食道癌的放射線治療

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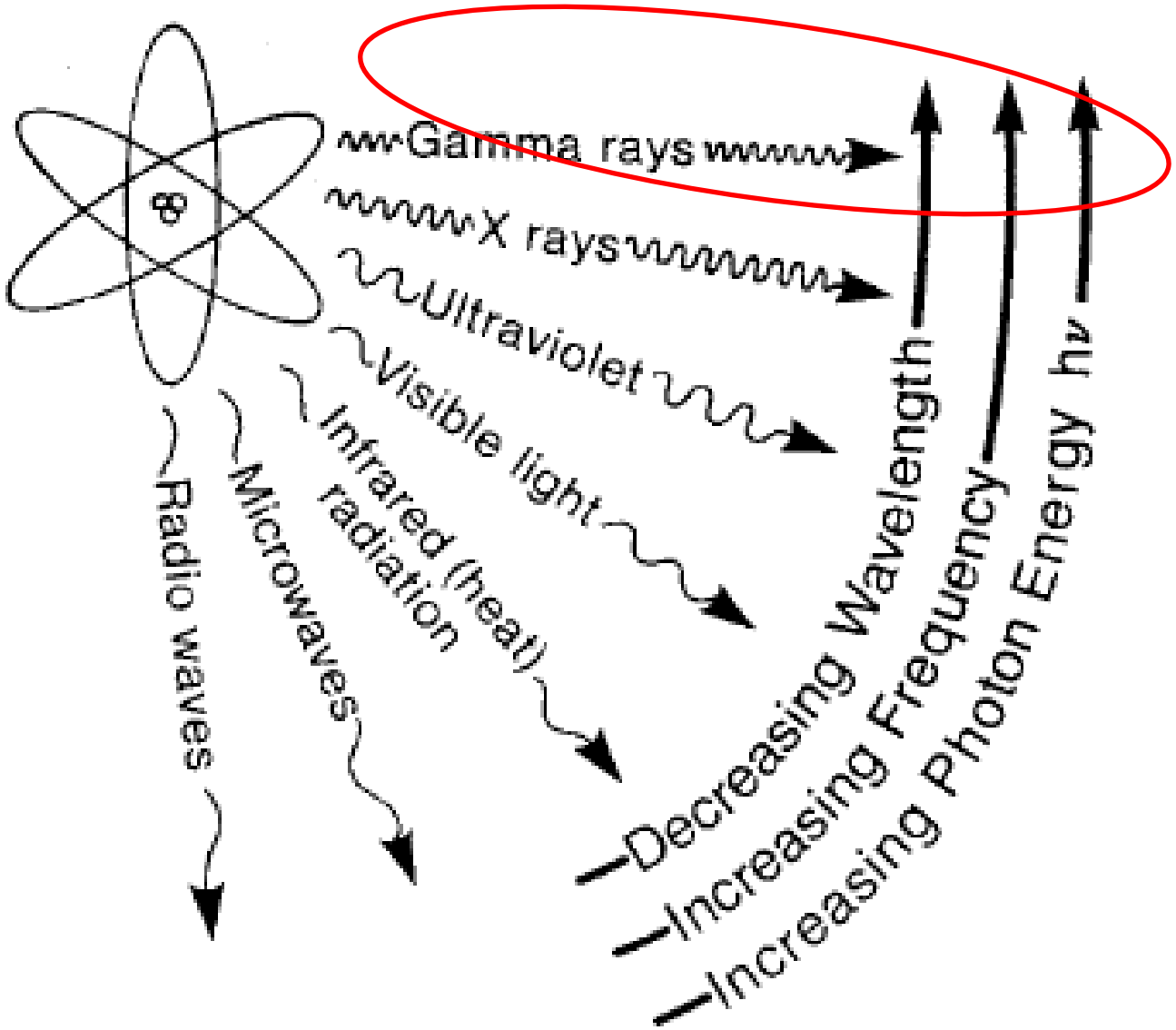
食道癌的治療選擇

- 手術治療
- 全身性治療
  - –化學治療 (Chemotherapy)
  - –標靶治療 (Target therapy)

- ●放射線治療 (Radiotherapy)

什麼是放射線？

電磁波 (輻射)


Gamma rays
X rays
Ultraviolet
Visible light
Infrared (heat) radiation
Microwaves
Radio waves
Decreasing Wavelength
Increasing Frequency
Increasing Photon Energy hν

游離輻射

- 電磁波
  - –X光（直線加速器）
  - –Gamma rays（放射性同位素）

- 粒子射線
  - –電子、質子、中子、α粒子、β粒子.....
  - –重粒子 (heavy charged particles)

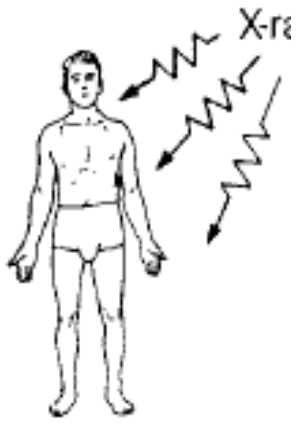
為何放射線可以殺死癌細胞？

放射線的生物效應並不是靠「能量」

Total-Body Irradiation

Mass = 70 kg
LD/50/60 = 4 Gy
Energy absorbed =

$$70 \times 4 = 280 \text{ joules}$$
$$= \frac{280}{4.18} = 67 \text{ calories}$$



X-ray

A

Drinking Hot Coffee

Excess temperature (°C) = 60° − 37° = 23°
Volume of coffee consumed to equal the energy in the LD/50/60 = $\frac{67}{23}$
= 3 mL
= 1 sip

B

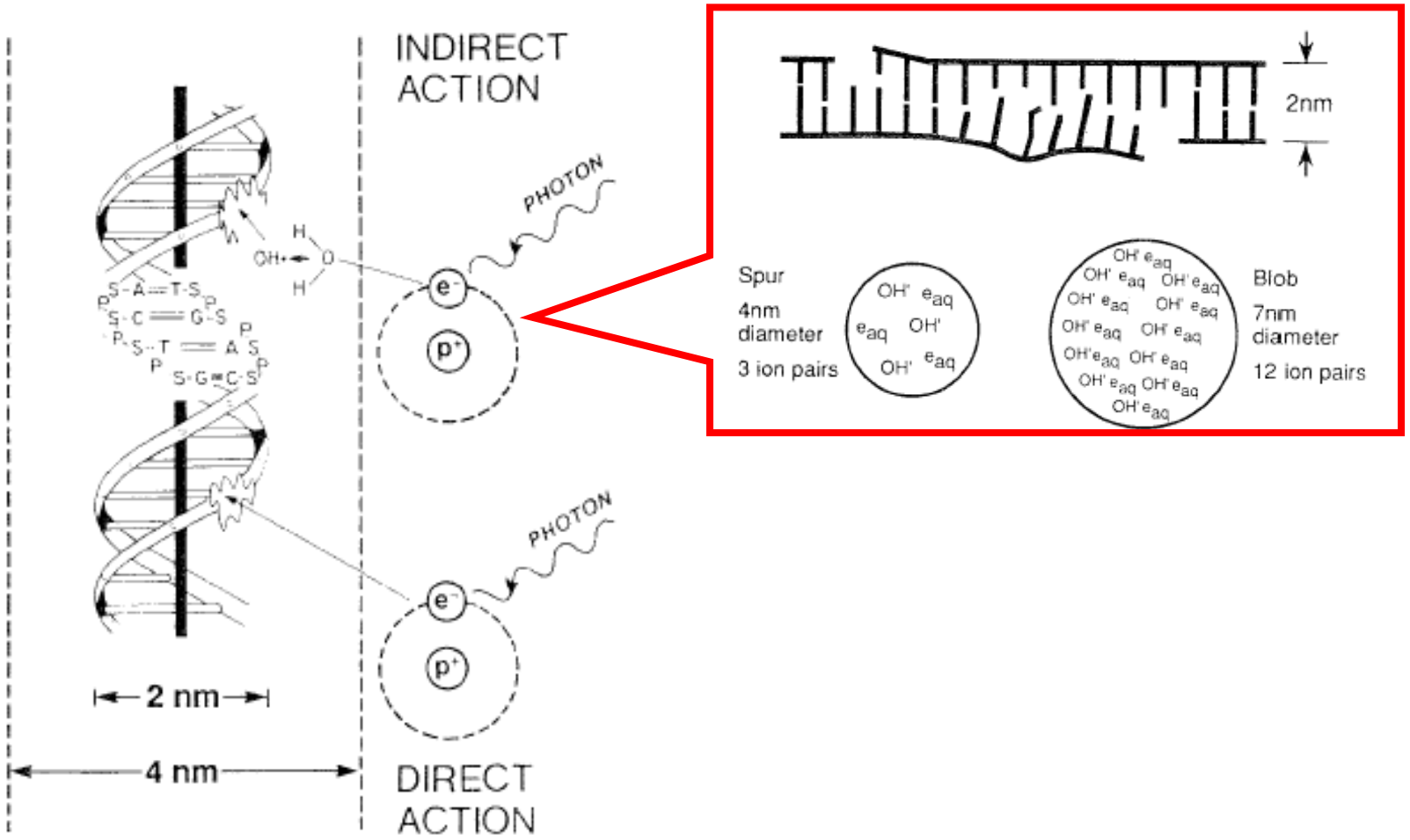
Mechanical Energy: Lifting a Person

Mass = 70 kg
Height lifted to equal the energy in the

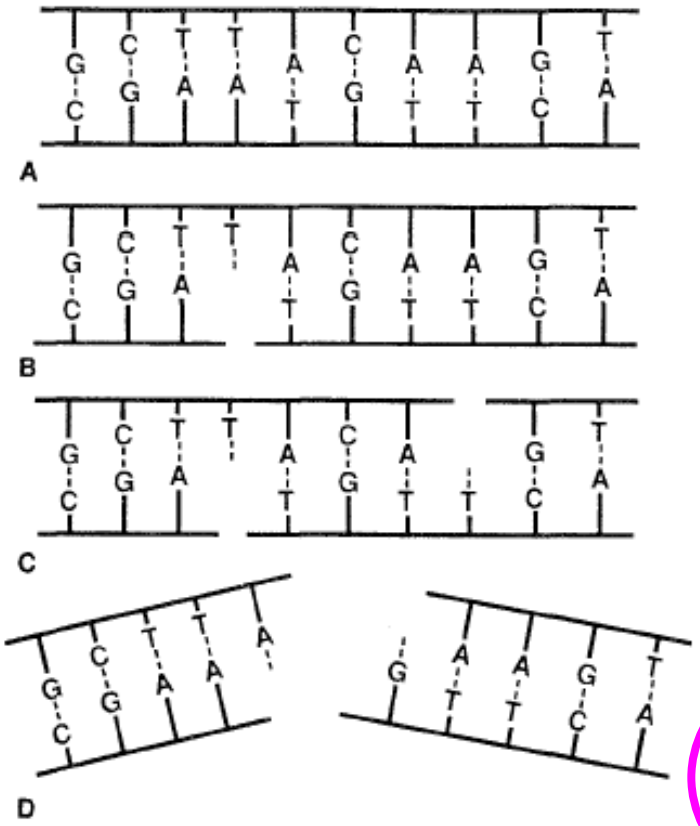
$$\text{LD/50/60} = \frac{280}{70 \times 0.0981}$$
$$= 0.4 \text{ m (16 inches)}$$

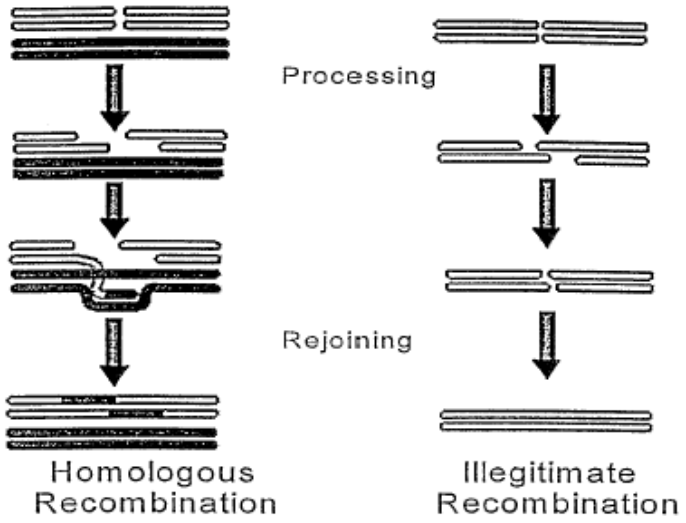
C

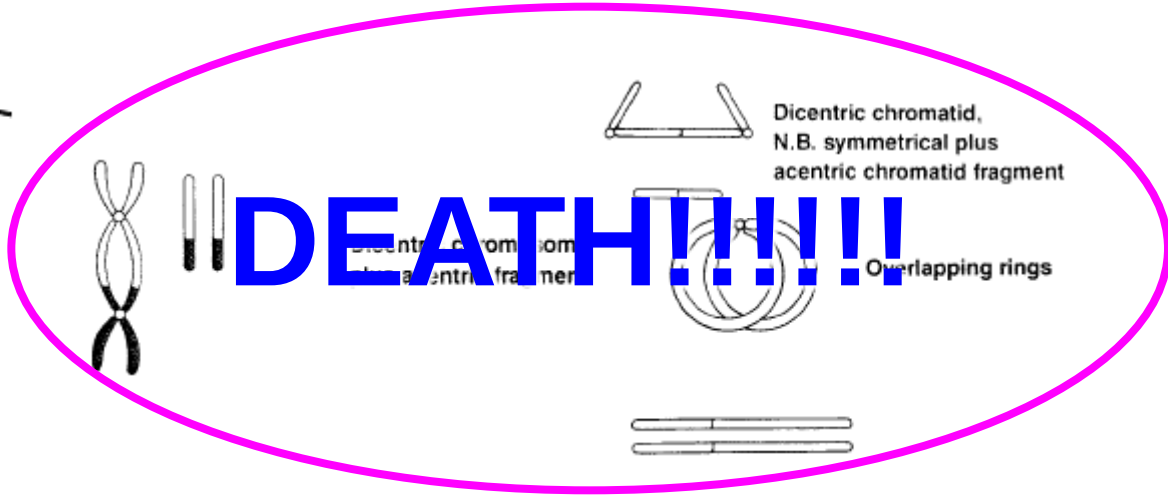
DNA是被攻擊的目標


INDIRECT ACTION
PHOTON
OH
H
H
O
e⁻
p⁺
PHOTON
e⁻
p⁺
2 nm
4 nm
DIRECT ACTION
2nm
Spur
4nm diameter
3 ion pairs
OH' eaq
eaq OH'
OH' eaq
Blob
7nm diameter
12 ion pairs

