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Full Length Research Paper

Calculation of organs radiation dose in cervical carcinoma external irradiation beam using day's methods

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The study was established to measure the amount of radiation outside the treatment field in external beam radiation therapy using day method of dose calculation, the data was collected from 89 patients of cervical carcinoma in order to determine if the dose outside side the irradiation treatment field for spleen, liver, both kidneys, small bowel, large colon, skin within the acceptable limit or not. The cervical field included mainly 4 organs which are bladder, rectum part of small bowel and hip joint these organ received mean dose of (4781.987±281.321), (4736.91±331.8), (4647.64±387.1) and (4745.91±321.11) respectively. The mean dose received by outfield organs was (77.69±15.24cGy) to large colon, (93.079±12.31cGy) to right kidney (80.688±12.644cGy) to skin, (155.86±17.69cGy) to small bowel. This was more significant value noted.

Keywords: Radiation Dose, Cervical Carcinoma, Day's Methods

INTRODUCTION

In 2008 it was estimated that 529 000 incident cases and 275 000 deaths due to carcinoma of the uterine cervix (cervical cancer) occurred annually worldwide. About 88% of this burden is borne by low and middle income countries (LMC) where cervical cancer is the leading malignancy among women (Day, 1950; Eifel et al., 2004). Screening with Pap smear decreases mortality by 70%. The mean age of women diagnosed with cervical intraepithelial neoplasia (CIN) is 15–20 years younger than those diagnosed with invasive disease. ACS recommends screening for all women who are sexually active or >20 years old. Following three normal annual exams after age 30, screening may be performed less frequently, at least once every 3 years (From clinical trials to clinical practice). The associated risk factors: early first intercourse, multiple partners, history of other STD's, high parity, smoking, immunosuppression, and prenatal DES exposure (clear cell CA). With 90-95% of cases is associated with HPV infection. More types 16 and 18 confer the highest risk of SCC and adenocarcinoma, respectively. HPV 6 and 11 are associated with benign warts. 80-90% of invasive tumors are SCC, 10–20% is adenocarcinoma, and 1–2% is clear cell. Preinvasive disease include the ASCUS (2/3 resolve spontaneously. Repeat Pap in 6 months and, if abnormal, perform

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colposcopy), LGSIL, and HGSIL. Prognostic factors include LN metastases, tumor size, stage, uterine extension, and Hgb level <10. With the risk of pelvic LN involvement for stage I, II, and III disease is approximately 15%, 30%, and 45%, respectively (Haie-Meder et al., 2005). Such cancerous disease can be diagnosed by Pap smear if not bleeding. Colposcopy, Cystoscopy, sigmoidoscopy, and/or barium enema for IIB, III, or IVA disease, or for symptoms, Laboratory tests and Imaging with CT/MRI of abdomen and pelvis and CXR. PET scans are sensitive (~85–90%) and specific (~95–100%). If stage IIIB, place renal stent prior to starting chemotherapy (Hansen et al., 2010).

In this realm several calculations is carried out carefully to determine level of doses out the field limits. EBPT is unavoidably associated with irradiation, at lower doses, of large volumes of normal tissue away from the beam path (Jane et al., 2009; Jeffrey et al., 2010; Johnsson et al., 1997; Keys et al., 1997). According to the latest recommendations of (ICRU) concerning the remaining volume at risk (RVR), the search for means of more accurately determining such doses is of renewed clinical interest. Indeed, according to ICRU Report 83 (ICRU 2010), all normal tissues that could potentially be irradiated should be included in the RVR, and the absorbed dose in the RVR might be useful for estimating risk of later effects such as carcinogenesis. In essence, the out-of-field dose arises from three main sources: (1) leakage from the treatment unit; (2) scatter from the treatment unit head and from beam modifiers such as wedges and blocks; and (3) internal scatter originating in the patient. Different scientists estimated the dose to points in the body outside the primary beam. Therefore a generalized model is developed to calculate this dose with reasonable accuracy better than ±30% (Keys et al., 1999; Keys et al., 2003; Kim et al., 2008). Radiation scattered in the patient and the radiation scattered from the collimator exhibit a strong dependence on field size and distance and are predominant only at short distances. At larger distances large amount of leakage with accuracy is better than ±50. Measurement of peripheral dose (PD), for instance, to the gonads, for specific treatment machines and/or techniques. Published data were available for ^{60}CO, 4, 6, 8, and 10 MV, and 18 to 25 for a large verity of treatment machines. Furthermore, an analysis of possible corrections for depth dependence, field elongation, irregularly shaped fields, wedges, and shielding blocks which affect received dose (Landoni et al., 1997). Some occasion when it measurement of dose level outside of field is proves to give radiotherapy to a pregnant patient. Especially at the time when pregnancy has not been confirmed, levels of radiation dose, The Code of Practice for the Protection of Persons against Ionizing Radiations provides that an occupationally exposed female should not receive in excess of 1.3rem, i.e. 0.013Gy, to the abdomen. Thus a maximum occupational exposure of 0.023Gy is "accepted" by the code of practice.

