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Computed tomography: between diagnostic indispensability and the imperative need for clinical justification

Tomografía computarizada: entre la indispensabilidad diagnóstica y la imperiosa necesidad de justificación clínica

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ABSTRACT

Computed tomography (CT) is one of the imaging modalities that has most transformed medical practice since its clinical introduction in 1971. Its ability to generate high-resolution, three-dimensional images has revolutionized the diagnosis of cerebrovascular, oncological, and trauma pathologies, particularly in emergency settings where time is critical. However, the widespread and sometimes indiscriminate use of this technology has generated growing concern regarding the risks associated with exposure to ionizing radiation, especially in the pediatric population. The recent EPI-CT study, published in 2023, confirms a dose-dependent association between CT radiation and the risk of hematological cancers in young people, estimating that for every 10,000 children examined, one or two will develop blood cancer within the next 12 years. This opinion piece argues that, while CT is indispensable in modern medicine, its prescription must be rigorously regulated by strict criteria of clinical justification and dose optimization, avoiding "defensive" use motivated by intolerance of diagnostic uncertainty. Continuing medical education in radiation protection principles and the establishment of technology appropriation protocols are ethical imperatives to maximize diagnostic benefit while minimizing radiological risks.

RESUMEN

La tomografía computarizada (TC) constituye una de las modalidades de imagen que más ha transformado la práctica médica desde su introducción clínica en 1971. Su capacidad para generar imágenes tridimensionales de alta resolución ha revolucionado el diagnóstico de patologías cerebrovasculares, oncológicas y traumatológicas, particularmente en contextos de urgencia donde el tiempo es crítico. Sin embargo, el uso generalizado y a veces indiscriminado de esta tecnología ha generado preocupación creciente respecto a los riesgos asociados a la exposición a radiaciones ionizantes, especialmente en población pediátrica. El reciente estudio EPI-CT, publicado en 2023, confirma una asociación dosis-dependiente entre la radiación de TC y el riesgo de cánceres hematológicos en jóvenes, estimando que por cada 10.000 niños examinados, uno o dos desarrollarán cáncer de sangre en los 12 años siguientes. Este artículo de opinión argumenta que, si bien la TC es indispensable en la medicina moderna, su prescripción debe rigorizarse mediante criterios estrictos de justificación clínica y optimización de dosis, evitando el uso "defensivo" motivado por la intolerancia a la incertidumbre diagnóstica. La formación médica continua en principios de radioprotección y el establecimiento de protocolos de apropiación tecnológica constituyen imperativos éticos para maximizar el beneficio diagnóstico minimizando los riesgos radiológicos.

The history of radiology, though brief compared to the history of medicine, represents one of the most significant revolutions in the understanding of human pathophysiology. ⁽¹⁾ Since the introduction of computed tomography (CT) by Godfrey Hounsfield in 1971, this diagnostic modality has evolved rapidly, progressing from single-slice scanners to state-of-the-art multislice CT scanners capable of reconstructing three-dimensional images with millimeter resolution. ^(2,3)

Currently, CT has become an indispensable tool in virtually all medical specialties. In the specific context of Cuba, where cerebrovascular diseases affect approximately 5 % of the population over 65 years of age and account for between 9 % and 10 % of deaths ⁽⁴⁾, CT provides critical information in seconds about brain parenchymal lesions and vascular involvement, enabling urgent therapeutic decisions that can mean the difference between life and death. ⁽⁵⁾

However, this meteoric expansion has generated a worrying phenomenon: the medicalization of diagnostic uncertainty. As Bastarrika points out, ⁽¹⁾ CT has become such a routinely required technique that specialists prescribe it to avoid clinical malpractice, and patients themselves demand it as a guarantee of quality medical care. This dynamic has led to an exponential increase in population exposure to ionizing radiation, the oncological consequences of which are beginning to be quantified with alarming precision.

The objective of this article is to critically analyze the balance between the undeniable diagnostic benefit of CT and the emerging radiological risks, particularly in the pediatric population, arguing in favor of a reinstitutionalization of clinical justification criteria that prioritizes the precautionary principle without compromising the quality of care.

CT as a Disruptive Technology in Medical Diagnosis

CT represents a technological paradigm that transcends the simple acquisition of anatomical images. Its ability to visualize three-dimensional structures with differentiated tissue contrast has made it possible to understand the natural history of diseases that previously could only be diagnosed clinically or confirmed post-mortem. ⁽¹⁾ Recent advances in multislice equipment, with solid-state detectors and the ability to acquire 64 slices per rotation, have reduced scan times to seconds, minimizing motion artifacts and enabling dynamic contrast studies. ⁽⁷⁾

In nuclear medicine, the consolidation of hybrid technologies such as SPECT/CT (commercially introduced in 1999) and PET/CT (since 2000) has exponentially expanded diagnostic applications, particularly in oncology for tumor staging and in cardiology for myocardial viability assessment. ⁽⁸⁾ These techniques, based on the visualization and quantification of the distribution of ultrashort-lived radioisotopes, have redefined diagnostic algorithms in neoplastic diseases. ⁽⁹⁾

