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Magnitudes de Dosis en TC

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Hospital Error Caused Radiation Overdoses

LA's Cedars-Sinai Blames Computer-Resetting Error for Exposing 206 Patients to Radiation

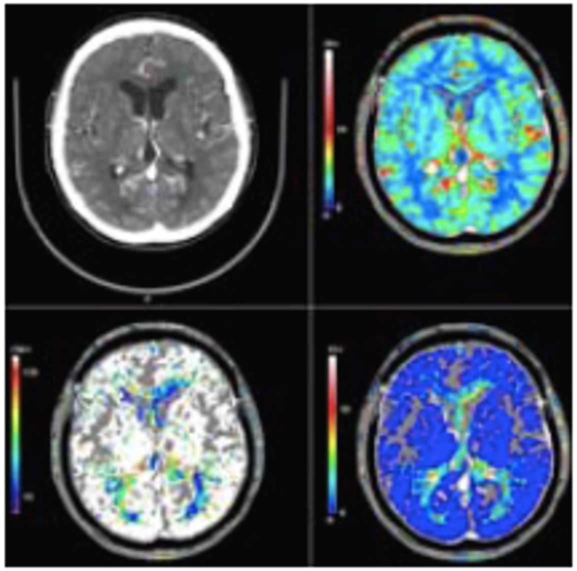
The Associated Press
5 comments

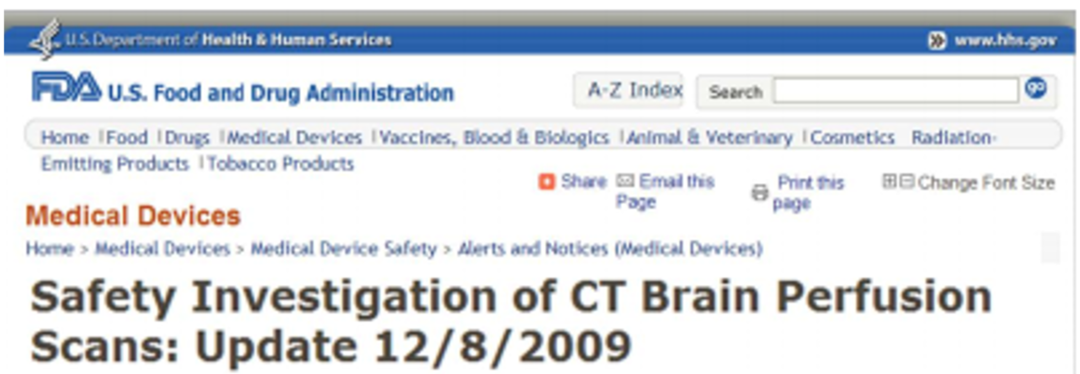
LOS ANGELES October 13, 2009 (AP)

New study finds that CT scans significantly raise one's risk of cancer.

Hospital officials say a computer-resetting error caused radiation overdoses for 206 patients who underwent CT scans at Cedars-Sinai Medical Center.

In a written statement Monday, hospital officials said "a misunderstanding about an embedded default setting applied by the machine" resulted in a higher than expected amount of radiation.

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Safety Investigation of CT Brain Perfusion Scans: Update 12/8/2009

Boone J.

California RT gives deposition in CT overdose case

By Donna Domino, AuntMinnie.com staff writer

December 10, 2009 -- The California radiologic technologist accused of operating the CT scanner that delivered a massive radiation overdose to a 23-month-old boy in 2008 testified last week that she only pushed the CT scan button a few times, and she doesn't understand how the toddler received 151 scans in a single imaging session.

ADVERTISEMENT
CT in the Emergency Department at Stony Brook University
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Raven Knickerbocker, who is accused of subjecting Jacoby Roth to more than an hour of continuous scanning, said she only pressed the scan button "two to four times," according to the Roth family's attorney, Don Stockett, who questioned her during a December 4 deposition in preparation for a civil trial in a lawsuit filed by the boy's parents.

Knickerbocker testified during the deposition that she performed two scout scans and then tried to start the examination, but the machine did one rotation before it stopped and displayed a fault code, said Stockett, whose practice is based in Folsom, CA. She asserted the scanning procedure lasted only about 20 minutes.

Jacoby Roth several hours after receiving 151 CT scans in a 68-minute period. Photo courtesy of Roth family attorney Don Stockett.

In January 2008, the boy was taken to the emergency room at Mad River Community Hospital in Arcata, a small town 290 miles north of San Francisco, after he fell out of bed and could hardly move his head.

The ER doctor ordered x-rays and CT scans to check for damage to the child's cervical spine. The boy was taken to the scanning room, where Knickerbocker performed CT scans at C-spine levels C1 through C4 in the same section of the midmaxillary sinuses, midclivus, and posterior fossa. Over the next 68 minutes, the toddler was exposed to 151 scans.

Within a few hours, the child developed a bright red ring around his head from the massive radiation

State of California—Health and Human Services Agency

California Department of Public Health

RON CHAPMAN, MD, MPH
Director & State Health Officer

EDMUND G. BROWN JR.
Governor

Information Notice Regarding California Health and Safety Code, Section 115111, 115112, and 115113

Date: July 17, 2012

To: Facilities Using X-Ray Computed Tomography (CT) Equipment

Subject: Assembly Bill 510, Senate Bill 1237, and Senate Bill 38 (California Health and Safety Code Sections 115111, 115112, & 115113) Questions and Answers (Q&A)

This Q&A only applies to Health and Safety Code sections 115111 and 115113 which became effective July 1, 2012, and section 115112 which becomes effective July 1, 2013.

Text of Health and Safety Code Sections 115111, 115112, and 115113

Text of Health and Safety Code Sections 115111, 115112, and 115113

115111. (a) Commencing July 1, 2012, subject to subdivision (e), a person that uses a computed tomography (CT) X-ray system for human use shall record the dose of radiation on every diagnostic CT study produced during a CT examination in the patient's record, as defined in Section 123105. CT studies used for therapeutic radiation treatment planning or delivery or for calculating attenuation coefficients for nuclear medication studies shall not be required to record the dose.
(b) The facility conducting the study may send electronically each CT study and protocol page that lists the technical factors and dose of radiation to the electronic picture archiving and communications system.
(c) (1) Until July 1, 2013, the displayed dose shall be verified annually by a medical physicist for the facility's standard adult brain, adult abdomen, and pediatric brain protocols, to ensure the displayed doses are within 20 percent of the true measured dose measured in accordance with subdivision (f).
(2) A facility that has a CT X-ray system that is accredited by an organization that is approved by the federal Centers for Medicare and Medicaid Services, an accrediting agency approved by the Medical Board of California, or the State Department of Public

NCRP 160 (2009)

