

BroadcastMed | 3D printing in cardiovascular medicine-2

- LAPRINCESS BREWER:** Greetings, I'm Doctor LaPrincess Brewer, cardiology fellow at Mayo Clinic. Today on the heart.org, we'll be discussing the role of 3D printing in congenital heart disease. I'm joined by my colleague Dr. Thomas Foley, assistant professor of radiology who specializes in multi modality imaging. Welcome Dr. Foley.
- THOMAS FOLEY:** Thank you.
- LAPRINCESS BREWER:** 3D printing is a compelling new technology that has the potential to revolutionize cardiac interventions. We're eager to hear how this new, innovative technology will enhance our knowledge and understanding of structural heart disease. So to start, what is 3D printing?
- THOMAS FOLEY:** 3D printing, which also goes by the name of additive manufacturing and rapid prototyping, is a technology that uses a machine called a 3D printer to build three dimensional models one layer at a time, so it lays on one thin layer of material and binds it together with another thin layer of material and over time it builds a model up from the bottom. And it bases this on a computer aided design model, so the model's made in a computer program, sent to the printer, and then the printer prints it over time. There are several different technologies for doing this. The models that we have here were made on a printer that uses a liquid resin that is solidified when exposed to a UV light of a certain frequency. And then it is bonded together at the same time.
- Other printers use powders such as gypsum powder which can be glued together with a super glue like material. There are printers that print with metal that is melted together with a laser. Other printers use a plastic which is melted together with heat. Some printers even use things such as chocolate to print so you can have edible prints.
- LAPRINCESS BREWER:** OK so what is the process for creating a 3D model of the heart or valves?
- THOMAS FOLEY:** So to create a model of the heart or any body part, you just need to start with an imaging modality. In most cases, this is either CT or MRI, so a patient has a CT of the heart in this case. And what we need is a volumetric data set, so a data set that has a whole stack of images that can be put together without any gaps in the anatomy. And then after that is acquired, somebody segments the anatomy, or they go through and select what they want to print. That process can take anywhere from a few minutes to a few hours to get all the anatomy that's needed. Once that anatomy has been segmented out of the images, it's sent to another program where it's processed in this step, things such as any noise that was in the model would be smoothed out. If the model was supposed to be hollow such as this model we can hollow them out. If you want to make a cut such as this cut clean here so you can see inside the model, that is done at that time. And if you have a model where parts are not physically connected, such as this model, you can place pegs to connect them so the model doesn't fall apart.
- LAPRINCESS BREWER:** OK so it truly gives you that spatial relationship to allow you that tangible manipulation of the cardiac structure.

THOMAS FOLEY: Yeah, and then once that portion is done you bring it back into the-- overlay it onto the images that were initially acquired so you can verify that what's in the models actually correspond to the actual patient's anatomy. And then after that you send it to the printer and it prints. And our printer would take anywhere from four hours to print a small model like this up to 12 hours to print a larger heart model. Some other anatomic models have taken several days to print.

LAPRINCESS BREWER: Excellent, this is very, very interesting. And have there been any studies comparing 3D models to more traditional cardiovascular imaging techniques.

THOMAS FOLEY: There have been a few, are several case reports of individual cases or some small case series that have looked at this but those are mostly anecdotal. They usually report what a single surgeon's experience has been. They usually say that it helps improve the safety of the technique or reduce the time, but there have been no controlled trials looking at outcomes to see if there's improved outcomes when 3-D printing is use or any studies that have proven that there is a cost savings to this. But despite that, we still think it's a good technique. The studies will come I think in time as there are some planned, but if a surgeon tells us this is beneficial for them and it makes them feel more confident in the surgery, we'll make them the model.

It's also helpful for patients both when you're doing an informed consent so that they can better understand the surgical procedure. And they just like to know a little bit more on how the surgery is going to work, so we found that patients really like this too.

LAPRINCESS BREWER: Okay, so you just touched on a little bit about the cost savings. So are there any cost savings in using 3-D models and is it covered by insurance at all?

THOMAS FOLEY: So as I said previously it's not in any control studies that have shown that, but we think that there probably is just because the cost of operating time and anesthesia time is so high, even a small cost savings from a surgeon knowing the anatomy before entering the chest would pay for the models right there. So no, to answer your question, there's no studies that have shown that but we think that there will be. And also if they improve any outcomes, safety, prevent any complications, that will cover the cost of a model too. And to answer the second part of the question right now because there are no studies that show any cost savings or improved outcomes, insurance companies and Medicare do not cover the costs of the models. Most of our models are done under development funds. Some places the surgeons will pay for them for the operating costs.

LAPRINCESS BREWER: And what is the future of 3D printing? What do you foresee?

THOMAS FOLEY: I think that there's a very vast future for this technology. I think in the near term the main uses of this will still be for surgical planning such as what we do here. This model was used, this is a patient that had ventricular septal defect, six-year-old that had a ventricular septal defect in the pulmonary atresia had multiple collateral arteries coming off the aorta and going to the lungs. And this was used to determine where the collaterals were because some of these had to be reconnected to the main pulmonary artery, some of them had ligated, and the surgeon felt that this was very helpful in planning the procedure and knowing exactly what he needed to do. So I think for surgery, surgical planning would be one of the main things in the near future.

Another thing that is being done, some now is planning interventional procedures such as placing percutaneous valves. We've done a few cases of that here where they actually test deploy a valve on the bench top to see how well they'll fit, to see if they think the procedure would be successful. Moving beyond that, I think that we'll start to print things such as implantable devices such as cardiac valves that will be custom sized to the patient or conduits. And these have the potential to be printed with biological material that could grow with the patient so if you place this in a young child they may not need another valve replacement or may prolong the time to needing another valve replacement. And even beyond that there are some researchers that have said that they'll be able to 3D print a functional beating heart so that is on the horizon. I don't think it'll happen anytime soon but we may see it.

LAPRINCESS BREWER: Wow so the opportunities seemed limitless. So the access to this seems pretty limited. What types of centers actually have 3D printing for patients, and surgeons, and cardiologists to take advantage of?

THOMAS FOLEY: So I know of several centers in the congenital heart disease world that do this. We do this, several universities do this such as Arizona State in partnership with Phoenix Children's Hospital does this, the University of Toronto has a large program for 3D printing, University of Pennsylvania, I know there are others that I'm forgetting. There are several centers in Europe that do this and in Asia. But even some smaller centers are doing this. And then even if you don't have a 3-D printer, there are several companies that will make the models for you where you can send them the data, tell them what you want, they'll make the model, and then if you're a surgeon they'll send you the preliminary digital model to see if it is including all the anatomy that you want and then they'll print it. Or there are companies that will just do the printing so you can actually make the model yourself in the computer and then send it just to be printed somewhere else. So there is several centers around the world that are doing it in house, but there are also other options for doing it to contract out to other businesses.

LAPRINCESS BREWER: This is wonderful. So thanks Dr. Foley for these very great insights on this innovative tool that will be used to enhance patient centered care. And thanks to our viewers. We hope you will continue to check out future content on Mayo Clinic page at the heart.org on Medscape cardiology.