Contribution ID: **16** Type: **not specified**

Engineering 3D human tissues equivalent as reliable and predictive tools for clinical implementation of personalized and precision medicine

Personalized medicine and precision medicine are the current paradigms steering the changes in medicine practice and healthcare industries. Following these two paradigms, it is expected soon to radically transform medical interventions by providing effective, precise and tailored therapeutic and diagnostic strategies based on molecular (omics) profile adapted to current individual state of a given patience. To operate this revolution, better and personalized therapeutical trial assay must be developed.

Tissue and organ on chip (TOC) devices are microfluidic systems with controlled, dynamic microenvironments in which cultured human in vitro engineered tissues or organs exhibit functions that emulate organ-level physiology. They have been developed to permit the study of human physiology in a tissue-specific context, to enable development of novel in vitro disease models, and to potentially serve as replacements of animals in drug development and toxics testing. ToC device can be 'personalised' to recapitulate individual physiology, for instance by using primary cells harvested from the specific patient or derived from induced pluripotent stem cell (iPSC) patient specific to engineering in vitro autologous pieces of highly competent and patient specific tissue or organ, introducing these engineered tissues in microphysiological systems able to tune key physico-chemical culture microenvironment features based on personal health data. The individual nature of such systems, combined with appropriate molecular and cellular read-outs, provides a powerful tool for person-specific clinical trial by assessing drug efficacy and safety, as well as personalised strategies for treatment, prediction and prevention of disease. All together these devices might contribute significantly towards the practical implementation of precision and personalized medicine.

As today there are several examples of personalized ToC models, with examples including lung-on-a-chip, gut-on-chip, liver-on-chip, skin-on-chip obtained by using primary patient harvested cells, along with multi-organ on chip systems to allow the assessment of the dynamics occurring among organs through their molecular crosstalk. However, for OoC technology to meet the expectation to faithful recapitulate the complex native in vivo behaviour of human tissue and organs, it is mandatory to proceed towards the use of tissue and organs that correctly reproduce in composition and organization the extracellular space. Indeed, while sophisticated microdevices have been designed, the engineered tissues still remain surrogates of the native counterparts. The major challenges for the effective implementation of personalized organs-on-chips in precision medicine are related to obtaining in vitro engineered tissue and organ functionally and structurally competent, as well as to obtaining data on patient outcomes that can confirm the predictive value of personalized organs-on-chips.

In this lecture ToC or OoC devices and their potential utility in personalized medicine will be presented along with their potential to push the clinical implementation of precision medicine. Current and projected use of OoC in different disease and treatment scenarios will be discussed including examples on tumor, rare disease, pulmonary disorder, skin disease where these devices could be integrated into the decision-making process for physicians and healthcare providers. Use of ToC devices in nutraceutical and cosmeceutical field will also be commented.

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