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调节性 T 细胞在母胎免疫耐受及相关妊娠并发症中的研究现状与展望

高睿 马光宇 秦朗

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【摘要】 调节性 T 细胞 (regulatory T cells, Tregs) 是一种具有免疫抑制功能的 T 细胞亚型, 在外周免疫耐受中发挥关键作用。妊娠过程中, 母体免疫细胞需要对携带同种半异体抗原的胚胎产生特异性的免疫耐受, 以支持其生长发育, 而 Tregs 在这一过程中发挥重要作用。Tregs 比例和功能异常与母胎免疫紊乱以及复发性流产、子痫前期等多种妊娠并发症的发生密切相关。近年来, 基于 Tregs 的疗法在临床应用中已取得了一定的进展, 但在妊娠并发症治疗领域的应用仍处于探索阶段, 疗效和安全性尚待证实。本文旨在总结 Tregs 在母胎免疫耐受及相关妊娠并发症中的研究现状, 并对未来的研究方向和应用前景进行展望。

【关键词】 T 淋巴细胞, 调节性; 妊娠并发症; 外周免疫耐受; 母胎免疫耐受

基金项目: 四川省科技厅项目 (2024YFFK0076)

Research status and prospects of regulatory T cells in maternal-fetal immune tolerance and related pregnancy complications

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【 Abstract 】 Regulatory T cells (Tregs) are a subset of T cells with immune-suppressive functions and play a key role in peripheral immune tolerance. During pregnancy, maternal immune cells develop specific immune tolerance to the embryo with semi-allogeneic antigens to support its growth and development, a process in which Tregs are crucial. Abnormal proportions and functions of Tregs are closely associated with maternal-fetal immune disorders and many pregnancy

complications, such as recurrent miscarriage and preeclampsia. In recent years, Tregs-based therapies have made some progress in clinical applications, but their use in treating pregnancy complications is still in the exploratory stage and the efficacy and safety remain to be confirmed. This article aims to summarize the current research on Tregs in maternal-fetal immune tolerance and related pregnancy complications, and to propose future research directions and application prospects.

【 Key words 】 T-lymphocytes, regulatory; Pregnancy complications; Peripheral immune tolerance; Maternal-fetal immune tolerance

Fund program: Science & Technology Department of Sichuan Province (2024YFFK0076)

述评

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我国人类精子库现阶段捐精志愿者精子检测的思考

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【摘要】 人类精子库职能之一是为接受供精辅助生殖项目治疗的女性提供安全、健康的精子。随着世界卫生组织精液分析手册的修订, 以及我国人类精子库20余年的实践和生殖医学中心的实际需求, 现行针对捐精志愿者的精液筛查项目与一些参数要求已不符合或不能满足现实需求。在现实情况下, 有必要修订捐精志愿者的精液筛查项目及其参数基本要求。因此, 本文提出优化建议: 调整精子参数的筛查要求, 拓展精子功能试验, 补充精液感染项目检测及提高检测频率, 试行遗传病基因筛查方案, 旨在为捐精志愿者进行严格的精子筛查、评估和管理提供参考资料, 以保障我国接受供精治疗的女性及其出生子代的健康。

【关键词】 人类精子库; 捐精志愿者; 精子检测; 筛查标准

Thoughts on sperm testing for donors in Chinese human sperm banks at the current stage

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【Abstract】 One of the functions of human sperm banks is to provide safe and healthy sperm for women undergoing assisted reproductive technology treatments. With the revision of the World Health Organization's semen analysis manual, and considering over two decades of operational experience in Chinese sperm banks as well as the evolving practical needs of reproductive medicine centers, the current semen screening items and certain parameter requirements for sperm donors no longer fully align with or meet actual clinical demands. Therefore, it is necessary to update the fundamental criteria for semen screening parameters and items for sperm donors. This paper proposes several optimization recommendations: adjusting the screening criteria for sperm parameters, expanding functional sperm testing, enhancing semen infection screening with increased frequency, and piloting genetic disease screening programs. These recommendations aim to provide a reference for improving the rigor of sperm screening, evaluation, and management of sperm donors in China, thereby protecting the health of women and offspring conceived through donor sperm.

【Key words】 Human sperm bank; Sperm donor; Sperm testing; Screening criteria

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不孕不育人群肥胖症/超重诊疗指南 (2025 年版)

中国医师协会生殖医学专业委员会

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【摘要】 肥胖症通过多种机制导致不孕不育的发生。近年来肥胖症对生育影响的研究增多, 治疗手段也不断丰富。本指南针对不孕不育人群中肥胖症/超重的诊断与管理制定中国专家推荐意见。遵循《世界卫生组织指南制订手册》及《中国

制订/修订临床诊疗指南的指导原则（2022 版）》，通过问卷确定临床问题，系统检索并评价截至 2024 年 12 月 31 日发表的中、英文文献，采用推荐分级的评估、制定与评价体系进行证据分级，由证据评价组提出草案，经共识专家组德尔菲法投票形成一致意见，最终经外审及中国医师协会生殖医学专业委员会批准。指南共提出 50 条推荐建议，涵盖肥胖症/超重筛查与诊断标准、对自然生育力及辅助生殖技术助孕结局的影响评估、生活方式干预、药物治疗、减重与代谢手术治疗及长期随访等内容。本指南旨在为生殖医学及相关学科医师提供当前最佳临床实践指导，规范不孕不育合并肥胖症/超重的诊疗路径，提高妊娠率及患者远期健康水平。

【关键词】 肥胖症； 不孕症； 实践指南； 循证医学； 结果评估； 疾病管理

实践指南注册：国际实践指南注册与透明化平台（PREPARE-2024CN676）

Guideline for the diagnosis and treatment of obesity/overweight in infertility populations (2025)

Reproductive Medicine Professional Committee of the Chinese Medical Doctor Association

