Science in Focus: Mending Broken Hearts with Cells and Bioprinting Technology

Q&A – Dr Carmine Gentile

Q: What is actually in the bioprinted patches? How is the heart tissue actually created through bioprinting?

A: We bioprint patches by mixing cells and "hydrogels" in what we call "bio-inks". These are then loaded in the nozzle of a 3D bioprinter that deposits layer-by-layer cells within hydrogels. The "recipe" for the best bio-ink (which types of cells and hydrogels to use) depends on the type of tissue and organ of choice. A liver contains cells that are not found in the heart and vice versa. Similarly, the hydrogel should present specific characteristics, such as stiffness and degradation over time to maintain cells happy before and after their transplantation. A bioink formulation may also change upon the application. For instance, we may bioprint heart tissues to test what the effects of a heart attack are in our body without having to transplant them. In this case, we don't create "patches", but rather smaller tissues containing similar cells and hydrogels, that allow us to easily run experiments in our laboratory. In terms of how the design of a bioprinted tissue, this is done through a series of software that use scans from the patient to identify the area that the patch will cover. Once this has been identified, we 3D model the patch and a computer connected to the bioprinter deposits cells and hydrogel according to our design.

Q: Would this kind of technology be transferrable to other contexts (e.g. damaged lung tissues) in the future?

A: Most tissues and organs in our body contain blood vessels, which are recreated in our cardiac bio-inks. By replacing cardiac cells with other tissue-specific cells we may be able to create other tissues as well.

Q: What criteria would patients need to meet to be eligible for this kind of treatment (e.g. age, level of disease/damage, other co-morbidities)?

A: This is a great question and we would like to know the answer. We are still in the preclinical phase and we are working with clinicians to find answers to questions like this one as soon as possible.

Q: How many people are collaborating with you on creating the bioprinted patches?

A: We work as a multidisciplinary team that brings together experts in cardiovascular bioengineering, biomaterials, pathophysiology, medicine, pharmacology and more recently robotics. In my team at UTS, we currently have 9 PhD students, one Bachelor student and two Visiting Scholars. Our collaborators from both industry and academia are in Australia, Europe, Asia and America.

Q: Who can be considered for treatment using this approach? Are elderly patients eligible - one who is at high risk for open heart surgery? Is this being used in Sydney now? What does a patient have to do to be considered for this treatment? E.g. where to go and who to talk to?

A: We are currently in the preclinical phase of our studies, to make sure it can be used as an effective and safe approach for patients. Our goal is to make sure that if successful it can be available for patients in the shortest time possible.

Q: Will this be used clinically sometime in the future?

A: Our team is working non-stop to make sure it can be available in the shortest time. We hope this can happen in the next five years.

Q: Thank you for the interesting talk! What would be the time and costs estimate to produce enough of the viable replacement tissue for cardiac lesion of medium size?

A: Thank you for the positive feedback. With access to current technologies in isolating and growing cells to make up enough to bioprint a patch, we would expect between 3 and 6 months. The most expensive component is related to the cells we use, which may cost between AUD 100,000 and AUD 200,000. This will vary on the area to cover. We are also studying on how to make this process as cost-effective as possible. Currently, a heart transplant costs approximatively AUD 140,000 in Australia, but it is also associated with risks for the patient and limited survival within few years following its transplantation.

Q: Is there a way for undergraduate students to be involved with your work?

A: Absolutely. Feel free to contact me.

Q: Which companies and countries manufacture 3D printing machines?

A: There are several companies from Spain, Sweden, South Korea, Switzerland, Germany, the US and Australia, just to name a few. It all depends on your level of competency with the technology (some are more user friendly than others) and your applications.

Q: Is it possible to bioprint a whole body?

A: This is beyond what we are trying to do in our team. However, in theory this could be feasible having access to enough cells and hydrogels to do so. Whether these cells would live and function like a human body it would have to be tested.

Q: What advice do you have for students who are interested in this type of work and want to learn more in order to be able to support this kind of research?

A: My best advice for students is to find out what they are passionate about. Our team has students with different research interests and background. What brings them together is their passion for research, despite the several sacrifices they do (some are living very far from their families). When I meet my students for the first time I try to understand if they have this passion. Research presents lots of frustrating moments as an experiment may not work as expected or other factors may play against us. However, that sparkle in the eyes that I see in our students reflects their passion for research and drives them to work non-stop in the laboratory for an answer that may help patients in the future.

Q&A – Paul Brown and Linda Dement

Q: Bridging the gap between art and science can be a challenging one - what can scientists learn from you artists in terms of communicating or presenting our research data so that is better understood by all

A: There are strong similarities in scientific research process and creative practice. Both address the unknown and often carry out material experiments to discover something new and to refine and clarify results. Creative practice can draw on widely eccentric sources in forming a work and so perhaps bring unexpected perspectives to the scientific which may spark other lines of enquiry or offer more layered ways of communicating, through aesthetics, feeling, multimedia, symbol, metaphor, storytelling and so on.

Q: How is the artistic component have a practical benefit towards the actual medical bioengineering?

A: These are impossible to predict. For example, in our previous collaboration in 2020, by making a human life sized patch for the artwork prompted the researchers to try out patches at that scale, which they hadn't before. Practical material issues of scale, flexibility and accurate fitting were investigated. Art practice can take unexpected approaches and so open up questions and avenues that might otherwise not be considered.

Q: What is the link to your blog?

A: http://heartproject2021.blog.anat.org.au/