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FUTURE OF SOLID ORGAN BIOPRINTING: 4 D TECHNOLOGY AND ZEROGRAVITY PRINTERS

Cardiology

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ABSTRACT

Donor organ shortage has been the Achilles heel of organ transplantation programmes. Bioprinted organs promise to bridge the gap and provide succor to this group of patients. Fusion of disciplines relating to cell biology, bioinformatics, physics, geneticists and material science could well make commercially available human organs a reality in near future. Biofabricated tissues have made a promising entry in this region augmenting our hopes on this technology to provide human organs in future too. Key materials that would be the limiting links in this journey to commercial success and viability would be recombinant protein biolinks, maturation and other growth factors.

KEYWORDS

Bioprinted organs, 3 D printing, Bioink, ITOP- Integrated Tissue Organ Printing System, SWIFT – Sacrificial Writing Into Functional Tissue and SEAS – using organ building blocks, SLAM- Suspended Layer Additive Manufacturing, SLATE- Sterolithography Apparatus For Tissue Engineering, FRESH-freeform reversible embedding of suspended hydrogel.

Heart diseases are the leading cause of death causing approximately 647,000 deaths per year (CDC, 2019). Approximately 121.5 million adults in USA have some form of cardiovascular disease as per American Heart Association 2019 reports. Of these around 1,13,000 people are in the heart transplantation waiting list [1] .Feasibility of bioprinting of cartilage, bone skin, blood vessel, muscle, cornea, lung, liver, brain, heart , kidney and other tissues are already being actively pursued. Bioorganoids and chips are being currently used for drug development also [2, 3]. 3 D printing also augments surgical preparation and technical planning ahead of the original procedure [4]. In silico creation or organ design by CAD, advanced software systems that use bioinks through a bio-printer, with final use of bioreactors to deliver a functional organ seems the roadmap to future commercial production of human organs. Collagen, laminins and elastin could serve as accelerator scaffolds to induced pluripotent stem cells. Precision, configuration similarity and maturation process places bioprinting at a higher citadel compared to traditional tissue engineering methods [5].

Stepping down from imagination to reality, ITOP- Integrated Tissue Organ Printing System, Bioprinted a urinary bladder which was implanted in a patient, followed by ear, bone and muscle implantation in animal studies [6].Adaptation and flexibility to all human endeavors is an absolute must if a technology has to survive. Zero gravity and microgravity challenges are also over come with 3 D Bioprinters that can function even in such extreme situations and can currently produce skin and bone tissues [7].Successful attempts have been reported with bioprinting of miniature heart, hydrogel models of air sacs, blood vessels with programmable rigidity control, spinal cord implants and functional renal tubules [8,9].Bioprinted organs retain the complexity close to original organs, with vascularity and intercellular communications.

Bioink formulation, speed and structural design dictate the method to the adopted. Due to lack of control extrusion method subject the final product to shear stress which has a telltale effect on cell viability. Inkjet and laser guided printing methods can induce temperature induced damage, while ink viscosity is another deciding factor for selection of printing method [10]. Two photon polymerization, SWIFT – Sacrificial Writing Into Functional Tissue and SEAS – using organ building blocks, SLAM- Suspended Layer Additive Manufacturing, SLATE- Sterolithography Apparatus For Tissue Engineering, FRESH-freeform reversible embedding of suspended hydrogel are emerging technologies in this direction [11, 12].Sterolithography, fused deposition modeling and selective laser sintering are also plagued by thermal issues. 3 D printers also in due course would be more customizable and affordable.

Bioink has to be bioactive and biocompatible [13].Natural proteins, synthetic polymers or acellular material with appropriate properties can serve as scaffolds [14].Cellular communication and reorganization is better with natural biopolymers [15].

CONCLUSION

Future of bioprinted organs is promising provided scalability and efficiency are routed into commercial activity. Stimuli responsive hydrogel that give the ability to change form or function with time under various stimuli enables 4 D to this concept in near future.

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