



Radiotherapie bij gemetastaseerd --- mamma- en longcarcinoom

Joost Verhoeff MD PhD, Head of department & Professor of Radiotherapy



Inhoud

Geschiedenis van de radiotherapie

Moderne radiotherapie

Mammacarcinoom

Longkanker

Conclusies

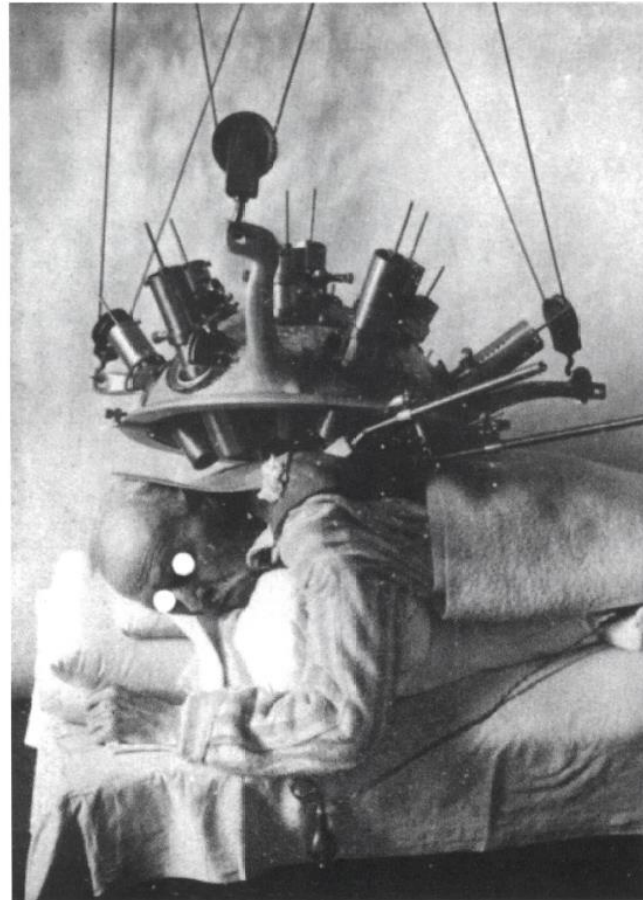


Figure 9.45. The Sluys-Kessler radium bomb, Brussels 1925, which was designed to carry 13 radium applicators fixed on a hemispherical cupola. A later design increased the number of radium foci from 13 to 18 [10, 152].

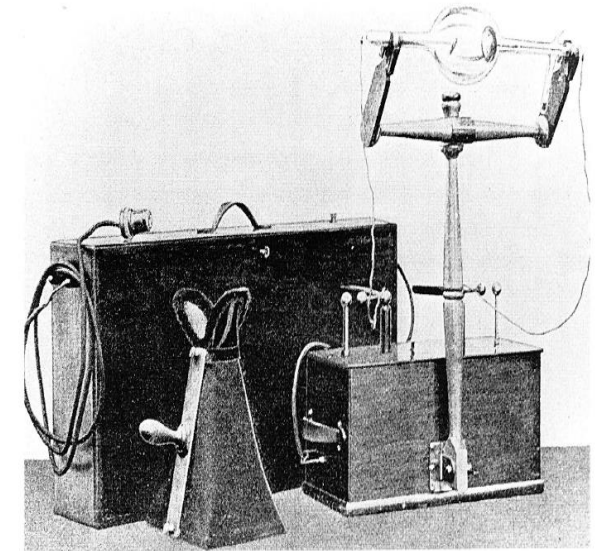


Fig. 2-6. Early portable X-ray unit. The smaller box contains the coil; the larger, the electrolytic interrupter. The hand fluoroscope and open tube as generally used are shown.



Geschiedenis van de radiotherapie

Ach, dass der Mensch doch durchsichtig wäre wie eine Qualle und dass man den Sitz seiner Leiden schauen könnte.

Wilhelm Conrad Röntgen (1845 - 1923)

1863-1865 technische studie in Utrecht: gezakt!

1888 Universiteit Utrecht Buys Ballot opvolgen?

Duitsland: Straatsburg, Giessen, Würzburg en München

128 jaar geleden: X-Strahlen



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X-Strahlen

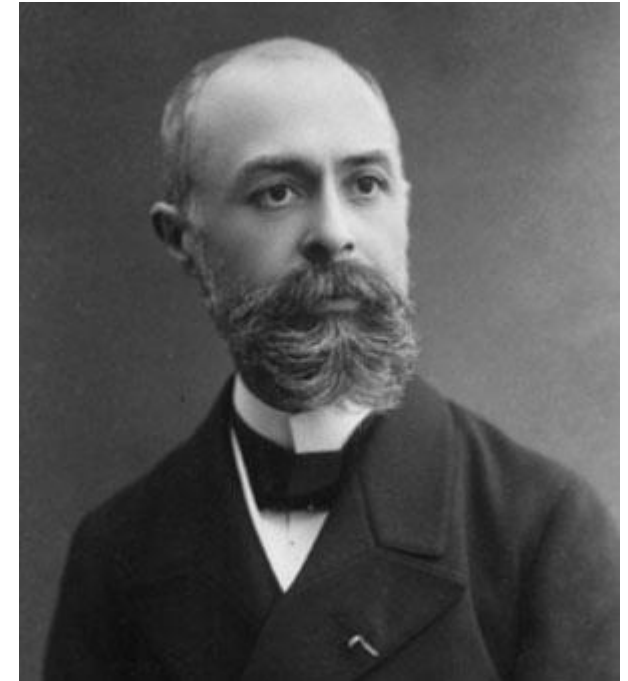
Vrijdag 8 november 1895: Onzichtbare kathodestrallen op bariumscherm dat er *toevallig* stond

Geen patentaanvraag uit principe

1901 Nobelprijs voor de Natuurkunde

1896: Henri Becquerel en uraniumzout
Rommelig lab en fotografische plaat: *toeval*
Rayons uraniques, uraniumstralen, stralen van Becquerel

Marie Skłodowska-Curie en Pierre Curie



Marie Skłodowska-Curie

Ontdekking van Polonium en Radium

1903 Nobelprijs voor de Natuurkunde (met Becquerel en Pierre)

1911 Nobelprijs voor de Scheikunde



Lorentz, Warburg, Curie, Planck, Rutherford, Kamerlingh Onnes, Einstein



Behandeling met X-stralen en radium

Leopold Freund 1896 Wenen
Meisje met harige moedervlek

Emil H. Grubbé 1896 Chicago
Teruggekeerde borstkanker

Indicaties radiotherapie 1900

- Ongewilde beharing
- Eczeem en acne
- Lupus erythematosus
- Kwaadaardige huid aandoen

Onderzoek naar epilepsie, tuberculose

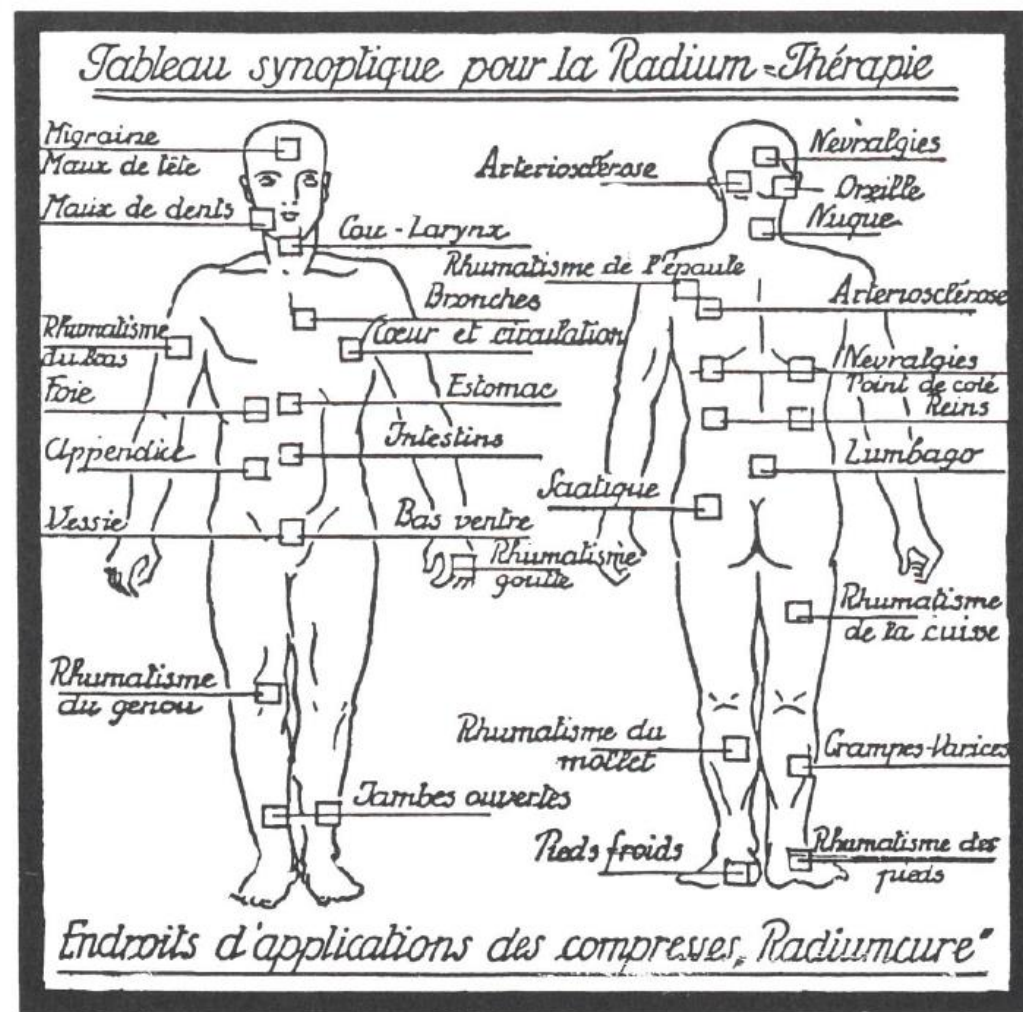


Figure 2.8. Summary table from sales literature of the 1920s for a Radium Compress from the Laboratories Pierre Koehren [Pharmacists] of Strasbourg.



Nederland en radiotherapie

14 april 1901

Nederlandsche Vereeniging voor Electrologie en Röntgenologie

26 november 1959

Nederlandse Vereniging voor Radiologie

18 februari 1978

Nederlandse Vereniging voor Radiotherapie en Oncologie



Nederlandse Vereniging voor
Radiotherapie en Oncologie



Radiotherapie bij

gemetastaseerd mamma- en longcarcinoom

Vormen van straling

α



Vel papier

Helium-4:

2 protonen + 2 neutronen



Werkt het?



Darmkankercellen: onbestraald en bestraald



Veiligheid staat voorop

Radiotherapie wordt extreem goed gemonitord en beveiligd

Leren van fouten uit het verleden



Na 4 dagen

17 dagen

41 dagen

Hand blootgesteld aan $> 1 \times 50$ Gy

Na 3.5 maanden

5 maanden

6.5 maanden

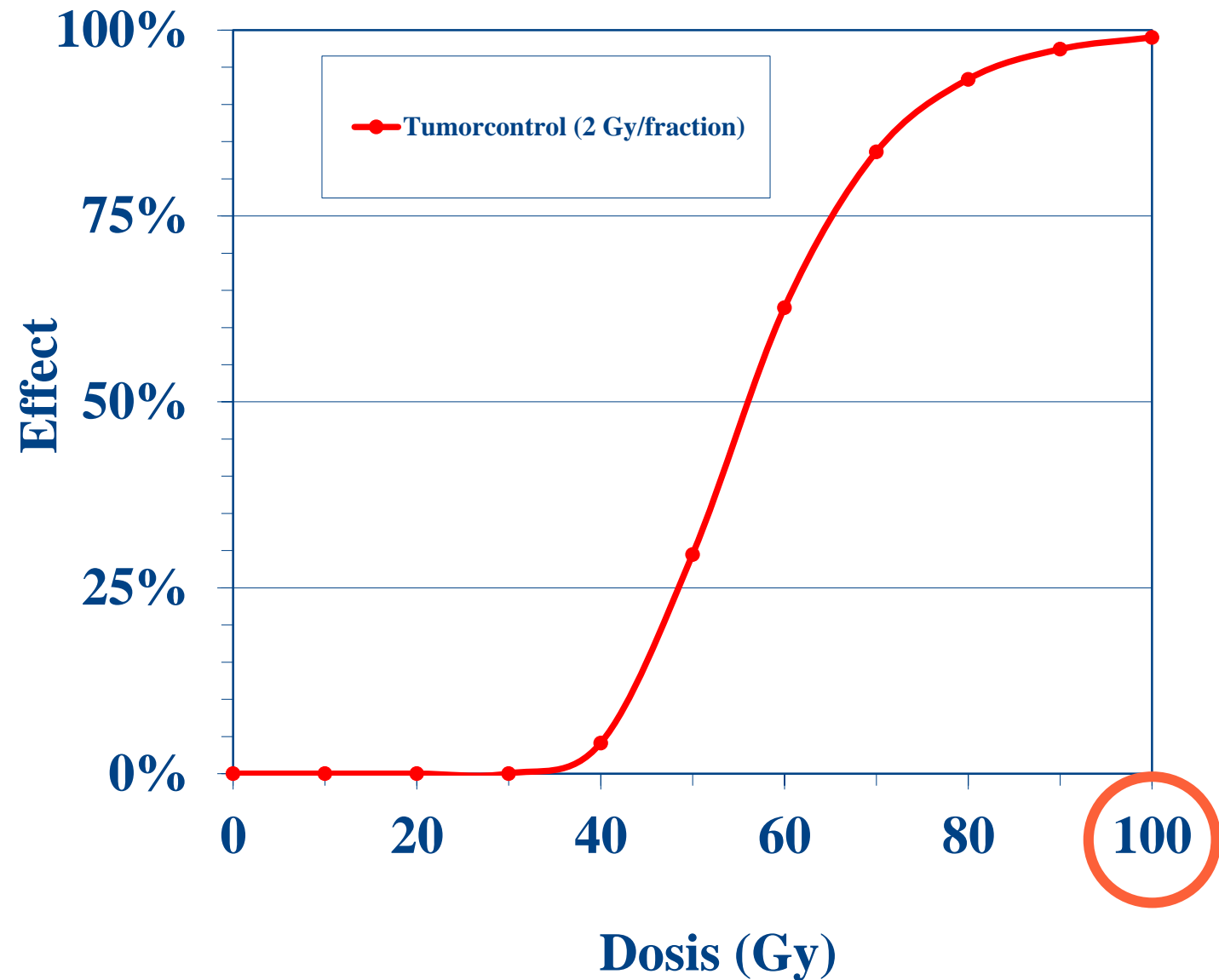


Radiotherapie bij

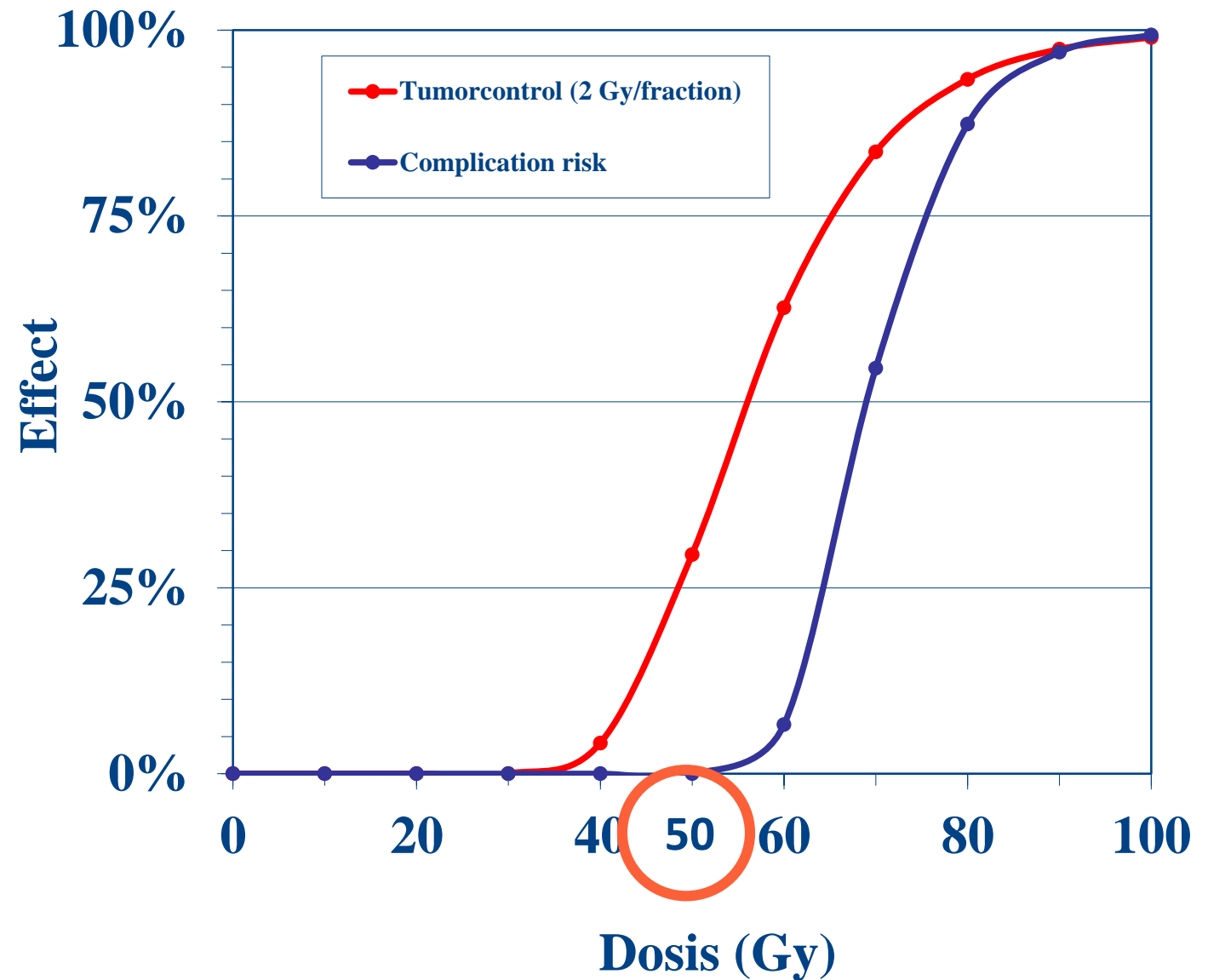
gemetastaseerd mamma- en longcarcinoom

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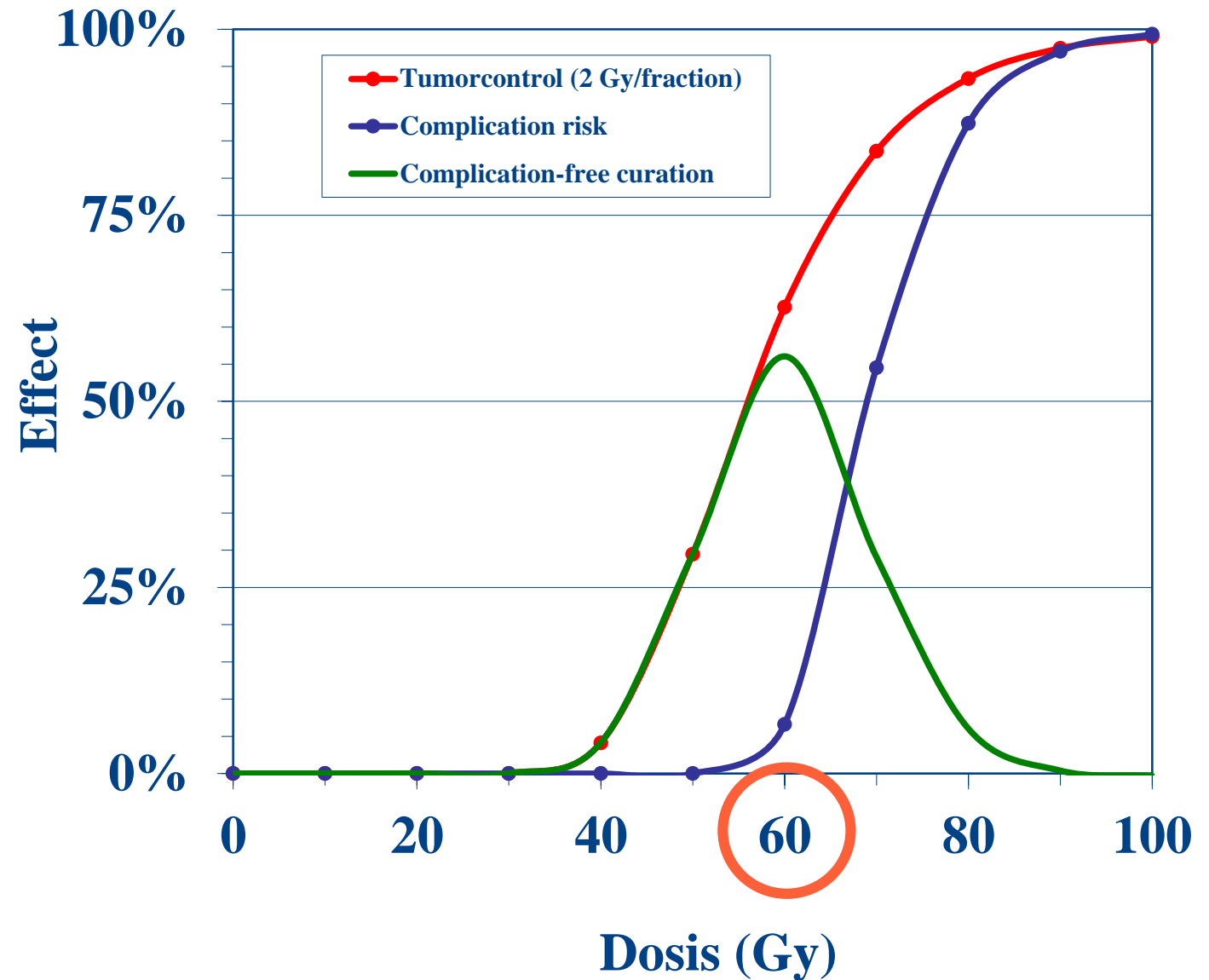
Holthusen curven (1928)