Corresponding authors: Yang Dongzi, Reproductive Medicine Center, Sun Yat-sen Memorial Hospital, Sun Yat-sen University, Guangzhou 510120, China, Email: yangdz@mail.sysu.edu.cn; Li Rong, Reproductive Medicine Center, Peking University Third Hospital, Beijing 100191, China, Email: roseli001@sina.com

【Abstract】 Obesity has been demonstrated to contribute to infertility through multiple pathophysiological mechanisms. In light of the mounting research on its reproductive impact and the expansion of therapeutic options in recent years, there is an urgent need for updated, evidence-based guidance. This consensus document presents the recommendations of Chinese experts for the diagnosis and management of obesity and overweight in individuals with infertility. The guideline was developed in strict accordance with the *World Health Organization Handbook for Guideline Development* and the *Principles for Developing/Revising Clinical Practice Guidelines in China (2022)*. The identification of clinical questions was achieved through the administration of surveys to patients and healthcare professionals, followed by systematic retrieval and evaluation of Chinese- and English-language literature published up to 31 December 2024. The evaluation of the evidence was conducted in accordance with the grading of recommendations assessment, development and evaluation approach. The draft recommendations were formulated by the Evidence Evaluation Group, refined through Delphi consensus among the Expert Panel, externally reviewed, and ultimately approved by the Reproductive Medicine Professional Committee of the Chinese Medical Doctor Association. The final document comprises 50 recommendations addressing: screening and diagnostic criteria for obesity/overweight; evaluation of adverse effects on natural fertility and assisted reproductive technology outcomes; lifestyle interventions; pharmacological therapy; metabolic and bariatric surgery; and long-term follow-up. The purpose of these recommendations is to provide reproductive medicine specialists and related clinicians with contemporary best-practice guidance, to standardise the management of infertility complicated by

obesity or overweight, and ultimately to improve pregnancy rate and long-term health outcomes for affected patients.

【Key words】 Obesity; Infertility; Practice guideline; Evidence-based medicine; Outcome assessment; Disease management

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子宫内膜异位症相关不孕诊治专家共识 (2025 年)

中国妇幼保健协会生育力保存专业委员会 中国医疗保健国际交流促进会生殖医学分会

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【摘要】 子宫内膜异位症引起的不孕症是辅助生殖领域面临的常见难题, 其临床诊治存在一定的争议和挑战。尽管国内外已有较多关于子宫内膜异位症的诊疗指南, 但尚缺乏针对子宫内膜异位症相关不孕的专项指南共识。本临床专家共识整合了国内外相关指南及我国专家建议共识, 系统性围绕子宫内膜异位症对女性生育力的影响、相关不孕的生育力评估、治疗方案以及生育力保护与保存四个方面进行全面综述, 提出具体推荐意见, 旨在为我国子宫内膜异位症相关不孕的临床实践提供建议和指导。

【关键词】 子宫内膜异位症; 不孕; 生殖技术, 辅助; 促排卵; 冻融胚胎移植; 生育力保存

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Expert consensus on the diagnosis and treatment of endometriosis-associated infertility (2025)

Fertility Preservation Committee of China Maternal and Child Health Association, Reproductive Medicine Branch of China International Exchange and Promotive Association for Medical and Health Care

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【 Abstract 】 Endometriosis-associated infertility presents a significant challenge in the realm of assisted reproduction, with clinical diagnosis and treatment remaining contentious and complex. Despite the existence of numerous domestic and international guidelines for managing endometriosis, a notable absence of specialized consensus guidelines addressing endometriosis-related infertility persists. This expert consensus synthesizes pertinent domestic and international guidelines alongside expert recommendations and consensus from China. It offers a thorough review of four critical aspects: the impact of endometriosis on female fertility, fertility assessment for related infertility, treatment options, and strategies for fertility protection and preservation. Specific recommendations are delineated to provide guidance and direction for the clinical management of endometriosis-associated infertility in China.

【Key words】 Endometriosis; Infertility; Reproductive techniques, assisted; Ovarian stimulation; Frozen-thawed embryo transfer; Fertility preservation

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男女双方高龄对 PGT 周期胚胎染色体异常发生率的影响

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【摘要】 目的 探讨男女双方高龄对胚胎植入前染色体异常(包括非整倍体、嵌合异常和片段异常)发生率的影响。方法 采用回顾性病例对照研究, 收集 2019 年 5 月至 2024 年 10 月在浙江大学医学院附属妇产科医院生殖中心接受植入前非整倍体遗传学检测 (preimplantation genetic testing for aneuploidy, PGT-A) 的 487 个周期的临床资料, 通过单因素和多因素 logistic 回归分析导致胚胎发生非整倍体、嵌合型胚胎和片段异常的影响因素。结果 多因素 logistic 回归显示, 与女方年龄<35 岁相比, 35~37 岁和≥38 岁女性的 PGT-A 周期胚胎非整倍体发生风险显著增加 (分别为 $OR=1.46$, 95% CI : 1.05~2.02, $P=0.025$; $OR=4.71$, 95% CI : 3.51~6.32, $P<0.001$) ; 与男方年龄<35 岁相比, 35~39 岁和≥40 岁男性的 PGT-A 周期嵌合型胚胎发生风险显著增加 (分别为 $OR=1.51$, 95% CI : 1.01~2.27, $P=0.047$; $OR=1.80$, 95% CI : 1.02~3.15, $P=0.041$) 。男女双方年龄对 PGT-A 周期胚胎片段异常的影响均无统计学意义 (均 $P>0.05$) 。结论 女方年龄≥35 岁对胚胎非整倍体率有影响, 男方年龄≥35 岁对嵌合型胚胎率有影响, 未发现男、女高龄对胚胎染色体片段异常率有显著影响。

【关键词】 胚胎植入前遗传学检测; 非整倍体; 嵌合型胚胎; 片段异常; 高龄

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Impact of advanced parental age on embryonic chromosomal abnormality rates in PGT cycles

