International Journal of Allied Medical Sciences and Clinical Research (IJAMSCR)

ISSN:2347-6567

IJAMSCR |Volume 8 | Issue 1 | Jan - Mar - 2020
www.ijamscr.com

Research article *Medical research*

Application of wiener filter computed radiography (CR) technique to eliminate noise (denoising) of image quality and anatomy in verification geometric radiotherapy

I Wayan Juliasa*[1], Hermina Sukmaningtyas[2], Ardi Soesilo Wibowo[3], A. Gunawan Santoso[2], CH. Nawangsih[2] and Gatot Murti Wibowo[3]

[1]*Postgraduate Program Master of Applied Imaging Diagnostic, Semarang Health Polytechnic, Indonesia*

[2]*Department of Radiology, Dr. Kariadi General Hospital Medical Center, Semarang, Indonesia*

[3]*Department of Radiodiagnostic and Radioteraphy Technic, Semarang Health Polytechnic Indonesia*

***Corresponding Author**: **I Wayan Juliasa**

Email id: juliasawayan82@gmail.com

ABSTRACT

The success of radiotherapy irradiation is very dependent on geometric verification, as for the geometric verification that is commonly done using Film, Electronic Portal Imaging Device (EPID) and Computed Radiography (CR). However, the main problem is the use of Megavolt energy (MV) on LINAC aircraft can cause compton effects that can cause a decrease in image quality, both spatially (blurring) or point (noise). The application of the denoising wiener filter technique for geometric radiotherapy image verification is carried out to minimize the noise caused by the use of high energy in the LINAC aircraft. This research method is a quasi experimental that aims to improve the quality of anatomical images in the verification of geometric radiotherapy, especially on CR images and compared with EPID as a gold standard. This study uses Phantom CIRS to minimize the effects of radiation and 7 observers of Radiation Oncologists for image evaluation. Significant results of all aspects of anatomic information between before and after the wiener filter technique was performed with a p-value <0.01, and there was no difference in the anatomical information between the EPID and after the wiener filter technique with a p-value> 0.05. The use of CR with wiener filters can be an alternative in verification geometric radiotherapy and is able to offset the gold standard EPID.

Keywords: Radiotherapi, Verification Geometic, LINAC, Chest, Head and neck

INTRODUCTION

The application of external radiation (teleterapy) radiotherapy has been proven to improve local control (LC) and overall survival (OS) for 5 years in cancer cases, especially in stage 2, the greatest benefit of external radiotherapy is the case of neck head cancer (LC 32%, OS 16 %) and cervix (LC 33%, OS 18%) [1]. External radiation is a method of radiotherapy irradiation with a radiation source located at a certain distance from the patient's body. This external radiation method has a wide radiation range so that in addition to the primary tumor that is getting

radiation, also regional lymph nodes (lymph nodes) [2].

External sources of radiation are Cobalt-60 and Linear Accelerator (LINAC). LINAC is better when compared to Cobalt-60, because of the potential risk of harm caused by the source of Cobalt-60 itself. LINAC is a tool used to accelerate atoms or particles that are accelerating along a straight line due to potential differences between the cathodes between these trajectories. The accelerator also contains an electric and magnetic force to control the direction of motion of the particles, the energy released by LINAC is Megavolt (MV) [3]. The success of radiotherapy irradiation is highly dependent on verification of the geometric irradiation set up. The purpose of verification of the radiation set up is to ensure that the accuracy of the radiation set up from the given radiation is still within the limits allowed in the radiation plan. Verification is commonly done by using Film, Computed Radiography (CR) and Electronic Portal Imaging Device (EPID) [4].

EPID is an additional hardware that can be integrated into a LINAC aircraft with a digitalization system that can be viewed on a computer monitor [5].The main problem is the low quality of the resulting image due to the use of MV energy released by LINAC and the occurrence of compton effects, thus requiring Digital Image Processing (DIP) as an alternative to improving image quality [6]. The DIP wiener filter technique can reduce the MSE value and increase the PSNR value when compared with other filter techniques such as: Unsharp filter, Average filter and Median Filter. The application of wiener filter technique is better in denoising the image, especially on CR [7].

