IOSR Journal of Applied Physics (IOSR-JAP)
e-ISSN: 2278-4861.Volume 10, Issue 3 Ver. I (May. – June. 2018), PP 20-27
www.iosrjournals.org

Determination of the Radiation Dose outside the Target Volume in Radiotherapy

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Abstract: - *Radiotherapy is the treatment of cancer patients by the use of radiation doses, during and after the treatment there is a side effect appears on patients. It is also used to treat a wide variety of conditions, but mainly to treat malignant diseases or cancer all over the world. In external beam radiotherapy, doses outside the treated volume is very important when organs at risk(OAR) with very low dose limits are involved, These organs are very sensitive to radiation and can completely loss its function and completely damaged if they received radiation dose larger than their limits or tolerances, for example the gonads in a patient treated from any type of tumors in pelvis region, the eyes lenses in head and neck tumors, the healthy breast tissues in case of breast cancer, the heart in case of left breast treatment and the embryo in case of pregnant woman. It is of extreme importance to determine the peripheral dose (PD) down to a level of 0.1% of the central axis maximum dose (Dmax) [1] and its determination has been PDs the subject of extensive investigation [2, 3, 4].*

The peripheral doses (PDs) are the peripheral doses (PDs) are the doses of ionizing radiation which absorbed in patient tissues/ organs at any point outside the treatment field size during the treatment course. From the other hand we must know the value of the peripheral doses when we deal with tissues/organs of low tolerances of radiation.

Detailed knowledge of magnitude and spatial distribution of the peripheral dose may be necessary [5]. Doses outside the irradiated volume cannot be ignored by the medical physicist and there are a multiple sources of it such these scattered radiations from the collimation system, shielding of radiation generator and the body of the patient who received radiation session. Scattered radiation to organs at risk deserves great attention during radiotherapy especially when the concern is about fertility [6]. The aims of this paper are accurately measure the radiation doses outside the treatment target volume in external beam radiation therapy related to the field size, the depth, the energy of the photon beam and the distance from edge of the radiation field using linear accelerator Dmax, PTW 30013 Ionization chamber and PTW UNIDOS E electrometer. And discuss the factors which affect peripheral doses increasing and decreasing.

Results*: knowledge of peripheral doses magnitude in details and its distribution away from treatment field border and the applicability of reduce these doses by professional choice of plan field's arrangement and treatment delivery method. The peripheral doses are decreasing with decreasing of the field size, the beam energy and the treatment time. It is very important for reduce dose outside the target volume to choice the treatment type and the accelerator model.*

Conclusions: *with proper choice of the accelerator model, treatment type, beam quality and field size we can achieve the goal of reducing the radiation dose outside the target volume (radiation protection) in radiotherapy.*

Date of Submission: 26-04-2018 Date of acceptance: 16-05-2018

I. Introduction

Radiotherapy is the treatment of cancer patients by the use of radiation doses. Around 52% of patients should receive radiotherapy at least once during the treatment of their cancer. During the treatment course cancer patients can take the radiation treatment course after or before surgery and chemotherapy it has an important step in treatment, 40% of those patients who are cured of their cancer [7].

Organs at risk (OAR) are very sensitive to radiation and can completely loss its function and completely damaged if they received radiation dose larger than their limits or tolerances, for example the gonads in a patient treated from any type of tumors in pelvis region, the eyes lenses in head and neck tumors, the healthy breast tissues in case of breast cancer, the heart in case of left breast treatment and the embryo in case of pregnant woman. It is of extreme importance to calculate the PD down to a level of 0.1% of the central axis maximum dose (dmax) [1] and its determination has been PDs the subject of extensive investigation [1, 4]. Diallo et al. found that 12% of second cancers occurred within the treated volume, 66% occurred at the periphery of the treated volume (within 5 cm of the field edge), and 22% occurred more than 5 cm away from the treated volume, although this was not limited to radiation-induced second cancers [8].

The peripheral doses (PDs) are the doses of ionizing radiation which absorbed in patient tissues/ organs at any point outside the treatment field size during the treatment course. From the other hand we must know the value of the peripheral doses when we deal with tissues/organs of low tolerances of radiation. Knowlegment of peripheral doses distribution outside the irradiated volume is very important when we deal with high sensitive organs to radiation. The peripheral dose can also be responsible for exposure to the fetus in a pregnant woman, and dose to breast and other tissues for which radiation induced carcinogenesis may be concern [9]. Children are several times more sensitive to radiation-induced cancers than adults, although the specifics of this sensitivity can vary among organs. The thyroid and female breast, for example, are very sensitive to radiation-induced cancer in young patients, but by late adulthood are relatively insensitive to radiation [10, 11].

