Residual Stress in Blood Vessels

Introduction

In general, there are two kinds of mechanical forces acting upon an object being bent: tension and compression. If you picture a beam that is being held up in the center and pulled down on either end, you can see that the top surface is being stretched and the bottom surface is being crushed. These phenomena result in tension on the top, or outer, surface and compression on the bottom, or inner, surface.

This tension compression-relationship occurs in a more pronounced fashion in materials that have been “bent” all the way into a tube, such as a blood vessel. The inner surface of the vessel is under a large amount of compression force, and the outer surface is under a large amount of tensile force. Such uneven stress distribution is highly undesirable and leads to early damage and failure of materials. Luckily, our bodies have built-in mechanisms to more evenly distribute stress through vessels. This process is called remodeling, and results in the tensile / compressive forces being roughly equal at the inner and outer surfaces of the vessel. Some imbalance always exists though, and this is termed residual stress. The amount of residual stress that is present can be measured using a simple ring test. In a ring test, a circular cross section of the vessel is cut and allowed to move freely. The presence of residual stress will force the tissue to spring apart to an unloaded state that is closer to a flat line than to a circle.

Experiment

1. Obtain your tissue specimen
2. Record the type of specimen in your notes
3. Lay the specimen flat on your dissecting tray so that you can see the circular shape as you look down on it
4. Using the superglue provided, glue one black marker on the side facing you
5. On the opposite side of the specimen from the marker (but still on the side facing you) shade a segment of the tissue with a pencil
   a. This will aid you in determining the edge of the tissue once it is cut
6. Glue the tissue to the post in the plastic dish provided, using the following guidelines:
   a. The point of attachment between the tissue and the post should be as close to the marker as possible
   b. The top of the tissue should be as close to the top of the post as possible
7. Pour water into the dish such that the entire tissue specimen is covered
8. **Read this whole step before continuing**
   a. In each image, capture a note with the image number in addition to the tissue (we recommend a tally system, but you can use whatever method you think would help you recognize which picture is which when you are analyzing them)
   b. Take a picture of the specimen. Record the time as the time = -1 image
   c. Cut the tissue directly across from the point where it is glued to the post
   d. Immediately take a picture and record this time as the time = 0 image
   e. Take another picture every 15 minutes for the next 2 hours. Record the time of each image. If it is not exactly 15 minutes that is fine, just make sure that you have the correct time recorded.

<table>
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<th>Time (min)</th>
<th>-1</th>
<th>0</th>
<th>15</th>
<th>30</th>
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<tbody>
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**Image Analysis**

1. Create a new folder on the desktop and load the images from the camera into it
2. Rename the images to their corresponding times
4. Select “Open Image” and browse to find the first image (time 0)
5. Click the MEASURE option and choose “angle”
   a. Measure and record the opening angle by clicking the marker, the bottom open edge, the marker, the top open edge
6. Repeat steps 4-5 for each of the recorded times