs and symptoms of this disease are not specific, and the severity of the disease varies, leading to clinical heterogeneity, which increases the difficulty of diagnosis. It seriously affects the quality of life of patients and also occupies a large amount of social health resources. Artificial intelligence (AI) refers to the ability of a computer technology to enable machines to simulate human intelligence, including perception, learning, reasoning, decision making and language understanding. AI serves as a powerful data-mining tool capable of processing large amounts of medical data and diagnosing, managing, and treating patients according to their specific conditions. Especially in the diagnostic process of EMS, the use of AI can improve the detection rate and shorten the diagnostic time while increasing the diagnostic sensitivity and specificity. In this paper, we provide an overview of the application of medical big data and AI to the diagnosis and treatment of EMS in order to provide new aids to further improve diagnostic efficiency and therapeutic efficacy.

【 Key words 】 Endometriosis; Artificial intelligence; Diagnosis; Therapeutics

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·ART 与 AI 专栏·

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生殖健康护理的智能化进展：探索人工智能技术在辅助生殖领域的应用与融合

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【摘要】 近年来智能化护理正逐步改变传统的护理模式, 人工智能 (artificial intelligence, AI) 技术在辅助生殖领域的应用逐步拓宽。本文系统分析了 AI 在生殖健康护理多个方面的应用, 同时总结了此过程面临的挑战, 包括数据隐私、技术可靠性、伦理道德和法律制度, 以及人文关怀等。本文对 AI 在辅助生殖领域的应用契机和随之而来的问题进行了深入剖析, 旨在为今后的研究提供方向, 以保障 AI 技术能够安全、高效地与生殖健康护理领域相融合。

【关键词】 人工智能; 生殖技术, 辅助; 护理; 智能化

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Advancements in the smartification of reproductive health care: examining the utilization and convergence of artificial intelligence technologies in assisted reproduction

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【Abstract】 Recently, intelligent care is gradually changing the traditional care way, and artificial intelligence (AI) application is gradually broadening in the field of assisted reproduction. This review systematically analyzes the AI application in multiple aspects of reproductive health care. It also indicates the challenge during the process, including data privacy, technical reliability, ethics and legal provisions, and humanistic care. Both the opportunities of AI in assisted reproduction are highlighted and the ensuing problems are analyzed in depth. The purpose is to provide ideas for future studies to ensure that AI technology can be safely, efficiently and responsibly integrated with the field of reproductive health care.

【Key words】 Artificial intelligence; Reproductive techniques, assisted; Nursing; Intelligence

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人工智能结合胚胎时差成像在临床胚胎选择中的应用

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【摘要】 人工智能(artificial intelligence, AI)与时差成像(time-lapse, TL)技术的结合在辅助生殖领域的胚胎选择中展现出巨大潜力。此技术不仅减少了传统胚胎选择过程中的主观性, 还显著减轻了医务人员的工作量。通过自动识别胚胎发育阶段及特征, 无创预测胚胎倍性, 以及预测胚胎移植后的种植、妊娠和活产结局, AI 为胚胎选择提供了更为精准的手段。本综述归纳了近年来该领域的代表性研究成果, 并从数据筛选、模型构建及评估 3 个维度深入探讨了 AI 结合 TL 进行胚胎选择的策略。尽管目前 AI 尚不能完全实现胚胎的自动化选择, 但它已能在一定程度上辅助胚胎学家进行胚胎标注与筛选, 有效减少了主观判断的差异, 并减轻了工作负担。现有的卵子质量评分、胚胎倍性预测及移植结局预测软件在临床研究中展现出良好的效能, 但未来仍需构建高质量的数据集, 并开展多中心、多设备、大样本的前瞻性研究以进一步优化和完善。AI 与 TL 技术在胚胎选择领域的融合发展, 无疑值得临床医生和胚胎学家给予持续关注与探索。

【关键词】 人工智能; 决策支持系统, 临床; 时差成像; 胚胎选择

Application of artificial intelligence combined with time-lapse imaging in clinical embryo selection

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【 Abstract 】 Artificial intelligence (AI) integrated with time-lapse (TL) imaging for embryo selection significantly minimizes subjectivity and workload in traditional methods, marking a pivotal advancement in the realm of assisted reproductive technology. This review comprehensively summarizes the representative studies conducted in recent years within these domains and delves into the application of AI combined with TL imaging for embryo selection from three perspectives: data selection, model selection, and model evaluation. While AI research has yet to fully achieve automated embryo selection, it has already commenced assisting embryologists in annotating and selecting embryos to a considerable extent, thereby reducing subjective discrepancies and easing the workload. Existing software for oocyte quality scoring, embryo ploidy prediction, and transfer outcome forecasting has exhibited promising performance in studies. However, there remains an ongoing need for the development of high-quality datasets and the conduct of prospective, multicenter studies with large sample sizes across diverse devices. The evolution of AI combined with TL imaging in the field of embryo selection merits heightened attention from both clinicians and embryologists.

【 Key words 】 Artificial intelligence; Decision support systems, clinical; Time-lapse; Embryo selection

·ART 与 AI 专栏·

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人工智能在胚胎形态学评估中的应用现状、局限性与技术瓶颈

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【摘要】 本文对人工智能 (artificial intelligence, AI) 技术在体外受精胚胎形态学评估中的应用现状、技术瓶颈及突破路径进行综述。AI 技术在胚胎图像处理 and 时差分析等方面展现出显著优势，能够克服传统人工评估中的主观性问题。然而，当前 AI 应用仍面临数据质量与数量不足、模型解释性欠佳、生物多样性带来的挑战以及临床实践中的实际瓶颈等问题。针对这些限制，文章提出了基于区块链的大规模数据共享、生成对抗网络数据扩充、多模态数据整合以及虚拟实验室平台等创新性解决方案。通过多学科交叉融合与技术创新，AI 有望在未来实现胚胎选择的个性化与精准化，进一步提升体外受精治疗的成功率。

【关键词】 生殖技术；辅助；胚胎选择；人工智能；区块链数据共享；多模态整合

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Current applications, limitations, and technical bottlenecks of artificial intelligence in embryo morphological assessment

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【 Abstract 】 This paper reviews the current applications, technical bottlenecks, and potential breakthrough pathways of artificial intelligence (AI) technology in embryo morphological assessment during *in vitro* fertilization (IVF). Research indicates that AI technology demonstrates significant advantages in embryo image processing and time-lapse analysis, effectively addressing the subjectivity issues inherent in traditional manual assessment. However, current AI applications still face several challenges, including insufficient data quality and quantity, limited model interpretability, challenges arising from biological diversity, and practical bottlenecks in clinical implementation. To address these limitations, the paper proposes innovative solutions, including blockchain-based global data sharing, data augmentation using generative adversarial networks, multimodal data integration, and virtual laboratory platforms. Through interdisciplinary integration and technological innovation, AI shows promise in achieving personalized and precise embryo selection, potentially improving IVF success rates in the future.