The cure rates of cancer tumor patients who's treated with high modern technology of radiotherapy increase, this is true but in the treatment course by different models of linear accelerators, few centimeter away from the treatment fields edges ,there is a small fraction of prescribed dose to the planning target volume is absorbed. These doses have a lot of description such out-of-field doses, outside field border doses which contain of three main parts, scatter form linac collimation system, scatter from the body of the patient and leakage radiation from the head of treatment machine(linac).

We must looking for patient safety first before taking the decision of treatment and make a comparison between the benefits of treatment and the danger of patient death. Before radiation treatment course started there is an important steps would be made, the important step is delineate of the cancer mass and surrounding healthy tissues. In these day the physicians can use the Dicom CT cuts to delineate the gross tumor volume (GTV), which consists of all clinically macroscopic disease, including what is visible on imaging modalities [12,13]. After GTV delineation we must add a margin related to the microscopic disease this margin called clinical target volume (CTV), then we must add a second margin because of the patient set-up errors this margin called the planning target volume (PTV).Doctors can participate in the reducing of peripheral doses to the organs at risk from radiation by reducing the size of the clinical target volume and the planning target volume. This reducing in CTV and PTV will make the sensitive organ to radiation in the safe region. The reduced high-dose volume is particularly relevant when second cancers are of concern because of the high incidence of second cancers in high-dose regions [14]. The successful of the treatment course not depend on only the physician but depend on the radiotherapy department stuff by carful Patient set-up during treatment sessions and take a portal film images three times in week to make sure that the patient lie in the correct position of treatment. In our center daily about 120 patient received radiation sessions five day per week and the therapists play an important role of observing the side effects which arise on the patient after he received some radiation sessions, then the therapist inform the physician about these side effects to back to the physicist to change the beams arrangement or find with physician side effects causes and try to find a solution.

The aims of this paper are accurately measure the radiation doses outside the treatment target volume in external beam radiation therapy as function of the field size, the depth, the energy of the photon beam and the distance from edge of the radiation field using linear accelerator Dmax, PTW 30013 Ionization chamber and PTW UNIDOS E electrometer. And discuss the factors which affect peripheral doses increasing and decreasing.

II. Material and methods

Materials: The experimental study of this paper was carefully performed in the Armed Forces oncology center of Assiut governorate at the department of radiation therapy in physics section, where all measurements were made with 6 MV and 15 MV photon beams of VARIAN DMAX – DC 2003 linear accelerator. PTW UNIDOS E dosimeter, 30013 Farmer chamber with 0.6 cc designed for use with PTW dosimeter and PTW Acrylic slab phantom type 2967 consists of 33 acrylic plates with the dimensions of 30 cm x 30 cm.

Connection cable for the total length of up to 100m was used between the chamber and the electrometer. Parometer model OPUS10 TPR for temperature and pressure reading inside the treatment room.

All measurements were taken under the following conditions:

- Temperature 22.8 c.
- Pressure 1010.2 hpa.
- Source to surface distance (SSD = 100cm).
- Machine unit (MU = 100).
- Dose rate 300.

Method: Measurements were made in Acrylic slab phantom type 2967 consists of 33 acrylic plates with the dimensions of 30 cm x 30 cm. First we connect the gas filled ionization chamber (0.6 cc waterproof Farmer type) to PTW UNIDOS E dosimeter by the connection cable of 100m length, then we put Acrylic slab phantom on the linac couch top and By combining slab phantom plates of different thicknesses, measurements in any depth of up to 30 cm can be made. Second we adjust the source to surface distance (SSD) to be 100 cm and put the ion chamber inside the plate of slab phantom designed for it, to get the peripheral doses of (5×5, 10×10 and 20×20 cm2) square field sizes at Dmax, 5cm and 10 cm depth for linear accelerator photon energies (6 MV and 15 MV) for the lateral distances of the geometric field size (2 to 30 cm). The readings taking from PTW UNIDOS E screen.

In our study we determine in detailed the radiation doses outside the target volume for 6 MV, 15 MV photon beam at different Field sizes of (5x5cm2, 10x10 cm2 and 20x20 cm2) and different depths of (Dmax, 5 cm, 10cm).The depth of dose maximum for 6 MV, 15 MV photon beam is 1.6 cm, 3 cm respectively.

All measurements were taken under the following conditions:
- Temperature 22.8 c.
- Pressure 1010.2 hpa.
- Source to surface distance (SSD = 100cm).
- Machine unit (MU = 100).
- Dose rate 300.
- 4D console is in standby mode.
- MlC of linac is retractable.
- The correction factors for temperature and pressure are added.

III. Results

In our study we determine in detailed the radiation doses outside the target volume for 6 MV, 15 MV photon beam at different Field sizes of (5x5cm2, 10x10 cm2 and 20x20 cm2) and different depths of (Dmax, 5 cm, 10cm).The depth of dose maximum for 6 MV, 15 MV photon beam is 1.6 cm, 3 cm respectively.

