Study of dose distribution in high energy photon beam used in radiotherapy

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The dose distribution in a medium traversed by a photon beam depends on beam energy, field size and medium nature. Percent depth dose (PDD), Dose Profile (DP) and Opening Collimator Factor (OCF) curves will be established to study this distribution. So, the PDD curves are composed by tree parts: the build-up region, the maximal dose and the quasi – equilibrium region. The maximum dose depth and the dose in depth increase with increasing photon beam energy but the dose surface decreases. The PDD increases with increasing field size.

1. INTRODUCTION

The dose distribution in a medium traversed by a photon for the recommended beam depends on beam energy, field size and medium nature. For the energy considered in radiotherapy, Compton Effect is the main interaction in tissue**.**

The main work is to study the dose distribution in a medium irradiated by a high energy X-Ray photon with an ionization chamber calibrated. Percent depth dose (PDD), Dose Profile (DP) and Opening Collimator Factor (OCF) curves will be established to study this distribution.

Six and twenty megavolt photon beam and different field size will be used to evaluate the energy and geometrical parameters influence on the dose distribution in the medium.

2. MATERIAL AND METHOD

2.1. Method

To follow in continuous the ionization on the central beam axis and the variation of dose profile, measure will be realized in a water phantom with an explorer beam on which fixed two ionization chambers. The first ionization chamber moving is used for measure and the second (reference ionization chamber) fixed, placed in beam size, serve to correct the first ionization chamber measures by fluency variation of primary beam (pulsed photon beam).

To study the energy and geometrical parameters on the dose distribution in de medium, we will make vary the field size, the Source Skin Distance (SSD) and the photon beam energy. The influence of these parameters will be evaluated by the measure of PDD and DP [1] [2].

According to the dosimetry protocol in International Atomic Energy Agency (IAEA), Technical Reports Series (TRS) n°277 [3], the absorbed dose is defined by:

$$D_{eau,Q} = \overline{L_Q^C} \cdot N_{Dair,Qo} \cdot S_{eau,air,Q} \cdot p_u \cdot p_{cel} \cdot p_{dis} \quad (1)$$

With:

$\overline{L_Q^C}$: non corrected measure

$N_{Dair,Qo}$: absorbed dose to air calibration factor

$S_{eau,air,Q}$: stopping – power ratio water to air

p_u : factor to allow for non – water equivalence of the ionisation chamber

p_{cel} : factor to take account of non - air equivalence of the material in the central electrode of an ionization chamber

p_{dis} : factor that accounts for the effect of replacing a volume of water with the detector cavity when the reference point of the chamber is taken to be at the chamber centre

The absorbed dose to water varies with the energy because S and p_u vary with the energy.

For a photon beam which traverse a medium, the fluency decrease with increasing the depth but its energy stay practically constant. So, for a photon beam, the PDD curve in ionization merge with the PDD curve in dose.

2.2. Used material

- One linear accelerator: VARIAN CLINAC 2300 C/D
- Two ionization chambers: Wellhöfer IC10 n°1956 and n°1945
- One electrometer: Wellhöfer
- One beam explorer

2.3. Measured conditions for

- Percent Depth Dose:
  - 6 MV photon beam, 20cm $\times$ 20 cm field size and 100 cm SSD (Source Skin Distance)
  - 20 MV photon beam, 20cm $\times$ 20 cm field size and 100 cm SSD
- Dose Profile:
  - 6 MV photon beam, 20cm $\times$ 20 cm field size, 10 cm depth and 100cm SSD
  - 20 MV photon beam, 20cm $\times$ 20 cm field size,10 cm depth and 100cm SSD
- Opening Collimator Factor:
  - 6 MV photon beam, 5cm x 5cm to 20cm $\times$ 20 cm fields size, 10 cm depth and 100 cm SAD (Source Axis Distance)
  - 20 MV photon beam, 5cm x 5cm to 20cm $\times$ 20 cm fields size, 10 cm depth and 100 cm SAD

3. RESULTS

3.1. Measured of Percent Depth Dose (PDD)

According to the Figure 1:

- the PDD curves are composed by three parts: the build-up region, the maximal dose and the quasi – equilibrium region.

- when the energy increase:

♦ the dose surface decrease because the contribution of retrodiffused electrons decrease

♦ the depth of the dose maximum and the dose in depth increase because the secondary electrons route increase

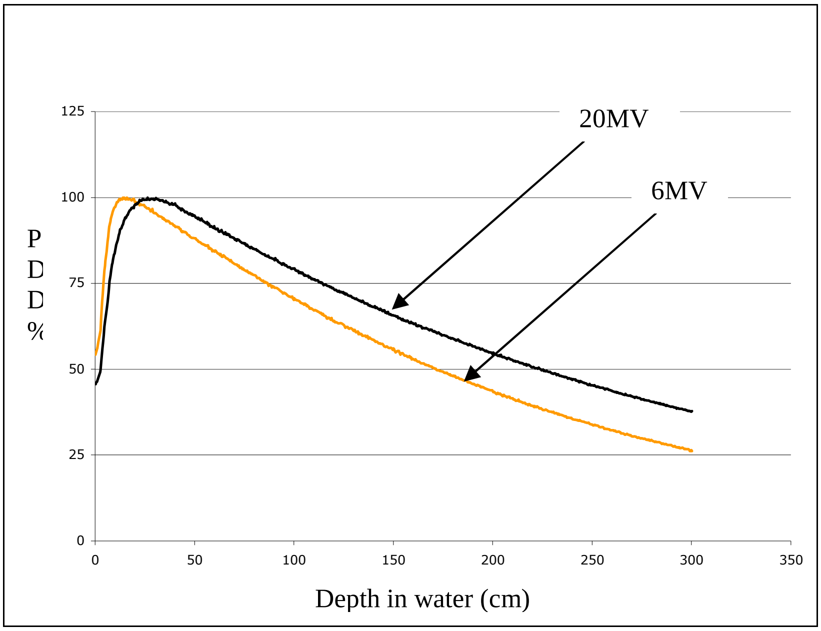

Figure 1: Percent depth dose curve, Skin Source Distance (SSD) 100cm, field size 20cmx20cm

3.2. Measured of Dose Profile (DF)

According to the Figure 2, the lateral distance between 80% and 20% of dose on the beam central axis, called semi-darkness, is the same for 6 and 20MV photon beam.

