MAMMOSITE BRACHYTHERAPY DOSIMETRY – EFFECT OF CONTRAST AND AIR INTERFACE ON SKIN DOSE.

A RESEARCH PAPER

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BY

IMENDRA PADMASRI RANATUNGA

ADVISOR RANJITH WIJESINGHE, PH.D

CO-SUPERVISOR ALVIS FOSTER, PH.D

BALL STATE UNIVERSITY

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CHAPTER 01

Introduction

1.1 Breast Cancer statistics

Among the many types of cancer, breast cancer is the type that causes the most deaths among women worldwide [1]. In 2013, the United States alone reported 232,340 new breast cancer cases and 39,620 deaths due to breast cancer [2]. It can be inferred using the rates from 2007-2009 that 12.38% of women born today will be diagnosed with breast cancer during their lifetime [3]. This means that one in eight women are going to be diagnosed with cancer during their life [4]. Table 1.1 shows increasing five-year relative survival rates in the United States [5]. The increasing rate of survival is thought to be due to advanced treatment options and early diagnosis.

<table>
<thead>
<tr>
<th>Year of diagnosis</th>
<th>5 year relative survival rate %</th>
</tr>
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<tbody>
<tr>
<td>1975-1977</td>
<td>74.8</td>
</tr>
<tr>
<td>1978-1980</td>
<td>74.4</td>
</tr>
<tr>
<td>1981-1983</td>
<td>76.1</td>
</tr>
<tr>
<td>1984-1986</td>
<td>78.9</td>
</tr>
<tr>
<td>1987-1989</td>
<td>84.0</td>
</tr>
<tr>
<td>1990-1992</td>
<td>85.2</td>
</tr>
<tr>
<td>1993-1995</td>
<td>86.4</td>
</tr>
<tr>
<td>1996-1998</td>
<td>88.2</td>
</tr>
<tr>
<td>1999-2003</td>
<td>89.9</td>
</tr>
<tr>
<td>2004-2010</td>
<td>90.5</td>
</tr>
</tbody>
</table>

Table 1.1 Relative survival rates from breast cancer
1.2 Treatments

There are mainly three types of cancer treatment techniques; radiation therapy, surgical procedures and chemotherapy. Radiation therapy is divided into two categories as external beam radiation therapy and brachytherapy.

1.2.1 External beam radiation therapy

External beam radiation therapy (EBRT) is one of the oldest and effective techniques used to treat cancer. EBRT is a method of delivering one or multiple beams of high-energy x-rays from an external source to a patient's tumor. Here, beams are generated outside the patient and are targeted at the tumor site [6]. The treatment time could vary from hours to several weeks depending on the type as well as the stage of the cancer.

Fig 1.1 External beam radiation therapy setup
1.2.2 Brachytherapy

Short distance treatment of cancer using radiation from small, an encapsulated radionuclide source is called Brachytherapy [7]. It is done by placing sources of radiation directly in or near the area to be treated. The dose of radiation has to be delivered continuously over a short period of time when temporary implants are used or over the lifetime of the source when permanent implants are used. The most common radiation modality used in brachytherapy is gamma photons.

There are two main types of brachytherapy treatments: Intracavitary (where the sources are placed adjacent to the treatment volume, e.g., gynecology HDR treatments) and Interstitial (where the sources are implanted inside the treatment volume, e.g., prostate LDR treatments) [7]. In this study we focus on an Intracavitary treatment method called MammoSite® brachytherapy.

