CHAPTER 5

FINDINGS AND DISCUSSION

5.1 FINDINGS

Various irradiation techniques were used to elevate the temperature difference between the breast cancer tissue phantom and the normal breast tissue phantom. The irradiation techniques used in the experimental study are Far infra red irradiation, Micro wave Single irradiation, Hybrid irradiation, Micro wave Double irradiation, Micro wave Multiple irradiation, Hybrid multiple irradiation techniques.

The findings are given below:

1. In the conductive heating method, the impact of external heating over the temperature difference between the normal and cancerous breast tissues was studied. It was proved by an experiment that external heating using a water bath (conductive heating) with heater arrangement and phantom model, elevated the temperature difference between the normal and cancerous breast tissues marginally. The thermoregulatory effect was also studied. This method increased a temperature difference of 1°C between the normal and cancerous breast tissues before external heating to 2°C after heating. Based the results obtained, a method of producing an active thermo gram to detect early breast cancer was proposed.
2. In the FIR irradiation method, the effect of far infra red irradiation and natural cooling on the temperature difference between the normal breast tissue and cancerous tissue phantoms was studied. It was found that this method also marginally increased the temperature difference between the normal and cancerous breast tissues; 1°C temperature difference between the normal and cancerous breast phantom before irradiation was found to be increased to 2°C after irradiation by this method also. Thermo grams of the phantom models of the normal and cancerous breast tissue phantoms were taken by thermal imager.

3. In the microwave single irradiation method, the effect of microwave irradiation and natural cooling on the temperature difference between the normal breast tissue and cancerous tissue phantoms was studied. It was found that the temperature difference between the normal and cancerous breast tissues was considerably increased by this method. 1°C temperature difference between the normal and cancerous breast phantom before irradiation was found to be increased to 4°C by this method. Hence this method would be more efficient than the FIR irradiation method. Based on the results, a method of obtaining an active thermo gram using microwave source of 2450 MHZ for external irradiation and natural thermoregulatory cooling was proposed to detect early breast carcinoma. The thermo gram was produced by using FIR emission from the microwave heated breasts phantom models.

4. In the Hybrid irradiation technique, irradiation by a FIR source followed by an irradiation from a micro wave source of
2450 MHz was proposed. The experimental results showed this method produced 5.75°C temperature difference for a 1°C cancer growth and much early detection of breast cancer is possible by this method. In the Hybrid multiple irradiation technique, after the FIR and microwave irradiation steps, the cancer phantom was once again irradiated by the same microwave source. The temperature of the cancer phantom was increased only to 48°C. The third irradiation did not produce considerable increase in cancer phantoms temperature compared to second irradiation, which elevated the cancer phantom’s temperature to 47°C. Since even the third irradiation did not have considerable impact on the temperature difference between the normal and cancer breast tissues, Hybrid multiple irradiation is not of practical use.

5. In the Microwave double and multiple irradiation techniques, a method of obtaining an active thermo gram by irradiating the patient’s breast twice, thrice using a microwave source of 2450 MHz and allowing them to cool naturally after every radiation is proposed. Results of the experiments conducted using phantom models show the temperature difference between the cancerous and normal breast tissues is increased by the first irradiation considerably; the second irradiation further elevated the temperature difference between the normal and breast tissues. The third irradiation did not have any impact. Results obtained show that both the double irradiation technique and triple irradiation technique produce a temperature difference of 6.75°C between the normal and cancerous breast tissues for a cancer tumor which produces a temperature difference of 1°C between normal and cancerous
tissues by passive radiation. Hence there is a marked intensity variation between the normal and cancer tissues of the breast in thermogram is produced by double irradiation and triple irradiation which makes the early diagnosis of breast carcinoma possible. Since even the third irradiation did not have any impact on the temperature difference between the normal and cancerous breast tissues multiple irradiation is not superior to double irradiation for early diagnosis of breast carcinoma.

5.2 DISCUSSIONS

The power emitted by the cancerous and normal breast phantom tissue phantoms and the contrast power were calculated based on the results obtained. Table 4.1 shows the contrast power produced by passive (conventional) thermograph method. Here $T_b$ is the temperature of breast phantom and $T_c$ is the temperature of breast cancer phantom, $P_a$ is the power emitted by breast phantom, $P_{cc}$ is the power emitted by the breast cancer phantom in passive (conventional) thermograph method; $P_{ca}$ is the power emitted by the breast cancer phantom in active thermograph method by various irradiation techniques. Table 4.2 shows the comparison based on temperature elevation, emission power, contrast power produced by various irradiation techniques of active thermograph method. Contrast power is calculated as the power difference between the power emitted by normal breast tissue phantom and breast cancer tissue phantom.

**Contrast power calculation**

Contrast power = power emitted by breast phantom($P_a$) - power emitted by the breast cancer phantom ($P_{cc}$)
**Emission power**

Stefan Boltmann states that, \( E = \varepsilon \sigma T^4 \) where \( E \) is the total emissive power, \( T \) is the temperature in Kelvin, \( \sigma \) is Stefan Boletzmann’s constant and is equal to \( 5.67 \times 10^{-8} \, \text{W/m}^2 \), \( \varepsilon \) is the emissivity and is taken as 1 for the breast skin.

Temperature of the breast phantom is 37°C. Hence the power emitted by the breast phantom is,

\[
E = (5.67 \times 10^{-8}) (310)^4 \, \text{W/m}^2 \\
= 52.36 \, \text{mw/cm}^2
\]

Temperature of the breast cancer phantom with 1°C growth is 38°C. Hence the power emitted by the breast cancer phantom is,

\[
E = (5.67 \times 10^{-8}) (311)^4 \, \text{W/m}^2 \\
= 53.04 \, \text{mw/cm}^2
\]

**Contrast power**

At 38°C

One degree cancer growth (i.e., cancer tumor at 38°C) by passive emission gives a contrast power with the normal breast tissues is,

\[
E = (53.04 \, \text{mw/cm}^2) - (52.36 \, \text{mw/cm}^2) \\
= 0.68 \, \text{mw/cm}^2.
\]

Similarly contrast power at 39°C, 41°C, 42.75°C, 43.75°C is calculated.