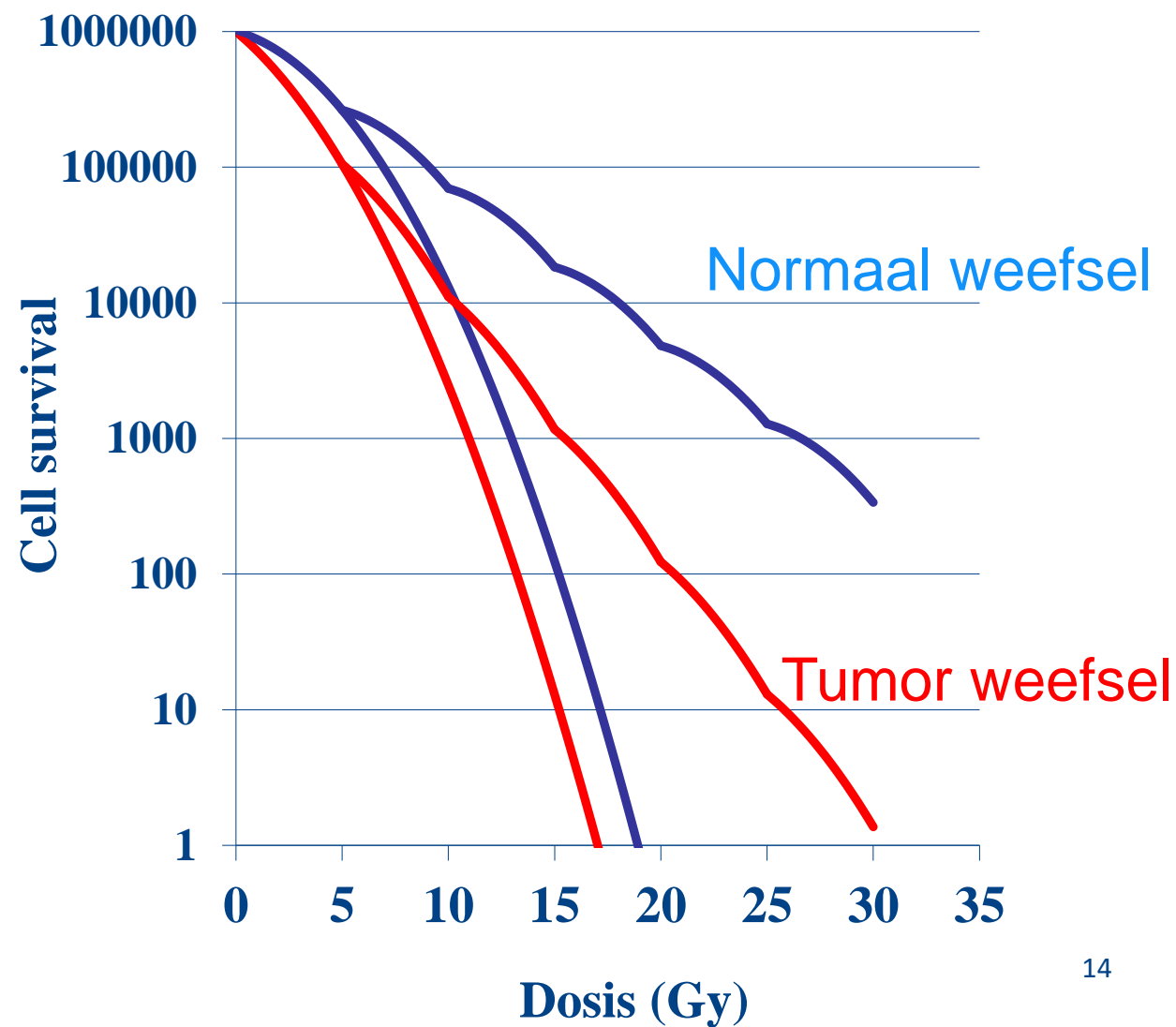
Holthusen curven (1928)



Holthusen curven (1928)



Fractioneren: elke dag een kleine dosis



Conventionele versus stereotactische radiotherapie



Moderne radiotherapie

Radium

Orthovolt bestraling (~1920)

Cobalt Megavolt bestraling (1951)

Protonen bestraling (1954)

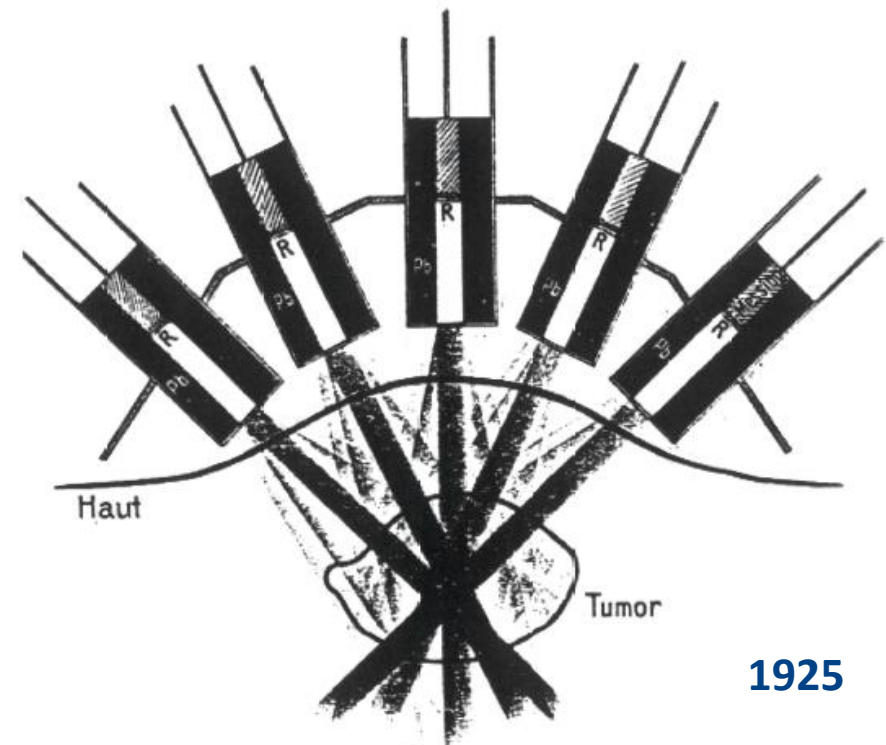
Lineaire versneller (1957)

Gamma knife (1968)

Cyber knife (1991)

CT-linac (1995)

MRI-linac (2014, 2017)



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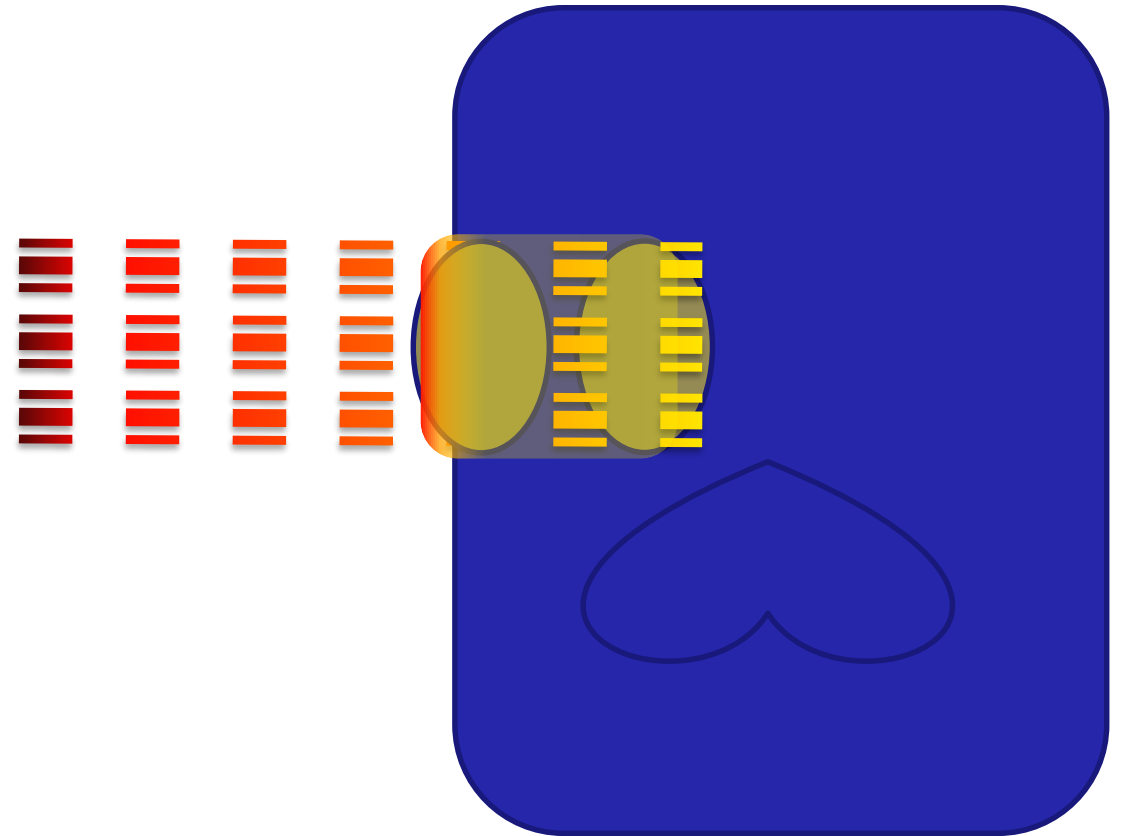
Orthovolt bestraling



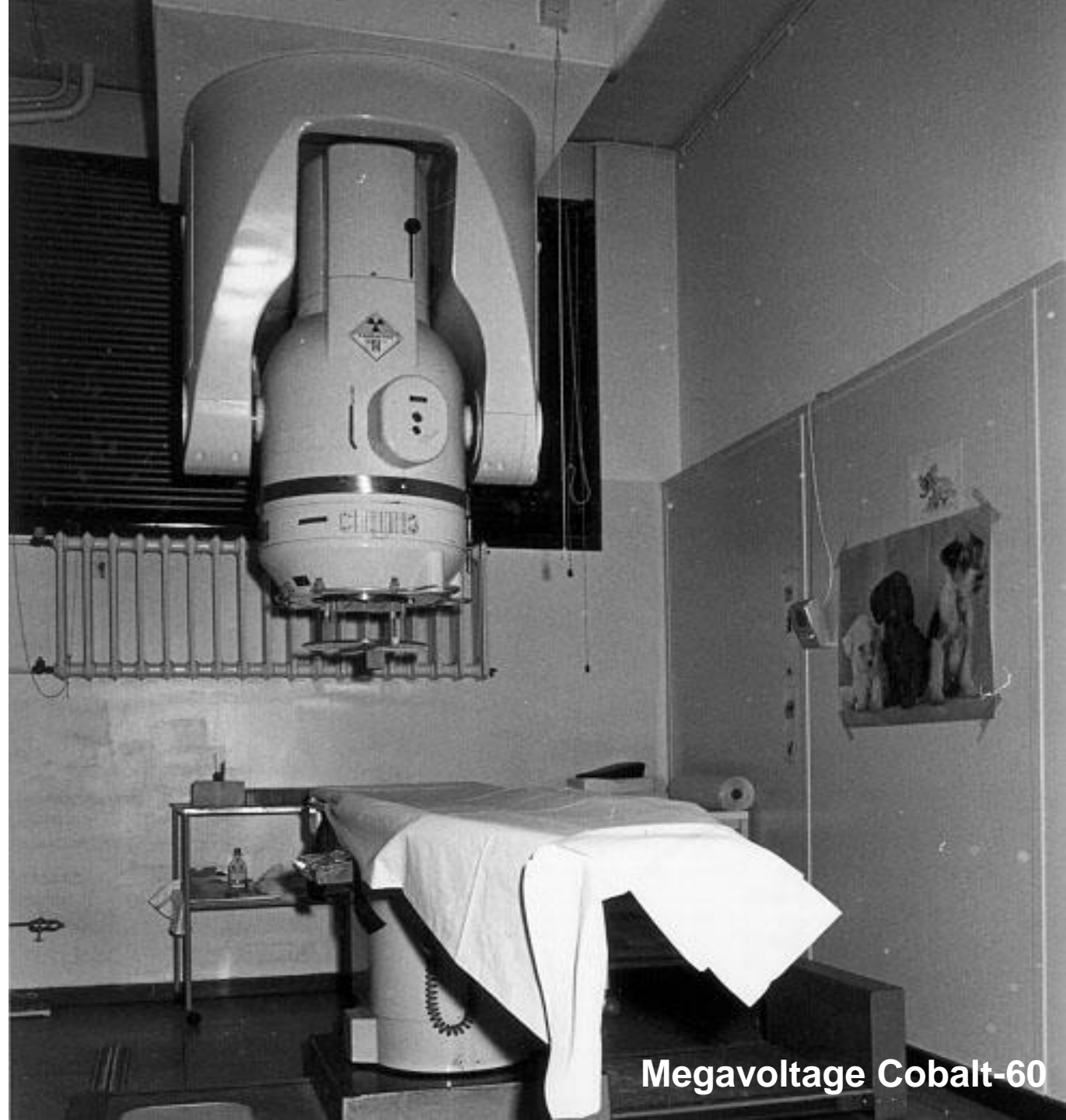
Radiotherapie bij

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Orthovolt bestraling



Megavolt bestraling



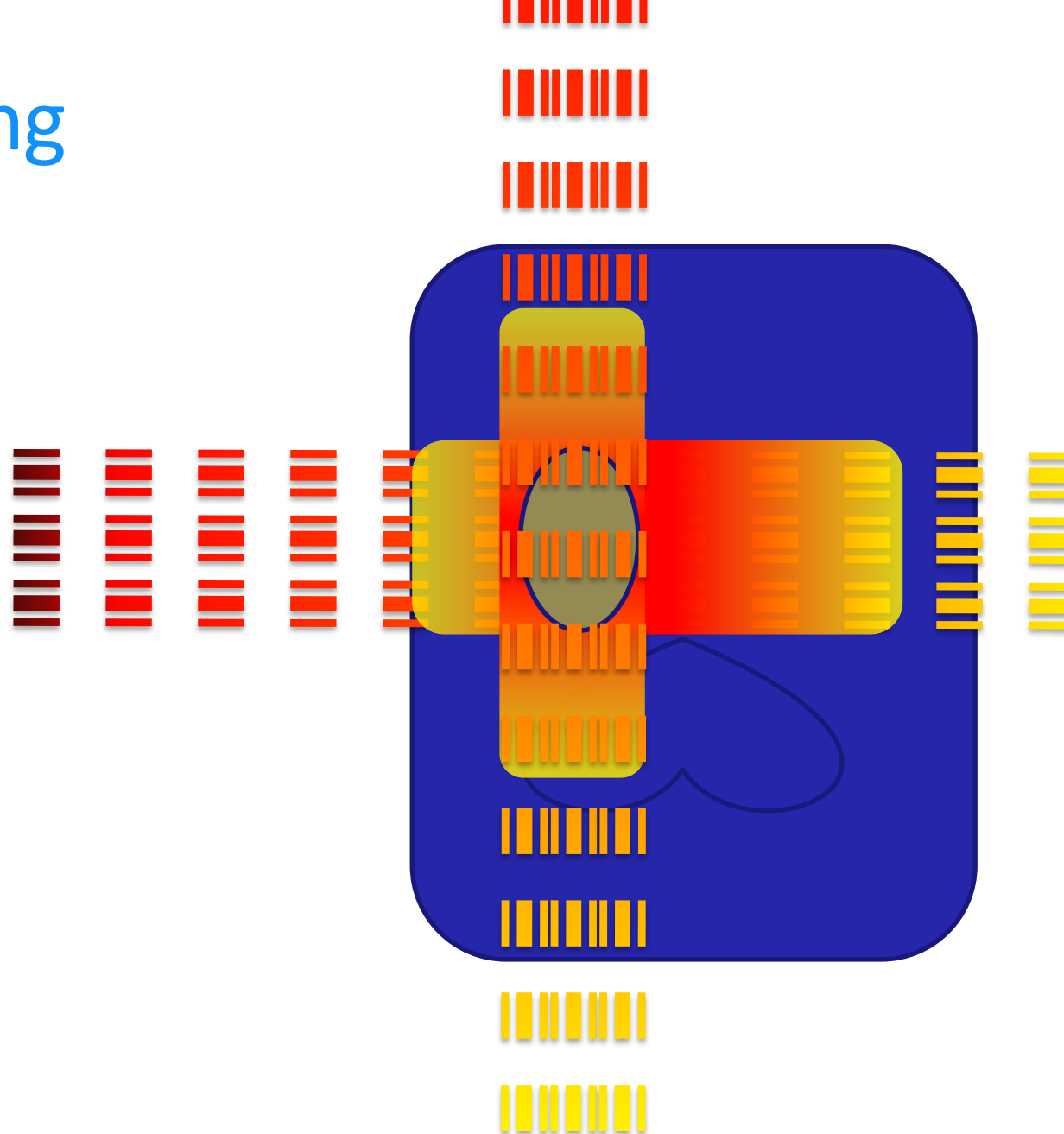
Megavoltage Cobalt-60



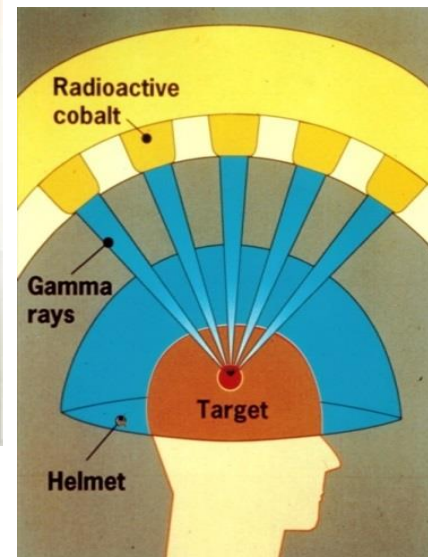
Radiotherapie bij

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Megavolt bestraling



Gamma knife (1968)



