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Dosimetric Difference of Urinary Bladder and Rectum in Patients Undergoing Intracavitary Brachytherapy for Cervical Cancer under Procedural Sedation and General Anesthesia: A Survey at Bugando Cancer Center and Ocean Road Cancer Institute

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ABSTRACT

Background: High-Dose-Rate Intracavitary Brachytherapy (HDR-ICBT) is a commonly employed treatment modality for cervical cancer, delivering a high dose of radiation directly to the tumor site while minimizing exposure to surrounding healthy tissues. Anaesthesia administration during HDR-ICBT varies, with some centres using Sedation (CS) and others employing General Anaesthesia (GA). Despite the widespread use of these anaesthesia techniques, their potential impact on dosimetric outcomes, particularly in the urinary bladder and rectum, remains an area of interest and investigation.

Objective: This study aimed to determine the dosimetric difference in the urinary bladder and rectum doses among cervical cancer patients undergoing HDR-ICBT under CS and GA. The study was conducted at Bugando Cancer Centre (BCC) and Ocean Road Cancer Institute (ORCI) to compare the dosimetric outcomes between the two anaesthesia techniques.

Methods: A total of 273 patients who underwent HDR-ICBT for cervical cancer were included in the study. Patients were divided into two groups based on the anaesthesia technique used during the procedure: 143 patients received GA, and 130 patients received CS. Dosimetric parameters of the urinary bladder and rectum doses were collected and analysed using descriptive statistics and the independent samples t-test.

Results: The findings demonstrated a statistically significant dosimetric difference in the mean urinary bladder dose between patients treated under GA and CS ($p < 0.001$). Patients under GA received a significantly lower mean urinary bladder dose compared to those under CS. However, no statistically significant difference was observed in the mean rectum dose between the two anaesthesia groups ($p = 0.689$).

Conclusion: The study reveals that the choice of anesthesia technique significantly impacts the urinary bladder dose during HDR-ICBT for cervical cancer. Patients receiving GA had a lower mean urinary bladder dose compared to those under CS. However, no significant dosimetric difference was observed in the mean rectum dose between the two anesthesia groups. These findings emphasize the importance of considering anesthesia techniques during treatment planning to optimize dosimetric outcomes and patient safety in HDR-ICBT. Further investigation and long-term follow-up are warranted to validate and expand upon these results. Collaboration between radiation oncologists and anesthesia teams is crucial to enhance treatment efficacy and minimize potential complications during HDR-ICBT for cervical cancer

KEYWORDS: Brachytherapy, General anesthesia (GA), Procedural/ Conscious sedation (PS/CS).

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INTRODUCTION

Cervical cancer (CC) is the fourth most frequent cancer in women worldwide and the primary cause of cancer death in women in sub-Saharan Africa, with an estimated 604,000 new cases and 342,000 deaths reported in 2020(1). Since they account for more than 80% of the worldwide burden of CC, low- and middle-income countries are disproportionately afflicted by the disease, with sub-Saharan Africa having the highest age-standardized incidence and mortality rates in 2021(1). The disease is worsened by the synergistic epidemic between HIV and human papillomaviruses (HPV). In Tanzania, Cervical cancer is the 1st most common disease among women, and 6525 women die from the disease each year while 10241 women were diagnosed with cervical cancer by 2023(2).

Concurrent chemoradiation with high dose rate intracavitary brachytherapy (HDR-ICBT) is the standard of care in patients with locally advanced cervical cancer (3). Brachytherapy can be delivered using either low dose rate(LDR), pulsed dose rate(PDR) or high dose rate(HDR).HDR-ICBT is the type of radiation treatment used to treat cancer which involves the insertion of small radioactive source into or near the tumor to deliver high dose radiation 8Gy per session for 3 sessions(each application done at weekly intervals) for a specific period of time to the cancer cells while minimizing the radiation exposure to surrounding organs at risk(OAR), with imaging technique such as conventional x-ray, Computed tomography(CT), Magnetic Resonance Imaging(MRI) , Ultrasound, PET to guide the placement of applicator where the patient is given medication(GA or sedation) to help reduce discomfort(4).

The American Brachytherapy Society(ABS) recommends a cumulative external beam and intracavitary(EBRT+ICBT) radiation dose of approximately 80-90Gy for definitive treatment of carcinoma of cervix and that HDR-ICRT to be performed under general anesthesia(4).In addition the overall treatment time of EBRT and brachytherapy should be less than 8 weeks, beyond which which local control and survival has been shown to decrease by 1% per day(5).Although examination under anaesthesia helps in better visualization of the diseased structure and delineation of parametrial extension of the disease, though chances of anaesthesia-induced complications are more (9). Moreover, there is long overall treatment time (OTT)(5).

