

## **RADIOGRAPHIC IMAGE QUALITY AND DOSE AT THÓRAX, ABDOMEN AND SKULL OF PATIENTS AT HC-FMB UNESP**

**Matheus Alvarez<sup>1</sup>, Diana R. de Pina<sup>2</sup>, Guilherme Giacomini<sup>1</sup>, Fernando A. Bacchim Neto<sup>1</sup>, Allan F. F. Alves<sup>1</sup>, Alexandre F. Velo<sup>1</sup> and José R. A. Miranda<sup>1</sup>**

<sup>1</sup> Departamento de Física e Biofísica – Instituto de Biociências de Botucatu (IBB)  
Universidade Estadual Paulista “Júlio de Mesquita Filho”  
Rua Bento Lopes, s/n - Rubião Júnior  
8618-970 Botucatu, SP  
matheus@ibb.unesp.br

<sup>2</sup> Departamento de Doenças Tropicais e Diagnóstico por Imagem – Faculdade de Medicina de Botucatu (FMB)  
Universidade Estadual Paulista “Júlio de Mesquita Filho”  
Rua Bento Lopes, s/n - Rubião Júnior  
8618-970 Botucatu, SP  
drpina@fmb.unesp.br

### **ABSTRACT**

ICRP 103 specifies reference dose levels to be used during radiographic exams. Usually, the radiographer qualitatively determines the best radiographic technique (kV and mAs) in order to obtain better image quality with the lowest dose. The objective of this study was to evaluate the doses used in examination of the chest, abdomen and skull in patients of different physical sizes, and infer about the amount of dose required to maintain acceptable radiological contrast in patients of different physical sizes.

Techniques used by experienced radiographers of HC-FMB-UNESP for examinations of the chest (PA), abdomen (AP) and skull (AP) for patients of different thickness (small, medium and thick body) were obtained. Dose measurements were performed referring to all kV/mAs combinations. PMMA phantoms were placed below the ionization chamber. The Signal Difference Noise Ratio (SDNR) of the images of the phantoms were calculated from an area of contrast and a region of normal tissue. The Figure of Merit (FoM) was calculated for each of the exam modality.

Measured FoM decreased according to the thickness of the chest and abdomen, indicating the need to increase the dose level to maintain the same level of image contrast. Patients thicker usually end up getting more than twice the dose of lean patients. Required image quality levels for correct diagnosis should be obtained using dose levels as low as reasonably practicable examination. These factors highlight the need for a program of quality assurance and effective dose studies in actual service.

### **1. INTRODUCCION**

In radiology it is necessary that the acquired image have clinical image quality for an accurate diagnosis using the minimum possible dose, following the ALARA principle [1]. Compared with other medical procedures, conventional radiology uses lower doses, however, it's the largest contributor for the collective dose between all artificial sources [2].

For different exam circumstances, for example, irradiated region, object to be observed and patient characteristics, are used different combinations between amount of photons per time and energy aggregated to them. These combinations can be obtained by manipulating the values of mAs and kVp, respectively, which can be called a radiographic technique [3].

Nowadays, computational enhancement of the radiographic images can result in an unnecessary increase of the doses used in the radiological service [1, 4]. Recent studies have encountered variations of two times the dose used in the acquisition of the same type of radiological exam, this fact yells the possibility to expose the patient to lower doses without harming the quality of the diagnosis [2]. In Brazil, Portaria/MS/SVS n°453 [5] regulates all radiological practices, also specifies reference dose levels (based on ICRP standards [6-7]) to be used. In practice, the radiographer determine what is the best radiographic technique in order to obtain the best image quality with the minimum possible dose [8].

Signal Difference Noise Ratio (SDNR) is one of the forms of quantitative evaluation of image quality, basically measures the detectability of one object like a calcification or a tumor in a X-ray image. Some inference can be made using squared SDNR per amount of dose at skin surface, which can be called Figure of Merit (FoM) [9].

In this work were measured the doses used in obtaining radiography of thorax, abdomen and skull for different physicals sizes and consequent image quality resulting from exposure. Were studied the improvements in the radiological service quality that can be reached with a dose optimization study for different physical sizes.

