Jayasundara N.Y.K.B, Wickramatunga B.L.D.N.K.K

MICRO-PHYSIOLOGICAL SYSTEMS: ORGANS ON CHIP

Tutor: senior lecturer Grigorian A.L.
Department of Normal physiology
Belarusian State Medical University, Minsk

Microphysiological systems represent a localized entity that mediates interactions between tissue and its surrounding fluid. The importance of developing technical systems that enable research beyond laboratory animals is highlighted. Furthermore, the creation of such a microphysiological system facilitates fundamental research into cell cultures and an understanding of living organisms as a whole.

Among the increasingly popular methods for studying pulmonary and coronary arteries, the development of "lung-on-a-chip" and "heart-on-a-chip" systems has been successful. These systems reflect the nature of the interaction between lung/heart tissue and their "microenvironment," making a deep understanding of the relationship between flow and tissue metabolic patterns an exciting area. We focused on identifying the advantages of these systems and their reliable use in future studies of the human hemocardiorespiratory system.

The "lung-on-a-chip" mechanism is designed to simulate a functional interface involving alveoli and pulmonary capillaries. This microphysiological system consists of two microchannels connecting a biological membrane that mimics a human cell membrane. The anterior membrane has similar or identical permeability coefficients for oxygen and carbon dioxide, which best replicate real-world conditions for gas exchange. The microchannels are divided into two groups: one represents the capillary "epithelium" and the other the "endothelium." Human stem cells serve as the material for the outer cells, allowing for the modeling of pathophysiological processes. This microchannel organization is necessary for air-liquid separation at the border, thereby simulating real-world conditions in the human body. Modern "lung-on-a-chip" models include the ability to 3D visualizes gas exchange, enabling the development of new treatments to reduce alveolar occlusion.

The "heart-on-a-chip" mechanism mimics the functional activity of cardiomyocytes, exhibiting contractile activity. The model is exposed to induced stem cells, which are grown in a closed environment under the influence of growth and differentiation factors. In this case, the grown cellular structure takes the form of a polymer microchannel scaffold and intense electric fields to simulate the function of the sinoatrial node. The advantages of this model lie in its ability to simulate the pathophysiological processes that occur when different groups of cardiomyocytes are blocked. Furthermore, the "heart-on-a-chip" unlocks the potential for controlling contractile processes at the metabolic level, identifying changes in the left chain function when exposed to cardiotoxic drugs.

Microphysiological systems fundamentally change the way researchers model preclinical testing, using human cells, fluid flow and mechanical forces to accurately replicate organ level function. MPS have demonstrated predictive accuracy in regards to the toxicity and efficacy of drugs providing researchers with more effective alternatives to animal testing for human-based applications. Through continued efforts in standardizing and scaling MPS, these systems will serve as an essential platform for drug development, personalized medicine and toxicology screening.