



核子醫學治療

高雄榮民總醫院.核子醫學科

邱宇莉醫師

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

放射核種.疾病

治療後

造影追蹤.副作用

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

放射核種.疾病

治療後

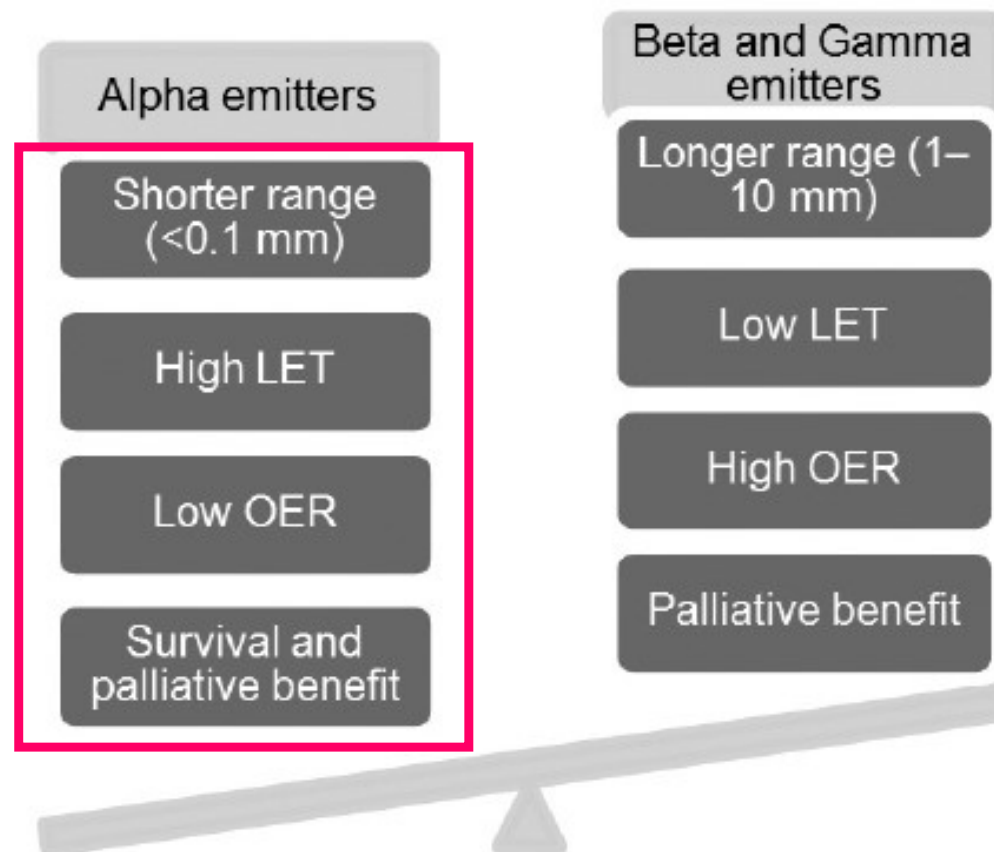
造影追蹤.副作用

- 口服
- 靜脈注射
- 體腔注射 (如: 關節, 腹膜)

