Efecto de las imágenes utilizadas en la planificación de la radioterapia

(dosis recibida por TAC de simulación y por IGRT)

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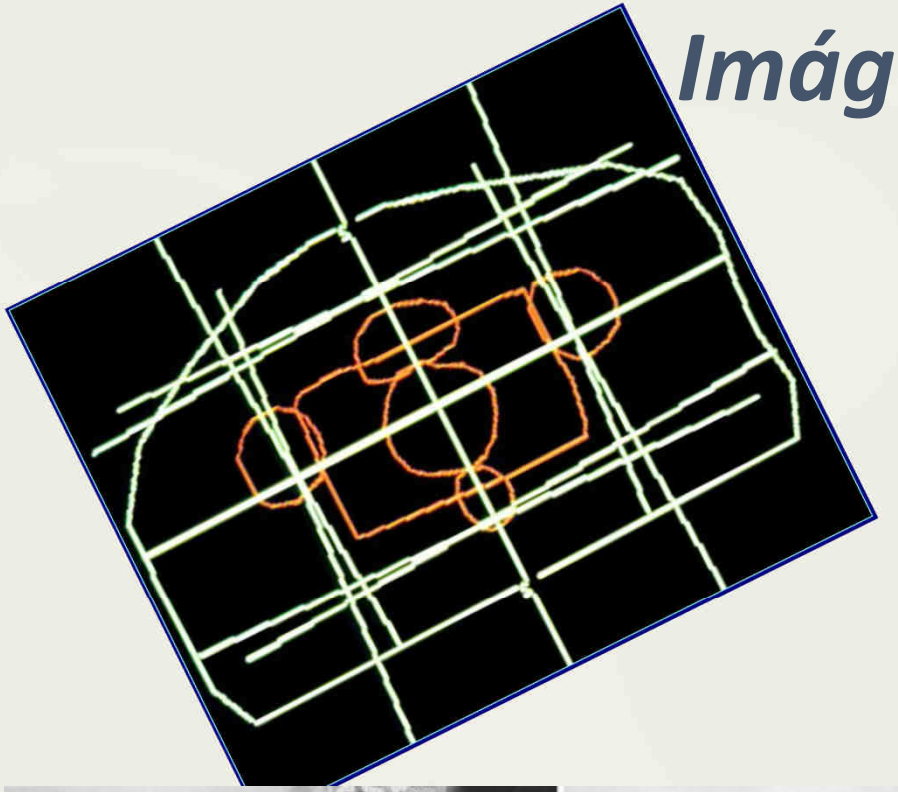
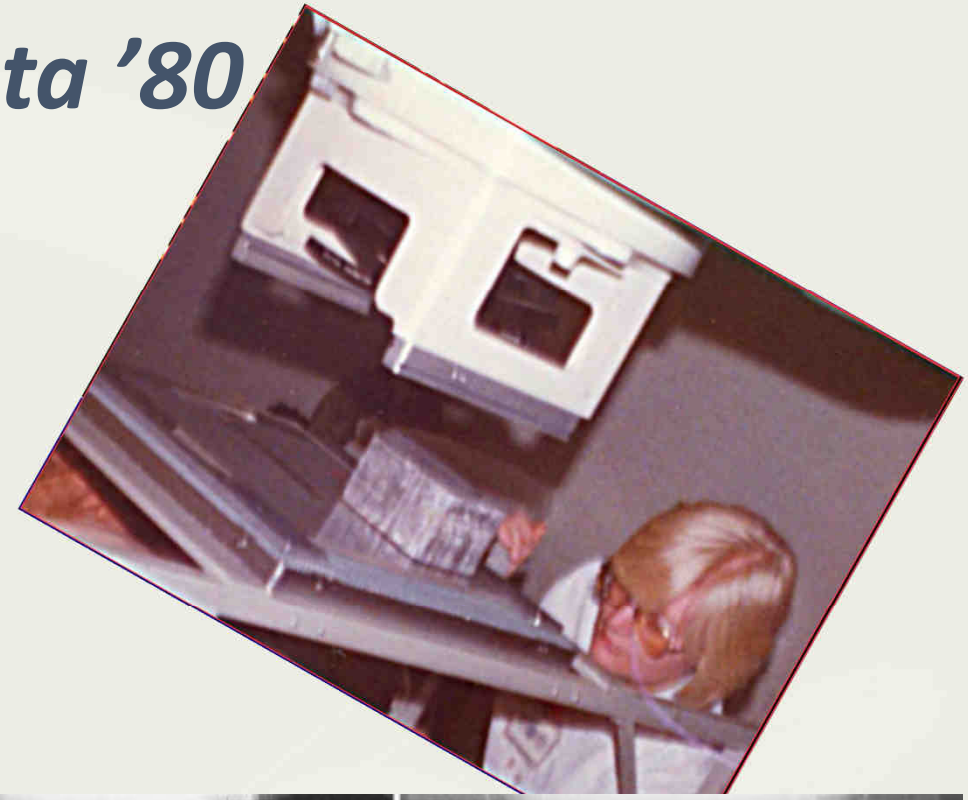
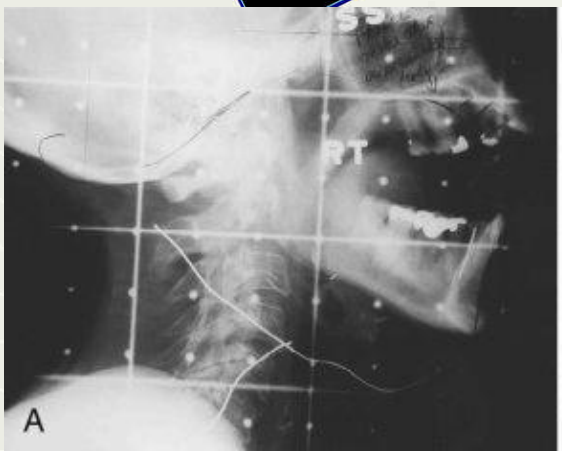
PROGRAMA DE EDUCACION CONTINUA
FUNDACIÓN MARIE CURIE 2013 - 2014