【 Key words 】 Reproductive technology, assisted; Embryo selection; Artificial intelligence; Blockchain data sharin; Multimodal integration

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维生素 D 缺乏对 PCOS 和卵巢储备功能正常女性 IVF-ET 助孕结局的影响

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【摘要】 目的 探究维生素 D 缺乏对多囊卵巢综合征 (polycystic ovary syndrome, PCOS) 和因输卵管因素或男方因素致不孕的卵巢储备功能正常 (normal ovarian reserve, NOR) 患者体外受精-胚胎移植 (*in vitro* fertilization and embryo transfer, IVF-ET) 助孕结局的影响。方法 通过回顾性队列研究, 选取 2018 年 1 月至 2023 年 12 月期间于郑州市妇幼保健院生殖遗传科首次行 IVF-ET 的不孕女性, 其中 PCOS 患者 318 例 (P 组), NOR 患者 528 例 (N 组)。根据血清 25 羟维生素 D [25 (OH) D] 水平将每组分为 3 个亚组: 严重缺乏亚组 [25 (OH) D < 12 μ g/L]、缺乏亚组 [12 μ g/L $\leq$ 25 (OH) D < 20 μ g/L] 和非缺乏亚组 [25 (OH) D $\geq$ 20 μ g/L]。分析维生素 D 缺乏对两组患者助孕结局的影响。再采用 1:1 倾向性评分对两组患者的基本资料进行匹配, 匹配到 P 组和 N 组患者各 158 例, 比较两组患者在相同维生素 D 状态下的助孕结局。结果 ①PCOS 患者亚组间一般资料和助孕情况差异均无统计学意义 (均 $P > 0.05$); 严重缺乏亚组的双原核 (two pronuclei, 2PN) 率 [59.93% (721/1 203)] 显著低于缺乏亚组 [63.70% (1 032/1 620)], 差异具有统计学意义 ($P = 0.045$), 且二者均低于非缺乏亚组 [68.06% (554/814)], 差异均具有统计学意义 ($P < 0.001$, $P = 0.037$); 亚组间获卵数、MII 卵数、MII 卵率、2PN 数、2PN 率、卵裂数、卵裂率、第 3 天 (day 3, D3) 可用胚胎数、D3 优质胚胎数、D3 优质胚胎率、临床妊娠率、胚胎着床率、早期流产率、活产率和早产率

差异均无统计学意义 (均 $P>0.05$) ; 女方年龄 ($OR=0.930$, 95% CI : $0.871\sim0.992$, $P=0.028$) 、移植日子宫内膜厚度 ($OR=0.877$, 95% CI : $0.791\sim0.971$, $P=0.012$) 、D3 优质胚胎数 ($OR=1.135$, 95% CI : $1.050\sim1.228$, $P=0.001$) 和促排卵方案 ($OR=2.230$, 95% CI : $1.153\sim4.314$, $P=0.017$) 为临床妊娠的独立影响因素。②NOR 患者亚组间一般资料、助孕情况、胚胎实验室参数和助孕结局相关的观察指标差异均无统计学意义 (均 $P>0.05$) ; 女方年龄 ($OR=0.944$, 95% CI : $0.900\sim0.990$, $P=0.018$) 、D3 优质胚胎数 ($OR=1.070$, 95% CI : $1.004\sim2.597$, $P=0.037$) 和移植胚胎数 ($OR=1.753$, 95% CI : $1.184\sim2.597$, $P=0.005$) 是临床妊娠的独立影响因素。③匹配后 P 组和 N 组间基本资料和助孕情况差异均无统计学意义 (均 $P>0.05$) ; 在维生素 D 严重缺乏状态下, P 组的 MII 卵率 [76.64% (525/685)] 、2PN 率 [59.69% (345/578)] 、胚胎着床率 [35.71% (30/84)] 和活产率 [34.00% (17/50)] 显著低于 N 组 [81.58% (465/570) , $P=0.033$; 67.00% (335/500) , $P=0.013$; 51.28% (40/78) , $P=0.046$; 55.32% (26/47) , $P=0.035$]; 在维生素 D 缺乏状态下, P 组的 2PN 率 [66.50% (532/800)] 显著低于 N 组 [72.00% (725/1 007) , $P=0.012$] 。结论 维生素 D 缺乏可能对 PCOS 患者 IVF-ET 助孕结局产生不利影响, 且在严重缺乏状态下表现更明显, 但对 NOR 患者的助孕结局无影响。

【关键词】 维生素 D 缺乏; 多囊卵巢综合征; 受精, 体外; 胚胎移植; 卵巢储备功能正常

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Effects of vitamin D deficiency on IVF-ET pregnancy outcomes in women with PCOS and normal ovarian reserve

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【Abstract】 **Objective** To investigate the impact of vitamin D deficiency on the outcomes of *in vitro* fertilization and embryo transfer (IVF-ET) in women with polycystic ovary syndrome (PCOS) and normal ovarian reserve (NOR). **Methods** A retrospective cohort study was conducted on infertile women undergoing their first IVF-ET cycle in the Department of Reproductive Genetics, Zhengzhou Maternity and Child Health Care Hospital from January 2018 to December 2023, including 318 PCOS patients (group P) and 528 NOR patients (group N). Each group was divided into three subgroups according to serum 25-hydroxyvitamin D [25(OH)D] levels: severe deficiency [25(OH)D<12 μ g/L], deficiency [12 μ g/L $\leq$ 25(OH)D<20 μ g/L], and non-deficiency [25(OH)D $\geq$ 20 μ g/L]. The impact of vitamin D deficiency on pregnancy outcomes was analyzed in each group. 1 : 1 propensity score matching was applied to match the baseline characteristics between group P and group N, resulting in 158 matched cases of PCOS (group P) and NOR (group N). Pregnancy outcomes were compared between the two groups under the same vitamin D status. **Results** 1) Among PCOS patients, there were no significant differences in general characteristics and pregnancy outcomes among the three subgroups (all $P>0.05$). The two pronuclei