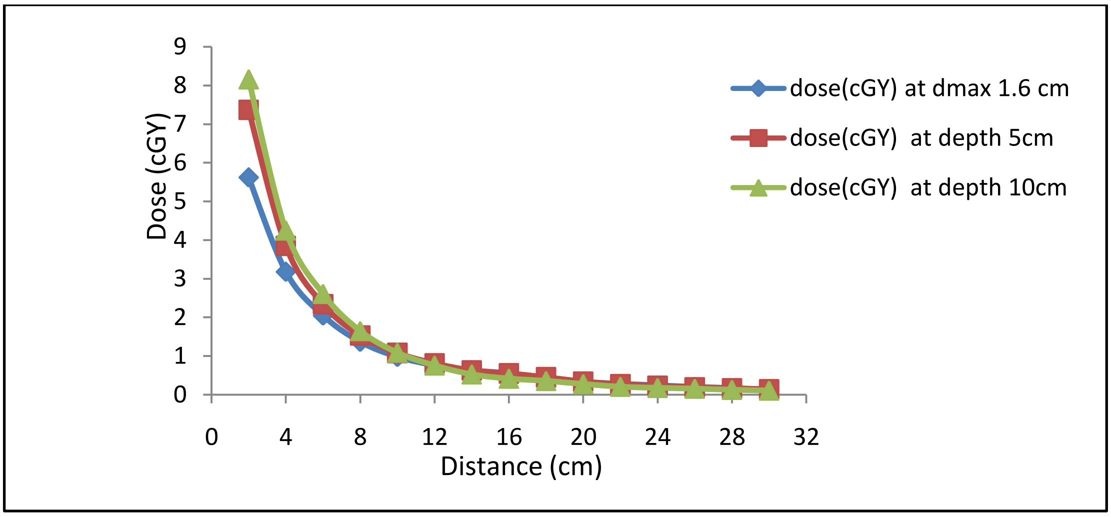

Fig 1: Effect of depth on peripheral dose for 6 MV Photon beam for field size 10cm x 10cm at depth of (dmax, 5cm, 10cm).

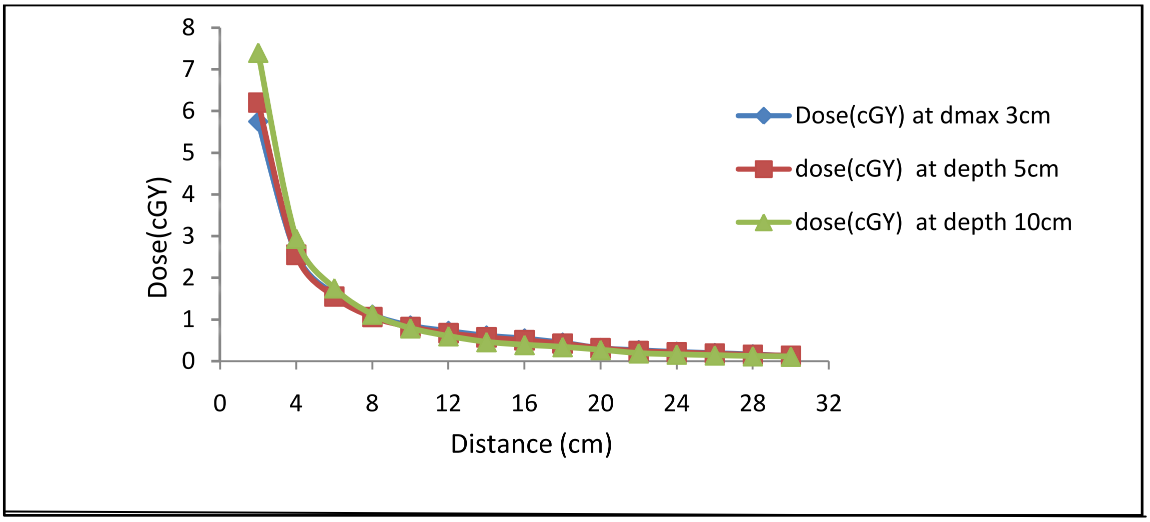

Fig 2: Effect of depth on peripheral dose for 15 MV photon beam for field size 10cm x 10cm at depth of (dmax, 5cm, 10cm).

