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Artificial Womb: A New Horizon in Assisted Reproductive Technology

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Abstract: In recent years, artificial womb technology (ectogenesis) has emerged as a novel approach to supporting extremely premature infants and assisting infertile couples. Early prototypes, such as the Biobag, have successfully simulated physiological conditions to support fetal growth in lambs ex utero, bringing this clinical vision closer to reality. Alongside these technical advancements, ethical and legal discussions surrounding the social, gender-related, and child rights implications have intensified. This letter provides a concise overview of key developments, ethical challenges, and the future outlook of artificial womb technology.

Keywords: Assisted reproductive technologies; artificial uterus; innovation; editorial.

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Introduction

According to the World Health Organization, approximately 15 million babies are born prematurely each year, and around 1 million of them die due to complications arising from preterm birth. In an effort to reduce neonatal mortality, artificial amnion and placenta technology commonly referred to as the "artificial womb" has been developed to provide an optimal environment for fetal development outside the human body. Since 1958, when Westin et al. constructed the first artificial womb through umbilical vessel cannulation, this technology has demonstrated significant potential in improving the clinical outcomes of critically preterm infants. Several functional models are currently under investigation, including the EXTra-uterine Environment for Neonatal Development (EXTEND) at the Children's Hospital of Philadelphia, the Ex-Vivo uterine Environment (EVE) at Tohoku University, and an ongoing project at the University of Western Australia. The world's first concept facility for artificial wombs, EctoLife, was launched on December 9, 2022, by a science communicator and filmmaker based in Berlin, Germany [1].

Ectogenesis refers to the partial or complete development of a fetus outside the biological uterus. While early reports stem from animal studies conducted decades ago, only in recent years owing to advances in biomaterials, pumpless systems, and extracorporeal life support has the possibility of sustained physiological support significantly improved [2].

The first successful model, Biobag, demonstrated that stable hemodynamic and physiological support of fetal lambs could be maintained for up to four weeks [3]. In September 2023, the U.S. Food and Drug Administration (FDA) held a landmark session to initiate the first official steps toward partial ectogenesis trials in humans. These trials aim to transfer extremely preterm fetuses from the maternal womb into an artificial system to complete gestation. A recent report from Duke University School of Medicine, published in Scientific Reports in collaboration with CHOP, showed that a new system without external pumps could maintain fetal stability for weeks after transfer [4].

Nonetheless, some researchers caution that rapid clinical implementation may exacerbate social inequalities and challenge parental rights. Feminist scholars have warned that unequal access to this technology could diminish the value of traditional pregnancy and threaten women's bodily and psychological autonomy. Bioethical debates continue to evolve around issues such as access prioritization, legal parenthood, and potential psychological effects on children who undergo gestation in artificial environments.

While the prospect of complete ectogenesis gestation from conception to birth entirely outside the human body remains a distant goal, it holds revolutionary promise for infertility treatment. It is anticipated that by 2027, the first successful clinical application may be implemented for infants born at less than 24 weeks of gestation. However, challenges such as infection control, nutritional support, and legal frameworks must still be addressed. The development of novel biomaterials to simulate amniotic conditions and enhance vascular access methods for fetal stability is expected to remain research priorities in the coming decade.

In conclusion, artificial womb technology represents a potential paradigm shift in neonatal care and infertility treatment. Recent advancements in animal models and initial steps toward human trials signal a promising future for this innovation. However, addressing the accompanying ethical dilemmas, regulatory policies, and equitable access is essential for the safe and effective integration of this technology into clinical practice.

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