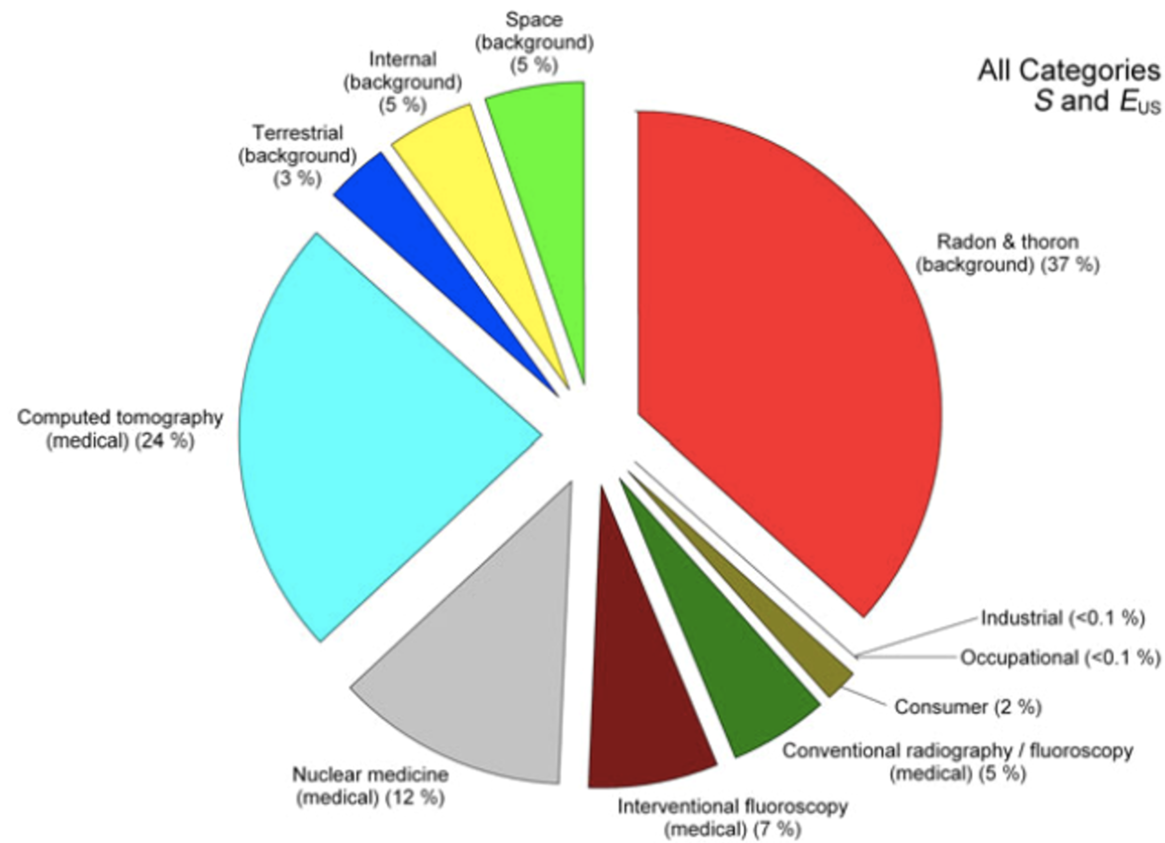


Fig. 1.1. Percent contribution of various sources of exposure to the total collective effective dose (1,870,000 person-Sv) and the total effective dose per individual in the U.S. population (6.2 mSv) for 2006. Percent values have been rounded to the nearest 1 %, except for those <1 % [see Table 1.1 for the values of S (person-sievert) and E_{US} (millisievert)].

Figure XII. Annual per caput effective dose (mSv) for the United States population in 1980 [M37]

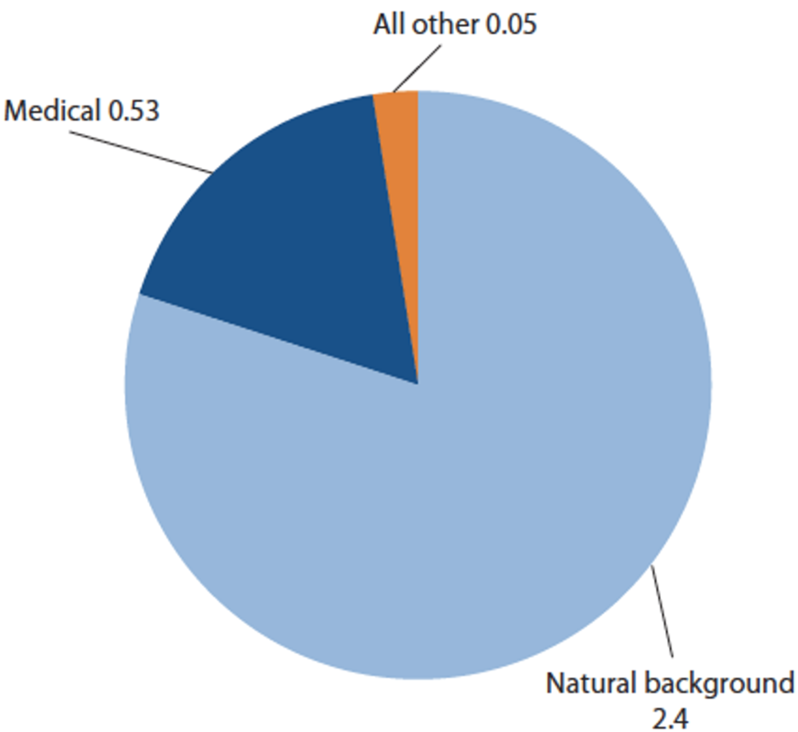
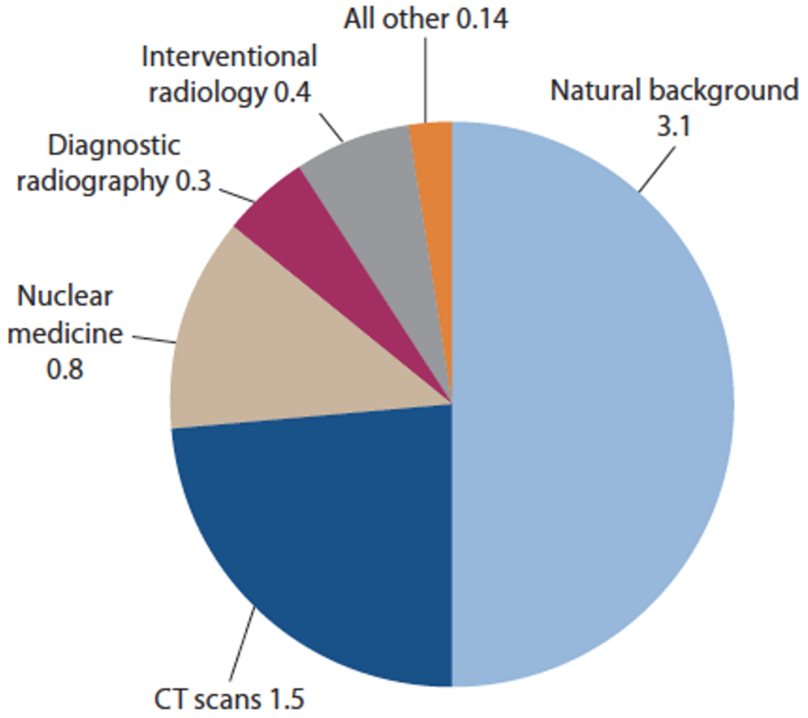


Figure XIII. Annual per caput effective dose (mSv) for the United States population in 2006 [N26]

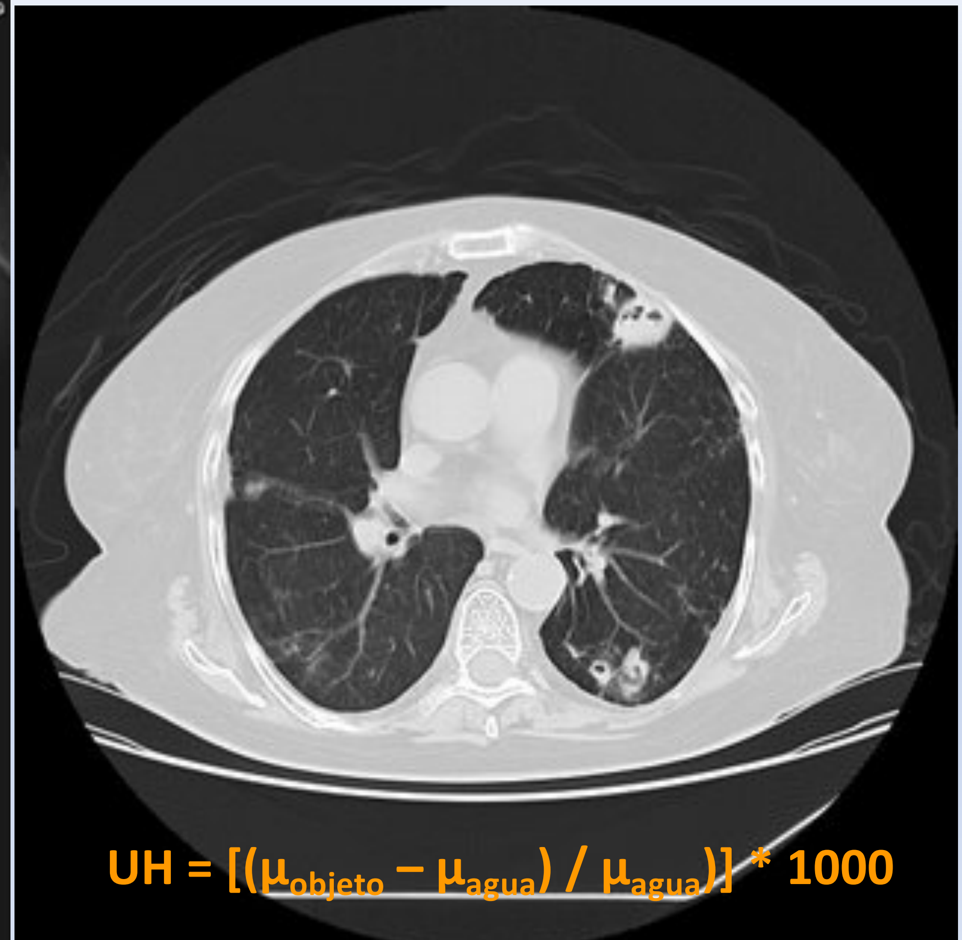


UNSCEAR 2008

¿A que se debe esta contribución?