Radiotherapie bij
gemetastaseerd mamma- en longcarcinoom



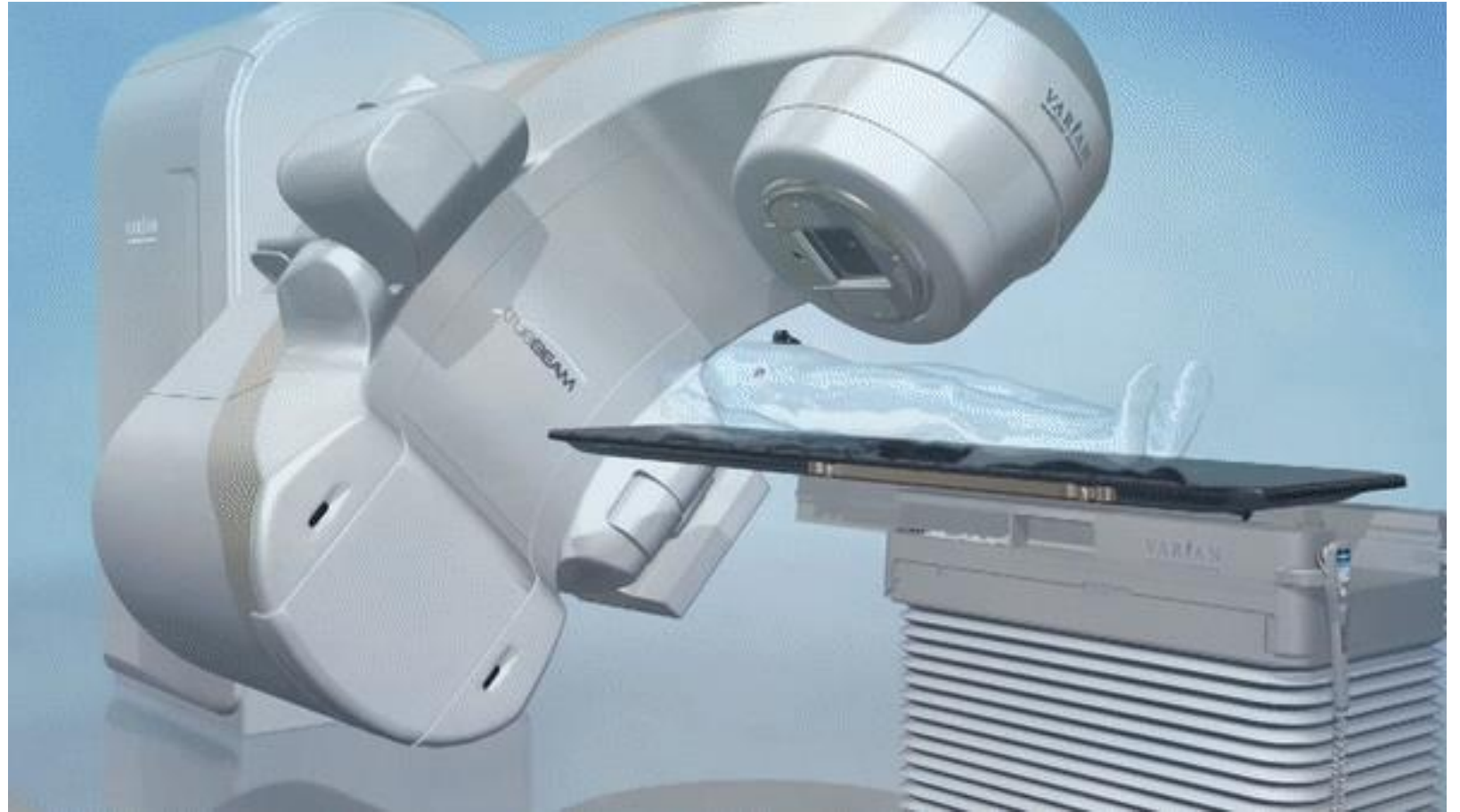
Cyber knife (1991)



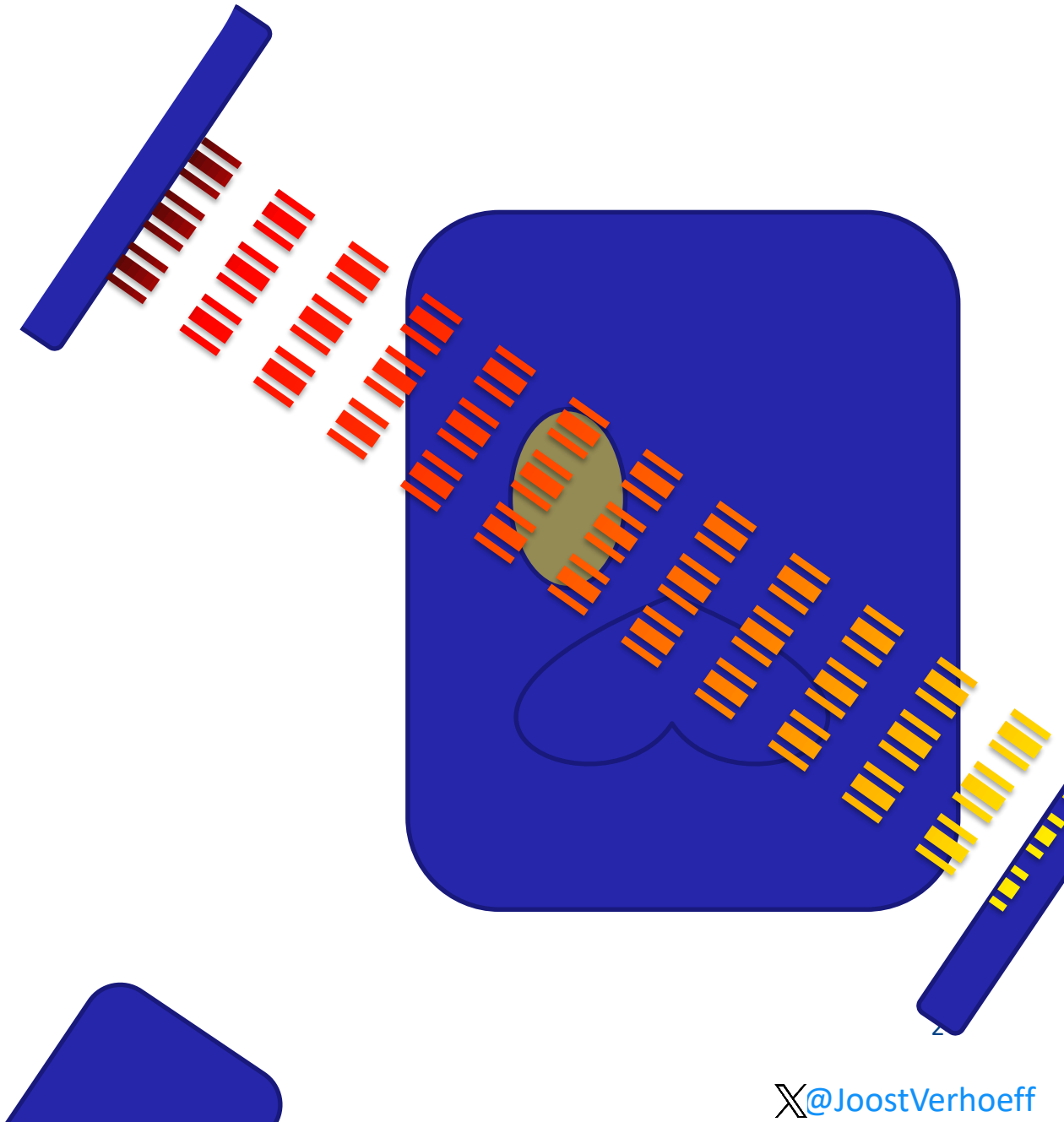
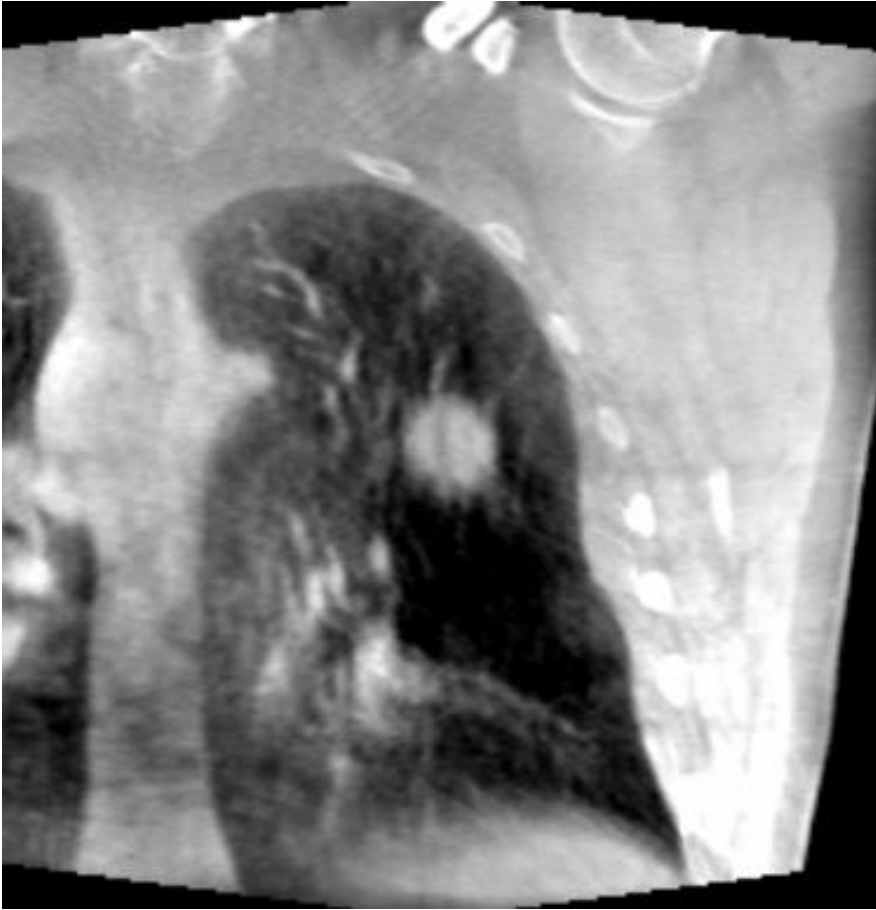
Image Detectors



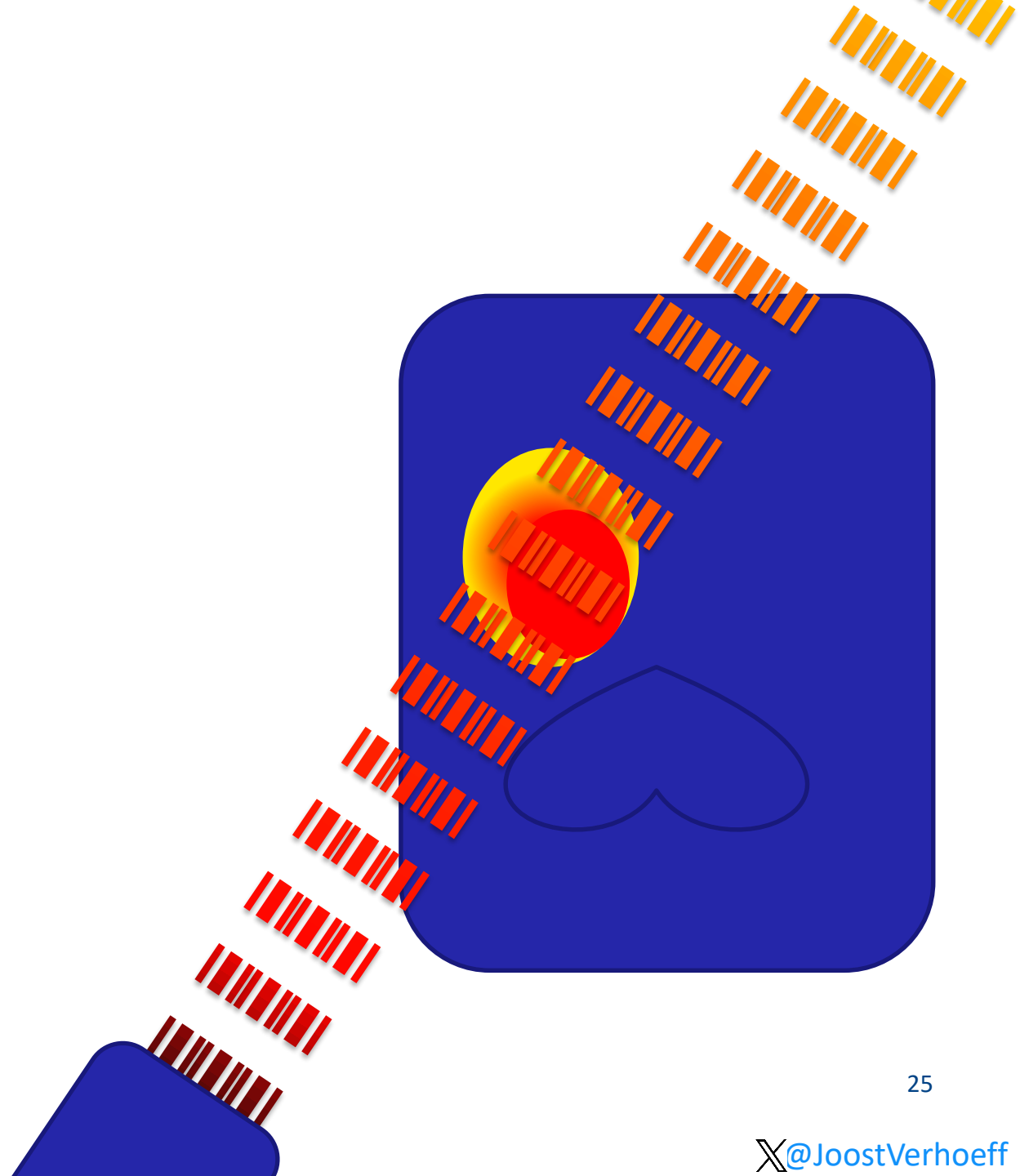
CT-linac (1995)



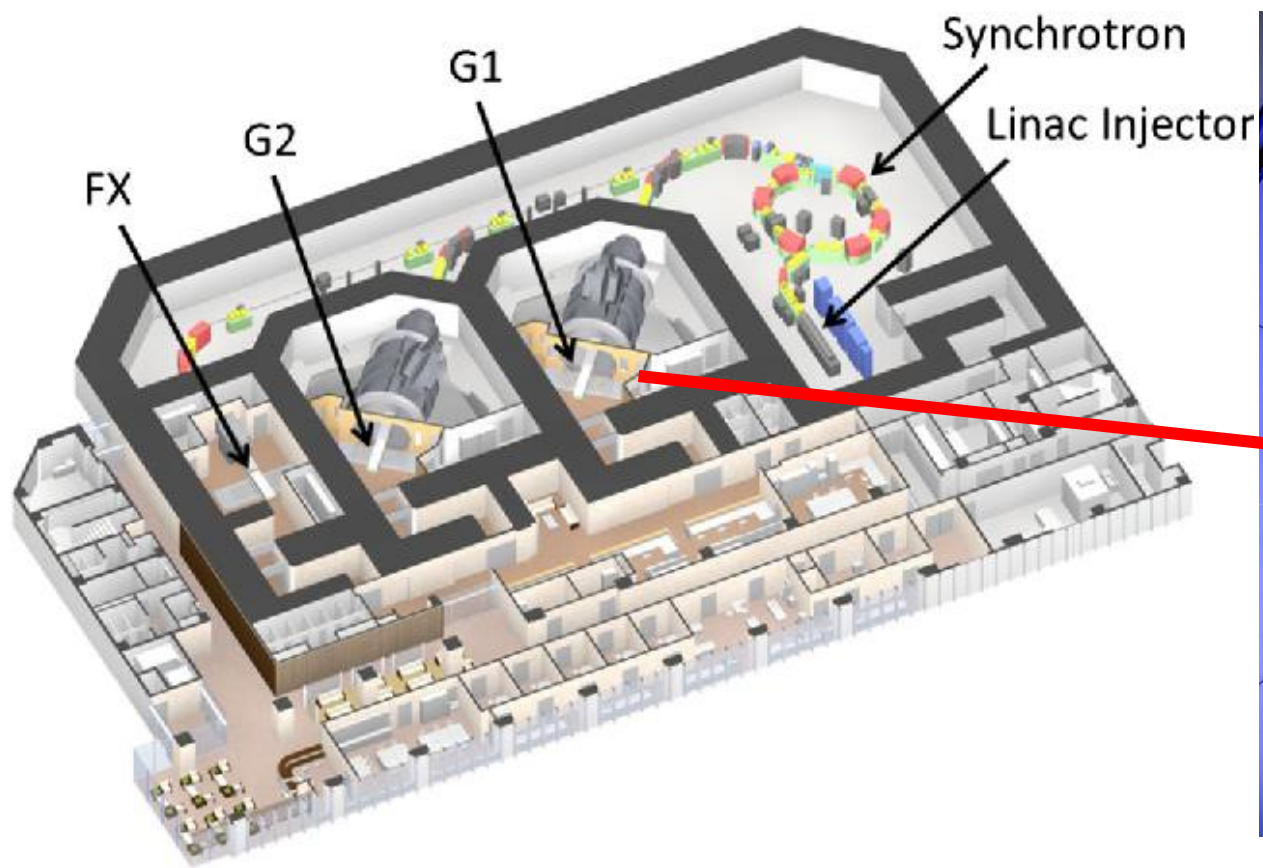
VMAT CT-linac bestraling



VMAT CT-linac bestraling



Protonen bestraling



Gefractioneerd of stereotactische radiotherapie

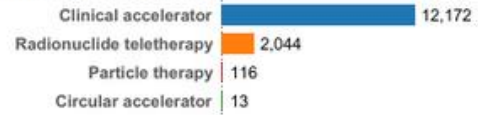


25 x 2Gy = 5 weken

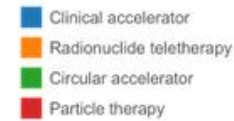


Equipment type

(Updated on : 4/23/2019 3:37:15 PM)

