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Optimization of mAs with iterative reconstruction (IR) on dose reduction and image information (phantom study on CT scan facial bone examination)

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ABSTRACT

The effective dose of CT scan of the facial bone is about 20.2 mGy - 42.1 mGy, the radiation dose is influenced by kV, mAs and pitch which are directly proportional to the image quality. When the dose is lowered the noise will increase, so Iterative Reconstruction (IR) is used to reduce noise and radiation doses.

There is a dose reduction in the use of mAs and differences in anatomical information with IR on CT Scan Facial Bone examination.

This type of research is a quasi-experimental pretest-posttest design with control. The study sample consisted of 5 variations of mAs in the treatment group and 1 control group sample. Measurements were carried out by univariate tests for radiation doses, differences in anatomical image information on variations of mAs with friedman test, followed by post hoc tests. Assessment of anatomical information is done quantitatively by 2 radiologists.

There was a decrease in radiation dose between control and treatment groups, a control group the resulting radiation dose mGy 53.66, the lowest dose treatment group 12.56 mGy at 37.5 mAs variations, differences in anatomy image information (p value <0.05) treatment and control groups

There was a decrease in radiation dose of routine protocols, use of mAs 37.5 on CT Scan of Facial Bone with IR to produce the lowest dose and optimal anatomical information.

Keyword: Iterative Reconstruction, mAs, CT Scan Facial Bone

INTRODUCTION

The radiation dose produced by CT Scan aircraft has now become a special concern, because the CT Scan dose is much larger than conventional examinations. The effective dose produced on CT scan is about 2mSv - 20 mSv for each examination, The mean effective doses were 7.7 mSv with MDCT and 3.63 mSv with excretory urography [1] whereas the conventional effective radiological examination is < 0.1 mSv - 1.5 mSv [2, 3]. The use of CT scans in children with a cumulative dose of about 50 mGy is three times more likely to be at risk for leukemia, while a radiation dose of around 60 mGy has a risk of developing brain cancer [4].

In CT scan, there are several factors that affect the radiation dosage such as tube voltage (kV), millimeter-second (mAs), section thickness, pitch and distance of the tube to isocenter CT scan [5,6]. This factor is a difficult combination that can affect the radiation dose, but the main factor in producing radiation is kV and mAs. kV affects the amount of x-ray emission produced to penetrate the object, kV determines the maximum radiation of the x-ray so that it affects the quality of x-ray radiation, while mAs affects the quantity of x-ray radiation produced, mAs is proportional to the number of electrons moving from the cathode to the anode per unit of time[7], mAs determine the number of photons or doses in the patient during scanning because the dose is directly proportional to mAs. The image quality of kV and mAs is the primary factor that influences the contrast of resolution and noise, while the spatial resolution is influenced by geometric factors [8].

Various efforts have been taken by the producers to reduce CT scan radiation doses such as modulation of tube current and low use of mAs. Setting mAs is the most common approach, when the current is reduced by half the radiation dose is reduced by about 50% [9] but when mAs are lowered there is an increase in noise in the image. Filter back projection (FBP) is one filter that tends to improve image quality by reducing noise but FBP cannot produce quality diagnostic images consistently.

Another method employed to reduce radiation doses is Iterative Reconstruction (IR)[10]. IR was first introduced in 2008, several clinical studies of this method can reduce noise and radiation doses by up to 50%. The reconstruction method in IR focuses more on reducing the patient's dose, resulting in clearer images without reducing image quality [11]. IR capability is thought to be able to improve image quality and reduce radiation doses by maintaining diagnostic acceptability were not ideal propagation data are reconstructed to be more significant than ordinary CT scans [12,13].

One of the tests that are often done is CT Scan facial bone or CT scan of facial bones. On the application of CT Scan Facial Bone examination using CT Scan head protocol and then reconstructing of post scanning. In the routine CT examination protocol of the facial bone itself, the radiation dose produced was 37 mGy while the CT Scan head dose was 60 mGy [14] so that the radiation dose received by the patient was greater than it should be, the concern that occurred due to the use of low doses would have an impact on image quality [15].