(2PN) rate in the severe deficiency subgroup [59.93% (721/1 203)] was significantly lower than that in the deficiency subgroup [63.70% (1 032/1 620)], with a statistically significant difference ($P=0.045$), and both were lower than that in the non-deficiency subgroup [68.06% (554/814)], with a statistically significant difference ($P<0.001$, $P=0.037$). There were no statistically significant differences in the number of oocytes retrieved and M II oocytes, M II oocyte rate, 2PN number, 2PN rate, cleavage number, cleavage rate, number of available embryos on day 3 (day 3, D3), number of high-quality embryos on D3, D3 high-quality embryo rate, clinical pregnancy rate, embryo implantation rate, early miscarriage rate, live birth rate, and premature birth rate among subgroups (all $P>0.05$). Female age ($OR=0.930$, 95% CI : 0.871–0.992, $P=0.028$), endometrial thickness on the day of transfer ($OR=0.877$, 95% CI : 0.791–0.971, $P=0.012$), number of D3 high-quality embryos ($OR=1.135$, 95% CI : 1.050–1.228, $P=0.001$), and ovulation stimulating protocol ($OR=2.230$, 95% CI : 1.153–4.314, $P=0.017$) were independent factors influencing clinical pregnancy. 2) Among NOR patients, there were no significant differences in general characteristics, pregnancy outcomes, laboratory parameters, or other outcome-related indices among the three subgroups (all $P>0.05$). Female age ($OR=0.944$, 95% CI : 0.900–0.990, $P=0.018$), number of D3 high-quality embryos ($OR=1.070$, 95% CI : 1.004–2.597, $P=0.037$), and number of transferred embryos ($OR=1.753$, 95% CI : 1.184–2.597, $P=0.005$) were independent factors influencing clinical pregnancy. 3) After matching, there were no significant differences in baseline characteristics and pregnancy outcomes between group P and group N (all $P>0.05$). In the severe vitamin D deficiency state, group P had significantly lower M II oocyte rate [76.64% (525/685)], 2PN rate [59.69% (345/578)], embryo implantation rate [35.71% (30/84)], and live birth rate [34.00% (17/50)] compared with group N [81.58% (465/570), $P=0.033$; 67.00% (335/500), $P=0.013$; 51.28% (40/78), $P=0.046$; 55.32% (26/47), $P=0.035$]. In the vitamin D deficiency state, the 2PN rate in group P [66.50% (532/800)] was significantly lower than that in group N [72.00% (725/1 007), $P=0.012$]. **Conclusion** Vitamin D deficiency may adversely affect IVF-ET outcomes in patients with PCOS, with more pronounced effects in cases of severe deficiency. However, it has no impact on the assisted reproductive outcomes in NOR patients.

【 Key words 】 Vitamin D deficiency; Polycystic ovary syndrome; Fertilization *in vitro*; Embryo transfer; Normal ovarian reserve function

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尿源性卵泡刺激素与重组卵泡刺激素 α 、 β 在早卵泡期长方案中的疗效、安全性与经济性比较

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【摘要】 目的 探讨尿源性卵泡刺激素 (urinary follicle-stimulating hormone, u-FSH)、重组卵泡刺激素 (recombinant follicle-stimulating hormone, r-FSH) α 和 r-FSH β 在年龄 <35 岁卵巢储备正常患者中行早卵泡期长方案的有效性、安全性和经济性。方法 本研究是一项回顾性队列研究。纳入2018年1月至2023年12月期间在郑州大学第三附属医院生殖健康医院就诊的年龄 <35 岁卵巢储备正常患者中行早卵泡期长方案促排卵，并使用体外受精或卵胞质内单精子注射助孕的新鲜周期和冻胚移植周期。根据使用促排卵药物的不同分为u-FSH组、r-FSH α 组和r-FSH β 组。卵巢刺激周期共纳入1 048个，3组分别为150个周期、490个周期、408个周期。新鲜周期取消移植的冻胚移植周期共纳入710个，3组分别为95个周期、320个周期、295个周期。比较3组人群的基线数据、妊娠结局、安全性、费用差异。主要观察指标为累积妊娠率和累积活产率 (cumulative live birth rate, CLBR)。通过二元logistic回归模型校正混杂因素，分析3种促排卵药物与CLBR的关系。结果 在有效性和安全性方面，u-FSH组、r-FSH α 组、r-FSH β 组3组间获卵数 [13.0 (10.0, 16.0) 枚、14.0 (11.0, 18.0) 枚、15.0 (11.0, 19.0) 枚， $P=0.012$] 和双原核胚胎数 [9.0 (6.0, 12.0) 枚、10.0 (7.0, 13.0) 枚、10.0 (7.0, 13.0) 枚， $P=0.046$] 差异均具有统计学意义。3组间可利用胚胎数、可利用胚胎率、优质胚胎数、优质胚胎率、可利用囊胚形成率、新鲜周期临床妊娠率、新鲜周期活产率、新鲜周期取消移植者冻胚累积妊娠率、新鲜周期取消移植者冻胚CLBR、累积临床妊娠率、CLBR、中重度卵巢过度刺激综合征发生率、异位妊娠率、多胎妊娠率、新生儿畸形率差异均无统计学意义 (均 $P>0.05$)。在经济性方面，u-FSH组人均促性腺激素使用总费用最低，为4 429.08 (3 198.78, 5 044.23) 元，

r-FSH α 组最高, 为 6 023.72 (5 433.75, 7 529.65) 元, r-FSH β 组为 5 480.00 (4 550.90, 6 437.86) 元, 3 组间比较差异有统计学意义 ($P<0.001$)。采用二元 logistic 回归分析, 以 u-FSH 为对照, r-FSH α 组、r-FSH β 组的 CLBR 与 u-FSH 组比较差异均无统计学意义 ($aOR=0.95$, 95% CI : 0.57~1.58, $P=0.838$; $aOR=0.89$, 95% CI : 0.54~1.48, $P=0.654$)。结论 对于 35 岁以下、卵巢功能正常的行早卵泡期长方案促排卵的患者, 3 种促排卵药物的有效性和安全性相似, 但 u-FSH 在经济性方面更有优势。

【关键词】 卵泡刺激素; 妊娠率; 活产; 有效性研究; 安全性; 经济性

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Comparison of the efficacy, safety, and cost-effectiveness of u-FSH, r-FSH alpha and beta in the long protocol of early follicular phase

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【Abstract】 **Objective** To explore the effectiveness, safety, and cost among urinary follicle-stimulating hormone (u-FSH), recombinant FSH (r-FSH) α , and r-FSH β in the early follicular phase prolonged protocol for patients under 35 years old with normal ovarian function. **Methods** It was a retrospective cohort study. Patients under 35 years old with normal ovarian function who underwent early follicular phase prolonged protocol for ovulation stimulation and using *in vitro* fertilization (IVF) or intracytoplasmic sperm injection (ICSI) for fertilization in Reproductive Health Hospital of the Third Affiliated Hospital of Zhengzhou University from January 2018 to December 2023 were recruited, including the fresh and frozen-thawed embryo transfer (FET) cycles. Patients were divided into u-FSH group, r-FSH α group, and r-FSH β group. A total of 1 048 ovarian stimulation cycles were included, with 150 cycles, 490 cycles and 408 cycles in the three groups respectively. A total of 710 FET cycles with fresh cycle cancellation were included, with 95 cycles, 320 cycles and 295 cycles in the three groups respectively. The baseline data, pregnancy outcomes, safety, and cost were compared among the three groups. The main observation indicators were cumulative pregnancy rate and cumulative live birth rate (CLBR). A binary logistic regression model was used to control confounding factors, and to analyze the relationship between three ovulation inducing medicine and CLBR. **Results** The difference in the number of oocytes retrieved among the u-FSH group, r-FSH α group, and r-FSH β group was statistically significant [13.0 (10.0, 16.0), 14.0 (11.0, 18.0), 15.0 (11.0, 19.0), respectively, $P=0.012$], and the difference in the number of 2PN embryos was statistically significant [9.0 (6.0, 12.0), 10.0 (7.0, 13.0), 10.0 (7.0, 13.0), respectively, $P=0.046$]. There were no statistically significant differences in the number of