The characterization of the incident photon beam is usually divided into its dependence on collimator setting (head-scatter factor) and off-axis position (primary off-axis ratio) (Howell et al., 2010). These parameters are normally measured "in air" with a build-up cap thick enough to generate full dose build-up at the depth of dose maximum. Unwanted radiation has been measured as a function of the distance outside the primary beam, and field size because this absorbed dose outside the radiation fields is clinically important, potentially affecting cataract formation, gonadal function, and fertility (Rafi et al., 2003). This dose can also be responsible for exposure to the fetus in a pregnant woman, and dose to breast and carcinogenesis may be a concern. Using a locally fabricated water phantom of dimensions 45cm×45cm×30 cm at 5.0 cm depth for horizontal beam. In the present study, a 0.1 cc ion chamber type 23323 in conjunction with a PTW UNIDOS electrometer has been used for dose measurement. Collimator-related radiation dose was about 3 times higher than that from the more modern machine. Therefore the scattered and leakage radiation show a strong dependence on field size and distance to the beam axis and is predominant only at short distances (Mohamed et al., 2012; Morris et al., 1999; Pearcey et al., 2002). In-field radiation doses can be accurately and rapidly calculated using commercially available treatment planning systems (TPSs) (Peters et al., 2000; Rose et al., 1999). These TPSs do not, however, accurately model doses outside the treatment field, nor are they commissioned for such calculations. A recent study evaluated the accuracy with which a commercial TPS calculated absorbed dose in regions where the isodose lines reported by the TPS were less than 5% of the prescribed dose (Rotman et al., 1995; Rotman et al., 2006). Which demonstrated that in this very low stray dose region, the predicted doses were at worst 60% lower than corresponding measured data and that the accuracy of the TPS calculated doses decreased with increasing distance from the treatment field. In CPRT, out-of-field organs are easily defined by their proximity to the field border which is defined by the collimating jaws. Radiation dose measurements in anthropomorphic phantoms are considered the gold standard in peripheral dose assessment and have frequently been used to determine peripheral organ doses in studies of radiation-induced late effects from photon radiotherapy (Stehman et al., 2007). In range of 3.75–11.25 cm from the edge of the treatment field, the TPS underestimated dose by an average of 40% ± 20%. As the distance from the treatment field increased, the TPS underestimated the dose with increasing magnitude. Documents dosage to radiation sensitive organs/structures located outside the radiotherapeutic target volume for four treatment situations: (a) head and neck, (b) brain (pituitary and temporal lobe), (c) breast and (d) pelvis.

MATERIALS AND METHODS

The data of this study was collected from NCI Aljazeera state with patients treated from cervical cancer radically using external radiation therapy. The treatment was delivered using two opposed fields 'anterior and posterior field' encompasses the true pelvis including the cervix, bladder and rectum. As well as uterus, parametrial tissue, part of small bowel and hip joint. The data were collected from the patient included the field sizes, AP separation, lateral separation, tumor dose, patient weight, height, given dose, Then from the patient CT images the distance from the field border with antro-posterior and postro-anterior depths of transfers colon, both kidneys, liver, skin depth at certain distance from the field border in addition to small bowel at outfield region, spleen depths and cervix as well were measured. The dose received by these organ from each field was calculated collectively using central dose calculation in respect to its positions from the mid-depth 'separation' of the Anterior and posterior field using day's method outside the field in respect to their arbitrary center.

Day's method for dose calculation outside the irradiated field

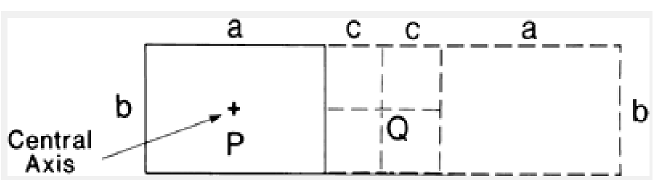

Figure 1. Shows Calculation of depth dose outside a rectangular field

The distances of the critical organs, then the % dose received by the critical were calculated using day's method as follows; suppose *Q* is a point outside the field at a distance *c* from the field border. Imagine a rectangle adjacent to the field such that it contains point *Q* and has dimensions *2c*. Place another rectangle of dimensions *a* *b* on the other side of *Q* such that the field on the right of *Q* is a mirror image of the field on the left, as shown in the figure. The dose at point Q at depth d is then given by subtracting the depth dose at *Q* for field $2c \times b$ from that for field $(2a + 2c) \times b$ and dividing by 2. The procedure is illustrated by the following example. Suppose it is required to determine percent depth dose at *Q* (relative to D_{max} at *P*) outside a 15 ×10 cm field at a distance of 5 cm from the field border. In Fig. 1 then, a = 15, *b* = 10, and *c* = 5. Suppose *Q* is at the center of the middle rectangle of dimensions $2c \times b$. Then the dose D_Q at 10-cm depth is given by: $\frac{1}{2}[D_Q(40 \times 10) - D_Q(10 \times 10)]$