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【Abstract】 Objective To investigate the effects of advanced paternal and maternal age on the incidence of chromosomal abnormalities (including aneuploidy, mosaicism, and segmental abnormalities) in preimplantation embryos. **Methods** This was a retrospective case-control study. Totally 487 preimplantation genetic testing for aneuploidy (PGT-A) cycles conducted at the Reproductive Center of the Women's Hospital, Zhejiang University School of Medicine, between May 2019 and October 2024, were included in this study. Univariate and multivariate logistic regression analyses were employed to identify factors influencing the occurrence of embryo aneuploidy, mosaic embryos, and segmental abnormalities. **Results** Multivariable logistic regression analysis revealed that, compared with women aged <35 years, women aged 35–37 years and ≥38 years had a significantly increased risk of aneuploidy in PGT-A cycles ($OR=1.46$, 95% CI : 1.05–2.02, $P=0.025$; $OR=4.71$, 95% CI : 3.51–6.32, $P<0.001$, respectively). Compared with men aged <35 years, men aged 35–39 years and ≥40 years had a significantly increased risk of mosaic embryos in PGT-A cycles ($OR=1.51$, 95% CI : 1.01–2.27, $P=0.047$; $OR=1.80$, 95% CI : 1.02–3.15, $P=0.041$, respectively). The impact of

parental age (both maternal and paternal) on segmental chromosomal abnormalities in PGT-A cycles embryos were not statistically significant (both $P>0.05$). **Conclusion** Maternal age ≥ 35 years impacts embryonic aneuploidy rate, while paternal age ≥ 35 years is associated with mosaicism rate. Neither advanced paternal age nor maternal age affects segmental abnormality rate.

【Key words】 Preimplantation genetic testing; Aneuploidy; Mosaic embryo; Segmental abnormalities; Advanced age

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CHST12 基因 c.216G>C 纯合错义突变导致人卵母细胞成熟阻滞的 1 例病例报道

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【摘要】 卵母细胞成熟阻滞 (oocyte maturation arrest, OMA) 是一种罕见的原发性不孕症, 其特征表现为卵母细胞减数分裂进程的异常停滞, 可观察到多个发育阶段的阻滞类型: 生发泡 (germinal vesicle, GV)、第一次减数分裂中期 (metaphase I, MI)、第二次减数分裂中期 (metaphase II, MII) 和 GV-MI 混合阻滞等。本文报道 1 例 *CHST12* 基因 c.216G>C: p.K72N 纯合错义突变导致卵母细胞成熟阻滞在 MI 时期的病例。Sanger 测序结果表明先证者的父母及其已生育的姐姐均为该突变位点的携带者, 先证者及其弟弟均为该位点纯合突变。跨物种比对揭示, 突变位点所对应氨基酸序列, 于人、恒河猴、犬科动物、象属生物及家禽类中, 呈现出高度保守性特征。同时, *CHST12* 在人卵泡生长过程的卵母细胞中逐渐表达增高, 通过构建正常及突变质粒转染 HeLa 细胞后发现该突变影响 *CHST12* 在核中的定位。综上所述, 我们推测 *CHST12* 基因 c.216G>C: p.K72N 纯合错义突变影响了 *CHST12* 在卵母细胞核中的定位及代谢过程。本研究报道了 *CHST12* 基因在卵母细胞中致病的可能性, 对 *CHST12* 基因导致卵母细胞 MI 时期阻滞提供了参考。

【关键词】 原发不孕； 卵母细胞成熟阻滞； *CHST12*； 减数分裂
基金项目：国家自然科学基金面上项目（82371667）；湖南省自然优秀青年基金（2024JJ4099）

A case report of human oocyte maturation arrest caused by homozygous missense mutation c.216G>C in the *CHST12* gene

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【 Abstract 】 Oocyte maturation arrest (OMA) represents a rare type of primary infertility, marked by abnormal halts in oocyte meiosis at various stages of development, such as the germinal vesicle stage (GV), metaphase I (M I) and metaphase II (M II) of meiotic divisions, or a mixed GV-M I arrest. This study reports a novel case of a homozygous missense mutation, c.216G>C (p.K72N), in the *CHST12* gene, leading to OMA specifically during the M I phase and consequently causing infertility. Sanger sequencing showed that the proband's parents and elder sister, who had given birth, carried this mutation in a heterozygous state. In contrast, the proband and her younger brother displayed homozygous mutations at this site. A cross-species analysis indicated high amino acid sequence conservation at the mutation site among humans, rhesus monkey, dog, elephant, and poultry. Additionally, *CHST12* expression progressively increases as human follicles grow and oocytes mature. After transfection of normal and mutant plasmids into Hela cells, it became evident that this mutation disrupts the nuclear localization of *CHST12*. In conclusion, we hypothesize that the homozygous missense mutation c.216G>C (p.K72N) in the *CHST12* gene disrupts the localization and metabolic processes of *CHST12* within oocyte nuclei. This investigation reveals the pathogenic role of the *CHST12* gene in oocytes and the mechanisms underlying M I -phase arrest.

【 Key words 】 Primary infertility; Oocyte maturation arrest; *CHST12*; Meiosis

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女性不孕症的表观遗传学研究进展

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【摘要】 不孕不育已成为全球性的重大公共卫生挑战, 影响约 17% 的育龄夫妇, 其中近半数与女性因素相关。女性不孕症病因复杂, 表观遗传学为其分子机制研究提供新的视角。表观遗传通过 DNA、染色质和 RNA 等多层面调控女性生殖功能, 其异常与多囊卵巢综合征、早发性卵巢功能不全、子宫内膜异位症、反复种植失败及其他不孕症相关疾病密切相关。随着检测技术的发展, 表观遗传标志物有望成为女性不孕的诊断手段, 而表观遗传药物干预则可能为临床治疗提供新方向。本文对表观遗传学在不孕症女性相关疾病中的作用机制及临床应用潜力进行综述, 重点围绕卵母细胞发生成熟、早期胚胎发育、子宫内膜功能及相关疾病的表观遗传调控机制展开, 为未来基础和临床研究提供参考和思路。