➤ α emitters: Ra-223

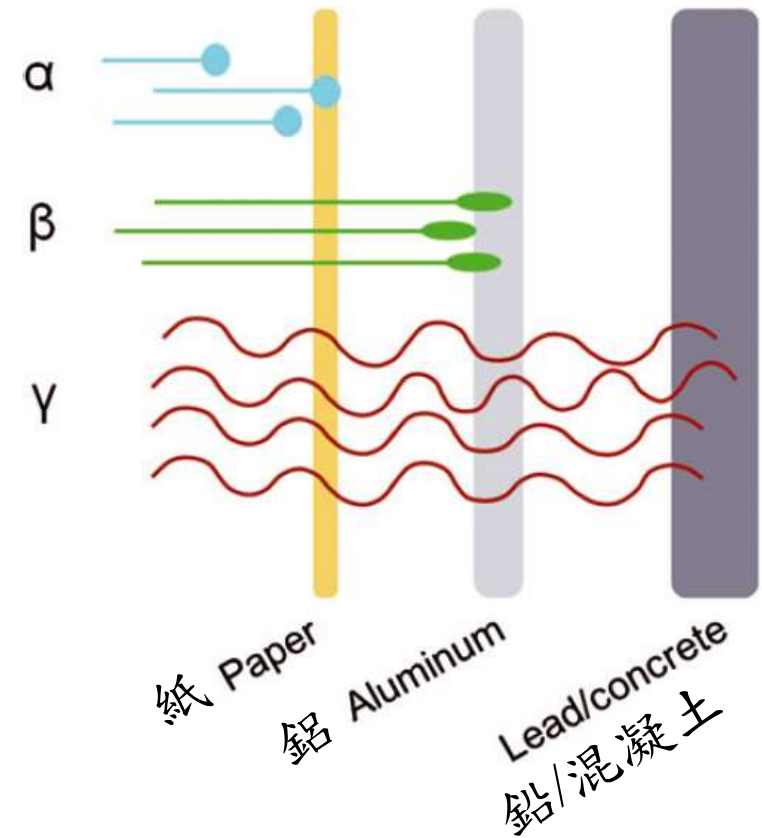
➤ β emitters: 最常見

1. 短射程
2. 高直線能量轉移 (LET; linear energy transfer)
3. 低氧增強比 (OER; oxygen enhancement ratio)



