THE ETHICS BEHIND 3-D PRINTING: TRANSPLANT ORGANS AND ARTIFICIAL ORGANS

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CASE STUDY: TRANSPLANT LIST OR ARTIFICIAL ORGAN

Engineer A works in the booming field of bioprinting in the year 2032. Bioprinting allows engineers and doctors to print fully functioning human organs from 3-D printers and place them into patients in dire need. Although bioprinting has taken off in the past few years, it still has not entirely replaced the traditional method of organ transplants. One of the main issues with bioprinting is the overwhelming cost to print these organs.

Engineer A is working in a hospital when a patient who needs an emergency liver transplant comes in. Engineer A surmises that the patient may survive being put on the transplant list but cannot afford an artificial organ. According to the National Society of Professional Engineers, Engineer A must “disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or quality of their services [1].” Engineer A debates whether to print an artificial organ for the patient or place him on the transplant list and hope an organ is found in time.

COST OF ARTIFICIAL ORGANS VS TRANSPLANT ORGANS

Cost of an Artificial Organ

One of the reasons for the high cost of these organs stems from the complexity that it takes to print them. Printing organs took years of trial and error. The biggest problem was finding a way to keep the blood vessels from collapsing. In 2013, engineers at the University of Pennsylvania found a way to create blood vessels that would not collapse by using a sugar based structure to print the vessels, then used water to wash away the sugar. This added strength to the structure and allowed for the blood to reshape them and add capillaries to the larger vessels [2]. This process is very complex and can be very expensive [3]. As a result, bioprinting is saved primarily for patients who can afford to finance the high cost of them.

Another reason for extreme costs is contributed to the amount of time and care that must go into the creation of the organs. First, the printers “clog” with biomaterials which slows the process of printing. To counteract the time it takes, the “ink” must be stirred regularly. On top of stirring it, engineers can add low viscous additives to the cell mixtures in order to allow easier flow through the nozzles. The problem is, if too much of the additives are mixed in, it can cause serious harm to the cells and damage the structure of the organ [4]. If serious enough damage is done during the printing process by these additives, the organ is rendered useless.

Finally, each organ must be printed with the proper cells. Each type of tissue inside the organs have several types of cells that must be replicated and placed in the proper places to complete their functions. If these cells are not properly handled, the organ as a whole may fail. In order to get the cells needed is a challenging feat. Getting the proper cells to proliferate properly during their finite lifespan to cover the organ as a whole takes a lot of care. The cells must be treated to multiply quickly enough to create the organ while printing, then must slowdown in order to reach homeostasis inside the patient. This means that the cells must differentiate into the desired cells, such as liver or kidney cells, quickly to create the organ, then slow down to the normal rate that cells form inside the body, or it puts the patient at risk for complications and even rejection of the organ [5].

These challenges add to the cost of printing these organs. While 3-D printing has made many other manufacturing fields cheaper and more efficient, bioprinting is proving to be a very expensive endeavor for engineers and doctors. The difference between transplanted organs and artificial organs comes between the health care coverage. Since artificial organs is a relatively new technology in the medical field, insurance companies have not figured out a proper way to cover the costs of printing them. As a result, many patients cannot afford to have organs printed for them. Until the healthcare market catches up to the technology, the cost of artificial organs will be too expensive more many patients who could benefit from it [3].

Cost of a Transplant Organ

While the cost of artificial organs is expensive, the cost of a transplanted organ is also high. According to the United States Department of Health and Human Services, the cost for organ transplants ranges anywhere from 250,000 dollars to over 1 million dollars depending on what organ needs to be transplanted [6]. While the cost is high, healthcare covers much of these costs, which allows it to be more affordable for patients who cannot come up with that much money.

Transplanted organs are much easier to pay for, but the “cost” of a transplanted organ comes elsewhere. On average, a new patient is added to the transplant list every 10 minutes and 21 people die every day waiting for an organ [6]. In the United States, there are over 120,000 people on the transplant list and there are only about 80,000 donors available. This means when a patient is added to the United Network for Organ Sharing, they must wait for a perfect match. This includes finding a perfect match for organ type, blood type, and size of the organ as well as addressing issues like distance from the donor, severity of their medical emergency and time on the waiting list. Once a donor is
found, there is a series of preliminary tests that must be done to ensure that the organ is a match for the recipient. Then, the organ must be transported to the recipient quickly; organs have a finite amount of time that they can be kept functional after being harvested. Overall, the biggest issues surrounding transplant organs that there are too many recipients and not enough donors, time on the waiting list, and the possibility of failure inside the patient [6].