available embryos, available embryo rate, the number of high-quality embryos, high-quality embryo rate, available blastocyst formation rate, fresh cycle clinical pregnancy rate, live birth rate in fresh cycle, cumulative pregnancy rate of frozen embryos with fresh cycle cancellation, CLBR of frozen embryos with fresh cycle cancellation, cumulative clinical pregnancy rate, CLBR, moderate to severe ovarian hyperstimulation syndrome incidence, ectopic pregnancy rate, multiple pregnancy rate and neonatal malformation rate among the three groups (all $P>0.05$). In terms of economy, the u-FSH group had the lowest total gonadotropin cost for each patient, while the r-FSH α group had the highest. The differences among the three groups were statistically significant [u-FSH group 4 429.08 (3 198.78, 5 044.23) yuan, r-FSH α group 6 023.72 (5 433.75, 7 529.65) yuan, r-FSH β group 5 480.00 (4 550.90, 6 437.86) yuan, $P<0.001$]. Binary logistic regression analysis was conducted, using u-FSH as a control. The CLBR of the r-FSH α group and r-FSH β group showed no statistically significant difference compared with the u-FSH group ($aOR=0.95$, 95% CI : 0.57–1.58, $P=0.838$; $aOR=0.89$, 95% CI : 0.54–1.48, $P=0.654$).
Conclusion For patients under 35 years old with normal ovarian function undergoing long protocol ovarian stimulation, the effectiveness and safety of the three ovarian-stimulating medicine are similar, but u-FSH has economic advantages.

【Key words】 Follicle-stimulating hormone; Pregnancy rate; Live birth; Effectiveness; Safety; Economics

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辅助生殖技术中中重度卵巢过度刺激综合征的三级风险预警模型的构建

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【摘要】 目的 构建辅助生殖技术中发生中重度卵巢过度刺激综合征 (ovarian hyperstimulation syndrome, OHSS) 的三级预警模型, 并对模型进行验证。**方法** 采用病例对照研究方法, 回顾性分析 2013 年 4 月至 2023 年 4 月期间在广州医科大学附属妇女儿童医疗中心生殖医学中心进行体外受精治疗的 10 181 例不孕症患者, 采用随机数字表法分为建模组 (8 145 例) 和验证组 (2 036 例)。分析两组患者的临床资料, 采用多因素 logistic 回归分析筛选出影响患者取卵术后中重度 OHSS 发生的危险因素, 分控制性卵巢刺激前、扳机前、取卵后 3 d 三个节点建立预警模型并绘制列线图, 通过受试者工作特征 (receiver operating characteristic, ROC) 曲线和校准曲线对各模型进行验证。**结果** 窦卵泡计数 (antral follicle count, AFC, $OR=1.045$, 95% CI : 1.020~1.071, $P<0.001$)、抗苗勒管激素 (anti-Müllerian hormone, AMH) $>3.36 \mu\text{g/L}$ ($OR=7.135$, 95% CI : 2.084~24.432, $P=0.002$)、周期数 ($OR=0.149$, 95% CI : 0.022~1.026, $P=0.049$) 纳入控制性卵巢刺激前预测模型。AFC ($OR=1.046$, 95% CI : 1.018~1.074, $P=0.001$)、AMH $>3.36 \mu\text{g/L}$ ($OR=5.780$, 95% CI : 1.661~20.116, $P=0.006$)、促性腺激素释放激素激动剂方案 ($OR=3.895$, 95% CI : 1.913~7.931, $P<0.001$)、雌激素峰值 $\geq 18\ 350 \text{ pmol/L}$ ($OR=2.258$, 95% CI : 1.092~4.666, $P=0.028$)、直径 $\geq 10 \text{ mm}$ 卵泡数量 >20 个 ($OR=2.377$, 95% CI : 1.092~5.172, $P=0.029$) 纳入扳机前预测模型。AMH $>3.36 \mu\text{g/L}$ ($OR=8.374$, 95% CI : 2.417~29.019, $P=0.001$)、雌激素峰值 $\geq 18\ 350 \text{ pmol/L}$ ($OR=3.947$, 95% CI : 1.533~10.167, $P=0.004$)、总获卵数 ($OR=1.042$, 95% CI : 0.996~1.090, $P=0.025$)、腹胀 ($OR=60.181$, 95% CI : 22.515~160.854, $P<0.001$)、新鲜移植 ($OR=21.766$, 95% CI : 7.119~66.544, $P<0.001$)、人绒毛膜促性腺激素扳机 ($OR=17.752$, 95% CI : 3.993~78.924, $P<0.001$) 纳入取卵后 3 d 预测模型。3 个模型 ROC 曲线下面积分别为 0.830 (95% CI : 0.782~0.878)、0.859 (95% CI : 0.812~0.906)、0.948 (95% CI : 0.919~0.977)。3 个模型验证组的 ROC 曲线下面积分别为 0.922 (95% CI : 0.880~0.965)、0.936 (95% CI : 0.886~0.986)、0.971 (95% CI : 0.938~0.999)。校准曲线提示预警评估模型具有良好稳定性。**结论** 中重度 OHSS 的三级预警模型区分度良好, 有可靠的预测性和临床实用性, 有利于医护人员动态、连续地评估中重度 OHSS 发生风险, 随时调整治疗方案, 及时采取有效预防措施。

【关键词】 生殖技术, 辅助; 受精, 体外; 胚胎移植; 卵巢过度刺激综合征; 风险预警; 预测模型

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Construction of a three-level early warning model for moderate to severe ovarian hyperstimulation syndrome in assisted reproductive technology