At 39°C
One degree cancer growth (i.e., cancer tumor at the elevated temperature 39 °c) by active emission by FIR external irradiation method gives a contrast power with the normal breast tissues is,

\[ E = (53.73 \text{ mw/cm}^2) - (53.04 \text{ mw/cm}^2) \]
\[ = 1.37 \text{ mw/cm}^2. \]

At 41 °c

One degree cancer growth (i.e., cancer tumor at the elevated temperature 41 °c) by active emission by microwave external single irradiation method gives a contrast power with the normal breast tissues is,

\[ E = (55.12 \text{ mw/cm}^2) - (53.73 \text{ mw/cm}^2) \]
\[ = 2.76 \text{ mw/cm}^2. \]

At 42.75 °c

One degree cancer growth (i.e., cancer tumor at the elevated temperature 42.75 °c) by active emission by hybrid external irradiation method gives a contrast power with the normal breast tissues is,

\[ E = (56.36 \text{ mw/cm}^2) - (55.12 \text{ mw/cm}^2) \]
\[ = 4.00 \text{ mw/cm}^2. \]

At 43.75 °c

One degree cancer growth (i.e., cancer tumor at the elevated temperature 43.75 °c) by active emission by double, multiple microwave external irradiation method gives a contrast power with the normal breast tissues is,

\[ E = (57.08 \text{ mw/cm}^2) - (56.36 \text{ mw/cm}^2) \]
\[ = 4.72 \text{ mw/cm}^2. \]
Table 5.1 Contrast power produced by conventional thermogram

<table>
<thead>
<tr>
<th>(T_b , ^\circ C)</th>
<th>(T_c , ^\circ C)</th>
<th>(P_a , (\text{mw/cm}^2))</th>
<th>(P_{cc} , (\text{mw/cm}^2))</th>
<th>Contrast power ((\text{mw/cm}^2))</th>
<th>Method</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>37</td>
<td>38</td>
<td>52.36</td>
<td>53.04</td>
<td>0.68</td>
<td>Passive emission – Conventional thermogram</td>
<td>1°C cancer growth (i.e., cancer tumor at 38°C) produces 0.68 mw/cm² contrast power by conventional thermography.</td>
</tr>
</tbody>
</table>

Table 5.2 Comparison of various irradiation techniques of the active thermogram method

<table>
<thead>
<tr>
<th>(T_c , \text{(after Heating)} , ^\circ C)</th>
<th>(T_c , \text{(after heating and cooling)} , ^\circ C)</th>
<th>(P_a , (\text{mw/cm}^2))</th>
<th>(P_{ca} , (\text{mw/cm}^2))</th>
<th>Contrast power ((\text{mw/cm}^2))</th>
<th>Method</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>43 (cancer Phantom)</td>
<td>39 (cancer phantom)</td>
<td>52.36</td>
<td>53.73</td>
<td>1.37</td>
<td>Active emission-FIR irradiation method-Active thermogram</td>
<td>1°C cancer growth (i.e., cancer tumor at 38°C) produces 1.37 mw/cm² contrast power by FIR irradiation technique since the temperature of the cancer phantom is elevated from 38°C to 39°C by FIR irradiation technique.</td>
</tr>
</tbody>
</table>
Table 5.2 (Continued)

<table>
<thead>
<tr>
<th>45 (cancer phantom)</th>
<th>41 (cancer phantom)</th>
<th>52.36</th>
<th>55.12</th>
<th>2.76</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active emission-Microwave single irradiation method-Active thermogram</td>
<td>1°C cancer growth (i.e., cancer tumor at 38°C) produces 2.76 mw/cm² contrast power by Microwave single irradiation technique since the temperature of the cancer phantom is elevated from 38°C to 41°C by Microwave single irradiation technique.</td>
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</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>47 (cancer phantom)</th>
<th>42.75 (cancer phantom)</th>
<th>52.36</th>
<th>56.36</th>
<th>4.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active emission-Hybrid irradiation method-Active thermogram</td>
<td>1°C cancer growth (i.e., cancer tumor at 38°C) produces 4.00 mw/cm² contrast power by Hybrid irradiation technique since the temperature of the cancer phantom is elevated from 38°C to 42.75°C by Hybrid irradiation technique.</td>
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</tr>
</tbody>
</table>
### Table 5.2 (Continued)

<table>
<thead>
<tr>
<th>49</th>
<th>43.75</th>
<th>52.36</th>
<th>57.08</th>
<th>4.72</th>
<th>1°C cancer growth (i.e., cancer tumor at 38°C) produces 4.72 mw/cm² contrast power by Microwave double irradiation technique since the temperature of the cancer phantom is elevated from 38°C to 43.75°C by Microwave double irradiation technique.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(cancer phantom)</td>
<td>(cancer phantom)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>49.25</th>
<th>Active emission-Microwave multiple irradiation method-Active thermogram</th>
<th>Microwave multiple irradiation did not increase the temperature of the cancer phantom considerably than the Microwave double irradiation technique. Hence it is of no practical use.</th>
</tr>
</thead>
</table>
These tables show that the active thermographic methods produce more contrast power for 1c cancer growth than the passive (conventional) thermographic method. Out of all the tested techniques, Microwave double irradiation technique is found to produce the most significant amount of contrast power.