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| RESEARCH ARTICLE

Use of *Low Melting Point Alloy* Mcp-96 Filter on Gammagraphic Optimization of Patient Position Verification with Telecobalt 60 Machine

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| ABSTRACT
Verification of the patient's position is a stage in external radiotherapy that aims to ensure the accuracy of radiation therapy administration according to plan. Equipment for the patient position verification process that is often used is Electronic Portal Image Devices (EPID) and film portals. However, not all Telecobalt 60 machines are equipped with EPID, so it requires alternative equipment to verify patient positions. One modality that can be utilized is Computed Radiography (CR). The study was conducted to analyze the use of MCP-96 low melting point alloy filters in imaging, verifying patient positions with CR devices on telecobalt 60 machine can calibrate radiation doses and provide good image quality and anatomical information. The study used a posttest-only control group design by comparing radiation dose, image quality, and anatomical information of the patient's position verification image. Imaging was performed using a phantom pelvis as an object and using CR equipment and low melting point alloy MCP-96 as a filter. The results showed that low melting points alloy MCP-96 with a thickness of 1 cm, 2 cm and 4 cm can calibrate the radiation dose output of the telecobalt 60 machine in accordance with recommendations for kilovoltage imaging. There was no significant difference in SNR and CNR images from imaging verification of patient positions with filter thicknesses of 1 cm, 2 cm, and 4 cm. Filter thickness of 1 cm produces images with optimal image quality and anatomical information in gammagraphic imaging verification of patient position using CR on telecobalt 60 machine. Thus, the use of low melting point alloy MCP-96 thickness of 1 cm and CR devices can be used in gammagraphic imaging of patient position verification on a telecobalt 60 machine as an alternative if you do not have EPID.

| KEYWORDS

MCP-96 alloy, patient position verification, telecobalt 60 machine, image quality

| ARTICLE INFORMATION

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1. Introduction
Radiotherapy is a medical service that uses or utilizes ionizing radiation in the form of x-rays or gamma rays and other particles for the treatment of cancer or non-cancer patients. The goal of radiotherapy services is to improve the survival and quality of life of patients by obtaining an optimal therapeutic ratio that optimizes local and regional controls and minimizes side effects caused (PORI. 2018), (Iramanda, 2021).

Radiotherapy methods can be done with external radiotherapy and brachytherapy services, either as a single modality or combined with other treatments such as surgery, chemotherapy, or other forms of treatment. External radiotherapy services are radiation therapy methods where the radiation source is outside or has a certain distance from the body. While brachytherapy is a radiation

therapy method with a temporary or permanent radiation source placed or brought close to the tumor (PORI. 2018) (Fitriatuzzakiyyah et al. 2017).
There are two types of radiation used in external radiotherapy services, namely electromagnetic radiation and particles. Electromagnetic radiation uses X-rays and gamma rays, while particle radiation uses electrons and protons. The modalities used in external radiotherapy services are the telecobalt 60 machine, *Linear Accelerator* machine (Linac) and *Proton Beam Therapy* (Gianfaldoni et al. 2017) (Beyzadeoglu et al. 2010) (Salminen et al. 2011)

The stages of the process in external radiotherapy services are setting the patient's position and immobilization so that during radiation therapy, the patient's position can be the same and accurate; image capture with a conventional simulator or *Computerized Tomography* (CT) Simulator to set the target volume; radiation planning based on the target volume and critical organs located around the target; evaluation and approval of dose planning; planning results are sent to modalities radiation therapy; verification of the patient's position can be used using a film portal or using *Electronic Portal Image Devices (*EPID); the process of administering radiation therapy; and quality assurance to ensure all stages of the process are running correctly and properly (Beyzadeoglu et al. 2010) (Kodrat et al. 2016)

Verification of the patient's position is a stage of the external radiotherapy service process carried out when the patient will first be in radiation therapy and periodically during the radiation therapy process given. This stage is to ensure the suitability of the patient's position, field area and depth as well as the dose given with the planning that has been designed in the *Treatment Planning System* (TPS) (Beyzadeoglu et al. 2010) (Warjono, 2012)

In developing countries, the telecobalt 60 machine is still widely used in radiotherapy services. In Southeast Asian countries in 2015, there were 72 (seventy-two) telecobalt 60 machines used for radiotherapy services, and in Indonesia in 2018, there were 16 (sixteen) telecobalt 60 machines that are still used in Radiotherapy facilities (Salminen et al. 2011))(Yahya et al. 2018)(PORI (2018)).

For telecobalt 60 units that are not yet equipped with EPID equipment, they can use special films and tapes to verify the patient's position as alternative equipment (Ryangga et al. 2011). However, the use of analog film as alternative equipment in verifying patient positions is now rarely used; this is due to the development of medical imaging technology that has provided a change from previously analog technology-based imagery to digital technology (*filmless*), especially in modern hospitals (Susilo et al. 2013). One of the digital imaging systems used to replace film is *computed radiography* (CR) equipment. However, the gammagraphic images produced by this CR equipment still have low image quality and anatomical information (Istiawan et al. 2014). This is because a telecobalt 60 machine with *megavoltage* energy will produce high radiation scattering.