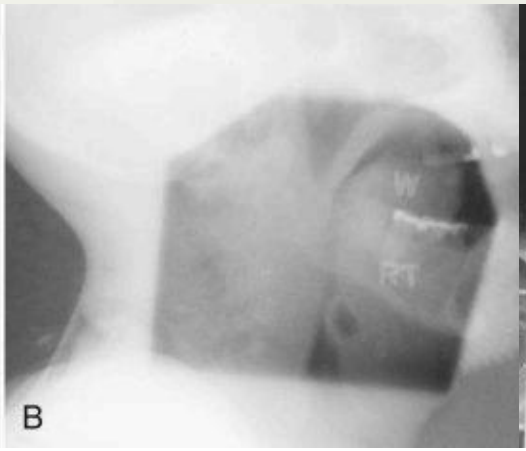
CURSO DE ACTUALIZACIÓN EN PROTECCIÓN RADIOLÓGICA

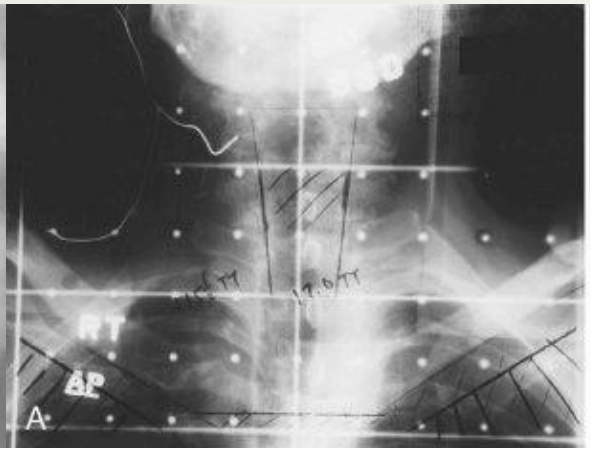
Imágenes hasta ’80

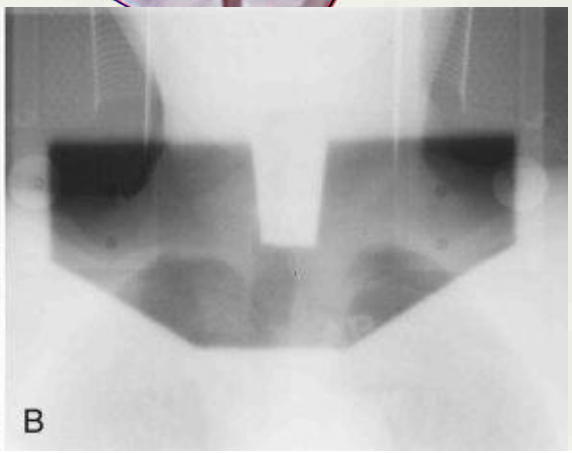


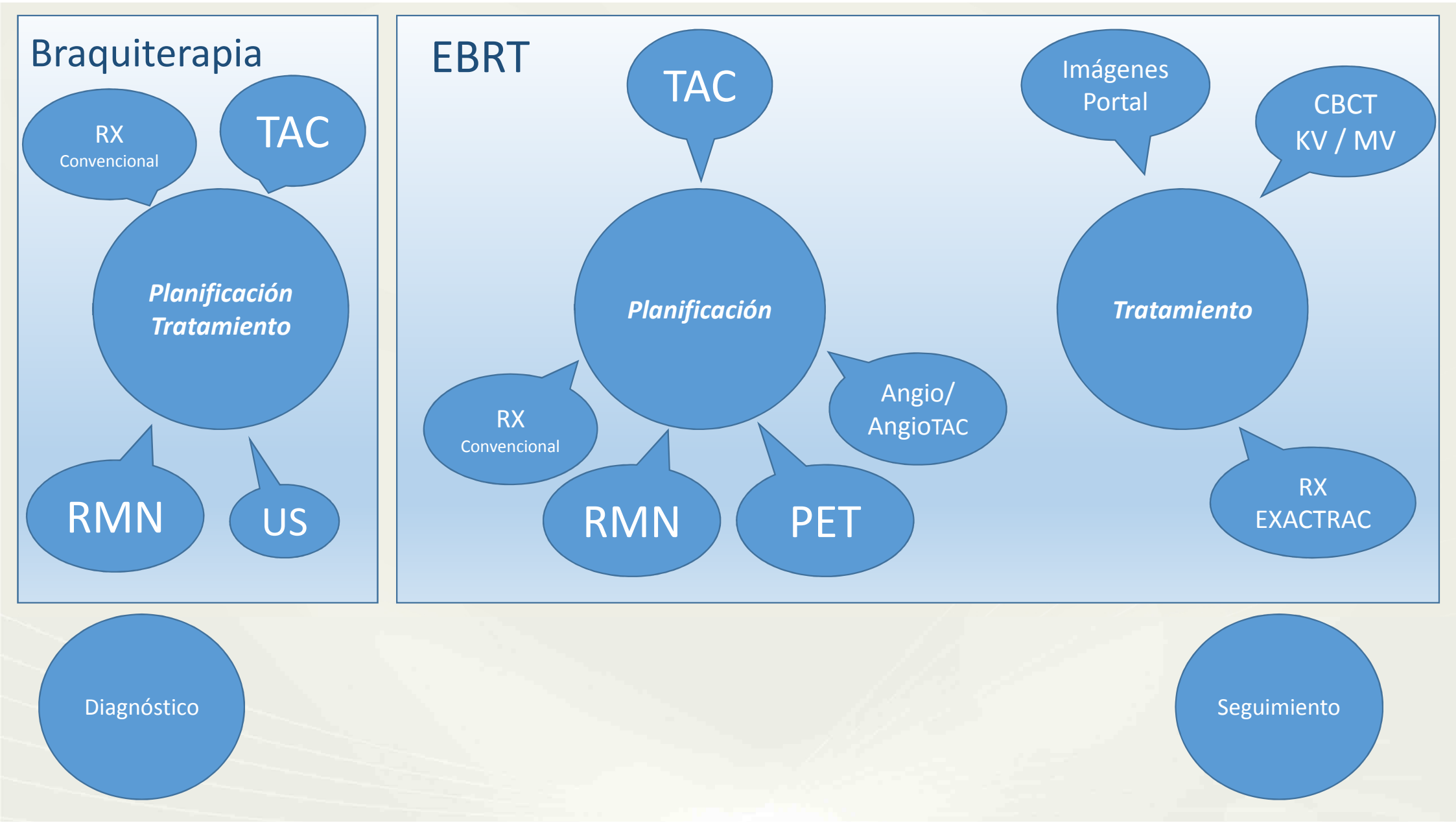











Braquiterapia
RX
Convencional
TAC
Planificación
Tratamiento
RMN
US
EBRT
TAC
Planificación
RX
Convencional
RMN
PET
Angio/
AngioTAC
Imágenes
Portal
CBCT
KV / MV
Tratamiento
RX
EXACTRAC
Diagnóstico
Seguimiento

Cancer Statistics, 2012

Rebecca Siegel, MPH[1]; Deepa Naishadham, MA, MS[2]; Ahmedin Jemal, DVM, PhD[3]

Abstract

Each year, the American Cancer Society estimates the numbers of new cancer cases and deaths expected in the United States in the current year a
based on incidence data from the
the North American Association of
Statistics. A total of 1,638,910 nev
United States in 2012. During the most recent 5 years for which there are data (2004-2008), overall cancer inci-
n women, while cancer death rates
ast 10 years of available data (1999-
l women of every racial/ethnic group
ave remained stable. The most rapid
.4% and 2.3% per year, respectively).
Death rates continue to decline for all 4 major cancer sites (lung, colorectum, breast, and prostate), with lung cancer accounting for almost 40% of the total decline in men and breast cancer accounting for 34% of the total decline in women. The reduction in overall cancer death rates since 1990 in men and 1991 in women translates to the avoidance of about 1,024,400 deaths from cancer. Further progress can be accelerated by applying existing cancer control knowledge across all segmen
nomic bracket. CA Cancer J Clin 20

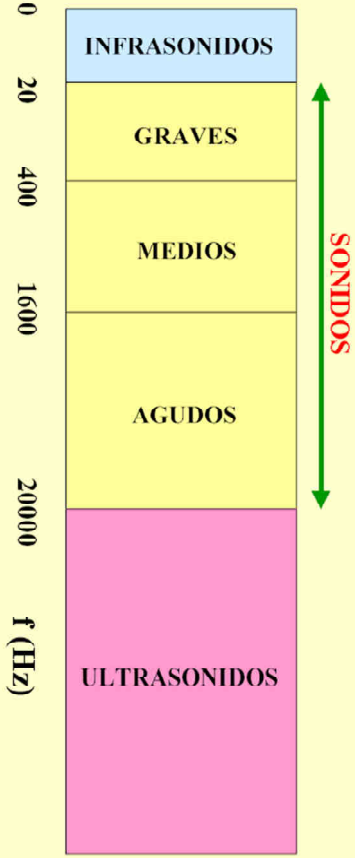
…1.638.910 nuevos casos de cáncer y 577.190 muertes son proyectadas en 2012 (USA)…

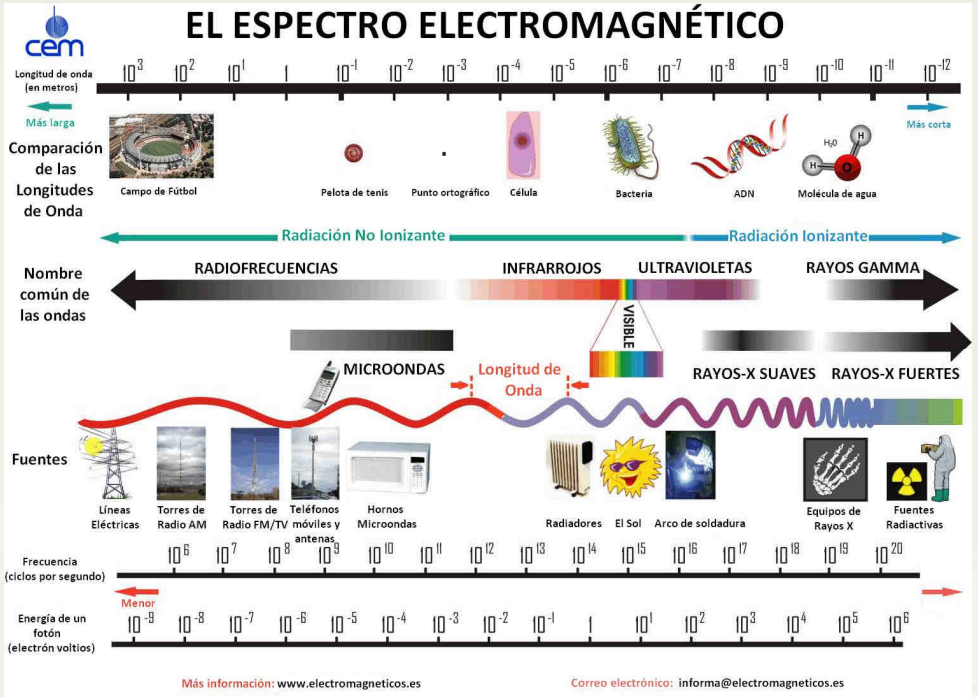
… durante (2004-2008) la incidencia de cáncer disminuyo levemente, mientras la tasa de muerte por cáncer disminuyo 1.8% en hombres y 1.6% en mujeres…

