OPTIMIZATION OF PEDIATRICS CHEST EXAMS AT INTENSIVE CARE UNITS

R.R JAKUBIAK[a], D.NARLOCH[a], J.A. LEDESMA[b]

[a] Technological Federal University of Paraná, Curitiba, Paraná, Brazil.
[b] Hospital Pequeno Príncipe, Curitiba, Paraná, Brazil.

Email address of main author: requi@utfpr.edu.br

Abstract

This paper shows the method for preparing the technical charts for chest children between zero and two years old, hospitalized in intensive care units (ICU). The main objective of this study, however, is to reduce the radiation dose in these patients due to repetition and lack of standardized procedures. The chest exams are the most commonly performed in ICU. Two portable X ray equipment have been tested for quality control, for further data collection with the technical parameters used and patient information: age, sex, reason for the examination and thickness of the chest in AP projection. The results were satisfactory and it was possible to standardize the radiographic examinations to ensure diagnostic quality and low dose.

1. INTRODUCTION

The interaction of X rays with the human body can cause biological damage, particularly in children where the cells are under development and are more sensitive to radiation effects. Therefore one must use techniques with low exposure time versus current (mAs) [1], considering the functional differences (high rate of heart beat, increased intestinal gas, rapid breathing and inability to stop breathing on command) and lack of patient cooperation [2].

Technical Chart is a document with the technical parameters (voltage, current, exposure time and distance source-receiver) appropriate for each anatomical region to be exposed during examination [3, 4]

The aim of Technical Chart is standard and to optimize the techniques of the exams so that the radiation dose to the patient is as small as possible in accordance with the ALARA (As Low As Reasonably Achievable) principle. It also reduces the repetition of examinations by inadequate parameters and provides better diagnostic quality fulfilling the legal requirements of Report 453/98. [3, 5]

The objective was to develop technical charts for the examinations of the chest AP projection of children between zero and two years old, conducted in two portable X ray in intensive care units (ICU). This age group was chosen because it represents the largest number of tests performed in ICU and also because they are more sensitive to radiation. According to the European Commission children up to age 10 are three to four times more sensitive to the risks caused by ionizing radiation than adults between 30 and 40 years. And children need age-appropriate care when performing the exam [2].

2. METHODS

The study was performed at Hospital Pequeno Príncipe located in Curitiba, Parana, Brazil. The Technical Chart showing the parameters suitable for radiographic examinations was drawn for two portable X ray equipment of VMI Áquilla Plus with Careatrem Direct View CR 830 System version 4.32; these are used in the cardiac, neo natal, surgical and general ICU rooms. These devices allow the user to select the current value of 50, 100 or 150 mA (small focus), and 200 or 300 mA (larger focus). The voltage adjust allows the setting of values between 30 to 125 kV with increments of 1 kV. The acquired images images are sent to Picture Archiving and Communications Systems (PACS).

The first step for the construction of the Technical Chart was to develop a quality control test in both equipments and CR system. For the patient's data, the specific table contains parameters such as voltage (kV), current (mA), time of exposition (t), focus to detector distance (FDD), and exposition indicator (EI). The value of EI indicated for Carestream must be between 1600 and 2000. Besides these parameters we recorded some data related to patient age, sex, reason for the examination and thickness of the chest, that was evaluated with a caliper.

During data collection it was observed that the techniques used for the 2 devices were similar, although there were different times of service use. Furthermore, the parameters adopted was a fixed value of 3 mAs and kV between 47 and 55, but the change was a random technique and the thickness of the patient was not measured, and the pathological condition was not considered. The values of EI with the application of these techniques ranged between 1640 and 1890, as recommended by the manufacturer.

According to the European Commission, the kVp optimum indicated for children is 60 to 80 kVp, and for newborns 60 to 65 kV, both without the use of anti scattering grid, and the FDD of 100 cm.

The value of mAs must be selected according to the thickness of the patient, in other words, for each increase in 4 cm thickness the value of mAs must be doubled, and for every 2 cm increase, mAs should be increased by 30% [3]. Furthermore, it is necessary to consider the pathological condition, as this may change the density of the anatomical structure. The most frequent pathologies in patients of ICU were pneumonia, pneumothorax, atelectasis, edema and heart disease.

It was not possible to use a technical rule of thumb for the relationship that for every four centimeters of thickness variation, the mAs value must be changed for a factor of two to maintain the density values [3], because for lower mAs, noise affected the image quality. The value of kV recommended by European Commission could not be followed because an increase in the kV should be followed by a reduction in mAs, and limitations of scale in the equipment did not allow an adequate combination without producing higher values of EI, in other words, increase in dose.

The last step was the application of the Technical Chart, where the techniques were recorded in a table, similar to that used for data collection, but with an image column to be completed with "approved" or "disapproved", and the reason. During this process the images were visualized by the physician radiologist responsible for evaluating the diagnostic quality. The images were evaluated on monitors from Planar 3M pixels.

3. RESULTS

The results of applying the Technical Chart to the portable X ray exams are presented in the following. The images below show some of the results of this work.

For all the exams we selected large focus of 200 mA and 3 mAs for patients with pneumonia, pneumothorax, atelectasis, and heart disease; and for those with edema, we selected 4 mAs. The FDD value varied, depending on the patient's bed height and how the equipment was positioned. For ICU neo-natal, for the patients that were in incubators, the maximum FDD was 80 cm. We applied 48 kV for the chest thickness between 6 and 8 cm. In general in ICUs, cardiac and surgical, the FDD used was 100 cm and the value of kV was increased by 15% resulting in 55 kV. For patients who were under the fixed heater, the maximum FDD possible was 64 cm, and 45 kV was applied.