【关键词】 不孕症; 表观遗传学; DNA 甲基化; 组蛋白修饰; 非编码 RNA

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Progress in epigenetic research on female infertility

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【 Abstract 】 Infertility has become a major global public health issue, affecting approximately 17% of couples of reproductive age, with female factors involved in about half of the cases. The etiology of female infertility is complex, and epigenetics provides a new explanatory framework. Epigenetic regulation, through DNA, chromatin, and RNA modifications, governs female reproductive function, and its dysregulation is closely associated with polycystic ovary syndrome, premature ovarian insufficiency, endometriosis, recurrent implantation failure, and other diseases that affect fertility. With the advancement of detection technologies, epigenetic biomarkers hold promise as diagnostic tools for female infertility, while epigenetic drug interventions may offer new directions for clinical treatment. This review summarizes the mechanisms and clinical application potential of epigenetic regulation in female infertility-related diseases, highlighting its impact on oocyte development and maturation, early embryonic development, endometrial function, and related disorders, providing references and insights for future basic and clinical research.

【 Key words 】 Infertility; Epigenetics; DNA methylation; Histone modifications; Non-coding RNAs

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多基因风险评分在胚胎植入前遗传学检测中的应用现状

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【摘要】 胚胎植入前遗传学检测 (preimplantation genetic testing, PGT) 是目前遗传性疾病一级预防中的核心手段。近年来, 随着全基因组关联分析的突破, 多基因风险评分 (polygenic risk score, PRS) 通过整合复杂疾病相关遗传变异位点的累积效应, 为多基因疾病胚胎植入前遗传学检测 (PGT for polygenic disorders, PGT-P) 提供了新工具。本文就 PRS 在 PGT 中的应用现状进行综述, 旨在为多基因疾病的精准防控提供理论参考, 并推动适用于中国人群的 PGT-P 技术发展。

【关键词】 全基因组关联分析; 植入前遗传学检测; 多基因风险评分; 多基因疾病

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Current application of polygenic risk score in preimplantation genetic testing

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【Abstract】 Preimplantation genetic testing (PGT) serves as a cornerstone strategy for the primary prevention of genetic disorders. In recent years, advancements in genome-wide association studies have facilitated the development of polygenic risk scores (PRS), which aggregate the cumulative effects of genetic variants associated with complex diseases. PRS has emerged as a novel

tool for PGT of polygenic disorders (PGT-P). This article reviews the current applications of PRS in PGT, aiming to provide theoretical insights into the precise prevention and control of polygenic diseases and to promote the advancement of PGT-P technologies specifically tailored for the Chinese population.

【Key words】 Genome-wide association study; Preimplantation genetic testing; Polygenic risk scores; Polygenic diseases

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早期胚胎停滞致病基因的研究进展

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【摘要】 早期胚胎发育是指从受精卵到囊胚的发育过程, 这一过程受到母源基因和父源基因的精确调控。辅助生殖技术显著提升了育龄夫妇的生育能力, 然而早期胚胎停滞仍是导致女性不孕的重要因素之一。随着测序技术的应用和人群队列研究的深入, 多个导致人类早期胚胎停滞的致病基因已被鉴定。这些致病基因通过影响早期胚胎发育的关键信号通路, 干扰早期胚胎分裂与分化过程, 最终导致发育停滞。本文主要对目前已被鉴定的早期胚胎停滞的致病基因以及相关的分子机制进行综述, 并对未来早期胚胎停滞遗传学研究方向进行展望。

【关键词】 生殖技术, 辅助; 不孕不育; 胚胎发育; 遗传变异

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Research progress on pathogenic genes causing early embryonic arrest

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【Abstract】 Early embryonic development refers to the process from fertilization to blastocyst formation, which is precisely regulated by both maternal and paternal genes. Assisted reproductive technologies have significantly improved the fertility of couples of reproductive age. However, in clinical practice, early embryonic arrest remains a major cause of female infertility. With the

advancement of sequencing technologies and population cohort studies, multiple pathogenic genes that cause early embryonic arrest in humans have been identified. These pathogenic genes disrupt critical signaling pathways involved in early embryonic development, interfering with embryonic division and differentiation, ultimately leading to developmental arrest. This review summarizes the currently identified pathogenic genes of early embryonic arrest and their molecular mechanisms, and discusses future directions in the development genetic research on early embryonic arrest.

【Key words】 Reproductive techniques, assisted; Infertility; Embryonic development; Genetic variations

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男性不育的遗传异质性与 PGT-A 的精准化应用

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【摘要】 男性不育具有高度遗传异质性, 涉及染色体数目/结构异常、Y 染色体无精子因子区微缺失、单基因突变等多维度机制。环境因素与表观遗传的交互作用可能进一步增加胚胎非整倍体风险。尽管国内外指南已将严重男性因素纳入胚胎植入前非整倍体遗传学检测 (preimplantation genetic testing for aneuploidies, PGT-A) 的适应证, 但其临床应用价值仍存在争议, 主要源于现行诊断体系对遗传缺陷的层级化评估不足, 导致无法精准识别 PGT-A 获益人群。本综述系统分析了男性不育的遗传异质性对胚胎非整倍体的影响机制, 深入探讨 PGT-A 在男性不育领域的临床应用争议, 并提出 PGT-A 的精准应用策略, 旨在为男性不育的 PGT-A 应用从经验性治疗转向个体化干预提供理论依据。

【关键词】 不育, 男性; 胚胎植入前非整倍体遗传学检测; 遗传异质性
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Genetic heterogeneity of male infertility and the precision application of PGT-A

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【Abstract】 Male infertility exhibits high genetic heterogeneity, involving multidimensional mechanisms such as numerical/structural chromosomal abnormalities, Y chromosome azoospermia factor region microdeletions, and monogenic mutations. Environmental factors and their interplay with epigenetic regulation may further elevate the risk of embryonic aneuploidy. Although current international and domestic guidelines have incorporated severe male factors as an indication for preimplantation genetic testing for aneuploidies (PGT-A), its clinical utility remains highly controversial. This controversy primarily stems from the insufficient hierarchical evaluation of genetic defects in existing diagnostic systems, which hinders the precise identification of populations likely to benefit from PGT-A. This review systematically analyzes the mechanisms by which the genetic heterogeneity of male infertility influences embryonic aneuploidy, provides an in-depth exploration of the clinical controversies surrounding PGT-A in male infertility management, and proposes precision-driven strategies for PGT-A application. The aim is to establish a theoretical foundation for transitioning PGT-A use in male infertility from empirical practice to individualized intervention.