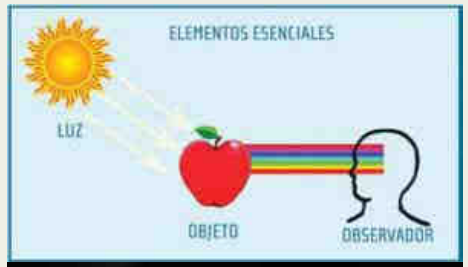
… la reducción en la mortalidad desde 1990 evitó **1.024.400** muertes por cáncer…progresos pueden ser acelerados…

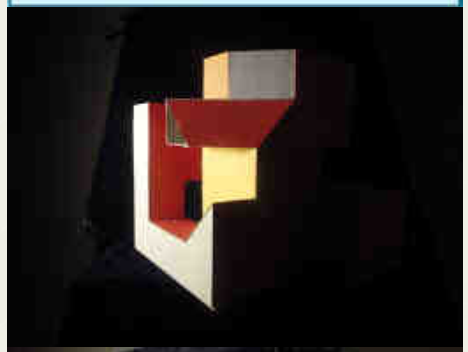
GENERACION DE LA IMAGEN

Idealización del Momento Magnético de un electrón.









EL ESPECTRO ELECTROMAGNÉTICO

cem

Longitud de onda (en metros)

10^{3} 10^{2} 10^{1} 1 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}

Más larga — Más corta

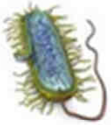
Comparación de las Longitudes de Onda


Campo de Fútbol

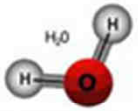

Pelota de tenis

Punto ortográfico


Célula


Bacteria


ADN



Molécula de agua

Radiación No Ionizante — Radiación Ionizante

Nombre común de las ondas

RADIOFRECUENCIAS — INFRARROJOS — ULTRAVIOLETAS — RAYOS GAMMA

VISIBLE

MICROONDAS — Longitud de Onda — RAYOS-X SUAVES — RAYOS-X FUERTES

Fuentes


Líneas Eléctricas


Torres de Radio AM


Torres de Radio FM/TV


Teléfonos móviles y antenas


Hornos Microondas


Radiadores


El Sol


Arco de soldadura


Equipos de Rayos X


Fuentes Radiactivas

Frecuencia (ciclos por segundo)

10^{6} 10^{7} 10^{8} 10^{9} 10^{10} 10^{11} 10^{12} 10^{13} 10^{14} 10^{15} 10^{16} 10^{17} 10^{18} 10^{19} 10^{20}

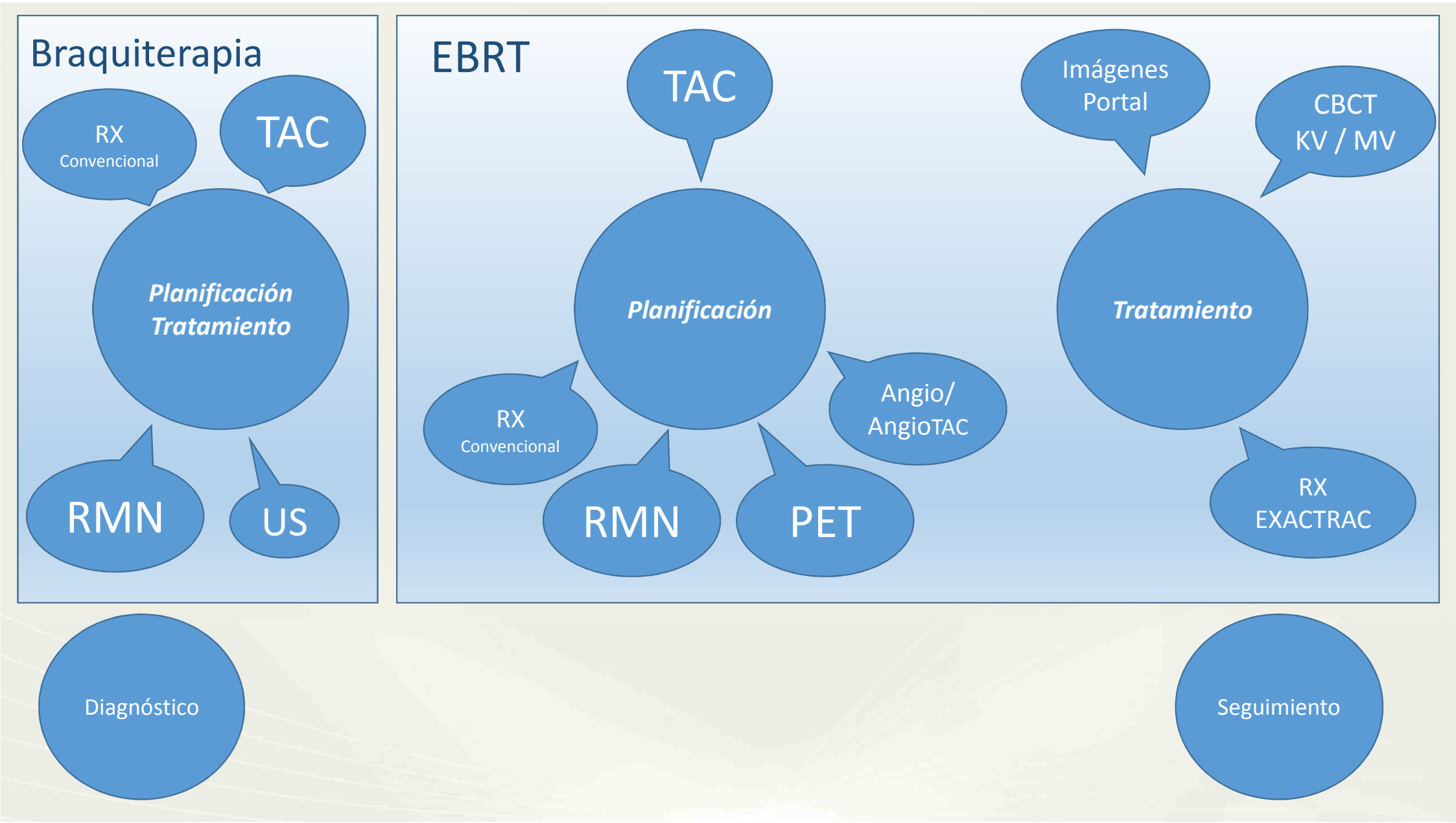
Menor

Energía de un fotón (electrón voltios)