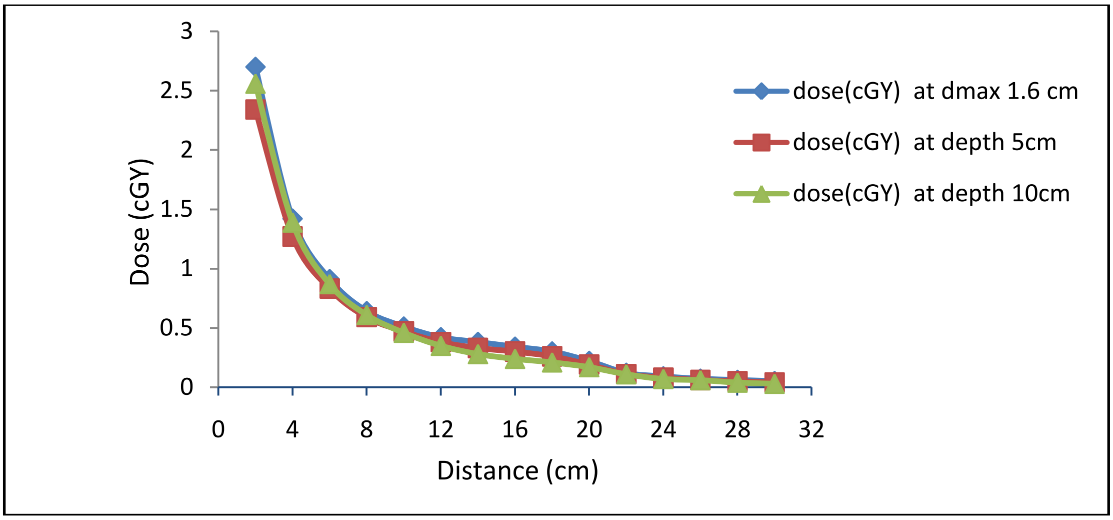

Fig3: Effect of depth on peripheral dose for 6 MV photon beam for field size 5cm x 5cm at depth of (dmax, 5cm, 10cm).

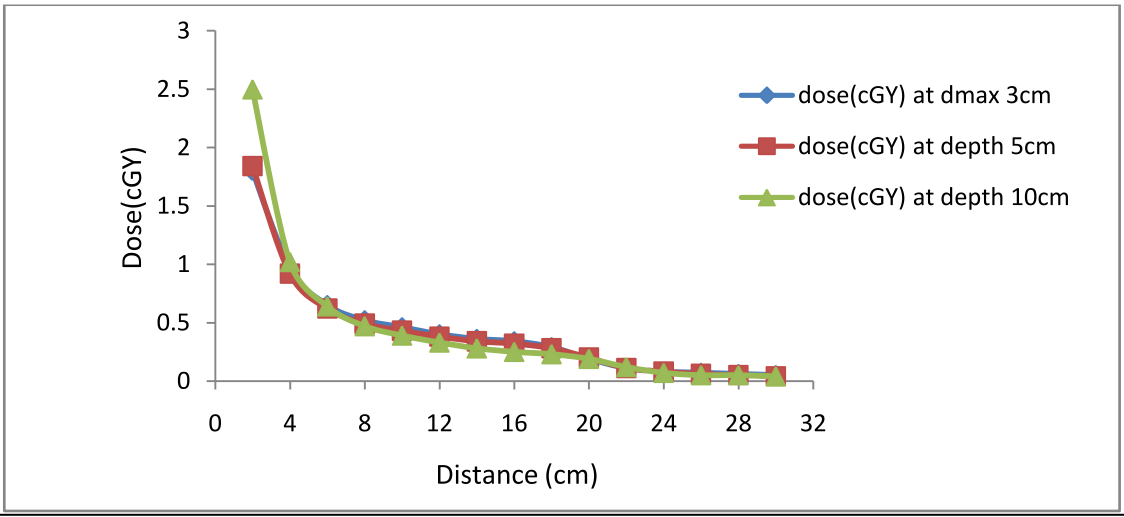

Fig4: Effect of depth on peripheral dose for 15 MV photon beam for field size 5cm x 5cm at depth of (dmax, 5cm, 10cm).

