IMPORTANCE OF VASCULARITY IN 3D BIOPRINTING

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INTRODUCTION:

Three-dimensional (3D) printing is driving major innovations and impact in diverse areas. One of the most important applications of this technology is related to regenerative medicine, addressing the need of organs suitable for transplantation. Compared to a classical 3D printing, it involves additional complexities (such as, vascularity) that need to be solved.

WHAT IS VASCULARITY?

It is responsible for transporting oxygen and other gases, hormones, nutrients and cellular waste matter through capillaries to the body.

WHY IS VASCULARITY IMPORTANT?

It determines which kind of structure can be printed depending on some characteristics, between other: cell and tissue type, complexity, function, size and/or time. It is needed a good built-in vascular architecture in order to progress and to achieve advanced and more complex structures either inside or outside of human body. Nevertheless, large volumes of implanted tissue and 3D bioprinting structures are unable to stimulate the formation of necessary and stable blood vessels for their survival.

FUGITIVE INK

The ink is composed of a triblock copolymer. It enables the creation of human tissues (>1 cm) replete with an engineered extracellular matrix, multiple cell types and channels inside by gel-to-fluid ink transition. They are printed within a 3D perfusion chip.

INTEGRATED TISSUE-ORGAN PRINTER (ITOP)

It is a system that deposits cell-laden hydrogels merged with synthetic biodegradable polymers to obtain the correct shape of any tissue construct. The procedure is a sophisticated nozzle system. It is capable of fabricating human-scale mandible bone, organized skeletal muscle and ear-shaped cartilage.

FREEFORM REVERSIBLE EMBEDDING OF SUSPENDED HYDROGELS (FRESH)

It is built by embedding the printed hydrogel (layer by layer) within a gelatin secondary one that serves as a temporary, thermoreversible and biocompatible support. It needs a previous digital 3D model. It allows obtaining some tissues such as, a human femur and a coronary artery tree.

CALCIUM PHOSPHATE ORMOGLASS PARTICLES

They are put at the (bio)ink that will be print by polymers deposition in solution. They are used to liberate Ca^{2+} ions in physiological concentrations through their degradation to elicit the local expression of angiogenic factors associated to a chemotactic effect on macrophages and sustained angiogenesis into the biomaterial.

CONCLUSIONS:

- 3D-bioprinted tissue constructs are being developed for transplantation, for use in drug discovery, analysis of chemical, biological and toxicological agents, and basic research.
- Multidisciplinary research will be needed to meet new challenges and realize the potential of 3D bioprinting to transform the field of regenerative medicine.

REFERENCES:

1. Kang, Hyun-Wook; Lee, Sang Jin; Ko, In Kap; Kengla, Carlos; Yoo, James J & Atala, Anthony: *A 3D bioprinting system to produce human-scale tissue constructs with structural integrity,* 2016. Nature, 32(3)312-319. doi:10.1038/nbt.3413
2. Kolesky, David B.; Homan, Kimberly A.; Skylar-Scott, Mark A. and Lewis, Jennifer A.: *Three-dimensional bioprinting of thick vascularized tissues,* 2016. PNAS: 113(12)3179-3184
3. Hilton, Thomas; *Three-dimensional printing of complex biological structures by freeform reversible embedding of suspended hydrogels*, 2015. Science Advances, 1(9)e1500758
4. Engel, Elisabeth; Oliveira, Hugo et al: *The proangiogenic potential of a novel calcium releasing biomaterial: Impact on cell recruitment*, 2016. Acta Biomaterialia, vol. 32, p. 435-445. http://dx.doi.org/10.1016/j.actbio.2015.10.003