10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}

Más información: www.electromagneticos.es

Correo electrónico: informa@electromagneticos.es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Tratamiento
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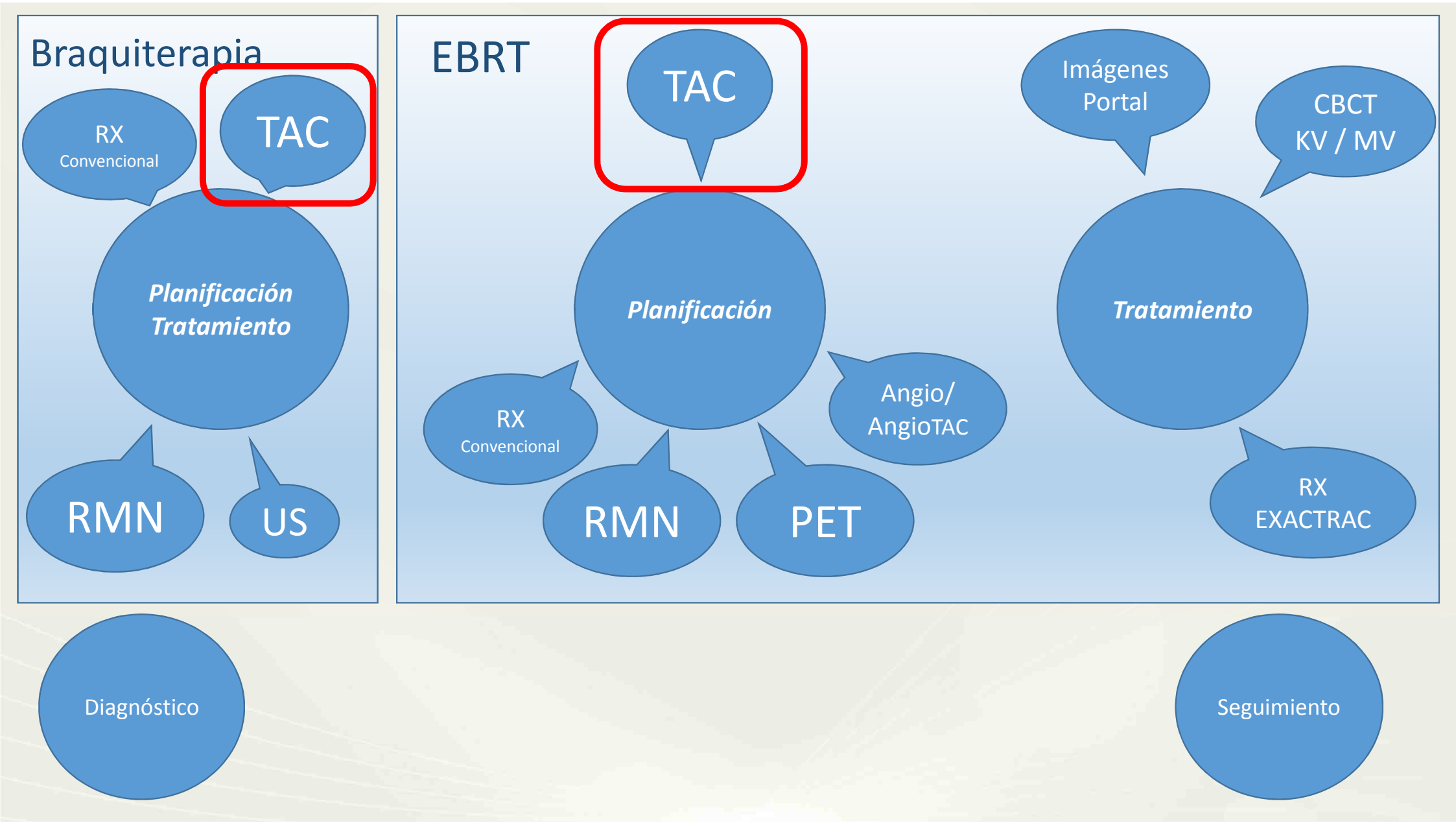
EXACTRAC
Diagnóstico
Seguimiento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RMN
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Angio/
AngioTAC
Imágenes
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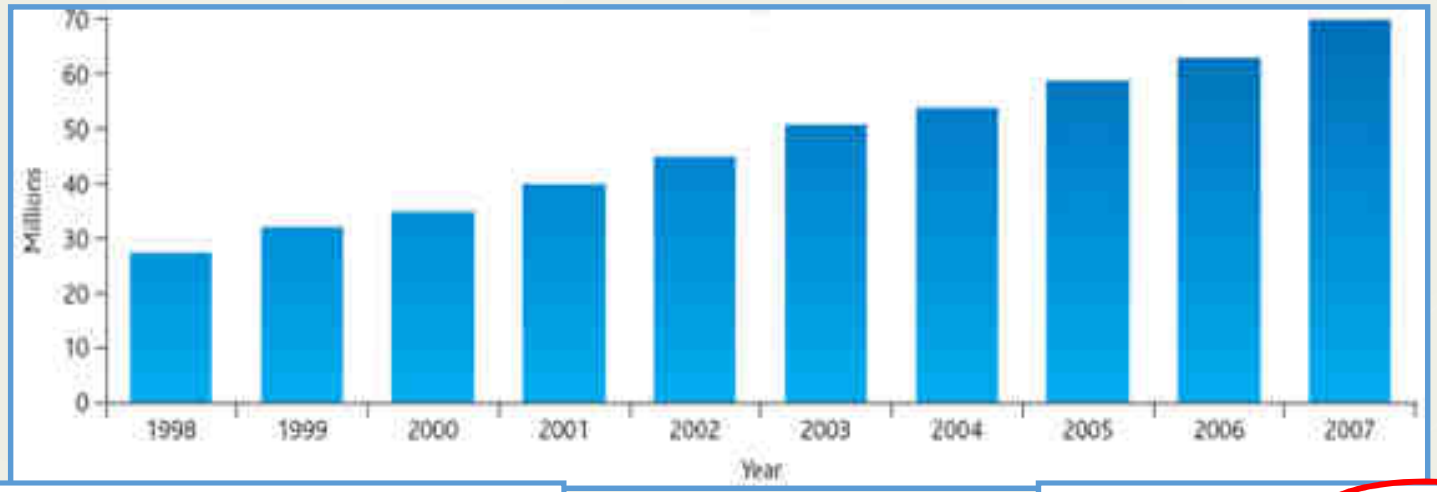
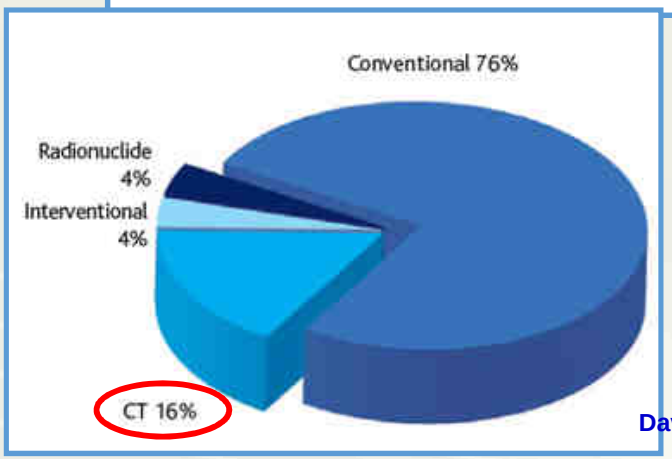
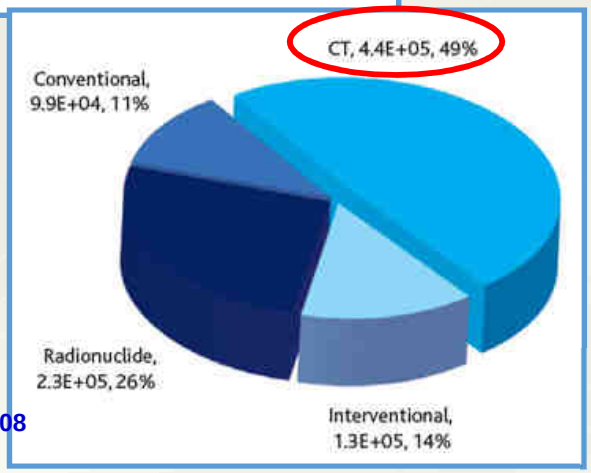
CBCT
KV / MV
Tratamiento
RX
EXACTRAC
Diagnóstico
Seguimiento

Dosis entregada a la población debido a estudios de TAC
(2007 USA)







David Sutton, C2I2, Volume VI, Issue 2, 2008

- Nueva Generación de escaner
- TAC helicoidal, fan o cone beam (MDCT)
- Nuevas técnicas de perfusion (mesa fija o con mov combinado)