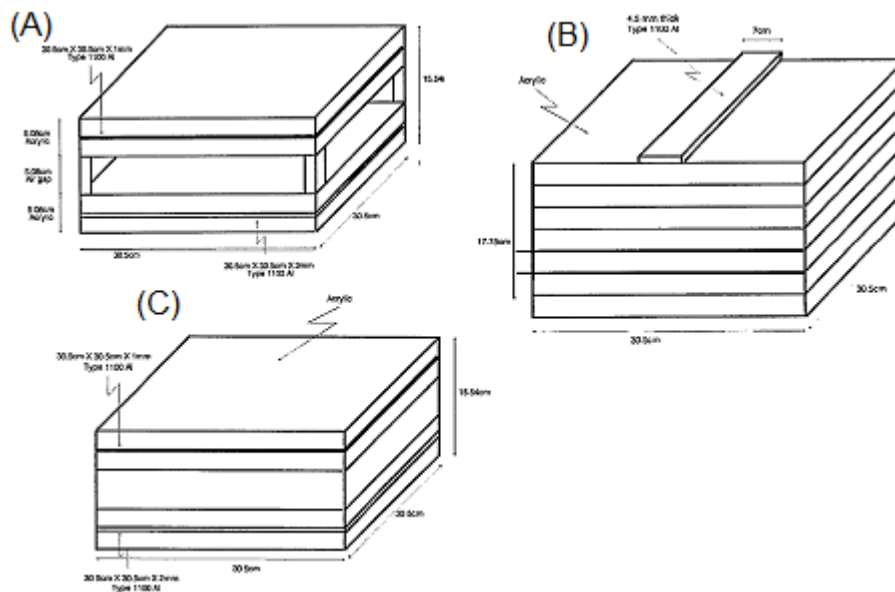
## **2. METHOLOGY**

### **2.1. Simulator Objects Confection.**

In the radiological simulators construction, were used geometries presented in the report #31 of the American Association of physics in medicine (AAPM) for the simulation of average structures as explicit in the figure 1. Were withdraw/placed polimethylmetacrilate (PMMA) plates whith different thickness for a better simulation of attenuation/scattering of different physical sizes.

The chest standard phantom (average thickness) was simulated using four plates of 30,5cm × 30,5cm × 2,54cm PMMA, 3 mm of aluminum 1100 and an area of 5cm air. Abdomen standard (average thickness) was simulated with five PMMA plates, and a plate of aluminum 1100. For skull were used six PMMA plates and a total volume of 30,5cm × 30,5cm × 3mm 1100 aluminum [10].

When simulating the thickness variation for thorax and abdomen, were removed 2,5 cm of PMMA for the minor thickness, and were added 2,5 cm of the same for the major thickness. An attenuation ladder, shown in figure 2, was placed above the PMMA to be used in SNDR calculation [9].



**Figure 1. Radiographic simulators of chest (A), abdomen (B) and skull (C) of standard adult presented at AAPM #31 [10].**



**Figure 2. Attenuation gradient used in the phantom development.**

## 2.2. Data obtainment

This stage was divided in radiographic technique obtainment, exam reproduction and data collection.

When obtaining the radiographic techniques, four experienced radiographers (with more than five years of professional experience) actives of HC-FMB UNESP were interviewed in order to obtain the techniques used in routine of thorax (PA), abdomen (AP) and skull (AP) exams for three patients of three different thickness. Each exam were reproduced using a Siemens Multix B X-ray equipment. The radiographies of the simulated objects were realized at the same time, with an ionization chamber of 6 cm cubic, coupled to an electrometer Radcal Mod. 9015 1cm of the simulator objects, the skin input doses was gauged. For abdomen and skull exam was used 1 meter of distance source chamber (DSC) and in thorax exam a DSC of 1,8 m, the same used in the acquisition of these examinations.

### 2.3. Data Analysis.

The image quality analysis occurred through the calculation of signal noise differential ratio (SDNR) and the figure of merit (FoM). The SDNR is used for comparison and visualization of details in the image obtained with different radiographical techniques. This quantity can be obtained by the knowledge of pixel intensity value of a specific region in the image. The SDNR is calculated through the equation:

$$\text{SDNR} = \frac{|A - B|}{C} \quad (1)$$

where A and B are the average intensity of the region of detail and the background, respectively, and C is the pattern deviation of the background region too [9, 11]. These values were obtained through the program ImageJ®.