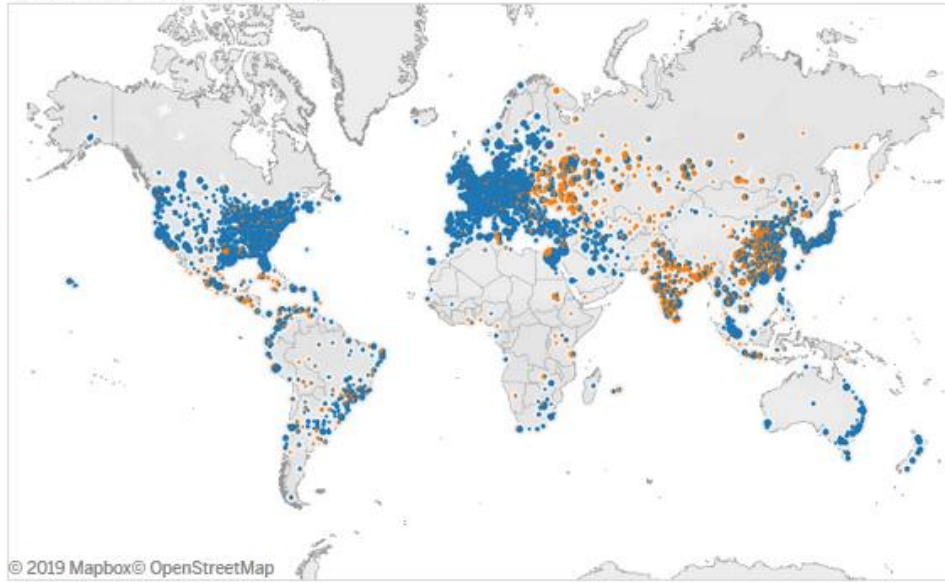


Income groups



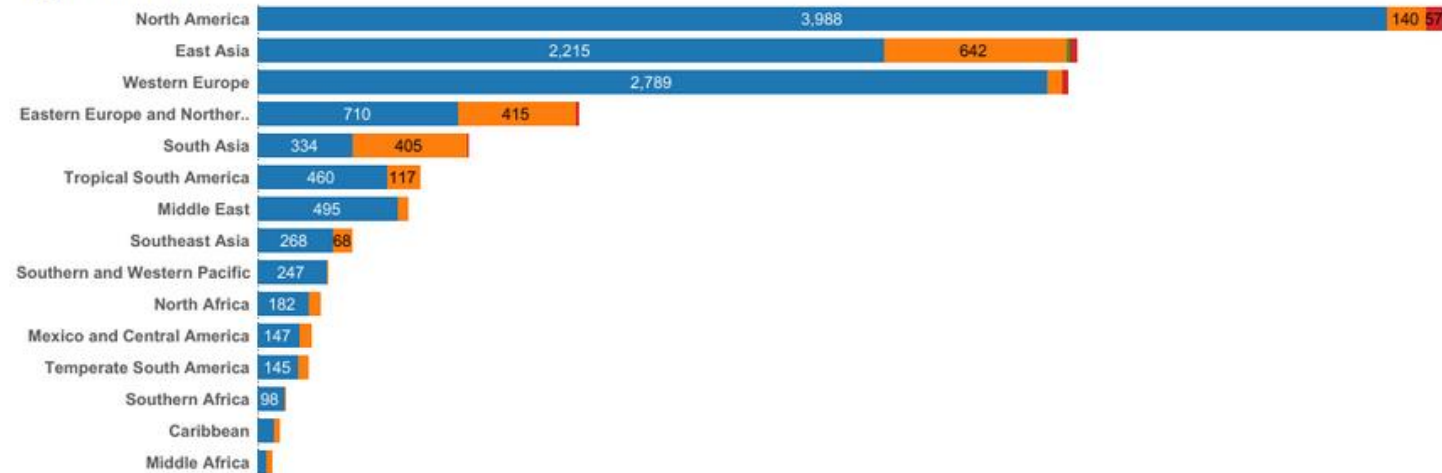
Radiation therapy centers

(Updated on : 4/23/2019 3:37:15 PM)



Countries	RT centers	Equipment	Linac	Radionuclide Therapy	Circular Accelerator	Particle Therapy
148	7461	14345	12172	2044	13	116

Regions and countries



Radiotherapie bij

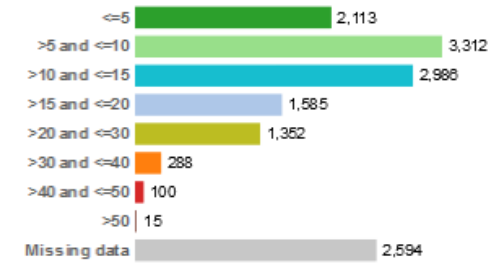
gemetastaseerd mamma- en longcarcinoom

<https://dirac.iaea.org>

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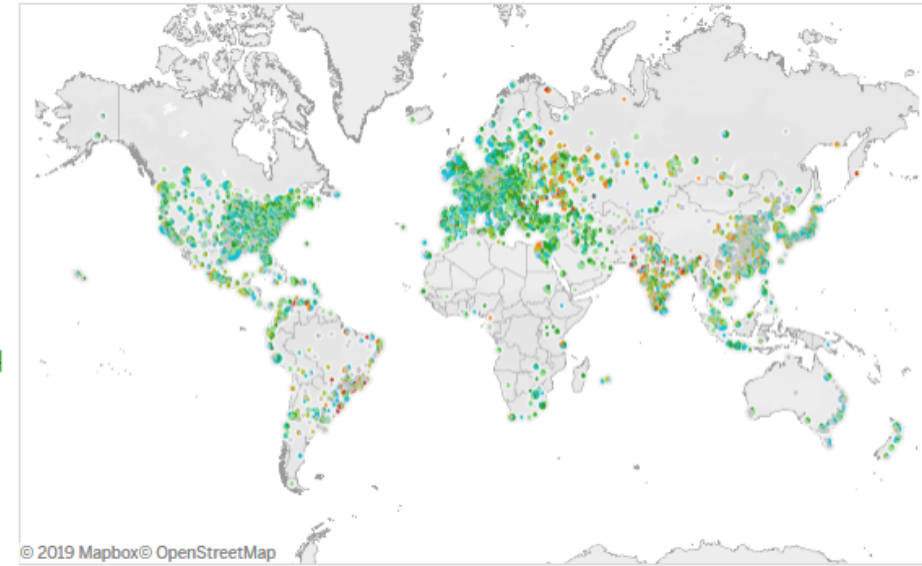
Equipment age categories

(Updated on : 4/23/2019 3:37:15 PM)

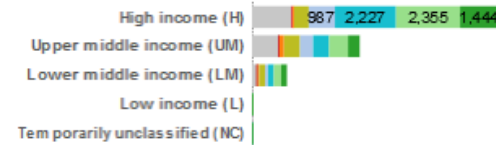


Equipment age

(Updated on : 4/23/2019 3:37:15 PM)

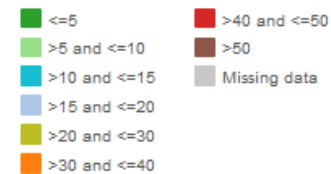


Income groups by equipment age



Countries: 148 **RT centers: 7461** **Equipment: 14345** **Linac: 12172** **Radionuclide Therapy: 2044** **Circular Accelerator: 13** **Particle Therapy: 116**

Regions and countries by equipment age



- Home
- Methodology
- Description of equipment
- Directory-
 - DIRAC data**
 - Data export
 - Data entry
- Data Collection-
 - Availability of Radiation Therapy
 - Comparison Tool
 - Status of Radiation Therapy Equipment
 - Equipment Age
- Maps-
 - Contact Us

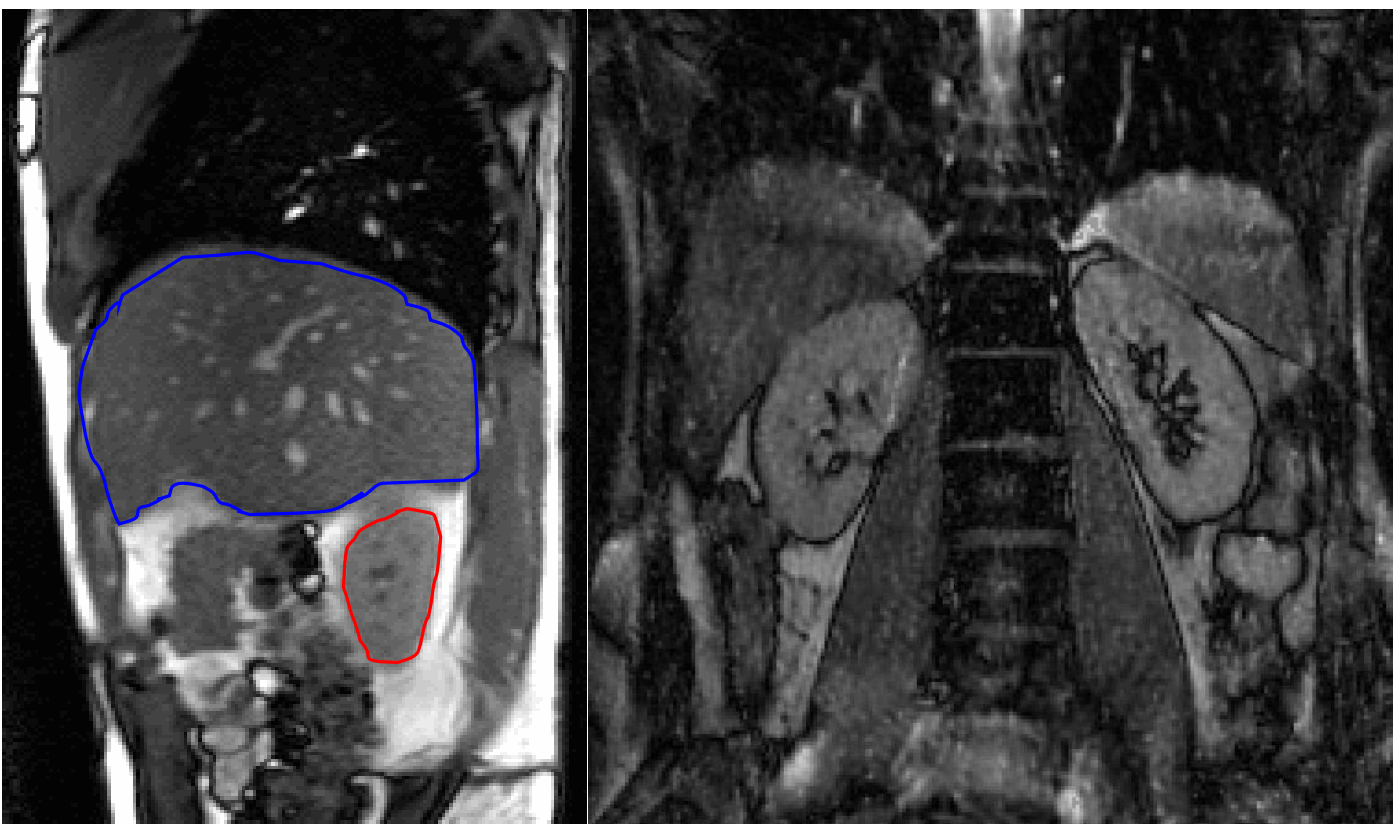
Albania	5
International Hospital Tirana	Tirana
Mother Teresa University Hospital, Neurosurgery Service, X-Knife Unit	Tirana
Institution Details	Operational
External Beam Therapy Equipment	1 operational machine(s)
Brachytherapy Equipment	0 operational machine(s)
Dosimetry	
EQUIPMENT:	
<input checked="" type="checkbox"/> Reference thimble ionization chamber(s)	
<input checked="" type="checkbox"/> Parallel plane ionization chamber(s)	
<input type="checkbox"/> Well-type ionization chamber(s)	
<input checked="" type="checkbox"/> Electrometer(s)	
<input checked="" type="checkbox"/> Others	
MONITORING INSTRUMENTS:	
<input type="checkbox"/> Survey Meter	
<input checked="" type="checkbox"/> Pocket Dosimeter	
<input type="checkbox"/> Others	
BEAM ANALYZER SYSTEM:	
<input type="checkbox"/> Manual	
<input checked="" type="checkbox"/> Computer Assisted	
TREATMENT PLANNING SYSTEM:	
<input type="checkbox"/> Manual	
<input checked="" type="checkbox"/> Computer Assisted	
IMAGING FACILITY:	
<input type="checkbox"/> Simulator	
<input checked="" type="checkbox"/> CT	
<input type="checkbox"/> Others	



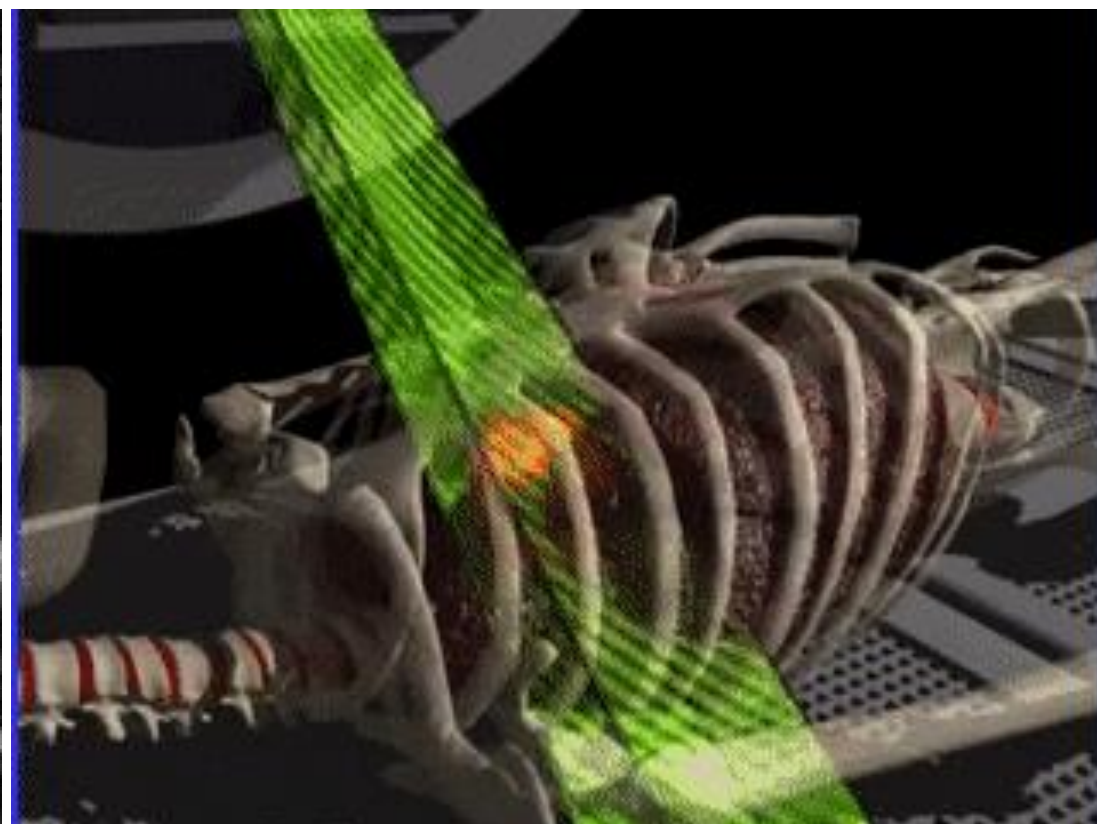
Beweging en veranderingen: Dagelijks en real-time

Adem vasthouden

Tumor volgen



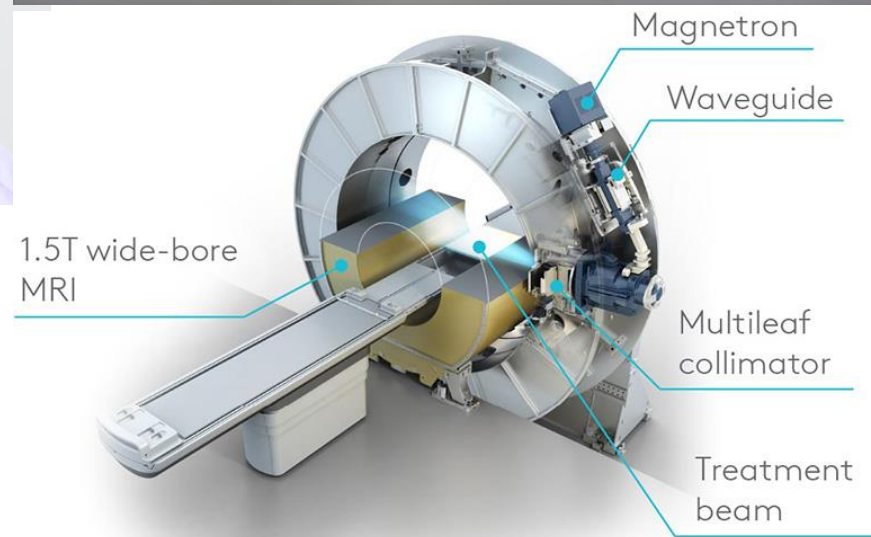
gemetastaseerd mamma- en longcarcinoom



MRI-linac (2017)



220 oral 1999
**MRI guided radiotherapy:
a MRI based linear accelerator**
J.J.W. Lagendijk¹, C.J.G. Bakker²
¹University Medical Center Utrecht,



Radiotherapie bij

gemetastaseerd mamma- en longcarcinoom

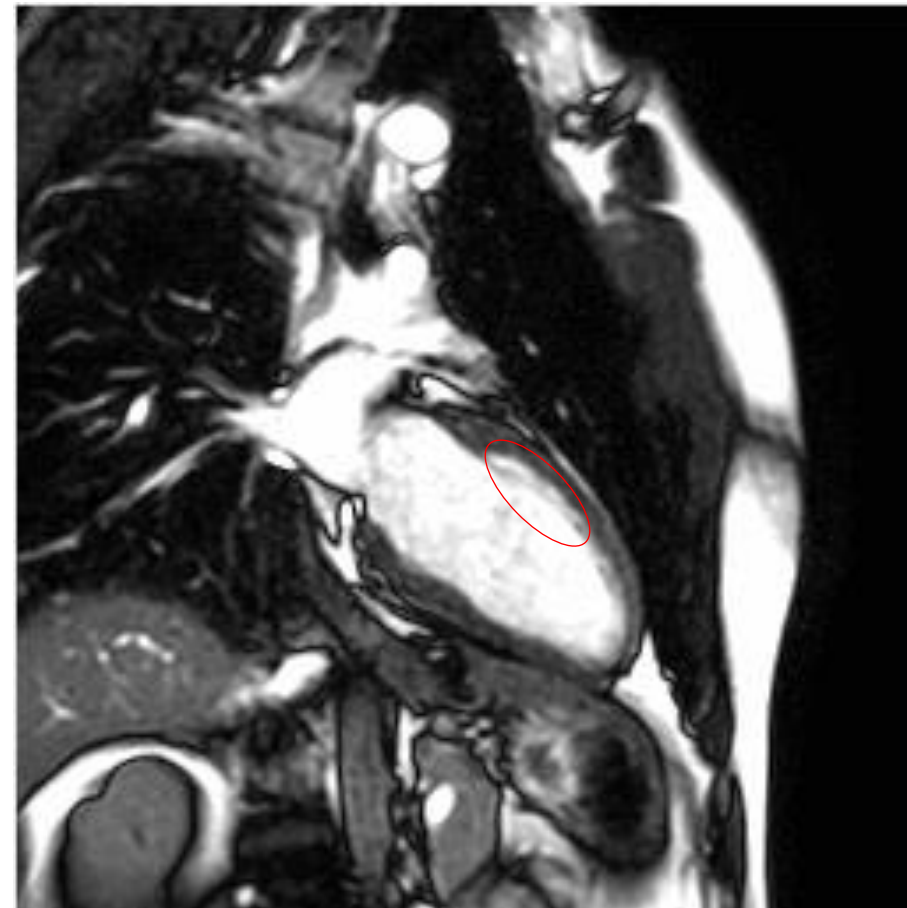
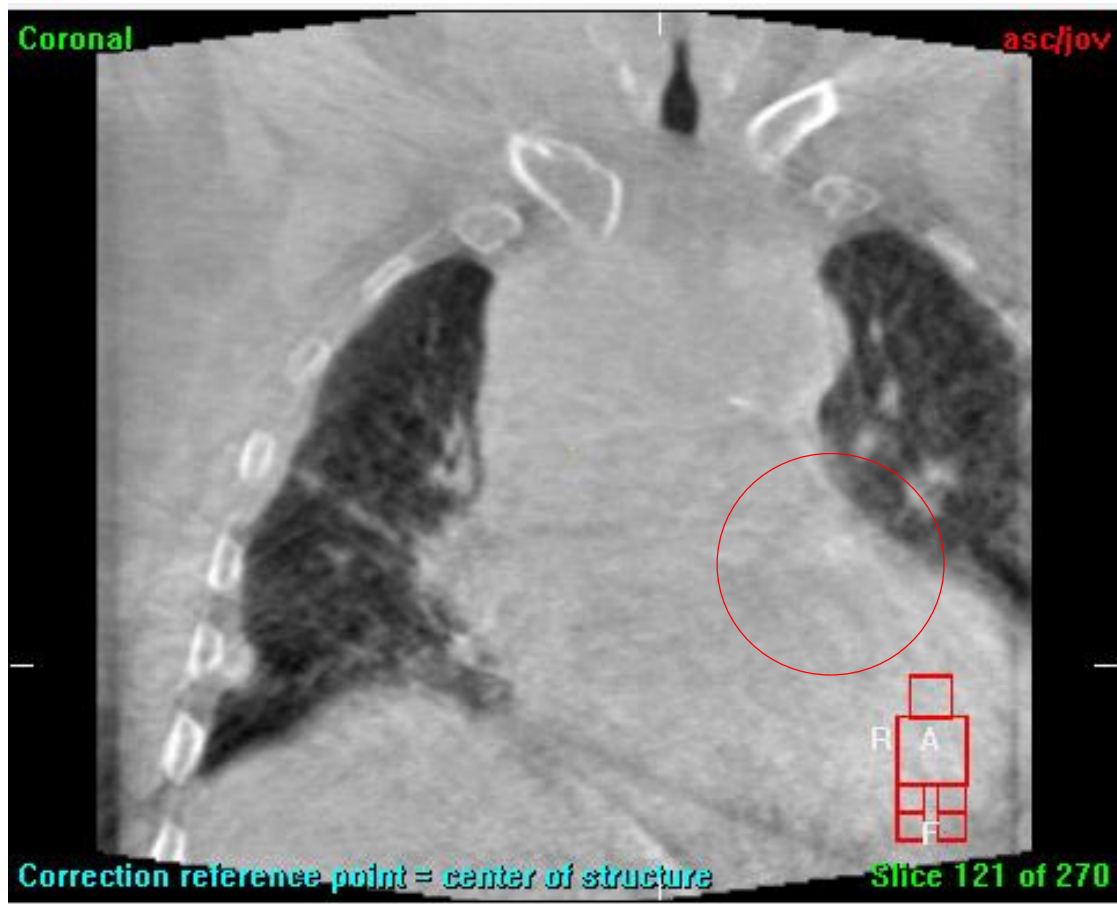
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Proof of Principle: MRI maken tijdens bestraling