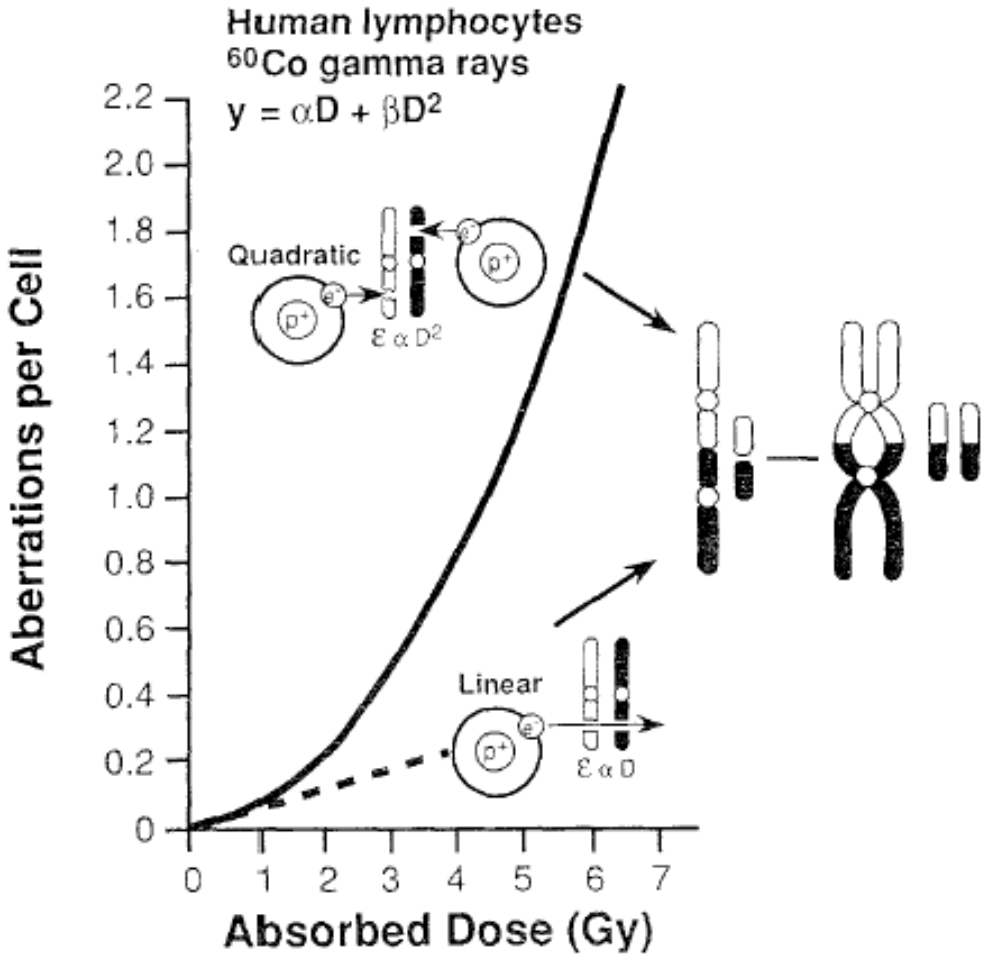
DNA的修復能力是關鍵







吸收劑量越高，發生染色體變異的機會越大

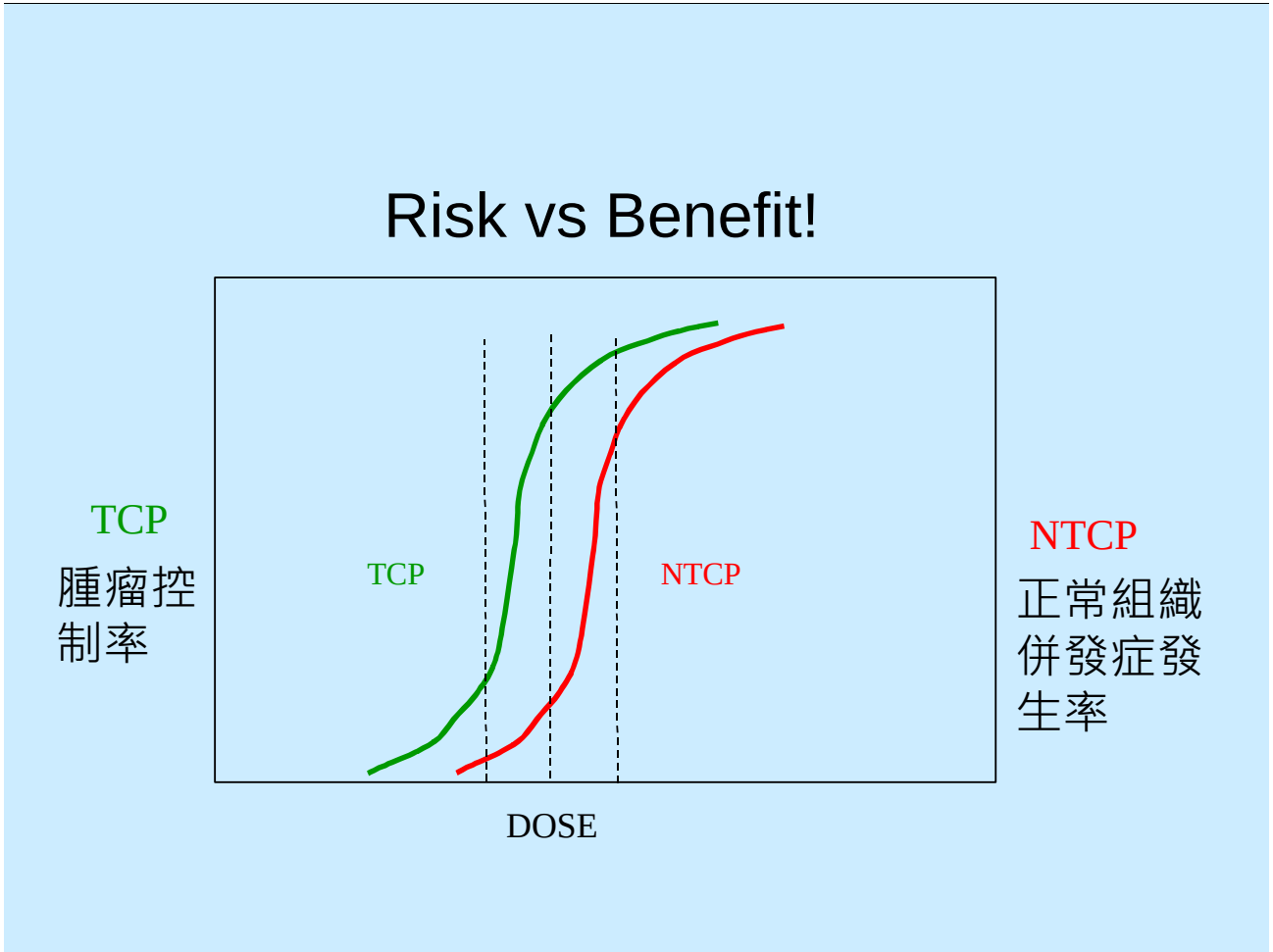


那，為何不一次把劑量統統給完？

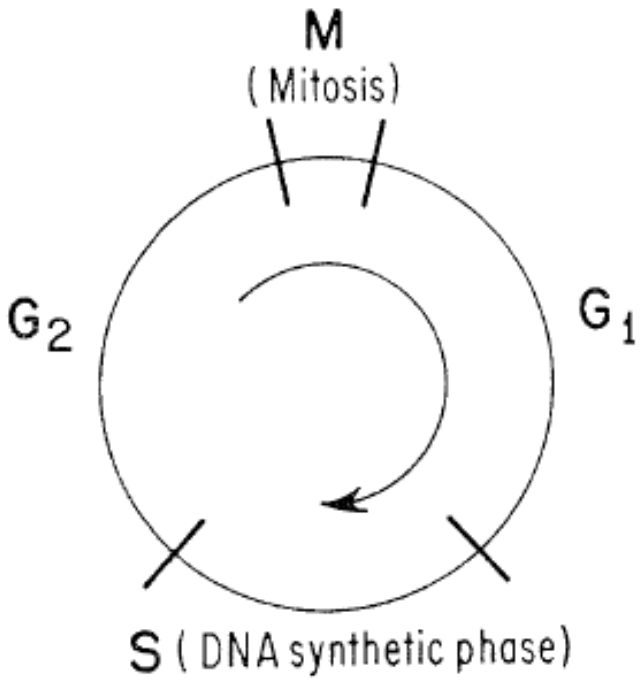
Fractionation (分次治療)

1920年代用放射線幫公羊去勢

1. 要保護正常細胞 (Rapair of sublethal damage & Repopulation)



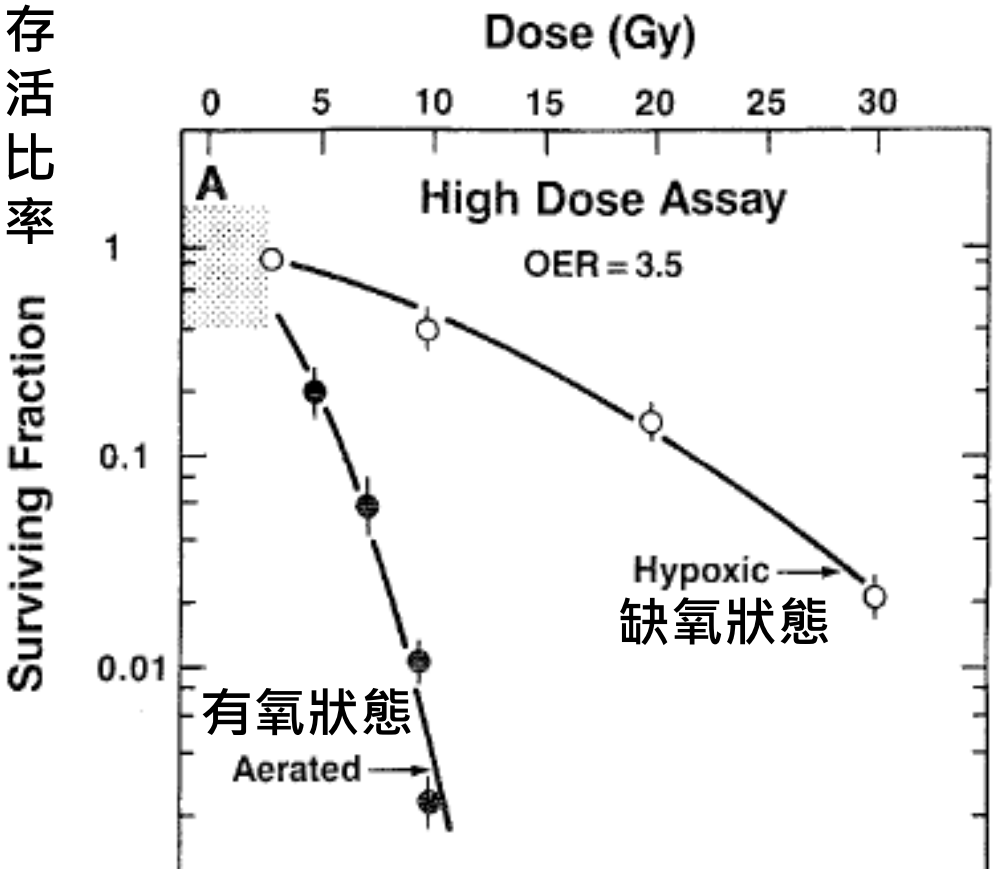
2. 細胞週期再分佈 (Reassortment of cells within the cell cycle)

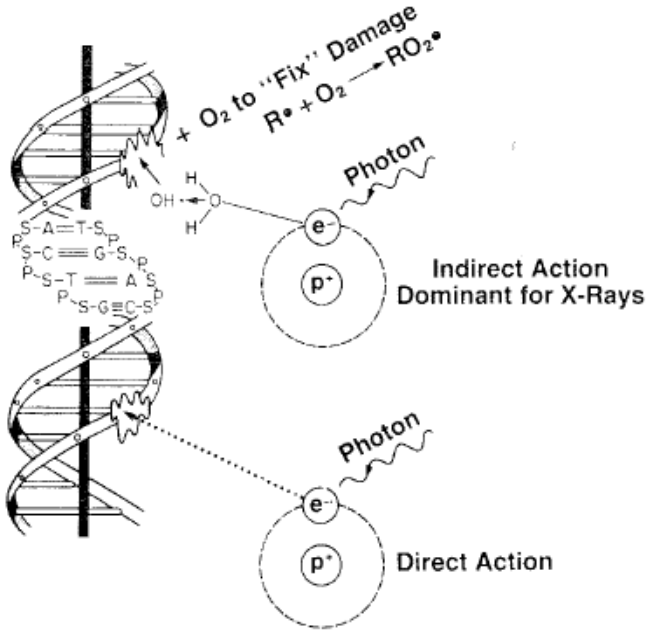


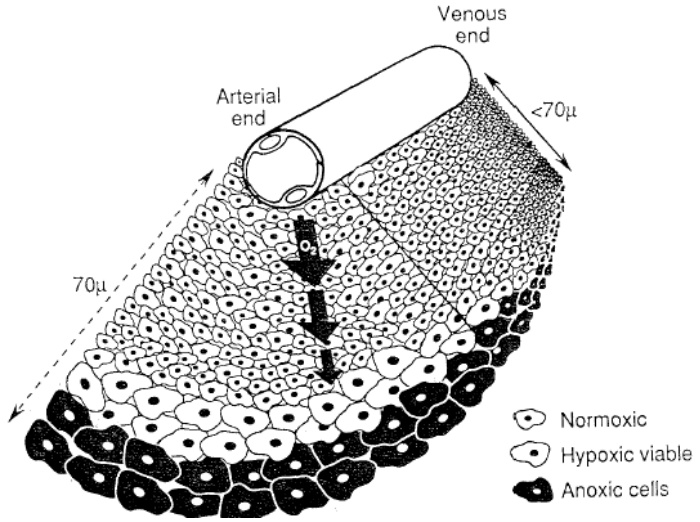
對放射線敏感：
G2, M (細胞分裂期)

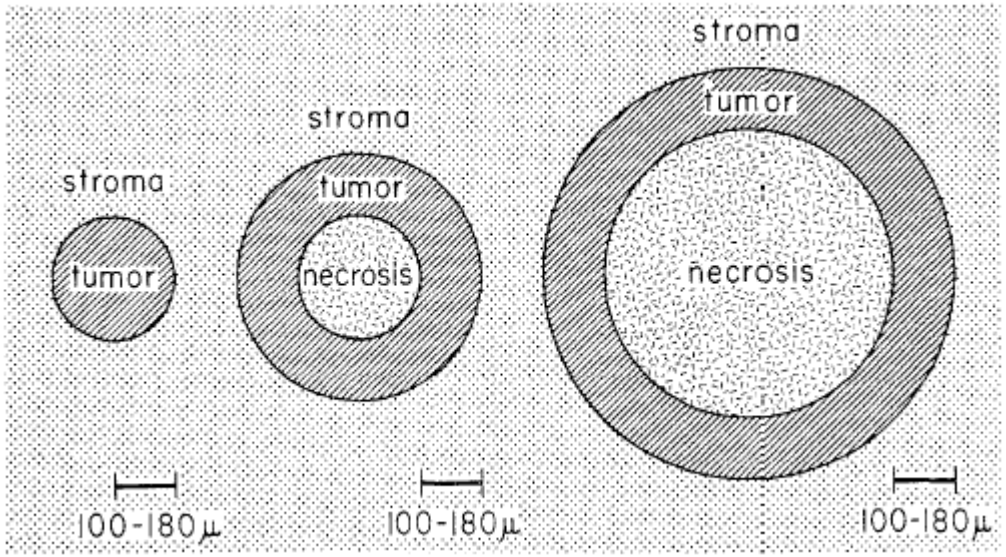
對放射線有抵抗性：
S (DNA合成期) 後期

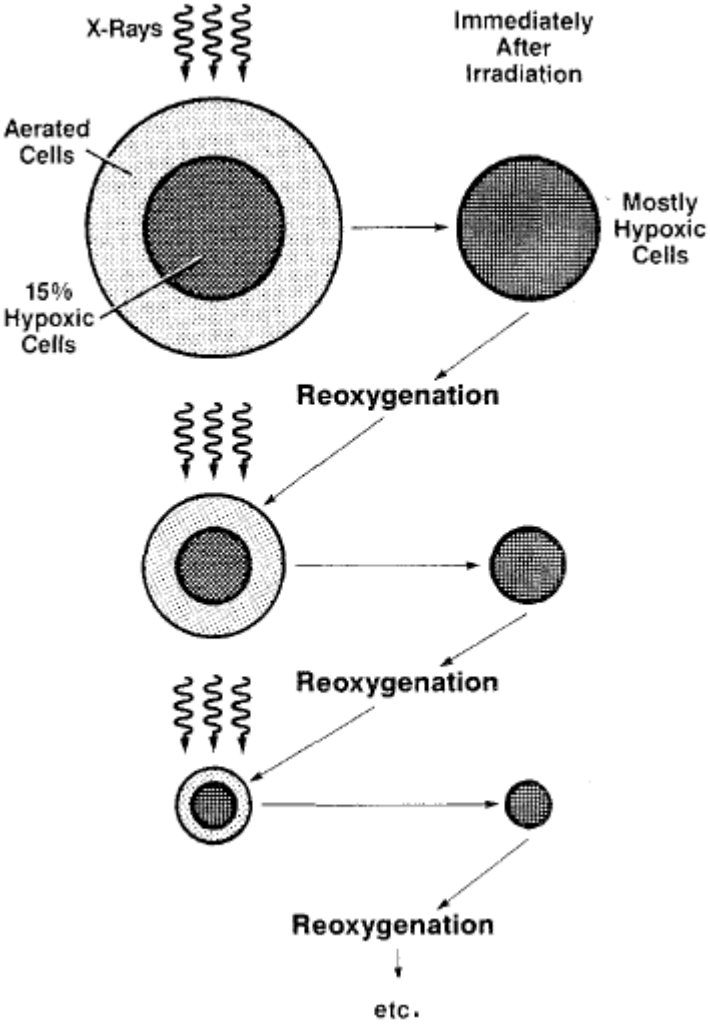
3. 讓細胞有氧可以加強治療效果 (Reoxygenation)



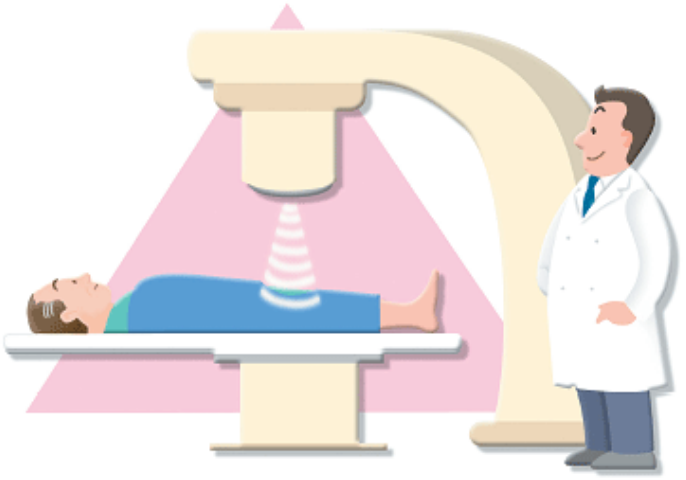



Venous end
Arterial end
<70μ
70μ
Normoxic
Hypoxic viable
Anoxic cells


stroma
tumor
stroma
tumor
necrosis
stroma
tumor
necrosis
100-180μ
100-180μ
100-180μ


X-Rays
Immediately After Irradiation
Aerated Cells
15% Hypoxic Cells
Mostly Hypoxic Cells
Reoxygenation
Reoxygenation
Reoxygenation
etc.

