ABSTRACT

The backscattered signal received from an insonified volume of tissue was modeled to determine the response of the backscattered signal to a change in temperature. The temperature dependent parameters of the model were velocity, attenuation and backscatter coefficient. Analysis of the model for a lipid scatterer and an aqueous scatterer in a water-based medium showed that the temperature dependence of backscattered power was dominated by the effect of temperature on the backscatter coefficient. The temperature dependence of attenuation had a small effect on backscattered power and the backscattered power was independent of effects of temperature on velocity. The temperature dependence of the backscatter coefficient was inferred assuming that the backscatter coefficient was proportional to the scattering cross-section of a small scatterer. Backscattered power increased nearly logarithmically with temperature over the range from 37 to 50 °C. Our model predicted a change of +5 dB for the lipid scatterer and -3 dB for the aqueous-based scatterer over that temperature range. The primary determinant to in vitro experimental verification has been outgassing at hyperthermic temperatures. Subjecting both tissue and water bath to a vacuum of 26 inches of mercury for 120 and 20 minutes respectively allowed the measurement of backscattered ultrasonic power at temperatures as high as 50 °C without noticeable outgassing in either the tissue or the surrounding water. Preliminary experimental results in bovine liver suggest that backscattered power change was similar to that predicted; it changed from +4 to -3 dB over the range from 37 to 45 °C.

SPEED OF SOUND IN A WATER-BASED MEDIUM

Polynomial Coefficients for Velocity as a Function of Temperature

<table>
<thead>
<tr>
<th>MEDIUM</th>
<th>VELOCITY, m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>a + bT + cT²</td>
</tr>
<tr>
<td>Breast Muscle</td>
<td>a + bT + cT²</td>
</tr>
<tr>
<td>Lipid Scattering</td>
<td>a + bT + cT²</td>
</tr>
<tr>
<td>Perimorial Fat</td>
<td>a + bT + cT²</td>
</tr>
</tbody>
</table>

The term in brackets in eqt (1) is nearly unity for the range of interest and will be neglected in this analysis.

Model for the Temperature Dependence of Backscattered Ultrasonic

The backscatter coefficient is inferred from the scattering cross-section of a small scatterer [1].

EFFECT OF BACKSCATTER COEFFICIENT

The calculated change in received power from 37 to 50 °C data showed a 5 dB increase in backscattered power. The calculated change in received power from 37 to 50 °C for a lipid scatterer and a 3 dB decrease over the same temperature range for an aqueous scatterer with a density of 1.05.

DISCUSSION AND CONCLUSIONS

• Our previously reported theoretical analysis of the temperature dependence of backscattered power was dominated by the temperature dependence of the backscatter coefficient.

• The calculated change in received power received based on equation (3) showed a 5 dB increase in the backscattered power from 37 to 50 °C for a lipid scatterer and a 3 dB decrease over the same temperature range for an aqueous scatterer with a density of 1.05.

• The trends in the measurements reported here were either an increase of about 3 dB or a decrease of about 3 dB in backscattered power with temperature beyond 37 °C. These trends are comparable in shape and magnitude to the values derived from our model.

It remains to be determined, however, whether or not the changes in backscattered power with temperature that we measured are due to the mechanisms assumed in our model.

REFERENCES