Efforts made to reduce the radiation dose received by patients were by reducing mAs, but by decreasing mAs it resulted in a decrease in resolution contrast, the smallest part of the facial bone such as fine bone structure, cleft joints and paranasal sinuses which needed very thin slice thickness did not appear so clear due to increased noise [16], the IR technique is combined with CT Scan facial bone protocol to reduce noise so that it can display the smallest anatomical structure of the bone.

MATERIAL AND METHODS

In this study conducted using an anthropomorphic phantom head. The use of head anthropomorphic phantom is intended as a substitute for the patient's head to avoid the risk of CT Scan radiation doses given during the study. The type of research used is quantitative with the pretest-posttest design with quasi-experimental design with control. In this research design aims to obtain the value of mAs with optimal IR. Variations of mAs used are 87.5 mAs, 75 mAs, 62.5 mAs, 50 mAs and 37.5 mAs. The radiation dose measuring instrument used is CTDIvol CT Scan monitor screen. CTDIvol is used as a dose index of radiation produced by CT Scan, to determine the estimated dose received by the patient. Information assessment of CT anatomical facial bone image to get the most optimal value of mAs with IR. The assessment is done by 1 competent radiology specialist and has more than 5 years experience in the interpretation of CT Scan Facial Bone. Assessment is done by giving a questionnaire with Assessment was carried out by giving a questionnaire with the criteria assessed, namely the coronal osteomeatal complex cuttings in lamina cribrosa, ethmoid sinus, maxillary sinus, inferior rice concha, medium rice concha, nasal septum, supraorbital incisura, lateral orbit and zygomaticum [8] with a score of 1, 2,3,4 for each of the biggest images is 4, the provisions carried out are large values given in the clearestimage. Univariate analysis was performed to describe the radiation dose received by the patient through CTDIvol measurements on the monitor screen by using radiation dose tables and graphs. Bivariate analysis is to assess information on anatomical images on variations of mAs with IR using the Friedman test. Followed by a post hoc to see the difference between variations in mAs values using the Wilcoxon test.

RESULT

CTDIvol CT Scan Facial Bone protocol in the intervention group and routine vendor settings protocol in table 1. Scan parameters of CT Scan Facial Bone examination kV and pitch between each treatment were the same ones, while the difference was mAs in each treatment and control group. Radiation doses with varying mAs values produce different radiation doses. In the treatment group with mAs 87.5 the radiation dose produced was 29.36 mGy, the dose with mAs 75 was 25.20 mGy, the dose with mAs 62.5 was 20.97 mGy, the dose with mAs 50 was 16.78 mGy and dosage with 37.5 mAs is 12.56 mGy, while in the control group mAs 300 the resulting radiation dose is 53.66.

Table 1. Scan parameters and radiation doses with variations of mAs

	kV	mAs	Pitch	CTDIvol (mGy)
Intervention group				
	120	87.5	0.5	29.36
	120	75	0.5	25.20
	120	62.5	0.5	20.97
	120	50	0.5	16.78
	120	37.5	0.5	12.56
Control group				
	120	300	0.5	53.66

Table 2. Different test between intervention group and control on variation of mAs with IR

Variation of mAs		p value
Intervention	**Control**	
mAs 87.5		0.046
mAs 75		0.046
mAs 62.5	Control with mAs 300	0.008
mAs 50		0.011
mAs 37.5		0.011

The table shows the p value <0.05 between all intervention groups and the control group, which mean that there are differences in anatomical information between each variation of mAs and the control group. The value of mAs by considering the lowest dose but has anatomical information that can be acceptable to the respondent at 37.5 mAs, the results of the evaluation of the 37.5 mAs total scoring obtained is 22