Dosis ➤➤ → Accidentes

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Parámetros de dosimetría

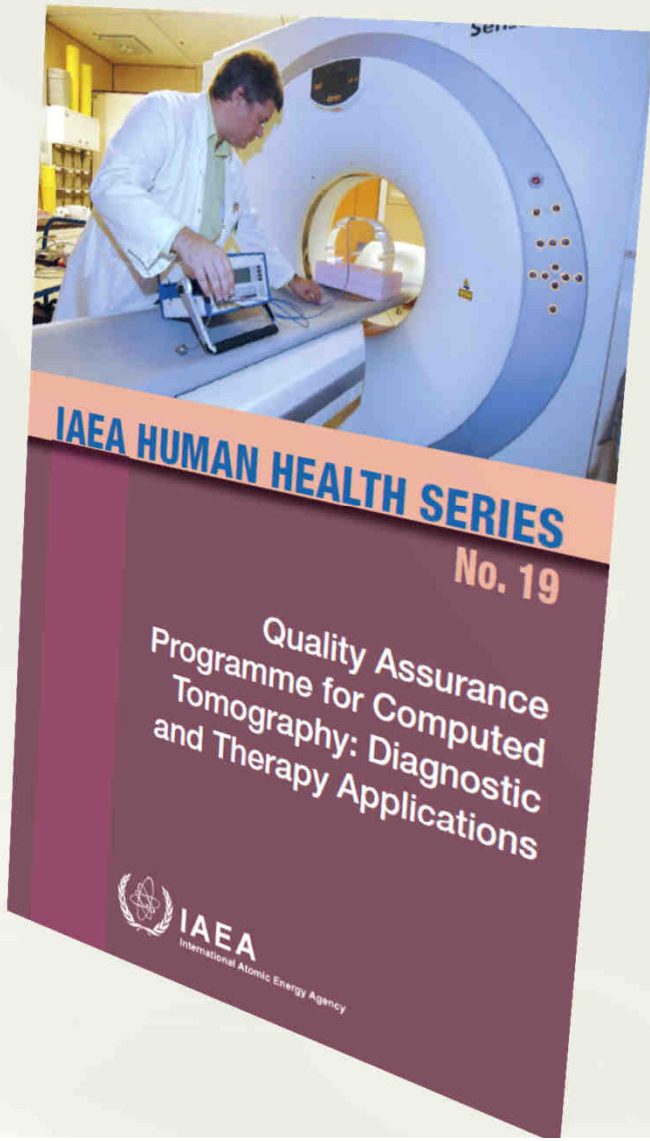
- **CTDI =** Computed Tomography Dose Index en mGy
- **MSAD =** Multiple scan Average Dose en mGy
- **DLP =** Dose Length Product en mGy.cm

CTDI y MSAD → Dosis a los órganos

DLP → Estimación del riesgo

TABLE 1. COMPARISON OF IAEA AND IEC DOSIMETRY TERMINOLOGY USED IN CT

Quantity	IAEA	IEC
Measured free-in-air:		
CT air kerma index	$C_{a,100} = \frac{1}{NT}\int_{-50}^{+50} K(z)dz$	$CTDI_{air} = 1/NT \int_{-\infty}^{+\infty} K_a(z)\, dz$
Measured in standard phantom:		
Weighted CT air kerma index	$C_w = \frac{1}{3}\left(C_{PMMA,100,c} + 2\ C_{PMMA,100,p}\right)$	$CTDI_w = 1/3\ CTDI_{100,c} + 2/3\ CTDI_{100,p}$
Normalized weighted CT air kerma index	${}_nC_w$	${}_nCTDI_w$
Volume CT air kerma index	C_{VOL}	$CTDI_{VOL}$
CT air kerma–length product	$P_{KL,CT} = \sum_j {}_nC_{VOL_j} l_j P_{lt_j}$	$DLP = CTDI_{VOL}\ L$



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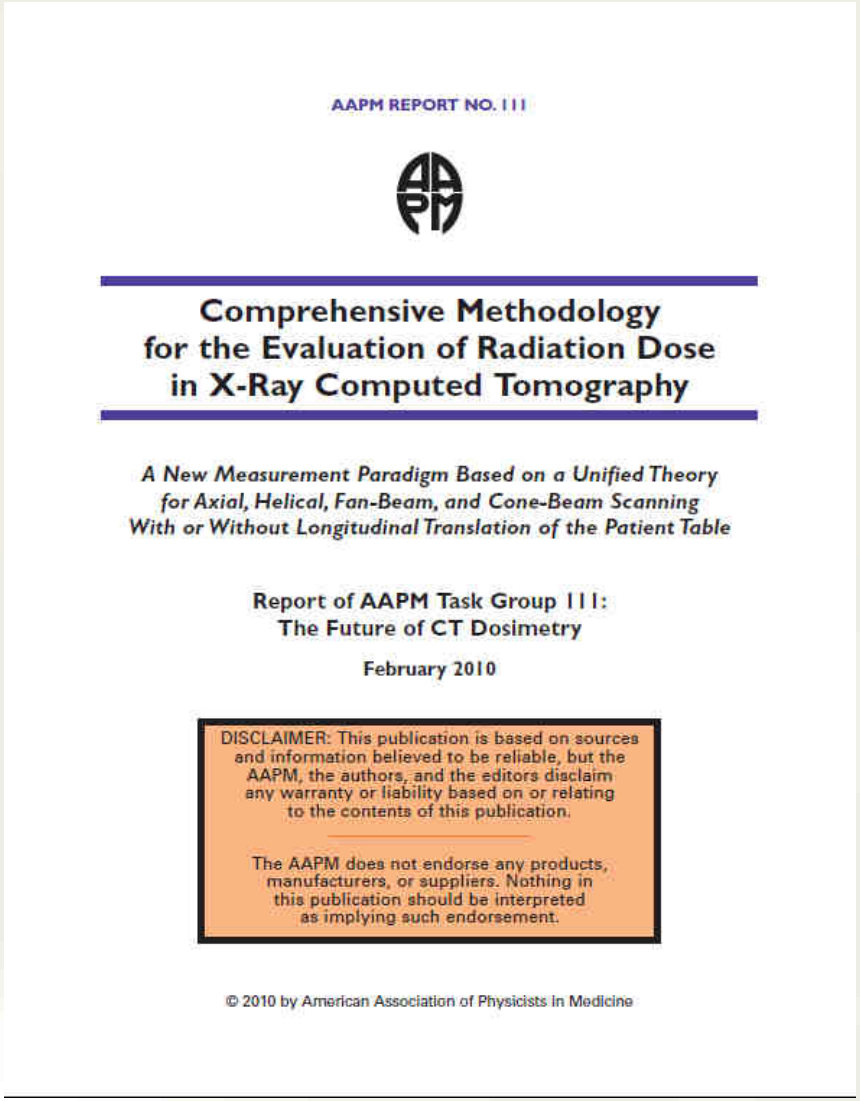
- Cámara de ionización de pequeño volumen
- Fantoma grande para asegurar equilibrio
- Aplicable a todas las técnicas actuales (axial, helicoidal, cone o fan beam, con o sin traslación de mesa



AAPM REPORT NO. 111

Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography

A New Measurement Paradigm Based on a Unified Theory for Axial, Helical, Fan-Beam, and Cone-Beam Scanning With or Without Longitudinal Translation of the Patient Table

Report of AAPM Task Group 111:
The Future of CT Dosimetry

February 2010

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JOURNAL OF APPLIED CLINICAL MEDICAL PHYSICS, VOLUME 13, NUMBER 6, 2012

Measurements of the dose delivered during CT exams using AAPM Task Group Report No. 111

C. Descamps,[1a] M. Gonzalez,[1] E. Garrigo,[1] A. Germanier,[2] D. Venencia[1]
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Received 10 February, 2012; accepted 26 June, 2012

Se propuso seguir la recomendacion de AAPM para evaluar la dosis entregada durante los examenes de TAC mas comunmente utilizados y compararlos con lo informado por el TAC (CTDI)

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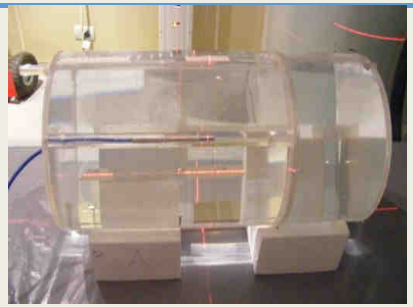
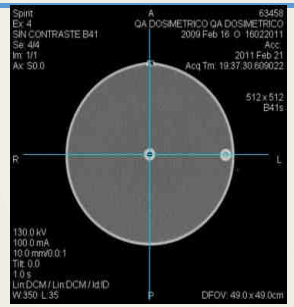
Materiales y Método