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【 Abstract 】 **Objective** To construct and validate a three-level early warning model of moderate to severe ovarian hyperstimulation syndrome (OHSS) in assisted reproductive technology. **Methods** A case-control study was conducted. Totally 10 181 infertility patients who underwent *in vitro* fertilization treatment in Reproductive Medicine Center, Women and Children's Medical Center Affiliated to Guangzhou Medical University from April 2013 to April 2023 were retrospectively analyzed and divided into modeling group (8 145 cases) and validation group (2 036 cases) by random number table method. The clinical data of the two groups were analyzed, and the risk factors affecting the occurrence of moderate and severe OHSS after oocytes retrieval were screened by multi-factor logistic regression analysis. The early warning model was established and the column diagram was drawn at three nodes which were before ovarian stimulation, before trigger and 3 d after oocyte retrieval. The receiver operating characteristic (ROC) curve and calibration curve were used to verify the models. **Results** The antral follicle count (AFC, $OR=1.045$, 95% CI : 1.020–1.071, $P<0.001$), anti-Müllerian hormone (AMH) $>3.36\text{ }\mu\text{g/L}$ ($OR=7.135$, 95% CI : 2.084–24.432, $P=0.002$) and number of cycles ($OR=0.149$, 95% CI : 0.022–1.026, $P=0.049$) were included in the pre-stimulation prediction model. AFC ($OR=1.046$, 95% CI : 1.018–1.074, $P=0.001$), AMH $>3.36\text{ }\mu\text{g/L}$ ($OR=5.780$, 95% CI : 1.661–20.116, $P=0.006$), gonadotropin releasing hormone-agonist protocols ($OR=3.895$, 95% CI : 1.913–7.931, $P<0.001$), estrogen peak $\geq 18\text{ }350\text{ pmol/L}$ ($OR=2.258$, 95% CI : 1.092–4.666, $P=0.028$), the number of follicles with a diameter of $\geq 10\text{ mm}>20$ ($OR=2.377$, 95% CI : 1.092–5.172, $P=0.029$) were included in the pre-trigger prediction model. AMH $>3.36\text{ }\mu\text{g/L}$ ($OR=8.374$, 95% CI : 2.417–29.019, $P=0.001$), estrogen peak $\geq 18\text{ }350\text{ pmol/L}$ ($OR=3.947$, 95% CI : 1.533–10.167, $P=0.004$), total number of oocytes retrieved ($OR=1.042$, 95% CI : 0.996–1.090, $P=0.025$), abdominal distension ($OR=60.181$, 95% CI : 22.515–160.854, $P<0.001$), fresh transplantation ($OR=21.766$, 95% CI : 7.119–66.544, $P<0.001$), human chorionic gonadotropin trigger ($OR=17.752$, 95% CI : 3.993–78.924, $P<0.001$) were included in the prediction model of 3 d after oocyte retrieval. The areas under ROC curves of the three models were 0.830 (95% CI : 0.782–0.878), 0.859 (95% CI : 0.812–0.906) and 0.948 (95% CI : 0.919–0.977), respectively. The areas under ROC curves of the validation groups of the three models were 0.922 (95% CI : 0.880–0.965), 0.936 (95% CI : 0.886–0.986), and 0.971 (95% CI : 0.938–0.999), respectively. The calibration curve indicated that the early-warning evaluation model has good stability. **Conclusion** The three-level early warning model of moderate and severe OHSS has good differentiation, reliable predictability and clinical practicability, which is conducive to the dynamic and continuous assessment of the risk of moderate and severe OHSS, adjustment of treatment plan at any time, and timely adoption of effective preventive measures.

【 Key words 】 Reproductive technology, assisted; Fertilization *in vitro*; Embryo transfer; Ovarian hyperstimulation syndrome; Risk early warning; Prediction model

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过氧化氢诱导人卵巢颗粒细胞氧化应激模型的建立与评价

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【摘要】 目的 探讨利用过氧化氢 (H_2O_2) 诱导人卵巢颗粒细胞 COV434 建立氧化应激损伤模型的方法。方法 将人卵巢颗粒细胞 COV434 细胞分为对照组及 H_2O_2 组, 对照组不作处理, H_2O_2 组分别给予 200 $\mu\text{mol/L}$ 、400 $\mu\text{mol/L}$ 、600 $\mu\text{mol/L}$ 、800 $\mu\text{mol/L}$ 、1 000 $\mu\text{mol/L}$ H_2O_2 进行处理 0.5 h、1 h、2 h、4 h、6 h, CCK-8 法测定细胞活性, 后续实验使用不同浓度 H_2O_2 处理 1 h; β -半乳糖苷酶染色法测定细胞衰老程度; 流式细胞术测定 DCFH-DA 荧光染色, 测定细胞活性氧 (reactive oxygen species, ROS) 水平; JC-1 染色法测定细胞线粒体膜电位; Western blotting 法测定细胞凋亡相关蛋白 Caspase-3、Caspase-9 的表达水平。建立模型成功后, 为验证细胞模型的可用性, 使用抗氧化剂维生素 E 对细胞预处理 12 h, 随后加入 H_2O_2 进行干预, 并对 ROS 水平、线粒体膜电位进行测定。结果 与对照组相比, H_2O_2 浓度 200 $\mu\text{mol/L}$ 、400 $\mu\text{mol/L}$ 组的细胞存活率呈现先下降后上升的趋势, 且在干预 1 h 后趋于稳定, 各时间点细胞存活率差异均无统计学意义 (均 $P>0.05$); 当 H_2O_2 浓度增加至 600 $\mu\text{mol/L}$ 时, 细胞存活率随处理时间逐渐下降并在 1 h 后趋于稳定, 显著降低且最接近 50% ($P<0.001$); 当 H_2O_2 浓度继续增加至 800 $\mu\text{mol/L}$ 、1 000 $\mu\text{mol/L}$ 时, 细胞存活率随处理时间逐渐下降并在 1 h 后趋于稳定, 且降至 10% 以下 (均 $P<0.001$)。当 H_2O_2 浓度分别为 200 $\mu\text{mol/L}$ 、400 $\mu\text{mol/L}$ 时, 处理 1 h 后的 β -半乳糖苷酶阳性细胞比值、相对 ROS 强度与对照组相比差异均无统计学意义 (均 $P>0.05$); 当 H_2O_2 浓度分别增加至 600 $\mu\text{mol/L}$ 、800 $\mu\text{mol/L}$ 、1 000 $\mu\text{mol/L}$ 时, β -半乳糖苷酶染色阳性细胞比值、相对 ROS 强度均显著增高 (β -半乳糖苷酶

染色: H_2O_2 浓度 600 $\mu\text{mol/L}$ 时 $P=0.011$, 800 $\mu\text{mol/L}$ 时 $P=0.003$, 1 000 $\mu\text{mol/L}$ 时 $P=0.005$; 相对 ROS 强度: H_2O_2 浓度 600 $\mu\text{mol/L}$ 时 $P=0.002$, 800 $\mu\text{mol/L}$ 及 1 000 $\mu\text{mol/L}$ 时 $P<0.001$ 。与对照组相比, 使用不同浓度的 H_2O_2 干预后, 细胞线粒体膜电位逐渐降低, 且与 H_2O_2 浓度呈负相关 (均 $P<0.001$)。与对照组相比, 200 $\mu\text{mol/L}$ H_2O_2 组的 Cleaved-Caspase-3 表达差异无统计学意义 ($P>0.05$), 在 400 $\mu\text{mol/L}$ 、600 $\mu\text{mol/L}$ 、800 $\mu\text{mol/L}$ 、1 000 $\mu\text{mol/L}$ H_2O_2 组表达明显增加 (均 $P<0.001$)。Caspase-3、Caspase-9 在所有 H_2O_2 处理组中的表达均明显升高 (均 $P<0.001$)。使用维生素 E 处理后, 与模型组相比, 维生素 E 组相对 ROS 强度显著降低 ($P=0.009$), 细胞线粒体膜电位显著升高 ($P<0.001$), 但尚不能恢复至对照组水平。结论 使用 600 $\mu\text{mol/L}$ 的 H_2O_2 持续处理 COV434 细胞 1 h, 可快速建立稳定有效的人卵巢颗粒细胞氧化应激损伤模型。

