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Diagnostic reference levels (DRL) in Computed Tomography during the period 2018-2022 in a private hospital in Chile

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Abstract: The aim of this study was to compare and optimize the diagnostic reference levels (DRL) of our institution obtained over 5 years, in order to find the appropriate balance between the patient dose and the quality of the clinical image for the most frequently used CT examinations.The typical values of 6 CT scanners of an institution were evaluated, taking as a reference the DRLs established in 2018. An optimization process was initiated in order to find the best balance between dose- diagnostic quality, finding that the DRLs obtained during that year were well below those published by the ACR, so we proceeded to prioritize the quality of the image by reasonably increasing the doses to the patient. In 2022, we purchased other patient dose monitoring software and got new optimized DRLs.The results obtained from the typical values of 2018 versus 2022 had a difference of 25% to 30%, with the DRLs of 2022 being higher as we were looking for, finding a significant improvement in the quality of the diagnostic images. The medians obtained are within what is published internationally, which is an indicator that our DRLs are within international standards.This research helped our CT Service considerably to obtain typical values with excellent quality of diagnostic images, and to standardize the protocols for all our CT scanners despite being of different brands and technology.

Keywords: diagnostic reference levels, computed tomography, optimization.

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Niveles de referencia diagnóstico (DRL) en Tomografía Computarizada durante el período 2018-2022 en un hospital privado de Chile

Resumen: El objetivo de este estudio fue comparar y optimizar los niveles de referencia diagnóstica (DRL) de nuestra institución obtenidos durante 5 años, con el fin de encontrar el equilibrio adecuado entre la dosis al paciente y la calidad de la imagen clínica para los exámenes de TC más utilizados. Se evaluaron los valores típicos de 6 tomógrafos de una institución, tomando como referencia los DRL establecidos en el año 2018. Se inició un proceso de optimización con el fin de encontrar el mejor equilibrio entre dosis-calidad diagnóstica, encontrando que los DRL obtenidos durante ese año estaban muy por debajo de los publicadas por la ACR, por lo que se procedió a priorizar la calidad de la imagen aumentando razonablemente las dosis al paciente. En 2022, compramos otro software de monitoreo de dosis de pacientes y obtuvimos nuevos DRL optimizados. Los resultados obtenidos de los valores típicos de 2018 versus 2022 tuvieron una diferencia de 25% al 30%, siendo los DRL de 2022 más altos tal como lo esperabamos, encontrándose una mejora significativa en la calidad de las imágenes diagnósticas. Las medianas obtenidas están dentro de lo publicado a nivel internacional, lo cual es un indicador de que nuestros DRL están dentro de los estándares internacionales. Esta investigación ayudó considerablemente a nuestro servicio de TC a obtener valores típicos con excelente calidad de imágenes de diagnóstico, y estandarizar los protocolos de todos nuestros escáneres de TC, a pesar de ser de diferentes marcas y tecnología.

Palabras claves: Niveles de referencia diagnsotica, tomografía computada, optimizacion.

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1. INTRODUCTION

Computed tomography (CT) has experienced exponential growth in the diagnostic application over recent decades, largely attributed to advancements such as helical acquisition and Multi row detector technology which have significantly reduce the acquisition time. As one of the most effective imaging modalities for the diagnosis of several clinical disorders, CT offers huge diagnostic capabilities. However, it is crucial to acknowledge that CT scans entail higher radiation dose in comparison to conventional radiography. According to the report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), in 2021, CT represents 62% of the collective effective dose [1,2]. Therefore, it is imperative to leverage tools that facilitate the optimization of clinical practice, aiming to minimize patient radiation exposure as low as reasonably possible (ALARA).

In Latin America, studies often lack proper justification, and there is insufficient work done in the process of dose optimization of tomographic protocols, generating a potential silent increase in the radiation dose in patients. Furthermore, there is a notable absence of establishment of dignostic reference levels [3].

The International Commission on Radiological Protection (ICRP) states that diagnostic reference levels (DRLs) are a practical tool to promote optimization, used in medical imaging to indicate whether, in routine conditions, the dose to the patient in a specific radiological procedure for medical imaging is unusually high or unusually low for that procedure [4].

