EFFECT OF BILIRUBIN CONCENTRATION ON RADIATION ABSORBED
DOSE EQUIVALENT USING LiF (TLD-100) CHIPS

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ABSTRACT

The effect of bilirubin concentration on dose equivalent of absorbed radiation was investigated in vitro in this study. Different concentrations of bilirubin were exposed to a fixed dose equivalent x-ray irradiation from an RSO1 x-ray generator. The fraction of radiation transmitted and the fraction absorbed were measured using LiF (TLD 100) chips as detectors, and the radiation absorbed by bilirubin was computed. Result indicate that at low concentrations (25μmol/L to 76μmol/L) absorbed doses decreased with increase in bilirubin concentration. At higher bilirubin concentrations (76μmol/L to 466μmol/L) and beyond, there was an increase in absorption with a strong positive correlation (r = 0.92) between dose absorbed and bilirubin concentration. The possible applications of this property of bilirubin as a modifier at high concentrations- to enhance radiation effect on diseased tissue during radiotherapy, and the danger inherent presenting neonates for radiodiagnostic examinations are discussed.

Key words: Bilirubin, radiation, absorption, radiotherapy, modifier.

INTRODUCTION

Bilirubin is a final product of red blood cells breakdown. In the presence of NADPH and oxygen, the microsomal enzyme of the reticuloendothelial system, particularly the liver and spleen, adds a hy·oxy·l group to the methenyl bridge between two pyrrole rings with concomitant oxidation of ferrous iron Fe²⁺ to ferric iron Fe³⁺ (Voet and Voet, 1999). Further oxidation results in cleavage of the porphyrin ring with release of ferric iron and carbon monoxide to yield a green pigment biliverdin, which is reduced to bilirubin. The resulting bilirubin is transported in plasma bound to albumin (Champe and Harvey, 1994).

Due to the short span of the erythrocytes and increased haemoglobin mass, neonates have higher bilirubin levels than adults (Cantar, 1989). Serum bilirubin levels are affected by both physiological and pathological conditions. They are elevated in both pregnancy and exercise (Eastham, 1985). Increased levels of total Bilirubin (conjugated and unconjugated has diagnostic implications as it is associated with liver diseases and hemolytic disorders in adults; and the newborn. Conjugated bilirubin is increased in biliary obstruction and hepatocellular disease (Eastham, 1985).

Serum bilirubin levels of patients are often requested before the radiographic examination of the renal system is performed. This is

<table>
<thead>
<tr>
<th>Bilirubin concentration (μmol/L)</th>
<th>Dose transmitted (μSv)</th>
<th>Dose absorbed by bilirubin (μSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25.65</td>
<td>0.004</td>
<td>0.0117</td>
</tr>
<tr>
<td>42.8</td>
<td>0.016</td>
<td>0.0400</td>
</tr>
<tr>
<td>59.8</td>
<td>0.035</td>
<td>0.1181</td>
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<td>76.0</td>
<td>0.052</td>
<td>0.2312</td>
</tr>
<tr>
<td>93.6</td>
<td>0.073</td>
<td>0.4073</td>
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<tr>
<td>111.5</td>
<td>0.093</td>
<td>0.6773</td>
</tr>
<tr>
<td>128.8</td>
<td>0.116</td>
<td>1.0070</td>
</tr>
<tr>
<td>145.5</td>
<td>0.136</td>
<td>1.3196</td>
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<tr>
<td>162.5</td>
<td>0.156</td>
<td>1.6814</td>
</tr>
<tr>
<td>179.5</td>
<td>0.176</td>
<td>2.0017</td>
</tr>
</tbody>
</table>

Table 1: Dose of radiation transmitted and absorbed by bilirubin concentrations of bilirubin.

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because excess bilirubin in the blood is known to dissolve contrast media (Mc Aurish, 1986). Apart from the contra-indication of high serum bilirubin level (17μmol/L or 0.8mg/ml) for intravenous urography, there is paucity of data on the relationship between bilirubin concentration and absorbed radiation in tissues. This work investigates this relationship, and the possible application of this property in Radiotherapy.