Using procedural sedation (PS)/ conscious sedation (CS) on patients can be a good alternative because longer overall treatment time (OTT) causes results to be subpar. Procedural sedation is a method of giving sedatives or dissociative substances along with or without analgesics to produce a condition that enables the patient to endure unpleasant operations while maintaining cardio-respiratory function. By lowering the degree of consciousness, it enables the patient to autonomously maintain oxygenation and airway control(5,9).

At BCC, brachytherapy is routinely performed under general anesthesia while procedural sedation being performed at ORCI. Although ICBT has received extensive research and is a crucial component of cervical cancer care, the anesthetic side of the procedure has received less attention(9,11,12).Comprehensive data correlating the use of GA or sedation that has influence on dose to the organs at risk(OAR) on 2D-BT is not available in our settings. Therefore this study to be focused on determining these dosimetric differences received by OAR in patients under sedation and GA at two medical facilities, BCC and ORCI. The study is likely to be of importance in the field of radiation oncology in reduction of urinary bladder and rectal toxicities among cervical cancer patients.

Depending on the patient's comfort, several anesthetic formulations may be utilized, according to American Brachytherapy Society (ABS) recommendations(13,14). General anesthesia/spinal anesthesia (GA/SA), paracervical block, and conscious sedation (CS) are some of the anesthetic techniques that have been utilized to insert the HDR-ICBT applicator(3). Various institutions pick the anesthetic technique that works best for their patients and the facility. Despite offering effective analgesia and muscular relaxation GA has long overall treatment time. PS, on the other hand, is straightforward and practical to apply but may result in pain, discomfort, and insufficient muscle relaxation(7,9,12), this might result in inadequate vaginal packing and incorrect ICBT applicator positioning, which would increase doses to organs at risk (OAR) and compromise dosimetry. Though ICBT has been vastly studied and constitutes an integral portion of cervical cancer treatment, there are limited studies regarding its anesthetic perspective(9,11,12). To the best of our knowledge, there are limited information from Tanzania correlating the anesthesia and the ICBT dosimetry. In order to determine if GA or sedation have impact on the dosimetry, this study therefore aims to address this gap in knowledge and provide valuable insights of dosage received to the urinary bladder and rectum at the two setups that is Bugando Cancer Center North western Tanzania and Ocean Road Cancer Institute, Eastern Tanzania.

MATERIALS AND METHODS

Study area

The study was conducted at Bugando Cancer Center, North-Western Tanzania and Ocean Road cancer Institute, Eastern Tanzania. Ocean Road Cancer Institute (ORCI) is located in Ilala District, in Dar es Salaam. It is the main referral center of the country for cancer patients. The institute receive approximately 7436 cancer patients annually. The center offers radiotherapy, screening programs and cancer prevention, nuclear medicine services, chemotherapy, palliative care, training and research.

Bugando Cancer Centre (BCC) is a tertiary care medical facility located in Nyamagana District, in Mwanza, along the southern shores of Lake Victoria. The cancer unit at Bugando is the second public cancer treatment center, with the capacity to attend 120 cancer patients on daily basis.

Study design and project duration

A hospital based analytical cross-sectional design with retrospective record review was utilized in this study, from May 2022 to December 2022.

Study population

The study included all patients' files that underwent HDR-intracavitary Brachytherapy for cervical cancer at Bugando Cancer Center and Ocean Road Cancer Institute. Patients who received three intracavitary Brachytherapy sessions under sedation or general anesthesia and had complete dosimetry data available for urinary bladder and rectum in medical record system were included in the study. Patients who received HDR-ICBT for palliative care and oncological emergency.

Ethical consideration

Ethical approval for the study was sought from the Joint Catholic University of Health and Allied Sciences and Bugando Medical Centre Research and Ethics Committee and also permission to collect data was granted by Institutional Review Board of the Ocean Road Cancer Institute and Bugando Cancer Center. Confidentiality was maintained throughout the process from data collection, data analysis, and management. In the case a participant states identifying information accidentally say name or other personal identifiers, removal of this information from the checklist and other excel sheet was done prior analysis. Identification number was used instead of participant names. All participants' information was kept on a secure; password protected computer and was not be disclosed.