The objective of this research work was to show our experience in the establishment of typical DRL values during the period 2018-2022, and how we have approached as an institution the optimization of our CT examinations, favoring patients seeking to obtain a balance between the doses administered and the quality and diagnostic image.

2. MATERIALS AND METHODS

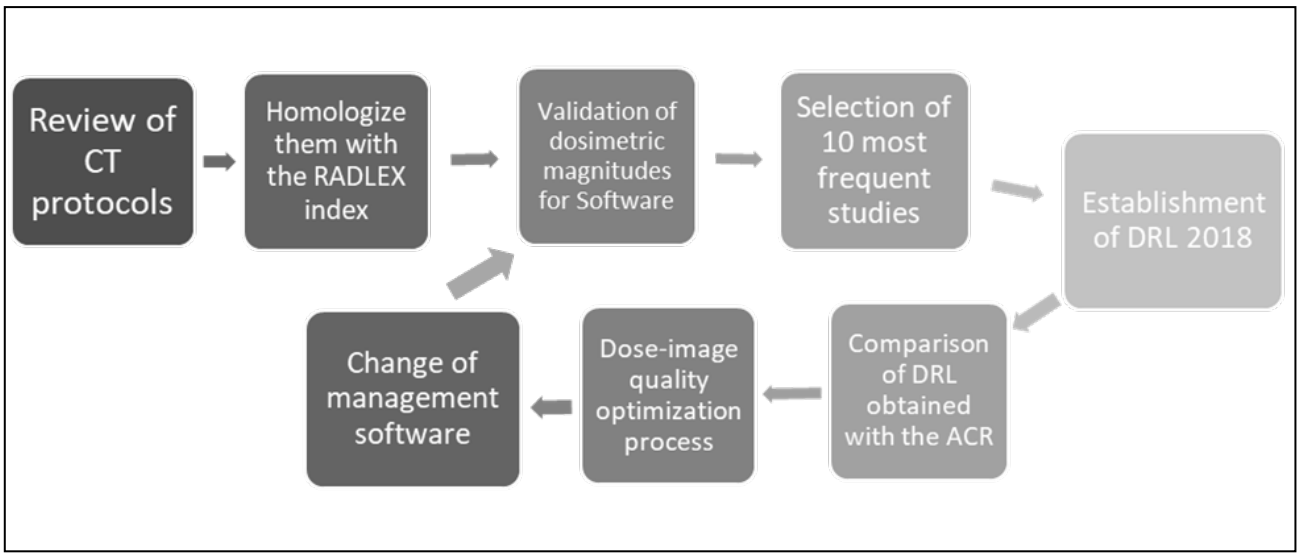
This research was conducted at the Clinica Alemana de Santiago (CAS), Chile, involving 6 CT scanners whose models and brands are shown in Table 1, located in 3 different facilities in the same city.

Table 1 : Description of computed tomography scanners used in the current study.

(MODEL AND BRAND)	LOCATION
CT1 Siemens Somatom Definition AS*	Vitacura
CT2 Canon Aquilion One	Vitacura
CT3 GE Revolution GSI	Vitacura
PETCT Siemens Biograph mCT	Vitacura
CTLD Siemens Somatom Definition AS+	La Dehesa
CTCH Siemens Somatom Go	Chicureo

To establish diagnostic reference levels for CT in our institution in 2018, a series of preliminary steps were undertaken, as depicted in the diagram illustrated in figure 1.

Figure 1: CT Diagnostic Reference Levels implementation process diagram in CAS during the 2018-2022 period.



The first stage involved the review of clinical CT protocols, where ambiguous, unused, and duplicated protocols were eliminated. Subsequently, sets of master protocols were

created and homologated with the RadLex Playbook index (RPID, RSNA) [5]. Following the implementation of standardized and approved protocols, the next step involved validating the dosimetric parameters provide by the scanners utilized to define the Diagnostic Reference Levels (DRL), utilizing both the Computed Tomography Dose Index (CTDIvol) and Dose-Length Product (DLP). During this phase, a comprehensive quality control assessment of all CT scanners was conducted, adhering to the American College of Radiology (ACR) quality control protocol. This protocol encompasses mechanical, dosimetric, and image quality evaluations [6].