Based on the explanation above, the author will conduct an optimization analysis of patient position verification using CR as an image receptor and *low melting point alloy* MCP-96 to atenuate the intensity of gamma radiation dose from telecobalt 60 machine into radiation dose used in diagnostic x-ray examination and produce the good image quality and anatomical information.

2. Method

This research is *quasi-experimental research, with a* post-test only control group design *research design carried out in external radiotherapy services with telecobalt 60 machine, especially in the imaging process of verifying patient positions using CR devices and filters from low melting point alloys* MCP-96 is used to reduce the radiation dose of telecobalt 60 machine so that the output dose of the machine matches that used in *kilovoltage imaging*.

This study used *phantom* pelvis as a substitute for patients with separations of 18 cm, 20 cm and 24 cm. For the study sample, extensive field radiation was used for field cases of cervical cancer, prostate cancer and vulvar cancer in the *posterior antero position* (AP).

The results of the image verification were carried out *signal to noise ratio (SNR) and contrast to noise ratio* (*CNR) analysis using the imageJ application with the* region of interest (ROI) technique. For anatomical information, visual assessments are carried out by radiation oncologists, radiotherapy radiographers and medical physicists on the specific anatomy of radiation field boundaries. Then, based on SNR, CNR and percentage of anatomical information, the most optimal filter thickness is analyzed in imaging to verify the patient's position with CR devices.

3. Results and Discussion

1. Radiation dose difference

Table 1. Radiation Dose Measurement Results

Thick Filter	Radiation Field Area	Average Radiation Dose (mGy)
1 cm	Cervical cancer	10.56
	Prostate cancer	9.24
	Vulvar cancer	9.9
2 cm	Cervical cancer	8.16
	Prostate cancer	7.4
	Vulvar cancer	7.35
4 cm	Cervical cancer	3.81
	Prostate cancer	3.88
	Vulvar cancer	3.67

In Table 1, it can be seen that the radiation dose output of telecobalt 60 machine has a downward trend where with the increase in thickness of the MCP-96 alloy low melting point *filter used in patient position verification imaging, the radiation dose output of telecobalt 60 machine* will be smaller. Based on the results of statistical tests from measuring the output radiation dose of telecobalt 60 machines using a surveymeter on gammagraphic imaging, verifying the position of patients without and using a *low melting point alloy* MCP-96 filter with three variations in radiation field area, there is a significant difference with a p-value *of* 0.024 (< 0.05). So there is an influence of the use of MCP-96 *alloy low melting point filters* used in imaging verification of patient positions with CR devices on telecobalt 60 machine on radiation doses, and the relationship between the two variables is very strong where the value of the correlation coefficient is in the range of 0.800 – 1,000 (Fauziah et al. 2018). This can be seen from the results of the Spearman correlation test with a correlation coefficient value of 0.974.

According to Rasuli et al., the recommended radiation dose value in routine pelvic radiology imaging to produce images with optimal quality and low patient radiation dose is no more than 10 mGy (Rasuli et al. 2017). As conveyed by research Rochmayanti et al., the suitability of using radiation doses in imaging techniques will produce optimal image quality (Rochmayanti et al. 2019). Thus, the use of MCP-96 *low melting point alloy* filters with a thickness of 1 cm, 2 cm and 4 cm can reduce the high radiation dose from *megavoltage* imaging to be the same as the radiation dose in *kilovoltage* imaging to provide optimal image quality.

2. Differences in Image Quality

Table 2. Radiation Dose Measurement Results

Thick filter	Field Area	Rerata SNR	Rerata CNR
1 cm	Cervical cancer	19.23	1.81
	Prostate cancer	14.10	3.34
	Vulvar cancer	16.51	2.92
2 cm	Cervical cancer	19.25	1.86
	Prostate cancer	14.06	3.99
	Vulvar cancer	16.49	2.85
4 cm	Cervical cancer	19.25	2.38
	Prostate cancer	14.06	3.90
	Vulvar cancer	16.53	2.66

From Table 2 above, it can be seen that the overall calculation of image quality parameters objectively, namely SNR and CNR values of images from gammagraphic imaging, patient position verification with CR devices on telecobalt 60 machine using *low melting point alloy* MCP-96 filters is categorized into image quality with minimum acceptable standards. This is supported by research from Sajati, which says that the minimum SNR of objects that can still be seen is 12.34, and the minimum SNR value of images that are feasible for the image improvement process is 19.05 (Sajati 2018).

Then, from the results of statistical tests, there was no significant difference in image quality in variations in gammagraphic imaging verification of patient positions with CR devices on the telecobalt 60 machine (*p-value* > 0.05). This is because imaging with *megavoltage order energy* has a mass attenuation coefficient between networks that is not much different, resulting in the contrast between networks that are not much different as well. In addition, scattering of radiation with high energy levels will cause deterioration in image quality due to high *noise* (Ryangga 2011).