Radiation may be used to treat breast cancer after the tumor has been removed with a lumpectomy. This method of treatment is used to kill residual cancer cells surrounding the lumpectomy cavity. The technique is known as accelerated partial breast irradiation (APBI) [1]. The device is called MammoSite® catheter, which consists of a small silicon balloon connected to an external inflation lumen and a internal lumen for the passage of a high dose rate Ir-192 brachytherapy source [8], as shown in figure 1.2. The device is placed into the lumpectomy cavity and inflated with a mixture of saline and radiographic contrast agent to fill the cavity [8]. The Ir-192 brachytherapy source is placed at the center of the balloon through a remote afterloader to deliver dose to the treated volume.
1.2.3 Treatment planning

Treatment planning is the process of determining the target (tumor volume) and optimal technique for radiation delivery. After implantation of the MammoSite® balloon catheter, the patient undergoes a CT scan. These CT imagers are used by the Nucletron treatment planning software to determine the area to be treated and those areas to be avoided. First, CT scans are transferred digitally to the treatment planning software to determine gross tumor volume (GTV), clinical tumor volume (CTV), and planning tumor volume (PTV). In MammoSite® brachytherapy, the excision of the lumpectomy cavity is defined as the gross tumor volume [9]; PTV is defined as the breast tissue immediately surrounding the balloon to a measured 1 cm distance from the balloon surface [10].
In MammoSite® technique, the PTV is considered to be the same as the CTV because, the implanted balloon moves with the target, therefore, compensation for variability of breathing motion is not needed. Contouring starts with definition of the GTV (Also, the planning target balloon surface) on a central slice of the CT scan, then on each axial CT slice moving superiorly and then inferiorly [11]. Once all of the contours are drawn, then CTV and prescribed dose limits are defined using isodose surfaces.
Finally, using dose calculation algorithms, the treatment planning software is used to design a source position sequence in various locations within the implant applicator to build a matching dose distribution according to the isodose surfaces. The amount of dwell time in one location determines the amount of dose delivered.

1.3 Statement of the problem

1.3.1 Effect of Contrast material

Computer tomography (CT) simulation is used for treatment planning [11]. Therefore, the balloon is inflated with saline solution and contrast media so it can be imaged through CT. But, the dosimetry of commercially available brachytherapy treatment planning systems like Nucletron Oncentra is based on the assumption that the HDR brachytherapy source is located in a unit density water medium [12]. Because the contrast medium contains elements with high atomic number (I-53) [8, 13], therefore, the balloon and it’s contents are no longer equivalent to water.
1.3.2 Effects of breast-air interface

Most of the treatment planning systems for brachytherapy procedures including Nucletron Oncentra use water-based dosimetry. A homogeneous medium is assumed in this process. But, this may result in errors, because the human body is heterogeneous. Therefore, these treatment planning systems assume that full scatter exists regardless of the amount of tissue density existing beyond and below the prescription line. This assumption is not true, especially when the tissue beyond the prescription line is thin [14]. As an example, when the balloon is closer to breast-air interface, dose contribution due to backscatter radiation is less (Figure 1.5), Therefore, it is important that treatment planning systems consider patient anatomy and heterogeneity when it calculates the target dose rate. Otherwise, it will over estimate the dose in the areas of breast-air and breast-lung interfaces.

![Diagram](image)

Figure 1.5 Dose contributions from over-laying tissues. A) Dose from full scatter (including backscatter contribution). B) Dose without backscatter contribution.
1.4 Significance of this study

Current radiation techniques do not have perfect efficacy. Also, healthy cells are killed as well as malignant cells [15]. This can result in significant patient morbidity. Delivering correct doses with an accuracy of +/- 5% is important in order to successfully treat cancer with radiation [1]. Some treatment options have been created to spare healthy cells while still having enough radiation to damage cancerous cells [1]. However, if the cancer cells are not completely destroyed then they may continue to grow and cause the tumor to grow [15]. This is why it is critical to understand how patient doses change due to contrast and breast air interface so that more accurate doses can be determined [15].
2.1 Dose Rate calculation

Most of the treatment planning systems used TG-43U1 model for calculation of dose distributions around a brachytherapy source [16]. TG-43 is the first report on the dosimetry of sources used in interstitial brachytherapy [16,17]. Since then due to the improved dosimetry methodologies and dosimetric characterization of particular source models, American Association of Physicists in Medicine (AAPM) introduced TG-43U1 the updated version of TG-43 [17].