Ribkarbonade (houdbaar tot 7-3-2009)



MRI-linac voordelen



Martin Fast

34

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Radiotherapie bij

gemetastaseerd mamma- en longcarcinoom

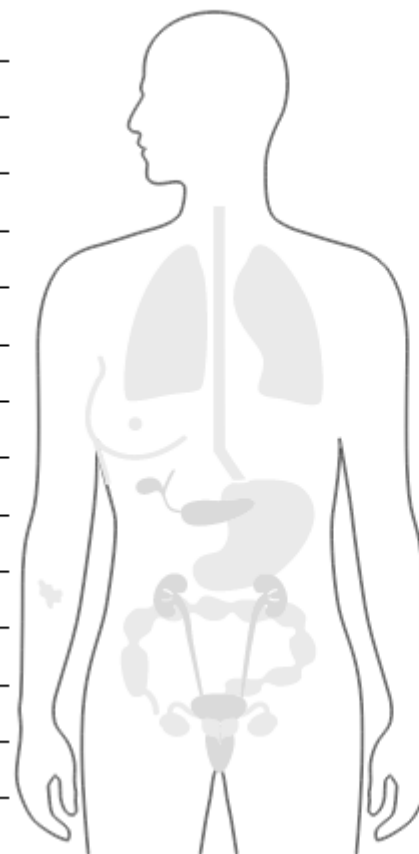


Uitgezaaide kanker

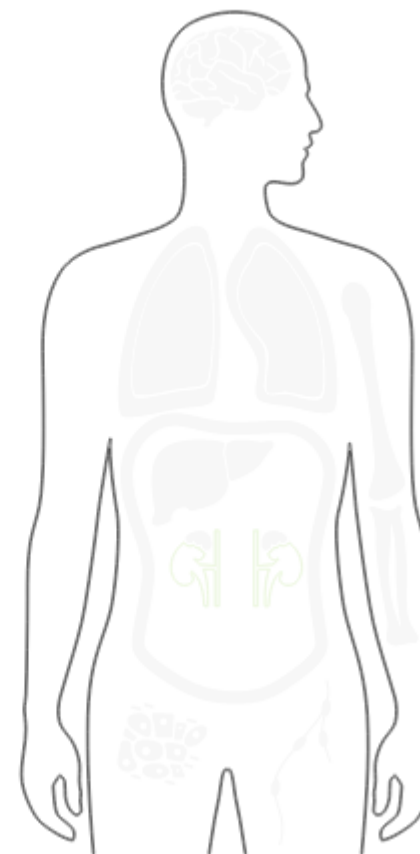
iknl.nl/uitgezaaide-kanker

Primaire tumor

- Alvleesklierkanker
- Blaaskanker
- Borstkanker
- Dikkedarmkanker
- Eierstok- en eileiderkanker
- Endeldarmkanker
- Galweg- en galblaaskanker
- Longkanker
- Maagkanker
- Melanoom
- Nierkanker
- Prostaatcancer
- Slokdarmkanker
- Overige kanker



Lokalisatie uitzaaiingen



- Hersenen
- Long
- Pleura (longvlies)
- Bot
- Lever
- Bijnier
- Peritoneaal (buikvlies)
- Huid
- Niet-regionale lymfklieren
- Overige



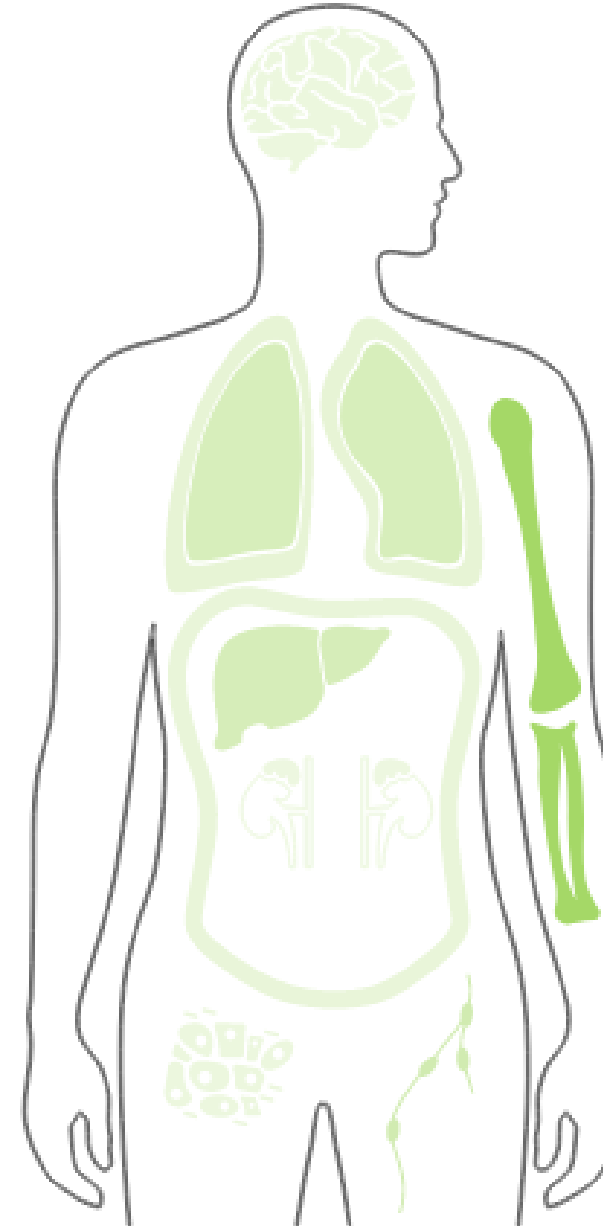
Mammacarcinoom

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen



Hersenen	3%
Long	23%
Pleura (longvlies)	8%
1 Bot	71%
3 Lever	24%
Bijnier	2%
Peritoneaal (buikvlies)	6%
Huid	3%
2 Niet-regionale lymfklieren	29%
Overige	5%

Longkanker

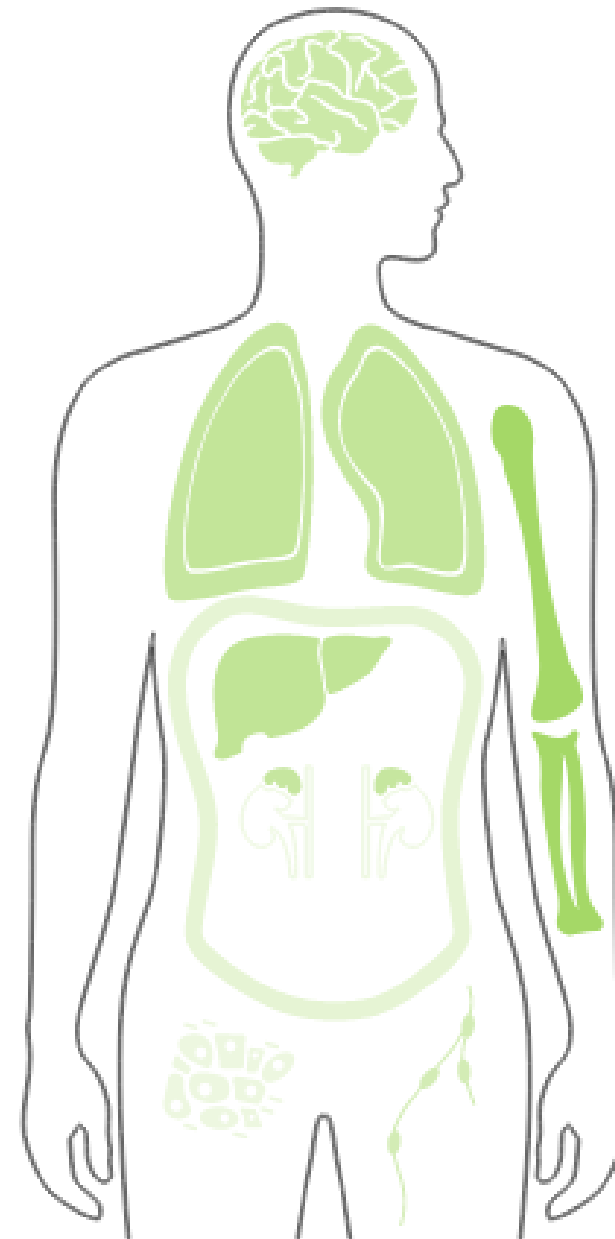
Botmetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenenmetastasen



Hersenen	19%
3 Long	24%
Pleura (longvlies)	22%
1 Bot	40%
2 Lever	25%
Bijnier	22%
Peritoneaal (buikvlies)	5%
Huid	1%
Niet-regionale lymfklieren	15%
Overige	14%

data laten leven

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Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenmetastasen



Olig

30.00

Hellr
Bepe
Lang

Oligo

te



of
Society

n and

Bouma MD ^c,
of Anne-Marie C
c E Lecouvet PhD
i MD ^m, Nicola S
ombal PhD ^P, Prof

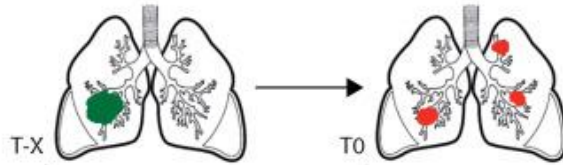
A De-novo oligometastatic disease

Synchronous oligometastatic disease



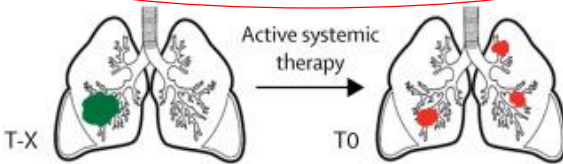
- T0: first time diagnosis of primary cancer (green) and oligometastases (red) within 6 months

Metachronous oligorecurrence



- T-X: diagnosis and treatment of primary cancer (green) in a non-metastatic state
- Systemic therapy-free interval
- T0: First time diagnosis of new oligometastases (red) >6 months after diagnosis of cancer

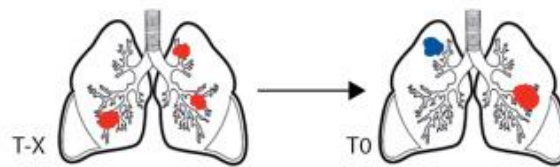
Metachronous oligoprogression



- T-X: diagnosis and treatment of primary cancer (green) in a non-metastatic state
- Under treatment with active systemic therapy
- T0: first time diagnosis of new oligometastases (red) >6 months after diagnosis of cancer

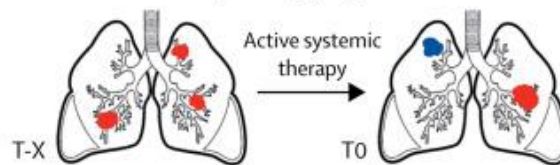
B Repeat oligometastatic disease

Repeat oligorecurrence



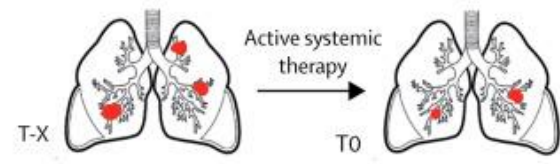
- T-X: diagnosis of oligometastases followed by local treatment or systemic treatment or both
- Systemic therapy-free interval
- T0: diagnosis of new (blue) and growing or regrowing (red) oligometastases

Repeat oligoprogression



- T-X: diagnosis of oligometastases followed by local treatment or systemic treatment or both
- Under treatment with active systemic therapy
- T0: diagnosis of new (blue) and growing or regrowing (red) oligometastases

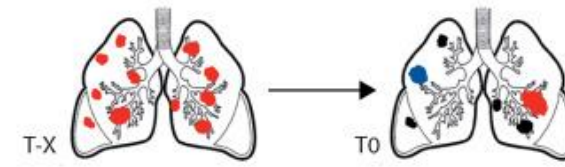
Repeat oligopersistence



- T-X: diagnosis of oligometastases followed by local treatment or systemic treatment or both
- Under treatment with active systemic therapy
- T0: diagnosis of persistent non-progressive (red) oligometastases

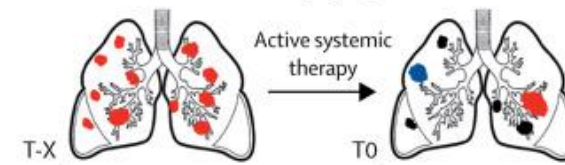
C Induced oligometastatic disease

Induced oligorecurrence



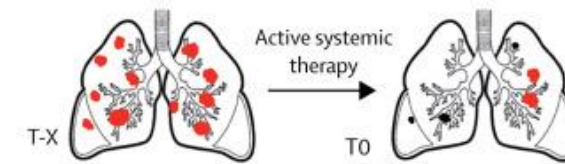
- T-X: diagnosis of polymetastatic metastatic disease followed by systemic treatment with or without local treatment
- Systemic therapy-free interval
- T0: diagnosis of new (blue) and growing or regrowing (red) oligometastases, possible residual non-progressive metastases (black)

Induced oligoprogression



- T-X: diagnosis of polymetastatic metastatic disease followed by systemic treatment with or without local treatment
- Under treatment with active systemic therapy
- T0: diagnosis of new (blue) and growing or regrowing (red) oligometastases, possible residual non-progressive metastases (black)

Induced oligopersistence



- T-X: diagnosis of polymetastatic metastatic disease followed by systemic treatment with or without local treatment
- Under treatment with active systemic therapy
- T0: diagnosis of persistent non-progressive oligometastases (red), where response is worse compared with other residual metastases (black)

Ra

Botmetastasen

Mogelijk lange overleving bij
ER+ borstkanker
Prostaatkanker
Gedifferentieerd thyroid carcinoom
Melanoom
Niercel carcinoom
EGFR gemuteerd longkanker



Botmetastasen Stabiliteit

Sprave et al. Radiation Oncology (2018) 13:134

Retrospectieve analyse 534 patienten met instabiele spinale botmetastasen behandeld met <10 fracties of >10 fracties

40% longkanker, 17% borstkanker, 15% niercelcarcinoom

mOS 5.5 maanden kort versus 9.5 maanden lang

Stabiliteit na radiotherapie

Kort schema 18% na 3 mnd en 31% na 6 mnd

Lang schema 24% na 3 mnd en 34% na 6 mnd



Botmetastasen: Pijn en Remineralisatie

Koswig et al. *Strahlenther Onkol.* 1999;175(10):500-8

Pijn

1x8Gy net zo goed als 10x3Gy

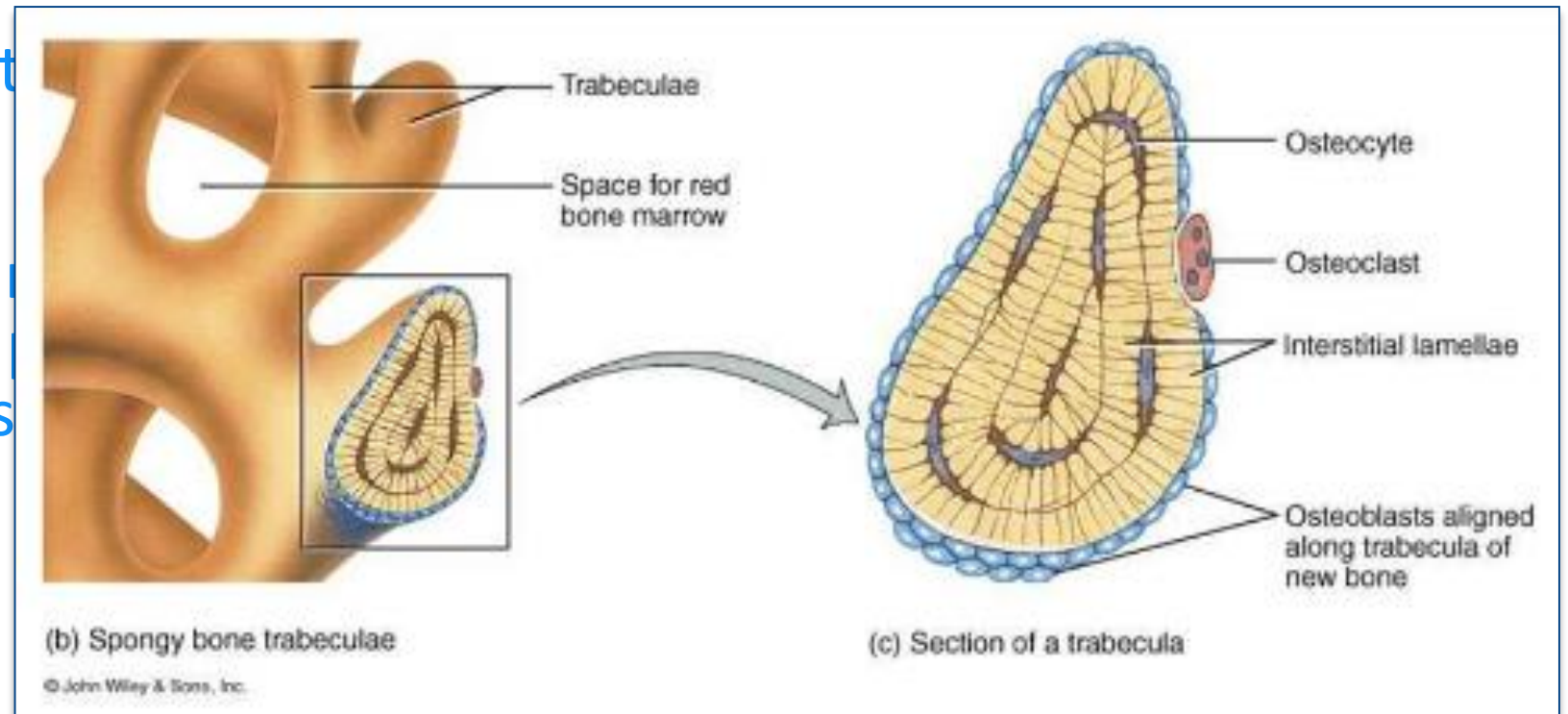
Remineralisatie

CT vooraf, dag na, 6 wk , 3 maanden en 6 maanden postRTH
10x3Gy beter bij borstkanker