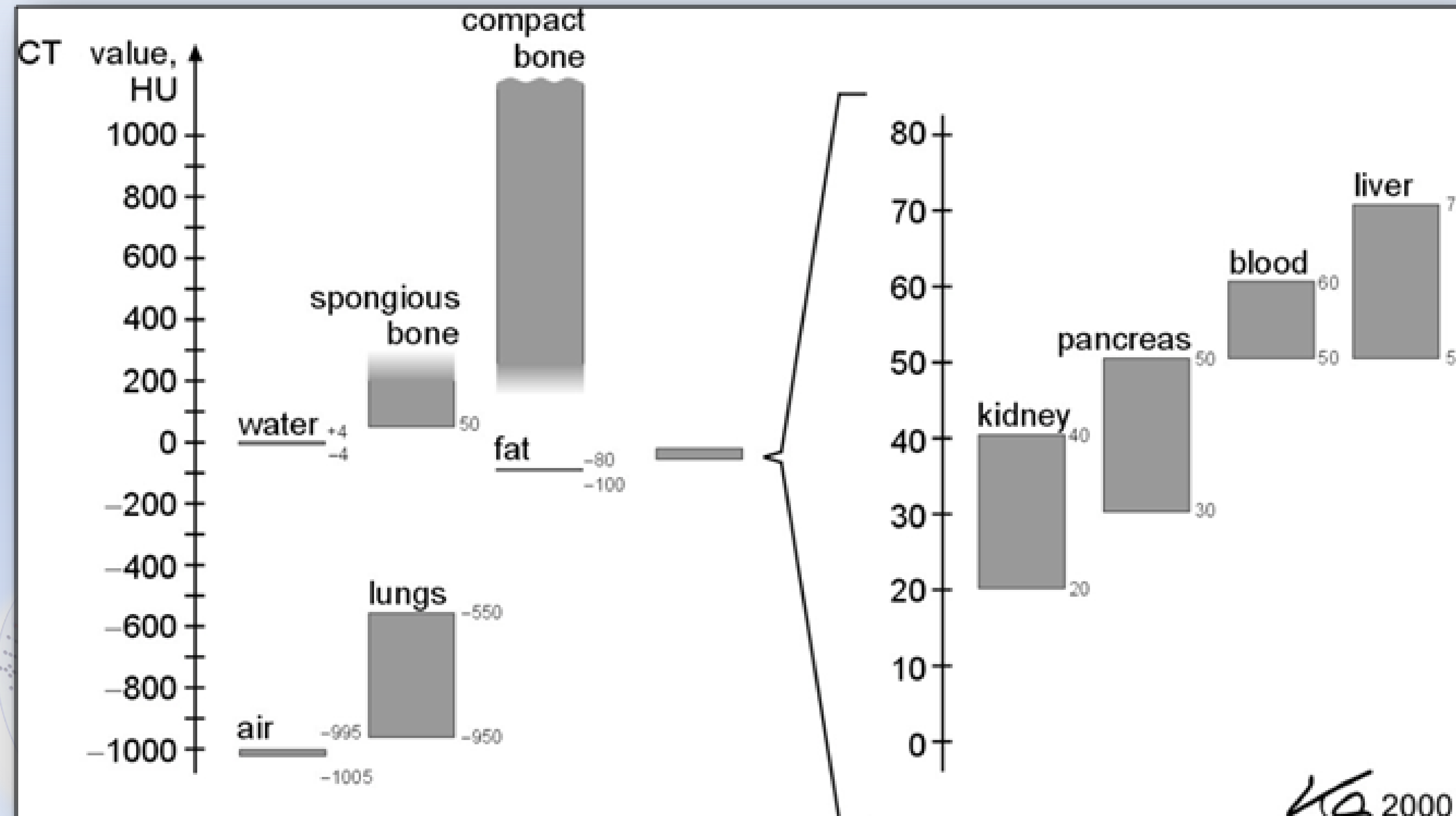
- Una mejor calidad de imagen se obtiene al aumentar los factores de exposición.

ICRP Publication 87



$$UH = [((\mu_{objeto} - \mu_{agua}) / \mu_{agua})] * 1000$$

Escala de Unidades Hounsfield



¿A que se debe esta contribución?

- Gran variabilidad en la aplicación de los parámetros técnicos de adquisición para una misma aplicación diagnóstica.

ICRP Publication 87

Table 5. Technical settings and dosimetry results (weighted computed tomography dose index ($CTDI_w$), dose–length product (DLP) and effective dose (E)) for abdomen examinations for the different CT units. Three ages are considered: 1-, 5- and 10-years-old

CT unit	Technical settings				Dosimetry quantities		
	Tube potential (kV)	Tube current–time (mAs)	Slice thickness (mm)	Table feed (mm)	$CTDI_w$ (mGy)	DLP (mGy cm)	E (mSv)
1-year-old							
A	120	120	5	7	13	217	4.56
B	120	50	10	10	7	171	3.91
C	120	180	5	5	25	576	15.5
D	120	20	10	10	4	104	2.33
E	120	221	5	7	23	381	10.1
F	120	220	5	7	28	468	11.0
G	120	60	4	4	15	349	9.66
5-year-old							
A	120	120	5	7	13	283	5.04
B	120	50	10	10	7	224	4.32
C	120	180	5	5	25	751	17.1
D	120	35	10	10	8	238	4.51
E	120	221	5	7	23	497	11.1
F	120	220	5	7	28	611	12.1
G	120	80	4	4	20	607	14.2
10-year-old							
A	120	120	7	9	13	363	5.06
B	120	150	8	8	24	830	12.0
C	120	180	5	5	25	876	15.9
D	120	55	10	10	12	437	6.59
E	na	na	na	na	na	na	na
F	na	na	na	na	na	na	na
G	120	120	4	4	30	1063	19.9

na, not available.

Pages J et al. The British Journal of Radiology, 76 (2003), 803–811

¿A que se debe esta contribución?

- En ocasiones se ocupan factores de exposición de pacientes adultos para exámenes pediátricos.

Radiation Protection Dosimetry Advance Access published February 11, 2010

Radiation Protection Dosimetry (2010), pp. 1–10

doi:10.1093/rpd/ncq015

PAEDIATRIC CT EXAMINATIONS IN 19 DEVELOPING COUNTRIES: FREQUENCY AND RADIATION DOSE

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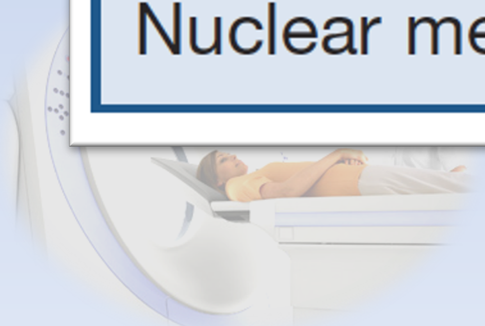
TC pediátrica

- Conclusiones:
  - Frecuencia de exámenes pediátricos es variable en distintas regiones geográficas.
    - África: 20%.
    - Asia: 16%.
    - Europa Este: 5%.
  - Aplicación de parámetros para pacientes adultos en exámenes pediátricos.

