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Application of 3-D Printing in Medicine

The existence of 3D-printers is well-known nowadays. Their development leads to the fact that current models are able to print a variety of plastic products, food, chocolate, shoes and even accessories and supplies for usage in space. Currently, scientists are thinking about how to direct the possibilities of this technology to more productive application. One of the latest developments in this area is the design of 3D-printers, that print human organs from biological material. Such kind of an invention would be a revolutionary breakthrough, because the donor organs are in large deficit. The creating of functioning human organs with the help of machines will allow us to help to a terribly huge number of patients and reduce the waiting queues.

Bioprinting is a relatively new trend in the elaboration of medicine, which appeared due to the rapid development of additive technology. Scientists are working on the creation of multifunction printers that can print workable organs such as heart, kidneys and liver.

It is noteworthy that today bioprinter prototypes are able to print implants of bone and cartilage as well as create complex biological food products, which contain fats, proteins, carbohydrates and vitamins. Engineers have learned to model and reproduce different elements of the human skeleton, such as pieces of phalanges, hip joints, parts of the thorax.

The bioengineer Thomas Boland reconfigured the desktop Lexmark and HP printers for printing DNA fragments in 2000. And he made a conclusion that the size of a human cell is comparable to the size of standard ink drop which is approximately 10 microns. Studies have shown that 90% of the cells remain viable during bioprinting. In 2003, Thomas Boland patented the technology of printing by

cells. According this fact, the organ's creating by 3D-printer will never be a fantasy. Within two private investigations in the laboratory turned into a rapidly expanding industry, which is capable of printing ears, heart valves, vascular tubes, as well as the reconstruction of bone tissue and skin for subsequent transplantation. [1]

The head of the research group from Wake Forest producing bladders, Anthony Atala named some main problems in creating artificial organs with the help of 3D-printing. The first problem is the short supply of materials which are needed to produce human organs. In addition, it is extremely difficult to make cells grow properly outside the body. Human bodies have a very complex composition so it is hard to implant an artificial organ, despite the fact that it consists of the same cells as a natural one. You cannot just sew printed organs to a man and hope that everything will be alright. Even if the artificial organs' cells divide outside the body, it does not mean that they will work smoothly. [2]

With the RepRap 3D-printer the bioengineering team from the University of Pennsylvania created working blood vessels. The key problem facing bioengineers is the creation of a system of blood vessels which could provide the exchange of nutrients and remove waste products from the internal tissue cells. Because of the lack of possibilities to create such blood vessels cells quickly suffocate and die. But the team from Pennsylvania offered a surprising solution to the problem. The bioengineers from the University of Pennsylvania used a 3D-printer called RepRap to print the system of blood vessels from sugar. After the introduction of this system into cells, sugar dissolves , but the functioning vasculature remains. When the sugar hardens, the gel mass with liver cells is added to the press form. This gel covers and surrounds the blood vessels. When the gel solidifies, it can be removed from the mold. The sugar form remains inside till the gel is washed off by water, and the sugar completely dissolves. The liquid sugar distills in the same blood vessels, which have been created with it, and this time cells are not harmed. [3]

Moreover, bioengineers managed to print a viable 3D-model of the thyroid gland. One organ which was printed on the printer was successfully transplanted to an experimental mouse. The experiment used the innovative Russian 3D-printer called 3DBio.

When speaking about the printing process, as in any other 3D-printing, the object is printed layer by layer, but unlike the 3d PLA or ABS technology, the living cells are used to create a living tissue, which are in the gelled mass. The cells grow and develop becoming a living tissue, bone and even the whole organs. Depending on the machine, the working material is supplied from a dispenser disguised as a constant stream or dosage drops. This approach is used to create a soft tissue with low cell density, for example, boxed skin and cartilage. Bone implants are made by the method of selective laser nitinol sintering as it is a high-strength material, which resembles bone tissues in its biochemical composition. During the printing process it uses 3D models which were obtained through computed tomography. The polymer prostheses are popular, too. Prostheses cannot be called organs, but the easiness with which the needy patients can get a mechanism allowing them to return to a normal way of life deserves attention. [3]

In conclusion we should say that over the history of the problem of human organs printing science could achieve only partial success. The problem of producing human organs has been solved, but most of them could function only for several days. For example, the Organovo company was able to create a liver, almost identical to human, which was capable of performing all the functions assigned to the organ. But a synthesized organ could function only for 40 days. Knowledge of bioprinting and further research in this direction are actively carried on in a variety of medical research and educational institutions because research in this area can lead to the creation of special devices that scan a person and determine the complexity and depth of the injury , and then print artificial organs directly onto the patient. [3]

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