Artificial intelligence-enabled studies on organoid and organoid extracellular vesicles

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In the field of medical research, studies of organoids and organoid extracellular vesicles (OEVs) are leading a revolutionary change.[1] Organoids are simplified, miniaturised versions of organs that simulate the microenvironment of human tissues, and have broad applications in disease modelling, drug development, and regenerative medicine. Extracellular vesicles (EVs) are tiny vesicles secreted from various cells, containing proteins, lipids, RNA, and other biomolecules, serving as an essential mechanism for intercellular communication and considered pivotal tools for future diagnostics and therapies.[2] Moreover, OEVs demonstrate better physiological and therapeutic effects than that of traditional EVs.[1] However, the application of artificial intelligence (AI) in the research and development of organoids and OEVs can significantly enhance the efficiency and accuracy of studying these complex systems. Recently, the journal *Nature* published a paper entitled "Seven technologies to watch in 2024", where AI leads the development of many hot technologies.[3]

The research of organoids aims to create platforms that can simulate the actual environment of biological organs, facilitating a better understanding of disease progression and organ development, as well as promoting new drug discoveries. In 2009, Sato et al.[4] constructed the first intestinal organoid, ushering in a new era of organoid technology development. In 2022, Chen et al.[5] first proposed "The horizon of bone organoid: A perspective on construction and application". Within organoids, multiple cell types should work together to mimic the interactions amongst them found in their natural environments. Precision manipulation and measurement within this complexity poses a great challenge. With the evolution of deep learning and machine learning technologies, AI presents new possibilities in the study of organoids. AI, with its advanced image recognition capabilities, can automatically track and analyse cell behaviour patterns within organoids. AI aids in monitoring the processes of cell growth, differentiation, and death, and can also identify various cell types and their interactions against complex backgrounds. Moreover, AI could help researchers extract valuable information from vast biological data and transform these complex datasets into actionable insights. Recently, Bai et al.[6] innovatively proposed 'AI-enabled organoids: construction, analysis, and application', marking an era of second-generation organoid investigation.

On the other hand, as a natural form of intercellular communication, EVs carry decisive information regarding the fate of cells.[7] By studying EVs, scientists aim to uncover how cells influence each other and transfer information throughout the body. EVs research has profound implications for diagnosis and treatment of various diseases, such as cancer and neurodegenerative disorders.[8] Due to the particularity of OEVs, Liu and Su[9, 10] also innovatively proposed the use of organoids and OEVs to treat complex bone diseases. In the study of OEVs, the use of AI to analyze high-throughput imaging data allows for rapid identification and classification of different vesicles, accelerating the process of biomarker discovery and validation. AI also enables researchers to identify changes more quickly in key signalling pathways within organoids and potential biomarkers within OEVs. In the realm of personalized medicine, AI can aid in designing precise treatments based on the specific characteristics of a patient's EVs.

Future research should integrate AI more fully into organoid and OEVs research to realize automated and intelligent experimental procedures. Furthermore, AI systems need deeper comprehension of complex biological processes, signalling continuous evolution and improvement of AI models and algorithms. However, AI-mediated organoid and OEVs research also faces considerable challenges. How can we ensure the accuracy and reliability of the AI system outcomes? The issue of AI interpretability is also of concern to scientists. Hence, developing AI systems that can explain their decision-making processes would provide scientists with a deeper understanding of the results yielded by data analysis. Another challenge lies in data privacy and security. Handling patient data requires full protection of their privacy and compliance with ethical and legal standards.

The application of AI in organoid and OEVs research is continuously driving progress in the field. With AI's smart data analysis and processing, a new era of diagnostics and treatment unfolds. On the path to precision and personalized medicine, AI undoubtedly stands as a formidable companion. Looking ahead, as AI technology continually advances and refines, there is every reason to believe that scientists will unlock more secrets of the life sciences, bringing a healthier future for humanity. To this end, it is fervently hoped that more excellent AI-related work on organoids and OEVs will be submitted to Biomaterials Translational for future publication.

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