RESULTS

Characteristics of the study participants

The study involved 273 participants with carcinoma cervix, ranging in age from 28 to 87 years, with a mean age of 53.16 years (SD = 9.89). The age distribution was relatively diverse, covering a broad range of ages. Among these 273 participants, 143 (52.4%) received treatment at Bugando Cancer Center, while the remaining 130 (47.6%) were treated at Ocean Road Cancer Institute. The distribution of participants across the two facilities indicates a balanced representation of patients from both centers.

Regarding the cancer stage of the participants, the study encompassed different stages of carcinoma cervix. Notably, the majority of participants were at stage IIB, accounting for 151 cases (55.3%). The next most common stage was IIIB, comprising 22.7% of the participants. Stages I and II together represented a significant portion of the cases, suggesting the study captured a diverse range of disease progression among the patient population.

During the Intra-Cavitary Brachy-Therapy procedures, two different techniques were used: General Anesthesia (GA) and Conscious Sedation (CS). Among the 273 participants, 143 (52.4%) received treatment under General Anesthesia, and 130 (47.6%) were treated under Conscious Sedation. The use of different techniques in the study allowed for a comparison of dosimetric parameters under different anesthesia and sedation conditions

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Table 1: Characteristics of the study participants

		Frequency	Percent
Facility name	BCC	143	52.4
	ORCI	130	47.6
	Total	273	100.0
Cancer stage	IB1	3	1.1
	IB2	8	2.9
	IB3	12	4.4
	IIA	22	8.1
	IIB	151	55.3
	IIIA	13	4.8
	IIIB	62	22.7
	IVA	2	.7
	Total	273	100.0
Type of technique	GA	143	52.4
	CS	130	47.6
	Total	273	100.0

	N	Minimum	Maximum	Mean	Std. Deviation
Age	273	28.00	87.00	53.1575	9.88616

The dose per fraction for Intra-Cavitary Brachy-Therapy was consistent at 8.0 Gy per 3 Fraction for all participants. Regarding ovoid size and tandem length, the majority of participants 162 (59.3%) had large-sized ovoids and tandems, 18 (6.6%) of patients had small ovoids, whereas, 93(34.1%) had medium-sized ovoids.

Table 2: Doses of ICBT received and the Ovoid size and Tandem length used

		Frequency	Percent
ICBT dose per fraction	8.0 Gy per 3 fraction	273	100.0
Ovoid size and Tandem length	Small	18	6.6
	Media	93	34.1
	Large	162	59.3
	Total	273	100.0

Dosimetric parameters of urinary bladder and rectum in patients of carcinoma cervix

The dosimetric parameters for the urinary bladder and rectum were analyzed. For the urinary bladder dose, the values ranged from 9.70% to 71.70%, with a mean of 32.0366% and a standard deviation of 12.62401%. In the case of the rectum dose, the values ranged from 5.80% to 61.30%, with a mean of 36.2678% and a standard deviation of 10.99061%. The relatively large standard deviations for both dosimetric parameters indicate variability in the data distribution, with wider spreads of values around the respective means.

Table 3: Dosimetric parameters of urinary bladder and rectum in patients of carcinoma cervix

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Urinary bladder dose	273	9.70	71.70	32.0366	12.62401
Rectum dose	273	5.80	61.30	36.2678	10.99061

Dosimetric Parameters of Urinary Bladder and Rectum in Patients of Carcinoma Cervix by Anesthesia Technique

Based on the provided descriptive statistics for the dosimetric parameters of the urinary bladder and rectum in patients of carcinoma cervix who underwent Intra-Cavitary Brachy-Therapy under General anesthesia (GA) and Sedation (CS), the following interpretations can be made:

The Urinary Bladder Dose

The mean under GA was 29.6483 with a standard error of 0.92973. The 95% confidence interval for the mean ranged from 27.8103 to 31.4862. The dose ranged from 9.70 to 54.70, with a variance of 123.610 and a standard deviation of 11.11798. The distribution exhibited a slight positive skewness of 0.431 and a negative kurtosis of -0.507. In contrast, under CS, the mean urinary bladder dose was 34.6638 with a standard error of 1.19834. The 95% confidence interval ranged from 32.2929 to 37.0348. The dose ranged from 9.70 to 71.70, with a variance of 186.681 and a standard deviation of 13.66314. The distribution displayed a slightly higher positive skewness of 0.641 and a positive kurtosis of 0.018

Table 4: Dosimetric parameters of the urinary under General anesthesia (GA) and Sedation (CS)