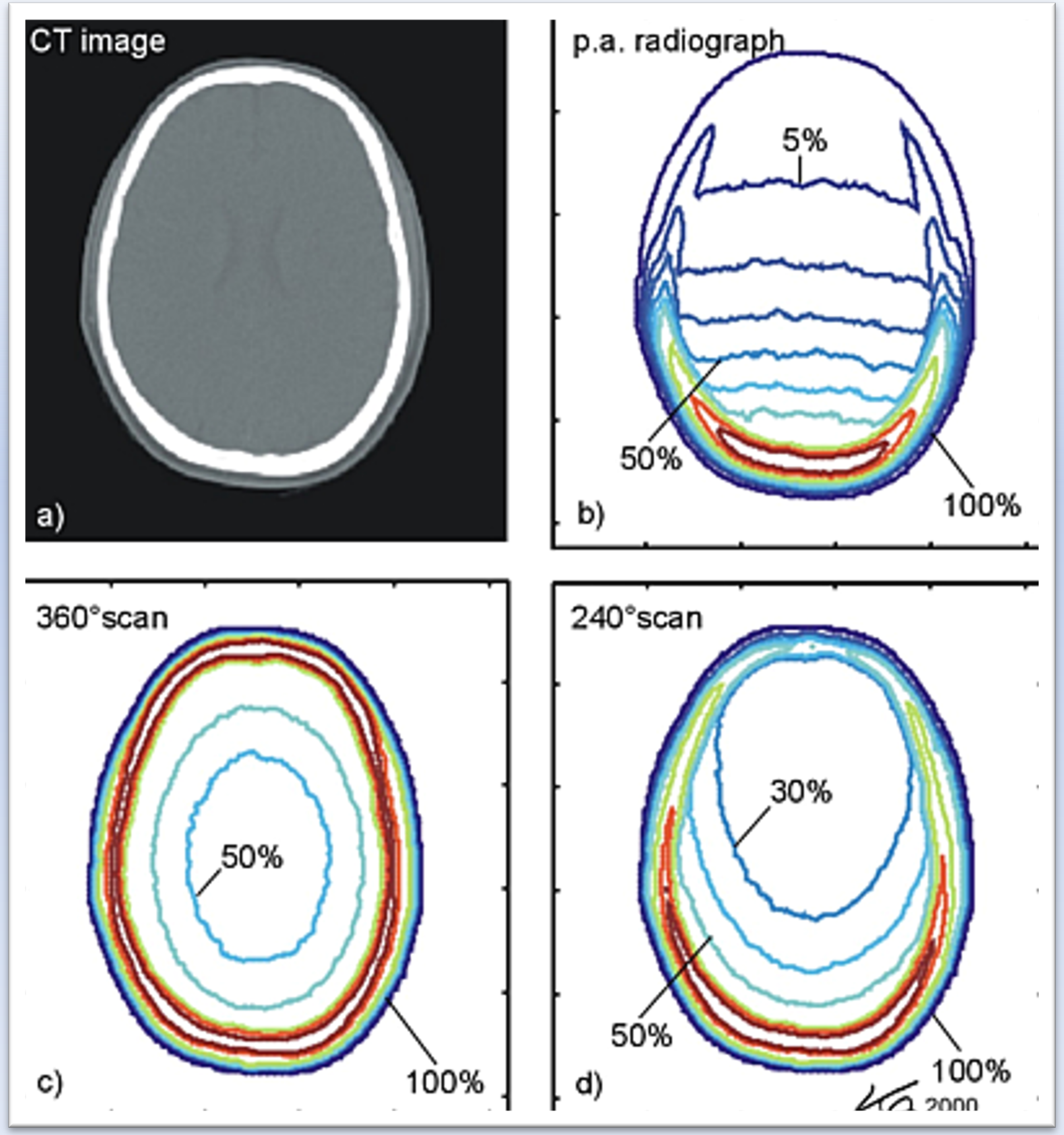
Mayor Dosis de Radiación

Table 1. Growth of computed tomography (CT) and nuclear medicine examinations in the United States (approximate) [5-8]

Examination	1980	2005
CT	3,000,000	60,000,000
Nuclear medicine	7,000,000	20,000,000



¿CÓMO DETERMINAR LA DOSIS EN TC?


CT image
a)
p.a. radiograph
5%
50%
100%
b)
360°scan
50%
100%
c)
240°scan
30%
50%
100%
d)

Computed Tomography Dose Index

- Computed Tomography Dose Index → **CTDI**
- Fue introducido en 1981 por Shope et al.
- Definición: Matemáticamente es la integral a lo largo de una línea paralela al eje de rotación **(z)** del perfil de dosis **D(z)** de un corte único, dividido por el grosor nominal **T** del corte* (ó $N_x T$).
- La unidad de medida del CTDI es el **Gray.**

Commission of European Communities. Quality Criteria fot Computed Tomography. 1999

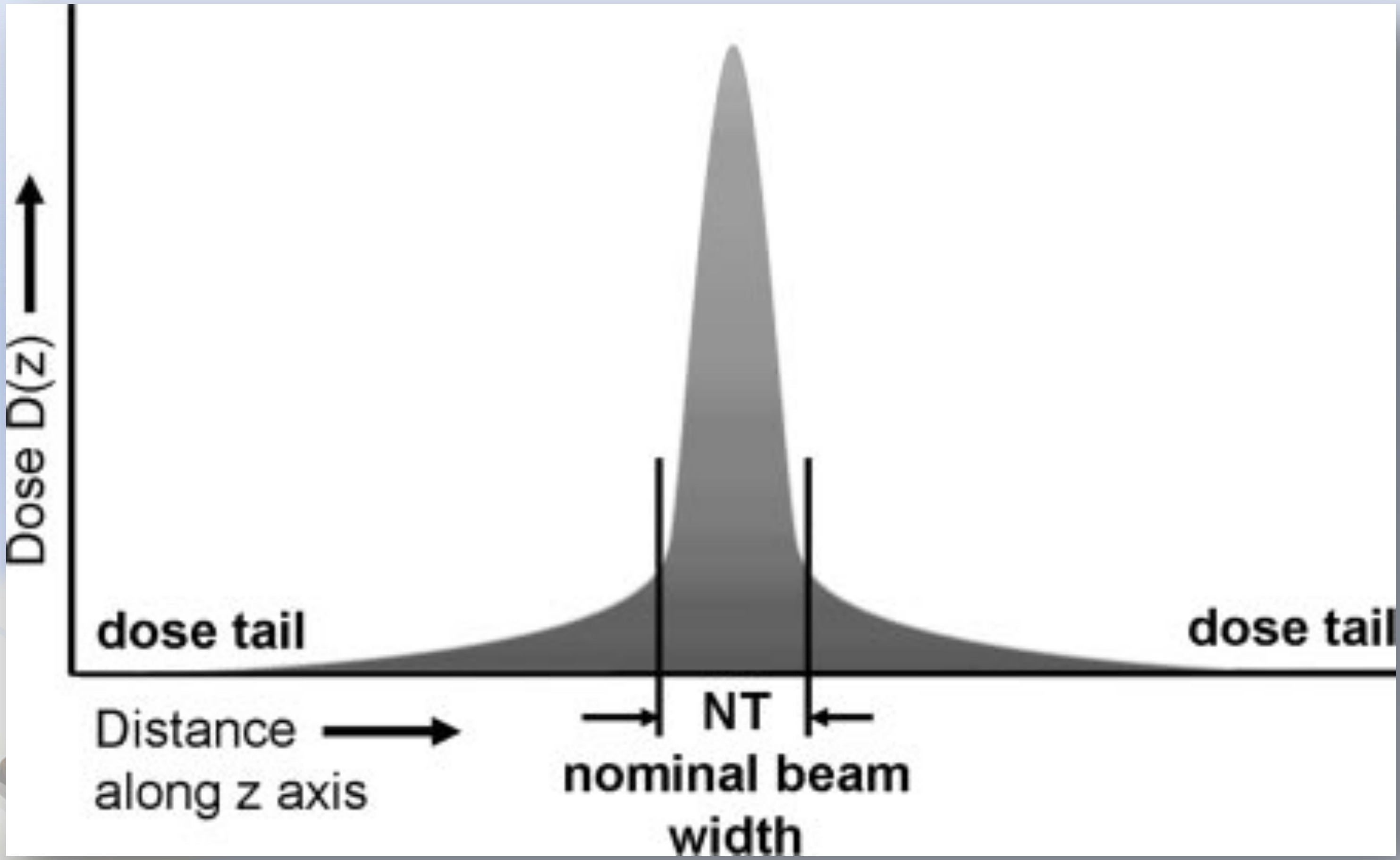
CTDI

- Definición: Matemáticamente es la integral a lo largo de una línea paralela al eje de rotación **(z)** del perfil de dosis **D(z)** de un corte único, dividido por el grosor nominal **T** del corte* (ó **NxT**).