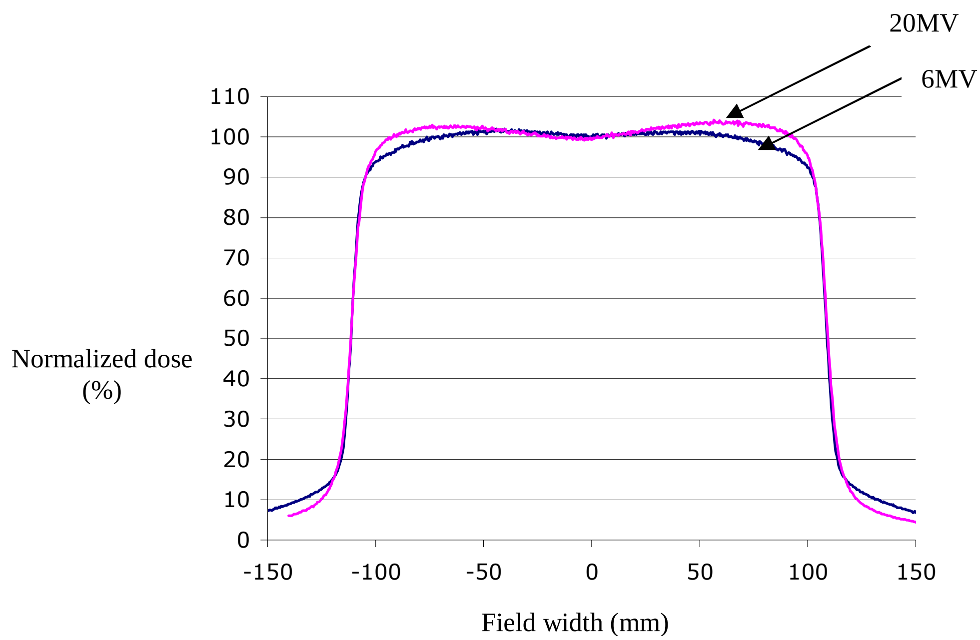

Figure 2: Dose Profile curve, SSD 100cm, field size 20cmx20cm, depth in water 10cm

3.3. Determination of the Opening Collimator Factor (OCF)

To establish the OCF curves, we calculate the ratio of the maximal absorbed dose and the absorbed dose in the reference depth, and then we make varied the field size. Theses curves are normalised to 10cm x 10cm field size. According to the Figure 3, for a given energy, the OFC increase with the field size. So, the dose in the measured point increases with the field size. This increasing is more important for higher photon beam energy.

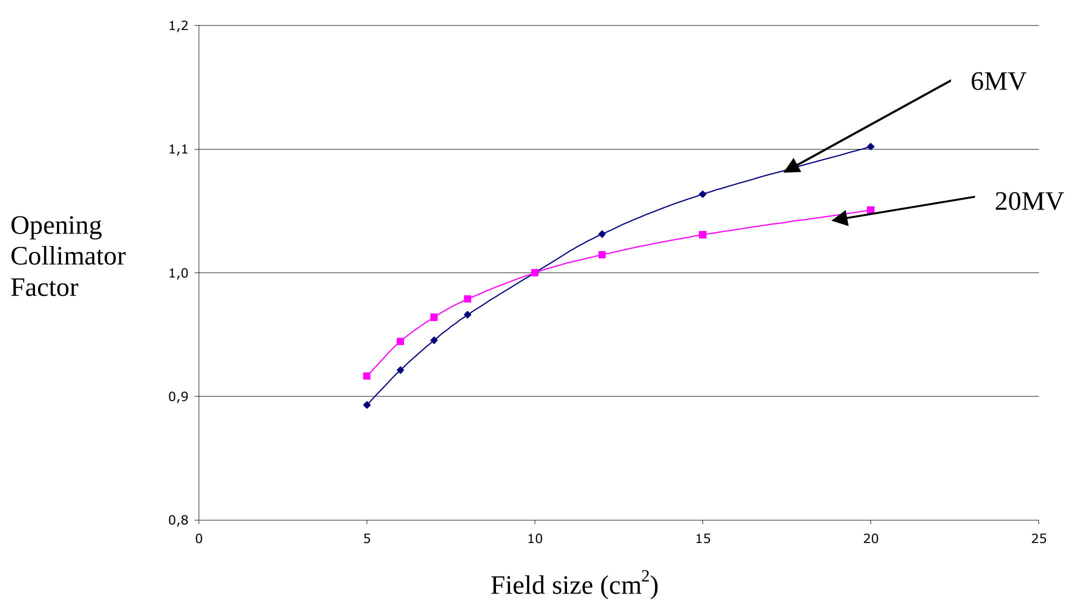

Figure 3: Opening Collimator Factor curve

4. CONCLUSION

The study of photon beam characteristic is necessary before calibration. Knowledge of energy and geometrical influence on different dosimetric parameters is indispensable for absorbed dose calculation.

Ackowledgments

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