The effects of wound dressings on the dose at surface and depth of maximum dose (d_{max}) for photon and electron beam radiotherapy

Raizulnasuha Ab Rashid, Norhayati Dollah, Reduan Abdullah, and Wan Nordiana W. Abd Rahman

Medical Radiation Programme, School of Health Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.

E-mail: wandiana@usm.my

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Abstract: The presence of wound dressing at the patients' skin surface during radiotherapy treatment may potentially alter the dose at surface and shift the dose distribution at depth. In this study, the effects of different types of wound dressing to the radiotherapy treatment were investigated. The dose measurement at surface and d_{max} were done using different energy of photon (6 MV and 10 MV) and electron (6 MeV and 15 MeV) beams at 100 cm source to surface distance (SSD). Markus parallel plate ionization chamber and solid water phantom were used to quantify the dose with the dressing types used are Alderm +Plus, Actisorb Plus 25, Gauze and Duoderm CGF Extra Thin. The results show increment of surface dose up to 93.9% by wet gauze for photon beams and around 21% of dose increase for electron beams. Effects of dressing to the the dose at d_{max} indicate shift of dose distribution towards surface with reduction of dose around 10% in wet condition for photon beams and up to 35% for electron beams. Significant changes in surface dose and dose at d_{max} due to the wound dressing indicate the presence of wound dressing during radiotherapy need to taken in account in calculating dose to the target.

Keywords*: dose at depth, dosimetry, radiotherapy, surface dose, wound dressing*

1. Introduction

Wound dressing is widely utilized to protect wound and skin injuries from bacterial and dust. In radiotherapy, the presence of wound dressing at the surface of the target area can potentially influence the radiation dose distribution. Early attenuation and scattering of the projected beam due to wound dressing can cause increase in skin dose and deviate the expected maximum dose and depth. Implication of the presence of wound dressing during radiotherapy have been investigated by Mac Nally and Woodings[2] suggesting changes in dose distribution occurs depending on the types and thickness of the dressing as well as types of radiation beam and energies used. The conditions of the dressing whether in dry or wet condition also influence the dose. Significant increase in surface dose for photon beam has been observed in the presence of wound dressing especially in wet condition. Study by Benoit et. al.[4] found the most commonly used dressing such as gauze will result in dose alteration. Gauze in wet condition was found to have physical density of 1.02 g/cm^3 which could perform as effectively as commercial bolus, especially for larger treatment fields. In this study, we investigate the effect of different types of wound dressing on surface dose and dose at depth of maximum dose (d_{max}) for clinical photon and electron beams.

2. Materials and methods

This study was conducted using photon and electron beams from medical Linear Accelerator (Siemen Primus Linac model 3347) at Department of Nuclear Medicine, Radiotherapy and Oncology, Hospital Universiti Sains Malaysia.

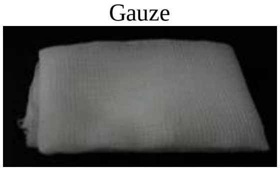
The energy of photon beams used in this study was 6 MV and 10 MV meanwhile for electron beams are 6 MeV and 15 MeV. All measurements were conducted with gantry angle at 0º, fixed field size 10 cm × 10 cm, 100 cm SSD and exposure at 100 monitor unit (MU). Markus® parallel – plate ionization chamber were used for dose measurement in the solid water phantom (30 cm × 30 cm × 15 cm) during irradiation. Dose measurements were carried out with and without the wound dressing, both at surface and at depth of maximum dose (d_{max}). The types and characteristic of wound dressing used in this study are described in Table 1. Similar measurements were repeated for all dressings in dry and wet conditions. The changes of dose due to wound dressing is presented as percentage difference of dose and were calculated as:

$$\% \text{ Dose differences} = [\text{Dose with dressing } (D_2) - \text{Dose without dressing } (D_1)] \times 100\ \% \quad (1)$$

3. Results and discussion

Figure 1 shows the percentage dose difference for 6 MV and 10 MV photon beams for all types of dressing in both dry and wet conditions. The most significant percentage differences presented by gauze in the range from 35.7% - 92.7% in both energies and conditions tested. Alderm $^{+}$Plus show percentage differences from 48.9% to 93.3% in wet condition while less significant result showed in dry condition with percentage differences around 10%. Duoderm and Actisorb show less than 30% percentage differences. Figure 2 shows the percentage differences in surface dose obtained for electron energies. Results indicate less effects of wound dressing to the surface dose for electron beam as compare to photon beam. All dressing shows percentage differences in the range between 2.6% to 21%. Percentage differences are more prominent for gauze in wet conditions which suggest obvious dose increase due to wet condition.

Table 1. The types and characteristic of wound dressing used.