If D_Q is normalized to D_{max} at *P*, one gets the percent depth dose at *Q* or $\%D_Q$.

$$\%D_Q = \frac{1}{BSF(15 \times 15)} \times {}^{1}/_{2}\ [BSF(40 \times 10) \times \%DD(40 \times 10) -$$

Thus for a ^{60}Co beam at $SSD = 80\ cm$,

$$\%D_Q = \frac{1}{(1.052)} \times {}^{1}/_{2}\ [1.054 \times 58.8 - 1.036 \times 55.6] = 2.1$$

RESULTS

Table 1. show (mean ±Std. deviation) of dose (cGy) received by organs outside the radiation treatment field in treatment 50 patient of cervical cancer

Organs	**Min** (cGy)	**Max** (cGy)	**Mean ±Std. Deviation**
Large bowel	48.1	128.5	77.7±15.2
Left kidney	53.8	113.4	74.8±11.6
Liver	44.8	95.7	62±9.6
Right kidney	68.7	137.2	93 ±12.3
Skin	51.9	119.7	80.7±12.6
Small bowel	117.5	210.6	155.9±17.7
Spleen	42.1	87.3	56.9±7.5

Table 2. Shows Mean ±Std. Deviation of the parameters used in dose calculation for cervical cancer Patient weight is 61.3±12.2, height 163.3±6.8, given dose 8409.5±600.1 and patient separation was 18.9±1.6

Organ	**AP depth** (cm)	**PA depth** (cm)	**Distance from field border**(cm)
Small bowel	5.7±0.35	13.22±1.244	6.384±0.117
Large colon	2.95±1.033	16.84±0.88	13.6±1.57
Liver	10.64±.398	8.28±1.19	16.96±1.31
Spleen	11.3±1.42	7.584±0.17	18.07±0.67
Skin	18.176±1.2	14.8±0.16	2.00±.000
Left kidney	11.16±1.28	7.79±0.321	14.44±1.25
Right kidney	11.8±1.3	7.2±0.28	11.6±0.9

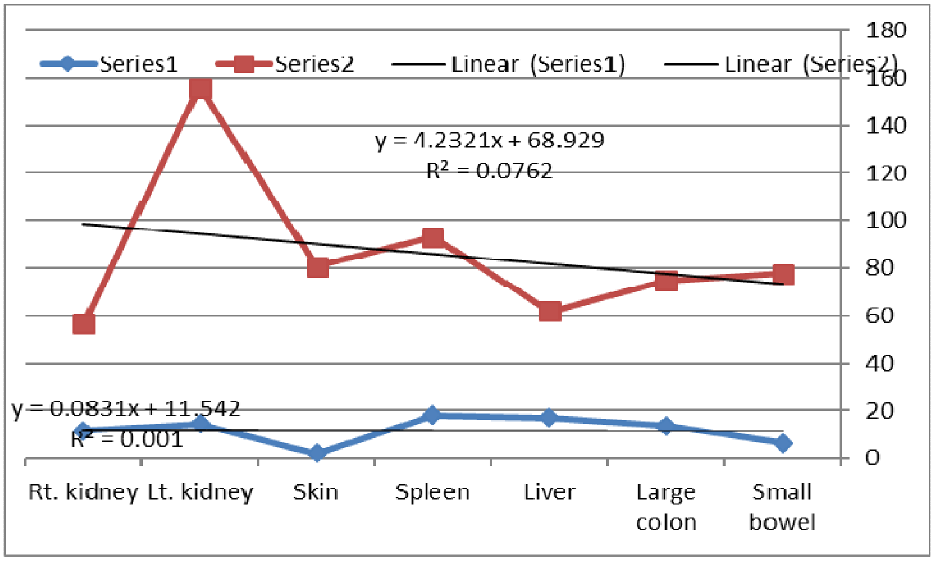

Figure 2. An illustration of radiation map created for doses received by organ inside and outside field margin of cervical cancer as distance from it measured by cm (arrowed).

