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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 absorbe radiation was investigated in vitro in this study. Different concentrations of bilirubin were exposed to a fixed dose equivalent x-ray irradiation from an R501 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 460µmol/L) and beyond, there was an increase in absoption 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 mocrosomal enzyme of the reticiloendothelial system, particularly the liver and spleen, adds a hydroxyl group to the methenyl bridge between two pyrrole rings with concomitant oxidation of ferrous ion-Fe^{2+} to ferric ion- Fe^{3+} (Voet and Voet,1990). 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 (Canter,1989). Serun 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

Tabel 1 Doses of radiation transmitted and absorbed by different concentrations of bilirubin

Bilirubin concentration (µmol/L)	Dose transmitted (µSv)	Dose absorbed by bilirubin (µSv)
25.65	0.0044	0.0112
42.75	0.0066	0.0090
59.85	0.0105	0.0051
76.95	0.0124	0.0032
94.05	0.0113	0.0043
111.15	0.0083	0.0073
128.25	0.0066	0.0090
145.35	0.0050	0.0106
162.45	0.0022	0.0134
179.55	0.0017	0.0139

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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 thermoluminiscent dosemeter 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 thermoluminiscent 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 160°C

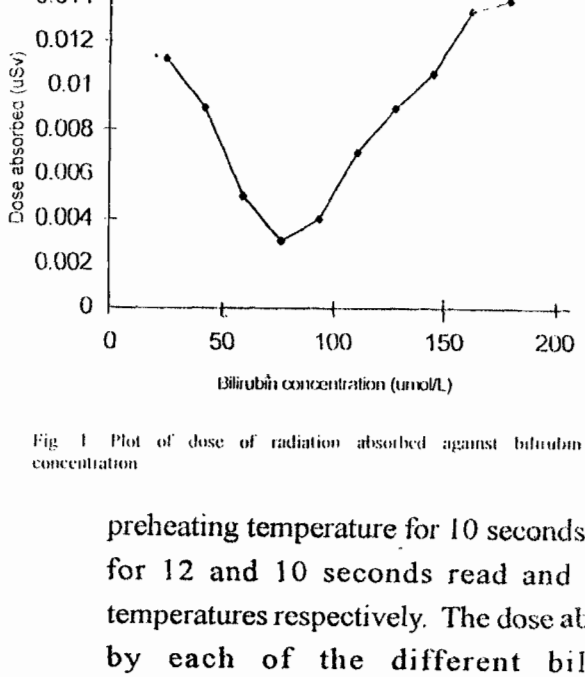

Fig. 1 Plot of dose of radiation absorbed against bilirubin concentration

preheating temperature for 10 seconds, 300 for 12 and 10 seconds read and ann temperatures respectively. The dose absor by each of the different bilirul concentrations was computed as follows fo normal incidence with negligible reflection

Dose absorbed = Incident radiation dose
Dose transmitted (TLD reading).

A plot of absorbed dose equivale against bilirubin concentration was obtained establish the relationship between bo parameters.

Statistical Analysis

Results obtained were analyzed usi Pearson's moment correlation coefficient to t the relationship between the two variabl (Snecdecor and Cochran, 1967).

RESULTS AND DISCUSSION

Table 1 presents results of the study showing t dose transmitted, dose absorbed and the co puted dose absorbed by the bilirubin. At high bilirubin concentrations (>76μmol/L), there w a strong positive correlation (r = +0.92) betwe bilirubin concentration and dose absorbed. low concentrations of bilirubin(25-75μmol/L there was a decrease in dose absorption, b

bove 75µmol/L, there was a continuos, though on uniform increase going up to 179.5µmol/L, e highest bilirubin concentration used for this ork

The elemental composition of any edium traversed by radiation is an important ctor governing the magnitude of interaction that ccurs within the medium (McAurish, 1986). By mplication every increase in the concentration f bilirubin (increase in elemental composition) hould lead to an increase in the attenuation bsorption) of the X -ray beam. Our results how a departure from this theory at low oncentrations of bilirubin. There was a marked nd continuos decrease in radiation absorbed t concentrations between 25µmol/L and 5µmol/L. Beyond 75µmol/L there was an ncrease in asorption. The sudden and nexpected "twist" in absorption suggests that ilirubin at concentrations below 76µmol/L ay display an anomalous absorption haracteristic.

Patients whose bilirubin concentra-ons fall within this range(25 -76µmol/L) ay be adjudged "relatively safe" to undergo adiological examination, since a high ercentage of the radiation dose in the rimary beam is transmitted (Christense et al, 978). This may not however imply a low egree of biological damage. Concentrations bove 76µmol/L show a remarkable greement with McAurish (1986). Increased oncentrations led to a continuous increase n the absorbed doses as the concentration ose, suggesting that a greater percentage of he incident beam is absorbed. This may have serious and grave consequence in the resence of oxygen, of which the body issues are largely composed. However, since he direct effect of radiation is quantitatively nore biologically harmful when compared to the indirect action, (Yarminenko, 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 to 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.

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