	Type of technique			Statistic	Std. Error
Urinary bladder dose	GA	Mean		29.6483	.92973
		95% Confidence Interval for Mean	Lower Bound	27.8103	
			Upper Bound	31.4862	
		Median		27.9000	
		Variance		123.610	
		Std. Deviation		11.11798	
		Minimum		9.70	
		Maximum		54.70	
	CS	Mean		34.6638	1.19834
		95% Confidence Interval for Mean	Lower Bound	32.2929	
			Upper Bound	37.0348	
		Median		32.2000	
		Variance		186.681	
		Std. Deviation		13.66314	
		Minimum		9.70	
		Maximum		71.70	

The Rectum Dose

Under GA, the mean was 36.5217 with a standard error of 0.92996. The 95% confidence interval ranged from 34.6833 to 38.3600. The dose ranged from 9.80 to 59.20, with a variance of 123.669 and a standard deviation of 11.12068. The distribution showed almost no skewness (skewness = -0.016) and a slightly negative kurtosis of -0.362. Under CS, the mean rectum dose was 35.9885 with a standard error of 0.95440. The 95% confidence interval ranged from 34.1002 to 37.8768. The dose ranged from 5.80 to 61.30, with a variance of 118.414 and a standard deviation of 10.88183. The distribution exhibited a slightly negative skewness of -0.312 and a positive kurtosis of 0.228.

Table 5: Dosimetric parameters of the Rectum under General anesthesia (GA) and Sedation (CS)

Rectum dose	GA	Mean		36.5217	.92996
		95% Confidence Interval for Mean	Lower Bound	34.6833	
			Upper Bound	38.3600	
		Median		35.5000	
		Variance		123.669	
		Std. Deviation		11.12068	
		Minimum		9.80	
		Maximum		59.20	
	CS	Mean		35.9885	.95440
		95% Confidence Interval for Mean	Lower Bound	34.1002	
			Upper Bound	37.8768	
		Median		36.2000	
		Variance		118.414	
		Std. Deviation		10.88183	
		Minimum		5.80	
		Maximum		61.30	

4.4. Dosimetric Difference of Urinary Bladder and Rectum under General Anesthesia versus Sedation

The independent samples t-test was conducted to compare the dosimetric parameters of the urinary bladder and rectum between patients treated under General Anesthesia (GA) and Sedation (CS) during Intra-Cavitary Brachy-Therapy (ICBT). For the urinary bladder dose, the assumption of equal variances was violated, as indicated by the Levene's test (F = 4.051, p = 0.045). Therefore, both equal and unequal variances were considered for the t-test. The results revealed a statistically significant difference in the mean urinary bladder dose between patients under GA and CS (t = -3.339, df = 271, p < 0.001). Patients treated under GA had a significantly lower mean urinary bladder dose (-5.01559) compared to those under CS. The 95% confidence interval for the difference in means ranged from -7.97276 to -2.05843 when assuming equal variances, and from -8.00281 to -2.02838 when not assuming equal variances.

Regarding the rectum dose, both equal and unequal variances were considered for the t-test. The Levene's test showed no significant difference in variances (F = 0.478, p = 0.490). The t-test results did not reveal a statistically significant difference in the mean rectum dose between patients under GA and SA (t = 0.400, df = 271, p = 0.690). The mean difference was small (0.53322), and the 95% confidence interval for the difference in means ranged from -2.09298 to 3.15941 when assuming equal variances and from -2.09032 to 3.15676 when not assuming equal variances.

Table 6: Comparison of the dosimetric parameters of the urinary bladder and rectum between patients treated under General Anesthesia (GA) and Sedation (CS) during Intra-Cavitary Brachy-Therapy (ICBT).

Independent Samples Test								
		t-test for Equality of Means						
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Urinary bladder dose	Equal variances assumed	-3.339	271	.001	-5.01559	1.50205	-7.97276	-2.05843
	Equal variances not assumed	-3.307	249.061	.001	-5.01559	1.51671	-8.00281	-2.02838
Rectum dose	Equal variances assumed	.400	271	.690	.53322	1.33394	-2.09298	3.15941
	Equal variances not assumed	.400	269.524	.689	.53322	1.33255	-2.09032	3.15676