食道癌的放射治療



前導性化學放射治療 (Preoperative CCRT)

- 適應症
  - –T2-T4a
  - –N+

主程性化學放射治療 (Definitive CCRT)

- 適應症
  - 無法手術的病人 (Medically inoperable or surgically unresectable)
  - 頸部食道 (Cervical esophagus)

輔助性化學放射治療 (Adjuvant CCRT)

- 適應症
  - Unfavorable T2
  - T3/T4
  - LN+
  - 淋巴結膜外侵犯 (Extranodal extension)
  - 腫瘤接近手術邊緣 (Close margin)
  - 手術邊緣有腫瘤細胞 (Positive margin)
  - 殘餘腫瘤 (Gross residual tumor)

緩解性放射治療 (Palliative RT)

- 原發腫瘤引起的局部症狀（阻塞、疼痛....）
- 腦部轉移
- 骨頭轉移
- 肝轉移
- 其它轉移

食道癌 v.s. 放射線治療

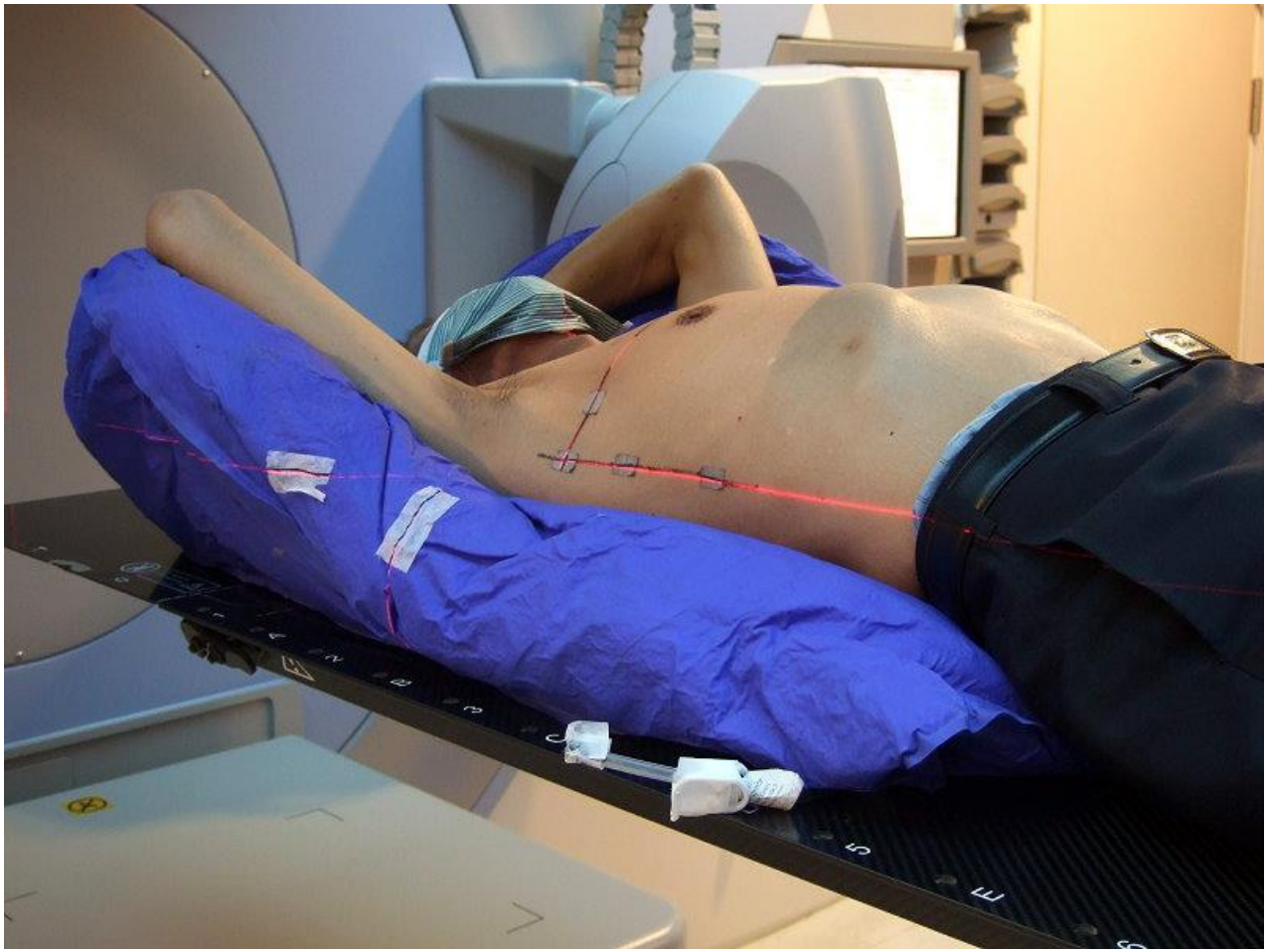
- 食道癌是對放射線敏感的腫瘤
- 食道癌放射線治療主要的困難點：
  - –對肺泡的傷害
  - –腫瘤位置的確定

放射治療的流程

醫療團隊

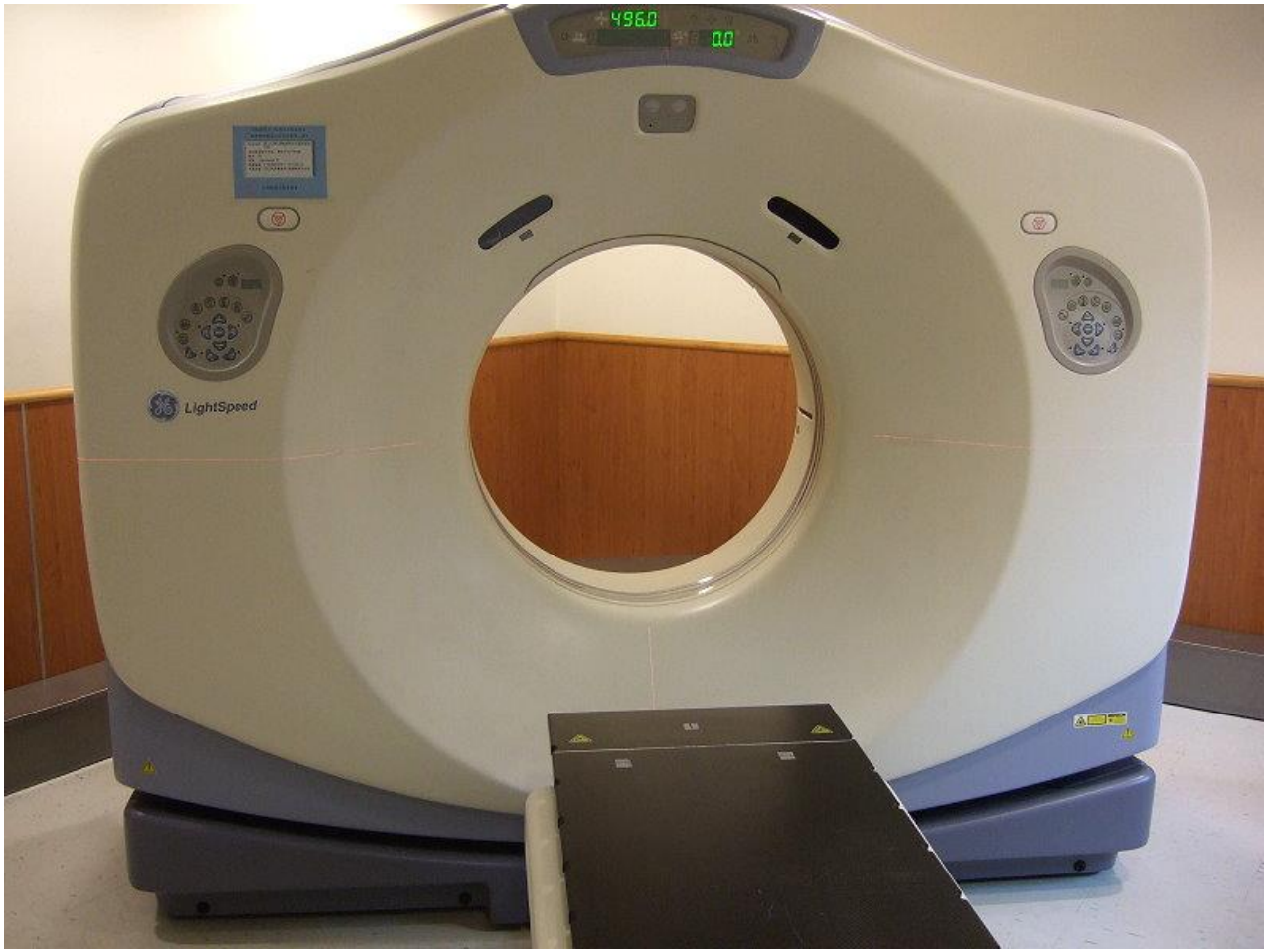
- 醫師：提供病人癌症諮詢、評估是否適合放射治療、決定治療範圍及計畫、醫療照顧
- 物理師/劑量師：治療劑量的計算及驗證、治療機器的品質保證及安裝、輻射防護業務、新治療技術研發
- 放射師：模具製作、模擬攝影定位、治療機器的操作
- 護理師：病人護理照護及衛教、協助侵入性醫療行為

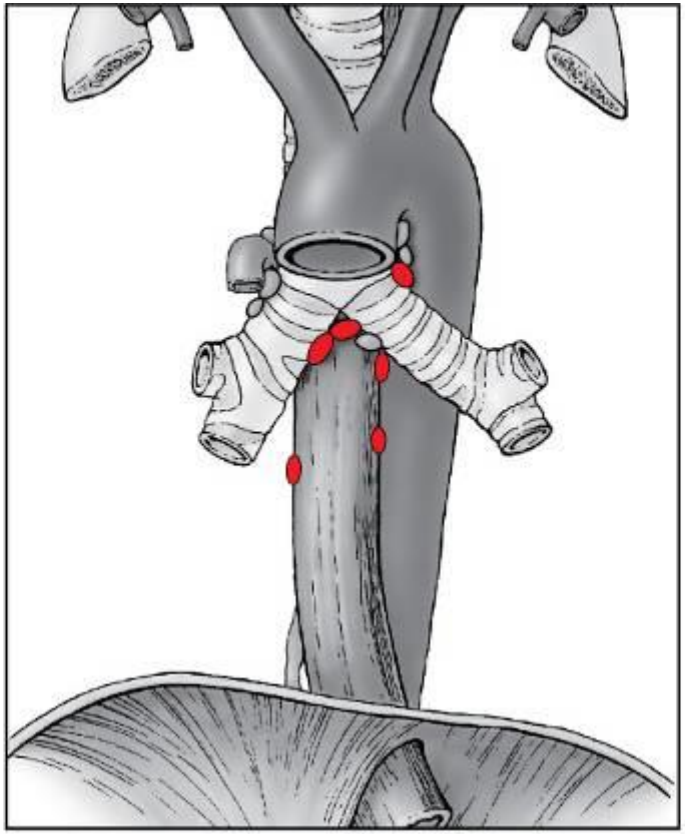
1.A. 製作固定器具



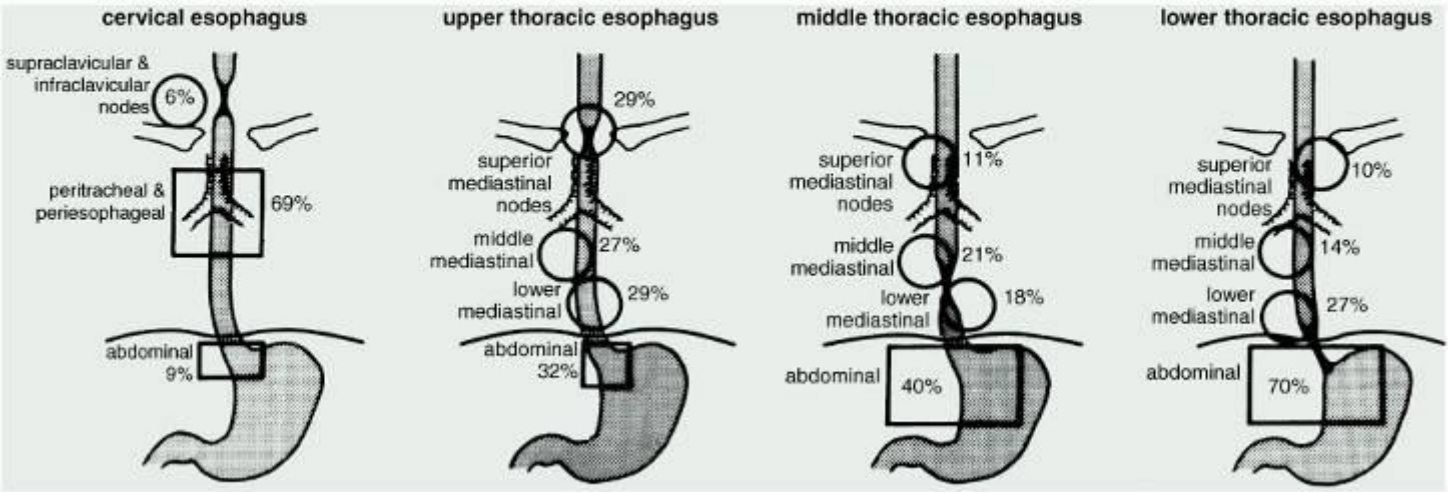
1.B. X光模擬攝影定位

1.C. 電腦斷層攝影



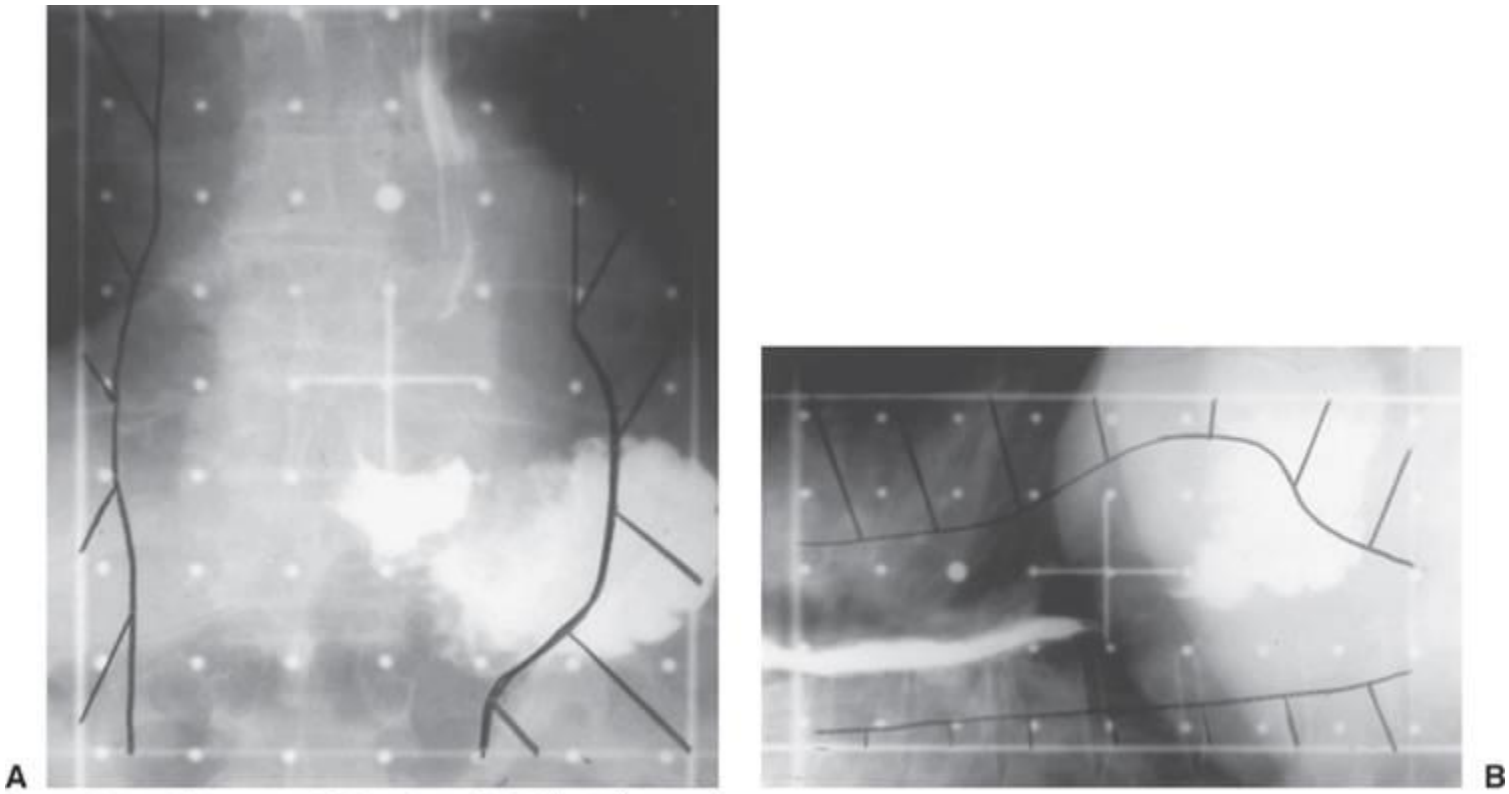


A


cervical esophagus
supraclavicular & infraclavicular nodes
6%
peritracheal & periesophageal
69%
abdominal
9%
upper thoracic esophagus
29%
superior mediastinal nodes
middle mediastinal
27%
lower mediastinal
29%
abdominal
32%
middle thoracic esophagus
superior mediastinal nodes
11%
middle mediastinal
21%
lower mediastinal
18%
abdominal
40%
lower thoracic esophagus
superior mediastinal nodes
10%
middle mediastinal
14%
lower mediastinal
27%
abdominal
70%

