The Development of a Bioartificial Liver

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The liver, the second largest organ in the body, is located at the upper right of the abdomen. The hepatic artery and portal vein supplies the kidney with blood while the hepatic vein drains the blood from the kidney. Hepatocytes, liver cells, have a unique ability to reproduce after liver injury and consequently, the liver is capable of regeneration of lost tissue.

The liver functions to regulate, synthesize, and secrete substances important in maintaining homeostasis, such as bile which aids in digestion and proteins important in blood formulation and blood clotting. The liver detoxifies the blood from dangerous pollutants and also stores iron, vitamins, minerals and glycogen.

Liver failure is the severe deterioration of liver function and is diagnosed as either acute or chronic. Acute liver failure occurs rapidly, within days or weeks, and chronic liver failure occurs gradually, over months or years.

Currently, liver failure treatments include liver transplant, hemodialysis, hemoperfusion, and plasmapheresis (or plasma exchange). Liver transplant is a problem because the amount of liver failure patients far outweighs the number of donor livers available. The other treatments often have limited success because while they may help in detoxification, they do not restore the synthetic and metabolic functions of the liver.

The current artificial liver assist devices are used to sustain patients awaiting a liver transplantation. The construction of an actual bioartificial liver is difficult because of all the important functions that a liver must carry out. A bioartificial liver and/or a liver assist device should be able to detoxify, regulate, and synthesize molecules in the fashion of a normal liver. Scientists and engineers are designing systems using hepatocytes to attend to specific metabolic tasks. The hepatocytes are contained in specially designed bioreactors which keep isolated liver cells in culture for long periods of time so that the cells are available for use in the liver assisting devices.

Some types of developing devices include the Extracorpal Liver Assisting Device (ELAD), HepatAssist, Modular Extracorporeal Liver Support (MELS), and the Amsterdam Medical Center Bioartificial Liver (AMC-BAL).

The ELAD is the first and only system to use human hepatocytes because it is difficult to obtain an abundance of human liver cells. The other systems utilize pig liver cells (porcine hepatocytes) instead since they are easier to acquire. In general, the systems use one of the current treatments to cleanse the blood of toxins and chemicals, combine the detoxified blood with the hepatocytes, and then filter the blood back into the body.

A clinical study was performed on 338 patients with acute or chronic liver failure. The patients were given artificial liver assist device treatment for 1-8 sessions and compared with 312 patients who were provided with conventional treatments. Symptoms and liver functions were greatly improved in the patients given the liver assist device treatment and their 30-day survival rates were 13.3% greater than those provided with conventional treatments.

Several limitations are keeping a fully functional bioartificial liver from developing, including liver cell mass, mass exchange over membranes, issues regarding the use of porcine hepatocytes (zoonosis, rejection, etc.), and appropriate cell source.

There are still many obstacles to overcome in the development of a liver assisting device and a bioartificial liver and, therefore, none of the devices have been FDA approved. Scientists and engineers expect that with the development of stem cell technology, highly functional human liver cells will become available within the next 10 years, which will greatly increase the progression of a bioartificial liver. Once a bioartificial liver is created, it is expected that nobody would die from liver failure.

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