Previous research conducted by Hakim and Gonzales using DIP on EPID images with Contrast Limited Adaptive Histogram Equalization (CLAHE) software and wavelet-based algorithms as an effort to denoise and improve the quality of radiotherapy images [8]. Ryangga in his study used CR as a radiotherapy treadment planning system to Verification. The high energy (MV) produced by LINAC can reduce image quality, using the metal filter method and the combination of material and thickness that has been done, as an effort to get good image quality. The weaknesses in this study are the results of variations in the object and the combination of material and filter thickness that is different in each organ [9].

Based on the results of a survey conducted in the Indonesian radiotherapy department, several Indonesian radiotherapy departments, there are still those who do not yet have the EPID hardware enhancements, therefore alternatives can be made using CR for the imaging process. Research conducted by Roberts comparing the visibility of landmarks of anatomic information (head and neck, chest) between CR and EPID, where the results of images from CR are comparable to EPID. The application of wiener filter on CR to do geometric verification, the researcher wants to assess the improvement of image quality, which includes geometric verification and comparing the resulting anatomical image information (before and after) and can accommodate the needs of Radiation Oncologists, Physicist Medical and Radiation Therapists with image and information quality optimal anatomy for conducting geometric verification.

METHOD

Type and Design of Reserch

This type of research is a quasi experimental study, with 2 researches designs namely Pretest Posttest without Control Group Design to compare before and after denoising wiener filter and Posttest Only without Control Group Design to compare EPID with CR after denoising wiener filter. In this study using phantom as a teaching aid to minimize high radiation dose receipts and 7 Radiation Oncologists who assess anatomical information visually

DATA ANALYSIS

Data analysis conducted by this study was testing the image quality, namely MSE and PSNR as well as anatomic information. Some statistical tests are also carried out such as, kappa test which aims to assess the level of understanding among observers. The strength level of this kappa score is a “good agreement”, and then proceed with the Wilcoxon test. This test is done to see the mean rank on the CR image before and after the wiener filter is performed. After getting the highest mean rank value then compared to the EPID as gold standard using the Mann Whitney statistical test.

RESULTS

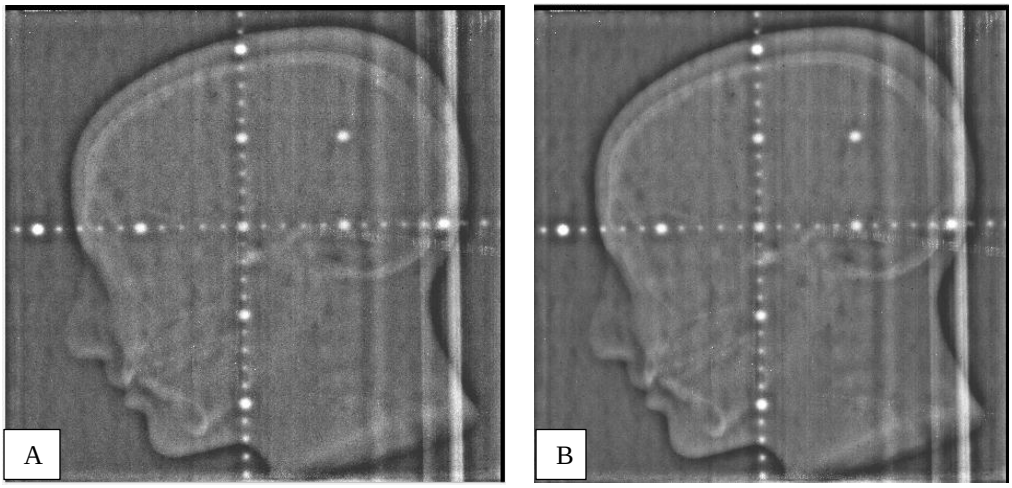
The results of the image from the verification of geometric radiotherapy with head and neck and chest objects, then denoising image processing using a wiener filter. Furthermore, an analysis with MSE and PSNR parameters was performed to determine differences in image quality between the two images. The following are the results of MSE and PSNR calculations on the image of geometric radiotherapy verification with CR, before and after the wiener filter technique is carried out, the following are the results of the MSE and PSNR calculations on the image of geometric radiotherapy verification with CR, before and after the wiener filter technique

Table 1. MSE And PSNR Calculation Results Image Verification CR

Citra	MSE	PSNR (dB)
Head and neck (AP)	0.0073	117.7252
Head and neck (Lateral)	0.0075	117.6029
Chest (AP)	0.0086	116.9904
Chest (Lateral)	0.0088	116.8869
Average	0.0081	117.3014