Both of these reports introduce new parameters like air kerma strength ($S_k$), dose rate constant ($\Lambda$), geometry function ($G_L(r,\theta)$), radial dose function ($g_L(r)$), and anisotropy function ($F(r,\theta)$) to calculate brachytherapy dose [16,17]. These dosimetry parameters consider geometry, encapsulation and self-filtration of the source, the spatial distribution of radioactivity within the source, and scattering in water surrounding the source [16,17]. According to this protocol, the absorbed dose rate distribution around a sealed brachytherapy source at point P (as shown in figure 2.1) with polar coordinates $(r,\theta)$ can be determined using the following formalism [16,17]
Figure 2.1 Schematic diagram of a seed and the point of interest \( P(r, \theta) \) used in TG 43.

\[
\dot{D}(r, \theta) = S_k \cdot \Lambda \cdot \frac{G_L(r, \theta)}{G_L(r = 1, \theta = \pi / 2)} \cdot g_L(r) \cdot F(r, \theta)
\]  

(2.1)

2.1.1 Air kerma strength

Air kerma strength, \( S_k \), this is the term that represents brachytherapy source strength. It is defined as the product of air kerma rate at a calibration distance \( (d) \) in free space (which is usually chosen as 1 m) along the perpendicular bisector of the source and the square of the distance \( (d^2) \) [16,17],

\[
S_k = K(d) \cdot d^2
\]  

(2.2)

Where, \( K(d) \), is the air kerma rate. The unit of \( S_k \) is \( U \left( 1U = 1cGy \cdot cm^2 \cdot h^{-1} \right) [16]. \)
2.1.2 Dose rate constant

The dose rate constant, $\Lambda$, for the source and surrounding medium is defined at $P(r_0, \theta_0)$ (1 cm away from the source on its perpendicular bisector where, $\theta_0 = \frac{\pi}{2}$). The $\Lambda$ is expressed in units of $cGy \cdot hr^{-1} \cdot U^{-1}$ [18]. Therefore, dose rate constant, $\Lambda$, given as follows [16, 17]:

$$\Lambda = \frac{D(r_0, \theta_0)}{S_k} \quad (2.3)$$

The value of the dose rate constant $\Lambda$ depends on the medium surrounding the radiation source, because it indicates the rate of the energy is absorbed by the medium [17, 18]. Therefore, it is taking into account factors like, source geometry, the spatial distribution of radioactivity within the source, encapsulation, and self-filtration within the source and scattering in the water surrounding the source [16, 17].

2.1.3 Geometry function

The Geometry function, $G_k(r, \theta)$, with units of $cm^{-2}$, describes the decrease in dose with distance from the source [16, 18].

For point source [16, 17]:

$$G_k(r, \theta) = r^2 \quad (2.4)$$

For line source [17]:

$$G_k(r, \theta) = \frac{(\theta_2 - \theta_1)}{L \cdot r \cdot Sin\theta} \quad (2.5)$$
2.1.4 Radial dose function

The radial dose function, \( g_L(r) \), takes into account absorption and scatter along the transverse axis of the source; and normalized to the value at 1cm from the source. \( g_L(r) \) is determined from the depth dose measurements along the perpendicular axis of the source [18, 17].

\[
g_L(r) = \frac{\dot{D}(r,\theta_0) \cdot G_L(r_0,\theta_0)}{\dot{D}(r_0,\theta_0) \cdot G_L(r,\theta_0)} \quad (2.6)
\]

2.1.5 Anisotropy function

Anisotropy function, \( F(r,\theta) \), accounts for the angular variation of photon absorption and scattering in the medium and in the source encapsulation [16, 17]. This function is expressed as a relative dose measurement, and it is normalized to the measurement at \( \theta_0 = \frac{\pi}{2} \) for each value of \( r \) [16, 17].

\[
F(r,\theta) = \frac{\dot{D}(r,\theta) \cdot G_L(r,\theta_0)}{\dot{D}(r,\theta_0) \cdot G_L(r,\theta)} \quad (2.7)
\]