Type of Dressings	Physical and Composition	Size (cm^2)	Thickness (mm)
Alderm $^{+}$Plus 	Latex-free hypoallergenic adhesive of dressing & wrapper.	8.8 × 9.5	1.03
Actisorb Plus 25 	Activated charcoal impregnated with silver, inside a spun bonded nylon sleeve	10.5 × 10.7	0.14
Gauze 	Cotton	7 × 8	8.15
Duoderm CGF Extra Thin 	Unique gelling (hydrocolloid)	10.3 × 10.3	0.12

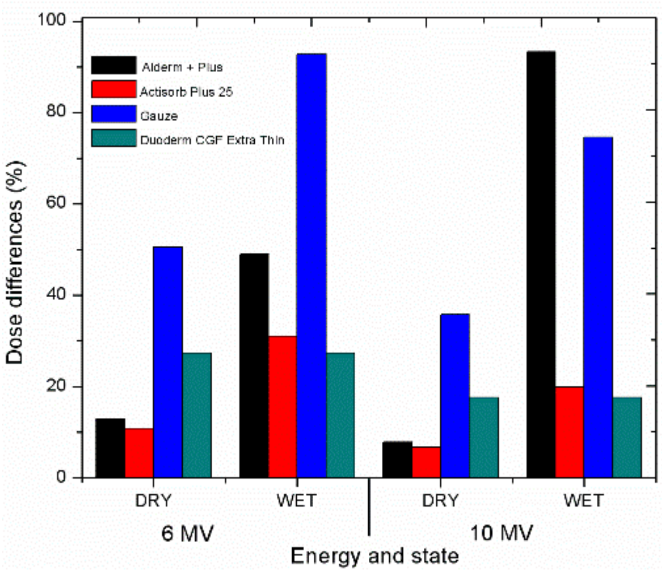


Figure 1. Percentage dose differences of dose at surface for photon beams.

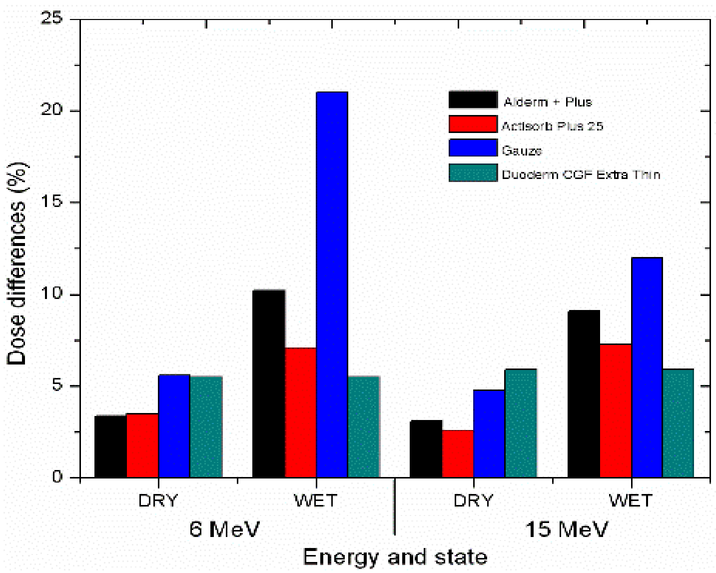


Figure 2. Percentage dose differences of dose at surface for electron beams.

Percentage dose differences measured for dose at d_{max} is presented in Figure 3 and Figure 4 for photon and electron beams respectively. Decrement of dose were observed for 6 MV beam with mostly visualized by Alderm dressing with -0.03% in dry condition and -9.6% in wet condition. Gauze dressing only showed -0.1% decrement in dry condition and -11.5% in wet condition. Actisorbs' percentage dose differences is around -0.5% in dry condition and -10.1% in wet condition. Meanwhile, Duoderm gave -9.9% decrement of dose in both dry and wet conditions. In contrast to 6 MV photon beam, the 10 MV photon beam showed an increase in percentage dose differences. The highest increment was observed in dry condition for gauze with maximum increase of 2.36%. Minimal effects of Actisorb, Alderm and Duoderm dressing on d_{max} were observed for photon beam. Figure 4 shows the percentage differences of dose at d_{max} for electron beams. The average dose differences measured at d_{max} mostly was in negative