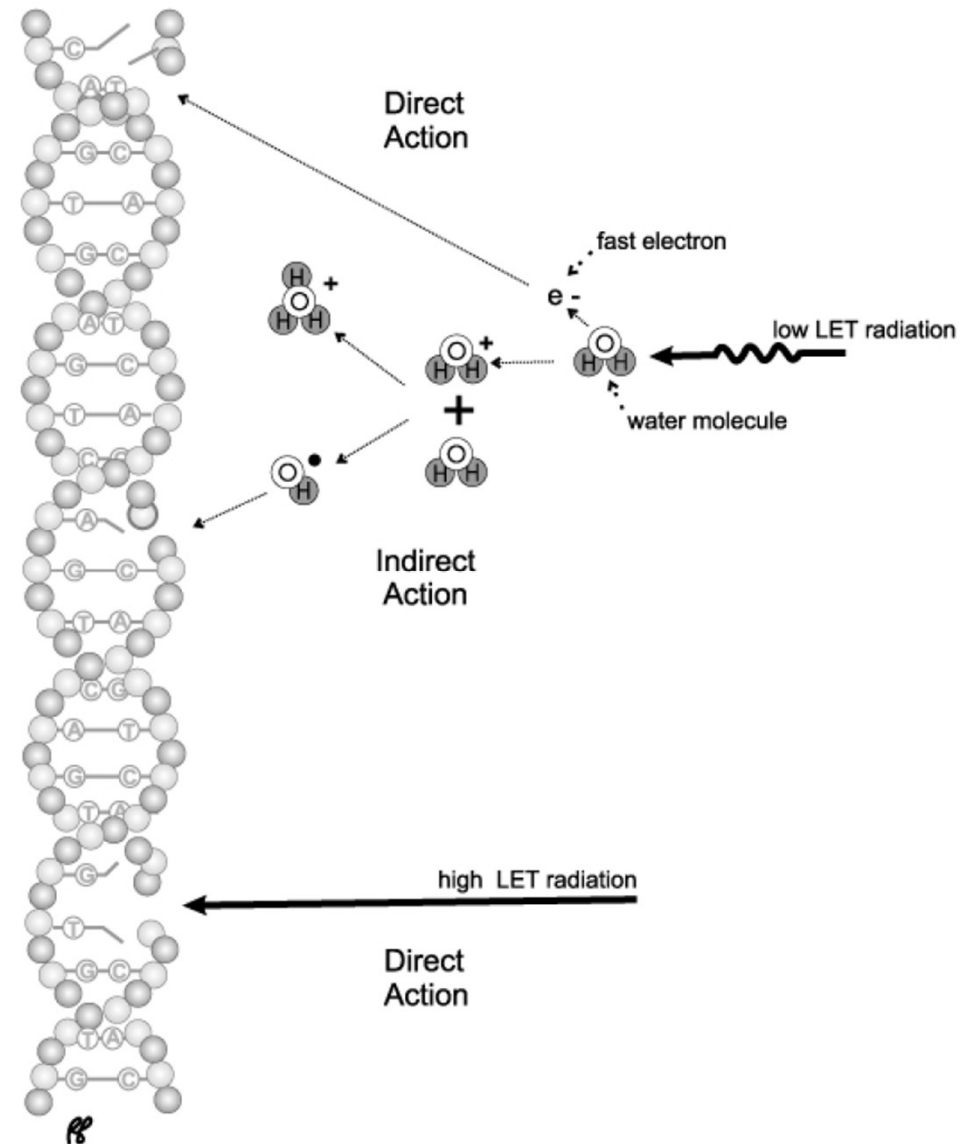
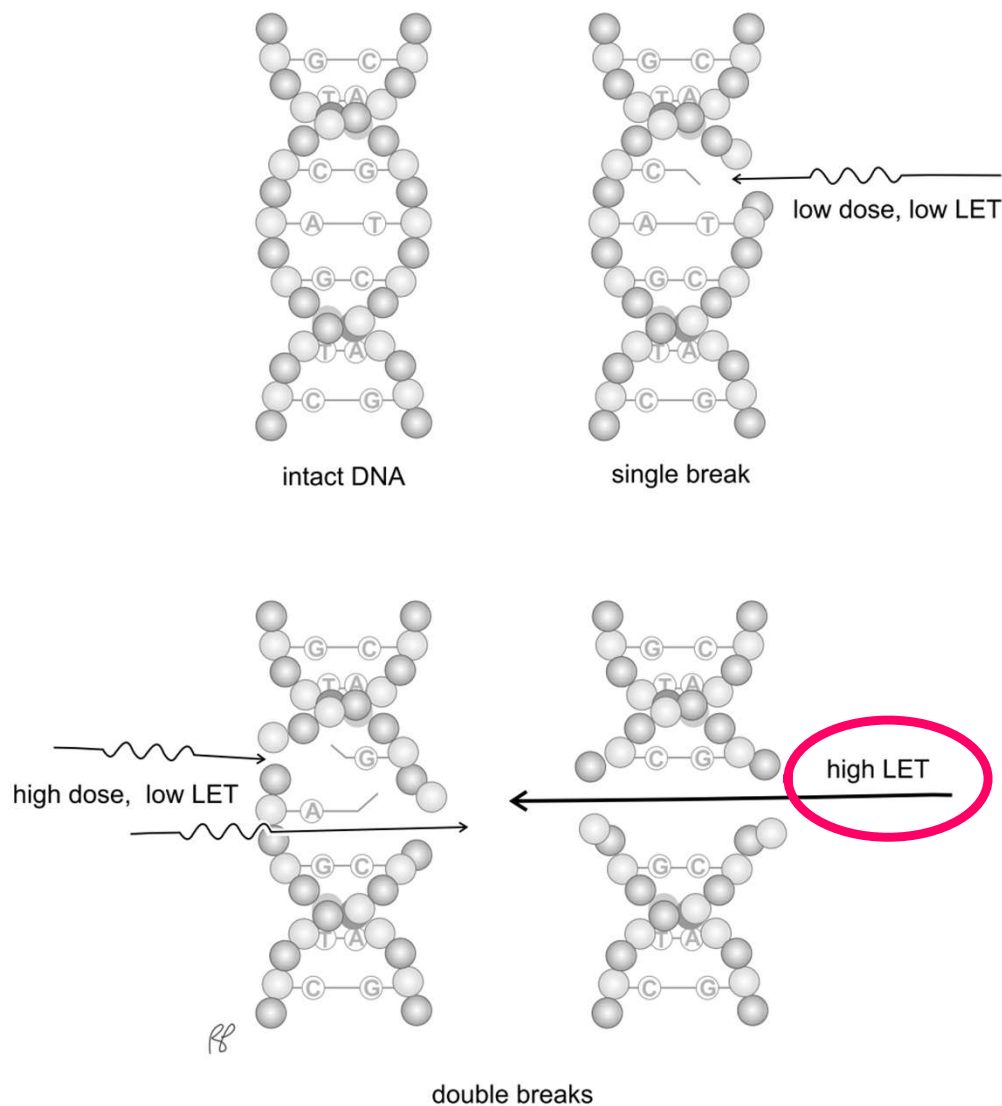
1. 短射程