PTW 30013
(Farmer)

Electrometro PTW
Unidos E





Fantoma 60cm Long 30cm diam

Siemens SOMATOM Spirit Power
2-slice CT scanner

TLD100 (rods)
TLD Reader 4000 (Harshaw)
GCA-New v3.0

Materiales y Método

Protocolo	Mode	KV	mA	Rotacion de tubo [s]	Cortes	Corte reconstruido
Referencia	Axial	130	100	1	2 of 5mm	10 mm
Mama	Helical (pitch1)	130	100	1	2 of 5 mm	10 mm
Prostata	Axial	130	100	1	2 of 1.5mm	3mm
Axial 5 mm	Axial	130	100	1	2 of 2.5	5mm

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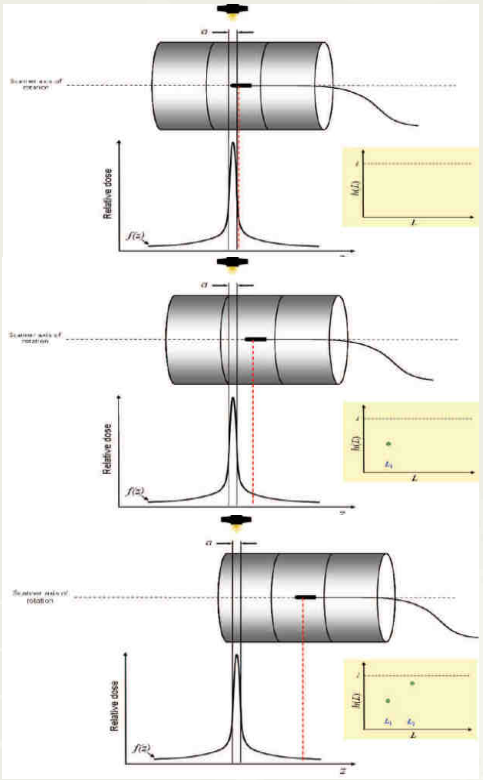
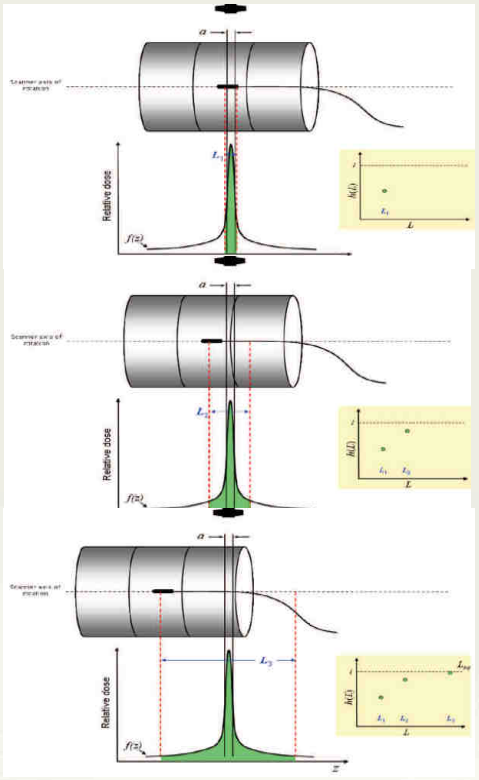
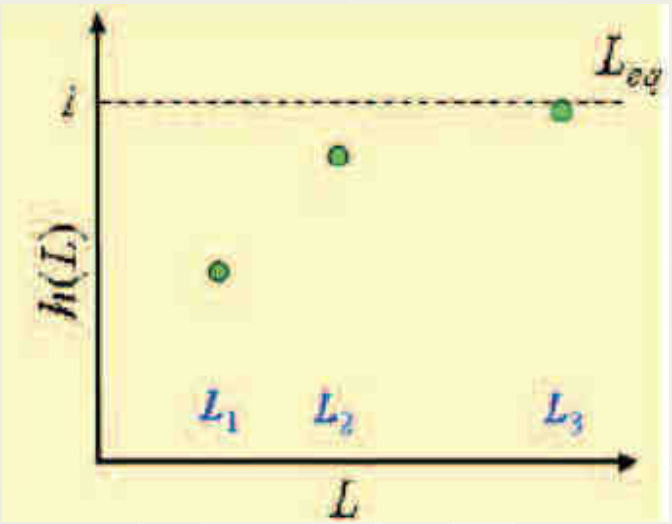
Materiales y Método

