THE CONTROL FACTORS TO MANAGE THE SITE ERRORS OF RADIOTHERAPY DELIVERY

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***ABSTRACT*:** *Radiotherapy was one of the modality of cancer disease which had been recommended by the ISCRO-USA and WHO for every cancer patient. There were two main techniques of radiotherapy delivery, namely teletherapy and brachytherapy. Yet, radiotherapy remained as a high risk treatment, especially the site error of radiotherapy delivery, due to its sophisticated and complex technology and one of the control factor strategies to manage the site error of radiotherapy delivery theoretically was verifying the equality of the irradiation field and the accuracy of the irradiation targets by using a portal imaging. Hence, the objectives of this study were to define the factors that theoretically had significant relationships to the equality of the irradiation field and accuracy of the irradiation target which would influence the certainty of the irradiation using telecobalt60 and the opinions of some experts in the radiotherapy field about the factors, as e control factors to manage the site error of the radiotherapy delivery. The results showed that the scheme, body size, and patient positioning factors had statistically significant relationships to the equality of the irradiation field, meanwhile, all the set-up of the patient, set-up of the teletherapy device, calibration the teletherapy device, quality of the conducting human resources, and mechanical malfunctioning of the teletherapy device factors had a statistically significant relationship to the accuracy of the irradiation target. Therefore, all the factors can be the control factors that need to be concerned to manage the site error of the radiotherapy delivery.*

Keywords: Control factors, Site error, Radiotherapy delivery

INTRODUCTION

Radiotherapy was one of the modality of cancer disease which had been recommended by the Inter-Society Council for Radiation Oncology (ISCRO) USA and the World Health Organization (WHO) for every cancer patient.[1, 2]

The inventions of radiotherapy had been developing since the early of 20th century and paved for the two main radiotherapy techniques, id est. teletherapy and brachytherapy.[3–5] further improved the irradiation targets' certainty as parallel to the invention of the MLC device and CT-Scan.[2–4, 6–8]

Yet, radiotherapy remained a high risk treatment, especially the site error of radiotherapy delivery, due to its sophisticated and complex technology followed by many processes and staff involved in the radiotherapy delivery which required special knowledge and human expertise to operate it, hence increasing the risk for occurring the errors in radiotherapy.[8–13]

The errors in the radiotherapy delivery were the wrong site being treated, the wrong receiving delivery dose of radiation to the patient, and the wrong patient being treated, with the control factor strategies theoretically successive verifying the equality of the irradiation field and the accuracy of the irradiation targets by using portal imaging, checking and re-checking the standard of procedures (SOP) and patient medical record by using the record and verify (RV) checklist system device, in which all of them were included in the guidelines of the quality assurance radiotherapy (QART). Of all the errors, the wrong site being treated (site) error was one of the main errors in radiotherapy which were due to the error in determining/obtaining, either to the equality of the irradiation field (contributed by the scheme of the simulator image, body size of the patient, and patient positioning factors) or accuracy of the irradiation target (contributed by set-up the patient, set-up the teletherapy device, calibration the teletherapy device, quality of the conducting human resources, and mechanical malfunctioning the teletherapy device factors).[9, 11, 12, 14, 15]

Hence, the objectives of this study were to define the factors that theoretically had significant relationships to the equality of the irradiation field and accuracy of the irradiation target which would influence the certainty of the irradiation using telecobalt60 and the opinions of some experts in the radiotherapy field about the factors, as the control factors to manage the site error of the radiotherapy delivery. This study was organized as follows; Section 2, described the method of how the study was conducted, and this was followed by section 3, which presented the results drawn from the study and we concluded the study in Section 4.

I. RESEARCH METHODOLOGY

The aims of this study were to define the factors (id est. the scheme of the simulator image, body size of the patient, or patient positioning) that theoretically had significant relationships to the equality of the irradiation field and the factors (id est. set-up the patient, set-up the teletherapy device, calibration the teletherapy device, quality of the conducting human resources, and mechanical malfunctioning of the teletherapy device) that theoretically had the significant relationship to the accuracy of the irradiation target which would influence the certainty of the irradiation using telecobalt60.

This study was conducted, either by observation to the data of some patients who had carried out the irradiation or by interviewing some experts in radiotherapy field. In the data observation study, the data was collected from observation to the verified computed radiography data of some patients who had conducted the irradiation several times in a week in the telecobalt60 radiotherapy installation of Dr.Moewardi public hospital, Surakarta, Central Java, Indonesia, in October 2018. Meanwhile, the interviewing study was conducted to the 10 subjects who were experts in daily radiotherapy field at some radiotherapy centers/installations in Indonesia and consisted of 4 (40%) subjects as a radiation oncologists, 3 (30%) subjects as a medical physicists, and 3 (30%) subjects as a radiation therapist.