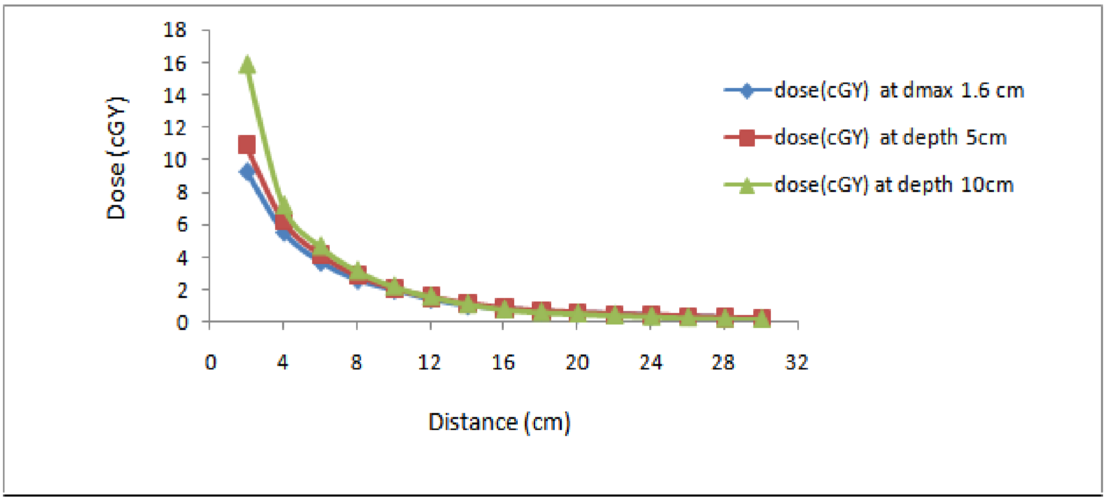

Fig5: Effect of depth on peripheral dose for 6 MV photon beam for field size 20cm x 20cm at depth of (dmax, 5cm, 10cm).

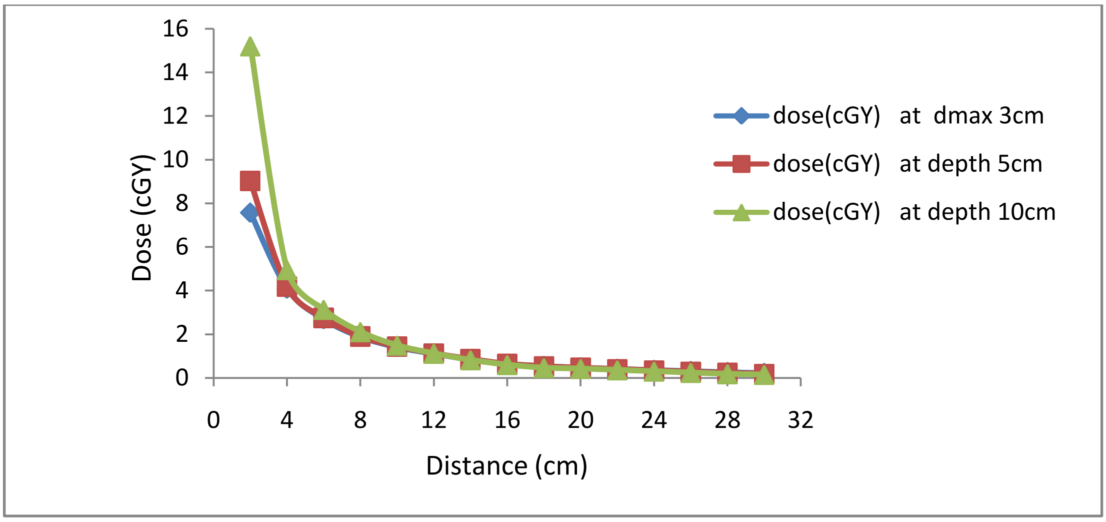

Fig6: Effect of depth on peripheral dose for 15 MVphoton beam for field size 20cm x 20cm at depth of (dmax, 5cm, 10cm).

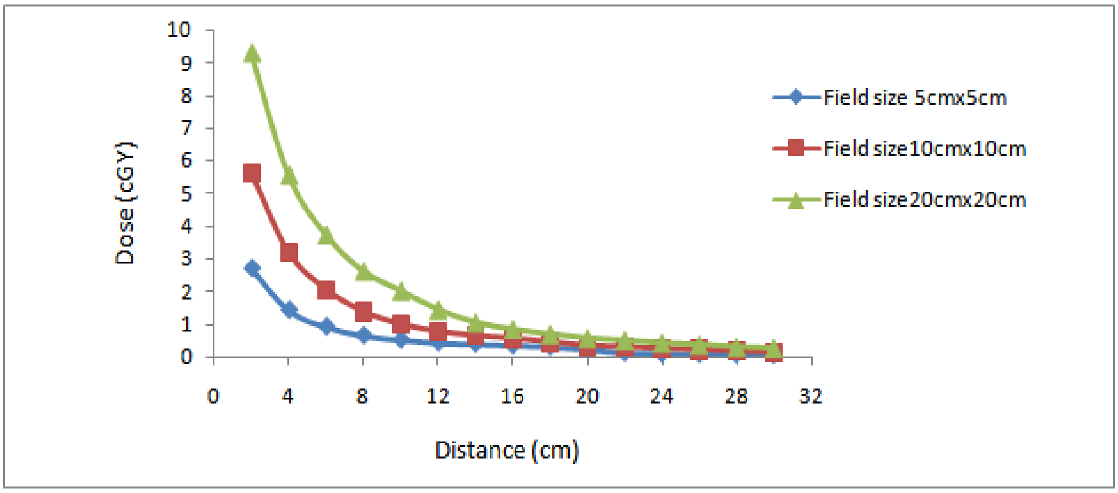

Fig7: Effect of field size on Dose outside the treatment field for Energy 6 MV photon beam at Dmax.