- La unidad de medida del CTDI es el **Gray** (J/Kg).

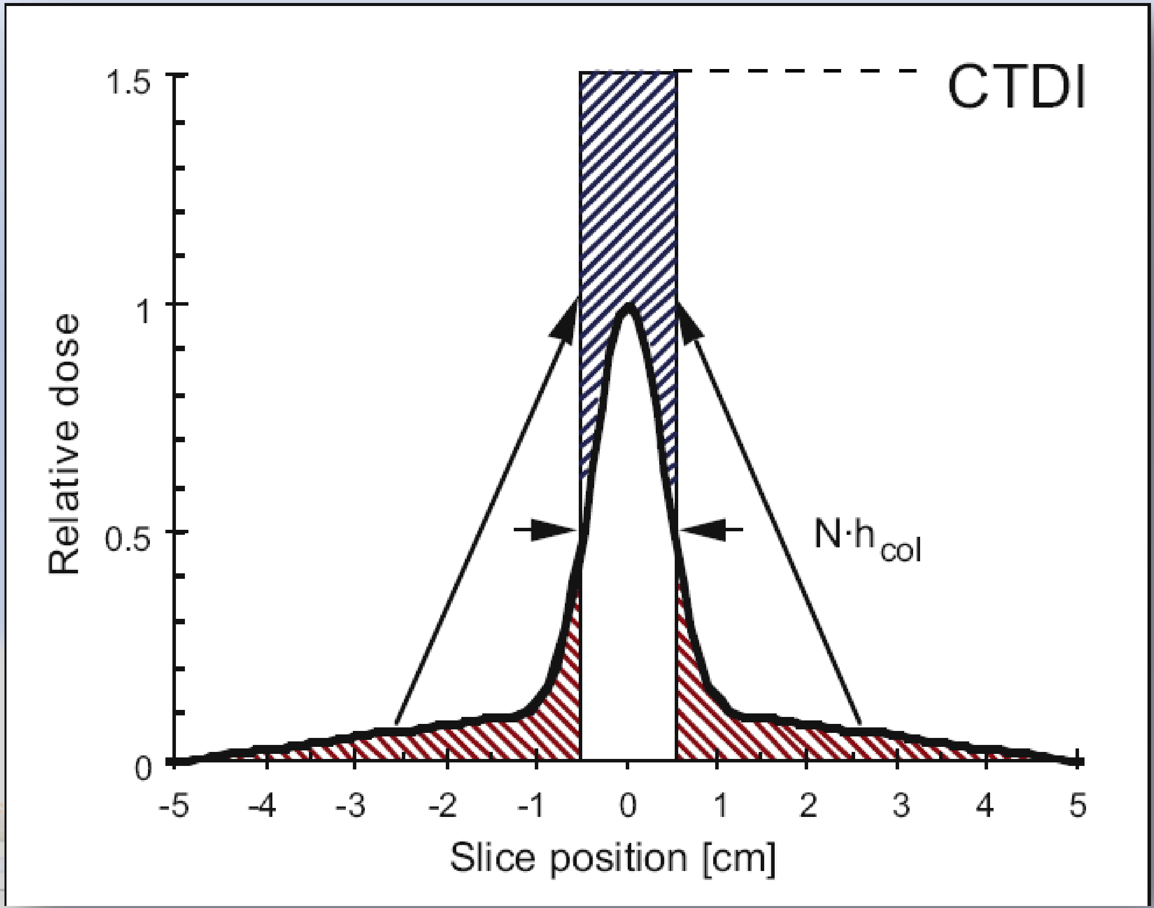
$$\mathrm{CTDI}_{\infty} = \frac{1}{T}\int_{-\infty}^{+\infty} D(z)\,dz$$

CTDI



RadioGraphics 2008; 28:245–253

CTDI



Cap4. H. D. Nagel. Radiation Dose from Adult & Pediatric MSCT

CTDI

- Limitación:
  - El CTDI nos da un índice de la dosis entregada SOLO en un corte único.