B

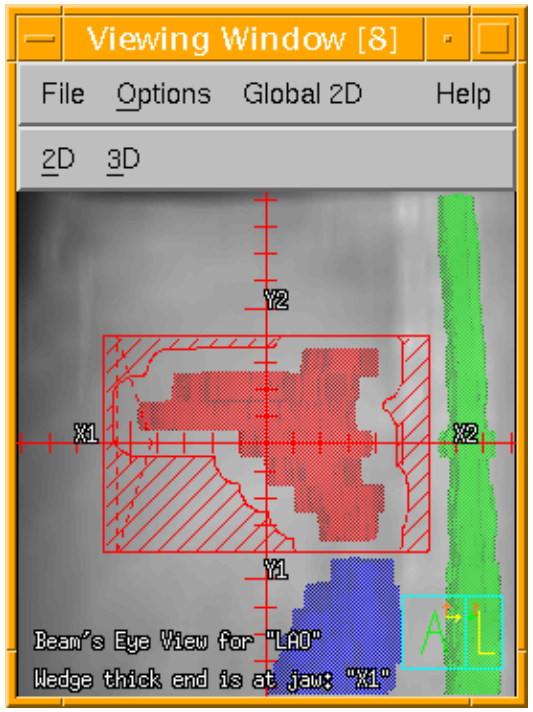
2.A. 傳統治療計畫擬定

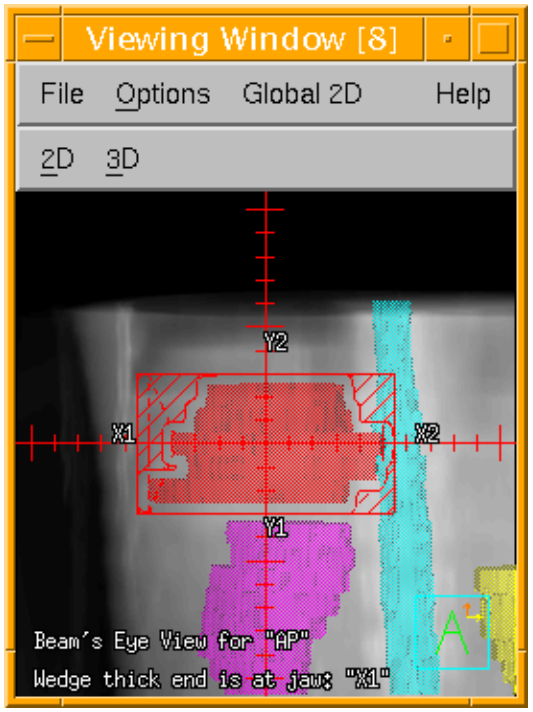


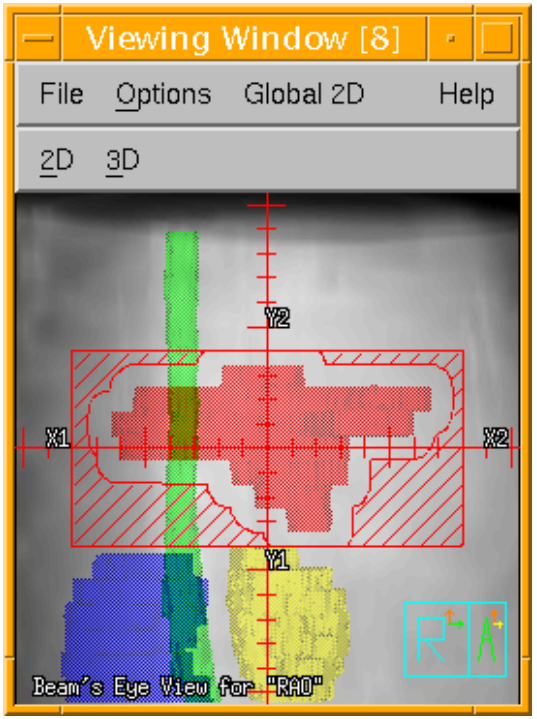
Source: DeVita VT, Lawrence TS, Rosenberg SA: *DeVita, Hellman, and Rosenberg's Cancer: Principles & Practice of Oncology, 9th Edition:* www.lwwoncology.com