2.2 Dose calculation

Section 2.1 described the estimation of the dose rate value \( \dot{D}(r,\theta) \) at a point of interest \( P(r,\theta) \). In calculating the absorbed dose value \( D(r,\theta) \) at the point of interest \( P(r,\theta) \), it was assumed that the source strength expressed as air kerma strength. Also; the dose rate is obtained by considering \( t_0 = 0 \) [19]. If the dwell time of the \(^{192}\text{Ir} \) source is \( T \), then the total dose delivered at the point of interest is obtained by using equation 2.6 [19]. Where, \( \lambda \) is the decay constant of the radioisotope.
\[ D(r, \theta) = \int_{t=t_0}^{t=T} \dot{D}(r, \theta, t_0) e^{-\lambda(t-t_0)} dt = \dot{D}(r, \theta) \left( \frac{1}{\lambda} \right) \left( 1 - e^{-\lambda T} \right) \]  

(2.8)

But, mean life, \( \tau \), is equal to \( \frac{1}{\lambda} \)

\[ D(r, \theta) = \dot{D}(r, \theta, t_0) \tau \left( 1 - e^{-\frac{T}{\tau}} \right) \]  

(2.9)

When \( T \ll \tau \), exponential part of equation 2.9 is

\[ e^{-\frac{T}{\tau}} \approx \left( 1 - \frac{T}{\tau} \right) \]  

(2.10)

Therefore, equation 2.9 can be expressed as

\[ D(r, \theta) = \dot{D}(r, \theta, t_0) \tau \left( 1 - \left( 1 - \frac{T}{\tau} \right) \right) \]  

(2.11)

\[ D(r, \theta) = \dot{D}(r, \theta, t_0) \tau T \]  

(2.12)

According to the equation 2.12, it can be assumed that the dose, \( D(r, \theta) \), at the particular point of interest, \( P(r, \theta) \), is proportional to the dwell time, \( T \). As a result, dwell time, \( T \), can be used as an indicator for dose.
CHAPTER 3

Material and method

3.1 Effect of Contrast Material

3.1.1 Phantom

In order to conduct this investigation, a clinical MammoSite® balloon of 4 cm diameter was used. The MammoSite® balloon was placed in the middle of the 30cm X 30cm x 30cm water phantom. A 0.6cc ion chamber was placed parallel to the catheter axis between the water surface and the balloon surface. The distance from water surface to the middle of the chamber axis was set to 7cm to assure full scatter (remove the uncertainty from breast air interference). We also set the distance between the middle of the chamber surface to the MammoSite® catheter axis to 5 cm. Both of the holders that are used to hold the MammoSite® catheter and ion chamber were made with tissue equivalent materials (similar electron density). These tissue equivalent materials and water simulate the attenuation and scattering of soft tissues.

3.1.2 CT simulation

The phantom was filled with water and aligned with positioning lasers on the General Electric Lite Speed 4 slice Computed Tomography (CT) scanner. Then, the MammoSite® balloon was then filled with 60 cm$^3$ of water, which representing 0% contrast. Then, helical CT scans were acquired throughout the phantom with a 1mm slice width. 10% of the water in the balloon was then replaced with an equal volume of a contrast solution and a repeat CT scan was acquired. The contrast medium used in this experiment is Iohexol, which is sold under the trade name called Omnipaque 300 [20]. It has a molecular composition of $C_{19}H_{26}I_3N_3O_9$ [20].
Omnipaque 300 contains 647 mg of Iohexol equivalent to 300 mg of organic iodine per milliliter [13]. The filling and scanning process of the MammoSite® balloon catheter was repeated for the balloon filled with saline and 20% of radiographic contrast concentration, and for the balloon filled with saline and 30% radiographic contrast concentration.