From table 1 above, it shows that the results of MSE and PSNR images before and after the denoising wiener filter technique are done each have an average value of 0.0081 and 117.3014 dB. Where the wiener filter technique is able to provide an MSE value close to 0, which means the smaller the MSE value, the better the image display, while the greater the MSE value, the display on the resulting image will get worse. As for PSNR, the wiener filter technique is able to provide PSNR values above > 40 dB which is 117 dB, where the wiener filter technique is able to eliminate good noise signals and get high image quality results, the higher the PSNR value the better the image quality to eliminate noise

The difference in anatomical information results, where the image before denoising experiences noise degradation which greatly disturbs the image results from geometric verification of radiotherapy. While in the image after denoising can reduce good noise so as to display clear antomi information, clear structure and firm boundaries



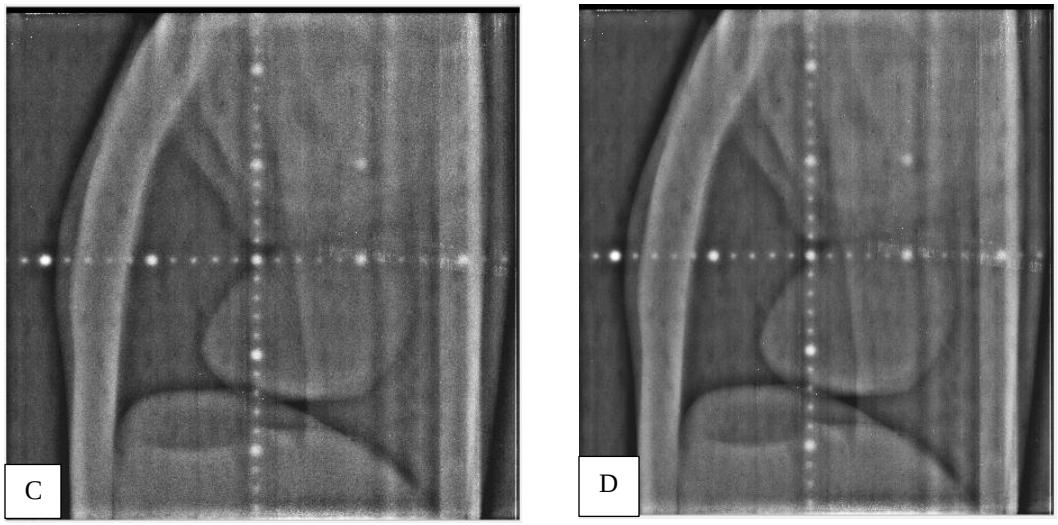


Figure 1. Geometric verification images of lateral projections, (a) CR head and neck image before denoising (b) CR head and neck image after denoising wiener filter. (c) CR chest image before denoising (d) CR chest image after denoising wiener filter.

For the assessment of anatomical information, a relative Visual Grading Analysis (rVGA) is performed by Radiation Oncologists as observers. This research was conducted with images between before and after the denoising wiener filter

Table 2. Wilcoxon Test Results Of CR Anatomical Information Before And After Denoising Wiener Filters On Head And Neck Objects

Anatomical	***Men Rank***		***P-Value***
Information	**Before**	**After**	
Frontal sinus	0,00	4,00	<0,01
Occiput	0,00	4,00	<0,01
Pituitary Fossa	0,00	4,00	<0,01
Orbital Ridge	0,00	4,00	<0,01
Maxila	0,00	4,00	<0,01
Cervical	0,00	4,00	<0,01

Table 3. Wilcoxon Test Results Of CR Anatomical Information Before And After Denoising Wiener Filter On Chest Object

Anatomical	***Men Rank***		***P-Value***
Information	**Before**	**After**	
Lung Apex	0,00	3,50	<0,01
Sinus Costophrenicus	0,00	4,00	<0,01
Heart	0,00	4,00	<0,01
Sternum	0,00	4,00	<0,01
Diagfragma	0,00	3,50	<0,01
Vertebrae	0,00	4,00	<0,01

Tables 2 and 3 show that the highest mean rank value obtained by the image after the denoising wiener filter technique is performed both on the head end neck and chest objects, while all anatomic information has a p-value <0.05, which means that there are significant differences in anatomic information.

After obtaining a high mean rank value after denoising, then it is compared again with the EPID as a gold standard which aims to compare the anatomical information on rVGA head and neck objects.