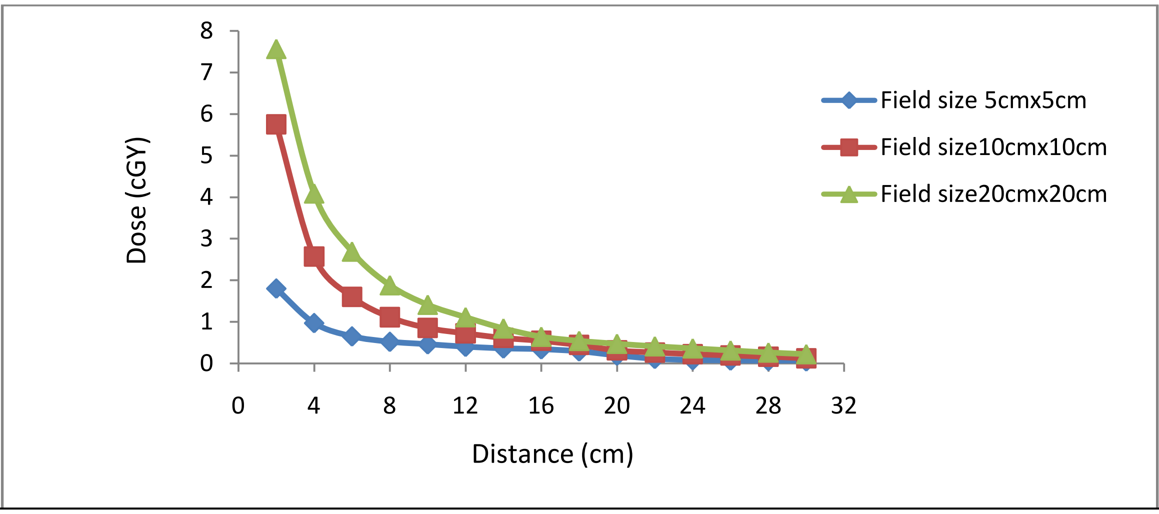

Fig8: Effect of field size on Dose outside the treatment field for Energy 15 MV photon beam at **Dmax**.

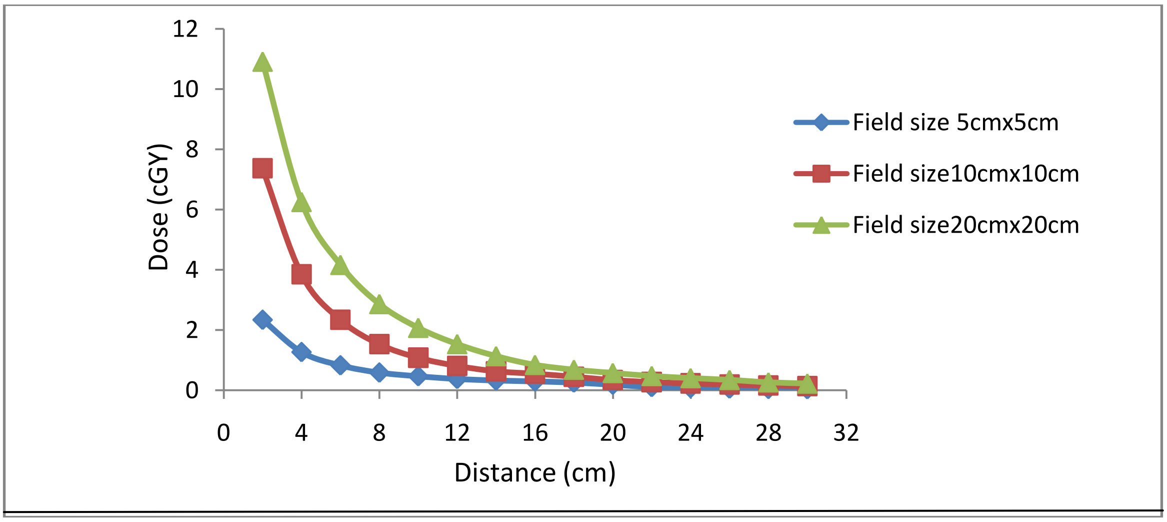

Fig9: Effect of field size on Dose outside the treatment field for Energy 6 MV beam at depth 5cm.