3. Differences in image-specific anatomical information

To see the agreement on the perception of observer assessment, a statistical test of *Cohen's Kappa* was carried out with the following results:

Table 3. *Cohen's Kappa Statistical Test Results*

Observer	Kappa *Index*	Information
Observer 1xObserver 2	0.646	Good
Observer 1xObserver 3	1.000	perfect
Observer 2xObserver 3	0.885	perfect

From Table 3, Kappa values of more than 0.60 are obtained for all observers. This means that the assessment of all three observers has a good agreement rate because the K value is greater than 0.60.

Furthermore, for the results of the visual observer's assessment of the percentage of specific anatomical information, the radiation field boundary image can be seen in Figure 2.

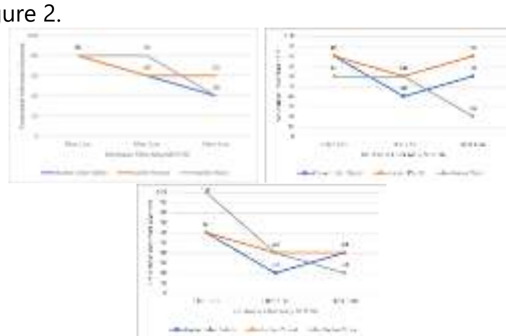

Figure 2. Visual Assessment Graph of Anatomical Information from 3 Observers

Based on Figure 2, it can be seen that the visual assessment results of the three observers have a downward trend in the percentage of image-specific anatomical information on gammagraphic imaging, patient position verification without and using *low melting point alloy* MCP-96 filters with a thickness of 2 cm and 4 cm.

This decrease in anatomical information is due to scattering radiation due to the interaction of radiation with filter material. Research by Juliasa said that the use of *megavoltage* energy would produce *noise* and cause *Compton* scattering; it affects radiotherapy image information (Juliasa 2020). And research by Anjam et al. (Anjam et al. 2019) said that photon energy on a high telecobalt 60 machine will produce scattering radiation that can reduce image contrast, causing difficulties in determining the anatomical boundaries of the radiation field.

Thus, the use of MCP-96 *alloy low melting point* filters affects subjective image quality by visual assessment of clarity of anatomical information of image gammagraphic imaging results of patient positions using CR devices on a telecobalt 60 machine.

4. The Most Optimal *Use of* MCP-96 Low Melting Point Alloy Filter

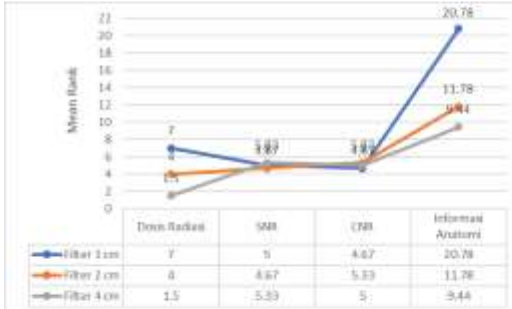

Figure 2. Comparison Results of the Effect of *Low Melting Filter Thickness Points Alloy* MCP-96

Based on the results of the *mean rank* in Figure 1, it can be seen that the difference in filter thickness and radiation dose has no effect on the SNR and CNR values of gammagraphic images shown by an insignificant difference in values. Supported by the results of the *Kruskal Wallis H* test, which shows no significant difference in the variation in the use of *low melting point filters of* MCP-96 alloy against SNR and CNR values with *p-values* above 0.05. This is due to the high *noise* produced in high-energy imaging by the telecobalt 60 machine. This is in line with the results of research from (Sparzinanda 2018 et al.), who said that the higher the energy given, the greater the value of contrast, quantity and brightness of the image.

Meanwhile, on anatomical information, the image of filter thickness and radiation dose has a significant influence, as seen in the significant difference in *mean rank*. This is supported by the results of the *Kruskal Wallis H* test, which has *a p-value of* less than 0.05, meaning that there is a significant difference in the use of 1 cm, 2 cm and 4 cm thickness filters for gammagraphic imaging to verify the position of patients with CR equipment on telecobalt 60 machines. The *highest mean rank* value is in the use of a *low melting point filter* alloy MCP-96 1 cm thick, so it can be interpreted that with the use of a 1 cm thickness filter can be produced the most optimal image anatomy information.

Thus, the use of a low melting point alloy MCP-96 filter with a thickness of 1 cm can produce the most optimal radiation dose, image quality and anatomical information in gammagraphic imaging verification of patient positions with CR equipment on telecobalt 60 machine.

4. Conclusion

The use of MCP-96 *alloy low melting point* filter that is most optimal for use in gammagraphic imaging verification of patient position with CR devices on telecobalt 60 machine is 1cm thick because it can reduce the radiation dose in patients according to the recommended dose on *kilovoltage* imaging and produce the acceptable image quality and anatomical information.

4.1 Research Limitations

The limitation of this research is that the object is used only in the pelvic area and uses the telecobalt 60 machine modality at Dr. Moewardi Hospital Surakarta. Digital image processing techniques have not been carried out to get optimal image quality.

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