Peer Reviewed **Case Study**

THE IMPACT OF BMI ON THE INCIDENCE AND SEVERITY OF RADIATION DERMATITIS ON PATIENTS UNDERGOING EXTERNAL BEAM RADIOTHERAPY: A CASE STUDY

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Abstract

It is known that over 90% of patients that are treated for various malignancies using external beam radiotherapy (EBRT) are exposed to radiation induced dermatitis (RID). Previous studies on breast cancer have reported positive association between body size and the severity of RID. In this study, a conservative population of 34 patients undergoing EBRT for cancers of the head and neck, abdomen, chest, extremities and pelvis was observed for RID. Observed skin reactions were evaluated weekly using a Wold Health Organisation (WHO) scoring instrument. The patients' body mass index (BMI) was measured before they commenced treatment. All were given the same skin care instructions. In all the observed regions of the body, a positive association between the incidence and severity of radiation dermatitis was observed. Improvements in EBRT patients' habits and practices towards reduced skin RID are recommended alongside implementation of more skin sparing techniques by service providers of EBRT. Further research may explore radiation interaction processes that are predominant in fatty tissue in the order to mitigate the effects.

Keywords: Body mass index, dark skinned

INTRODUCTION

Radiotherapy is the most used treatment modality for most cancers in Africa.[1] In the administration of EBRT the skin is exposed and gets radiation induced skin reactions. The incidence of radiation dermatitis varies with dose and area of the body irradiated.[2] Radiation induced dermatitis (RID) is brought about by the interaction of the radiation with the skin tissue. The skin sometimes receives a very significant radiation dose, if the field placement does not implement skin sparing techniques.[3] The current study describes the incidence of both chronic and acute radiation dermatitis. The incidence and severity of radiation dermatitis has been reported to be correlated to both patient characteristics and radiation treatment related factors. Treatment-related factors include total dose, fractionation schedule, use of a bolus and/or boost, treatment surface area or volume, radiation technique, and use of concurrent chemotherapy or targeted agents while patient factors include sun exposure, patient size, smoking status, diabetes, and obesity.[4] Furthermore, melanin has been observed to have a protective effect against radiation dermatitis.[5,6] The current paper presents results from an observational case study from Zimbabwe. Despite radiotherapy services being available in Zimbabwe for many decades no study has previously been conducted to document the incidence and severity of radiation dermatitis. The study had the following objectives.

1. To determine the incidence of radiation induced dermatitis in dark skinned patients with varying body mass indices among patients receiving external beam irradiation.
2. To determine the severity of radiation induced dermatitis in dark skinned patients undergoing external beam irradiation.
3. To determine the association between the patients' body mass index and severity of their skin reactions among dark skinned patients receiving external beam irradiation.

RESEARCH METHODOLOGY

Following ethics approval by the Research Ethics Commit-

tee and the Medical Research Council of Zimbabwe data were collected from cancer patients receiving external beam radiation at a privately owned cancer treatment centre located in Harare, Zimbabwe. The study site caters for patients from all over the country who choose not to use the services provided at public hospitals. Informed consent was obtained, and confidentiality was tightly maintained, and no personal identifying information was gathered. The study was designed as a cross-sectional observational. The participants' height and weight were measured before commencement of treatment to compute the BMI. The measurements and calculations were done by the radiographer. BMI was calculated using the BMI calculator.[7] The World Health Organisation (WHO) BMI classification categories were used.[8] Assessments for skin reactions were done visually after every five treatments and graded according to the WHO criteria for radiation dermatitis by the radiation oncologist. The WHO radiation dermatitis grading Scale[9] includes the following stages.

1. Grade 0 (no reaction)
    - No evidence of skin changes. The skin appears normal with no visible erythema or damage.
2. Grade 1 (mild reaction)
    - Mild erythema (redness of the skin) with no peeling or break in the skin.
    - The skin may show slight dryness or scaling but without any significant discomfort.
3. Grade 2 (moderate reaction)
    - Moderate erythema or dry desquamation (peeling of the skin).
    - Skin may show moist desquamation in limited areas, and the patient may experience mild to moderate pain or discomfort.
    - Possible early signs of blistering or small areas of skin breakdown.
4. Grade 3 (severe reaction)
    - Severe erythema or patchy moist desquamation that may be widespread.
    - Skin may break down with ulceration or large open areas that may require medical intervention.
    - Severe pain and discomfort, often requiring management of infection or wound care.
5. Grade 4 (very severe reaction)
    - Extensive skin necrosis or ulceration.
    - The skin is severely damaged, with widespread and possibly permanent loss of skin integrity.
    - May result in significant functional impairment and requires immediate and aggressive intervention.