Upon obtaining correction factors for all scanners through the dosimetric quality control, and incorporating them into the dose management software, follow-up quality control was carried out to verify the reliability of these dosimetric magnitudes from the Picture Archiving and Communication System (PACS) to the RADIMETRICS® dose management software. (BAYER®). Twenty studies were randomly selected for the 6 scanners, and it was verified that the CTDIvol and DLP magnitudes corresponded to those sent by the equipment to the PACS system and then to the management software.

The 10 most frequently used protocols in the institution were selected, and the typical values for each scanner were derived. These typical values were determined by calculating the median value of the dose distribution data collected by each scanner [2]. Data collection was performed through RADIMETRICS dose management software, which receives radiation dose structured reports (RDSR) from each CT scanner and stores them both in the PACS and to the Dose management software.

Once the typical values for each protocol were obtained, these values were established as the DRL for the year 2018 for the institution. The obtained values were compared with those reported by the ACR and the publisher by Karl et al. in 2017 about the DRLs of the 10 most frequent exams performed in the US [7].

The comparison of the obtained DRL with those reported by the ACR was done through the National Radiology Data Registry (NRDR DIR®) of the ACR, to which our institution has subscribed since 2017. This registration system sends us quarterly reports comparing our DRL for all CT scanners in the clinic with those obtained in all affiliated countries to this registry. This report contains 10 different clinical CT protocols. When comparing the DRL for 2018 with those reported by the ACR, it was noticed that for the clinical protocols analyzed, our DRLs were below those published by the ACR. These results do not imply that practices are being done correctly or incorrectly; it was simply a signal to verify the next step, according to the recommendations of the International Commission on Radiological Protection (ICRP), which is the assessment of image quality. For this, a multidisciplinary group (radiologists, medical physicists, and technologists) was created and a review of the diagnostic image quality of these protocols was conducted, In addition, a survey was conducted among the most experienced radiologists of the institution, where the clinical image quality for the 10 protocols studied was assessed. After this thorough review, it was concluded that indeed the diagnostic image quality was being affected in some cases by insufficient radiation doses in some CT protocols. This multidisciplinary team decided to increase the radiation doses to obtain diagnostic images with sufficient quality, always trying to maintain a balance between dose and image quality.

In 2021, the institution transitioned to a new patient dose management software, DOSE® (QAELUM, Inc.). To integrate this new software seamlessly, the institution retained the same standardized master protocols aligned with RadLex. However, to obtain favorable results in establishing the DRL, the entire process done with the previous software was replicated. After repeating the process (Figure 1), new DRLs were established, corresponding to the period from January to December 2022. To obtain these DRL, data were exported from DOSE® to a spreadsheet and filtered by acquisition technique: kV, pitch, age (adults), modulation type, and acquisition protocol (number of phases). This was

done to obtain a "standard" patient according to the recommendations of the ICRP for each of the scanners.

Once the DRLs for 2022 for our institution were obtained, they were compared with those obtained during 2018 and also compared with those obtained by the ACR.

3. RESULTS AND DISCUSSIONS

In Table 2, the results obtained during the establishment of DRL in the year 2018 at CAS for the 10 most frequent CT protocols conducted in the institution are shown.

Table 2: Diagnostic Reference Levels (DRL) for 2018 for the 10 most common studies.

MASTER PROTOCOL NAME	CTDIvol (mGy) P50 RADIMETRICS® 2018	DLP (mGy*cm) P50 RADIMETRICS® 2018
CT HEAD BRAIN WO IVCON	31,9	625
CT ABDOMEN PELVIS W IVCON	8,5	712
CT CHEST WO IVCON	10,0	427
CT PERINASAL CAVITIES WO	10,3	154
CT ABDOMEN PELVIS KIDNEY WO IVCON	7,9	386
CT CHEST ABDOMEN PELVIS W IVCON	8,7	945
CT L SPINE WO IVCON	20,4	621
CT ANGIO CEREBRO CUELLO	31,8	624
CT CHEST PULMONARY ARTERIES W IVCON	6,8	419
CT HEAD BRAIN WO AND W IVCON	31,01	1161

Because the institution is affiliated to the Dose Index Registry of the American College of Radiology (ACR -DIR), the obtained DRLs were compared with those reported by the ACR in the Executive Summary report corresponding to the period Jan-Jun 2018. The results of this comparison are shown in figure 2 (CTDvol) and figure 3 (DLP), respectively.