II. THE RESULTS

3.1. The observation data to the irradiation patients.

The results of the observation data of the scheme of the simulator image, body size of the patient, and patient positioning factors that theoretically had a significant relationship to the equality of the irradiation field were shown in table 1 below.

Table 1: The relationship of the factors to the equality of the irradiation field according to the patient's data observation.

No	Independent variable	Dependent variable	R (strength of confidence)	p (significance – p-standard)
1	S	Equality of the field	59%	0.001 (p<0.05)
2	BZ	Equality of the field	42%	0.021 (p<0.05)
3	PP	Equality of the field	54%	0.002 (p<0.05)

S: The scheme of the simulator image; BZ: Body size of the patient; PP: Patient positioning.

Based on table 1 above showed that the scheme, body size, and patient positioning factors had statistically significant relationships to the equality of the irradiation field with their significances and strength of confidence values were successive 0.001 - 59%; 0.021 - 42%; and 0.002 – 54%. Meanwhile, the values of the linear regression for the 3 factors to the equality of the irradiation were 0.372(S) + 0.651(BZ) + 0.651(PP) – 0.837 ($p < 0.03$). The linear regression values showed that the scheme of the simulator image (S) factor had a statistically significant relationship with 0.372 fold influencing to the equality of the irradiation field, and the body size of the patient (BZ) and the patient positioning (PP) factors also had a significant relationship which each of them had the same linear regression values with 0.651 fold influencing to the equality of the irradiation field.

Meanwhile, the results of the observation data of the set-up of the patient, set-up of the teletherapy device, calibration of the teletherapy device, quality of the conducting human resources, and mechanical malfunctioning of the teletherapy device factors that theoretically had a significant relationship to the accuracy of the irradiation target were showed to the table 2 below.

Table 2. The relationship of the factors to the accuracy of the target irradiation according to the patient's data observation.

No	Independent variable	Dependent variable	R (strength of confidence)	p (significance – p-standard)
1	SP	Accuracy of the target	54%	0.002 (p<0.05)
2	STD	Accuracy of the target	54%	0.002 (p<0.05)
3	C	Accuracy of the target	54%	0.002 (p<0.05)
4	QHR	Accuracy of the target	54%	0.002 (p<0.05)
5	MT	Accuracy of the target	54%	0.002 (p<0.05)

SP: Set-up of the patient; STD: Set-up of the teletherapy device; C: Calibration of the teletherapy device; QHR: Quality of the conducting human resources; MT: Mechanical malfunctioning of the teletherapy device.

Based on the table 2 above showed that the set-up the patient, set-up the teletherapy device, calibration the teletherapy device, quality of the conducting human resources, and (mechanical) malfunctioning of the teletherapy device factors, each of them had statistically the same significant relationship to the accuracy of the irradiation target with their significances and strength of confidence values were successive 0.002 and 54%. Meanwhile, the values of the linear regression pattern for each of the factor to the accuracy of the irradiation target were the same and successive 0.667(SP) – $8.8.10^{-17}$ (p=0.002), 0.667(STD) – $8.8.10^{-17}$ (p=0.002), 0.667(C) – $8.8.10^{-17}$ (p=0.002), 0.667(QHR) – $8.8.10^{-17}$ (p=0.002), and -0.667(MT) + 0.667 (p=0.002). All the set-up of the patient (SP), set-up of the teletherapy device (STD), calibration of the teletherapy device (C), and quality of the conducting human resources (QHR) factors had statistically significant relationship which each of them had the same linear regression values with 0.667 fold influencing to the accuracy of the irradiation target, but (mechanical) malfunctioning teletherapy device (MT) linear regression value was -0.667 fold influencing to the accuracy of the irradiation target.

3.2. **The expert opinions in the radiotherapy field**

The results of interviewing the expert in the radiotherapy field were shown in table 3 below.

Based on table 3 above showed that all of the subjects explained that the scheme of the simulator image, body size of the patient, and patient positioning factors influenced the equality of the irradiation field, meanwhile set-up the patient, set-up the teletherapy device, calibration of the teletherapy device, quality of the conducting human resources, and (mechanical) malfunctioning of the teletherapy device factors influenced to the accuracy of the irradiation target.

Their opinions explained that the scheme of the simulator image from the simulator x-ray would allow the certainty of the irradiation by giving justification to the determination in equality of the irradiation field. Meanwhile, the body size of the patient would influence to the equality of the irradiation field by justification to the consistency of determination of the proper clinical skin marking as parallel to the large of the body size of the patient (fat or skinny) and/or the alteration (shrinkage) of the tumor size in the body after several weeks exposed by the irradiation. Furthermore, the patient positioning would influence to the equality of the irradiation field by justification to the convenience of the patient body position while conducting the irradiation.