【Key words】 Infertility, male; Preimplantation genetic testing for aneuploidies; Genetic heterogeneity

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临床研究

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单胚胎移植策略对新鲜周期妊娠结局的影响：基于间断时间序列分析的实证研究

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【摘要】 目的 评估单胚胎移植 (single embryo transfer, SET) 策略对新鲜周期妊娠结局的即时效应与长期趋势, 并分析年龄分层差异。方法 采用回顾性单中心观察性研究设计, 通过间断时间序列 (interrupted time series, ITS) 分析, 纳入西北妇女儿童医院生殖中心 2015 年 1 月 1 日至 2023 年 12 月 31 日共 42 910 个新鲜胚胎移植周期资料。以 2018 年第 3 季度策略实施为节点, 构建分段回归模型 ($Y_t = \beta_0 + \beta_1 \times \text{time}_t + \beta_2 \times \text{strategy}_t + \beta_3 \times \text{time_after_strategy}_t + \varepsilon_t$), 评估 SET 策略实施前后临床妊娠率、多胎妊娠率、活产率及多胎活产率的变化, 并按年龄分层 (<35 岁、35~37 岁、38~39 岁和 ≥40 岁) 进行进一步分析。结果 SET 策略实施后移植胚胎数 [(1.27±0.45) 枚] 比实施前 [(1.64±0.49) 枚] 显著减少, SET 率 [72.75% (21 434/29 461)] 和囊胚移植率 [58.00% (17 086/29 461)] 比实施前 [35.96% (4 836/13 449)、36.36% (4 890/13 449)] 均显著提升 (均 $P<0.001$)。策略即时效应显示, 整体年龄段多胎妊娠率显著下降 12.60% ($P<0.001$), 临床妊娠率下降 8.47% ($P<0.001$), 活产率下降 7.16% ($P<0.001$), 多胎活产率下降 11.33% ($P<0.001$); 年龄分层分析显示, <35 岁患者多胎妊娠率降幅最大, 为 15.72% ($P<0.001$), ≥40 岁患者活产率降低 9.82% ($P=0.008$)。策略长期趋势分析显示, 多胎妊娠率和多胎活产率策略实施前后均保持稳定 (均 $P>0.05$), SET 策略实施后, 临床妊娠率和活产率均呈现下降趋势 ($\beta=-1.26$, 95% CI: -1.65~-0.86, $P<0.001$; $\beta=-1.05$, 95% CI: -1.46~-0.64, $P<0.001$)。结论 SET 策略实施后, 新鲜胚胎移植周期的临床妊娠率和活产率的即时效应和长期变化均呈下降趋势, 年龄分层分析显示不同年龄组患者的策略效应存在显著差异。

【关键词】 体外受精; 间断时间序列分析; 新鲜胚胎移植; 单胚胎移植; 年龄分层

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Impact of single embryo transfer strategy on fresh cycle pregnancy outcomes: an empirical study based on interrupted time series analysis

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【Abstract】 Objective To evaluate the immediate effects and long-term trends of the single embryo transfer (SET) strategy on reproductive outcomes in

fresh cycles, and to analyze age-stratified differences. **Methods** A retrospective single-center observational study was conducted using interrupted time series (ITS) analysis. A total of 42 910 fresh embryo transfer cycles from the Reproductive Medicine Center of Northwest Women's and Children's Hospital between January 1, 2015 and December 31, 2023 were included. Using the strategy implementation date (the third quarter of 2018) as the intervention point, segmented regression models ($Y_t = \beta_0 + \beta_1 \times \text{time}_t + \beta_2 \times \text{strategy}_t + \beta_3 \times \text{time_after_strategy}_t + \varepsilon_t$) were constructed to assess changes in clinical pregnancy rate, multiple pregnancy rate, live birth rate, and multiple live birth rate after the implementation of SET strategy. Subgroup analyses were stratified by age (<35, 35–37, 38–39 and ≥ 40 years). **Results** After the implementation of the SET strategy, the number of embryos transferred decreased significantly (1.27 ± 0.45 vs. 1.64 ± 0.49 , $P < 0.001$), while SET rate [72.75% (21 434/29 461)] and the blastocyst transfer rate [58.00% (17 086/29 461)] rose markedly compared with the pre-strategy values [35.96% (4 836/13 449), 36.36% (4 890/13 449), respectively, both $P < 0.001$]. Immediate impact analyses showed that the multiple pregnancy rate fell by 12.60%, clinical pregnancy rate declined by 8.47%, live birth rate decreased by 7.16%, multiple live birth rate dropped by 11.33% (all $P < 0.001$); stratification by maternal age revealed that the largest reduction in multiple pregnancy rate occurred in women aged <35 years (–15.72%, $P < 0.001$), women aged ≥ 40 years experienced a 9.82% reduction in live birth rate ($P = 0.008$) and a 1.02% increase in multiple pregnancy rate ($P = 0.006$). Long-term trend analyses demonstrated stable multiple pregnancy rate and multiple live birth rate before and after the policy (both $P > 0.05$); after the implementation of the SET strategy, both clinical pregnancy rate ($\beta = -1.26$, 95% CI: –1.65––0.86, $P < 0.001$) and live birth rate ($\beta = -1.05$, 95% CI: –1.46––0.64, $P < 0.001$) declined. **Conclusion** After the SET strategy was introduced, both the immediate impact and the long-term trend show declining clinical pregnancy rate and live birth rate in fresh embryo-transfer cycles, with age-stratified analyses revealing significant differences in policy effect across patient age groups.