As shown in figures 2 and 3, the obtained DRLs for the studied protocols are lower than reported by the ACR, except protocol 4, which exceeds the median and protocol 5, which is not included in our study. These results prompted a review of the diagnostic image quality within the institution, following the recommendations of the ICRP.

Figure 2: National Radiology Data Registry Executive Summary Report, Jan-Jun 2018 CLINICA ALEMANA (Facility ID: 112177) Dose Index Registry American College of Radiology. (CTDIvol per Scan).

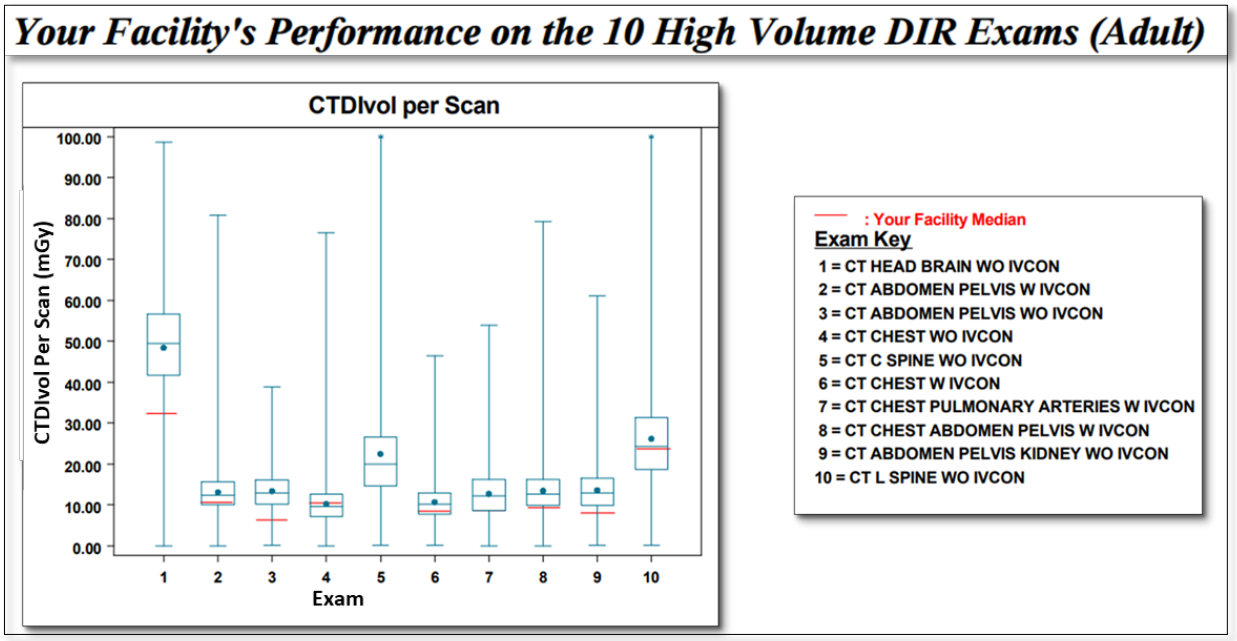
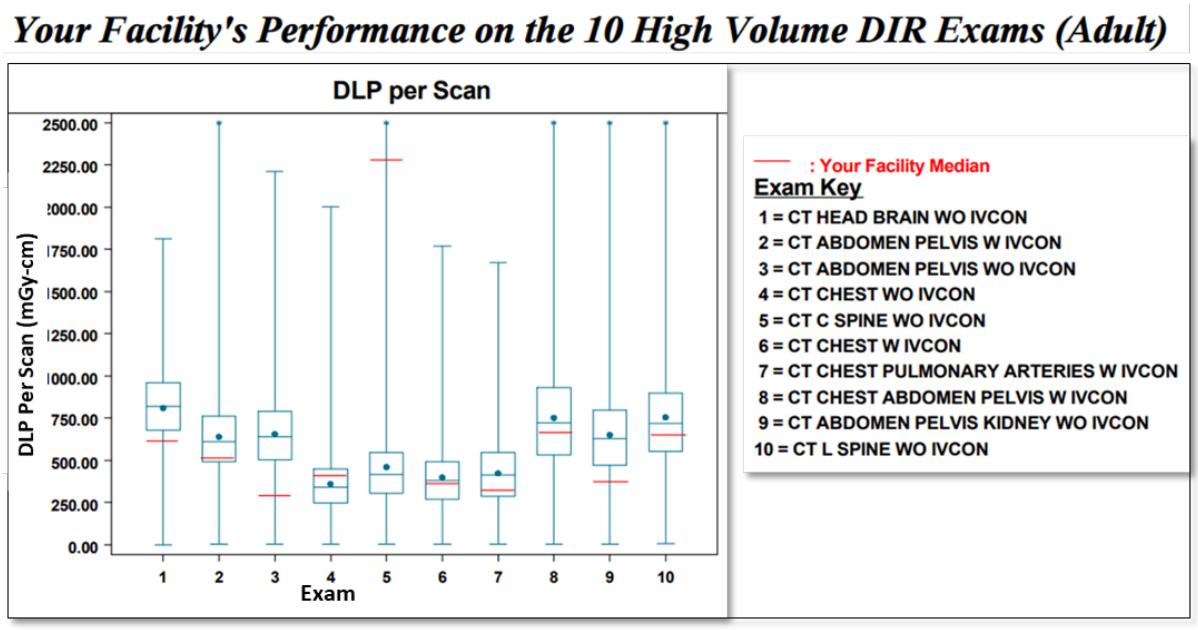