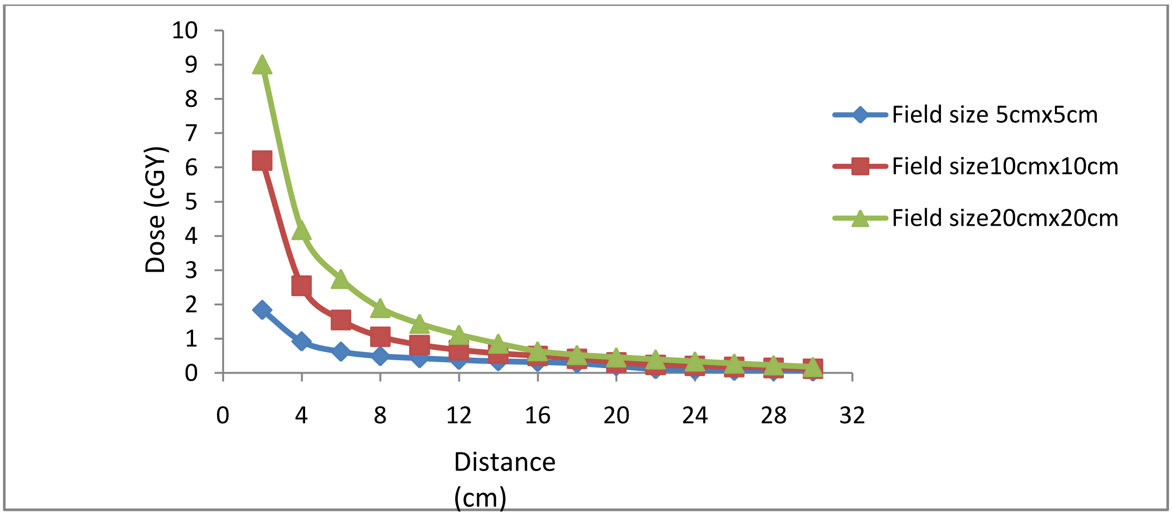

Fig10: Effect of field size on Dose outside the treatment field for Energy 15 MV photon beam at depth 5cm.

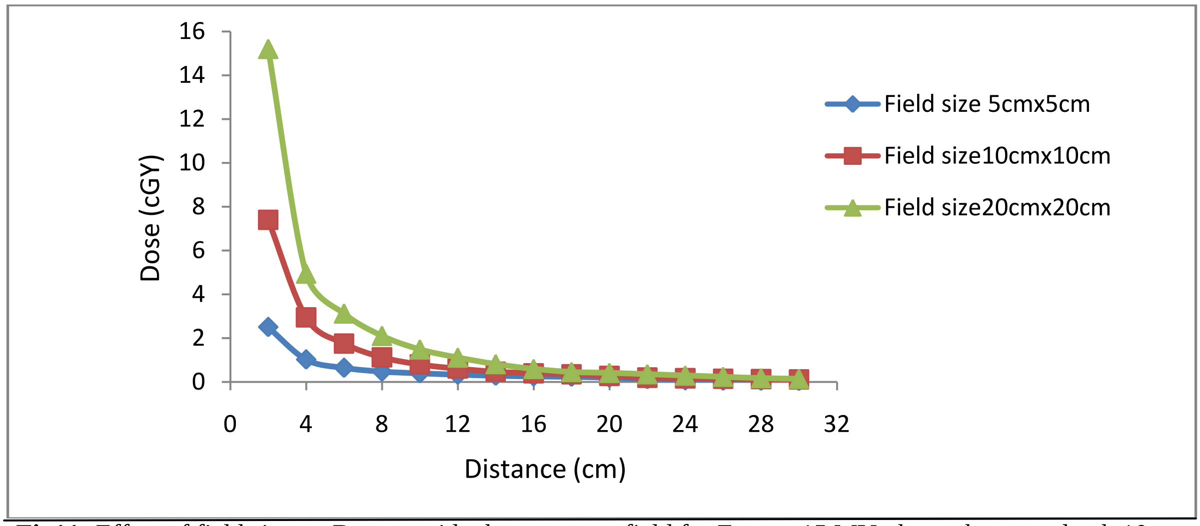

Fig11: Effect of field size on Dose outside the treatment field for Energy 15 MV photon beam at depth 10cm.