【Key words】 Fertilization *in vitro* ; Interrupted time series analysis; Fresh embryo transfer; Single embryo transfer; Age stratification

Fund program: Shaanxi Provincial Key Research and Development Program (2023-ZDLSF-48)

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冻融胚胎不同移植策略对 ≥ 40 岁不孕患者妊娠结局的影响：一项回顾性队列研究

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【摘要】 目的 探讨冻融胚胎移植 (frozen-thawed embryo transfer, FET) 周期不同的胚胎移植策略对 ≥ 40 岁不孕患者妊娠结局的影响，明确囊胚移植获得最佳临床妊娠率的年龄范围。**方法** 采用回顾性队列研究，分析 2019 年 1 月至 2024 年 12 月中国人民解放军联勤保障部队第九〇一医院生殖医学中心 ≥ 40 岁不孕患者的 610 例 FET 周期临床资料。根据胚胎移植类型及数量分为 5 组：单卵裂组 ($n=91$)、双卵裂组 ($n=193$)、单囊胚组 ($n=209$)、双囊胚组 ($n=79$) 及序贯组 ($n=38$)，比较各组的基础资料及妊娠结局。通过多因素 logistic 回归分析评估协变量对妊娠结局的影响，并利用受试者工作特征 (receiver operating characteristic, ROC) 曲线检验囊胚移植周期患者年龄对临床妊娠的预测效能。**结果** 5 组间比较，临床妊娠率、种植率、持续妊娠率、多胎率、活产率和每周期费用差异均有统计学意义 ($P<0.001$ 、 $P<0.001$ 、 $P=0.002$ 、 $P<0.001$ 、 $P=0.005$ 、 $P<0.001$)，流产率组间比较差异无统计学意义 ($P>0.05$)。经两两比较，单卵裂组 [8.79% (8/91)] 和双卵裂组 [16.58% (32/193)] 的临床妊娠率均低于单囊胚组 [32.06% (67/209)] 及双囊胚组 [37.97% (30/79)]，差异均有统计学意义 (均 $P<0.05$)；在种植率的比较中，单卵裂组 [8.79% (8/91)]、双卵裂组 [10.62% (41/386)] 及序贯组 [13.16% (10/76)] 的种植率均低于单囊胚组 [32.54% (68/209)]，均 $P<0.05$ ，双卵裂组显著低于双囊胚组 [22.15% (35/158)]， $P<0.05$ ；单卵裂组的持续妊娠率 [5.49% (5/91)] 低于单囊胚组 [19.14% (40/209)] 和双囊胚组 [22.78% (18/79)]，差异均有统计学意义 (均 $P<0.05$)；双卵裂组 [28.13% (9/32)]、双囊胚组 [16.67% (5/30)] 及序贯组 [25.00% (2/8)] 的多胎率均高于单囊胚组 [1.50% (1/67)]，均 $P<0.05$ ；单卵裂组的活产率 [3.33% (3/91)] 低于单囊胚组 [15.79% (33/209)] 和双囊胚组 [16.46% (13/79)]，差异均有统计学意义 (均 $P<0.05$)；单卵裂组和单囊胚组的每周期费用 [(21 056.35 $\pm$ 2 851.13) 元、 (22 037.70 $\pm$ 4 672.47) 元] 低于双卵裂组 [(24 689.45 $\pm$ 5 673.28) 元]、双囊胚组 [(29 116.27 $\pm$ 6 878.34) 元] 及序贯组 [(28 894.42 $\pm$ 5 762.12) 元]，双卵裂组每周期费用低于双囊胚组及序贯组，差异均有统计学意义 (均 $P<0.05$)。多因素 logistic 回归分析显示，患者的年龄与临床妊娠呈负相关 ($OR=0.68$ ，95% CI : 0.61~0.77， $P<0.001$)；抗米勒管激素与临床妊娠呈正相关 ($OR=1.21$ ，95% CI : 1.06~1.38， $P=0.005$)。单囊胚组 ($OR=4.51$ ，95% CI : 2.03~10.01)、双囊胚组 ($OR=6.16$ ，95% CI : 2.57~14.78) 和序贯组 ($OR=3.20$ ，95% CI : 1.07~9.53) 的临床妊娠率分别是单卵裂组的 4.51 倍、6.16 倍和 3.20 倍，差异均有统计学意义 (均 $P<0.05$)。ROC 曲线结果显示，在囊胚移植周期，年龄对妊娠结局具有一定预测价值，其曲线下面积为 0.704，95%

CI: 0.642~0.765, $P<0.001$, 囊胚移植年龄的截断值为 42.5 岁。结论 对于 ≥ 40 岁的患者,单囊胚移植维持较高临床妊娠率,降低多胎妊娠风险,并兼具经济效益,应作为首选策略。40~42 岁患者通过囊胚移植仍可获得较满意的妊娠率,但当患者年龄 ≥ 42.5 岁,临床妊娠率显著下降。

【关键词】 体外受精; 高龄; 胚胎移植; 囊胚期胚胎; 卵裂期胚胎

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Impact of different embryo transfer strategies on pregnancy outcomes in infertile patients aged ≥ 40 years during frozen-thawed cycles: a retrospective cohort study