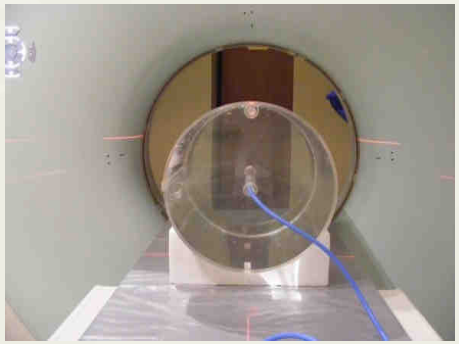






Desde L=50 mm to L=Longitud del fantoma menos nT

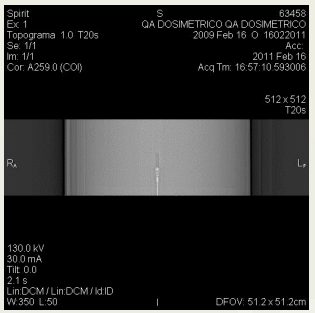
Resultados

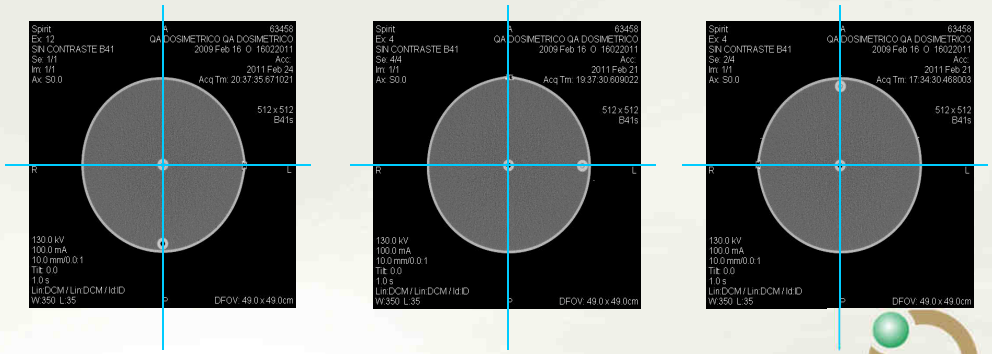


Posición Central

Posición Periferica

Repetibilidad : 0.44%





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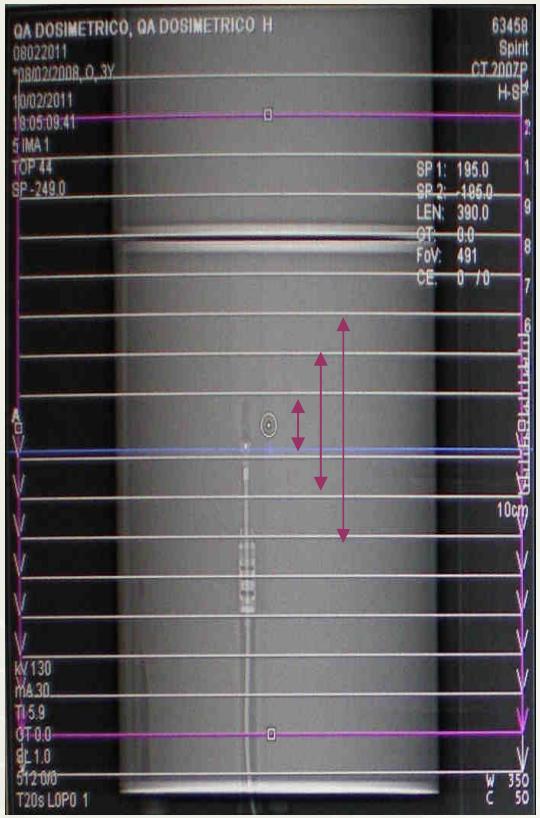
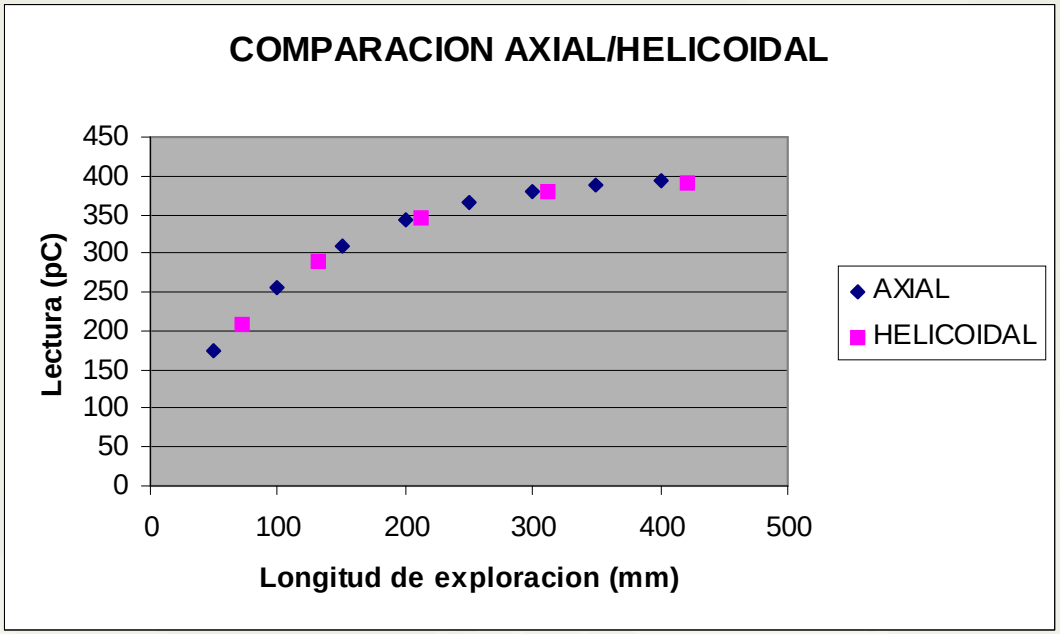
Resultados

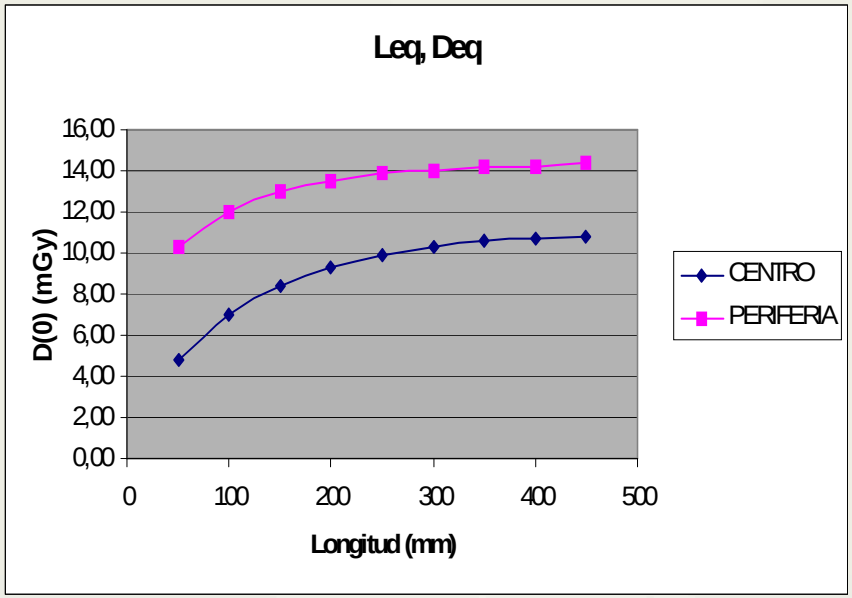
Comparación de modos de escaneo





Resultados

Dosis de equilibrio, periferica y central



$$D_L(z=0) = h(L)\,D_{eq}$$

Centro

D_{eq}=11.0 mGy

α =0,88

L_{eq}=450 mm

PERIFERIA

D_{eq}=14,4 mGy

α =0,47

L_{eq}=380 mm

$$h(L) \approx (1-\alpha) + \alpha\left[1-\exp\left(-4L/L_{eq}\right)\right] = 1-\alpha\exp\left(-4L/L_{eq}\right).$$

Primaria

Dispersa

Resultados

Calibración TLDs (TRS277)

Cámara Farmer N_k= 47,90 mGy/nC HVL = 0,23 mm Cu $(\mu en/\rho)_{w,air}$= 1,032

$D_{eq,c}$: TLDs vs Farmer Chamber

Dosímetro	Dosis [mGy]
TLD	12.4
Chamber	12.3
Dif[%]	*0.89*

D(0): comparación TLDs y cámara Farmer

Protocolo	Mama	Prostata	Axial 5 mm
Camara Farmer [mGy]	10.8	10.8	10.9
TLD [mGy]	10.4	10.7	10.9
Dif[%]	*3.4*	*0.6*	*0.3*

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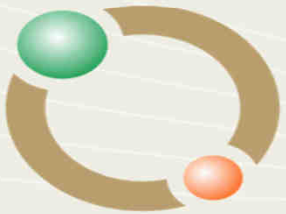
Resultados

Dosis de equilibrio(mGy) acumulada en la posicion z =0

$D(0) = \frac{1}{2} D_c + \frac{1}{2} D_p \quad (D_{eq} \propto r^2)$

Comparación con CTDIvol reportado por el TAC

Protocolo	Mama	Prostata	Axial 5 mm
CTDI vol [mGy]	9.1	9.3	9.3
Deq [mGy]	12.3	12.3	12.5
Dif[%]	***29.9***	***27.9***	***29.0***



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Programa de cálculo

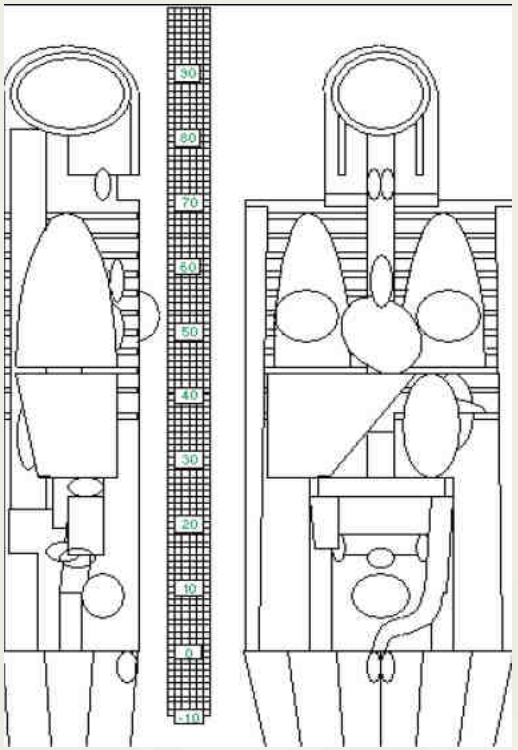
Freeware

CT Dose 1.0.1
http://www.mta.au.dk/ctdose/index.htm (2008-04-26)
Dose calculations for CT-exams (last update 2003-11-11)

Omni mAs
http://omnimas.arwen.se/ (2008-04-26)
Calculation of mAs settings for different patient diameters
Effective dose via conversion factors for DLP

D2ED (Palm)
http://www.mh-hannover.de/1604.html
Estimation of patient exposure using conversion factors (DAP, CTDI and DLP)

QuickDose (Windows Mobile 6)
http://www.mh-hannover.de/1604.html
Estimation of patient exposure using conversion factors (DAP, CTDI and DLP)



- Fantoma antropomórfico
- Párametros de entrada
- Ej. : CTDose, WinDose
- ***Monte-Carlo***

Medical Physics
The International Journal of Medical Physics Research and Practice

Estimating peak skin and eye lens dose from neuroperfusion examinations: Use of Monte Carlo based simulations and comparisons to CTDIvol, AAPM Report No. 111, and ImPACT dosimetry tool values

Di Zhang, Chris H. Cagnon, J. Pablo Villablanca, Cynthia H. McCollough, Dianna D. Cody, Maria Zankl, John Demarco, and Michael F. McNitt-Gray