Figure 3.1 Cross sectional diagram of the phantom setup for

Figure 3.2 Actual phantom setup
3.1.3 Treatment planning

The CT images of the phantom, with the MammoSite® balloon as described in section 3.1.2, were imported to the Nucletron Oncentra treatment planning system for contouring. After the countering, a 100 cGy isodose curve was defined at 5cm from the center of the balloon. The dose of 100 cGy is arbitrary and was chosen for convenience of measurement confirmation. This whole process was repeated for all of the contrast concentrations.

![Diagram of a 100 cGy isodose curve](image)

**Figure 3.3 Schematic diagram of a 100 cGy isodose curve appear in treatment planning system**

3.1.4 Radiation Delivery

The treatment planning data from Nucletron Oncentra treatment planning system was exported to the afterloader. The phantom was placed on a stable counter top, and the MammoSite® catheter was connected to the afterloader using a transfer tube. Treatment was delivered to the phantom. This was done by twice to get an average measurement; both dwell times as well as ionization chamber readings were recorded. The same procedure was repeated for the rest of the contrast concentration setups.
3.2 Effect of Breast Air Interface

3.2.1 Phantom

The same MammoSite® balloon and phantom setup were used as in section 3.1.1. The distance from the center axis of the ion chamber to the center axis of the MammoSite® catheter was kept at 5cm.

3.2.2 CT simulation

The phantom was filled with water up to the center axis of the ion chamber, where d is equal to zero. Then, helical CT scans were acquired throughout the phantom with 1mm slice width using the same CT scanner described in section 3.12. The filling and scanning process was repeated for different d values, where d was equal to 1cm, 2 cm, 5 cm and 7 cm. This represents the different tissue thicknesses beyond the point of measurements.
3.2.3 Treatment Planning

The CT images of the phantom, with the MammoSite® balloon as described in section 3.2.2, were imported to the Nucletron Oncentra treatment planning system for contouring. Like section 3.1.3, the 100 cGy isodose curve was defined at 5 cm from the center of the balloon. This was repeated for all of the over-lying water levels.
3.2.4 Radiation Delivery

The treatment planning data from the Nucletron Oncentra treatment planning system was exported to the afterloader. As described in section 3.1.4, the planned treatment was delivered to the phantom. This was done twice to get an average measurement; both dwell times as well as ionization chamber readings were recorded. The same procedure was repeated for the rest of the over-lying water thickness setups.

3.3 MammoSite® Balloon Catheter

![Figure 3.7 Mammosite® Balloon](image)

Figure 3.7 Mammosite® Balloon

The MammoSite® device used in this experiment consists of a single-lumen catheter and a silicone balloon. The external lumen is used as an inflation channel; and the central lumen accommodates the radioisotope high (e.g., $^{192}$Ir) [21]. The diameter of the spherical balloon is 4 cm when the fill volume equals to 60 cm$^3$ [21].
3.4 Ion chamber

Figure 3.8 0.6 cc PTW Farmer Chamber

The 0.6 cm$^3$ PTW Farmer ion chamber that was used in this experiment is the most convenient as well as accurate dosimeter for measure radiation dose in radiotherapy. Ionization chambers do not measure dose directly, so it is necessary to convert measured ionization to absorbed dose by the chamber [22]. This is done by multiplying the ion chamber reading with, $N_{D,W}$, which called the dose to water calibration coefficient [22]. Before multiplying by $N_{D,W}$, the raw reading from the ion chamber must be corrected for environmental conditions as well as some aspects of operation of instrument as indicated in the equation 3.1 [22].

\[
M = M_{\text{raw}} \cdot P_{TP} \cdot P_{\text{ion}} \cdot P_{\text{pol}} \cdot P_{\text{elec}} \tag{3.1}
\]

Where, $P_{TP}$ is a correction for the temperature (T) and pressure (P) [22]. $P_{\text{ion}}$ is a correction factor for the incomplete collection of ions at electrodes in the ion chamber [22]. $P_{\text{pol}}$
is the polarity correction factor for differences in the sensitivity of the ionization chamber when the operating voltage is reversed [22]. \( P_{elec} \) is the electrometer correction factor for the response of the electrometer to the connected ion chamber [22].