【关键词】 颗粒细胞; 氧化应激损伤; 细胞模型; 过氧化氢; 卵巢储备功能减退

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Establishment and evaluation of a model of hydrogen peroxide-induced oxidative stress in human ovarian granulosa cells

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【Abstract】 **Objective** To establish an oxidative stress injury model by using hydrogen peroxide (H_2O_2) to induce human ovarian granulosa cells COV434. **Methods** Human ovarian granulosa cells line COV434 were randomly divided into 6 groups, control group was not treated, H_2O_2 groups were treated with H_2O_2 of 200 $\mu\text{mol/L}$, 400 $\mu\text{mol/L}$, 600 $\mu\text{mol/L}$, 800 $\mu\text{mol/L}$ and 1 000 $\mu\text{mol/L}$ for 0.5 h, 1 h, 2 h, 4 h and 6 h, respectively, and the cell viability was determined by CCK-8 method. The follow-up experiments were treated with different concentrations of H_2O_2 for 1 h. β -galactosidase staining was used to determine the degree of cell senescence. DCFH-DA fluorescence staining was determined by flow cytometry, and the level of reactive oxygen species (ROS) in cells was determined. JC-1 staining was used to determine the mitochondrial membrane potential of cells. Western blotting was used to determine the expression levels of apoptosis-related proteins Caspase-3 and Caspase-9. After the successful establishment of the model, in order to verify the usability of the cell model, the cells were pretreated with the antioxidant vitamin E for 12 h, followed by the addition of H_2O_2 for intervention, and the ROS level and mitochondrial membrane potential were measured. **Results** The cell viability of the 200 $\mu\text{mol/L}$ and 400 $\mu\text{mol/L}$ groups decreased first and then increased compared with the control, and tended to be stable after 1 h of intervention, and there was no significant difference in cell viability at each time point (all $P>0.05$). When the concentration of H_2O_2 increased to 600 $\mu\text{mol/L}$, the cell viability gradually decreased with the treatment time and tended to stabilize

after 1 h, and decreased significantly to nearly 50% ($P<0.001$). When the concentration of H_2O_2 continued to increase to 800 $\mu\text{mol/L}$ and 1 000 $\mu\text{mol/L}$, the cell viability gradually decreased with the treatment time and stabilized after 1 h, and decreased to less than 10% (all $P<0.001$). When the concentration of H_2O_2 was 200 $\mu\text{mol/L}$ and 400 $\mu\text{mol/L}$, there was no significant difference in the ratio of β -galactosidase-positive cells and the relative ROS intensity after 1 h compared with the control (all $P>0.05$). When the concentration of H_2O_2 increased to 600 $\mu\text{mol/L}$, 800 $\mu\text{mol/L}$ and 1 000 $\mu\text{mol/L}$, the ratio of β -galactosidase-positive cells and the relative ROS intensity increased significantly (β -galactosidase staining: $P=0.011$ at 600 $\mu\text{mol/L}$, $P=0.003$ at 800 $\mu\text{mol/L}$, $P=0.005$ at 1 000 $\mu\text{mol/L}$; the relative ROS intensity: $P=0.002$ at 600 $\mu\text{mol/L}$, $P<0.001$ at 800 $\mu\text{mol/L}$ and 1 000 $\mu\text{mol/L}$). Compared with the control, the mitochondrial membrane potential of cells decreased gradually after intervention with different concentrations of H_2O_2 , and was negatively correlated with H_2O_2 concentration (all $P<0.001$). There was no difference in the expression of Cleaved-Caspase-3 in the H_2O_2 group at 200 $\mu\text{mol/L}$ compared with the control, and the expression was significantly increased at 400 $\mu\text{mol/L}$, 600 $\mu\text{mol/L}$, 800 $\mu\text{mol/L}$ and 1 000 $\mu\text{mol/L}$ (all $P<0.001$). The expressions of Caspase-3 and Caspase-9 were significantly increased in all H_2O_2 treated groups (all $P<0.001$). Compared with the model group, the relative ROS intensity of the vitamin E group was significantly reduced ($P=0.009$), and the mitochondrial membrane potential was significantly increased ($P<0.001$), but it could not be restored to the level of the control. **Conclusion** Using 600 $\mu\text{mol/L}$ H_2O_2 to continuously treat COV434 cells for 1 h can quickly establish a stable and effective oxidative stress injury model of human ovarian granulosa cells.

【 Key words 】 Granulosa cells; Oxidative stress damage; Cell model; Hydrogen peroxide; Diminished ovarian reserve

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人脐带间充质干细胞联合高压氧对模拟高原环境下小鼠卵巢功能损伤的修复作用研究

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【摘要】 目的 探讨人脐带间充质干细胞 (human umbilical cord mesenchymal stem cells, hUCMSCs) 联合高压氧 (hyperbaric oxygen, HBO) 对模拟高原环境下小鼠卵巢功能损伤的修复作用及作用机制。**方法** 按照随机数字表法将 64 只 6 周龄 C57BL/6 雌鼠随机分为模型组、hUCMSCs 组、hUCMSCs+HBO 组和对照组, 每组 16 只。其中模型组、hUCMSCs 组、hUCMSCs+HBO 组小鼠放置在低压氧舱模拟海拔 6 500 m 高原环境中持续饲养 15 d, 构建卵巢功能损伤模型。从造模成功后第 1 天开始给予对照组与模型组 0.2 mL 生理盐水尾静脉注射, hUCMSCs 组、hUCMSCs+HBO 组给予 0.2 mL/只 hUCMSCs (1×10^6 个细胞) 尾静脉注射, 1 次/周, 共 3 次, 持续干预 15 d, hUCMSCs+HBO 组每天予以 HBO。记录小鼠一般情况、体质量、动情周期变化、性激素水平、双侧卵巢湿重、卵巢指数、各级卵泡计数情况、卵巢组织病理变化及超微结构改变, Western blotting 检测卵巢组织中转化生长因子 $\beta 1$ (transforming growth factor beta 1, TGF- $\beta 1$)、Smad 家族成员 3 (Smad family member 3, Smad3) 蛋白的表达, 以及各组小鼠产仔数、子代体质量, 从而评估各组小鼠生育能力。**结果** ①与 hUCMSCs 组比较, hUCMSCs+HBO 组小鼠动情周期、体质量、双侧卵巢湿重、卵巢指数差异均无统计学意义 (均 $P > 0.05$); 血清抗苗勒管激素 (anti-Müllerian hormone, AMH)、雌二醇、孕酮、卵泡刺激素 (follicle-stimulating hormone, FSH)、黄体生成素 (luteinizing hormone, LH) 水平及各级卵泡计数差异均无统计学意义 (均 $P > 0.05$), 但 hUCMSCs+HBO 组卵巢组织颗粒细胞的核膜完整、个别线粒体轻度肿胀、粗面内质网无扩张、高尔基体无肿胀等, TGF- $\beta 1$ 、Smad3 蛋白表达水平均升高 ($P = 0.010$, $P < 0.001$), 子代情况及窝仔数差异均无统计学意义 (均 $P > 0.05$)。②与对照组比较, hUCMSCs+HBO 组小鼠体质量、双侧卵巢湿重、卵巢指数、血清 AMH、雌二醇、孕酮水平略低, 血清 FSH、LH 水平稍偏高, 但差异均无统计学意义 (均 $P > 0.05$), 各级卵泡计数间