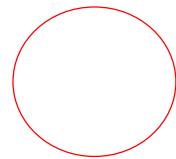
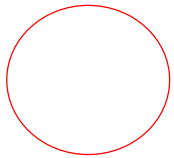
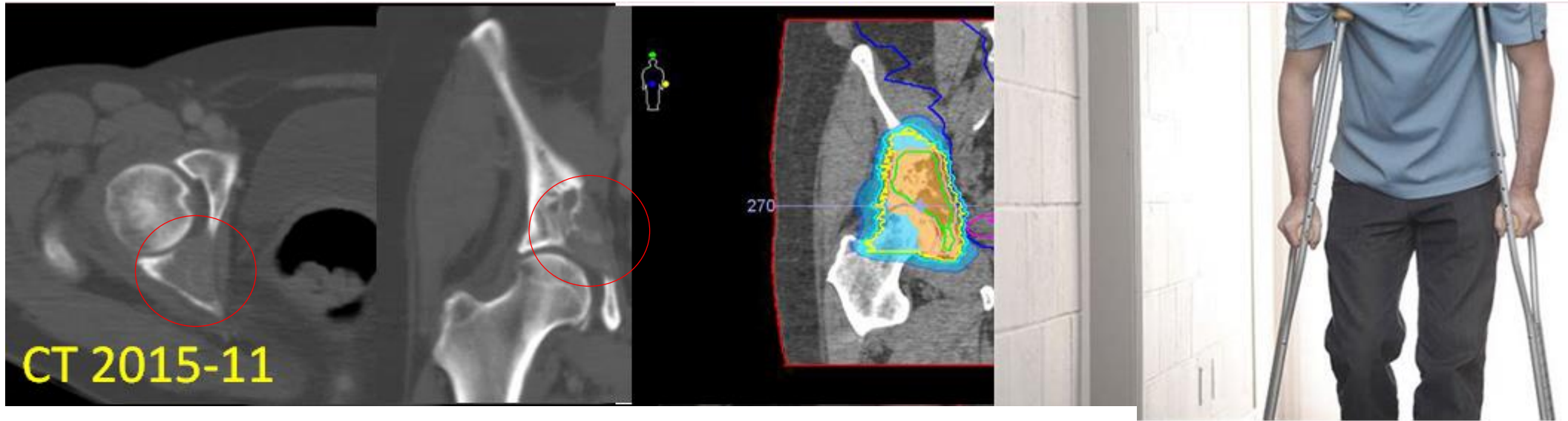


Botmetastasen: Remineralisatie

- Gefractioneerde radiotherapie meer remineralisatie dan na 1x8Gy bij borstkanker
- Bisfosfonaten vooraf RT betere botkwaliteit door voorkomen RT geïnduceerde afbraak van trabeculair bot
- Totale destructie van trabeculair bot bij lytische laesie
- SBRT 3x 10Gy geeft latere remineralisatie en bij radioresistente tumoren (endotheliale apoptose)



Oligometastase borstkanker 11 jaar na behandeling



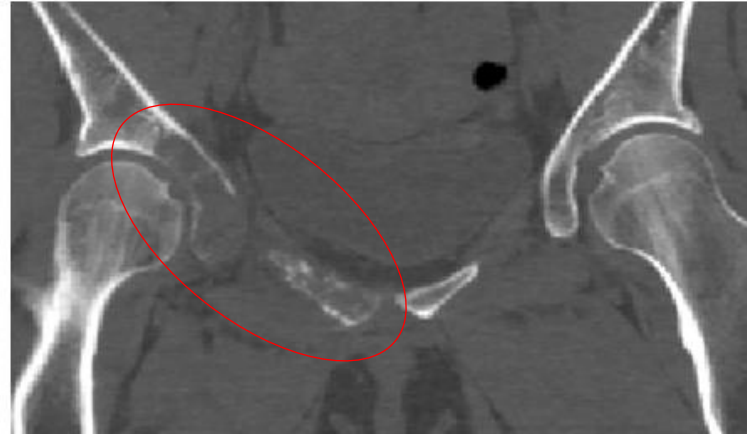
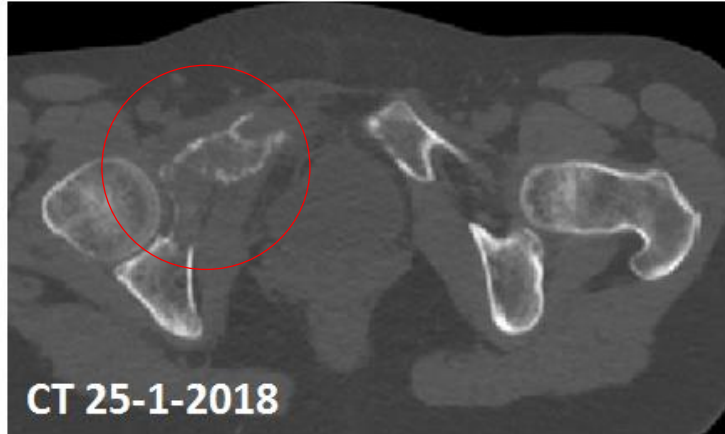
Bisphosfonaten 1 maand voor start RT

Nu geen pijn, geen tumor activiteit op PET-CT

Loopt weer normaal

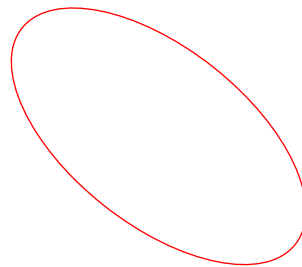
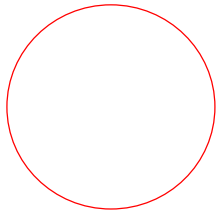


Gemetastaseerd borstkanker



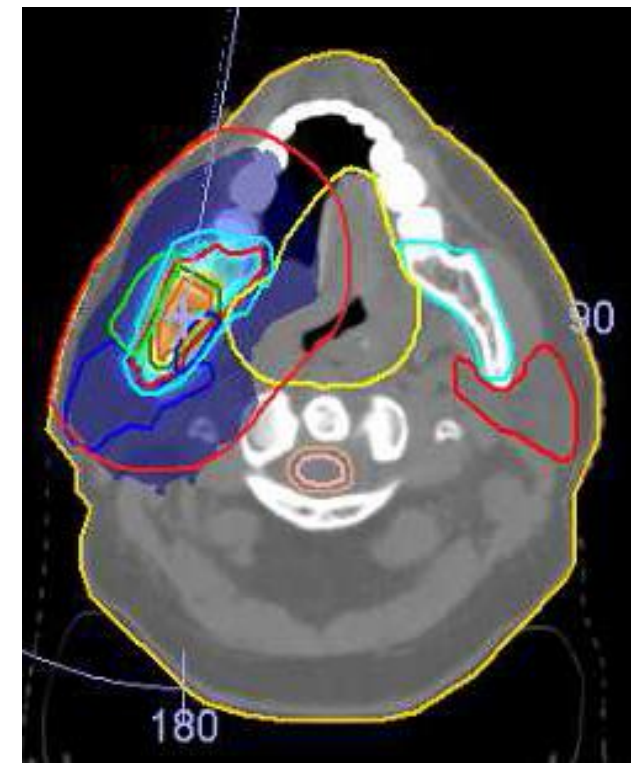
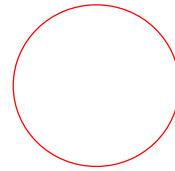
Painscore
NRS 4
paracetamol
Antalgic gait

7-2016 Bisfosfonaten
2-2018 16x 3Gy
2-2018 Fulvestrant
6-2018 Capecitabine



Mandibula metastase ER+ borstkanker

2018-1 before RT



2-2018 15x3Gy

Niet met bisfosfonaat
ivm risico
osteoradionecrose van
de kaakkop



Conclusies botmetastasen

1x 8Gy is standaard

Elke botmetastase verdient een andere aanpak

Pijn: geen verschil lang/kort

Stabiliteit: geen verschil lang/kort

Betere remineralisatie: gefractioneerd (langer) schema, met name borstkanker

Pijnlijke botmeta dragend bot 10-16x 3Gy ipv 1x 8Gy

Bisfosfonaten vooraf start voorkomt botafbraak door osteoclast activatie



Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

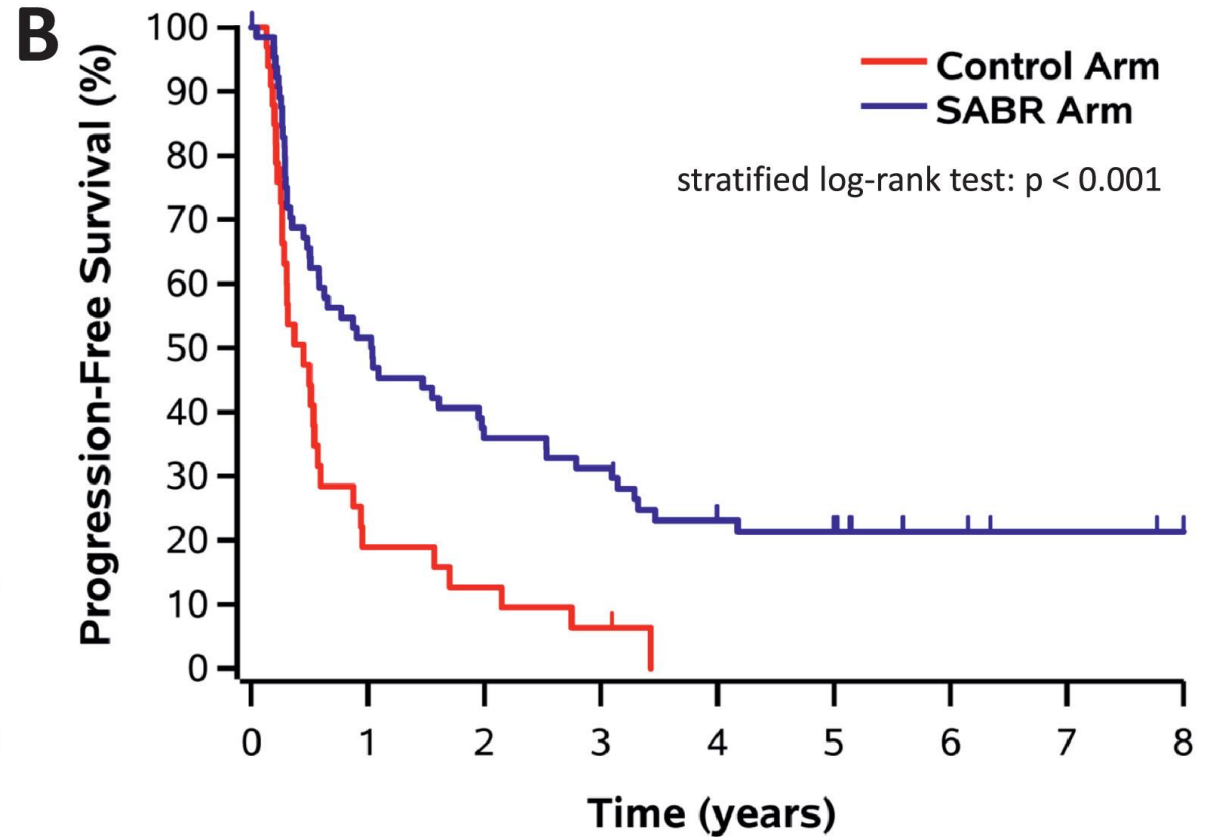
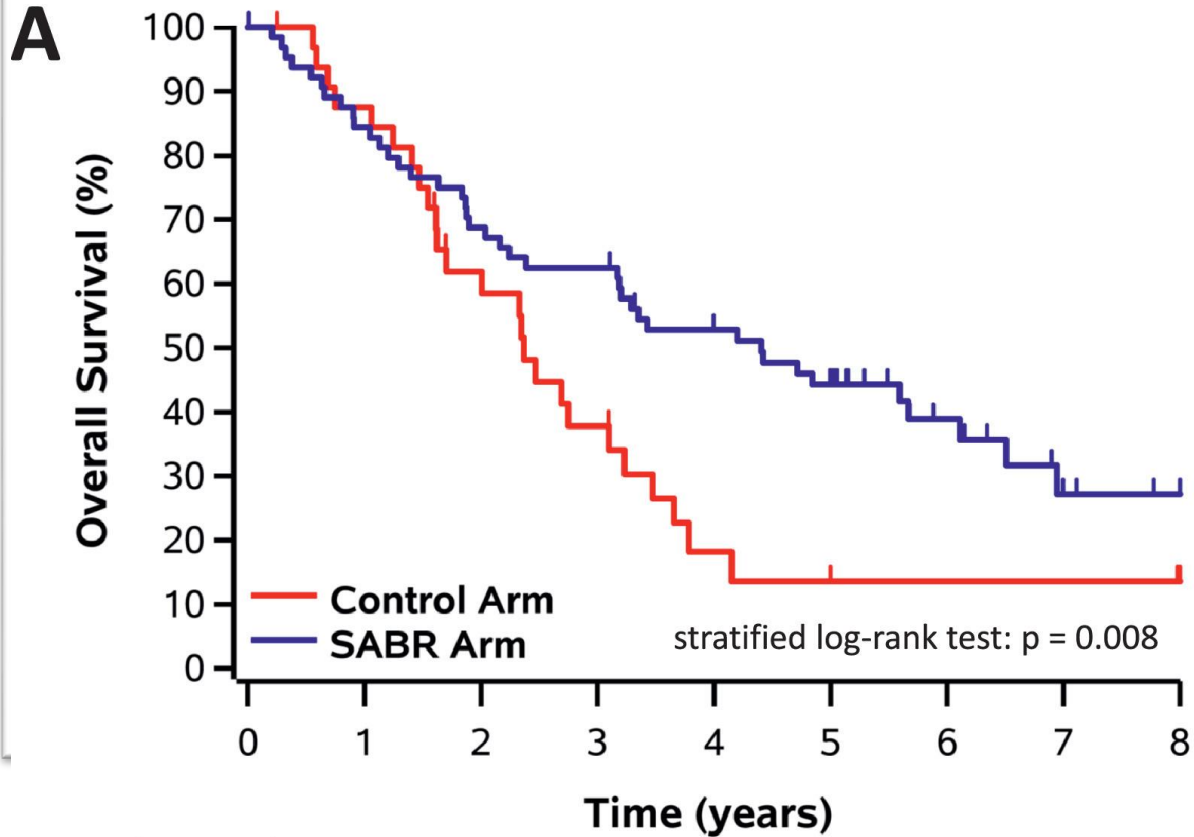
Levermetastasen

Longmetastasen

Bijniermetastasen

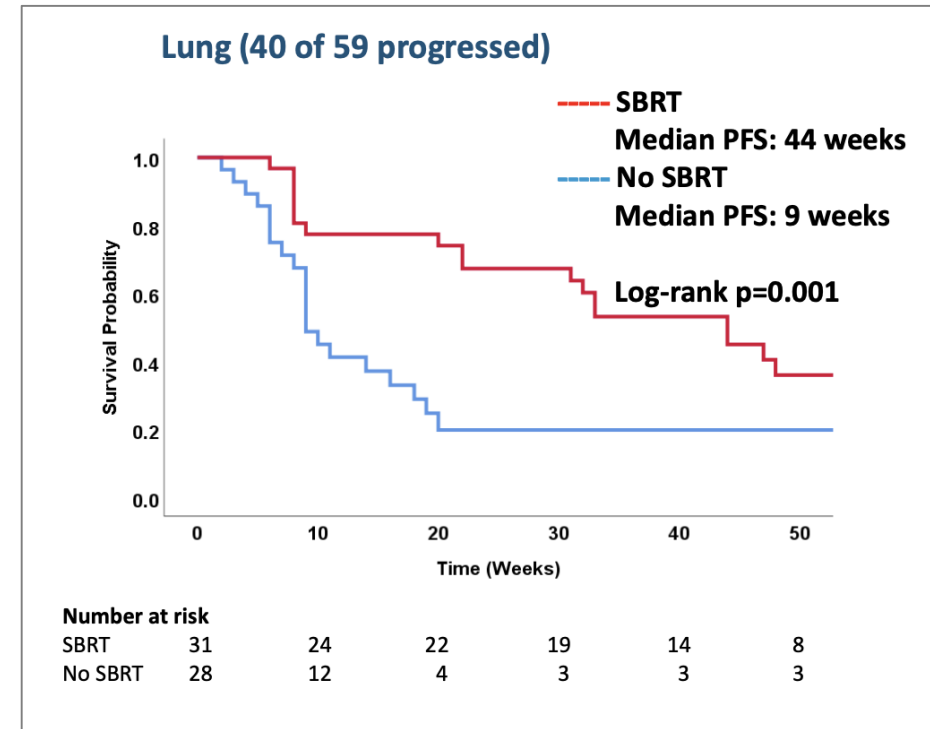
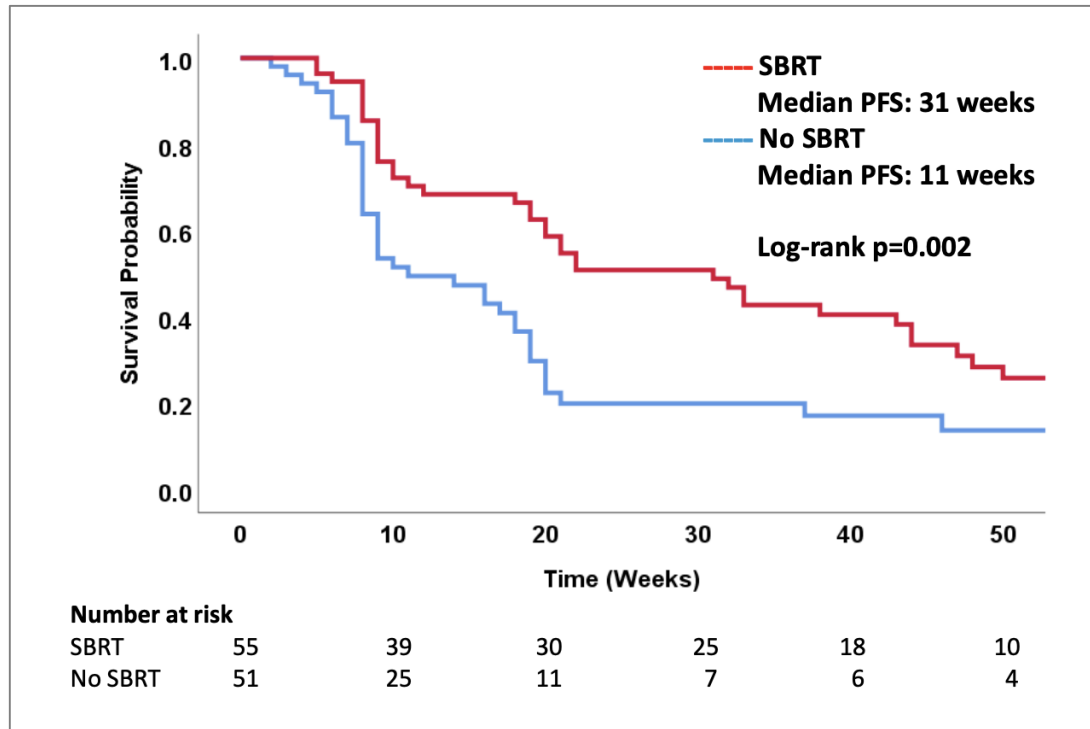
Hersenmetastasen