2.B. 電腦治療計畫擬定

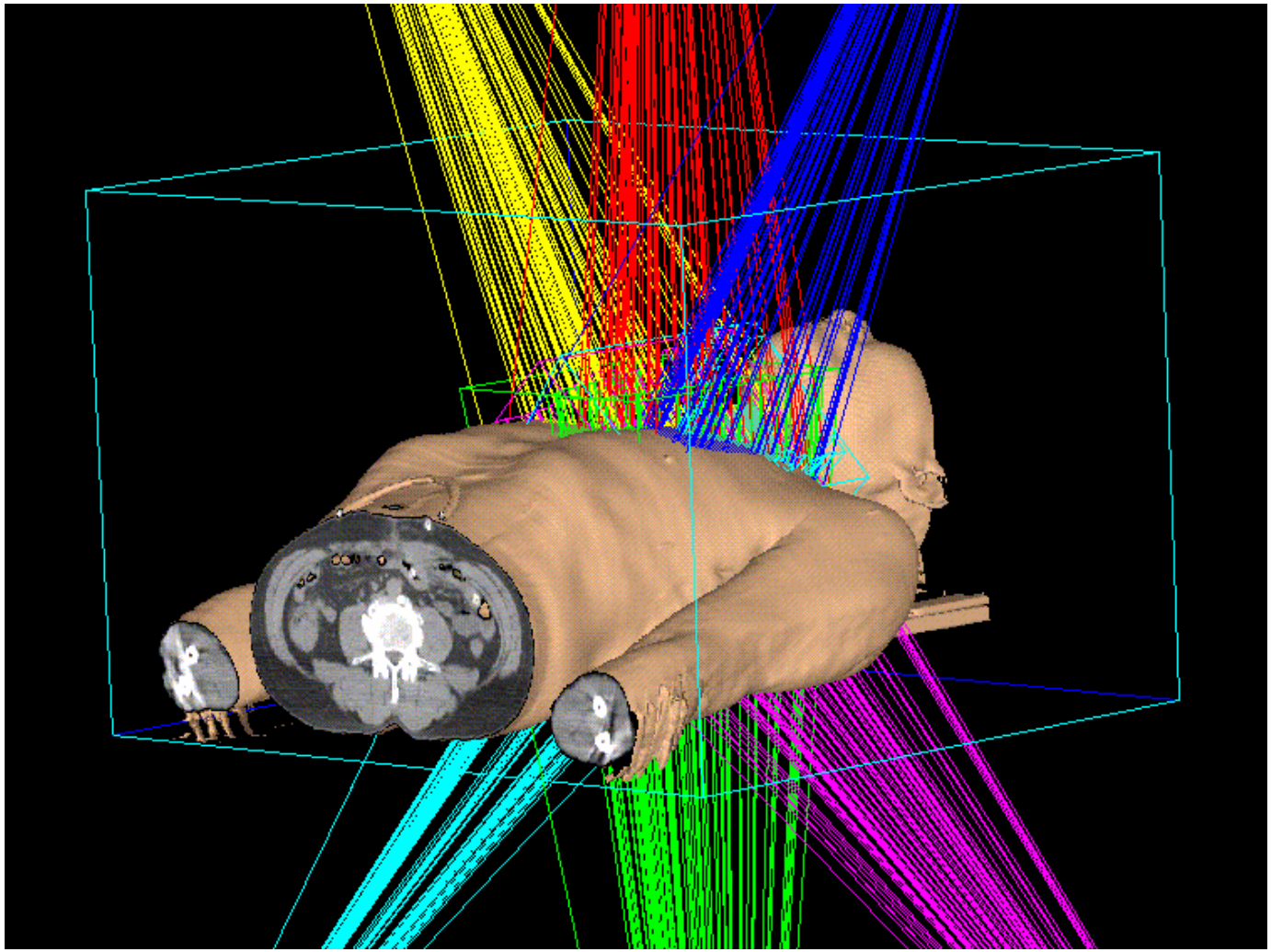
Beam’s eye view

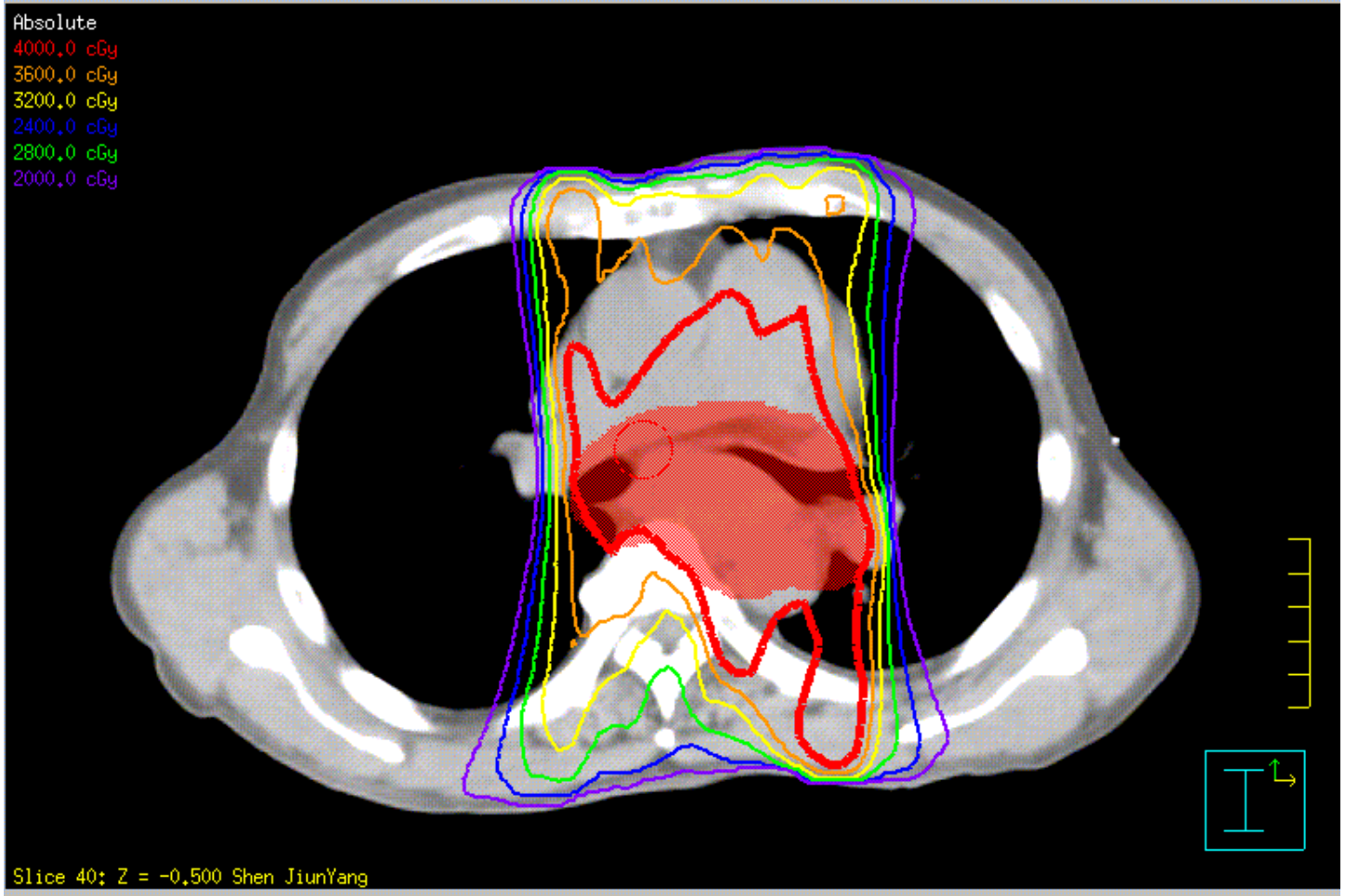


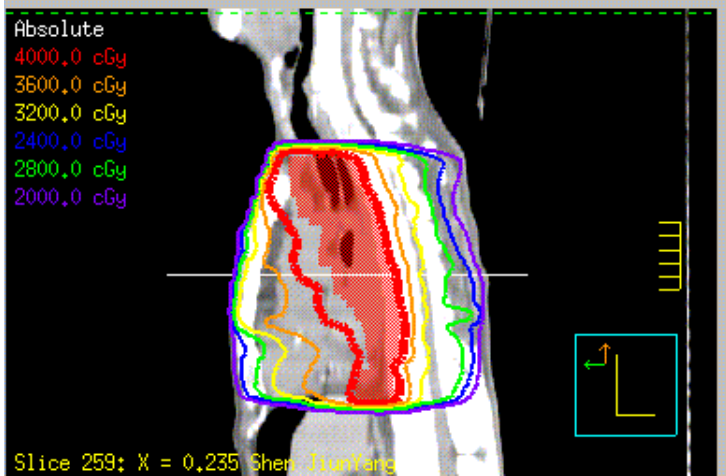


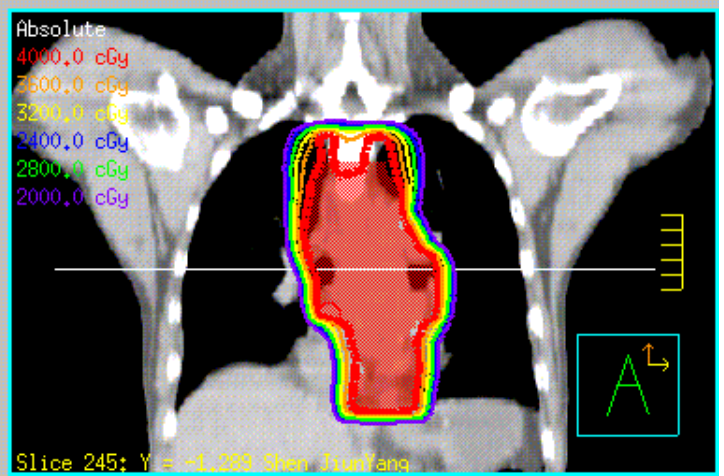


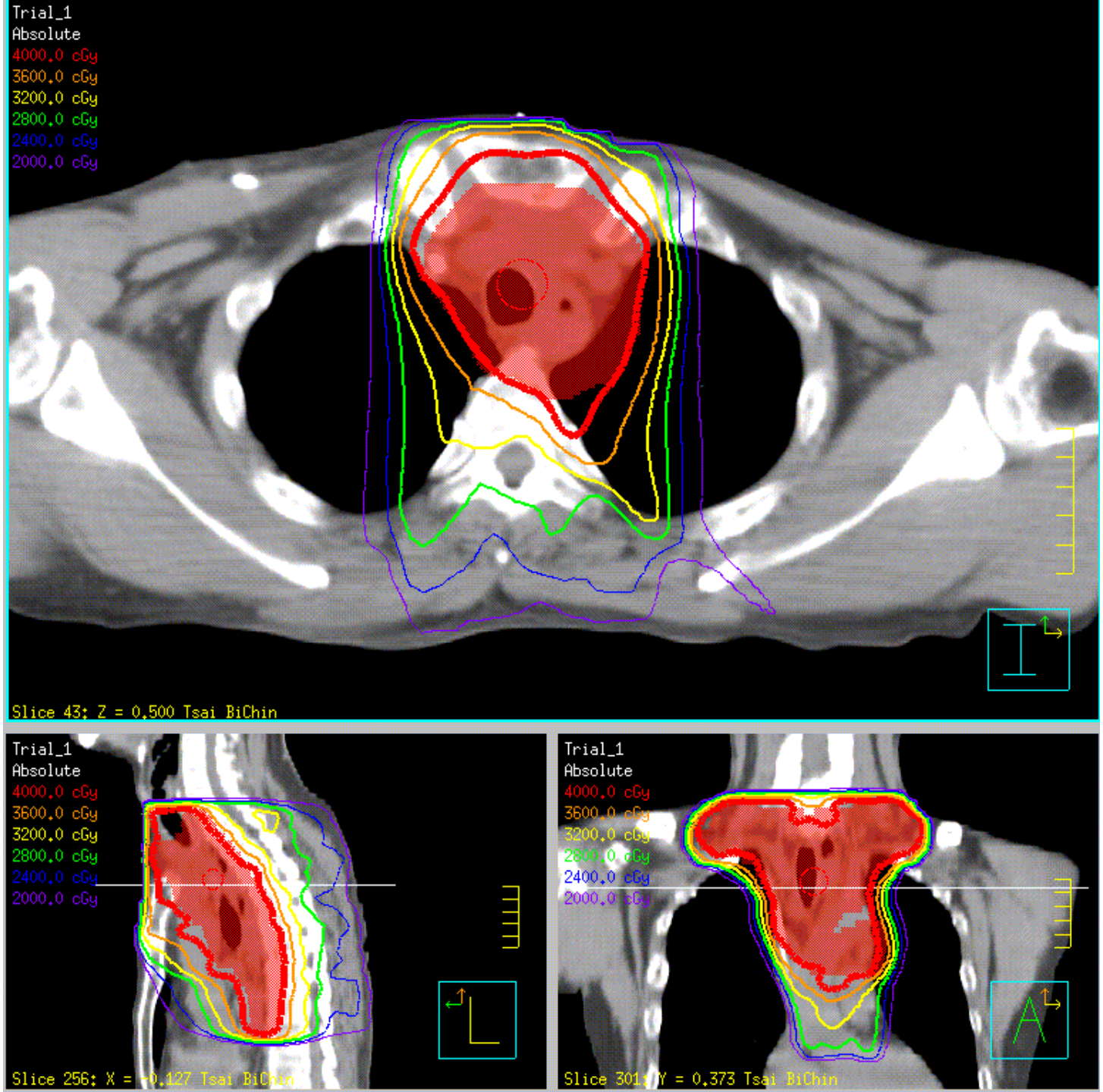
2.B. 電腦治療計畫擬定

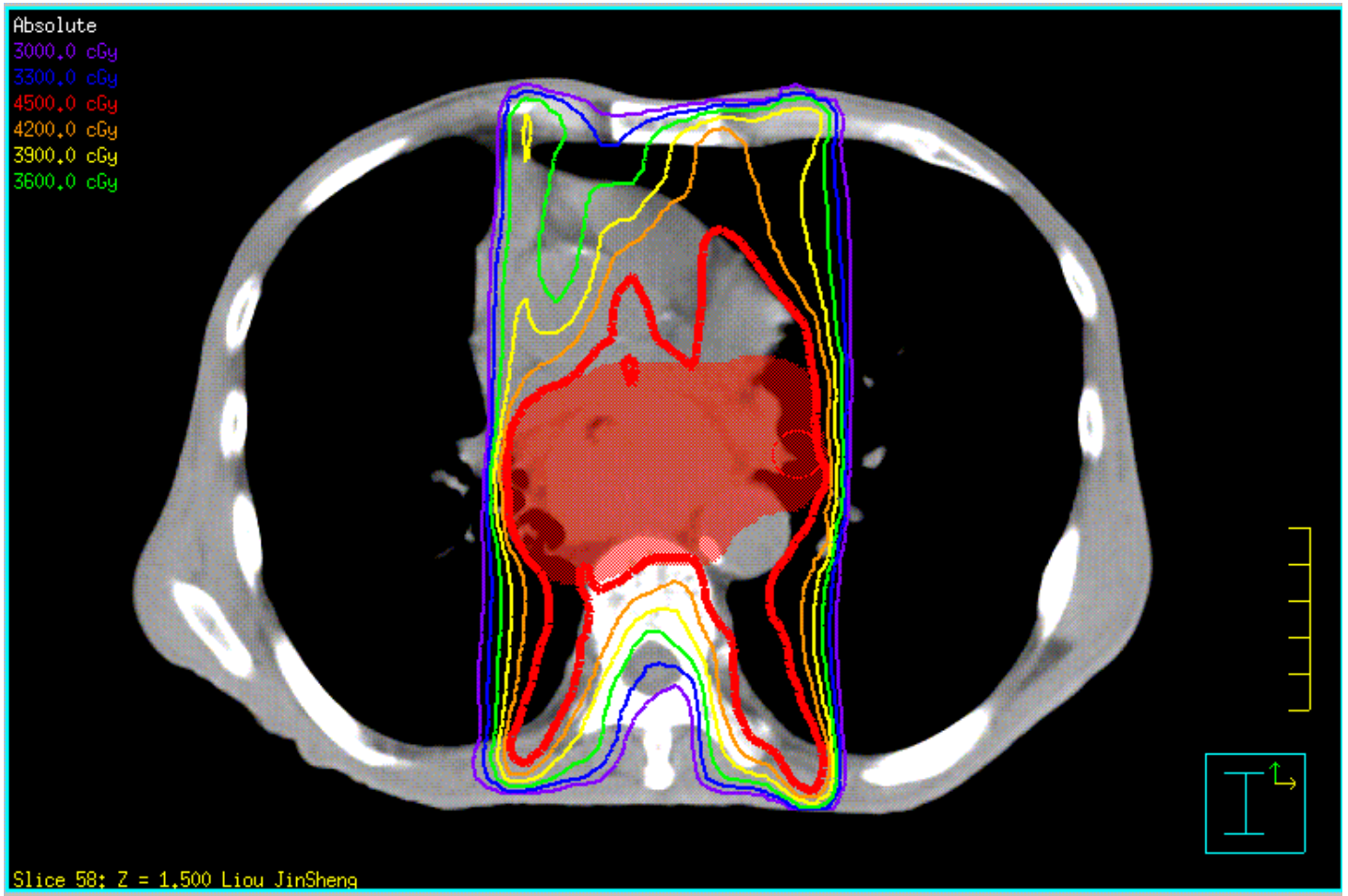


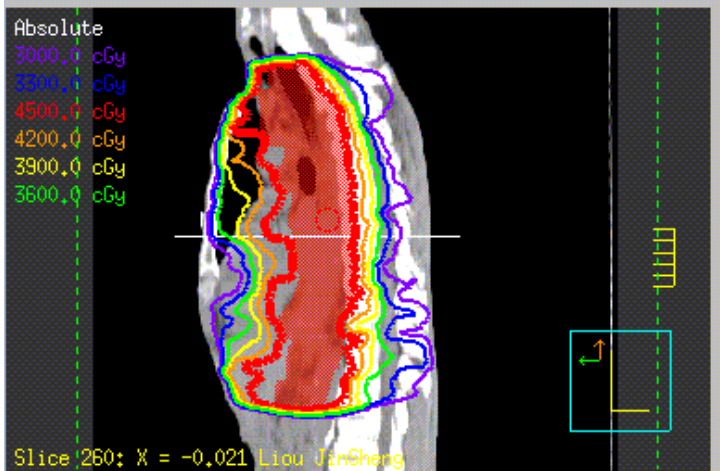

Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2400.0 cGy
2800.0 cGy
2000.0 cGy
Slice 40: Z = -0.500 Shen JiunYang

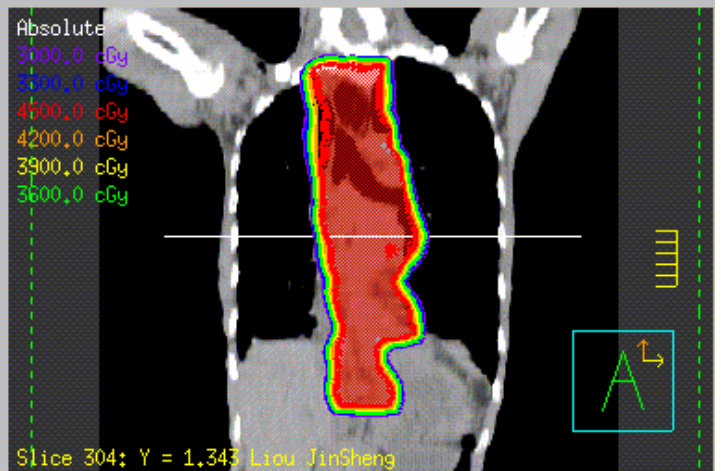

Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2400.0 cGy
2800.0 cGy
2000.0 cGy
Slice 259: X = 0.235 Shen JiunYang

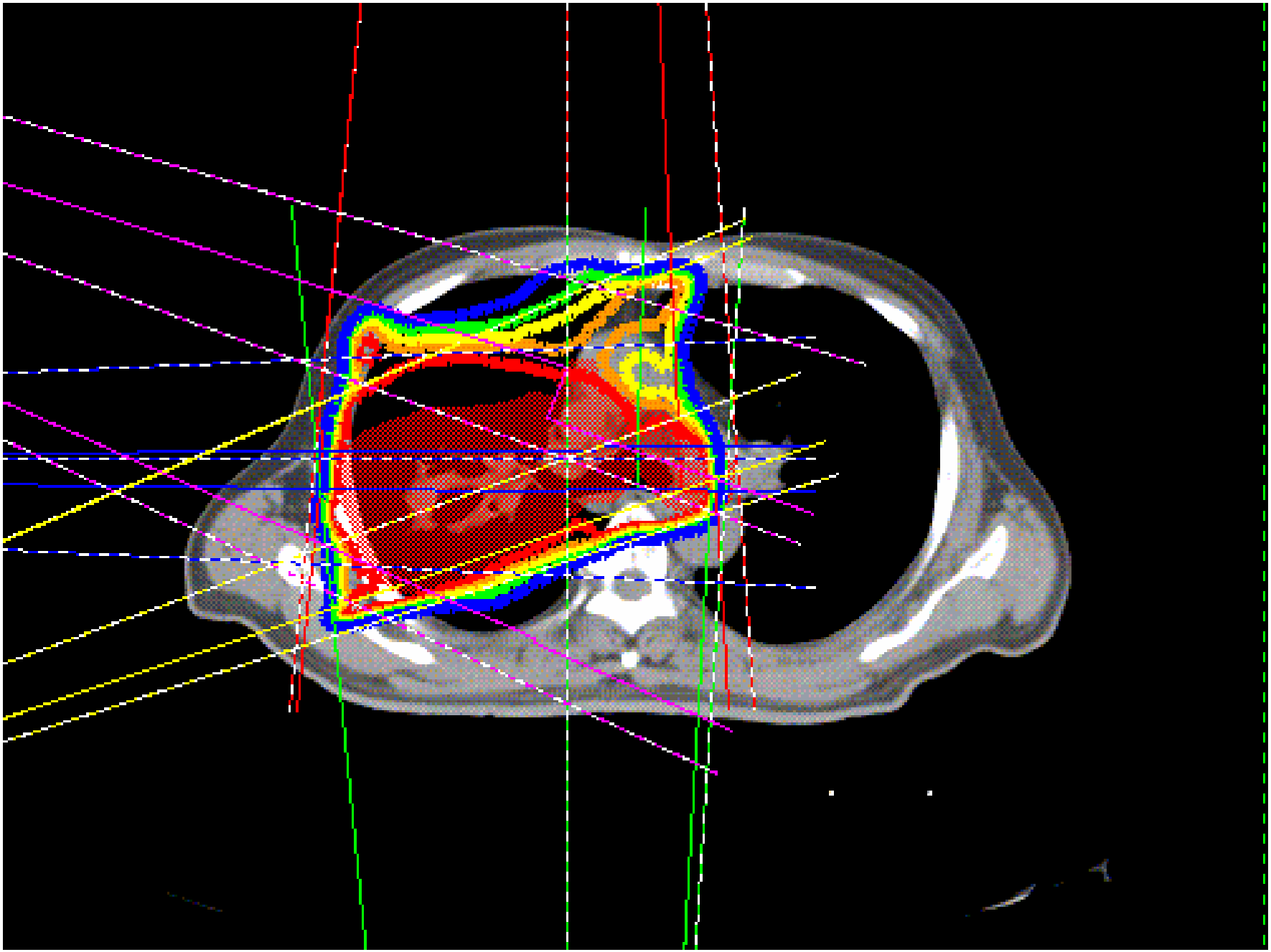

Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2400.0 cGy
2800.0 cGy
2000.0 cGy
Slice 245: Y = -1.203 Shen JiunYang


Trial_1
Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2800.0 cGy
2400.0 cGy
2000.0 cGy
Slice 43: Z = 0.500 Tsai BiChin
Trial_1
Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2800.0 cGy
2400.0 cGy
2000.0 cGy
Slice 256: X = -0.127 Tsai BiChin
Trial_1
Absolute
4000.0 cGy
3600.0 cGy
3200.0 cGy
2800.0 cGy
2400.0 cGy
2000.0 cGy
Slice 301: Y = 0.373 Tsai BiChin

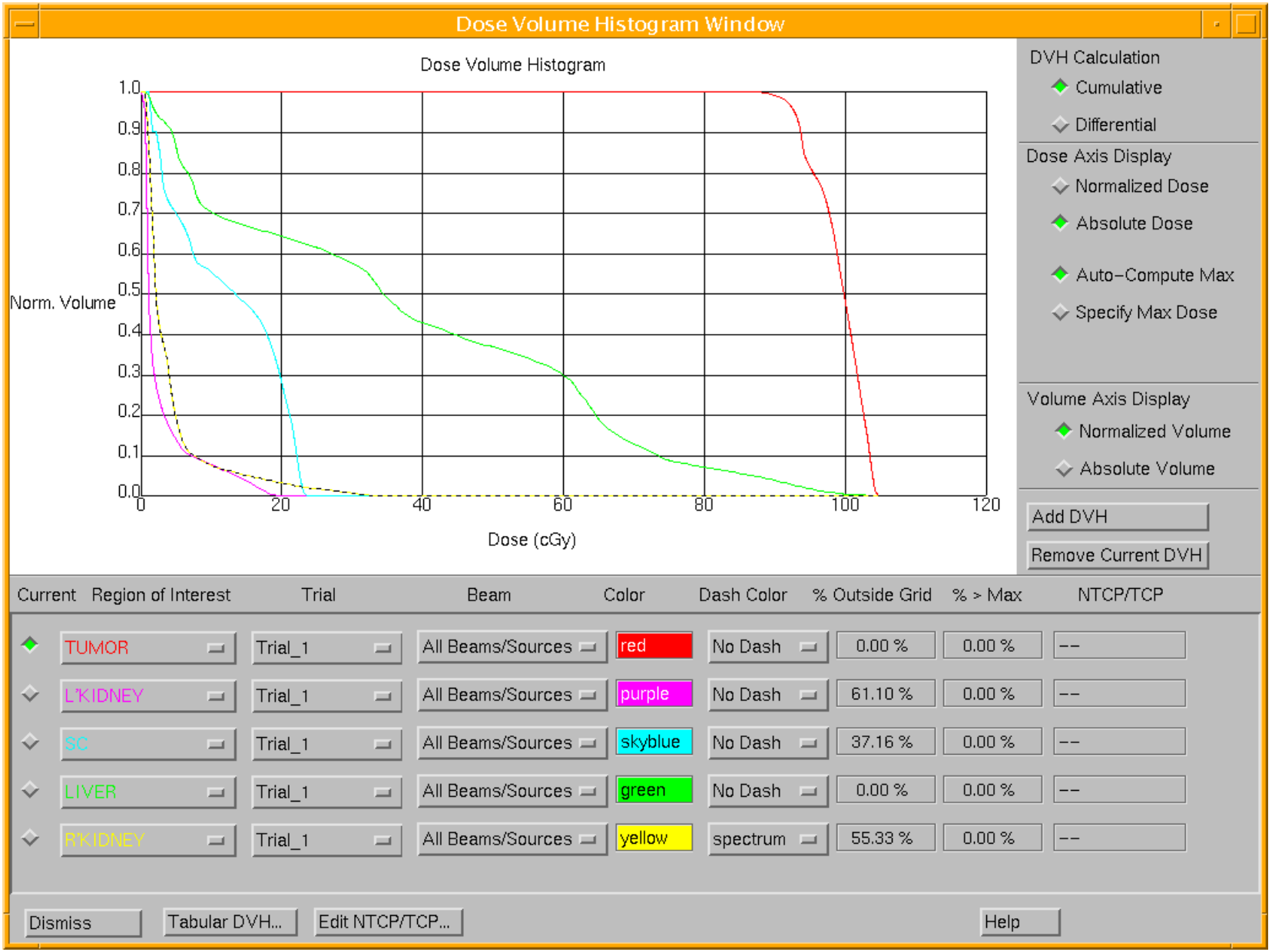

Absolute
3000.0 cGy
3300.0 cGy
4500.0 cGy
4200.0 cGy
3900.0 cGy
3600.0 cGy
Slice 58: Z = 1.500 Liou JinSheng