差异亦均无统计学意义 (均 $P>0.05$) , hUCMSCs+HBO 组卵巢组织颗粒细胞的核膜、线粒体、粗面内质网、高尔基体等细胞器结构接近于对照组超微结构变化。hUCMSCs+HBO 组和对对照组 TGF- β 1 蛋白表达差异无统计学意义 ($P=0.253$) 。hUCMSCs+HBO 组 Smad3 蛋白表达水平高于对照组 ($P<0.001$) , 子代体质量、窝仔数及生活习性组间差异均无统计学意义 (均 $P>0.05$) 。结论 hUCMSCs 联合 HBO 干预治疗和 hUCMSCs 的单一治疗均能安全、有效地促进高原环境下受损卵巢组织的卵巢功能修复作用, 但 hUCMSCs 联合 HBO 修复作用更好。hUCMSCs 联合 HBO 可能是通过上调 TGF- β 1/Smad3 信号通路, 修复受损卵巢组织的功能, 从而提高缺氧环境下小鼠的生育能力。

【关键词】 高原; 卵巢损伤; 高压氧治疗; 人脐带间充质干细胞; 联合治疗; 生育力保护

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Study on the repair of ovarian tissue injury in mice in simulated plateau environment by human umbilical cord mesenchymal stem cell transplantation combined with high-pressure medical treatment

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【 Abstract 】 **Objective** To investigate the reparative effects and underlying mechanisms of human umbilical cord mesenchymal stem cells (hUCMSCs) in conjunction with hyperbaric oxygen (HBO) on ovarian dysfunction in mice exposed to simulated high-altitude conditions. **Methods** A total of 64 six-week-old female C57BL/6 mice were randomly allocated according to random number table, assigned to control group, model group, hUCMSCs group and hUCMSCs+HBO group, with 16 mice in each group. Mice in model group, hUCMSCs group and hUCMSCs+HBO group were placed in a hypobaric oxygen chamber to simulate a high-altitude environment at an elevation of 6 500 m for 15 d, thereby establishing a model of ovarian dysfunction. Beginning on the first day following model establishment, the control and model groups received intravenous injections of 0.2 mL saline via the tail vein. In contrast, the hUCMSCs group and the hUCMSCs+HBO group received 0.2 mL hUCMSCs (1×10^6 cells) per mouse through tail vein injection, administered once a week for three weeks, with continuous intervention lasting 15 d. Furthermore, the hUCMSCs+HBO group were subjected to daily hyperbaric oxygen treatment. The recorded variables included general health status, body weight, estrous cycle changes, serum hormone levels, bilateral ovarian wet weight, ovarian index, follicular development assessment, pathological alterations of ovarian tissue, ultrastructural changes, and the expression levels of transforming growth factor beta 1 (TGF- β 1) and Smad family member 3 (Smad3)

detected by Western blotting in ovarian tissue. Additionally, litter size and offspring body weight were measured across all groups to evaluate the reproductive capacity of the mice. **Results** 1) Compared with the hUCMSCs group, the hUCMSCs+HBO group exhibited no statistically significant differences in estrous cycle, body weight, bilateral ovarian wet weight, or ovarian index (all $P>0.05$). Furthermore, serum levels of anti-Müllerian hormone (AMH), estradiol, progesterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH), as well as counts of various stages of follicles in hUCMSCs+HBO group, did not demonstrate statistically significant differences compared with hUCMSCs group (all $P>0.05$). Notably, in the hUCMSCs+HBO group, the integrity of the nuclear membrane in granulosa cells of the ovarian tissue was preserved, with only mild swelling observed in individual mitochondria, while no expansion of the rough endoplasmic reticulum or swelling of the Golgi apparatus were noted. Additionally, expression levels of TGF- β 1 and Smad3 proteins in the hUCMSCs+HBO group were significantly elevated compared with the hUCMSCs group ($P=0.010$, $P<0.001$). The conditions of the offspring and litter size showed no statistically significant differences between the two groups (all $P>0.05$). 2) Compared with control group, the hUCMSCs+HBO group had slightly lower values for body weight, bilateral ovarian wet weight, ovarian index, serum levels of AMH, estradiol, and progesterone, while had slightly higher serum levels of FSH and LH without statistically significant differences (all $P>0.05$). Importantly, the ultrastructural characteristics of granulosa cells in the ovarian tissue of the hUCMSCs+HBO group closely resembled those of control group, displaying intact structures of the nuclear membrane, mitochondria, rough endoplasmic reticulum, and Golgi apparatus. There was no significant difference in TGF- β 1 protein level between hUCMSCs+HBO group and control group ($P=0.253$), but Smad3 protein level in hUCMSCs+HBO group was higher than that in control group ($P<0.001$). No statistically significant differences were detected in offspring body weight, litter size, or behavioral tendencies (all $P>0.05$). **Conclusion** Both hUCMSCs and the combination of hUCMSCs with HBO intervention demonstrated a safe and effective promotion of functional repair in damaged ovarian tissue under hypoxic conditions. Notably, the combination treatment of hUCMSCs with HBO exhibited a synergistic effect compared with hUCMSCs alone. The potential mechanism underlying this enhanced functional repair may involve the upregulation of the TGF- β 1/Smad3 signaling pathway, which could ultimately improve fertility outcomes in mice subjected to hypoxic environments.