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View online: http://dx.doi.org/10.1118/1.4816652
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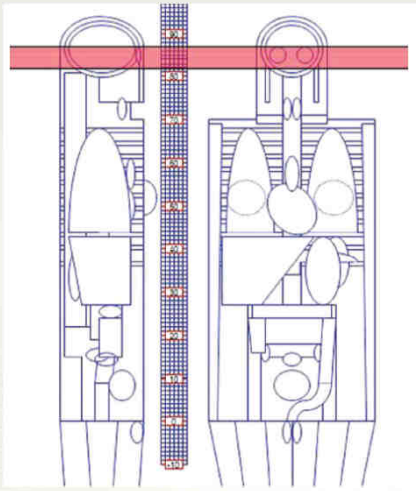

M Y M

- 4 MDCT
- Estudios de Perfusión cerebral
- 4 Fantomas cerebro
- Varios KV – 100 mAs
- Dosis en piel y cristalino
  - MC
  - CTDI
  - AAPM 111
  - ImPACT

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Medical Physics
The International Journal of Medical Physics Research and Practice

Estimating peak skin and eye lens dose from neuroperfusion examinations: Use of Monte Carlo based simulations and comparisons to CTDIvol, AAPM Report No. 111, and ImPACT dosimetry tool values

Di Zhang, Chris H. Cagnon, J. Pablo Villablanca, Cynthia H. McCollough, Dianna D. Cody, Maria Zankl, John Demarco, and Michael F. McNitt-Gray

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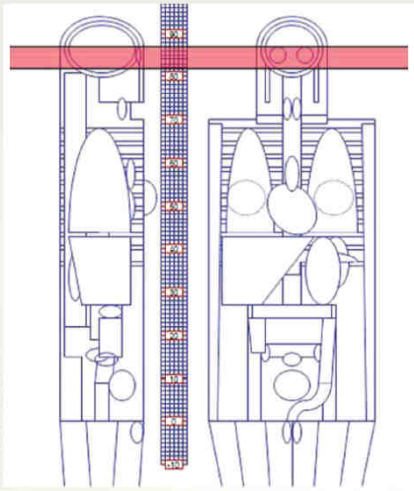
Conclusion

CTDI e ImPACT, sobreestiman 40-60%
AAPM 111 mejor predictor

CTDI, Software, AAPM 111. Solo índices predictores (no dosis real)



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AAPM Report No. 204

Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations

Report of AAPM Task Group 204, developed in collaboration with the International Commission on Radiation Units and Measurements (ICRU) and the Image Gently campaign of the Alliance for Radiation Safety in Pediatric Imaging

Fantoma 16cm o 32cm

$$CTDI_w = \frac{1}{3} CTDI_{100}^{center} + \frac{2}{3} CTDI_{100}^{periphery}.$$

$$CTDI_{vol} = \frac{CTDI_w}{pitch},$$

Fantoma llevado a “paciente”

$$size\ specific\ dose\ estimate = SSDE = f_{size}^{32.X} \times CTDI_{vol}^{32},$$

for the 32 cm diameter $CTDI_{vol}$ reference phantom, and

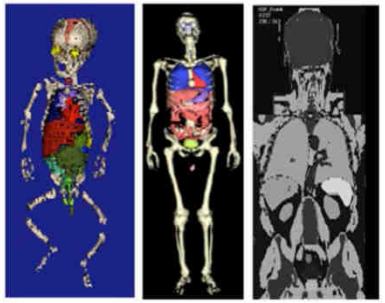
$$size\ specific\ dose\ estimate = SSDE = f_{size}^{16.X} \times CTDI_{vol}^{16}$$

for the 16 cm diameter $CTDI_{vol}$ reference phantom.

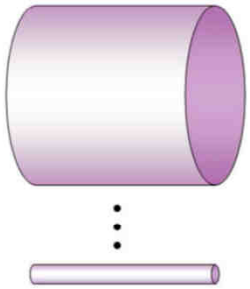
The various tools used by the four independent research groups are illustrated Figure 3.

A. Physical Anthropomorphic Phantoms
(McCollough and collaborators, Mc)

B. Cylindrical PMMA phantoms
(Toth and Strauss, TS)



C. Monte Carlo Voxelized Phantoms
(McNitt-Gray and collaborators, MG)



D. Monte Carlo Mathematical Cylinders
(Boone and collaborators, ZB)

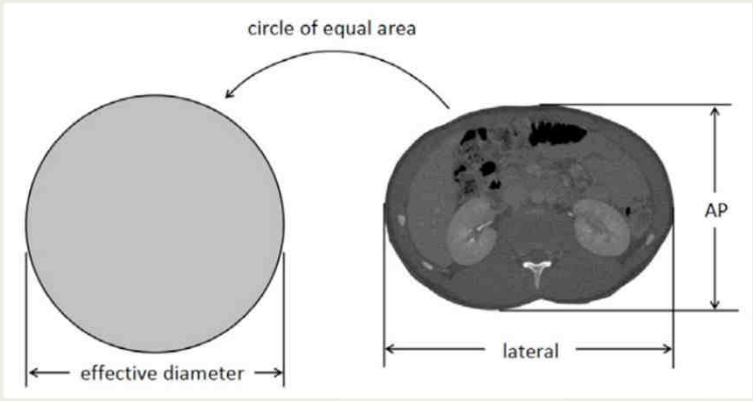


Table 1A

Lat+AP Dim (cm)	Effective Dia (cm)	Conversion Factor
16	7.7	2.79
18	8.7	2.69
20	9.7	2.59
22	10.7	2.50
24	11.7	2.41
26	12.7	2.32
28	13.7	2.24
30	14.7	2.16
32	15.7	2.08
34	16.7	2.01
36	17.6	1.94
38	18.6	1.87
40	19.6	1.80
42	20.6	1.74
44	21.6	1.67
46	22.6	1.62
48	23.6	1.56
50	24.6	1.50
52	25.6	1.45
54	26.6	1.40
56	27.6	1.35
58	28.6	1.30
60	29.6	1.25
62	30.5	1.21
64	31.5	1.16
66	32.5	1.12
68	33.5	1.08

Table 1B

Lateral Dim (cm)	Effective Dia (cm)	Conversion Factor
8	9.2	2.65
9	9.7	2.60
10	10.2	2.55
11	10.7	2.50
12	11.3	2.45
13	11.8	2.40
14	12.4	2.35
15	13.1	2.29
16	13.7	2.24
17	14.3	2.19
18	15.0	2.13
19	15.7	2.08
20	16.4	2.03
21	17.2	1.97
22	17.9	1.92
23	18.7	1.86
24	19.5	1.81
25	20.3	1.76
26	21.1	1.70
27	22.0	1.65
28	22.9	1.60
29	23.8	1.55
30	24.7	1.50
31	25.6	1.45
32	26.6	1.40
33	27.6	1.35
34	28.6	1.30

Table 1C

AP Dim (cm)	Effective Dia (cm)	Conversion Factor
8	8.8	2.68
9	10.2	2.55
10	11.6	2.42
11	13.0	2.30
12	14.4	2.18
13	15.7	2.08
14	17.0	1.98
15	18.3	1.89
16	19.6	1.81
17	20.8	1.73
18	22.0	1.65
19	23.2	1.58
20	24.3	1.52
21	25.5	1.45
22	26.6	1.40
23	27.6	1.34
24	28.7	1.29
25	29.7	1.25
26	30.7	1.20
27	31.6	1.16
28	32.6	1.12
29	33.5	1.08
30	34.4	1.05
31	35.2	1.02
32	36.0	0.99
33	36.8	0.96
34	37.6	0.93

Table 1D

Effective Dia (cm)	Conversion Factor
8	2.76
9	2.66
10	2.57
11	2.47
12	2.38
13	2.30
14	2.22
15	2.14
16	2.06
17	1.98
18	1.91
19	1.84
20	1.78
21	1.71
22	1.65
23	1.59
24	1.53
25	1.48
26	1.43
27	1.37
28	1.32
29	1.28
30	1.23
31	1.19
32	1.14
33	1.10
34	1.06

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Conclusion

- Debemos conocer que dosis estamos entregando en para cada protocolo.
- Recordar: Justificación de la práctica, Optimización (ALARA), Límites de Dosis
- AAPM 111 parece ser mejor **índice predictor** que CTDI y programas
- CTDI “standard”. AAPM 204 1er intento para dosis “real”
- MC el ideal
- Futuro TAC ->E?

MUCHAS GRACIAS