Absolute
3000.0 cGy
3300.0 cGy
4500.0 cGy
4200.0 cGy
3900.0 cGy
3600.0 cGy
Slice 260: X = -0.021 Liou JinSheng

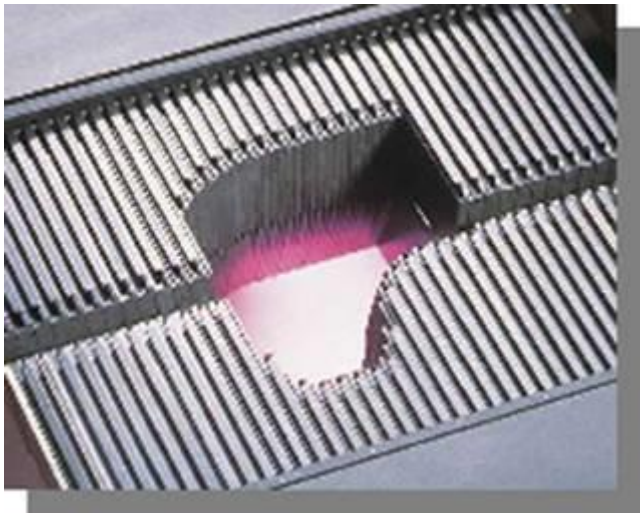

Absolute
3000.0 cGy
3300.0 cGy
4500.0 cGy
4200.0 cGy
3900.0 cGy
3600.0 cGy
Slice 304: Y = 1.343 Liou JinSheng



Dose volume histogram (DVH)



3. 模具製作或將參數輸入治療機



4. 治療病人

常用的放射劑量

- 肺腫瘤及轉移淋巴結
  - 60~70格雷(Gy)/30~39分次
  - 可考慮劑量加強到70~78格雷(Gy)
- 手術後照射
  - 50~60格雷(Gy)/25~33分次
  - 可考慮劑量加強到60~66格雷(Gy)
- 預防性全腦照射
  - 25格雷(Gy)/10分次

治療時間

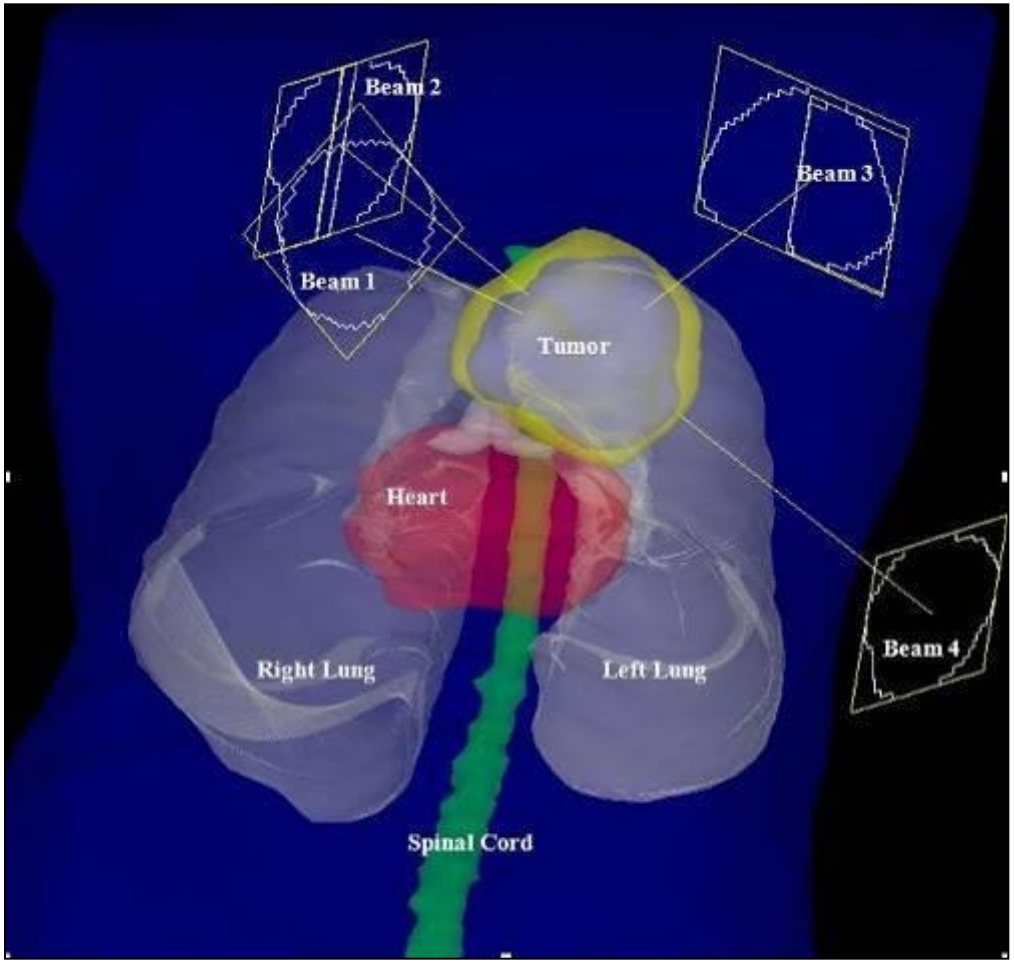
- 放射治療的時間是星期一到星期五，每天一次
- 每天在治療室中約十至十五分鐘，此時只有一人在治療室內，務必放鬆心情、靜躺不動且平和呼吸。
- 在這5-8週的時間，每週會有一次的例行門診，主治醫師會針對治療的副作用給予適當的治療。

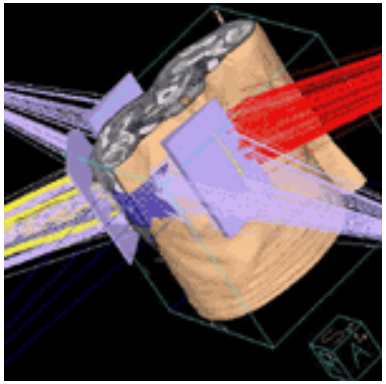
放射治療的技術

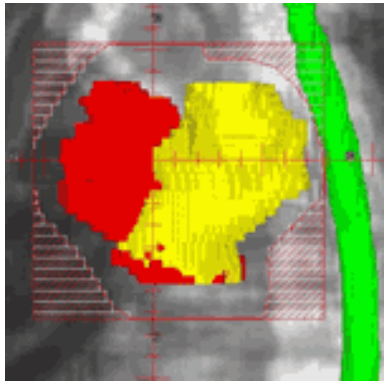
放射治療技術

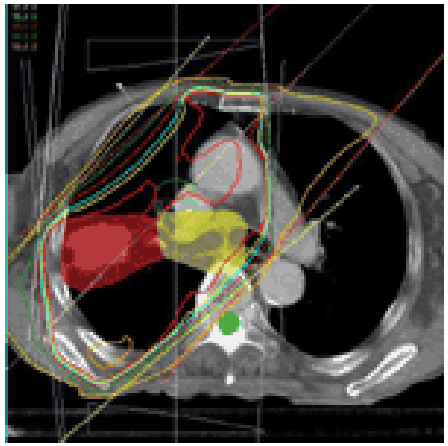
- Conventional (傳統治療)
- 3D Conformal Radiotherapy (三度空間順形治療)
- IMRT (強度調控治療)
- IGRT (影像導引治療)
- Tomotherapy (螺旋斷層放射治療，螺旋刀)
- Stereotactic Radiosurgery (立體定位放射手術)

三度空間順形治療

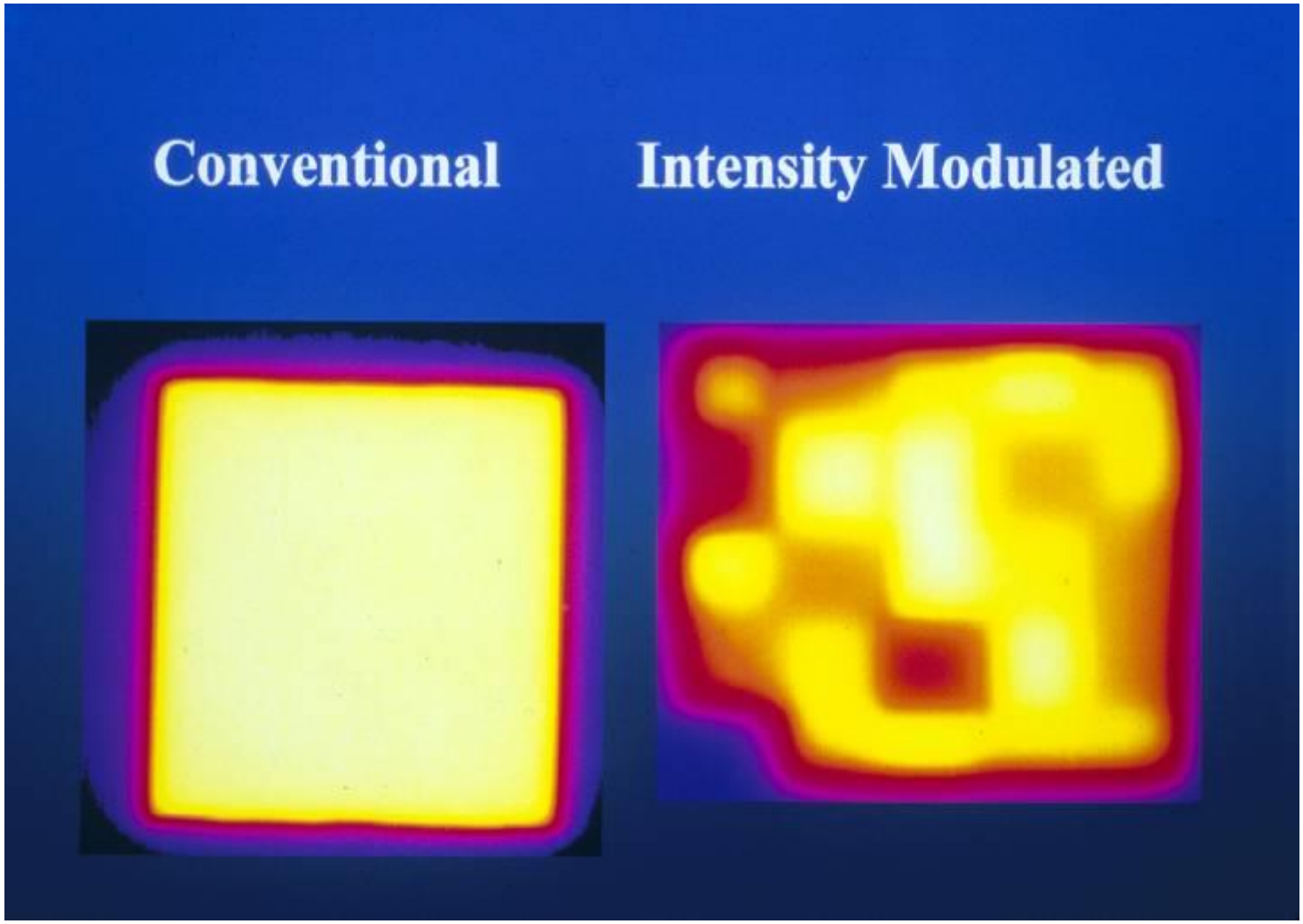

Beam 2
Beam 3
Beam 1
Tumor
Heart
Beam 4
Right Lung
Left Lung
Spinal Cord







強度調控治療 (IMRT)



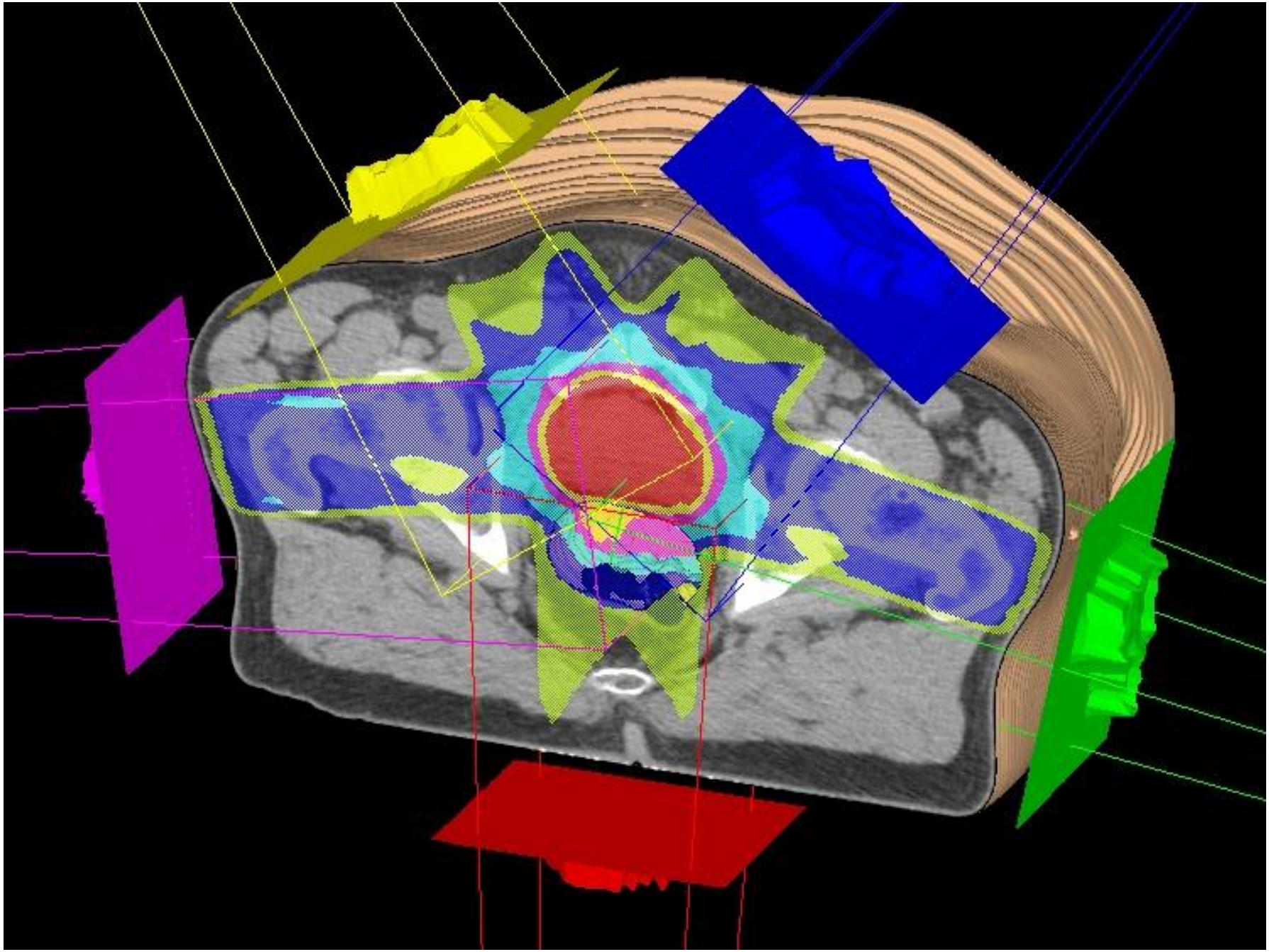
Conventional Conformal Therapy v.s. IMRT

Conventional Conformal Therapy

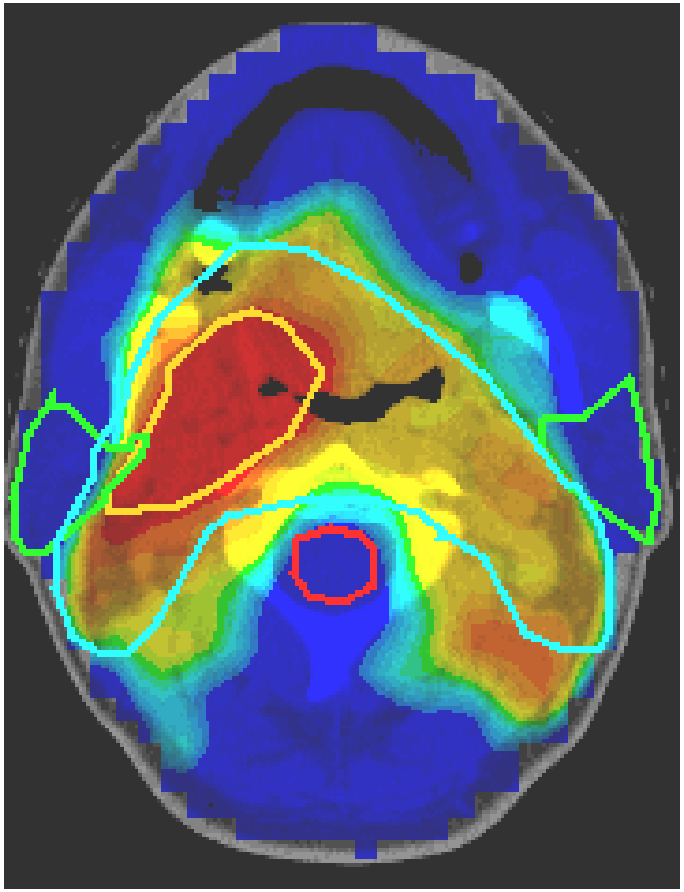
Field shape conforms to the outline of the target, uniform (open field) or linear (wedge field) intensity distribution across the field.

