The Bio-artificial Liver

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***Abstract*— This paper will address the research, functionality and limitations of modern day bio-artificial livers as well as the associated techniques in treating terminal liver complications. An understanding of the liver and its role in the human body will also be included.**

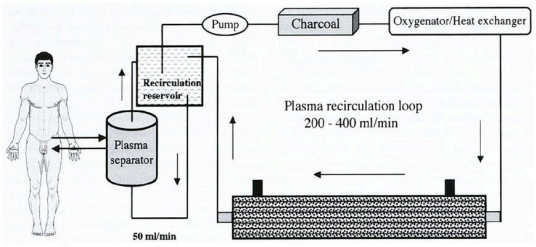
I. Introduction

The liver is the largest internal organ and gland in the human body and plays an integral role in the overall health and functioning of many other organs due to its ability to filter blood. The liver is believed to be responsible for up to 500 separate functions, usually in conjunction with other organs and systems. The livers weight can vary from 1.2-1.6kg (3.2-3.7lb) and it consists of four lobes of unequal size and shape that are connected to the hepatic artery and the portal vein. The hepatic artery carries oxygen rich blood from the aorta where as the portal vein carries nutrient rich blood from the small intestine. These vessels eventually divide into capillaries that are fed into thousands of lobules in the liver that are rich in hepatic cells. Hepatic cells are essential to a healthy liver because they make up 80% of the liver volume and are responsible for all liver functions.

The liver is vital for survival and can be affected by many kinds of infections that can lead to disease that may require transplantation and/or liver therapy. The most common include; hepatitis A thru E, alcohol damage, fatty liver, cirrhosis, cancer and drug damage. If a transplant is not available, bio-artificial livers can help lengthen the survival time for patients with liver complications.

II. Methods

Bio-artificial livers have recently emerged as a possible tool in aiding patients with liver failure. Although there are several variations of bio-artificial livers being researched, they commonly consist of a plasma separator, recirculation reservoir, a pump, charcoal cylinder filter, oxygenator/heater and some kind of bioreactor. The plasma separator isolates the plasma and cellular components of the blood. The cellular components remain in a storage device to later be reunited with the plasma. The plasma then gets fed through a charcoal cylinder that filters plasma bacteria and matter that the hepatic cells cannot handle. The plasma then gets fed through some kind of hepatocyte-lined bioreactor device. During this process the plasma and hepatocytes are constantly being kept at body temperature and oxygenated. The newly cleaned plasma is then reunited with the cellular component and fed back into the patient. The bioreactors used in a bio-artificial liver device can vary. The current bioreactor devices are either; hollow fiber, flat plate and monolayer, perfused beds/scaffolds, encapsulation and suspension. Of the bioreactors mentioned, they are all accompanied with their own pros and cons.



Bioreactor loaded with pig liver cells

III. Results

Bio-artificial livers can help a patient live long enough until a replacement liver becomes available. In addition, due to the livers unique regenerative abilities, bio-artificial livers can allow a liver to heal itself by providing support in accomplishing the natural functions of the liver. Although there is not currently an artificial liver device on the market that can take the place of a liver, bio-artificial livers ultimately serve as a means of therapy for patients with liver diseases. Bio-artificial livers in order to be successful must provide at least 10% of liver functioning, which requires approximately 10^{10} hepatocytes. A major obstacle when considering patients with liver complications can only have one liter of blood and plasma drawn.

IV. Discussion

The main difficulties in the development of either an extracorporeal artificial liver device or implantable artificial livers are the challenges involved with hepatic cells. First, obtaining such a large number of hepatocytes is problematic in that they require a large amount of time, money and resources. Utilizing animal hepatocytes such as pigs is also controversial due to possible transmission of viral infections to humans. In addition, the materials used in the bioreactors and the filtration processes have shown mixed results in the fostering of hepatocytes. Careful attention needs to be paid to the survival of the hepatic cells when they come in contact with the plasma because they are not only put through tremendous stress but do not fare well in low concentrations of oxygen levels. The future of bio-artificial is promising but still faces a long road ahead. The major successes have been in extracorporeal devices where as, implanted devices still have many challenges to address. This is largely due to the sheer size and length of tubing required to account for the extreme number of hepatocytes needed to serve as a healthy, normally functioning liver.

References

[1] Brown Bio Med <http://biomed.brown.edu/Courses/BI108/BI108_2002_Groups/liver/webpage/intro.html>.
[2] Wikipedia: The Liver <http://en.wikipedia.org/wiki/Liver>.
[3] Palakkan, A. A., Hay, D. C., PR, A. K., TV, K. and Ross, J. A. (2013), Liver tissue engineering and cell sources: issues and challenges. Liver International. doi: 10.1111/liv.12134.
[4] <http://www.xconomy.com/boston/2007/09/20/bioengine-one-step-closer-to-artificial-liver-device/>