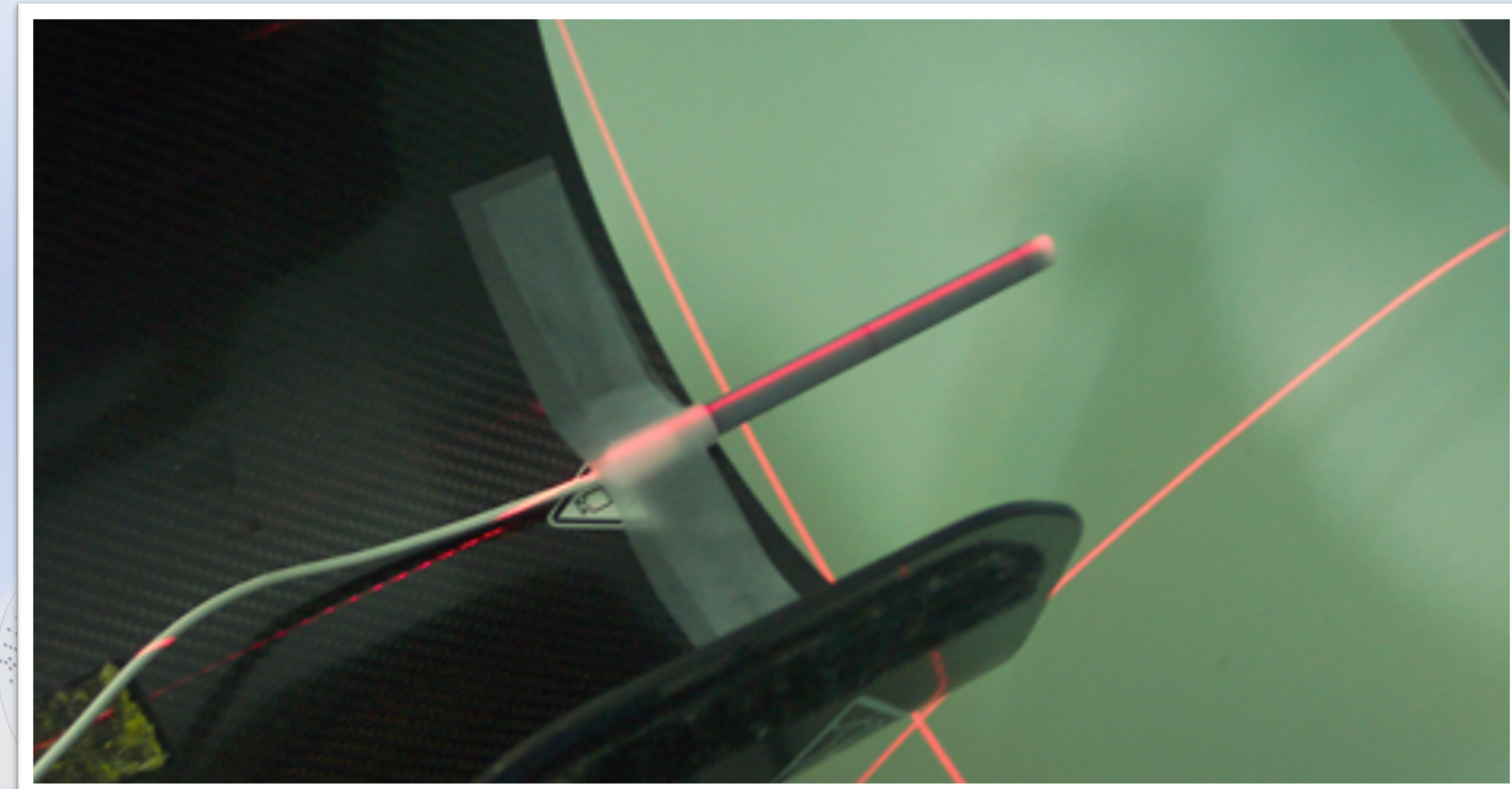
$CTDI_{100}$

- Para el $CTDI_{100}$ los límites de integración del perfil de dosis son ±50mm, centrados en el perfil.
- Este limite corresponde al largo de 100mm de las cámaras de ionización de tipo lápiz disponibles en el mercado.
- El $CTDI_{100}$ es medido utilizando estas cámaras de ionización y los fantomas de CTDI introducidos por la FDA.

Cámara Ionización 100mm

OIEA. TRS 457

$CTDI_{aire}$



$CTDI_{aire}$

$CTDI_{100}$ - Aire

$$CTDI_{100,a} = \frac{\bar{M} \times cal \times f_C \times L}{N \times T}$$

Prom. Lectura*

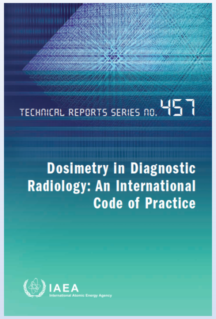
Factor Calibración Cámara

Largo Activo Cámara

Factor Conversión Unidades
($8,76 \times 10^{-3}$ mGy/mR)

Ancho Total Haz
(N° canales N x grosor corte efectivo T)

** Lectura en Exposición o Kerma*



CTDI_{100} - Aire

Prom. Lectura

Factor Calibración Cámara

Factor Corrección por Tº y Pº

$$C_{a,100} = \frac{1}{NT}\bar{M}N_{P_{KL},Q_0}k_Q k_{TP}$$

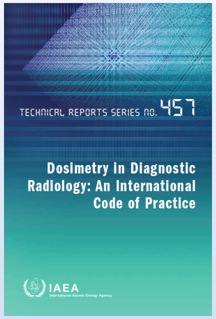
Ancho Total Haz

(N° canales N x grosor corte efectivo T)

Factor Corrección por Calidad del Haz

** Lectura en mGy·cm*

OIEA. TRS 457

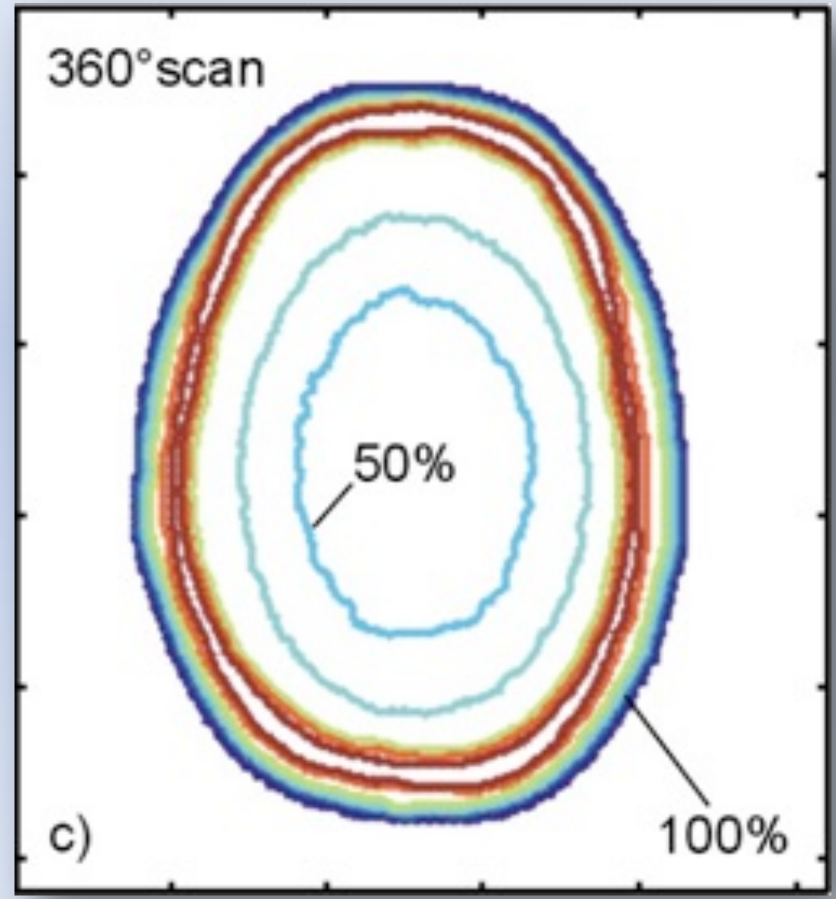


$CTDI_{100}$ - Aire

$$k_{TP} = \left(\frac{273.2 + T}{273.2 + T_0}\right)\left(\frac{P_0}{P}\right)$$