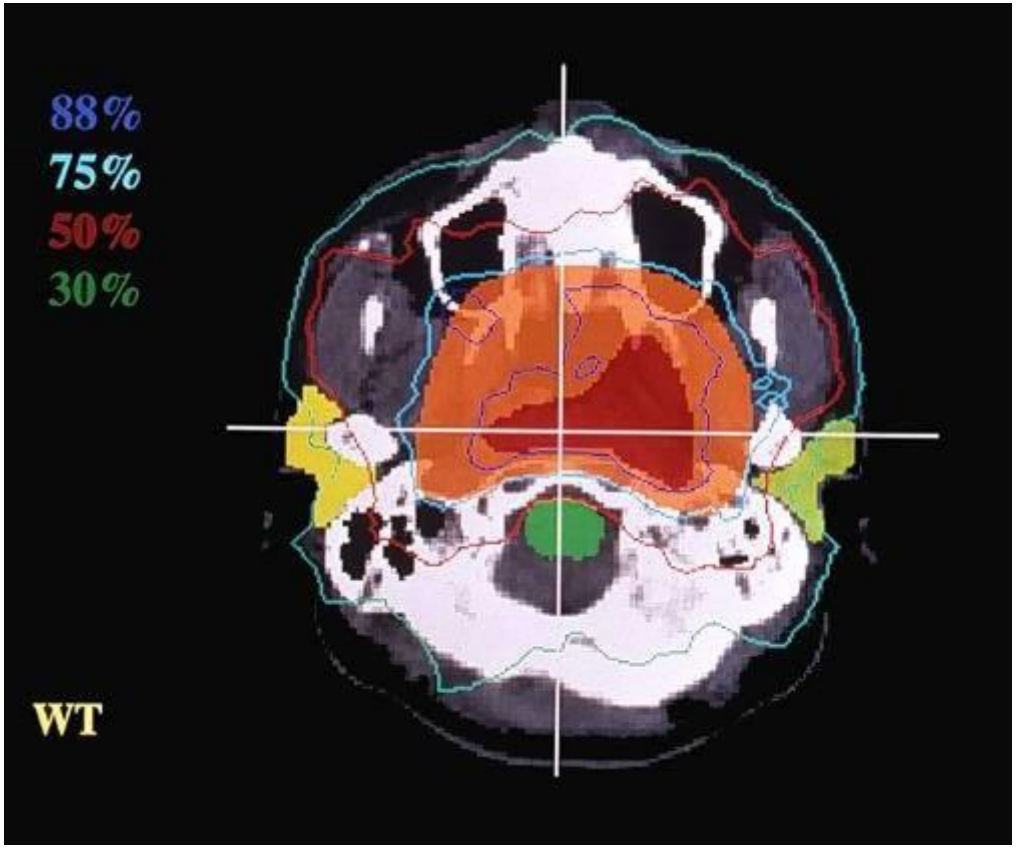
IMRT

Non-uniform intensity inside the field to achieve optimum dose distribution



強度調控治療 (IMRT)

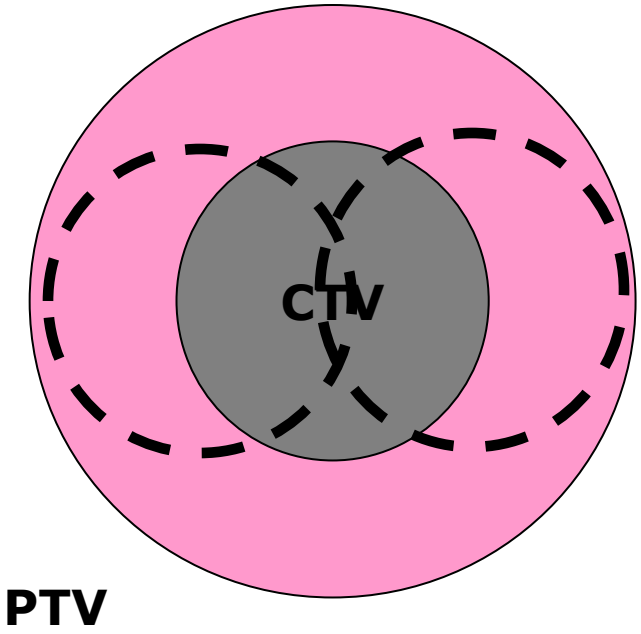




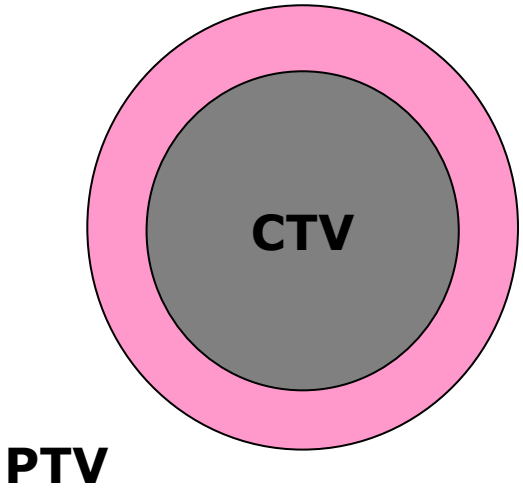
IMRT v.s. 3DCRT

- 更好的放射劑量分布
  - –腫瘤包覆率
  - –重要器官保護
- 治療時間較長
- 需要更準確的定位

影像導引治療 (IGRT)

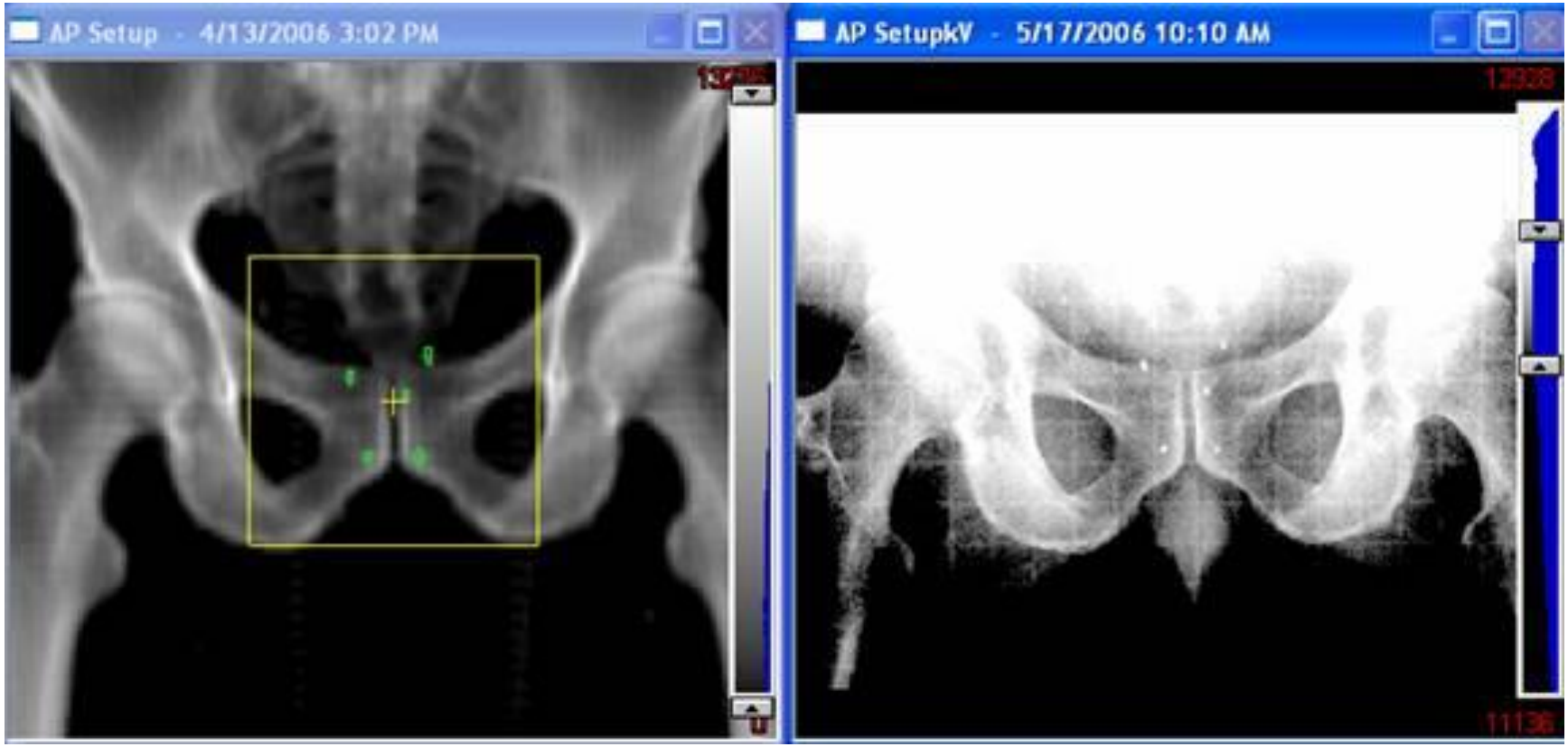


Without Imaging



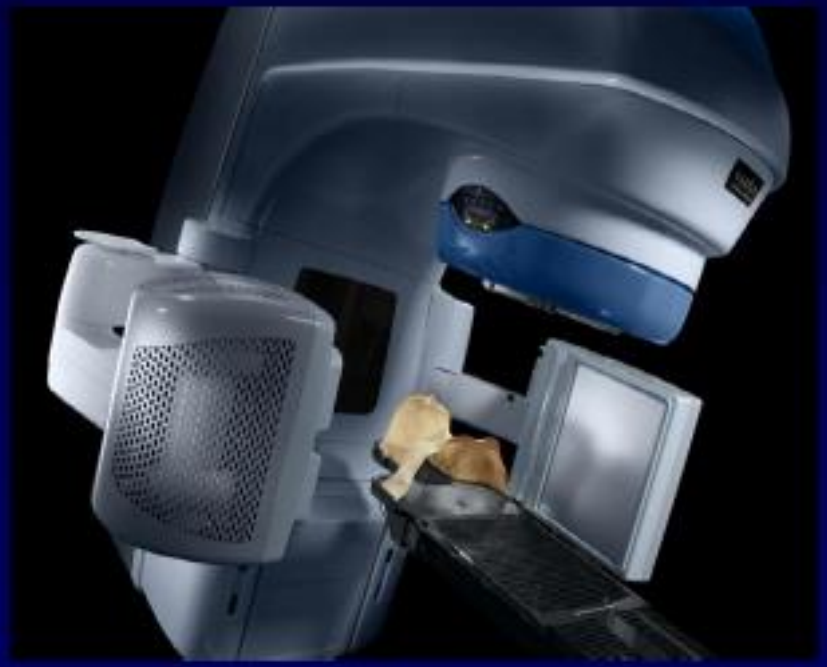
With Imaging

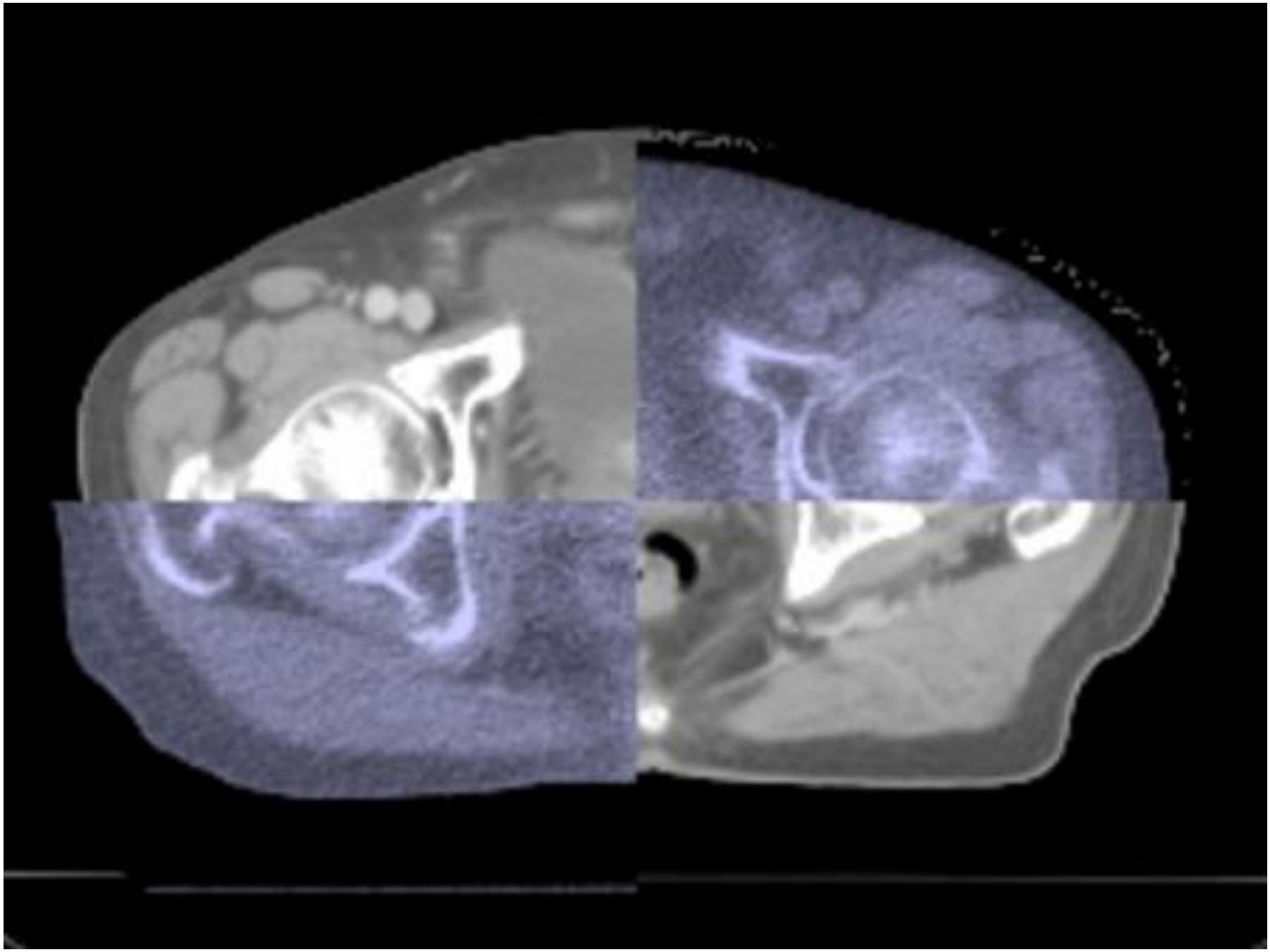
Identification film



The Role of the On-Board Imager

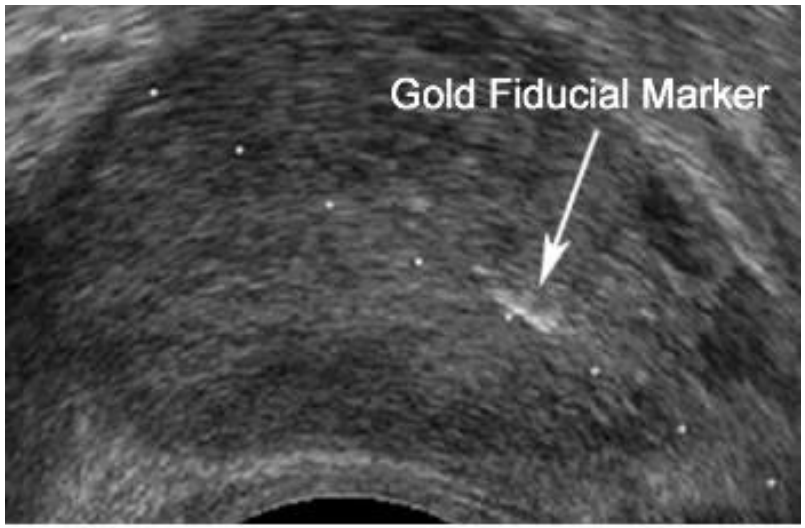
- The On-Board Imager™(OBI) provides improved tumor targeting and motion management with high-resolution, low-dose imaging in the treatment room.