Observations were made when the participants presented at the selected study site for their weekly treatment check-ups. The inclusion criteria were all dark skinned patients with a prescription indicating that they receive at least 20 Gy of mega voltage external beam therapy. Dark skinned patients were the focus of the study because of the presence of melanin as a protective factor. Specifically, they had to be undergoing photon treatment. The treatment was delivered by Elekta Linac with 6 MV and 10 MV capabilities. Since radiation injury is positively correlated to the absorbed dose and the fractionation, only patients receiving 2 Gy per fraction were included. Patients undergoing treatment for skin cancers were excluded from the study because in such treatments skin sparing techniques are not used. Different patients had different prescriptions depending on the diagnosis. However, only participants whose daily fraction size was 2 Gy were included. This made it possible to compare all participants at a particular time point regardless of total dose. For example the analysis compared the incidence and severity of radiation dermatitis for all, regardless of diagnosis and total prescribed dose at 10 Gys, 20 Gys, 30 Gys etc. The participants were instructed to generally keep the treatment area dry after tender cleaning.

Primary and secondary data were used in this research in the form of a questionnaire. An analysis of the participants' treatment records was utilised for data collection in this research. The questionnaire was developed internally and administered by a radiographer who collected it as soon as it was completed. It was used to capture the participants' demographic data as well as record their skin care practices. The questionnaire was administered at the commencement of treatment and updated every week if any new observations were made and to update any missing data. Pearson's correlation co-efficient was used to determine the association between the participants' BMI and severity of their skin reactions among dark skinned patients receiving external beam irradiation.

RESULTS

A total of 34 patients participated in the study. They were split equally by gender. Most (58.8%) of the participants were overweight (obese); 82.4% were above the age of 40. The mean age was 54.7 years. Twenty-three participants (67.6%) were treated with 6 MV photons. Most of the participants followed the instructions to keep the treatment area dry as shown in Figure 1. While gentle washing was popular, the participants generally avoided hot bathing, rubbing, applying lotion or cornstarch to the treatment areas.

After 10 Gy of radiation treatment, Grade 2 desquamation was reported in eight participants, six (75%) of whom were overweight (see Table 1). The remainder were in the normal weight BMI group. No Grade 3 desquamation was reported at 10 Gy. The most common skin reaction reported at 10 Gy was Grade 1 desquamation. Of the 10 participants that were assessed to have Grade 1 desquamation seven (70%) were either overweight or obese. Of the four obese patients, three (75%) were assessed to have developed Grade 1 desquamation after 10 Gy, compared to three (20%) out 15 in the combined normal and underweight group.

After 20 Gy, six out 15 (40%) of the overweight group, and three out four (75%) of the obese group developed Grade 2 desquamation. In comparison, three (20%) out of the 15 in

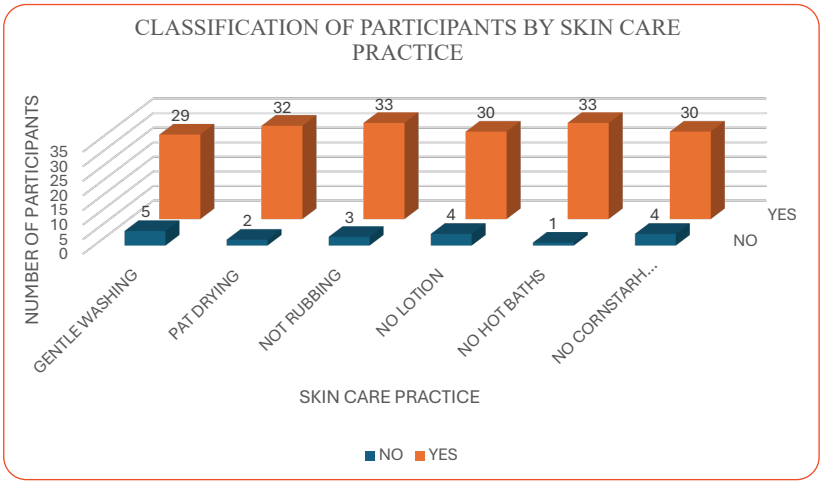

Figure 1. Classification of participants by skincare practices.