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【Abstract】 Objective To investigate the effects of different embryo transfer strategies on pregnancy outcomes in patients aged ≥ 40 years undergoing frozen-thawed embryo transfer (FET) cycles, and to define the optimal age range for the highest clinical pregnancy rate through blastocyst transfers. **Methods** A retrospective cohort analysis was conducted on the clinical data of 610 FET cycles in patients aged ≥ 40 years at the 901st Hospital of the Joint Logistics Support Force of the PLA from January 2019 to December 2024. Based on the type and number of embryos transferred, patients were divided into five groups: 91 cases receiving single cleavage-stage embryo transfer were classified as the single cleavage (SC) group, 193 cases receiving double cleavage-stage embryo transfer were classified as the double cleavage (DC) group, 209 cases with single blastocyst transfer were classified as the single blastocyst (SB) group, 79 cases with double blastocyst transfer were classified as the double blastocyst (DB) group, and 38 cases with combined transfer of one cleavage-stage embryo and one blastocyst were classified as the sequential embryo (SE) group. Baseline characteristics and pregnancy outcomes were compared among the five groups. The impact of covariates on pregnancy outcomes was evaluated through multivariate logistic regression analysis, while the predictive efficacy of patient age for clinical pregnancy in blastocyst transfer cycle was examined using receiver operating characteristic (ROC) curve analysis. **Results** There were statistically significant differences in clinical pregnancy rate, implantation rate, ongoing pregnancy rate, multiple pregnancy rate, live birth rate and cost per cycle among the five groups ($P<0.001$, $P<0.001$, $P=0.002$, $P<0.001$, $P=0.005$, $P<0.001$, respectively). No statistically significant difference was observed in the miscarriage rate among the five groups ($P>0.05$). After pairwise comparison, the clinical pregnancy rates in the SC group [8.79% (8/91)] and the DC group [16.58% (32/193)] were significantly lower than those in both the SB group [32.06% (67/209), all $P<0.05$] and the DB group [37.97% (30/79), all $P<0.05$]. The implantation rate in SC group [8.79% (8/91)], the DC group [10.62% (41/386)] and the SE group [13.16% (10/76)] was

significantly lower than that in the SB group [32.54% (68/209), all $P<0.05$], which was lower in the DC group than in the DB group [22.15% (35/158), $P<0.05$]. The ongoing pregnancy rate in the SC group [5.49% (5/91)] was lower than that in the SB group [19.14% (40/209), $P<0.05$] and the DB group [22.78% (18/79), $P<0.05$]. The multiple pregnancy rate in the DC group [28.13% (9/32)], the DB group [16.67% (5/30)] and the SE group [25.00% (2/8)] was all significantly higher than that in the SB group [1.50% (1/67), all $P<0.05$]. The live birth rate in the SE group [3.33% (3/91)] was lower than that in the SB group [15.79% (33/209), $P<0.05$] and the DB group [16.46% (13/79), $P<0.05$]. The cost per cycle of the SC group [(21 056.35±2 851.13) yuan] and the SB group [(22 037.70±4 672.47) yuan] was lower than that of the DC group [(24 689.45±5 673.28) yuan], the DB group [(29 116.27±6 878.34) yuan], and the SE group [(28 894.42±5 762.12) yuan]. The cost per cycle of the DC group was lower than that of the DB group and the SE group, and the differences were all statistically significant (all $P<0.05$). Multivariate logistic regression analysis found that patients' age was negatively correlated with clinical pregnancy ($OR=0.68$, 95% CI : 0.61–0.77, $P<0.001$). Anti-Müllerian hormone was positively correlated with clinical pregnancy ($OR=1.21$, 95% CI : 1.06–1.38, $P=0.005$). The SB group ($OR=4.51$, 95% CI : 2.03–10.01), the DB group ($OR=6.16$, 95% CI : 2.57–14.78) and the SE group ($OR=3.20$, 95% CI : 1.07–9.53) had 4.51, 6.16 and 3.20 times higher clinical pregnancy rates, respectively, compared with the SC group (all $P<0.005$). ROC curve analysis demonstrated that patients' age had predictive value for pregnancy outcomes in blastocyst transfer cycles, with an area under the curve of 0.704 (95% CI : 0.642–0.765, $P<0.001$). The optimal age cut-off point for blastocyst transfer was determined to be 42.5 years. **Conclusion** For patients aged ≥ 40 years, single blastocyst transfer can maintain a high clinical pregnancy rate while reducing the risk of multiple pregnancies and demonstrating cost-effectiveness, making it the preferred strategy. Patients aged 40–42 years can still achieve a satisfactory pregnancy rate through blastocyst transfer, but when the patient's age is ≥ 42.5 years, the pregnancy rate declines significantly.

【 Key words 】 Fertilization *in vitro*; Advanced age; Embryo transfer; Blastocyst-stage embryo; Cleavage-stage embryo

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·现场调查·

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基于原型意愿模型探讨行辅助生殖技术患者卵母细胞捐赠意愿的研究

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【摘要】 目的 探索影响接受辅助生殖技术 (assisted reproductive technology, ART) 患者卵母细胞捐赠意愿的因素。方法 采用横断面研究的方法, 通过便利取样法选取 2024 年 9 月至 2025 年 3 月期间在广东省妇幼保健院生殖中心接受 ART 的患者作为研究对象 ($n=1\ 019$)。采用一般资料调查表、汉化版原型意愿模型 (prototype willingness model, PWM) 量表、利他主义量表和人际反应指标量表对影响 ART 患者卵母细胞捐赠意愿的因素进行数据分析。结果 ART 患者卵母细胞捐赠意愿得分为 (3.88 ± 1.74) 分。PWM 量表对 ART 患者卵母细胞捐赠意愿的解释力显著 ($R^2=0.58, P<0.001$)。多重线性回归分析显示, 大专及本科学历 ($B=-0.27, P=0.015$)、PWM 态度 ($B=0.32, P<0.001$)、PWM 主观规范 ($B=0.25, P<0.001$) 和 PWM 原型好感度 ($B=0.40, P<0.001$) 是影响 ART 患者卵母细胞捐赠意愿的主要因素。结论 ART 患者卵母细胞捐赠意愿仍处于中低水平。ART 患者卵母细胞捐赠意愿与患者文化程度呈负相关。PWM 态度、PWM 主观规范、PWM 原型好感度对 ART 患者卵母细胞捐赠意愿具有正向作用。