CURB: fase II trial voor oligoprogresieve borst ca & NSCLC

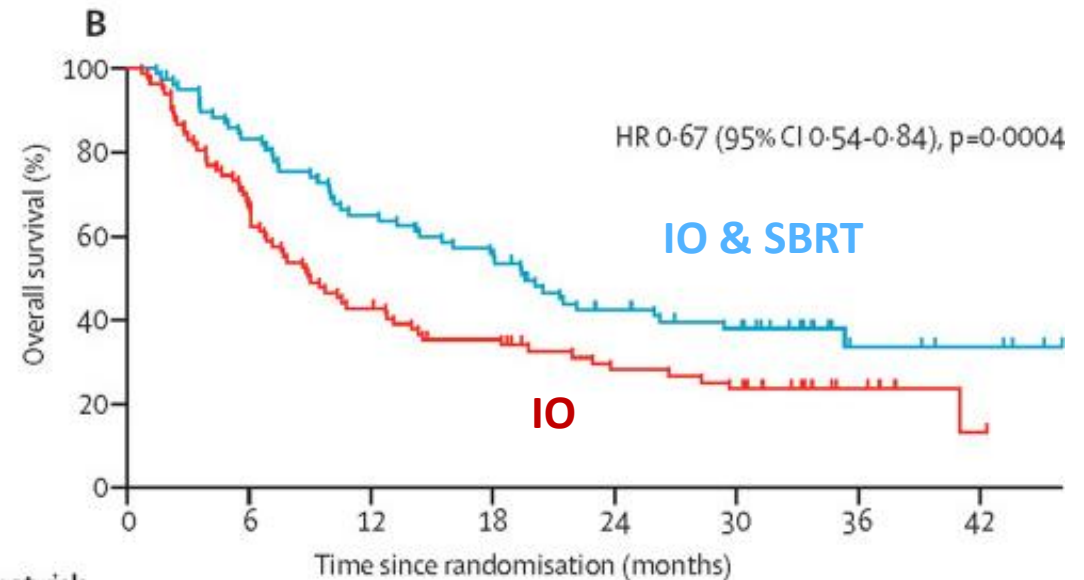
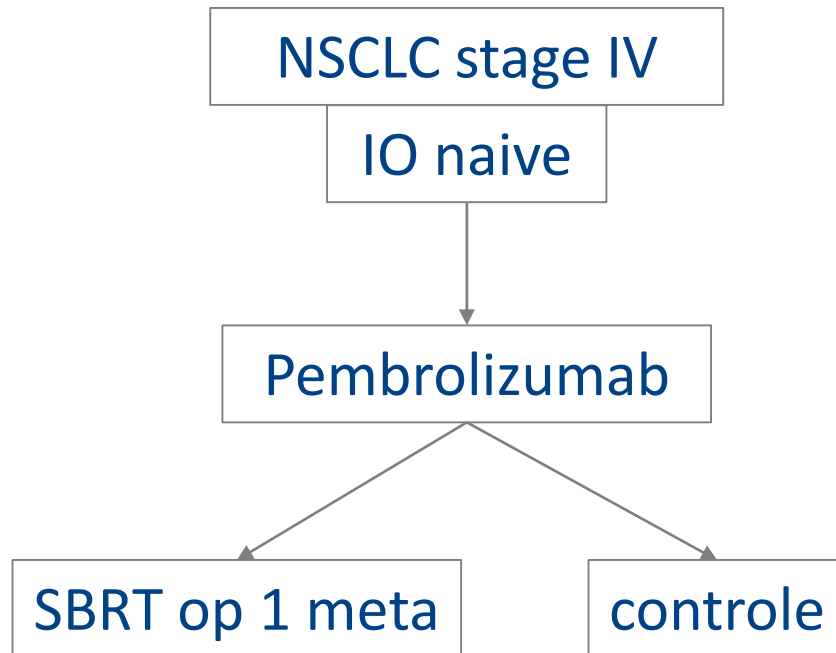
SBRT to all oligoprogresieve sites (max. 5) & SoC vs SoC alleen



➤ Significant survival voordeel in het NSCLC cohort

Enkele laesie SBRT om immunotherapie te versterken

— Gepooled analyse van 2 vergelijkbare NSCLC phase II trials



	Number at risk (number censored)							
	0	6	12	18	24	30	36	42
Pembrolizumab alone	76 (0)	54 (0)	33 (1)	26 (2)	18 (5)	15 (5)	6 (14)	2 (17)
Pembrolizumab plus radiotherapy	72 (0)	63 (1)	49 (1)	40 (1)	29 (4)	23 (7)	7 (12)	5 (14)

Veelbelovend, maar moet bevestigd worden in andere studies



Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenmetastasen



Levermetastasen: lange termijn resultaten SBRT

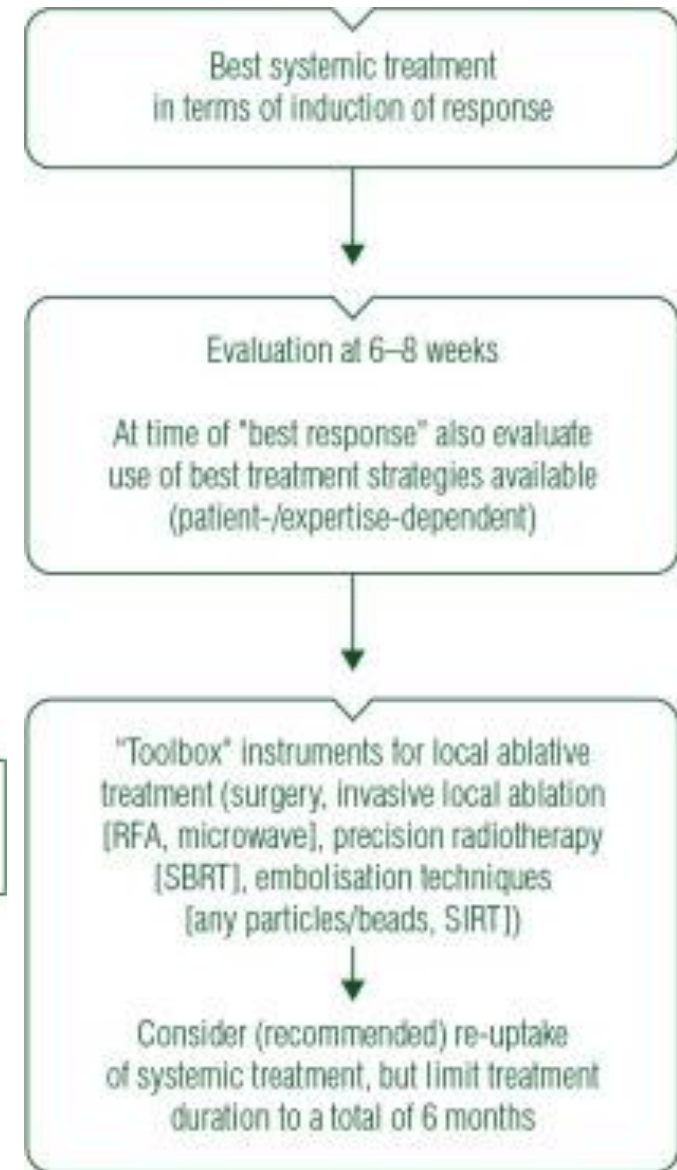
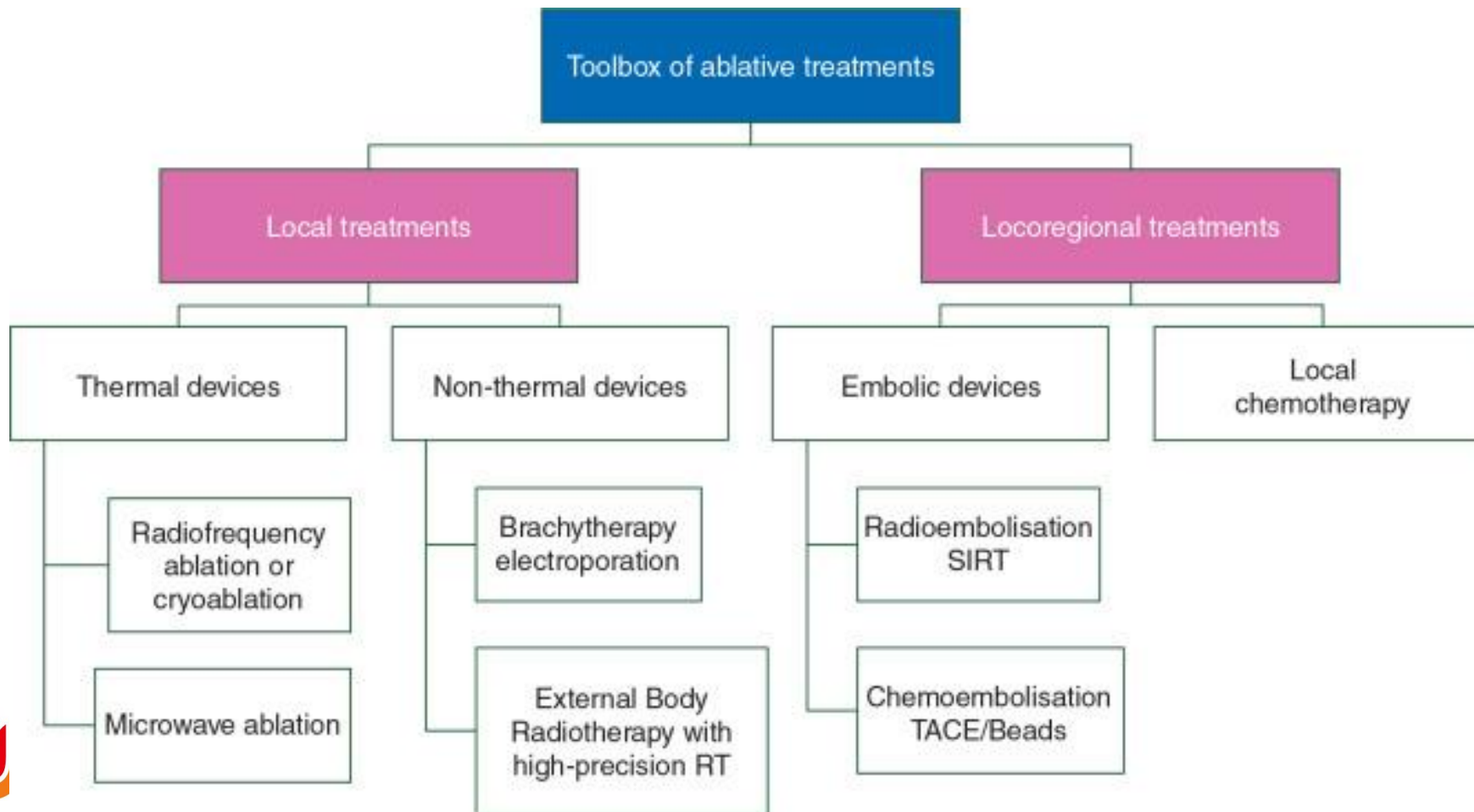
Author, (reference) design study, year	Patients with liver metastases	Dose (Gy/ fr)	Follow-up (median)	Local control (%)		Overall survival (%)		Toxicity ≥G3
				1-year	5-yeras	1-year	5-years	
Hoyer, [15] Phase II, 2006	44	45Gy/3fr	4.3 years	79% at 2 years	–	67%	13%	48%
Fode, [18] Retrospective, 2015	212 (321 tot oligometastatic patient)	BED10 = 72–195 Gy	5 years	91%	–	80%	23%	4%
				(Not specified for liver metastases)		(Not specified for liver metastases)		
Goodman, [39] Retrospective 2016	81	32–60/3–5 fr	2.25 years	96%	91% at 4 years	89.9%	28% at 4 years	4.9%
McPartlin, [28] Phase I-II, 2017	51	22.7–62.1 Gy /6 fr	2.3 years	49.8%	26% at 4 years	63%	9% at 4 years	3%
Joo, [29] Retrospective 2017	70	45-60Gy/3–4fr	2.8 years	93%	68% at 3 years	75% at 2 years		0%
Mendez Romero [40] Retrospective, 2017	40	37.5 Gy / 3fr	2.2 years	96%	66% at 3 years	95%	48% at 3 years	7.5%
		50.25 Gy / 3 fr		90%	81% at 3 years	94%	65% at 3 years	
Present study	61	75Gy/3 fr (82% of lesions) 67.5–52.5 Gy/3fr (18% of lesions)	6.1 years	94%	78%	85.2%	18%	1%

Scorsetti et al 2018 PMID: 30477560



Levermetastasen

ESMO guideline: ook SBRT in de *Toolbox*



Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenmetastasen



Longmetastasen

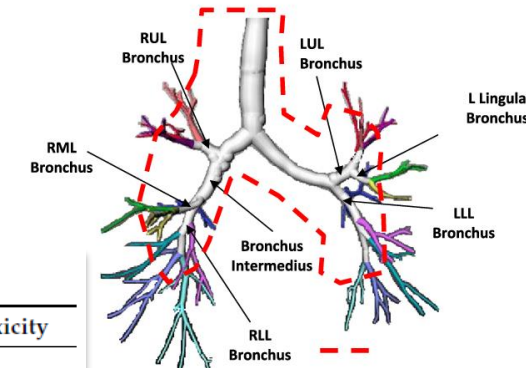


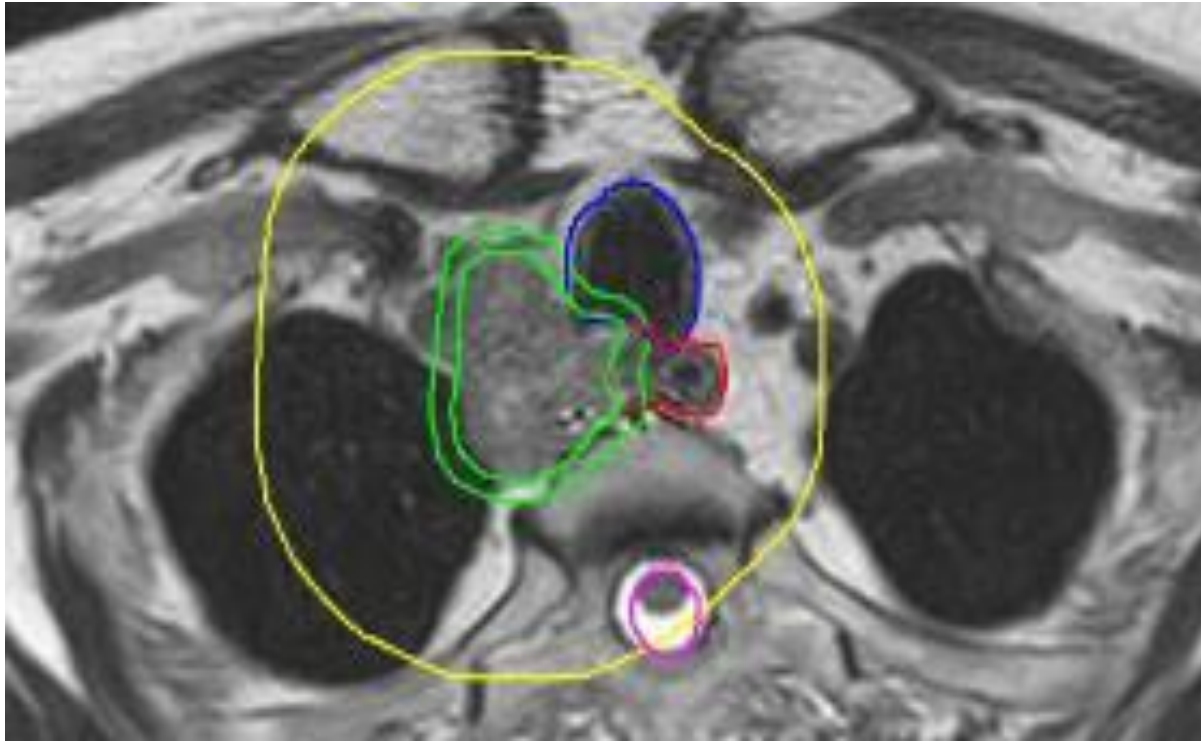
Table 2. Brief Summary of published studies of lung SBRT-treated central and central/peripheral lung metastases and differences in the prescribed dose.

Author/Year	Location	Technique Description	Prescribed Dose	Local Control	Overall Survival	Grade > 3 Toxicity
Milano et al. 2009 [79]	Central	Relaxed end-expiratory breath holding	Dmean 50 Gy (30–63 Gy) most in 4–5 Gy per fx	73% at 2 yr	47% at 2 yr	5/53 pts w/grade 5
Unger et al. 2010 [83]	Central	CyberKnife system with synchrony fiducial tracking technology	30–40 Gy in 5 fx	63% at 1 yr	54% at 1 yr	3/20 pts w/severe pneumonitis
Rowe et al. 2012 [84]	Central 100%	4D-CT with ITV and CBCT guidance system	75% BED 100 Gy 57% 12.5 Gy × 4 fx 25% BED <100 Gy	75% at 2 yr	————	5/47 patients
Nuyttens et al. 2012 [85]	Central	CyberKnife respiratory tumor tracking system	45–60 Gy/5–6 Fx	64% at 2 yr	75% at 2 yr	No grade 4–5 toxicity, 17.12% grade 3
Nuyttens et al. 2014 [86]	Peripheral Size >3 cm	Real-time tumor tracking + radiopaque markers	60 Gy/3 fx	90% at 2 yr	58% at 3 yr	No grade 4–5 toxicity
	Peripheral Size <3 cm		30 Gy/1 fx	74% at 2 yr		
	Central		60 Gy/5 fx	100% at 2 yr		
Chaudhuri et al. 2015 [80]	Central 50%	IMRT/4D-CT/PET respiratory gating CyberKnife with synchrony respiratory motion tracking system	56 Gy/7 fx	100% at 2 yr	73.8% at 2 yr	3% at 3 yr
	Peripheral 50%		(78%) 50 Gy/4 fx; (22%) 50.4 Gy/5 fx. Proportionally, more centrally located with 5 fx.	————		
Davis et al. 2015 [76]	Central	4D-CT with ITV and CBCT guidance system	Dmean 37.5 Gy (16–60 Gy) in 1–5 fx (media 3 fx), Dmean BED 93.6 Gy	69.8% at 2 yr	49.5% at 2 yr	No grade 3–5 toxicity
Haseltine et al. 2015 [87]	Central	Synchrony respiratory motion tracking system with fiducial markers	36–60 Gy in 2–5 fx, 56% received 45 Gy in 5 fx	77.4% at 2 yr	63.9% at 2 yr	12%, four patients with grade 5
Lischalk et al. 2016 [78]	Central	————	35–40 Gy/5 fx BED 59.5–72 Gy	57.4% at 2 yr No differences regarding the prescribed dose	40% at 2 yr No differences regarding the prescribed dose	15% (one patient with grade 4)
Lindberg et al. 2017 [88]	Central ≤1 cm from the proximal bronchial tree	————	56 Gy/8 fx	————	————	28% grade 3–5

ITV: Internal target volume; Dmean: Mean dose; BED: Biologically equivalent dose; Gy: Gray; fx: Fractions; and yr: Years.