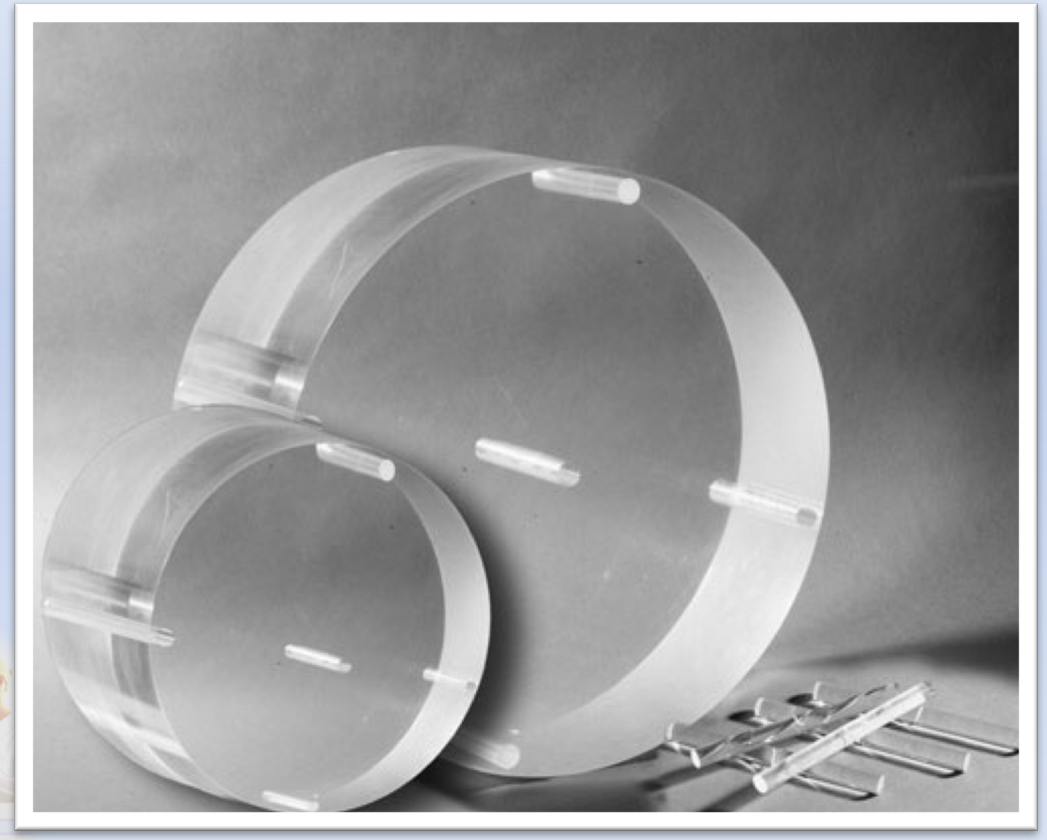
$T_0 = 20^{o}C$ $P_0 = 101.3$ kPa

Consideración



W. Kalender. Computed Tomography

Fantomas CTDI



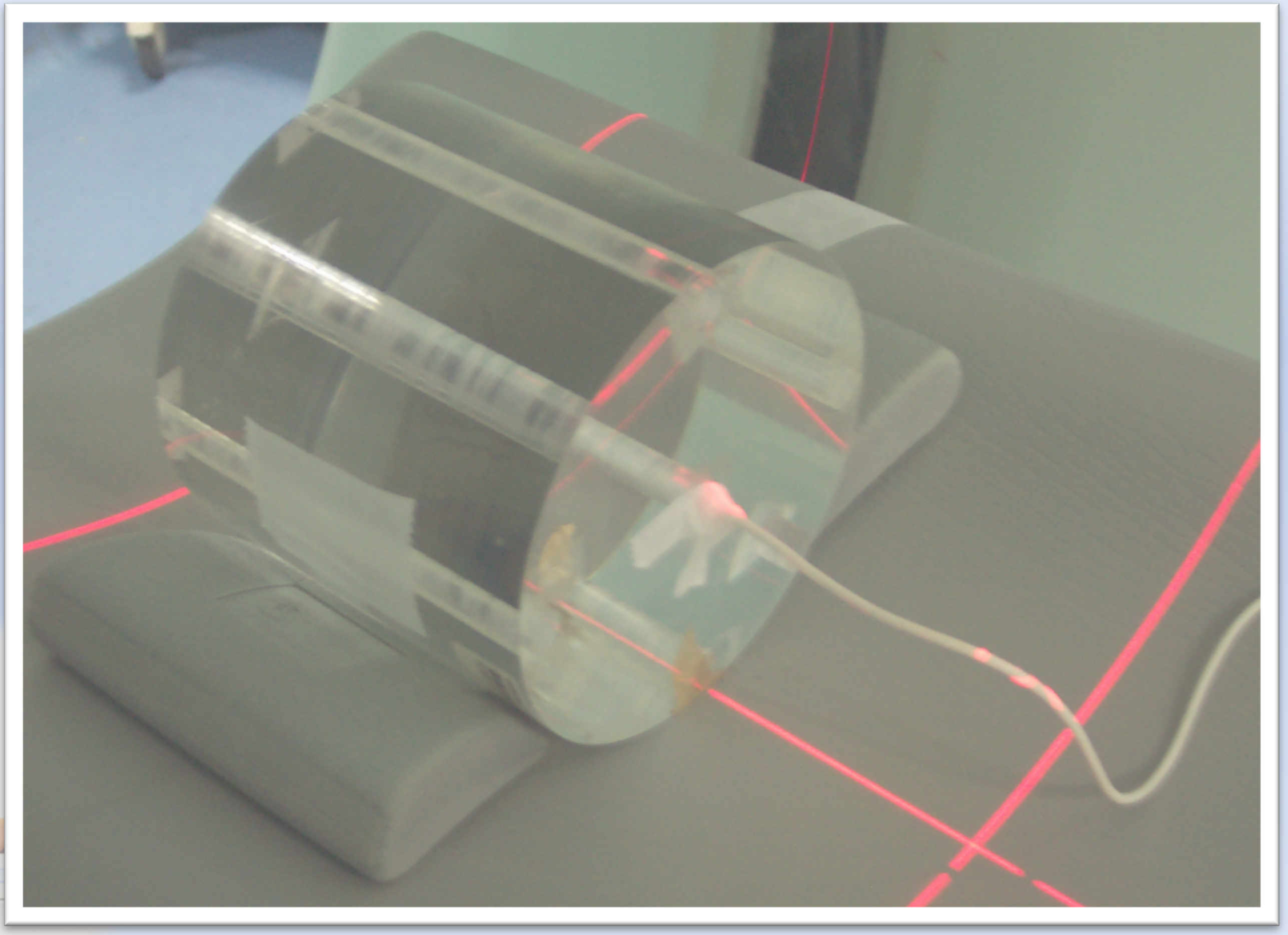
CTDIw

- Tomando en cuenta esta consideración, se introdujo un nuevo parámetro que pondera (weighted) de forma diferente la contribución de las mediciones de $CTDI_{100}$ realizadas en la periferia y centro del fantoma.

$$CTDI_w = \frac{1}{3} CTDI_{100,c} + \frac{2}{3} CTDI_{100,p}$$

Commission of European Communities. Quality Criteria fot Computed Tomography. 1999

CTDIw



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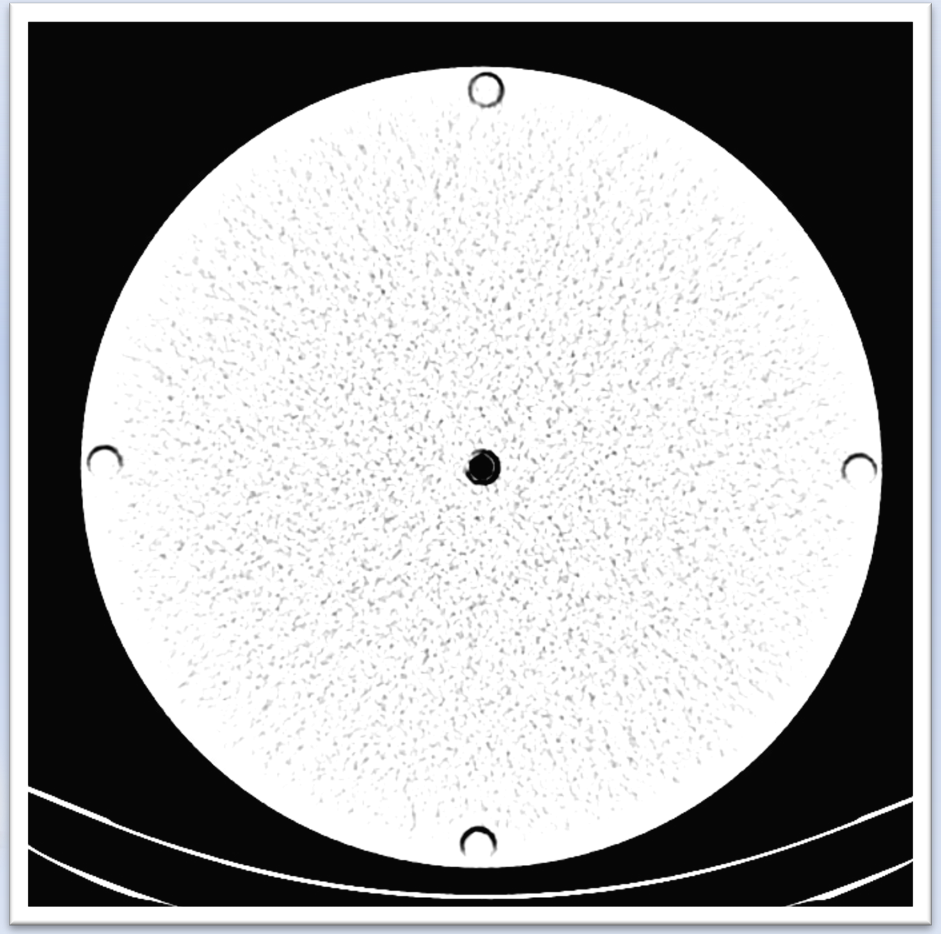
CTDIw



$CTDI_{vol}$

- $CTDI_{vol}$ representa la dosis para un corte en un protocolo de barrido helicoidal, que generalmente considera una serie de rotaciones.

- Toma en consideración los gap y superporsiciones de perfiles de rotaciones consecutivas.

$$CTDI_{vol} = CTDI_w/pitch$$

- Este parámetro nos permite considerar el efecto de la velocidad de avance de la camilla en la cuantificación de la dosis entregada en un protocolo específico.