The FoM was calculated by the square ratio of de SDNR by the dose in each exam circumstance:

$$\text{FoM} = \frac{\text{SDNR (arbitrary unit)}^2}{\text{Dose (mGy)}} \quad (2)$$

By analyzing the FoM values, can be evaluate differences between image quality by dose unit, and so compares then quantitatively.

## 3. RESULTS

Doses and SNDR by simulated thickness, for each studied region, are showed on table 1.

It can be noted, even with the dose increase for thicker patient, the SNDR decays considerably that shows a decrease in image quality.

The decrease in SDNR is due, among other factors, the increased attenuation in the incident beam in thicker patients, evidencing the reduction of incidence of beams with less energy, providing images with a lower contrast.

The value of the dose abdomen exam in patients thicker surpasses the reference levels of portaria/MS/SVS No. 453 [5].

Regarding skull exams, because doesn't have significant variation in thickness relative to physical bearing of the individual, was not possible determine the difference in contrast between the exams, obtaining a constant value as shown in Table 1.

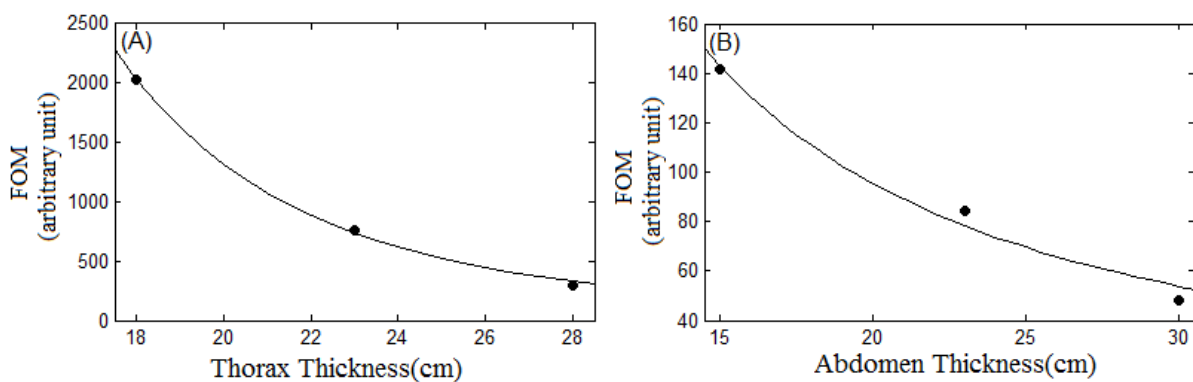
The decays of FoM in relation to the thickness of the thorax and abdomen are detailed in Figures 3.

**Table 1. Simulated thickness of each region, with yours respective values of SNDR and doses.**

	Simulated Thickness (cm)	SDNR (arbitrary unit)	Dose (mGy)
<b>Thorax</b>	18	13,12	0,09
	23	8,62	0,10
	28	5,84	0,12
<b>Abdomen</b>	15	25,58	4,61
	23	24,09	6,89
	30	23,38	11,29
<b>Skull</b>	23	20,39	5,61

The variation of thicknesses in relation to FoM shows the decrease in image quality per unit dose to thicker patients for abdomen and thorax exam. In the case of the skull, the thickness was considered constant, there wasn't obtained with respect to thickness variation in the FoM, which remained constant at 70.05.

The data analysis shows that the diagnosis involving thicker patients is made with a lower image quality and a higher dose.



**Figure 3: FoM for each thickness simulated abdomen(A) and thorax(B).**

#### 4. DISCUSSION

In the case of thorax exam, considering the SDNR rates obtained for medium patient as standard, Table 2 shows that doses to lean patients provide a higher contrast. This fact suggests that doses of lean patients can be even more reduced, while the contrast of the image remains within the range suitable for medical diagnosis.

It can be noted despite the contrast in the abdomen decreases slightly, the dose used for obese patients becomes approximately three times the dose found in the lean. This demonstrates the need for a study which is intended suggest to radiographers increased kV instead of mAs, as is usually done. This substitution would lead to a possible reduction of dose since increase the effective energy of the beam and decrease the dose delivered to the patient during the exam.