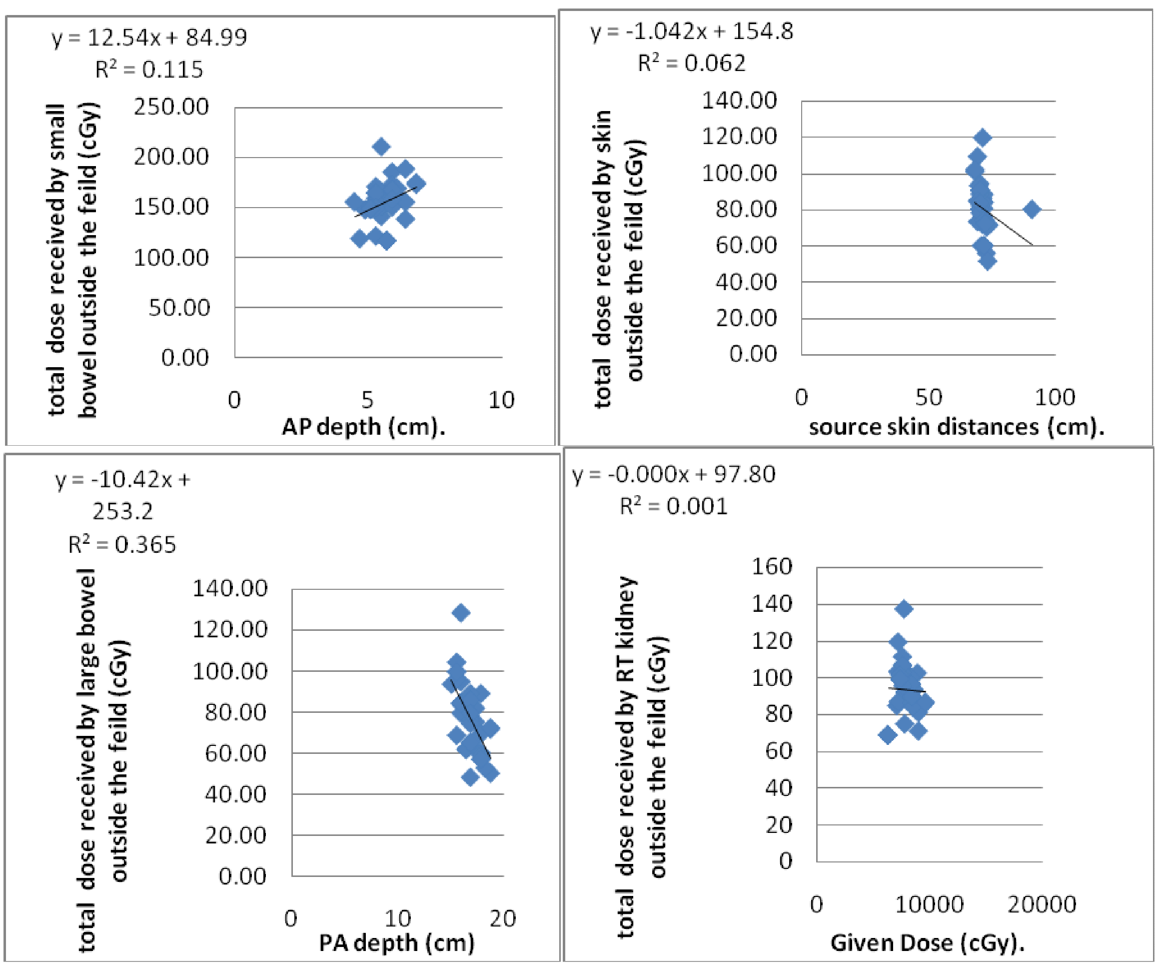

Figure 3. A, B, C, D, E Shows total dose received by small bowel, skin, large bowel and Right kidney.

CONCLUSION

The study were established to measurement the amount of radiation outside the treatment field in external beam radiation therapy using day method of dose calculation, the data were collected from 89 patients of cervical carcinoma in order to determine if the dose outside side the irradiation treatment field for spleen, liver, both kidneys, small bowel, large colon, skin within the acceptable limit or not. The method for assessing organ doses throughout the body from photon radiotherapy described here can be used in studies that require accurate knowledge of a wide range of doses from both primary and scatter radiation, especially the scatter radiation which it is contribution consider to be very critical issue in EBRT, so the quality assurance test should be carried out to assess the amount of leakage radiation and scatter radiation outside of definite field size to determine if desirable radiotherapy dose distribution and calculation design for specific treatment field can delivered the radiation with high therapeutic ratio. Such broad information will be of particular use in studies of radiation-induced late effects, which require accurate knowledge of doses to in-field, out of-field and partially in-field organs to predict the risk to organs throughout the body.

The mean dose received by outfield organs was (77.69 ± 15.24cGy) to large colon, (93.079 ± 12.31cGy) to right kidney (80.688±12.644cGy) to skin, (155.86±17.69cGy) to small bowel. This was more significant value noted.

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