Figure 3: National Radiology Data Registry Executive Summary Report, Jan-Jun 2018 CLINICA ALEMANA (Facility ID: 112177) Dose Index Registry American College of Radiology. (DLP per Scan).



The assessment of diagnostic image quality for the selected protocols revealed that, due to the low doses, the image quality was compromised with a poor signal-to-noise ratio. This allowed us to reasonably increase the doses for these clinical protocols in order to enhance image quality, achieving comparative results with international reference levels, given the absence of national DRLs.

The diagnostic reference levels obtained with the new patient dose management software, DOSE, for 2022 are shown in Table 3.

Table 3: Diagnostic Reference Levels (DRL) for 2022 at CAS for the 10 most frequently studies.

MASTER PROTOCOL NAME	CTDIvol (mGy) P50 QAELUM® 2022	DLP (mGy*cm) P50 QAELUM® 2022
CT HEAD BRAIN WO IVCON	42	796
CT ABDOMEN PELVIS W IVCON	13	876
CT CHEST WO IVCON	12	436
CT PERINASAL CAVITIES WO	11	157
CT ABDOMEN PELVIS KIDNEY WO IVCON	10	482
CT CHEST ABDOMEN PELVIS W IVCON	11	1464
CT L SPINE WO IVCON	23	669
CT CHEST PULMONARY ARTERIES W IVCON	7	243
CT HEAD BRAIN WO AND W IVCON	41	1532

In figures 4 and 5, the comparison between the CAS 2018 DRLs and CAS 2022 DRLs is presented, showing an increase in both CTDIvol (figure 4) and DLP (figure 5) for the selected protocols, as expected, a significant improvement in the contrast-to-noise ratio of the images was observed, according to the qualitative results of the survey conducted with the radiologists. This is due to modifications made to the protocols aiming to enhance the diagnostic image quality.

Figure 4: Comparative results of Diagnostic Reference Levels for CTDIvol (mGy) 2018-2022 at Clinica Alemana de Santiago.