Then this corrected ionization reading, M, is converted to dose in the water at the point of reference by using equation 3.2 [22]:

\[
D_W = M \cdot N_{D,W} \cdot k_Q \\
(3.2)
\]

Where, \( k_Q \) is called the quality conversion factor which depending on the type of ion chamber, and the energy of the radiation [22].

Therefore, using equations 3.1 and 3.2:

\[
D_W = M_{raw} \cdot \left( P_{TP} \cdot P_{ion} \cdot P_{pol} \cdot P_{elec} \cdot N_{D,W} \cdot k_Q \right) \\
(3.3)
\]

If we assume temperature and pressure are constant throughout the experiment then equation 3.3 becomes,

\[
D_W = M_{raw} \cdot \text{Constant} \\
(3.4)
\]

Because, \( P_{ion}, P_{pol}, P_{elec}, N_{D,W}, \) and \( k_Q \) all depend on the ion chamber, electrometer’s operating voltage, and radiation energy, which were constant throughout the experiment. Therefore, in this experiment, we can use the direct ion chamber reading (\( M_{raw} \)) as an indicator for radiation dose.
CHAPTER 04

Results

4.1 Effect of Contrast Material

The dwell times calculated with the treatment planning system for 100 cGy radiation dose at 5 cm from the MammoSite® catheter axis were recorded for different contrast concentrations; and then the dwell time data were normalized to 0% contrast. At the same time readings from 0.6cc Farmer ion chamber were also recorded and normalized to 0% contrast concentration.

<table>
<thead>
<tr>
<th>Contrast concentration (%)</th>
<th>Dwell time to deliver 100cGY</th>
<th>Normalize to 0% concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading 1 (Seconds)</td>
<td>Reading 2 (Seconds)</td>
</tr>
<tr>
<td>0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>10</td>
<td>268.8</td>
<td>268.8</td>
</tr>
<tr>
<td>20</td>
<td>268.8</td>
<td>268.8</td>
</tr>
<tr>
<td>30</td>
<td>268.8</td>
<td>268.8</td>
</tr>
</tbody>
</table>

Table 4.1. Recorded dwell times from Nucletron Oncentra treatment planning systems for different contrast concentrations
Contrast concentration (%)  | Ion chamber reading for 100cGy (nC)  | Normalize to 0% concentration  
--- | --- | ---  
| Reading 1 (nC) | Reading 2 (nC) | Average (nC) |  
0 | 2.845 | 2.850 | 2.848 | 1.000 |  
10 | 2.798 | 2.801 | 2.800 | 0.983 |  
20 | 2.691 | 2.688 | 2.690 | 0.944 |  
30 | 2.670 | 2.670 | 2.670 | 0.938 |  

Table 4.2. Recorded ion chamber readings for different contrast concentrations

![Normalized Dose Vs. Contrast Concentration](image)

Figure 4.1. Comparison of the normalized dose as a function of contrast concentration for the MammoSite balloon placed in cubical water phantom, at 5 cm from catheter axis. a) Delivered dose measurements from Nucletron Oncentra treatment planning system. b) Measured dose measurements from 6cc Farmer chamber.
4.2 Effect of Breast Air Interface

The dwell times calculated by the treatment planning system for 100 cGy radiation dose at 5 cm from the MammoSite® catheter axis were recorded for different over-lying water thicknesses; and then data were normalized to over-lying water thickness d, where d is equal to 7 cm. At the same time 0.6cc Farmer ion chamber was used to measure the dose at 5 cm from the MammoSite® catheter axis for different over-lying water thicknesses; and normalized to d equal to 7 cm (full scatter state).