In Figures 1 and 2, both of the newborns patients and exposed the same parameters: AP, 48 kV and 3 mAs, FDD of 93 cm, resulting in EI of 1800 and 1870, respectively. The image quality of Figure 1 was approved, but the image in Figure 2, although it had EI within the value indicated by the manufacturer, did not obtain diagnostic quality due to the patient having developed pulmonary edema and bleeding. In this case it would be necessary to increase the value of mAs. It is therefore very important to consider the pathology before making the exposure.

FIG. 1. Examination of the chest of newborn patient, AP, 48 kV with 3 mAs, and EI of 1800. Image with diagnostic quality.

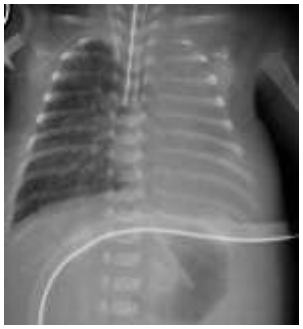

FIG. 2. Examinationof the chest of a newborn patient, AP, 48 kV with 3 mAs, and EI of 1870. This image needs a change in the technique due to pulmonary edema and bleeding.

Table I shows the data for each ICU room of: patient pathologies, FDD, thickness and techical parameters applied (kV, total mAs, and current).

TABLE I. FINAL TECHNICAL CHART FOR THE EXAMINATIONS OF THE AP CHEST OF PATIENTS BETWEEN ZERO AND TWO YEARS OF AGE HOSPITALIZED IN ICUs (Portable Equipment Aquila VMI Plus)

Condition of the patient	FDD	Thickness (cm)	kV	mAs	mA
Neo-natal ICU					
Pneumonia, pneumothorax,atelectasis, heart disease	80	6-8	48	3	200
Edema	80	6-8	48	4	200
General ICU, cardiac and surgery					
Pneumonia, pneumothorax, atelectasis, heart disease	100	8-15	55	3	200
Edema	100	8-15	55	4	200
Pneumonia, pneumothorax, atelectasis, heart disease	64	8-15	45	3	200
Edema	64	8-15	45	4	200

Figures 3 and 4 show images of the same patient. The chest thickness was 10 cm and the technique adopted for Figure 3 was 55 kV and 3 mAs, with an EI of 1750. The image quality was approved. The next day, the patient was submitted to a further X ray control at ICU (Figure 4). Because in the previous examination, the patient presented a image of pleural effusion and massive cardiac area, the technique of exposure was adjusted to obtain better quality (55 kVp with 4 mAs). However EI was set to 2070, greater than the EI limit specified by the manufacturer. It is noted that the presence of the drain in the right lung indicated that there is no more pleural effusion, so there was no need to alter the radiographic technique. It is very important to assess the condition of the patient – observed and recorded daily – before selecting the exposure parameters.

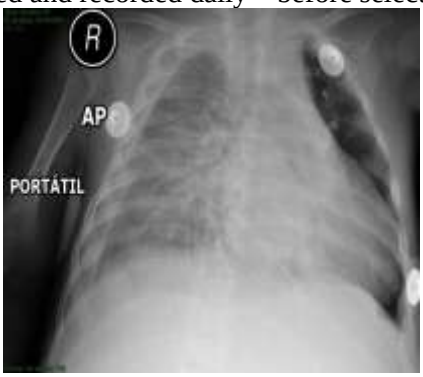

FIG. 3. Chest X ray, patient with pleural effusion and cardiomegaly.
Technique of 55 kV, 3 mAs and EI of 1750

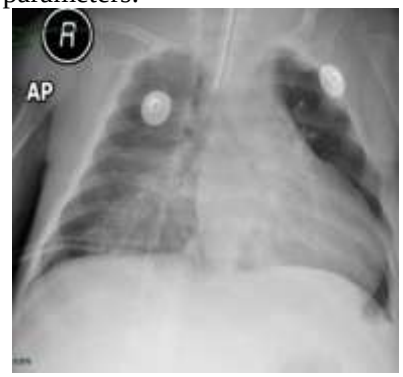

FIG. 4. Chest X ray AP, patient with chest drain.
Technique of 55 kV, 4 mAs and EI of 2070.

4. DISCUSSION

All stages of work were essential to obtain the Technical Charts: the bibliographical study alone would not be enough as it is important to know what X ray equipment is used, and whether the system is conventional or digital. The techniques used in this study differed from those recommended by the European Commission because the apparatus used in this work is mobile, and has exposure limitations. Because of this, a set of almost fixed mAs provided a wide range of good images and thickness of patients. If lower mAs values had been used, the noise images would have required repeat examinations.

The Technical Charts for the ICUs must be used as a guide: it is so hard to maintain the same technique the day before, because the patient's condition changes every day. Thus the Technical Charts must be adjusted according to the condition~~s~~ of the patient. Regarding the values of EI during application of the Technical Charts, only a few exams required higher than recommended values; ~~this h~~elped to assemble the final Technical Charts, and direct techniques according to the most frequent pathologies in patients who are in ICU. The professional radiologist must always be attentive to details related to the patient to facilitate the selection of the appropriate radiographic technique.

5. CONCLUSIONS

The work presented satisfactory results, but showed that the hospital had no method of standardization of radiographic technique that could be used as a guide for the technical possibilities to reduce radiation dose in pediatric patient due to repetition and lack of standardized procedures.

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