However, this technological sophistication entails a clinical paradox: while image quality improves, the cumulative radiation dose per patient increases, especially in serial or combined studies. A current abdominal CT scan is equivalent to approximately 20 months of background radiation, and a cranial CT scan to up to 8 months. In absolute terms, more than one million children undergo CT scans annually in Europe, contributing significantly to the population's radiation burden. ⁽¹⁰⁾

The Dilemma of Clinical Justification: Between Benefit and Risk

Contemporary medicine faces an unresolved ethical tension: intolerance of diagnostic error has generated a culture of "overdiagnosis" where CT functions as a legal amulet rather than a rational tool. This trend is particularly dangerous in the pediatric context, where the radiosensitivity of developing organs and the longer life expectancy after exposure increase the risk of radiation-induced carcinogenesis. ⁽¹¹⁾

The EPI-CT study, published in Nature Medicine in 2023 and coordinated by the Barcelona Institute for Global Health, is the first large-scale, multicenter analysis specifically designed to quantify this risk. ^(12,13) With a cohort of 876 771 people exposed to CT before the age of 22 in nine European countries, the researchers demonstrated a dose-dependent association between CT radiation and the risk of hematological cancers (leukemias and lymphomas). The results indicate that a 100 mGy dose to the bone marrow increases the risk by a factor of 3, implying that a current CT scan (with an average dose of ~8 mGy) increases the risk by approximately 16 %. ⁽¹²⁾

In terms of absolute risk, this means that for every 10 000 children who undergo CT scans, one or two will develop radiation-attributable hematologic cancer within 12 years of the examination. While this individual risk may seem modest, its population impact is considerable given the volume of studies performed: it is estimated that in the United States, out of approximately 600 000 pediatric CT

scans annually, about 500 cases of fatal cancer could eventually be attributed to this exposure. ^(13,14)

These data reinforce previous evidence from national studies suggesting an increased risk of cancer after CT, but which were criticized for methodological limitations related to imprecise dosimetry and selection bias. ⁽¹⁵⁾ The strength of EPI-CT lies in its estimation of dose at the organ-specific level (bone marrow) and its long follow-up (mean of 7.8 years, extending to more than 20 years in subgroups), providing unprecedented statistical robustness. ⁽¹²⁾

Towards a Medicine Based on Technological Appropriation

The response to these findings should not be to abandon CT—its diagnostic benefit in serious illnesses is undeniable—but rather the rigorous implementation of the principle of clinical justification. The International Commission on Radiological Protection states that, while it is not appropriate to apply dose limits in medical settings (given that the patient's condition may be more critical than the exposure), it is imperative to apply the ALARA (As Low As Reasonably Achievable) principle to ensure doses are as low as reasonably achievable. ⁽¹⁰⁾

This justification implies that each CT scan must be evaluated individually: Is there a diagnostic alternative with less or no radiation (ultrasound, MRI) that answers the same clinical question? Will the study result modify the therapeutic approach? Does the information obtained justify the radiological risk? When the answer is yes, optimization should proceed: adapting protocols to the patient's size (especially in pediatrics), limiting the anatomical extent explored, and avoiding unnecessary serial studies. ⁽¹⁰⁾

Continuing medical education in these principles is an ethical imperative. Data suggest that the risk is cumulative: multiple CT scans progressively increase the probability of cancer. ⁽¹⁶⁾ Therefore, the recording and monitoring of the cumulative dose per patient—the concept of a "radiological passport"—should be systematically implemented, as is already the case in some Spanish hospitals that demonstrate the positive impact of individually monitoring radiological procedures. ⁽¹⁰⁾

In the Cuban context, where technological resources are limited but the quality of training is high, there is a unique opportunity to lead policies for technological adoption. Training general practitioners and specialists in diagnostic algorithms that prioritize radiation-free modalities, and establishing radiological justification committees in

tertiary hospitals, could minimize population exposure without compromising clinical outcomes.

In the authors' opinion, computed tomography represents one of the most significant technological advances in modern medicine, whose diagnostic benefit in acute and complex pathologies is undeniable. However, the widespread and often insufficiently justified use of this modality has generated a population-level radiation burden whose oncological consequences—particularly in pediatric hematological cancers—are beginning to be quantified with alarming precision.

Current evidence, spearheaded by the EPI-CT study ⁽¹²⁾, does not question the usefulness of CT when indicated, but underscores the urgent need to reinstitutionalize strict criteria for clinical justification and dose optimization. Defensive prescribing motivated by intolerance of diagnostic uncertainty constitutes an ethically unsustainable medical practice that exposes the population to avoidable risks.

The systematic implementation of continuing medical education programs in radiation protection, the establishment of cumulative dose registries per patient, and the development of clinical practice guidelines that prioritize radiation-free diagnostic alternatives when they are equivalently effective are recommended. CT should remain a precision diagnostic tool, not a first-line resource in the medicalization of clinical anxiety.

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CONFLICTS OF INTEREST

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