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Quality determination in Medical Radiology

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1. Introduction

Regulatory entities have been increasingly concerned about keeping radiation exposure within acceptable levels [1], [2]. Keeping radiology exams doses as low as reasonably achievable has been a constant pursuit. Other aspects not directly related to patient and occupational exposure increase are also undesired.

One way to approach and analyze several aspects of a radiology facility is to determine standardized quality indicators, which will be scored according to the degree of compliance with the specifications, and combined in order to calculate the Quality Index. [2], [3], [9].

Quality is the degree of compliance with the specifications. It is not a static concept, given that the specifications can be modified at some point. Quality encompasses items and specifications that are not clearly established and can be subjective [4], [5].

The Quality Index purpose is to evaluate the quality of a Medical Radiology Facility, by attributing it a score, within a percentual range, as the final result of this evaluation. It is an auxiliary tool for radiodiagnosis processes and performance optimization. The Quality Index can be calculated according to equations 1, 2 and 3.

The quality indicators are divided into two major groups: critical and non-critical. Each indicator is scored from 1 to 5, where I_{Ci} is the critical group´s score and I_{NCi} is the non-critical group´s score. The ICi´s geometric mean (equation 2), and the INCi´s arithmetic mean (equation 3) are used to determine the Quality Index, Q, in equation 3 [6], [7].

$$\overline{I_{NC}} = \frac{\sum_{j=1}^{m} I_{NCj}}{m} \tag{1}$$

$$\overline{I_C} = \sqrt[n]{\prod_{i=1}^{n} I_{Ci}} \tag{2}$$

$$Q = 20 \times \sqrt{\overline{I_C} \times \overline{I_{NC}}} \tag{3}$$

The purpose of this work is to assess the Quality of Medical Radiology Facilities situated in the state of Rio de Janeiro, with the following objectives:

– To define the quality indicators that are based on measurable physical quantities;

- To define the quality indicators that are based on other desirable aspects.

The quality indicator´s definition will be based on the regulatory authorities' technical requirements and dose limits, in addition with good practices defined by technical recommendations from literature [2], [8], [9], [10].

The next step will be to assess the Quality of the facilities contemplated by this study, and to compare the quality indexes in terms of the most or least non conformity incidences.

2. Methodology

In this work conventional radiology equipment, mammographs and 110 CT-Scanners from the state of Rio de Janeiro were assessed using the quality indicators that were available in the database from the Radiological Sciences Laboratory (LCR) of the State University of Rio de Janeiro (UERJ).

Quality analysis was carried out from indicators divided into 3 sectors: Regulation and Management; Equipment; Image Quality and Dosimetry. The Regulation and Management sector assessed the legalization and regulatory processes regarding the sanitary surveillance agency, the Equipment sector assessed the conditions of the CT scanners installations and the results of physical quantities measurements of the X-ray beams, and the Image Quality and Dosimetry sector assessed the radiation doses and the radiographic images quality.

Each of the imaging modalities will be assessed using one defined set of quality indicators, which includes, for example:

- Beam related measurements (kVp, HVL, dosimetry);
- Radiation control (records, regulation requirements);
- Image quality (phantom images analisys, when applicable).

3. Results and Discussion

The 110 CT scanners were classified according to the number of channels of the equipment, as can be seen in Figure 1.

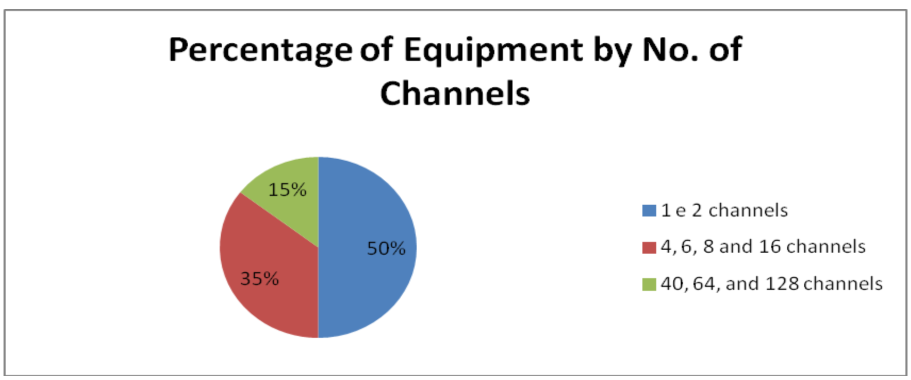

Figure 1: The percentage distribution of the analyzed CT scanners according to the number of channels

As can be noted in Figure 2, in every analyzed sector the best results were for the scanners with 4 to 16 channels. The oldest scanners showed similar results compared to the ones with more recent technology, with up to 128 channels. That can be attributed to the use of incorrect parameters and configuration on the recent scanners.

It can be concluded that the more recent equipment should be better configured in order to achieve better image quality performances. However, the sample size for these equipment is small, only 15%, as can be seen in Figure 1.

Figure 3 shows that 54% of the facilities had a Quality Index for the image quality that was lower than 80%.

