Laser Soldering of Blood Vessels using GaAs and CO_2 Lasers and Albumin Solder

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The research hypothesis had been that laser soldering, using two lasers (GaAs and CO_2) is more suitable for the anastomosis of tubular organs , such as blood vessels. The proposed method was supposed to work as follows: two parts of the tubular organ are approximated and albumin solder is spread both in the inside of the organ and outside. Then one laser acts on the outer surface while the other laser penetrates the tissue and acts on the inner surface of the tubular organ (i.e. inside the tube). On each side the albumin layer should be heated to roughly 60C for 10 seconds in order to obtain strong bonding. It was assumed that such soldering would generates a much stronger bonding in blood vessels, because it involves two layers of albumin: inside and outside the tube. .

During the last year we have been working on the subject, but from the theoretical and the experimental point of view. At first, a computer simulation was written to visualize the simultaneous heating of a blood vessel with two lasers. We are now able to determine the exact temperature reached at each point of a blood vessel model. In particular we wanted to make sure that the temperature of the intima, inside the blood vessel, will not increase much and will not cause thermal damage to the intima. The simulations proved that one can indeed heat the two albumin layers to 60C, without causing damage to the intima.

In order to carry out experiments we decided to use pure albumin solder on the outer side of the tubular organ, and heat this albumin with a CO_2 laser beam. We also used albumin, mixed with Indocyanine Green (ICG) on the inside of the tube. The radiation of a GaAs laser is not aborbed well by tissue but it is strongly absorbed by the green colored, ICG doped, albumin. Therefore the GaAs laser radiation will penetrate through the wall of a blood vessel and will heat only the green colored albumin inside the blood vessel.

An experimental system for two lasers soldering was constructed. It contained of three optical fibers. A glass fiber carried the GaAs laser energy needed to heat the green colored albumin inside the tubular organ. One AgClBr fiber carried out the CO_2 laser beam needed to heat the outer layer of pure albumin. Another AgClBr fiber was used for monitoring the temperature of the outer albumin layer.

We found that we could use the temperature reading of the outer albumin to control both the temperatures of the outer albumin and the inner albumin layers. This temperature was kept at 60C. The distal tip of these 3 fibers was inserted into a special holder that we have constructed, and which made it easier for a surgeon to carry out bonding experiments..

It is not easy to work on blood vessels, because their diameters are small. In order to test the system we decided to work on larger tubular organs, such as the trachea or the esophagus. We cooperated with a surgeon, Dr. Abergele, of the ENT Department of the Ichilov Hospital. Dr. Abergele used our system and carried out many experiment for the soldering of the esophagus of a farm pig, in-vitro. Cuts were made in the esophagus and they were bonded with the two laser system. The burst pressure of the bonded esophagus was found to be 360cm water. This pressure is much higher than than pressure of 200 cm of water, which is the maximum pressure generated in the esophagus naturally. It seems that the laser bonding system worked very well.

The success of our first experiments in tubular tubes will pave the way for using the laser bonding system for blood vessels. We are planning to carry out experiments on large blood vessels, such as the aorta, in the near future.