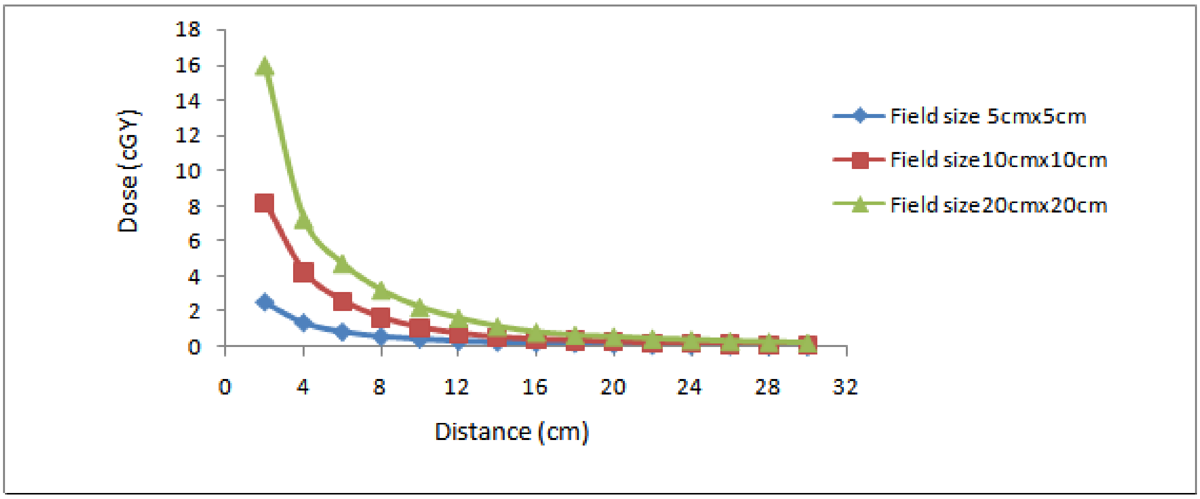

Fig12: Effect of field size on Dose outside the treatment field for Energy 6 MV photon beam at depth 10cm.

IV. Conclusions

The larger field sizes have been shown to result in a high magnitude of radiation doses outside volume targeted near to field size border of the useful primary beam because of the volume scattering increase, and then the magnitude of these doses at the large distance far from the field border be low, this make me sure that these radiation doses coming from linac head leakage and scattering from the collimation system 30 cm from the border of the field of the primary beam. Radiation doses outside the primary beam treatment field are high close to phantom surface and at the depth of dose maximum it reach a minimum value and then at depth larger than Dmax become constant. Forward scattering of low energy photon beams is less than high energy photon beams so we note that peripheral doses for low energy photon beams are is high.

We noted that for the value of determine peripheral doses outside the primary beam field size is decrease with increasing of the distance away from the field size edge. Finally With proper choice of the accelerator model, treatment type, beam quality and field size we can achieve the goal of reducing value of the radiation doses outside the treated volume and safe patient organs/tissues from radiation side effects (radiation protection) in radiotherapy.

References

[1]. Reissland JA. BEIR III 'The effects on populations of exposure to low levels of ionising radiation'. J Soc Radiol Prot. 1981;1:17–22.
[2]. van der Giessen PH. Peridose, a software program to calculate the dose outside the primary beam in radiation therapy. Radiother Oncol. 2001;58:209–213.
[3]. Francois P, Beurtheret C, Dutreix A. Calculation of the dose delivered to organs outside the radiation beams. Med Phys. 1988;15:879–883
[4]. Fraass BA, van de Geijn J. Peripheral dose from megavolt beams. Med Phys. 1983;10:809–818.

[5]. Brian J. McParland, Heather I. Fair. 1992. A method of calculating peripheral dose distributions of photon beams below 10 MV. Med. Phys. 1992, Vol. 19, 2, pp. 283-293.
[6]. Journal of the Egyptian National Cancer Institute (2014) 26, 99–101.
[7]. The Swedish Council on Technology Assessment in Health Care (SBU). Systematic Overview of Radiotherapy for Cancer including a Prospective Survey of Radiotherapy Practice in Sweden 2001 – Summary and Conclusions. Acta Oncologica, 2003, 42:357–365.
[8]. Diallo I, Haddy N, Adjadj E, et al. Frequency distribution of second solid cancer locations in relation to the irradiated volume among 115 patients treated for childhood cancer. Int J Radiat Oncol. 2009;74:876–883.
[9]. Antypas C, Sandilos P, Kouvaris J, Balafouta E, Karinou E, Kollaros N, Vlahos L (1998) Fetal dose evalua_on during breast cancer radiotherapy. Int J Radia_on Oncology Biol Phys, 40(4): 995-999.
[10]. Cardis E, Krewski D, Boniol M, et al. Estimates of the cancer burden in Europe from radioactive fallout from the chernobyl accident. Int J Cancer. 2006;119:1224–1235.
[11]. Stovall M, Smith SA, Langholz BM, et al. Dose to the contralateral breast from radiotherapy and risk of second primary breast cancer in the WECARE study. Int J Radiat Oncol. 2008;72:1021–1030.
[12]. ICRU report 50: Prescribing, recording, and reporting photon beam therapy. Bethesda, MD: International Commission on Radiation Units and Measurements; 1993.
[13]. ICRU report 62: Prescribing, recording, and reporting photon beam therapy (Supplement to ICRU report 50). Bethesda, MD: International Commission on Radiation Units and Measurements; 1999.
[14]. Kry, Stephen F., et al. "AAPM TG 158: Measurement and calculation of doses outside the treated volume from external- beam radiation therapy." Medical physics (2017)

IOSR Journal of Applied Physics (IOSR-JAP) is UGC approved Journal with Sl. No. 5010, Journal no. 49054.

Ahmed.H.Abotaleb "Determination of the Radiation Dose outside the Target Volume in Radiotherapy.” IOSR Journal of Applied Physics (IOSR-JAP) , vol. 10, no. 3, 2018, pp. 20-27.