MATERIALS AND METHODS

Lithium Fluoride thermoluminescent dosimeter chips (TLD-100) and pure bilirubin powder were obtained from the Sigma Chemical Company, England, and used for the experiments. An X-ray generator, model R501, with an output of 25 - 150 kV, 40 - 500 mA and 0.01 - 0.3 seconds, having a light beam diaphragm was used as the source of radiation, while the Lithium Fluoride thermoluminescent chips were used for recording transmitted doses as absorbed by the chips - therein read as absorbed doses (Gangadharan et al., 1986; Kitis et al., 1993).

Different concentrations of bilirubin ranging from 1.5mg/100ml to 10.5mg/100ml, and corresponding to the approximate range of serum bilirubin levels in the different body compartments were prepared by dissolving weighed quantities of bilirubin powder in distilled water. The concentrations were expressed in μmol/L. The flasks were each labelled with the respective concentration and a control with distilled water only, set up.

Each of the concentrations was exposed to x-ray irradiation of dose equivalent 0.01668μSv and doses transmitted by the various concentrations and absorbed by the Lithium Fluoride chips were read off with a vinten Solaro dual channel TLD reader, model 680. The reader was operating at 160ºC preheating temperature for 10 seconds, 300ºC for 12 and 10 seconds read and annealed temperatures respectively. The dose absorbed by each of the different bilirubin concentrations was computed as follows for normal incidence with negligible reflection.

\[
\text{Dose absorbed} = \text{Incident radiation dose} - \text{Dose transmitted (TLD reading)}.
\]

A plot of absorbed dose equivalent against bilirubin concentration was obtained to establish the relationship between both parameters.

Statistical Analysis

Results obtained were analyzed using Pearson's moment correlation coefficient to test the relationship between the two variables (Snedecor and Cochran, 1967).

RESULTS AND DISCUSSION

Table 1 presents results of the study showing the dose transmitted, dose absorbed and the computed dose absorbed by the bilirubin. At higher bilirubin concentrations (>76μmol/L), there was a strong positive correlation (r = +0.92) between bilirubin concentration and dose absorbed. At low concentrations of bilirubin (25-75μmol/L), there was a decrease in dose absorption, but
Above 75 μmol/L, there was a continuous, though non-uniform increase going up to 179.5 μmol/L, the highest bilirubin concentration used for this work.

The elemental composition of any medium traversed by radiation is an important factor governing the magnitude of interaction that occurs within the medium (McAurish, 1986). By implication every increase in the concentration of bilirubin (increase in elemental composition) should lead to an increase in the attenuation (absorption) of the X-ray beam. Our results show a departure from this theory at low concentrations of bilirubin. There was a marked and continuous decrease in radiation absorbed at concentrations between 25 μmol/L and 75 μmol/L. Beyond 75 μmol/L, there was an increase in absorption. The sudden and unexpected “twist” in absorption suggests that bilirubin at concentrations below 76 μmol/L may display an anomalous absorption characteristic.

Patients whose bilirubin concentrations fall within this range (25-76 μmol/L) may be adjudged “relatively safe” to undergo radiological examination, since a high percentage of the radiation dose in the primary beam is transmitted (Christensen et al., 1978). This may not however imply a low degree of biological damage. Concentrations above 76 μmol/L show a remarkable agreement with McAurish (1986). Increased concentrations led to a continuous increase in the absorbed doses as the concentration rose, suggesting that a greater percentage of the incident beam is absorbed. This may have a serious and grave consequence in the presence of oxygen, of which the body tissues are largely composed. However, since the direct effect of radiation is quantitatively more biologically harmful when compared to the indirect action, (Yarminko, 1988) it is suggested that bilirubin at high concentration may be a possible modifier in radiotherapy owing to its ability to absorb significant proportions of radiation.

When injected into cancerous tissue before radiotherapy, bilirubin may enhance radiation effects on the diseased cells, during treatment. It is suggested from the above that neonates (3 to 14 day old babies) and pregnant women should not be presented for radiodiagnostic examination unless there is no alternative to such an examination since at this age and during gestation, serum bilirubin levels are very high (1.0 to 10 mg/100 ml) according to Eastham (1985).

**CONCLUSION**

Bilirubin concentration displays significant radiation absorption *in vitro*, especially at high concentrations but its radiation absorption characteristics fail to agree with the results of McAurish (1986) as witnessed at lower concentrations.

**REFERENCES**


Christensen, E., Curry, T.S. and Darcey J. E., 1978. An Introduction to Physics and