ICRP 102. 2007

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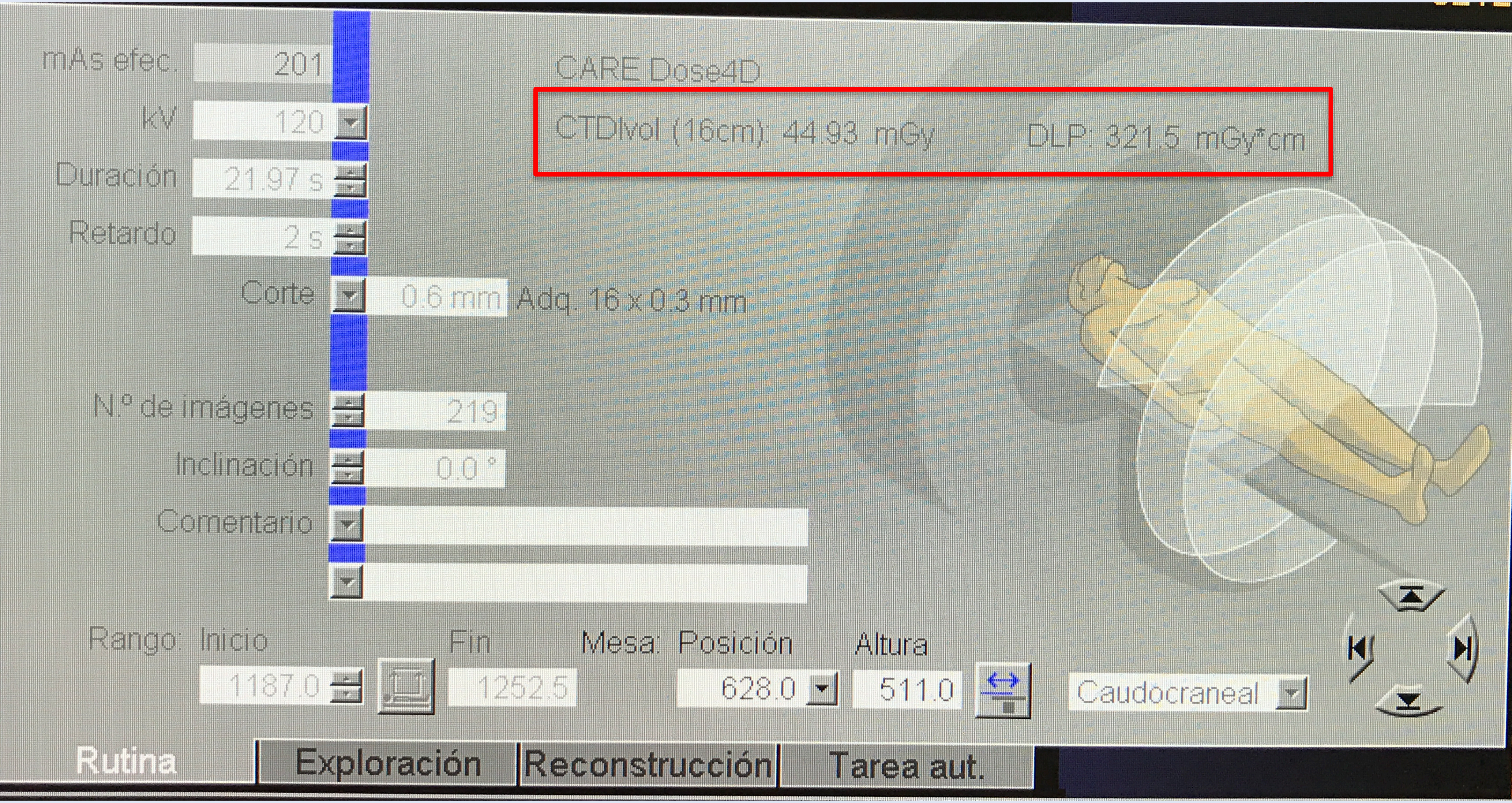
Dose Length Product

- El DLP nos entrega la exposición total de un barrido para un protocolo específico y un largo de exploración determinado.

DLP

$$\mathrm{DLP} = \mathrm{CTDI}_{\mathrm{vol}} \cdot \text{scan length.}$$

RadioGraphics 2002; 22:1541–1553


mAs efec. 201
kV 120
Duración 21.97 s
Retardo 2 s
Corte 0.6 mm Adq. 16 x 0.3 mm
N.º de imágenes 219
Inclinación 0.0 °
Comentario
CARE Dose4D
CTDIvol (16cm): 44.93 mGy
DLP: 321.5 mGy*cm
Rango: Inicio 1187.0
Fin 1252.5
Mesa: Posición 628.0
Altura 511.0
Caudocraneal
Rutina
Exploración
Reconstrucción
Tarea aut.

13-May-2011 11:48

Estación: 601
Médico examinador: especialista^medico
Técnico:

Total mAs 3944 DLP total 313

	Scan	KV	mAs	/ ref.	CTDIvol	DLP	TI	cSL
posición del paciente F-SP								
Topograma	1	120					5.3	0.6
Exploración de Control	2	120	40		2.42	2	0.5	10.0
TestBolus	3	100	40		8.42	8	0.5	10.0
AngioTEP 100	9	100	231	/ 300	10.28	303	0.37	0.6

W 50 : L 200

Dosis Efectiva

- La D_{ef} se puede estimar a través de los valores de DLP.

$$E = E_{DLP} \times DLP$$

- E_{DLP} es un factor de conversión que representa un valor de D_{ef} normalizado a una región anatómica específica.

Dosis Efectiva

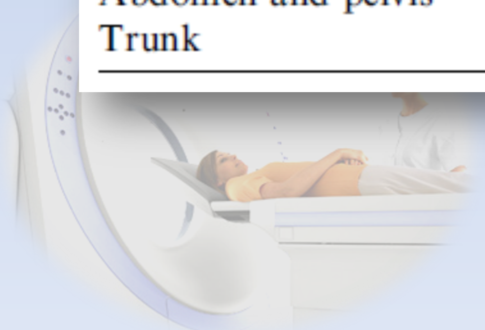
Region of body	Normalised effective dose, E_{DLP} (mSv mGy^{-1} cm^{-1})
Head	0.0023
Neck	0.0054
Chest	0.017
Abdomen	0.015
Pelvis	0.019

Commission of European Communities. Quality Criteria fot Computed Tomography. 1999

Dosis Efectiva

Table A.2. Normalised effective dose per dose–length product (DLP) for adults (standard physique) and paediatric patients of various ages for various body regions. (Bongartz, et al. 2004, Shrimpton et al. 2006)

Region of body	k ($mSv \cdot mGy^{-1} \cdot cm^{-1}$)				
	0-year-old	1-year-old	5-year-old	10-year-old	Adult
Head and neck	0.013	0.0085	0.0057	0.0042	0.0031
Head	0.011	0.0067	0.0040	0.0032	0.0021
Neck	0.017	0.012	0.011	0.0079	0.0059
Chest	0.039	0.026	0.018	0.013	0.014
Abdomen and pelvis	0.049	0.030	0.020	0.015	0.015
Trunk	0.044	0.028	0.019	0.014	0.015



ICRP- 102

Dosis Efectiva

Table 1. Relative radiation level designations along with common example examinations for each classification

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range	Example Examinations
O	0	0 mSv	Ultrasound; MRI
☢	<0.1 mSv	<0.03 mSv	Chest radiographs; Hand radiographs
☢☢	0.1-1 mSv	0.03-0.3 mSv	Pelvis radiographs; Mammography
☢☢☢	1-10 mSv	0.3-3 mSv	Abdomen CT, Nuclear medicine bone scan
☢☢☢☢	10-30 mSv	3-10 mSv	Abdomen CT without and with contrast; Whole body PET
☢☢☢☢☢	30-100 mSv	10-30 mSv	CTA chest abdomen and pelvis with contrast; Transjugular intrahepatic portosystemic shunt placement

*The RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, the region of the body exposed to ionizing radiation, the imaging guidance that is used, etc). The RRLs for these examinations are designated as "Varies."

ACR 2007

Continuará...