【关键词】 生殖技术, 辅助; 卵母细胞; 捐赠意愿; 原型意愿模型

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Study on the oocyte donation willingness of patients undergoing assisted reproductive technology based on prototype willingness model

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【Abstract】 **Objective** To explore the influencing factors of oocyte donation willingness among patients undergoing assisted reproductive technology (ART). **Methods** A cross-sectional study was conducted, A total of 1 019 patients who received ART at Reproductive Center of Guangdong Women and Children Hospital from September 2024 to March 2025 were selected for this study. through the convenience sampling method The factors affecting ART patients' oocyte donation intention were analyzed using general information questionnaire, Chinese version of prototype willingness model (PWM) scale, altruism scale and interpersonal response index scale. **Results** The score for the willingness to donate oocytes among ART patients was 3.88 ± 1.74 . The PWM significantly explained the willingness to donate oocytes among ART patients ($R^2=0.58, P<0.001$). Patients with associate's or bachelor's degrees ($B=-0.27, P=0.015$), PWM attitudes ($B=0.32, P<0.001$), PWM subjective norms ($B=0.25, P<0.001$), and PWM prototype

favorability ($\beta=0.40$, $P<0.001$) were all significant predictors of the willingness to donate oocytes among ART patients detected by multiple linear regression analysis.

Conclusion The willingness to donate oocytes among ART patients remains low. The willingness of ART patients to donate oocytes is negatively correlated with their educational level. PWM attitude, PWM subjective norms, and PWM prototype favorability positively influence their willingness to donate oocytes.

【Key words】 Reproductive techniques, assisted; Oocyte; Donation willingness; Prototype willingness model

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综述

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子宫内膜异位症与妊娠失败的新进展

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【摘要】 子宫内膜异位症是一种常见的生殖系统疾病, 影响 10%~15% 的育龄期女性, 并与不孕症及多种不良妊娠结局密切相关, 尽管辅助生殖技术为子宫内膜异位症患者带来了生育希望, 但她们仍面临着较高的反复种植失败风险。因此, 探讨子宫内膜异位症对妊娠失败的潜在影响成为了生殖医学中的重要研究领域。本文将系统阐述子宫内膜异位症及其相关病变(子宫腺肌病/瘤)对妊娠失败的影响, 分析其潜在的病理机制, 包括慢性炎症、氧化应激、子宫内膜容受性降低等, 旨在评估子宫内膜异位症对女性从受孕至早期妊娠维持的潜在影响, 为临床实践提供参考。

【关键词】 子宫内膜异位症; 复发性流产; 自然流产; 反复种植失败; 妊娠失败

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New advances in endometriosis and pregnancy failure

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【Abstract】 Endometriosis is a common reproductive system disease that affects 10%-15% of women of reproductive age and is closely related to infertility and various adverse pregnancy outcomes. Although assisted reproductive technology has brought hope for fertility to patients with endometriosis, those women still face a higher risk of recurrent implantation failure. This review aims to systematically discuss the impact of endometriosis and its related lesions (such as adenomyosis/adenomyoma) on pregnancy failure, analyzes their potential pathological mechanisms, including chronic inflammation, oxidative stress, and reduced endometrial receptivity, and assesses the potential impact of endometriosis on women from conception to early pregnancy maintenance, providing reference for clinical practice.

【Key words】 Endometriosis; Recurrent pregnancy loss; Spontaneous abortion; Recurrent implantation failure; Pregnancy failure

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白血病睾丸浸润生殖毒性机制及生育力保护进展

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【摘要】 白血病可能累及睾丸, 其中急性淋巴细胞白血病 (acute lymphoblastic leukemia, ALL) 最为常见, 约 20% ALL 患儿出现睾丸浸润, 其发生可能与 CXC 趋化因子配体 12 / CXC 趋化因子受体 4 介导的 ALL 细胞迁移相关, 睾丸内药物浓度和免疫豁免环境等因素也可对其产生影响。在治疗 ALL 睾丸浸润时采用全身治疗与局部治疗相结合的方式。然而, 这些治疗手段可能会通过氧化应激、炎症反应、血-睾屏障破坏、内分泌紊乱等途径直接或间接产生生殖系统毒性反应, 对患儿未来的生育能力和生活质量造成潜在的负面影响。目前, 针对患儿生育力保存的措施主要包括青春期患者的精液冷冻保存、青春期前患者的睾丸组织冷冻保存, 以及成年后的显微解剖睾丸精子提取等方法。本文对 ALL 睾丸浸润的可能发病机制、

主要治疗方式的生殖系统毒性, 以及生育力保存的可能措施进行了系统的总结与综述。

【关键词】 急性淋巴细胞白血病; 睾丸浸润; 生殖毒性; 生育力保存

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Mechanisms of leukemia testicular infiltration and gonadotoxicity and therapeutic advances

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【 Abstract 】 Leukemia may involve the testis, with acute lymphoblastic leukemia (ALL) being the most common. About 20% of children with ALL experience testicular infiltration. This occurrence may be related to the migration of ALL cells mediated by CXC chemokine ligand 12/CXC chemokine receptor 4. Factors such as intratesticular drug concentration and the immune-privileged environment could also have an impact. In the treatment of ALL testicular involvement, a combination of systemic and local therapies is adopted. However, these therapeutic approaches may directly or indirectly produce gonadotoxic effects through pathways such as oxidative stress, inflammatory response, disruption of the blood-testis barrier, and endocrine disorders, potentially causing negative impacts on the future fertility and quality of life of children. Currently, measures for fertility preservation mainly include sperm cryopreservation for adolescent patients, testicular tissue cryopreservation for prepubertal patients, and microdissection testicular sperm extraction in adulthood. This article systematically summarizes and reviews the possible pathogenesis of ALL testicular involvement, the gonadotoxicity of therapeutic methods, and possible measures for fertility preservation.

【 Key words 】 Acute lymphoblastic leukemia; Testicular infiltration; Gonadotoxicity; Fertility preservation

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