Organ-on-a-Chip: New Tool for Personalized Medicine

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Newly developed drugs need to be tested by using cell culture and in vivo using animals. Following these experiments, medicines can then enter into clinical trials to first assess their safety and then efficacy. After appropriate acceptable results obtained, producers apply for approvals from concerned bodies, such as the FDA in the United States. In many cases even with medicines that are approved, complications may occur.[1,2] Because of the failure of two-dimensional (2D) cell culture system to recapitulate in vivo events and failure of animal models to be representative of a different species, that is, human,[3] it remains necessary to search for new possibilities and be able to overcome limitations related to current drug testing methods.[4]

Given also the fact of demanding that all medicines and chemicals undergo animal testing, the cost of development will be tremendously huge, and will be reflected in the prices of developed drugs and time they take before they become available. With new EU regulation (REACH Policy for Registration, Evaluation, and Authorization of Chemicals) requesting the testing for toxicity of c. 30,000 chemicals, we will need about 2.5 to 54 million animals[5] to use for testing (costing about 1.3–9.3 trillion Euros).[6,7] The development of a single drug formulation can take up to 13.5 years[8] and cost 2.5 billion USD.[9]

With the advent of organ-on-a-chip technology which evolved from lab-on-a-chip[10] by culturing cells into microchannels, it seems that an alterative to 2D culture and animals is emerging with promises to be more biomimetic to human physiology. So far, various tissue models were developed to represent lung,[11] gut,[12,13] kidney,[14] heart,[15] liver,[16,17] and bone marrow.[18] Multiorgan-on-a-chip devices were also connected to develop a more biomimetic system to test for studying systemic[19] and secondary[20] toxicity where kidney, liver gut, and so on can interact and provide more reliable results regarding drug absorption, metabolism, clearance, and toxicity. With a more complex level, where about 10 organ-on-a-chip organ types are connected, human-on-a chip is developed to study systemic toxicity.[21]

In addition to drug testing and development, organ-on-a-chip technology represents also a good platform to study physiology and pathology of certain disease processes. Using cells taken from patients, it will be possible to develop personalized medicine in future where specimens taken from patients are tested to define appropriate drug and dose for individual patients in a way similar to what we have today with antibiotic sensitivity testing.

Organ-on-a-chip technology is well welcome and funding agencies are putting calls forward for applications to carry our projects in this important niche area. Organ-on-a-chip technology is projected to have a global market of $6.13 billion by 2025.[22] It is important to prove that the organ-on-a-chip platform can effectively address the core criteria of drug absorption, distribution, metabolism, and excretion. Nevertheless, it will be necessary to validate this technology against well-established standard tests and outcomes in the current practice that are obtained with known compounds.[23] Once established, we will certainly be able to avoid a lot of limitations, problems, and unnecessary loading of patients with ineffective drugs, toxic medicines, or over- or underdosing. We will certainly have more effective medicines and efficient practice of medicine in the next decade, with the use of this new tool, organ-on-a-chip.

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