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Cultivating Complexity: Advancements in Hollow-fibre Infection Models for Fastidious Organisms

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DESCRIPTION

The study of infectious diseases is a multifaceted endeavor, often complicated by the diverse and dynamic nature of microbial pathogens. Fastidious organisms, characterized by intricate growth requirements and challenging culturability, present unique hurdles for researchers seeking to unravel their pathogenic mechanisms and devise effective therapeutic strategies. In this context, the hollow-fibre infection model (HFIM) has emerged as a valuable tool, offering a versatile platform for the culture and assessment of fastidious organisms in a controlled in vitro environment. Historically, HFIMs were primarily employed in pharmacokinetic and pharmacodynamic studies, facilitating the evaluation of antimicrobial agents against bacterial pathogens. However, recognizing the need to expand its utility to encompass a broader spectrum of infectious agents, researchers have increasingly tailored HFIMs to accommodate the growth requirements of fastidious organisms. This necessitated adaptations in culture media composition, growth conditions, and assessment methodologies to create an optimal environment conducive to the proliferation and study of these challenging microbes. One of the key adaptations involves the formulation of specialized growth media tailored to the nutritional requirements of fastidious organisms. Traditional culture media may lack essential nutrients or growth factors necessary for the viability of these microbes, thereby impeding their cultivation within HFIMs. By customizing media formulations based on the metabolic preferences and physiological characteristics of specific pathogens, researchers can create an environment that closely mimics the in vivo conditions conducive to microbial growth and virulence expression. Moreover, advancements in HFIM technology have facilitated precise control over environmental variables such as temperature, pH, oxygen tension, and nutrient availability. These parameters can be finely tuned to replicate the microenvironment encountered by pathogens within the host, thereby enhancing the physiological relevance of HFIMs for studying host-pathogen interactions. By modulating these environmental cues, researchers can simulate niche-specific conditions conducive to the growth and persistence of fastidious organisms, providing valuable insights into their pathogenic mechanisms and host adaptation strategies. In addition to culture optimization, the assessment of fastidious organisms within HFIMs necessitates the development of robust methodologies for quantification, phenotypic characterization, and evaluation of virulence attributes. Traditional microbiological techniques may be insufficient to capture the intricacies of fastidious organism behavior within the complex microenvironment of HFIMs. Hence, researchers have embraced innovative approaches such as molecular diagnostics, high-throughput sequencing, metabolomics, and proteomics to decipher the molecular signatures of infection and unravel the host-pathogen interplay at a systems level. Furthermore, the integration of HFIMs with advanced imaging modalities such as confocal microscopy, live-cell imaging, and multi-photon microscopy has enabled real-time visualization of infection dynamics within complex three-dimensional tissue-like structures. This facilitates the spatiotemporal tracking of pathogen dissemination, host immune responses, and therapeutic interventions, offering unprecedented insights into the dynamic interplay between fastidious organisms and their host milieu.

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CONFLICT OF INTEREST

The author declares there is no conflict of interest in publishing this article.

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