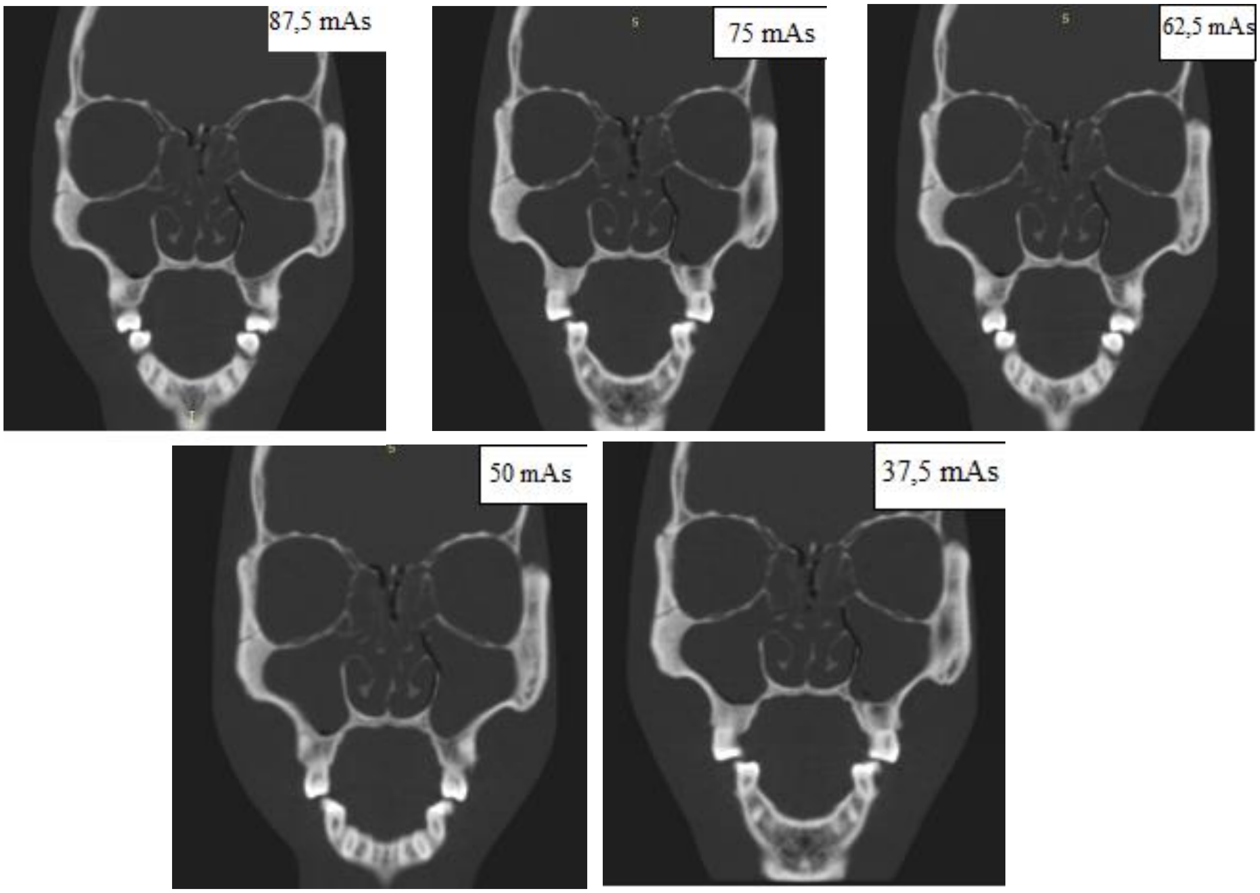

Figure 1. Variation of mAs on CT scan of facial bone with ASIR 60%

DISSCUSSION

The dose decreased with the decreasing value of mAs given, obtained in routine protocols mAs used 300 mAs with a radiation dose of 53.66 mGy, whereas in the highest treatment group mAs used were 87.5 mAs with a dose of 29.36 mGy then mAs the most low is 37.5 mAs with a dose of 12.56 mGy.

In this study, there was a dose reduction of more than 50% of the treatment group with the lowest mAs compared to the control group which was a routine examination protocol. mAs affect the quantity of x-rays produced in proportion to the number of electrons moving from the cathode to the anode per unit of time, mAs determines the number of photons (doses) in the patient during scanning because the dose is directly proportional to mAs [8], mAs is the multiplication of the tube current (mA) and time (s) equally affects noise and radiation doses so mA or mAs are considered the same [17].