<table>
<thead>
<tr>
<th>d, over-lying water thickness (cm)</th>
<th>Dwell time to deliver 100cGy</th>
<th>Normalize to full scatter (d = 7cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading 1 (Seconds)</td>
<td>Reading 2 (Seconds)</td>
</tr>
<tr>
<td>0.0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>0.5</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>1.0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>2.0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>5.0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
<tr>
<td>7.0</td>
<td>266.7</td>
<td>266.7</td>
</tr>
</tbody>
</table>

Table 4.3 Recorded dwell times from Nucletron Oncentra treatment planning systems for different over-lying water thicknesses.
<table>
<thead>
<tr>
<th>d, over-lying water thickness (cm)</th>
<th>Dwell time to deliver 100cGy</th>
<th>Normalize to full scatter (d = 7cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Reading 1 (nC)</td>
<td>Reading 2 (nC)</td>
</tr>
<tr>
<td>0.0</td>
<td>2.629</td>
<td>2.631</td>
</tr>
<tr>
<td>0.5</td>
<td>2.684</td>
<td>2.683</td>
</tr>
<tr>
<td>1.0</td>
<td>2.696</td>
<td>2.696</td>
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<td>2.0</td>
<td>2.773</td>
<td>2.793</td>
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<tr>
<td>5.0</td>
<td>2.842</td>
<td>2.841</td>
</tr>
<tr>
<td>7.0</td>
<td>2.845</td>
<td>2.850</td>
</tr>
</tbody>
</table>

Table 4.4. Recorded ion chamber readings for different over-lying water thicknesses
Figure 4.2 Comparison of the normalized dose as a function of over-lying water thickness for the MammoSite® balloon placed in cubical water phantom, at 5 cm from catheter. a) Delivered dose measurements from Nucletron Oncentra treatment planning system. b) Measured dose from 6cc Farmer chamber.
CHAPTER 05

Conclusion

5.1 Effect of Contrast Material

Both of these experiments were carried out using the same MammoSite® balloon, where diameter was equal to 4 cm. In first experiment, the contrast was changed from a concentration of 0% to 30% while keeping the same phantom setup. According to table 4.2, we observed a prescribed dose reduction from 1.7% to 6.2% at 5 cm away from the balloon axis relative to dose obtained without contrast material. The largest dose reduction occurred when contrast concentration is at its greatest. According to the table 4.1 and figure 4.1, we observed the predicted dose form the treatment planning system was constant with the different contrast concentrations.

Therefore, using these observations we can conclude that treatment-planning system does not take into account dose perturbation as a function of different contrast concentrations. Dose perturbations due to contrast concentration has minimal affect on the MammoSite® dosimetry as long as the concentration is below 20%.

5.2 Effects of Breast-Air Interface

In the second experiment, we changed the over-lying water thickness from 0 cm to 7 cm while keeping the other parameters the same. Also In this experiment we assumed 7cm of over-lying water thickness is more than sufficient for full scatter. According to table 4.4, we observed the prescribed dose reduction from 0.21% to 7.7% at 5 cm away from the balloon axis relative to dose obtained with full scatter (when d is equal to 7cm). According to the table 4.3 and figure
4.2, we observed that the predicted dose form the treatment planning system was constant with the different over-lying water thicknesses (d).

Therefore, the same as section 5.1, we can conclude that the treatment-planning system does not take into account dose perturbation due to the effect of the breast air interface. According to the figure 4.2, when the over-lying water thickness d is less than 1 cm, there is a considerable dose reduction to PTV. Therefore, we can recommend that caution should be used when planning a MammoSite® technique to treat lumpectomy cavities close to the skin surface as the predicted dose may be clinically different than that predicted.

According to the above results, it is important to develop a treatment planning systems that performs heterogeneity correction for breast air interface, and different contrast materials as well as different contrast concentrations. In this experiment we only considered two variables, therefore, to quantify the uncertainties from the MammoSite® brachytherapy technique completely, work needs to be done regarding the uncertainty due to balloon deformation, and source position [8].
REFERENCE


[16] Brachytherapy Edited by Kazushi Kishi