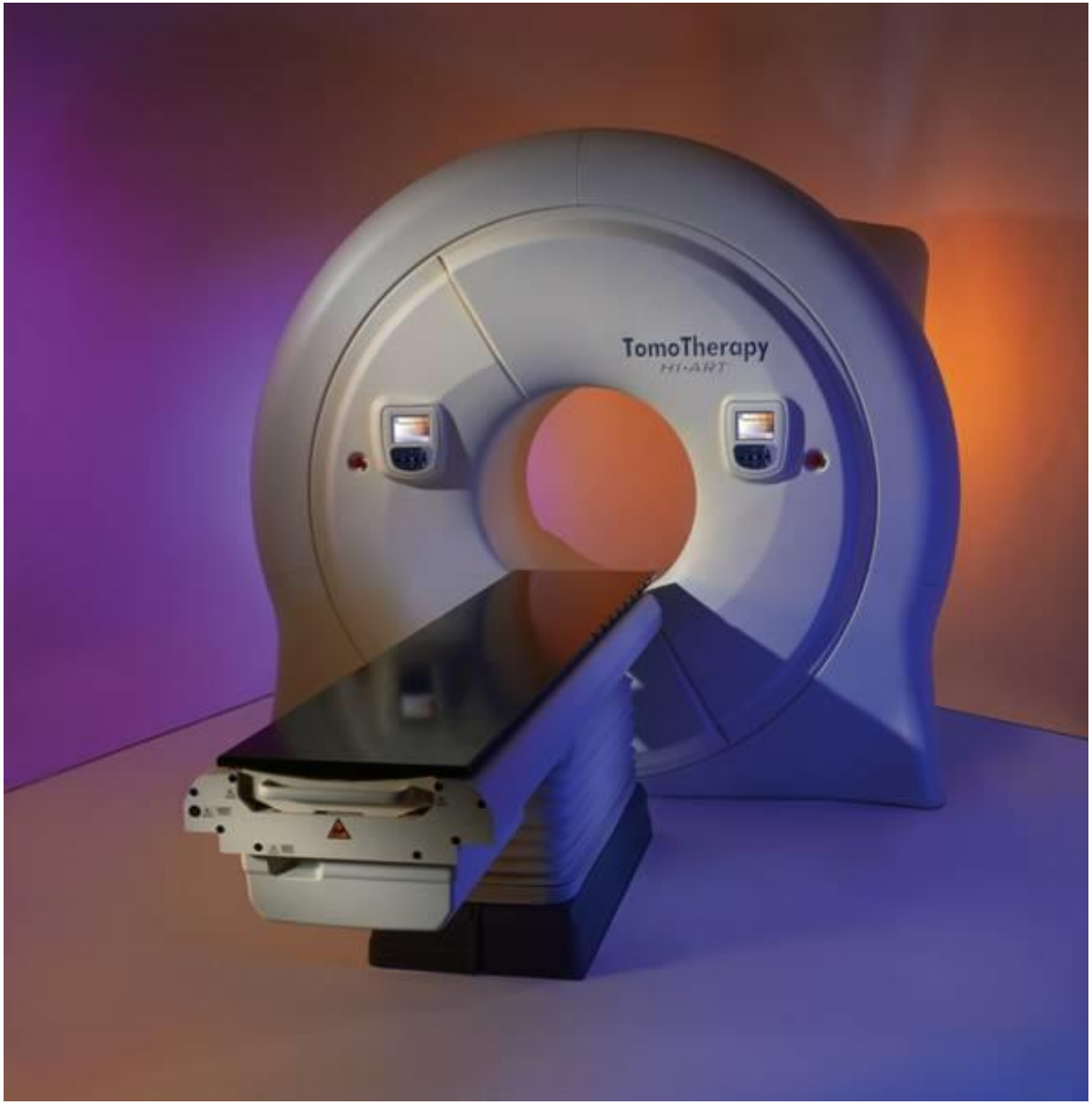
影像導引治療 (IGRT)

Markers attached to patient

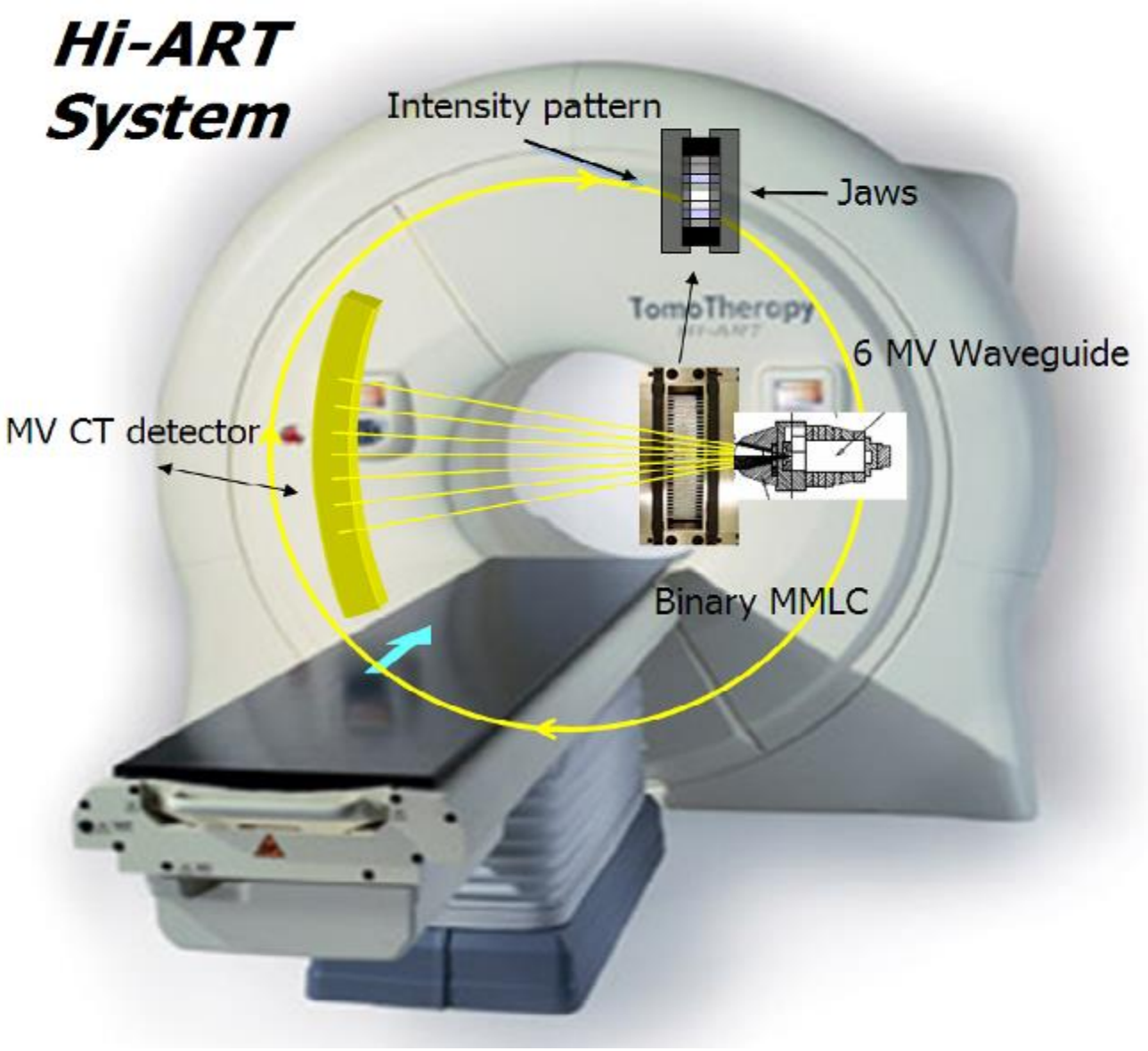


Prostate radiation external beam therapy includes Dr. Gheiler placing 4 tiny gold fiducial markers into the prostate so the radiation beam targets the prostate better.

螺旋斷層放射治療、螺旋刀 (Tomotherapy)


TomoTherapy
HI·ART

Basic structure of a Helical Tomotherapy Machine



鋭速刀、迅弧刀 (Rapid Arc)

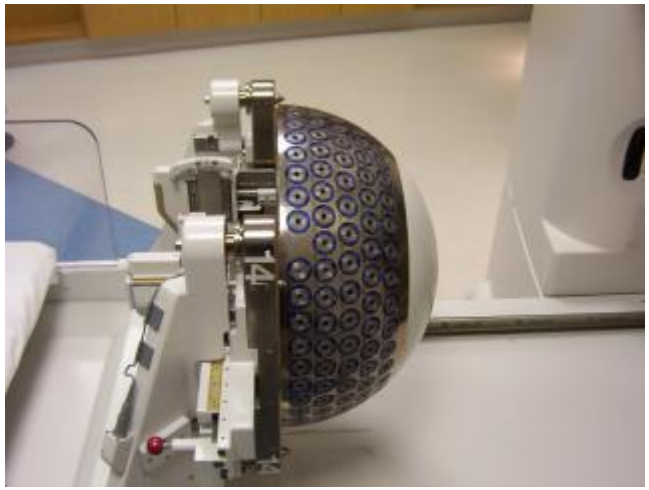
立體定位放射手術 (SRS)

- 以超高劑量的射線，經由幾百個角度，穿透組織，直接聚焦於腫瘤，殺死癌細胞
- 由於劑量很大，需配合非常精細的定位技術
- 早期用於腦部腫瘤
- 進一步用於全身其他腫瘤 → 立體定位放射治療 (SRT)

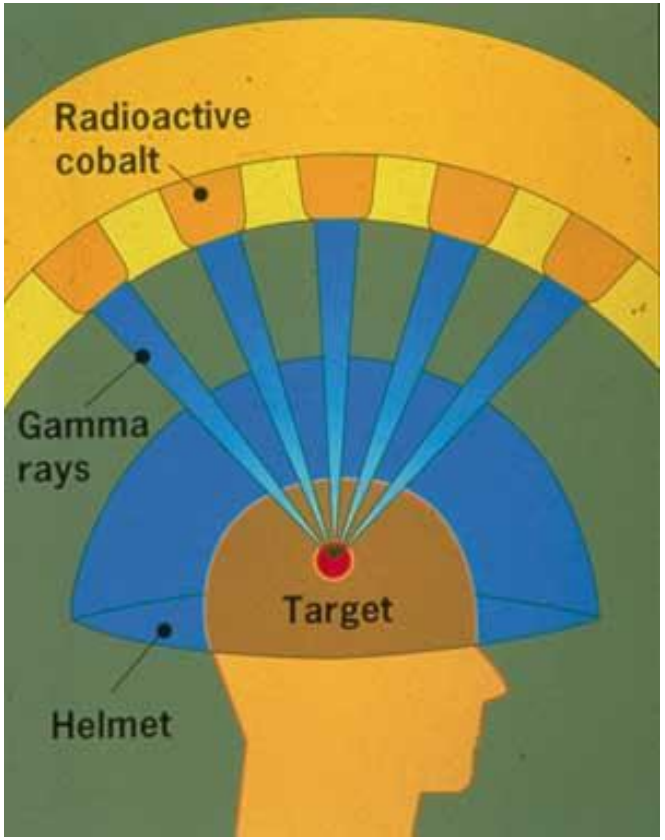
立體定位放射手術 (SRS)

- 依據射源可分為：
  - X ray (光子刀、電腦刀、諾力刀……_)
  - Gamma ray (伽馬刀)
  - 質子

立體定位放射手術 (SRS)



Gamma knife



立體定位放射手術(SRS)

Cyberknife

放射治療的副作用

- 放射治療是局部治療，只會影響治療區域內細胞，治療時感覺就像照X光一樣，不會引起任何顯著熱量或電擊感，照射後在體內也不會有任何放射物質存在
- 急性反應：在大部分病人療程中隨劑量累積逐漸出現，但在療程結束後也一定會緩解
- 亞急性反應和慢性反應：療程結束後追蹤期才會出現，也僅發生在少數病人

急性反應

放射性皮膚炎

- 在放射治療約三到四星期後，在治療範圍內（包括前胸和後背）的皮膚會有紅、癢、色素沉著的反應。
- 避免用肥皂清洗或磨擦，只能用溫清水輕輕洗過，以柔軟毛巾輕輕拍乾而不是擦乾。
- 在療程結束一到二週後方可使用肥皂。

放射性食道炎

- 在治療約二到三星期後，若部分食道或咽喉在治療範圍內，會有喉嚨乾、吞嚥疼痛與異物感的現象。
- 在這段期間飲食宜採軟、流質的食物，避免菸酒、太辛辣、過熱、過冰的食物。
- 這現象於放射治療結束後，約一至二週會慢慢消失。

疲倦感

- 在接受放射治療的期間常會變得較疲倦，尤其在治療的最後幾週，一般在療程結束後會逐漸恢復。

亞急性反應

放射性肺炎

- 通常可能於治療期間內或放射治療結後一至六個月內發生
- 症狀為持續性乾咳、呼吸急促、輕度發燒，醫師在排除感染的可能後，方能確定診斷
- 可能會給予類固醇以緩解症狀，通常會在幾週後緩解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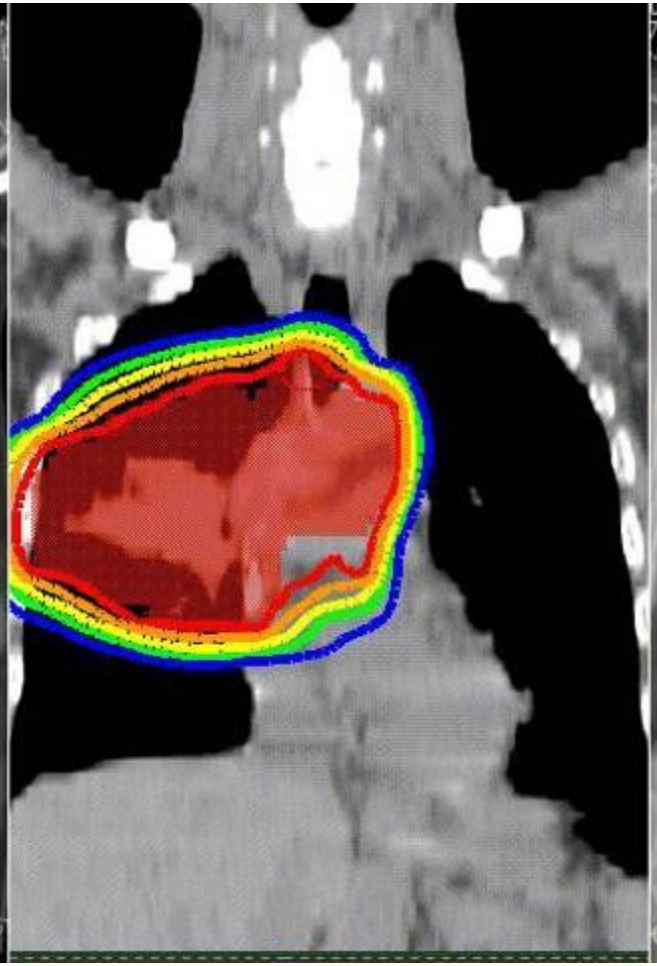


R18

慢性反應

放射性肺纖維化

- 可能會導致被照射的肺組織纖維化，於治療結束後幾個月發生
- 纖維化很像結疤，多數病人因纖維化程度不高不會有任何症狀，纖維化量多時才會影響肺的正常功能，引起咳嗽、氣喘、呼吸困難
- 可用藥物及氧氣治療

放射性脊髓炎

- 一般發生率極低，多是特異性體質，在治療後幾年內發生脊髓病變，下半身麻木感覺或麻痺，可用高壓氧治療。

放射治療的效果