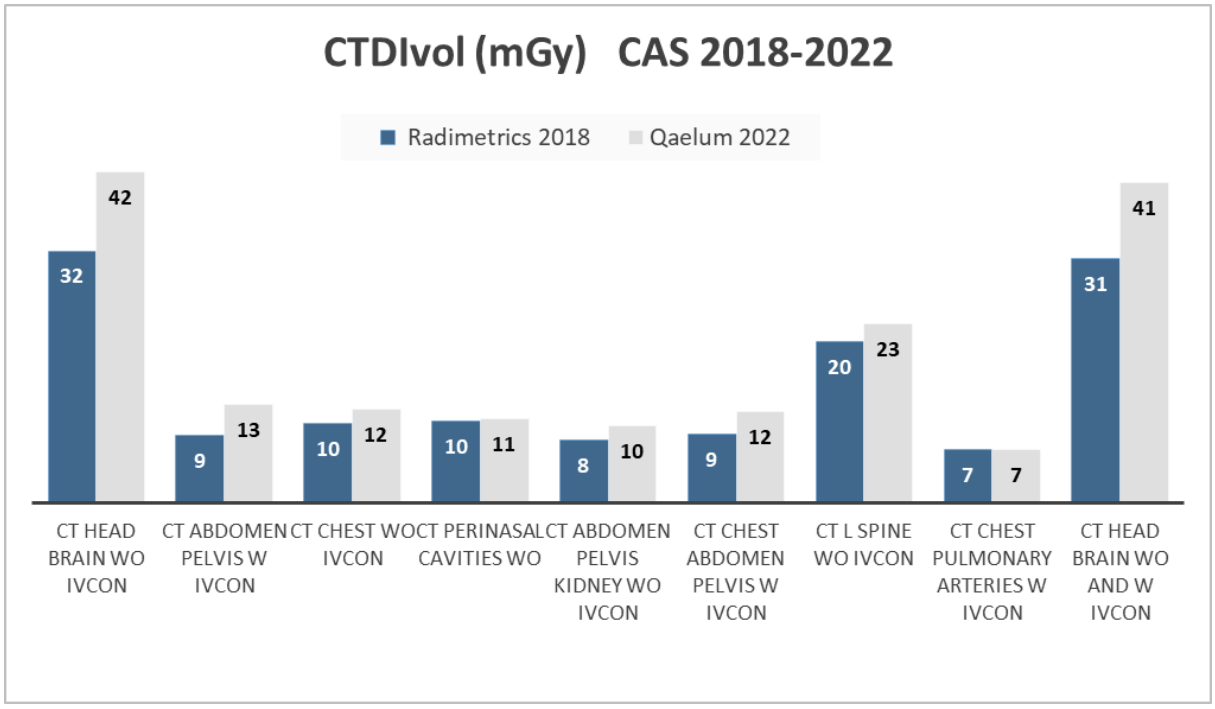
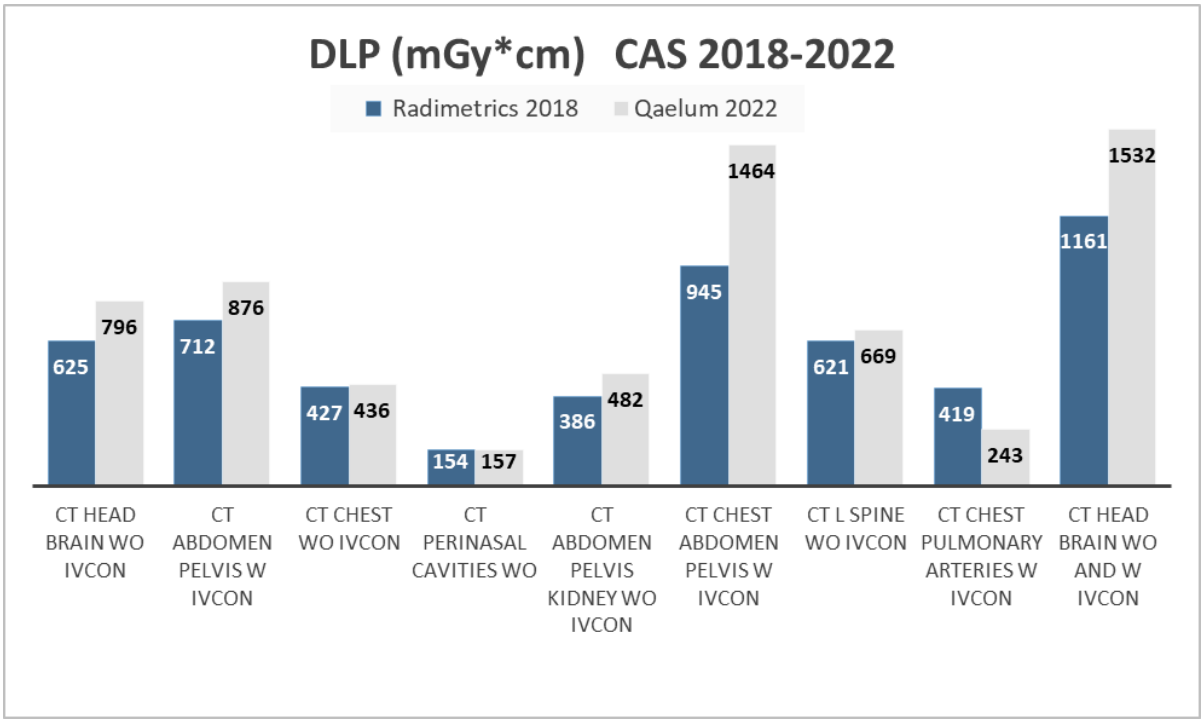