Table 4. Mann Whitney Test Results Of EPID And CR Anatomical Information After The Denoising Wiener Filter Technique Was Performed On The Head And Neck object

Anatomical Information	*Men Rank*		*P-Value*
	EPID	After	
Frontal sinus	8,50	6,50	>0,05
Occiput	7,00	8,00	>0,05
Pituitary Fossa	8,50	6,50	>0,05
Orbital Ridge	9,00	6,00	>0,05
Maxila	9,00	6,00	>0,05
Cervical	8,50	6,50	>0,05

Table 5. Mann Whitney Test Results Of EPID And CR Anatomical Information After The Denoising Wiener Filter Technique Was Performed On The Chest Object

Anatomical Information	*Men Rank*		*P-Value*
	EPID	After	
Lung Apex	8,50	6,50	>0,05
Sinus Costophrenicus	8,50	6,50	>0,05
Heart	8,50	6,50	>0,05
Sternum	8,50	6,50	>0,05
Diagfragma	8,50	6,50	>0,05
Vertebrae	8,50	6,50	>0,05

Based on the results of tables 4 and 5 show that the Mann Whitney test mean rank value with anatomical information (head and neck and chest) on the verification of geometric radiotherapy with EPID has a higher mean rank compared to the image after the denoising wiener filter. While the significance of the Mann Whitney p-value test with anatomical information (head and neck and chest) on the verification of geometric radiotherapy with EPID and CR after denoising with a wiener filter, has a p-value above above 0.05, meaning there is no difference in anatomic information (head and neck and chest) on the verification of geometric radiotherapy with EPID and CR after denoising the wiener filter

DISCUSION

Wiener filter is a method that is able to suppress the noise speech magnitude signal spectrum S ˆ (ω) and original signal magnitude spectrum S (ω) [10]. Noise on the radiotherapy image is caused by the MV energy released by the LINAC aircraft, at energies of more than 1 MV, this compton effect will occur which causes the radiotherapy image to degrade noise or blurring so that the compton effect can cause the image quality in the radiotherapy to decrease.Wiener filters can filter out noise that has been damaged by the signal, this filter is based on a statistical approach. Most of all filters are designed to respond to the desired frequency. Wiener filters can filter out noise and give a different look to the image. The purpose of this filter is to reduce the average square error as much as possible and be able to reduce noise and reduce function. The overall difference in anatomic information on the EPID is due to the EPID using its imaging device using a Charge Coupled Device (CCD) to the A-siflat panel device which has a good advantage of improving image quality and produces lower noise compared to the use of CR. Based on the results of the significance value in the Mann Whitney test states that overall there is no significant difference in the anatomical information of geometric radiotherapy verification images (head and neck, chest) with EPID and CR after the denoising wiener filter has a significance value of p-value > 0.05. This shows that between CR after a denoising

wiener filter and EPID there is no visual difference from anatomic information.

The use of CR in radiotherapy verification is because CR is an imaging tool that does not require the use of hard copy (film), CR images are obtained by Photostimulating Stroge Phosphor (PSP) to acquire data so that the process from analog to digital systems [11]. The application of CR becomes feasible in radiotherapy verification. Limitations in this study using denoising wiener filters can reduce noise in CR images of geometric radiotherapy verification using phantom objects, but have never been applied to human objects that have clinical history (with pathology) or other organs. Meanwhile in the application of direct practice because there has never been a test of precision, accuracy and sensitivity as well as refinement of appearance so that it can facilitate both the Radiation Oncologist, Physicist Medical and Radiation Therapists in running the wiener filter image program

CONCLUSIONS

Based on the results and discussion in this study, it can be stated that there is an increase in image quality both in MSE and PSNR calculations and there are significant differences in the application of the denoising wiener filer technique in the geometric verification image of CR. There is no significant difference between the CR geometric verification image and the wiener filter, so that it is able to offset the EPID as a gold standard

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How to cite this article: I Wayan Juliasa, Hermina Sukmaningtyas, Ardi Soesilo Wibowo, A. Gunawan Santoso, CH. Nawangsih and Gatot Murti Wibowo. Application of wiener filter computed radiography (CR) technique to eliminate noise (denoising) of image quality and anatomy in verification geometric radiotherapy. Int J of Allied Med Sci and Clin Res 2020; 8(1): 51-56.
Source of Support: Nil. **Conflict of Interest:** None declared.