Cancer Therapy Dynamic Phantom

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Introduction
Heat treatment methods for cancer therapy are being developed and need a way to be accurately and ethically tested.

In order to develop these methods, there is a need to better understand:
- How thermal energy spreads within the human body
- The cooling effects of blood flow

This device (a.k.a. “phantom patient”) is a replica of blood vessels inside the human body and is made from PVC plastic tubes and agar gelatin. It will help researchers understand these concepts so they can further develop the heat treatment cancer therapies.

Design & Testing

Testing Procedure
- Phantom was heated to a uniform temperature at 30°C and then water was pumped through the tubing network at 23°C.
- Testing was performed inside of a Magnetic Resonance Imaging (MRI) machine.
- The MRI measured the agar temperature while being cooled via water flow inside tubes.

Metrics & Results

<table>
<thead>
<tr>
<th>Metric</th>
<th>Target</th>
<th>Actual</th>
<th>Percent Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling Rate (°C/s)</td>
<td>0.01 – 0.4</td>
<td>0.009 – 0.001</td>
<td>10% – 99.75%</td>
</tr>
<tr>
<td>Perfusion Rate (kg/m³/s)</td>
<td>0.5 – 40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure at Inlet (mm Hg)</td>
<td>80 – 120</td>
<td>120</td>
<td>0%</td>
</tr>
<tr>
<td>Uniform Flow at Terminal Vessels</td>
<td>≤ 10%</td>
<td>2.9%</td>
<td>0%</td>
</tr>
</tbody>
</table>

Conclusion
The phantom device gave relevant results and was successful in reproducing the cooling effects of blood flow inside the body.

Areas of Concern
- Air bubbles caused inaccurate MRI readings
- Agar layers contributed to air bubbles
- Number of capillary vessels in phantom was too small
- Geometric spacing of vessel network not fully considered

Recommendations
- Increase number of capillary tubes for future phantoms
- Pour agar mixture into container at site of testing for minimal movement and in as few layers as possible

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