治療	造影
阿爾發/貝他粒子 短射程/破壞DNA	伽馬射線 穿透人體/輻射危害
	



2. 高直線能量轉移 (LET; linear energy transfer)

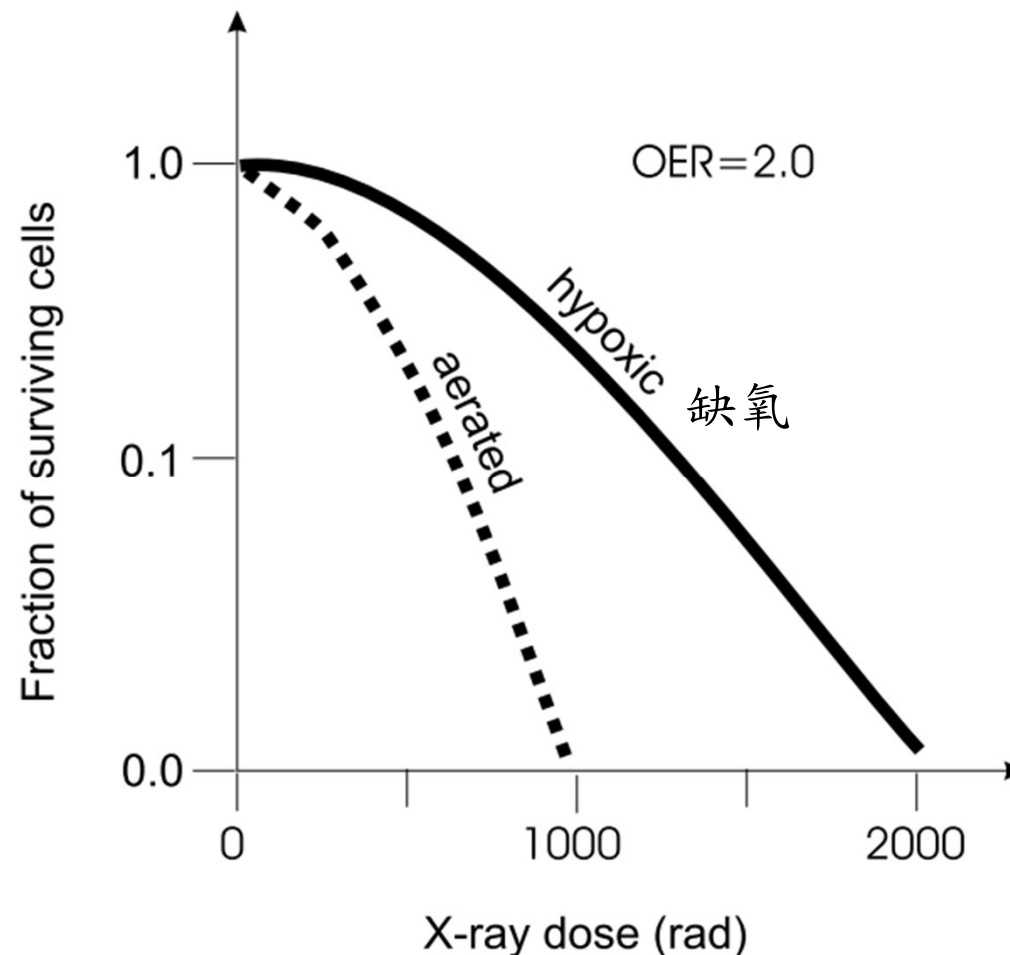
雙股vs. 單股斷裂；直接vs.間接作用



3. 低氧增強比 OER (oxygen enhancement ratio)

低LET輻射氧對細胞存活曲線的影響

$$\text{OER} = \frac{\text{Dose to produce a given effect without oxygen}}{\text{Dose to produce the same effect with oxygen}}$$