Table 1. Characteristics of the research sample

Sex	Frequency	%
Male	17	50
Female	17	50
BMI category		
Underweight (less than 18.5)	5	14.7
Normal weight (18.5 and 24.9)	9	26.5
Overweight (between 25 and 29.9)	16	47.1
Obese (Above 30)	4	11.8
Photon energy		
6MV	23	67.6
10MV	11	32.4
Age group		
<20 yrs	1	2.9
20-30 yrs	3	8.8
30-40 yrs	2	5.9
40-50 yrs	5	14.7
>50 yrs	23	67.7
Anatomical region		
Head and Neck	8	23.5
Chest	9	26.5
Pelvis	10	29.4
Extremities	3	8.8
Abdomen	4	11.8

the combined normal and underweight group had Grade 2 desquamation. The number of participants in the normal and underweight group reporting Grade 1 desquamation increased from three to nine, as the dose was increased from 10 Gy to 20 Gy. After 30 Gy, only one, who was in the overweight category, developed Grade 3 desquamation. The number of participants in the combined underweight and normal categories reporting grade desquamation increased from three to 14. After 40 Gy, three developed Grade 3 desquamation. This number increased to six after 50 Gy. All that reported Grade 3 desquamation were in the overweight category. The Pearson correlation of the skin reactions to the body mass index was found to be positive and significant at each dose (see Table 2).

DISCUSSION

A few salient observations can be made from this study. The distribution of the participants by BMI ranges showed the majority to be either overweight or obese (58.9%). This is in keeping with reports that link increased incidence and increased virulence of different types of cancers with obesity.[10-14] The BMI statistics in each BMI category are in keeping with reports on BMI and prevalence of obesity in Zimbabwe.[9] This has huge implications for the cancer control and prevention programme in Zimbabwe. Interventions that target weight management need to be explored for possible positive impact on cancer control and prevention.

This study demonstrated a positive correlation between the incidence and severity radiation dermatitis and is in keeping with previous reports.[15-17] This is also in keeping with the dose-dependent nature of acute radiation effects. Most importantly, in line with the objectives of this study, both the incidence and severity of skin reactions increased with BMI. This can be attributed to several mechanisms. It is not uncommon for obese and overweight patients to have skin folds, which can trap moisture and result in increased[18] skin irritation and breakdown during radiation therapy. In obesity there is increased blood flow to the skin,[19] and increased activity of the sweat glands.[20] Increased blood flow leads to increased oxygenation, which, in turn increases the radio-sensitivity of the area under treatment potentially impairing the skin's ability to heal and recover from radiation damage. Sweat causes moisture which is also associated with increased radiation dermatitis. Excess fatty tissue increases the patient separation and impacts on the isodose curves potentially leading to higher absorbed radiation doses. Fatty, muscle and cartilage all have different compositions and therefore different radiation absorption propensities. The presence of fatty under the skin can therefore result in increased radiation dose to the skin. Additionally, obesity alters the inflammatory response of the skin[21] thereby impairing healing from radiation damage.

The study has a few limitations. The field size was not taken into consideration. Field sizes have implications on dose distributions which in turn can impact the total skin dose. Additionally, the study was limited to standard 2 Gy fractions, five days a week treatment regime. The difference in the severity of desquamation between patients treated with 6 MV and 10 MV photons was not analysed in this study. The study did also not take into consideration other factors such as other underlying conditions, for instance diabetes and HIV. The small sample size possibly affected the internal and external validity of this study and might have affected the probability of the findings.

Table 2. Cross tabulation of BMI, radiation dose and desquamation grade

BMI	Dose	10 Gy				20 Gy				30 Gy				40 Gy				50 Gy			
	Desquamation Grade	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3
Underweight		3	2	0	0	0	3	1	0	0	0	4	0	0	0	2	0	0	0	2	0
Normal weight		6	1	2	0	0	6	2	0	0	1	5	0	0	0	5	0	0	3	4	0
Overweight		6	4	6	0	2	4	6	0	1	3	8	1	1	0	7	3	1	0	7	6
Obese		1	3	0	0	0	0	3	0	0	0	2	0	0	0	2	0	0	0	2	0

NB: The numbers in each category diminish because some patients did not get to 50Gys.

CONCLUSIONS

This observational study reports increased incidence and severity of RID in overweight and obese patients. The patients in the higher BMI groups have to exercise a lot of caution and pay particular attention to skin care during treatment. Further research employing objective RID measuring instruments, such as spectrophotometer and colorimeters which give numeric measures of the skin reaction is recommended.

CONFLICT OF INTEREST

The authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

FM (UZ) was the main researcher; SN (NUST) helped conceive the research idea and presentation of the results; SL (NUST) assisted with interpretation of the results; PM (NUST) was helpful in the design of instruments for data collection. GRC (SU) drafted the manuscript. NS and SL provided critical comments and recommendations regarding literature review and statistical presentation.

DISCLAIMER

The views and opinions expressed in this article are those of the author/s and do not necessarily reflect the views of the publisher and editorial board.

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