The Figure 4 left side shows the comparison of all the Image Quality Indicator Results, and it can be seen that the CTDI dosimetry and the HU value for bone were the ones that failed the most.

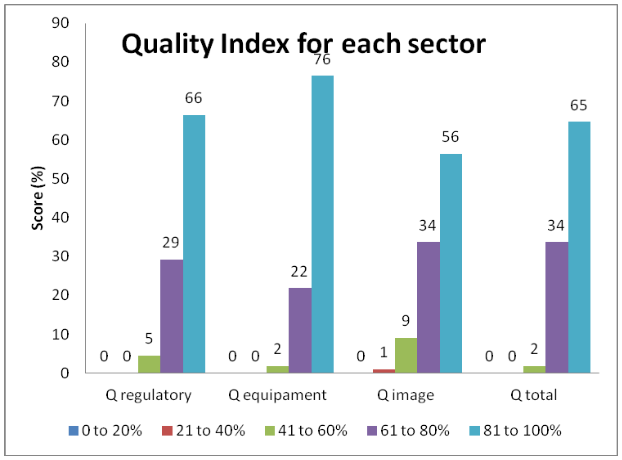

Figure 3: Results of the Quality Index obtained for each sector and the Total Quality index for all analyzed equipment.

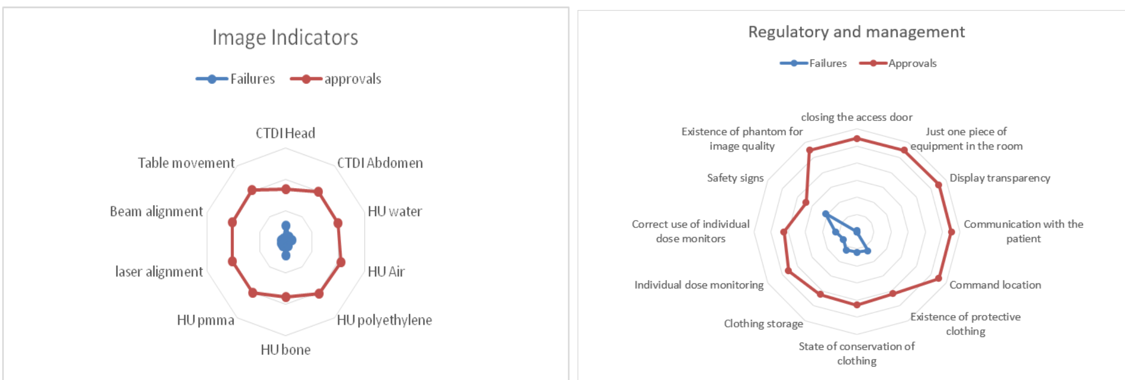

Figure 4: In left side show Image Quality Indicator Results. In right side show Regulatory and management indicator results.

In the Figure 4 right side, it can be seen that the indicator with most non conformities was the one concerning the lack of safety signs. These signs are very important in order to avoid accidental exposures, such as when one person unwittingly enters the exam room at the time of a radiation exposure.

The Head CTDI was the indicator with the worst performance, where 34% of the equipment were above reference values. It can be seen in Figure 5 that the Head CTDI values are considerably more dispersed than the Abdomen CTDI, which suggests the existence of a larger number of different protocols in use. Overall, those protocols should be redefined with better standards.

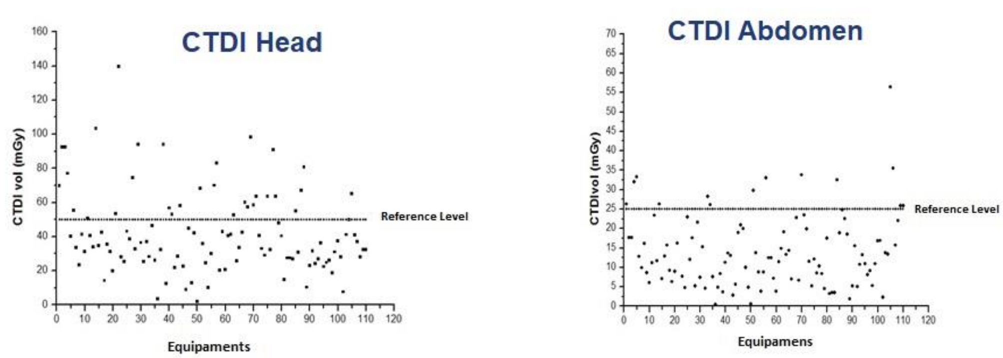

Figure 5: (left side) Head CTDI indicators and (right side) Abdomen CTDI indicators of all evaluated

equipment.

4. Conclusions

The Quality Index methodology allowed the identification of a problem that is occurring with the recent technology equipment. The newer equipment showed similar performances to the older ones, some with over 15 years of use.

About 65% of the facilities that were assessed had a Quality Index of over 80%, and increasing this number should be a constant pursue.

The Head CTDI indicator showed very dispersed results, which indicates the use of unstandardized exam protocols.

The conventional radiography equipment and mammograph assessments will be included in this work in the future, as it is still in progress.

Acknowledgements

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