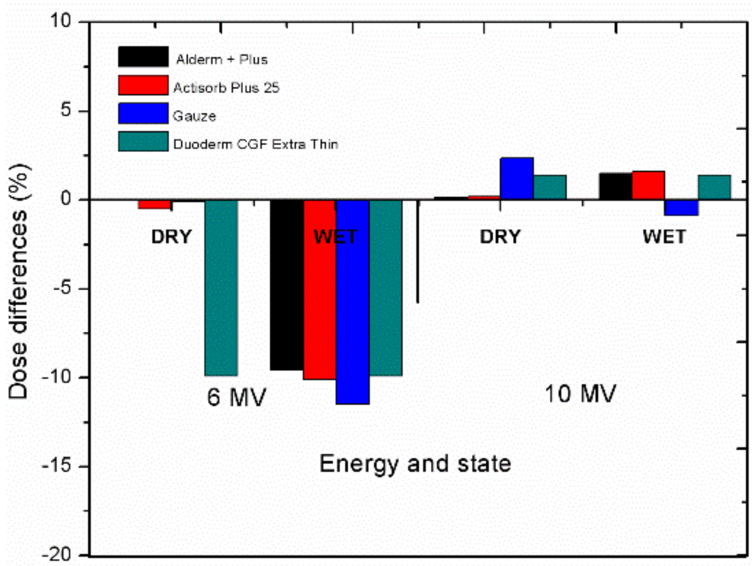


Figure 3. Percentage dose differences of dose at d_{max} for photon beams.

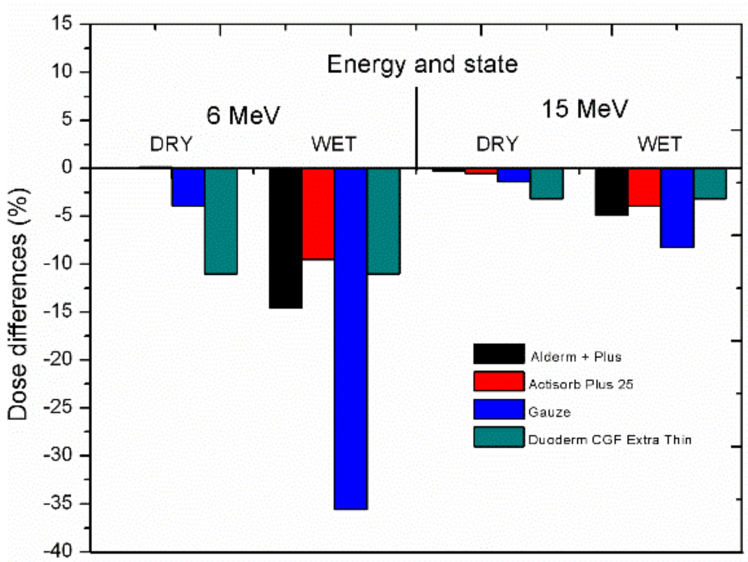


Figure 4. Percentage dose differences of dose at d_{max} for electron beams.

outcome or dose reduction from -0.23% to -35.6% for 6 and 15 MeV respectively. Gauze shows highest decrement with -35.6% in wet condition, while most less decrement shows by -0.23% for Alderm in dry condition. While for other dressings less significant result given with average from -0.49% to -14.5% respectively.

The effects of wound dressing that cause the changes in dose may due to the photon slowing down as it had interact with material of wound dressing, thus shorten the build-up region. Similar outcome where increase in dose were observed for photon and electron beams surface dose with less effects for electron beams because of its own characteristic that act for superficial cancer treatments. Measurement of dose at d_{max} showing opposite results where reduction of dose occurs for both photon and electron beams with prominent decrease for electron beams. Early attenuation of the beam by the dressing shifting the dose toward the surface, then reduce the dose at d_{max} and shorten the buildup dose. The energy of the beams also have significant effects where higher energy will be more penetrative causing less effects to the surface dose. Whilst at low energy, beams are scattered very easily and as a result the path of the beams become very oblique and the maximum dose occur faster and at shorter distance.[1]

Comparison between different types of dressing found that gauze gives the most significant effects to the dose either at surface or at d_{max}. The thickness of gauze which is more chunky compare to other dressing may contribute to the increase in surface dose due to the buildup effects. Gauze in wet condition with a physical density of 1.02 g/cm^3 could act similarly like bolus and are adequate to substitute bolus material with flexibility to conform to most surface contours.[4] Another factors that contribute to the alteration of dose is the presence of air gap in between the dressing and surface area. Early build up starts to occur in the dressing, secondary electrons or photon exit the dressing material in air are partially scattered and lost, thus will not contribute much for dose at depth received.[4]

4. Conclusion

The presence of wound dressing are found to increase surface dose for photon beams that could reach up to 90% of dose increase which may induced a clinically significant dose to the skin. Effects to the dose at d_{max} are less significant with dose increment less than 5%. Meanwhile, there were significant effects for dose at d_{max} compare to surface dose for electron beam. The dose at surface was observed to increase around 21% and reduction of dose up to 40%. The effects are more prominent when the dressing in wet condition compare to dry condition. In clinical situation, it may be desirable to change or take off the dressing prior to the treatment delivery. A significant increase of dose to the skin is not to be expected with all the wound dressings available, but its thickness and ability for moist absorption should be taken into account when calculating the actual applied dose.

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