In previous studies on CT Colonography examination using a routine protocol of 50 mAs, using ASIR was able to reduce 50% of the routine dose to 25 mAs without reducing image quality [18]. Other studies [12] reduced radiation dose by reducing mAs by 35-60% from the initial protocol on abdominal CT scan by using 40% ASIR, which resulted in a dose based on CTDIvol of 12.5 mGy. The lowest radiation dose always has an effect on changes in the body's biological system, both at the molecular and cell levels. When viewed from the radiation dose the radiation effect is divided into a stochastic and deterministic effect. The stochastic effect is the effect that occurs due to radiation exposure with doses that cause cell changes, while the deterministic effect does not possess a threshold dose that causes cell death due to radiation exposure to the body [19]. When radiation interacts with the body, the biological effect produced depends on the amount of energy absorbed and the type of radiation. In children with a cumulative dose of about 50 mGy it is three times more likely to be at risk of developing leukemia, while a radiation dose of around 60mg has a risk of developing brain cancer [4]. The high risk factor of cumulative dose on CT scan is children with age less than 17 years [20].

When viewed from the concept of ALARA (As Low As Reasonably Achievable) by utilizing the lowest possible radiation by obtaining optimal results, one of them is optimizing the factors that can influence the radiation dose. Optimization refers to the lowest possible dose reduction by maintaining the required image quality to make a diagnosis [8]. In this study, researchers optimized the value of mAs to get acceptable image results. The radiation dose generated is based on a routine protocol which is a factory setting of 53.66 mGy, whereas from the measurement results and calculations carried out by the radiation dose can be reduced initial dose to 12, 56 mGy.

Some of the main factors that influence image visibility in displaying anatomical, tissue and pathological structures are image quality that influences information on anatomical imagery. Image quality consists of contrast resolution, detail or spatial resolution, noise and artifacts that affect each other. One parameter that affects contrast resolution is mAs, mAs is the multiplication of mA and s equally affects dose and contrast resolution [17]. CT scans contrast resolution is a characteristic imaging process that displays differences in soft tissue with bone. The resolution contrast is directly proportional to mAs and inversely proportional to noise, when mAs are lowered the resolution decreases so that soft tissue cannot be clearly visualized because it is filled with noise, but objects with high density like bones can still be visualized [21] even though spatial resolution or the details also decreased, the decrease in spatial resolution was not only caused by physical parameters such as the focal spot size and the dimensions of the detector elements but at the time of image reconstruction also affected the image results [22].

Iterative Reconstruction (IR) is one of the algorithms used to process images after data acquisition. IR performs a hybrid mathematical iteration process and statistical modeling to identify selectively reduce noise in an image [20]. IR changes are repeatedly the value of the pixel Hounsfield image until the final value is found using matrix algebra to change the value of each pixel (y) to the estimated new pixel value. In this study, IR was used to reduce doses and improve image quality because the value of mAs given was lower than routine protocols on facial bone CT scans. The type of IR used is Adaptive Statistical Iterative Reconstruction (ASIR) 60% is considered to have been able to reduce noise and improve image quality, according to previous studies the use of ASIR below 50% does not significantly improve image quality with very low doses [24] whereas in research Another finding ASIR levels in 20-40% failed to show a significant difference in increasing signal-to-ratio (SNR) compared to FBP, using ASIR 60% and significantly higher can improve image quality [25]. According to the author, IR is often considered as an attempt to reduce the radiation dose to the patient indirectly, because IR is used to reconstruct a data made with a low exposure factor, so that a lot of noise arises so that it is done with repetitive reconstruction.

One of the purposes of using IR on facial bone CT scans aims to reduce noise so as to get maximum anatomical information. The results showed that there were different in anatomical information on each variation with p-value 0.0001 ($p<0.05$). Determination of the optimal category by considering the variables of radiation dose produced at 37.5 mAs value of 12.56, in addition to consideration of anatomical information variables because radiographic images that have the power to perform interpretations are radiology specialists. Previous research [26] conducted ASIR arrangements to see how far image quality could be maintained, obtained ASIR 20% and 20% mA reduction with the same noise as the use of standard protocols reconstructed with FBP, decreasing mAs from routine parameters of 300 mAs to 37 5 mAs so that the reduction of doses up to 50% is possible because it uses a bone window, not for soft tissues such as gray matter, white matter and CSF so that noise does not significantly affect SNR, but in the paranasal sinuses changes in mAs affect contrast resolution decreases and noise increases so can not properly display mucosal features in the sinuses.

CONCLUSION

There was a decrease in radiation dose of routine protocols, use of mAs 37.5 on CT Scan of Facial Bone with IR to produce the lowest dose and optimal anatomical information.

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