PUBLIC OPINION

Big Business Sparks Debate

A paper in 2014 suggested that a lack of public knowledge may spark a ban on 3-D printing in general, not just bioprinting [3]. While no ban was placed on 3-D printing, the public did not immediately accept this new innovation. The use of 3-D printing in general sparked the debate of regulation on printing. While many of the top companies in the world were using 3D printing to print stock items and companies were being built solely around the new technology, many were concerned that billions of dollars would be lost in Intellectual Property [7]. This was contributed to the idea that 3D printing made complex and difficult designs and structures easily printable. As a result, many of the large companies in the world used printers to expand their markets and print custom items for relatively cheap. Many small businesses struggled because they could not keep up with large companies using printers to print cheaper and better products.

With all this happening, regulations were placed on printing. This inhibited the growth of 3D printing technologies, including in the bioprinting field. This stifled advancement of printing organs. Some say today that this led to the overpricing of printing these lifesaving organs.

ETHICS IN ENGINEERING

In this scenario, Engineer A must keep in mind that it is his job as a professional biomedical engineer to, “strive by action, example, and influence to increase the competence, prestige, and honor of the biomedical engineering profession,” and “Consider the larger consequences of their work in regard to cost, availability, and delivery of health care” [8]. Even though Engineer A can print a liver for this patient, he must also consider that the patient will be unable to pay for that organ. Whether the engineer decides to print the organ or add the patient to the waiting list for a transplant, they must first consult with the patient and consider all routes of treatment. Engineer A must also keep in mind that his actions do not only reflect upon himself, but on all engineers as well. If he decides to print the organ for the patient, he must consider that many will fault him for printing an organ that the patient cannot afford on his own. If he chooses to put the patient on the waiting list for a liver and he does not survive the wait for a match, many will fault him for allowing his patient to die even with the means to save that patient. As an engineer, they must consider all options to the welfare of their patients, as well as implications their actions have on their career and engineering as a whole.

INSPIRATION AND ADVICE

Some sources that Engineer A can pull advice from include other engineers who may have been faced with similar challenges. While bioprinting has saved many lives, it is not the first case that a person has been faced with a challenge that did not have a simple answer. One such example includes President Harry Truman. Although Truman was not a doctor or engineer, Truman was faced with a difficult decision to make. He had to decide whether dropping an atomic bomb on Japan was a course of action that he was willing to take. President Truman was faced with killing thousands of people and ending a war, or allowing the war to rage on, potentially killing more people. Engineer A is not faced with killing thousands of people, but his decision is very similar. He can either place his patient on the waiting list or potentially watch him die, or he can print the organ that would save his patient’s life but place him into back breaking debt. Making this decision is just like Truman’s decision to drop a bomb on Japan. It was not an easy decision for Truman, and it will not be an easy decision for Engineer A either.

Another example that Engineer A can draw inspiration from is Denzel Washington’s “John Q.” In this movie, Denzel Washington’s son is going to die from an enlarged heart. Denzel’s character takes a hospital hostage in order to force the surgeons to replace his son’s heart with his own. Denzel’s insurance would not cover putting his son on the waiting list for an organ, and Denzel goes to extreme measures in order to ensure his son’s safety, even giving his own heart to his son. Engineer A can draw parallels to this by seeing how desperate people can become when they have no options left. Denzel made the decision to forfeit his life to save his son’s life. Engineer A is faced with a similar decision to put this man on the transplant list or replace his liver with an artificial one. Although it would put his patient in debt, it would save his life. If he does not, the patient may die. Denzel decided that his son’s life was more important than his own. Engineer A will have to make a choice, but he can look to his colleagues, historical figures, and fictional characters for guidance in his decision making process.

FINAL DECISION

Engineer A considers all the options he has in front of him and all of the pros and cons of each. In regards to cost, Engineer A clearly sees that an organ transplant is the cheapest option. Not entirely sure that he wants to put the patient on the list based solely off of cost, he decides to talk to the patient’s family. After hearing what the patient’s family
had to say, Engineer A also considers the safety of printing the organ versus the transplant. Recalling that the organ would be made with the patient’s personal cells, and confident in his ability to make an organ, he wonders if an organ is found in time, if it would be a perfect match for his patient. Although Engineer A does not come up with a decision immediately, he does make several phone calls to colleagues and former professors asking for their advice. He also turns to his own family. He asks them what they would do if it were him. After some time and hours of debate, he decides that he will place the patient on the transplant list, and if it does not seem that he will receive a liver in time, he will print an organ for his patient even with the high cost.

REFERENCES


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