Their opinions also explained that set-up the patient, set-up the teletherapy device, calibration the teletherapy device, quality of the conducting human resources, and (mechanical) malfunctioning of the teletherapy device factors would influence to the accuracy of the irradiation target by justification to the consistency of determination of the proper clinical marking and teletherapy device which would be accumulated to the whole of the irradiation field teletherapy program. Nevertheless, the calibration and (mechanical) malfunctioning of the teletherapy device factors were more influences to the irradiation given dose.

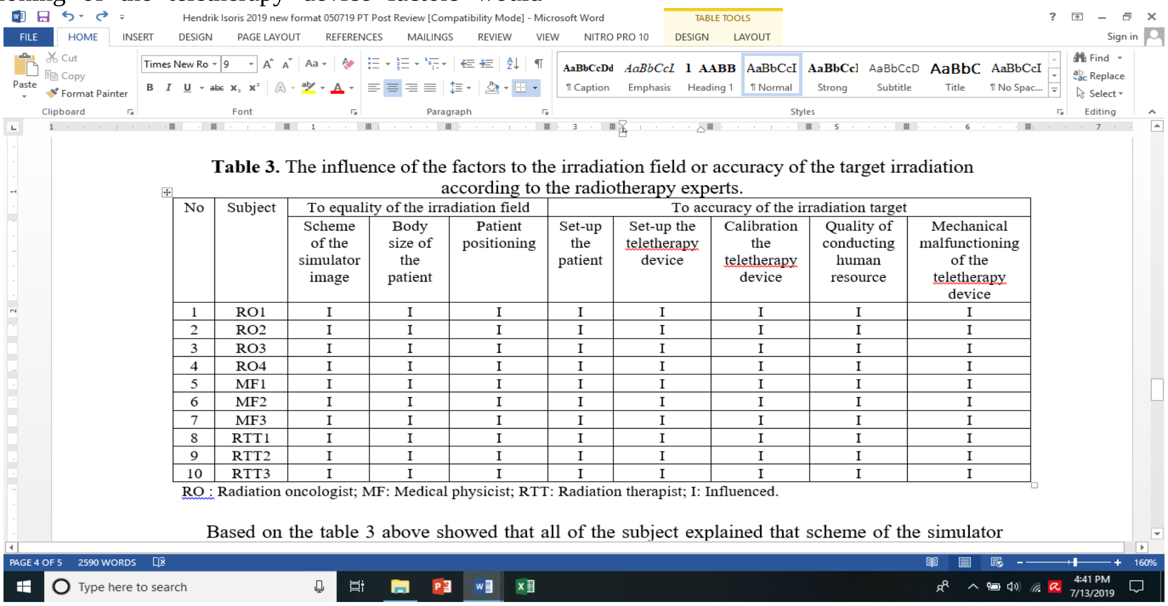

Table 3. The influence of the factors to the irradiation field or accuracy of the target irradiation according to the radiotherapy experts.

No	Subject	To equality of the irradiation field			To accuracy of the irradiation target				
		Scheme of the simulator image	Body size of the patient	Patient positioning	Set-up the patient	Set-up the teletherapy device	Calibration the teletherapy device	Quality of conducting human resource	Mechanical malfunctioning of the teletherapy device
1	RO1	I	I	I	I	I	I	I	I
2	RO2	I	I	I	I	I	I	I	I
3	RO3	I	I	I	I	I	I	I	I
4	RO4	I	I	I	I	I	I	I	I
5	MF1	I	I	I	I	I	I	I	I
6	MF2	I	I	I	I	I	I	I	I
7	MF3	I	I	I	I	I	I	I	I
8	RTT1	I	I	I	I	I	I	I	I
9	RTT2	I	I	I	I	I	I	I	I
10	RTT3	I	I	I	I	I	I	I	I

RO : Radiation oncologist; MF: Medical physicist; RTT: Radiation therapist; I: Influenced.

Based on the table 3 above showed that all of the subject explained that scheme of the simulator

III. CONCLUSION

The factors which consisted of the scheme, body size, and patient positioning factors had statistically significant relationships to the equality of the irradiation field, meanwhile, the other factors which consisted of the set-up of the patient, set-up of the teletherapy device, calibration of the teletherapy device, quality of the conducting human resources, and mechanical malfunctioning of the teletherapy device factors had statistically significant relationships to the accuracy of the irradiation target. Therefore, all the factors can be the control factors that need to be concerned to manage the site error of the radiotherapy delivery.

For future work, it will be needed to formulate the standard of procedures (SOP) as a guideline of quality assurance in radiotherapy delivery which will be clearly able to define check/re-check and verification processes to the control factors to manage the site error of the radiotherapy delivery.

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