MRI-gestuurde radiotherapie



Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenmetastasen

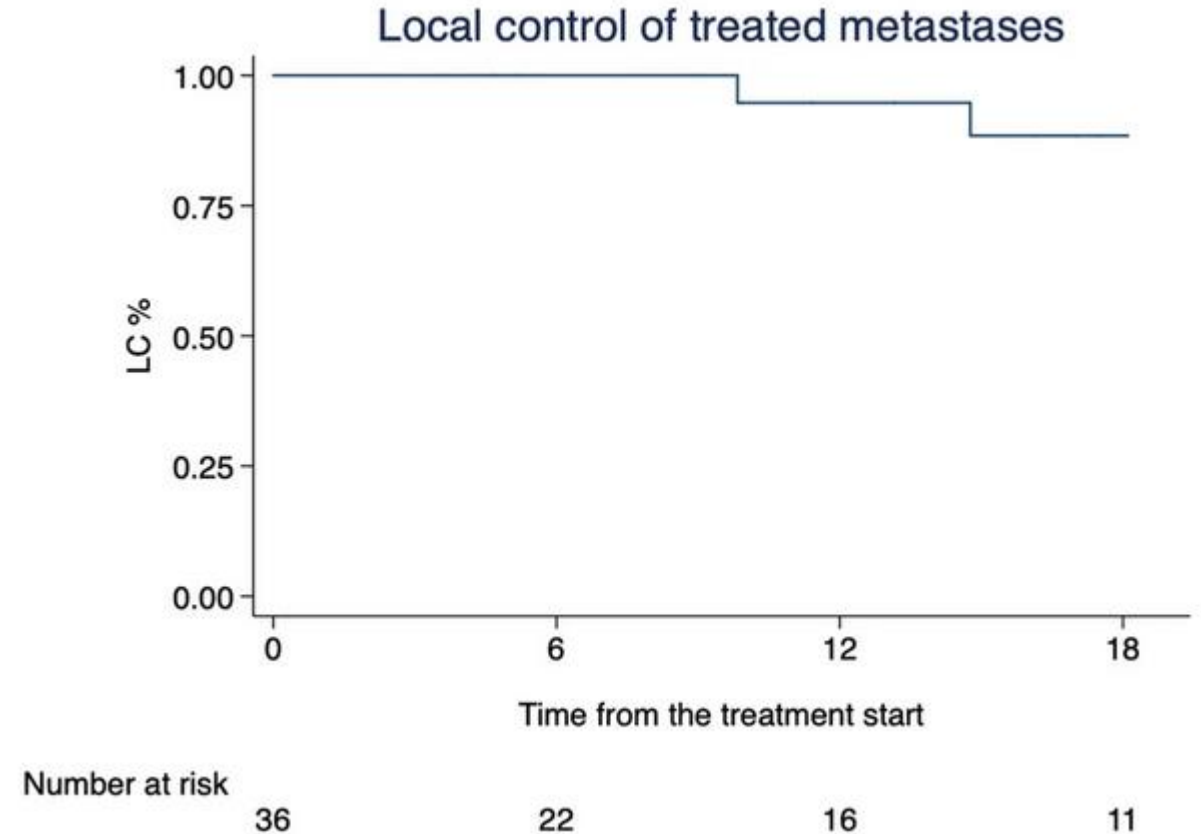


Bijniermetastasen

Techniek SBRT 3x15Gy

93% lokale controle
20% graad 1-2 toxiciteit

ACTH, cortisol and DHEA-S licht hoger
3-6 maanden na SBRT, hierna naar
baseline (altijd binnen
referentiewaarden)



Franzese et al 2021 PMID: 34537907



Doelgebieden van radiotherapie

Botmetastasen

Lymfkliermetastasen

Levermetastasen

Longmetastasen

Bijniermetastasen

Hersenmetastasen



Hersentumoren in Nederland

Metastasen (~10.000)

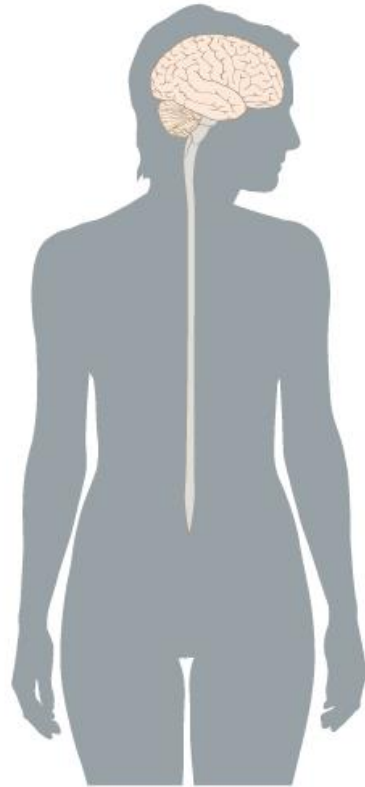
Gliomen (~1100)

Meningeomen (~500)

Hypofysetumoren (~450)

Brughoektumoren (~150)

~120 kinderen



gro

klei

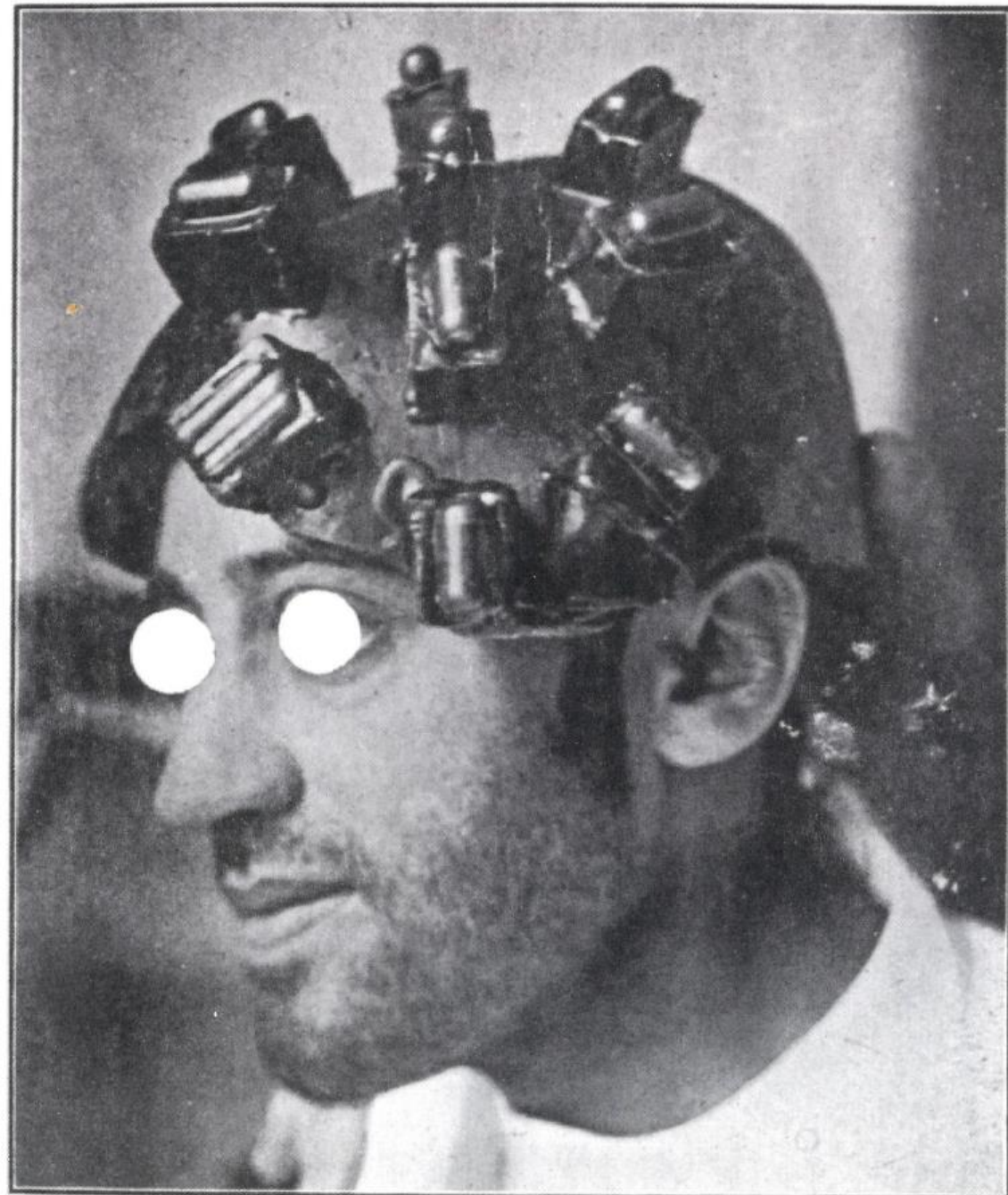


Figure 9.8. Treatment of a cerebral tumour [10].



Radiotherapie bij

gemetastaseerd mamma- en longcarcinoom

hersenmetastasen



Richtlijndatabase

[RICHTLIJNEN](#) [Q ZOEK](#) [NIEUWS](#) [INSTRUCTIES](#) [OVER](#) [CONTACT](#) [APP](#)

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Hersenmetastasen

[+ VOLGEN](#)

Initiatief: NVN

Aantal modules: 30

[Bijlagen](#)

[Download richtlijn](#)

Hersenmetastasen

Zoeken binnen deze richtlijn



Alles openklappen



Startpagina - Hersenmetastasen ⋮

Beoordeeld: 27-08-2020

Waar gaat deze richtlijn over?

De richtlijn behelst het traject van diagnostiek, behandeling, voorlichting en begeleiding van volwassen patiënten met hersenmetastasen van solide tumoren. Metastasering naar de hersenen van

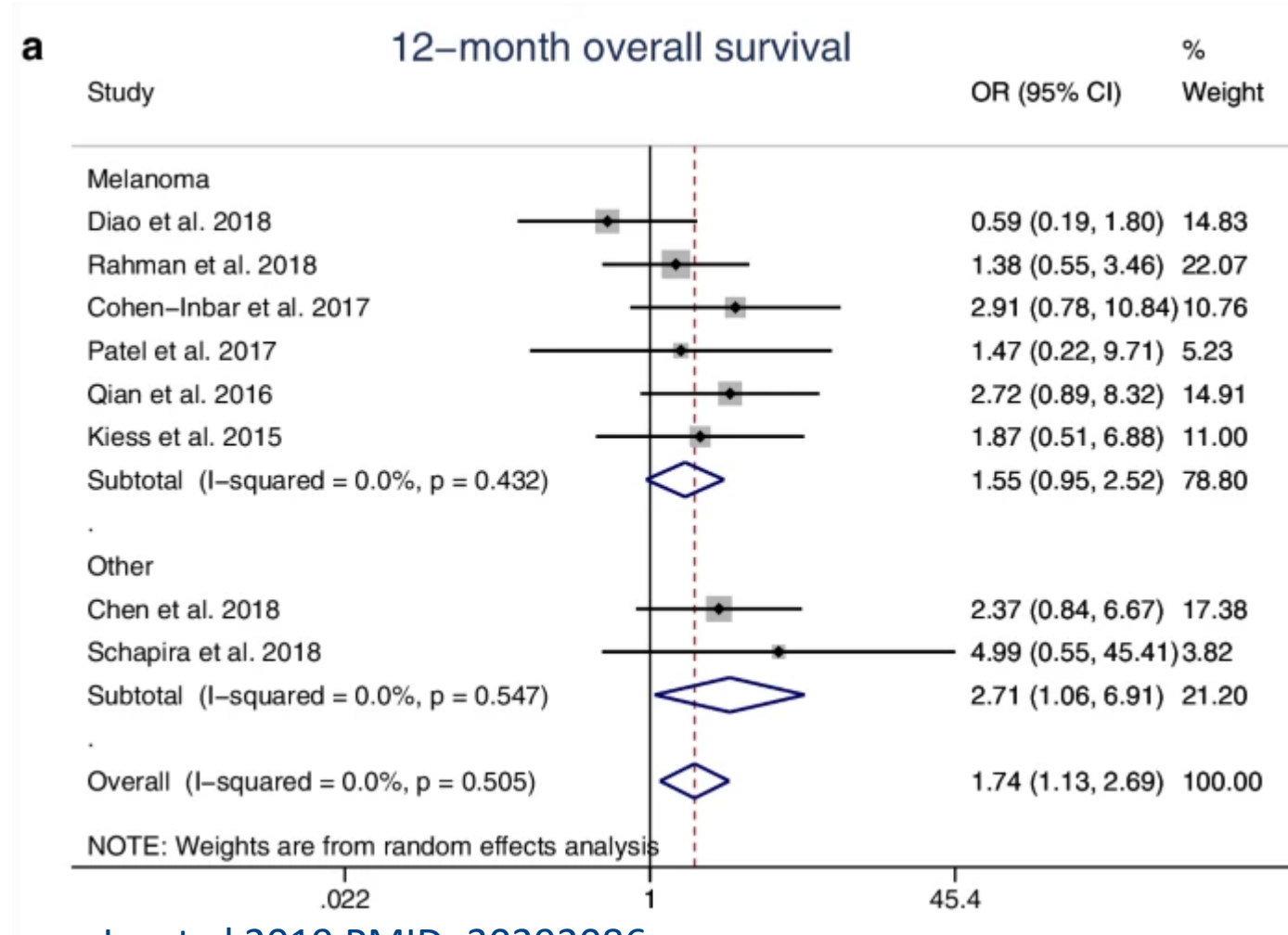
Hersenmetastasen en immuuntherapie

SRS +/- immuuntherapie

n=408

OS12 62% vs 50% (p = 0.011)

Combineren geeft betere OS

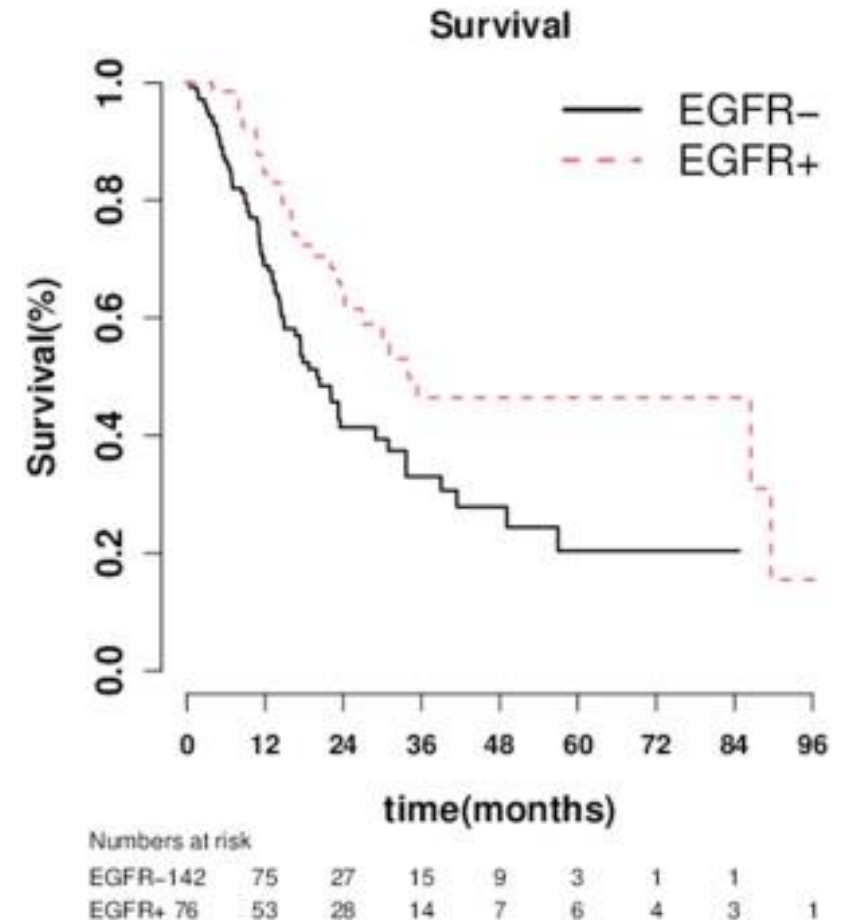


Hersenmetastasen longkanker

615 laesies, TKI concurrent 62%, post 93%

Lokale controle na 2 jaar
EGFR mut 94%, EGFR wt 84%

Kans op radionecrose in 2 jaar
EGFR mut 4%, EGFR wt 6%



Moraes et al 2021 PMID: 33721614



Conclusies radiotherapie

Radium

Orthovolt bestraling (~1920)

Cobalt Megavolt bestraling (1951)

Protonen bestraling (1954)

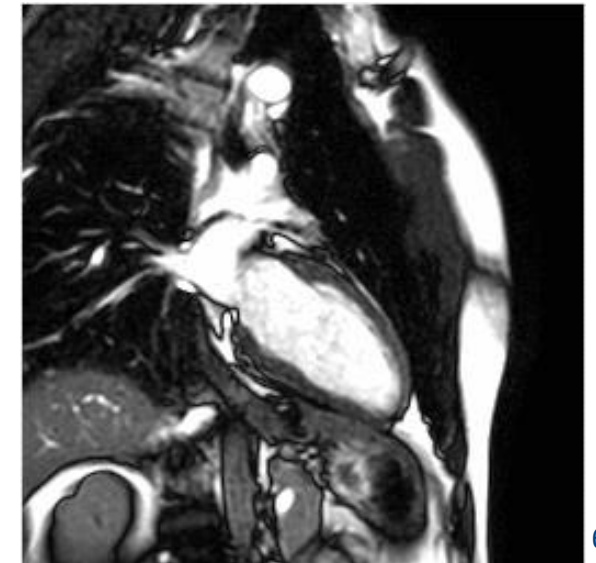
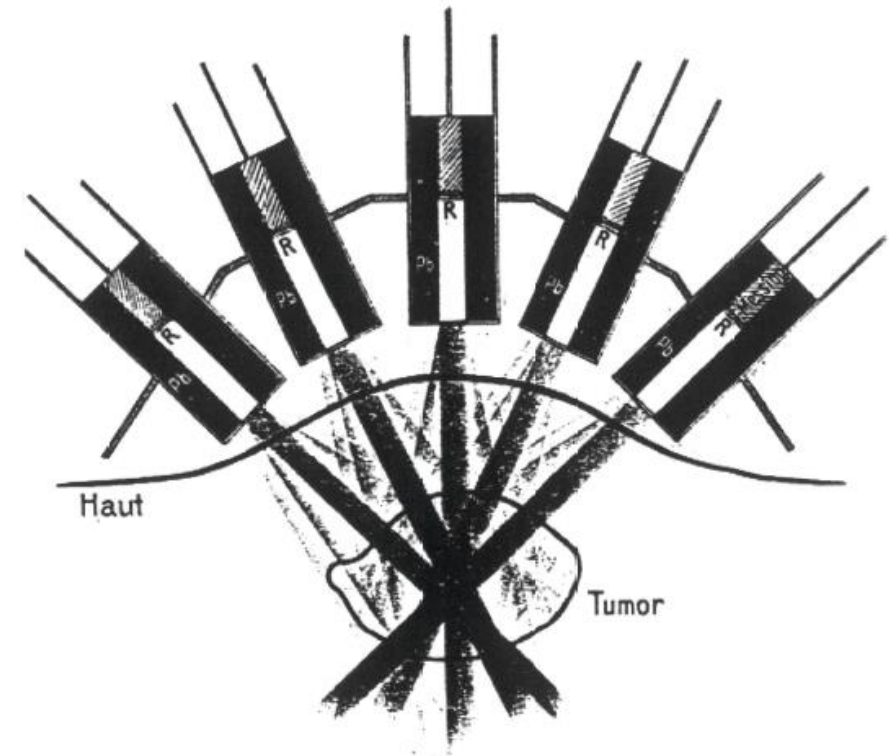
Lineaire versneller (1957)

Gamma knife (1968)

Cyber knife (1991)

CT-linac (1995)

MRI-linac (2014, 2017)



Conclusies radiotherapie

Botmetastasen

1x8Gy of SBRT (1-5x)

- Pijn en Stabiliteit geen verschil
- Remineralisatie lang schema
- Bisfosfonaten

Lymfkliermetastasen

- Verdubbeling PFS
- Mogelijk langere OS

Levermetastasen

- SBRT goede optie
- Zeer lage toxiciteit

Longmetastasen

- Veel ervaring
- Perifeer uitstekende lokale controle
- Centraal 70%

Bijniermetastasen

- Goede lokale controle
- Lage toxiciteit
- Hormonen binnen referentiewaarden

Hersenmetastasen

- Richtlijn tot 10 met SRS
- WBRT exit
- Goede lokale controle
- Te combineren met immuuntherapie