【Key words】 Hypoxia; Ovarian injury; Hyperbaric oxygen therapy; Human umbilical cord mesenchymal stem cells; Combined modality therapy; Fertility preservation

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失独家庭胚胎捐赠的医学和伦理学问题

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【摘要】 重新获得子代是我国失独家庭最常提出的医学需求, 然而失独夫妇常常因年龄较大无法再次自然生育。随着辅助生殖技术的成熟, 胚胎捐赠是一种潜在有效的帮助失独家庭重新获得子代的方法, 但在我国目前尚缺乏相应法规和操作规范。本文回顾国内外有关胚胎捐赠的研究进展, 结合本单位辅助生殖工作经验, 探讨利用辅助生殖技术进行胚胎捐赠为失独家庭重获子代的可行性和实际操作中需考虑的医学和伦理学问题, 以供相关部门参考。

【关键词】 生殖技术, 辅助; 失独家庭; 胚胎捐赠; 伦理学

Medical and ethical issues of embryo donation in only-child loss families

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【Abstract】 Regaining offspring is the most common medical demand for families who lost their only-child in China. However, couples who lost their only-child are often unable to have children naturally due to their old age. With the maturity of assisted reproductive technology (ART), embryo donation is a potentially effective method to help families regain their offspring. However, there is still lack of corresponding laws and operating standards in our country. This article reviews the research progress of embryo donation at home and abroad, and the experience of ART in our hospital, and discusses the feasibility of using ART to regain offspring of families who lost their only child, as well as the medical and ethical issues that need to be considered in practical operation, so as to provide reference for relevant departments.

【Key words】 Reproductive technology, assisted; Only-child loss families; Embryo donation; Ethics

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地诺孕素在子宫内膜异位症不孕患者中的应用研究进展

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【摘要】 相较于传统促性腺激素释放激素类似物, 地诺孕素具有不良反应低、成本效益高及改善生活质量的优点。本文综述了地诺孕素在治疗子宫内膜异位症及相关不孕症中的临床应用, 探讨了其作为合成孕激素的治疗机制, 包括抑制病灶生长和控制局部炎症反应, 以减轻症状和对卵巢功能进行保护以改善生育预后。未来研究需进一步验证地诺孕素在辅助生殖技术中应用的效果及安全性, 为子宫内膜异位症合并不孕症患者提供更有利的治疗选择。

【关键词】 子宫内膜异位症; 不孕症; 生殖技术, 辅助; 地诺孕素

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Application of dienogest in infertile patients with endometriosis

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【Abstract】 Compared with traditional gonadotropin-releasing hormone analogues, dienogest demonstrates several advantages, including a more favorable side effect profile, enhanced cost-effectiveness, and improved quality of life for patients. This article provides a comprehensive review of the clinical applications of dienogest in the management of endometriosis and its associated infertility. It explores the drug's mechanisms of action as a synthetic progestin, including its ability to inhibit the growth of endometriosis lesions and modulate local

inflammatory responses, thereby alleviating symptoms and preserve ovarian function to enhance fertility outcomes. Future research should focus on validating the efficacy and safety of dienogest within assisted reproductive technology, ultimately providing more effective therapeutic options for individuals facing endometriosis-related infertility.

【 Key words 】 Endometriosis; Infertility; Reproductive technology, assisted; Dienogest

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综述

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双酚 A 参与多囊卵巢综合征发生发展的研究进展

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【摘要】 双酚 A 是人类日常生活中广泛接触的环境化学物质, 因其具有类雌激素作用而备受关注。多囊卵巢综合征 (polycystic ovary syndrome, PCOS) 是育龄期女性最常见的一种内分泌代谢性疾病, 其发病机制涉及遗传、环境和内分泌紊乱的相互作用。近年来, 越来越多的研究指出双酚 A 在 PCOS 的发生发展中发挥着重要作用。双酚 A 通过干扰机体胰岛素敏感性、免疫反应和改变卵巢结构及功能等多途径促进 PCOS 的发生发展。此外, 双酚 A 暴露水平与 PCOS 患者的高雄激素

血症、胰岛素抵抗、肥胖、血脂异常和卵巢储备功能下降有关。本综述总结了双酚 A 在卵巢功能、糖脂代谢、炎症反应方面对 PCOS 的作用，以便更清楚地认识双酚 A 在 PCOS 发生发展中的作用机制对临床干预和预防提供理论依据。

【关键词】 多囊卵巢综合征； 受体，雌激素； 胰岛素抵抗； 肥胖； 双酚 A

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Research progress of bisphenol A involved in the occurrence and development of polycystic ovary syndrome

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【Abstract】 Bisphenol A (BPA) is an environmental chemical that is widely exposed in human daily life. It has attracted much attention because of its estrogenic effect. Polycystic ovary syndrome (PCOS) is the most common endocrine metabolic disease in women of reproductive age. Its pathogenesis involves the interaction of genetic, environmental and endocrine disorders. In recent years, more and more studies have shown that BPA plays an important role in the occurrence and development of PCOS. BPA promotes the development of PCOS by interfering with insulin sensitivity, immune response and changing ovarian structure and function. In addition, BPA exposure levels are associated with hyperandrogenism, insulin resistance, obesity, dyslipidemia, and decreased ovarian reserve in PCOS patients. This review summarizes the effects of BPA on PCOS in terms of ovarian function, glucose and lipid metabolism, and inflammatory response, so as to provide theoretical basis for clinical intervention and prevention of BPA in the development of PCOS.

【Key words】 Polycystic ovary syndrome; Receptors, estrogen; Insulin resistance; Obesity; Bisphenol A

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综述

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乳酸调控蜕膜微环境的作用机制研究进展

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【摘要】 乳酸在蜕膜化过程中大量生成, 成为蜕膜微环境的一个显著特征。乳酸不仅作为代谢途径中的关键产物, 参与能量的快速生成与转换, 还通过调节微环境的酸碱平衡, 影响细胞的功能状态。此外, 乳酸作为一种信号分子, 在调控蜕膜免疫代谢、促进蜕膜血管生成以及滋养层侵袭过程中发挥着核心作用, 对胚胎植入具有至关重要的影响。近年来, 乳酸在表观遗传学中的作用也逐渐被揭示, 乳酸化修饰参与调控基因表达, 维持蜕膜微环境稳态。本文将详细探讨乳酸在蜕膜微环境中的具体作用, 以为妊娠相关疾病的研究提供新的视角和理论依据。

【关键词】 乳酸; 胚胎植入; 乳酸化; 蜕膜化

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Research progress on the mechanism of lactic acid regulation in the decidual microenvironment

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【Abstract】 During decidualization, lactic acid is produced and accumulated in large amounts, becoming a prominent feature of the decidual microenvironment. Lactic acid not only serves as a key product in metabolic pathways, participating in rapid energy generation and conversion, but also influences cellular functional states by regulating the acid-base balance of the microenvironment. Furthermore, as a signaling molecule, lactic acid plays a central role in regulating decidual immune metabolism, promoting decidual angiogenesis, and facilitating trophoblast invasion, all of which are crucial for embryo implantation. In recent years, the role of lactic acid in epigenetics has also gradually emerged, with lactylation

modifications involved in regulating gene expression and maintaining the homeostasis of the decidual microenvironment. This article will delve into the specific roles of lactic acid in the decidual microenvironment, aiming to provide new perspectives and theoretical foundations for the study of pregnancy-related diseases.

【 Key words 】 Lactic acid; Embryo implantation; Lactylation; Decidualization.

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