It was evident, too, that the images of the phantom skull showed the same signal noise ratio that abdomen exam. This fact leads us to two possible conclusions. The first would be that a higher dose is needed to ascertain the present low contrast between the skull bones. The second would be that, for usually need to view high contrast found between the structures of the sinuses and skull bones (such as the thorax, one must view the present high contrast between the ribs and the lung) dose in head exams are high

The fact that the examination of the thorax to be carried a distance greater (1.80 m) used in the exams in other modalities (1.0 m) would help in increasing the SDNR examinations of the thorax since the beam hardening is greater with increasing distance. However, in our results, the SDNR found in examinations of the thorax was much lower than that obtained in examinations of the skull and abdomen. Therefore, more studies are needed about the possibility of reducing the doses to obtain SDNR's in the range of those obtained in examinations of the thorax, the other two modalities, and its possible application in clinical practice.

There is a clear reduction of SDNR and FoM in obese patients for thorax and abdomen. . Fact that shows the correct doses made by radiographers mentally not always imply contrasts acceptable for accurate diagnosis. Finally, it should be hypothesized dose optimization not only for patients considered standard, like many studies aimed at, but also to obtain an efficient and practical rule for performing a test on different physical sizes.

#### 5. CONCLUSION

It is not the knowledge of the authors any optimization study applied to routine practice of the sector X-ray of HC-FMB UNESP. Despite this fact, the vast majority of doses measured are found below the reference levels of the Portaria 453 [5], which shows the concern of radiographers with the doses administered. Our study raised several aspects that can be improved with the realization of dose optimization in patients of various physical sizes.

Became clear that the letters of optimized techniques normally developed in clinical routine may not be the best way to guarantee the quality of service, since such studies usually relate to patients considered standard. Maybe a study aimed at optimizing the dose in different physical sizes can be better used during the exams.

## 6. REFERENCES

1. T. A. C. Furquim and P. R. Costa, "Garantia de Qualidade em Radiologia Diagnóstica," *Revista Brasileira de Física Médica*, vol. 3(1), pp. 91-9, 2009.
2. A. B. B. Souza, *et al.*, "Avaliação do Kerma no Ar na Superfície de Entrada e da Qualidade da Imagem em Radiografias de Tórax," *Radiologia Brasileira*, vol. 42(5), pp. 315-319, 2009.
3. E. E. Christensen, *et al.*, *Christensen's Introduction to the physics of diagnostic radiology*, 3rd ed. Philadelphia: Lea & Febiger, 1984.
4. H. A. S. Macedo and V. M. C. P. Rodrigues, "Programa de Controle de Qualidade: a visão do técnico de radiologia," *Radiologia Brasileira*, vol. 41(1), pp. 37-41, 2009.
5. "Portaria/MS/SVS nº 453, de 01 de junho de 1998 D.O.U. 02./06/98."
6. International Commission on Radiological Protection., *Radiological protection and safety in medicine*. Terrytown, New York: Published for the Commission by Pergamon Press, 1996.
7. J. Valentin and International Commission on Radiological Protection., *The 2007 recommendations of the International Commission on Radiological Protection*. Oxford, England: Published for the International Commission on Radiological Protection by Elsevier, 2007.
8. T. A. C. Furquim and D. Y. Nersissian, "Estudos de Otimização de Dose e Qualidade de Imagem em Processos de Transição Tecnológica em Mamografia," *Revista Brasileira de Física Médica*, vol. 4(3), pp. 11-14, 2011.
9. P. Bernhardt, *et al.*, "X-ray spectrum optimization of full-field digital mammography: simulation and phantom study," *Med Phys*, vol. 33, pp. 4337-49, Nov 2006.
10. R. Y. L. Chu, *et al.*, *AAPM Report No. 31: Standardized Methods for Measuring Diagnostic X-Ray Exposures*. New York, USA: American Association of Physicists in Medicine by the American Institute of Physics, 1990.
11. A. Bloomquist, *et al.*, *IAEA Human Health Series No.17: Quality Assurance Programme for Digital Mammography*. Vienna, Austria: International Atomic Energy Agency, 2011.