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Setup Reproducibility of Supine Position in Radiotherapy of Rectal Cancer Patients

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ABSTRACT

Setup reproducibility is crucial in the delivery of dose in radiotherapy as it determines the accuracy and treatment success of the procedure. Previous studies reported supine as an alternative to prone; however, the comparison was not straightforward as several factors were overlooked. This retrospective study attempted to determine the setup reproducibility as measured by displacement of bony landmarks in the lateral, longitudinal, and vertical axes of supine position relative to the standard prone position. Sixteen rectal cancer patients were positioned in supine (N=6) and prone (N=10) as per radiation oncologists and medical physicists in 2018. On each daily fraction, the displacement of the bony landmark in the three axes was calculated by the medical physicists and radiation therapists, and a total of 61 measurements were recorded. Results revealed that both supine and prone positions demonstrated an unacceptable reproducibility value. The setup reproducibility did not significantly differ in both positions. Based on the results of the study, the supine position, as reported by previous studies to exhibit superior setup reproducibility than prone position, is still unacceptable in radiotherapy of rectal cancer patients.

Keywords: Prone; Radiotherapy; Rectal Cancer; Retrospective; Setup Reproducibility

INTRODUCTION

Globally, colorectal cancer (CRC) is the third most diagnosed cancer, with almost 861,000 recorded deaths in 2018 (Macrae, 2016). Among the severe types of CRC is rectal cancer. In the Philippines, CRC is the leading gastrointestinal cancer (Afinidad-Bernardo, 2017).

The standard treatment for primary and advanced rectal cancers is preoperative chemoradiotherapy. This method is a combination of chemotherapy and radiotherapy given before the surgical procedure (Kennedy, Vella, Macdonald, Wong, & McLeod, 2015; Wong et al., 2010). During this approach, an external beam radiotherapy unit transmits highly intense radiation to the patient positioned in prone. The dose of radiation is delivered in fraction daily until the total dose needed to treat a specific rectal cancer case is achieved. The multimodal treatment demonstrated a 70-74% survival rate in 5 years (Kye & Cho, 2014).

Despite the therapeutic value of this method, several drawbacks have been reported in the use of prone position. The prone position exhibited less setup reproducibility during the fractional treatments, more considerable patient discomfort, and high risk of fall and injury during the procedure (Bayley et al., 2004; Froseth et al., 2015; Kim et al., 2017). In radiotherapy, setup reproducibility refers to the ability to implement repeated measurements with the same setup procedures, to produce the same result as that of the first reference procedure. This parameter is very crucial in the delivery of dose in radiotherapy as it determines the treatment success of the procedure (Kye, & Cho, 2014). Any deviation from the reference treatment compromises the treatment efficiency; and increases the unnecessary dose to healthy tissue and exposure and toxicity to the nearby organs at risk (OAR) such as small bowel (Alasti, Petric, Catton, & Warde, 2001; Langmack, 2001).

Several authors recommended patient immobilization as solution to the issue of setup reproducibility (Li et al., 2010; Rosenthal et al, 1993; White, 2014). However, immobilizing devices do not always eliminate all errors and may cause further patient discomfort during the treatment procedure (Dieterich, Ford, Pavord, & Zeng, 2015; Lu et al., 2018). With this, an alternative position to prone is worthwhile to investigate.

The supine is a position in which the back part of the body is lying on the surface. Two studies compared the setup reproducibility between the prone and supine positions. Both reported that the supine position exhibited a statistically higher setup reproducibility as measured by displacement in the lateral, longitudinal, and vertical axes of the bony landmarks compared to the standard prone position (Froseth et al., 2015; Kim et al., 2017). However, only patients undergoing preoperative radiotherapy were included in the study, and the results may not be applicable to other rectal cancer cases. Also, no more than 43% of the measurements were analyzed, which may represent a sampling bias. To date, there is no existing literature that explored alternatives to prone in the Philippine setting, despite the high incidence of CRC.

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In light of these gaps, the present study attempted to determine the setup reproducibility as measured by displacement in the lateral, longitudinal, and vertical axes of the bony landmarks of supine position for rectal cancer radiotherapy using a retrospective research design. In doing so, the study analyzed the displacement of the prone and supine positions in the three axes of the bony landmarks, and compare the displacement values.

MATERIALS AND METHODS

Patient Selection

This study was conducted using a retrospective design. Prior to the study, rectal cancer patients underwent radiotherapy and were treated in either prone or supine position as per the protocol of radiation oncologists and medical physicists. Sixteen patients of a medical center in the Philippines were selected for the review based on the following inclusion criteria: at least four consecutive sessions completed, no hip prostheses, and intact lower limbs. Of the 16 patients, ten were treated in prone, and the remaining six were treated in supine. To ensure confidentiality and anonymity of patients, the given data only contain ordered numbers in the first column of the Microsoft Excel file representing the number of patients enrolled, the reference values in the second column, and the measurement values per fraction in the third to tenth columns.

Reproducibility Metrics

In this study, the setup reproducibility was measured based on the displacement of bony landmarks in the lateral, longitudinal, and vertical axes using the MOSAIQ system and EPID iView software. The individual displacement was calculated by subtracting the measurement value at a given fraction to the reference value. The total displacement was computed by getting the square root of the sum of the individual displacements. A displacement of at most 2 mm is considered as acceptable reproducibility value; however, beyond this value is deemed to be unacceptable (Washington & Leaver, 2015).

Procedure

A communication letter stating the permission to conduct the research was sent to the administrator of the oncology department of the selected medical center in the Philippines. It was given by the researchers personally to obtain immediate approval. It took two weeks before the hospital approved the study.