Figure 5: Comparative results of Diagnostic Reference Levels for DLP (mGy*cm) 2018-2022 at Clinica Alemana de Santiago.



4. CONCLUSIONS

This research significantly aided our CT (Computed Tomography) service in obtaining typical values with excellent quality diagnostic images. Additionally, we successfully standardized protocols for all our CT scanners, despite being from different brands and technologies, confirming that Diagnostic Reference Levels (DRLs) should be continuously reviewed by a multidisciplinary team of specialists to find practice optimization.

The DRLs established in this research will serve as a guide for the institution's medical technologists in clinical practice for these protocols, optimizing the doses received by patients.

The utility of Diagnostic Reference Levels (DRLs) has been demonstrated in enhancing the provision of high-quality patient care within a Radiology Department.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest.

REFERENCES

[1] UBEDA DE LA C., Carlos et al. Niveles de referencia para diagnóstico: Una herramienta efectiva para la protección radiológica de pacientes. **Revista chilena de radiología**, v. 25, n. 1, p. 19-25, mar. 2019. Disponível em: https://doi.org/10.4067/s0717-93082019000100019.

[2] UNITED NATIONS. **Sources, Effects and Risks of Ionizing Radiation, United Nations Scientific Committee on the Effects of Atomic Radiation 2020/2021 Report:** Scientific Annex d - Evaluation of Occupational Exposure to Ionizing Radiation. [S. l.]: United Nations Environment Programme, 2022. ISBN 9789211392098.

[3] PLOUSSI, Agapi et al. Local diagnostic reference levels in pediatric CT examinations: a survey at the largest children's hospital in Greece. **The British Journal of Radiology,** v. 93, n. 1116, p. 20190358, 1 dez. 2020. Disponível em: https://doi.org/10.1259/bjr.20190358.

[4] ICRP - International Commission on Radiological Protection. The 2017 Diagnostic Reference Levels in Medical Imaging. **ICRP Publication 135**. Annals of the ICRP, v. 46, n. 1, 2017.

[5] WANG, Kenneth C. et al. Use of Radiology Procedure Codes in Health Care: The Need for Standardization and Structure. **RadioGraphics**, v. 37, n. 4, p. 1099-1110, jul. 2017. Disponível em: https://doi.org/10.1148/rg.2017160188.

[6] ACR - **American College of Radiology**. 2017 ACR Tomography Computed Quality Control.

[7] KANAL, Kalpana M. et al. U.S. Diagnostic Reference Levels and Achievable Doses for 10 Adult CT Examinations. **Radiology**, v. 284, n. 1, p. 120-133, jul. 2017. Disponível em: https://doi.org/10.1148/radiol.2017161911.

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