DISCUSSION

The objective of this study was to assess the dosimetric variations in the urinary bladder and rectum among cervical cancer patients undergoing HDR intracavitary Brachytherapy under two different techniques: sedation and general anesthesia. The research was conducted at Bugando Cancer Center (BCC) and Ocean Road Cancer Institute (ORCI). The study aimed to determine whether there was a statistically significant dosimetric disparity in the urinary bladder and rectum doses between patients receiving sedation and those under general anesthesia during the intracavitary Brachytherapy treatment for cervical cancer. In this study, the results revealed a statistically significant difference in the mean urinary bladder dose between patients under GA and CS ($t = -3.339$, $df = 271$, $p < 0.001$). Patients treated under GA had a significantly lower mean urinary bladder dose (-5.01559) compared to those under CS. On the other hand, the t-test results did not reveal a statistically significant difference in the mean rectum dose between patients under GA and CS ($t = 0.400$, $df = 271$, $p = 0.690$). The mean difference was small (0.53322), and the 95% confidence interval for the difference in means ranged from -2.09298 to 3.15941 when assuming equal variances and from -2.09032 to 3.15676 when not assuming equal variances.

Upon comparing the findings of this study with the other literature, several similarities and differences have emerged concerning dosimetric parameters and the use of different anesthesia techniques during HDR-ICBT for cervical cancer. Similar to Kumar et al.'s findings, our study revealed no statistically significant difference in the mean rectum dose between patients treated under General Anesthesia (GA) and Sedation (CS). In his study, the dose received by 0.1 and 2 cc of sigmoid colon and bladder between the two groups showed no statistically significant difference, but 0.1 and 2 cc of the rectum got a dosage that was substantially higher under PS than under GA (p value 0.05). This might be as a result of improved muscle relaxation during GA, which would result in more suitable vaginal packing. Similarly, Rathore et al.'s results align with ours, showing that dosimetric parameters, including the mean dose to the rectum, were comparable in both anesthesia and conscious sedation (CS) groups. In a his study, Rathore et al. found that the mean dose to the rectum varied between 32.5 and 77.73% and between 21.07 and 79.16% in the anesthesia and conscious sedation (CS) groups, respectively. They came to the conclusion that the dosimetric parameters in both groups were similar and did not depend on the type of anesthesia (21).Moreover, our study's findings support Sharma et al.'s results, as we observed no significant difference in the mean urinary bladder dose between GA and CS groups, resembling the lack of significant disparity in the mean dose to the bladder reference point reported in their research. Sharma et al revealed that the mean dose to the bladder reference point was 5.0 Gy (71.85% of point A dose) in the anesthesia group compared to 4.90 Gy (70% of point A dose) in patients without anesthesia (p value 0.6), and the mean dose to the rectal point was significantly higher in the anesthesia group compared to patients without anesthesia (5.09 Gy) (3). Additionally, Chen et al.'s findings about local vaginal anesthesia align with our focus on comparing anesthesia techniques for patient comfort during HDR-ICBT. However, there are notable differences in the literature. Sharma et al. reported that the mean dose to the rectal point was significantly higher in the anesthesia group compared to patients without anesthesia (3), which contrasts with our study's finding of no significant difference in the mean rectum dose between GA and CS groups. These discrepancies may be attributed to variations in treatment protocols, patient populations, or anesthesia administration techniques employed across different studies. Furthermore, Lim et al. observed considerably greater complications associated with GA during HDR Brachytherapy (4), while our study did not analyze anesthesia-related complications, and none were reported. This discrepancy may stem from differences in patient selection, medical practices, or factors contributing to anesthesia-related complications.

CONCLUSION

Based on the findings of this study, it can be concluded that there is a statistically significant dosimetric difference in the urinary bladder dose between patients undergoing HDR-ICBT for cervical cancer under General Anesthesia (GA) and Conscious Sedation (CS). Specifically, patients treated under GA received a significantly lower mean urinary bladder dose compared to those under CS. However, no statistically significant difference was observed in the mean rectum dose between patients undergoing HDR-ICBT under GA and CS. This suggests that the choice of anesthesia technique may not have a significant impact on the mean rectum dose in this patient population. Based on this findings it is recommended that when planning HDR-ICBT treatment, healthcare providers should carefully consider the choice of anesthesia technique as it may impact the dose received by the urinary bladder. Although no significant difference was observed in the mean rectum dose between GA and CS groups in your study, it is essential to continue monitoring the rectum dose during HDR-ICBT. The rectum is a critical organ at risk, and its dose should be closely monitored to ensure patient safety and minimize potential side effects, and considering using 3D (three dimensional) Treatment Planning will help to show the urinary bladder and rectum for appropriate planning of the treatment dose each will receive.

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