A total of 61 measurements were collected (37 values for prone and 24 values for supine) from 16 patients. The patients were treated using the Elekta Synergy Linear Accelerator in 2018. On each daily fraction, the displacement in the lateral, longitudinal, and vertical axes was calculated by the medical physicists and radiation therapists and recorded. The recorded data were then analyzed using the appropriate statistical tools.

Data Analysis

Mean was used to determine the average displacement of bony landmarks in the lateral, longitudinal, and vertical axes in supine and prone positions. The Mann-Whitney U test was utilized to determine if there is a significant difference in the displacement of bony landmarks in the three axes between prone and supine positions. A p-value of less than 0.01 was considered significant.

RESULTS AND DISCUSSION

In this study, the setup reproducibility of prone and supine positions as measured by displacement of bony landmarks in the lateral, longitudinal, and vertical axes, was analyzed and compared. Descriptive analysis revealed that both positions have an acceptable setup reproducibility in the lateral axis (Table 1). However, the use of either position demonstrated an unacceptable setup reproducibility in the longitudinal and vertical axes. The total displacement was comparable in both positions. The supine position, as reported by previous studies to exhibit superior setup reproducibility than prone position (Froseth et al., 2015; Kim et al., 2017), is still unacceptable in radiotherapy of rectal cancer patients based on the results of the study. However, other parameters not measured in the study, such as the actual dose received by the patients and dose received by OAR, may be further compared between the prone and supine positions in the future. The BMI of the

Table 1

Mean Displacement of Bony Landmark Axis

Bony Landmark Axis	Position	N	Mean Displacement (mm)	Interpretation
Lateral	Prone	37	1.01	Acceptable
	Supine	24	0.63	Acceptable
Longitudinal	Prone	37	3.27	Unacceptable
	Supine	24	3.85	Unacceptable
Vertical	Prone	37	2.28	Unacceptable
	Supine	24	2.05	Unacceptable
Total	Prone	37	4.84	Unacceptable
	Supine	24	4.84	Unacceptable

Legend: ≤ 2 mm – acceptable, > 2 mm – unacceptable

Table 2

Test of Difference in the Total Degree of Displacement

Bony Landmark Axis	Mann-Whitney U
Lateral	302.00^{ns}
Longitudinal	306.50^{ns}
Vertical	439.00^{ns}
Total	375.00^{ns}

Note: ns=not significant

patients and its relationship with setup reproducibility may also be explored.

A test of difference using Mann-Whitney U was employed to compare the displacements of the prone and supine positions (Table 2). The total and individual displacements in the three axes of the bony landmark were statistically the same in both positions ($p>0.01$).

Setup reproducibility is a vital parameter in radiotherapy of rectal cancer patients. A reproducible reference treatment yields greater treatment efficiency, higher healthy tissue sparing, lower exposure to OAR, and lower toxicity to the patient. In the daily treatment setup, the position of the patient influences the reproducibility of the treatment as defined by the displacement of reference bony landmarks in the lateral, longitudinal, and vertical axes. The study found that the total displacement, as well as displacements in the lateral and vertical axes, has unacceptable reproducibility value. This result corroborated the findings of Froseth et al. (2015), which reported an unacceptable total displacement value in both positions. However, that study calculated higher overall displacement values (7.1 mm for prone, 5.8 mm for supine) compared to the present investigation. This finding may be attributed to the upper Body Mass Index (BMI) values (>30 kg/m2) of the studied patients, which were associated with higher displacement during positioning (Lin et al., 2012; Yoon et al., 2012). It is also noteworthy to report that these patients are more challenging to position in the actual practice. In this study, the BMI of each patient was not measured before and after each daily radiotherapy session. Change of BMI is one of the effects of radiotherapy (Ottosson et al., & Laurell, 2013), and this effect may have an impact on setup reproducibility as observed in previous reports (Lin et al., 2012; Yoon et al., 2012). Future studies may be explored to examine the BMI of the patients and its influence on setup reproducibility.

The setup reproducibility, as measured by displacements of bony landmarks, did not significantly differ in both positions. The results reported by Froseth et al. (2015) and Kim et al. (2017) disproved the results obtained in this study, which found that reproducibility metrics demonstrated a significant difference between the supine and prone positions. In their studies, the comparison between prone and supine positions was not straightforward due to sampling bias. Only patients undergoing preoperative radiotherapy were selected, and no more than 43% of the collected data were included in the analysis. This study addressed these issues and sampled all cases of rectal cancer and examined all the collected data based on the inclusion criteria. Differing results may be attributed to the inclusion of other cases not selected in the previous studies and sampling of all data available.

Because setup reproducibility determines the accuracy of the dose given to the patient (Hong et al., 2005), the accuracy of dose delivery is statistically equal in both prone and supine positions, as observed in the study. This result supports the study of Gomez et al., (2018), who reported no significant difference in the coverage of treatment volume when patients undergoing rectal radiotherapy are analyzed according to the type of setup position. Moreover, the findings confirmed the results of Surendra et al. (2014), who revealed that there is no significant dosimetric difference to small bowel when positioning rectal radiotherapy patients in prone without a belly board versus supine.

CONCLUSION

The supine position demonstrated an unacceptable reproducibility value based on the total displacement in the bony reference landmark. It was also noted that the typically used prone position exhibited the same reproducibility value as that of supine. The setup reproducibility, as measured by the displacements of bony landmarks, did not significantly differ in both positions. Nevertheless, this study may provide insights into the radiation oncology treatment team in the selection of positions that will offer higher setup reproducibility and greater treatment efficiency. Other treatment positions and devices may be explored in the future.

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