From microfluidic technology to organ-on-a-chip platfroms: new opportunities to develop physiologically relevant *in vitro* models

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1. Introduction

Lab-on-a-chip technology (LOC) has reached a mature state and has become highly popular for life sciences, due to the numerous advantages it offers. While microfluidic developments have initially been driven by the field of bioanalysis, LOC applications have been extended to cell experimentation, for which LOC technology presents additional advantages: an *in vivo*–like and tunable microenvironment, dynamic culture, and a unique capability to couple cell culture, treatment and analysis on one single platform. In this presentation, I will particularly discuss two applications of microfluidics, in the fields of assisted reproductive technologies (ART) and cancer research.

2. Microfluidics for assisted reproductive technologies (ART)

In the field of ART, LOC technology offers alternative approaches for all *in vitro* steps of the treatment, to eventually remedy currently encountered issues [1]. So far, we have focused on two steps, the pre-implantation *in vitro* culture of embryos, and (ii) their characterization, to monitor their growth and identify embryos with the highest developmental competence before transfer. A first microfluidic platform was developed and validated on mouse embryos, demonstrating that microfluidic chambers support the full-term development of mouse embryos down to the single embryo level, with birth rates comparable to group culture in a conventional format (droplet culture) [2]. After upgrade, the device was tested on donated frozen human embryos [3]. Next, an electrochemical sensor has been developed, together with an original measurement protocol, to monitor in real-time variations in the dissolved oxygen concentration in the culture chamber [4]. Current work concerns the integration of the sensor in the culture device.

3. Tumor-on-a-chip models – evaluation of nanomedicine delivery and penetration

For drug screening, and to evaluate the penetration and efficiency of nanomedicines, sophisticated and biomimetic *in vitro* models are required that incorporate essential features of the tumor microenvironment. In that contact, we are developing a tumor-on-a-chip platform that relies on the use of 3D tumor models (spheroids) [5] prepared from either a mono-culture (breast tumor cells) or a co-culture (breast tumor cells and fibroblasts), to yield a model closer to the *in vivo* situation [6]. In our first generation platform, spheroids are trapped in a microfluidic chamber, and this platform has been applied to evaluate the penetration of fluorescently nanoparticles, employed here as surrogates for nanomedicines, under either static conditions or flow. A second generation platform is under development, where the 3D tumor model is combined to a vascular system for the delivery of the drugs/nanomedicines to the tumor site.

References

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