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3D Bioprinting and its Potential Impact on Cardiac Failure Treatment: An Industry Perspective

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Editorial

3D printing is proving to be a game-changing discovery in the treatment of heart failure patients. The ability to manufacture personalised devices at the point of care will have an impact on cardiac disease detection and therapy. The development of new computer assisted design and computer assisted manufacturing methods, as well as the advent of bioinks including cells and biomaterials, has ushered in a new technique known as 3D bio printing. Cardiac tissue micro physiological systems have been successfully generated using small-scale 3D bio printing. 3D bio printing allows researchers to assess the construction of specific heart parts, most notably heart valves. With the advancement of instrumentation and bioinks, as well as a better understanding of cardiac tissue growth, 3D bio printing may be able to enable the fabrication of a fully bio fabricated heart.

Heart failure is a huge medical problem around the world, and it almost always necessitates a heart transplant. However, the number of donor organs available for transplant is always far less than the number of people who need a heart transplant. Patients who do obtain a heart transplant are required to take immunosuppressive medication for the rest of their lives, which drastically reduces their quality of life. Heart failure affects more than 6.2 million people in the United States, and it was responsible for 78 356 deaths in 2016. Heart failure has a significant economic burden, which was estimated to be $30.7 billion in 2012. 1 Between 2002 and 2009, patients who received a heart transplant had a median survival rate of 12.5 years. The capacity to bioengineer a fully bio fabricated heart is the holy grail of tissue engineering, and it will surely benefit heart failure patients all around the world. The area of whole heart engineering has progressed tremendously in recent years, thanks to important technological breakthroughs that have put bio fabricated hearts within reach. The field of whole heart bioengineering has become a near-term reality thanks to advances in stem cell engineering, 3D bio printing technology, and bioreactor development.

We present a concise overview of the subject of whole heart bioengineering, with a focus on the application of 3D bio printing technology. We give an overview of tissue engineering as a topic and cover various bioengineering methodologies for bio artificial hearts. We present an outline of the field's obstacles as well as a rational and methodical method for bio printing human hearts for clinical transplantation.

3D bioprinting: A historical perspective

Physicians treating heart failure patients have a variety of medical devices at their disposal to stabilise the patient and, at the very least, delay the progression of cardiac dysfunction. Replacement of the failing heart with a viable heart *via* allograft transplantation is the ultimate biologic remedy to cardiac failure. Advanced regenerative medicine procedures are now being developed, with the goal of 3D bioprinting and assembling a complete heart from biologic/cellular precursors. The heart, once built, would be a biologic and artificial construct, prompting the term "biofabricated" to be coined to characterise these assembled biologic replacement parts. The current state of 3D bioprinting technology is discussed, as well as efforts toward an implanted Total Biofabricated Heart.

3D printing of surgical guides to aid clinicians in the planning of difficult operations marked the beginning of additive manufacturing in the medical industry. 3D printed models of the vasculature can help separate conjoined twins, and 3D printed models of the heart can help plan tissue reconstruction in patients with cardiac congenital defects. In a growing number of clinical cases, additive manufacturing of implantable medical devices has been used. These 3D printed implants are made from patient-specific data (e.g., MRI, CT images), and the dimensionality of the printed devices matches that of the tissue being replaced. Complex jaw, tracheal, cranial, and sternum replacements all employ them. The significant breakthroughs that have hastened the adoption of

Bioprinting is an additive manufacturing technique. Francoise Willeme was the first to use additive manufacturing, transferring photographic images to a three-dimensional physical construct that replicated the original shape in 1856. 3 With the advancement of computers and plastics, additive manufacturing has quickly become a viable method of producing a wide range of products. Computer assisted design (CAD) is used to provide instructions to computer assisted manufacturing (CAM) equipment, which uses a layer-by-layer additive process to create the product.

The shift from 3D printing to 3D "bio"printing acknowledges that tissue is a three-dimensional structure with a complex arrangement of cells and extracellular matrix that exists and operates (ECM). The first paper outlining a way to 3D bioprint living materials into complex structures is credited to Wilson and Boland. A HP inkjet printer was used, with the ink cartridge being cleaned of conventional ink and replaced with a solution containing a bacterial suspension. The printer was designed to deposit this bacterial bio-ink layer by layer onto a surface in a shape defined by the computer. In parallel with Boland's ink-jet bioprinting, researchers at the University of Arizona and Sciperio, Inc. modified a 3-axis robotic electronic printer to print bioinks including mammalian cells layer by layer. These early studies proved the potential to generate 3D dimensional tissues using CAD to CAM concepts. The Biological Architecture Tool, or BAT, was the first 3-axis robotic bioprinter. Jakab and Mironov pioneered the field of bioprinting with their early work. This previous research focused on aggregating cells to create spheroids and using these cell spheroids as the basic unit of bioprinting.

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