大綱

簡介

1. 甲狀腺疾病

2. 骨骼疾病

3. 肝臟疾病

4. 淋巴疾病

5. 神經內分泌疾病

6. 攝護腺癌

總結

治療前

造影評估.準備

治療

碘I-131.甲狀腺癌/機能亢進/腫大

治療後

造影追蹤.副作用

週 期 表

說明

原子序
元素符號
元素名稱
原子量

1H
1008
氫

氣體
液體
固體
人造元素

説明																		原子量		元素名稱		人造元素		情性氣體																									
1																		2		金屬										非金属										18									
IA																		IIA												IIIA										IVA		VA		VIA		VIIA		VIIA	
1																		2												13										14		15		16		17		18	
氫																		鋰												硼										碳		氮		氧		氟		氖	
1008																		6941												1081										1201		1401		1600		1900		2018	
3																		4												5										6		7		8		9		10	
鈉																		鎂												鋁										矽		磷		硫		氯		氬	
2299																		2431												2698										2809		3097		3207		3545		3995	
4																		5												6										7		8		9		10		11	
鉀																		鈣												鎵										鍺		砷		硒		溴		氪	
3910																		4008												6972										7259		7492		7896		7990		8380	
5																		6												7										8		9		10		11		12	
銣																		鐳												銦										錫		銻		碲		碘		氙	
8547																		8762												1124										1187		1218		127		1269		1313	
6																		7												8										9		10		11		12		13	
銻																		鉍												鉍										鉛		铋		鉍		砒		氡	
1329																		1373												2044										2072		2090		(210)		(210)		(222)	
7																		8												9										10		11		12		13		14	
銩																		釷												汞										鐳		錒		釷		釷		釷	
(223)																		(226)												2006										2044		2090		(210)		(210)		(222)	
8																		9												10										11		12		13		14		15	
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
9																		10												11										12		13		14		15		16	
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
10																		11												12										13		14		15		16		17	
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
11																		12												13										14		15		16		17		18	
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
12																		13												14										15		16		17		18			
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
13																		14												15										16		17		18					
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
14																		15												16										17		18							
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
15																		16												17										18									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
16																		17												18										19									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
17																		18												19										20									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
18																		19												20										21									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
19																		20												21										22									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
20																		21												22										23									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
21																		22												23										24									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
22																		23												24										25									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
23																		24												25										26									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
24																		25												26										27									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
25																		26												27										28									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
26																		27												28										29									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
27																		28												29										30									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
28																		29												30										31									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
29																		30												31										32									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
30																		31												32										33									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
31																		32												33										34									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
32																		33												34										35									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
33																		34												35										36									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
34																		35												36										37									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
35																		36												37										38									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
36																		37												38										39									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
37																		38												39										40									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
38																		39												40										41									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
39																		40												41										42									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
40																		41												42										43									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
41																		42												43										44									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
42																		43												44										45									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
43																		44												45										46									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
44																		45												46										47									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
45																		46												47										48									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
46																		47												48										49									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
47																		48												49										50									
銩																		釷												銩										釷		釷		釷		釷		釷	
223																		226												2006										2044		2090		(210)		(210)		(222)	
48																		49												50										51									
銩																		釷												銩										釷									

放射碘

造影 造影 造影&治療
↓ ↓ ↓
I-123, I-124, I-125, **I-131**
↑
檢驗

碘 Iodine-131 ($^{131}\text{I-NaI}$)

	I-131	I-123	I-124	I-125	Tc-99m
Mode of decay (%)	β^- (100)	Electron capture (100)	Electron capture, β^+ (77/23)	Electron capture (100)	Isometric transition (100)
Half-life	8 days	13.2 hr	4.2 days	60 days	6 hr
γ -ray energy (keV)	284, 364, 637	159	511 (annihilation)	35 X-ray (27-32)	140
Abundance	6, 81, 7%	83%	46%	7%	90%
Common production method	$^{130}\text{Te}(n,\gamma)^{131}\text{Te}$ $^{235}\text{U}(n,f)^{131}\text{Te}$ $^{131}\text{Te} \rightarrow ^{131}\text{I}$	$^{121}\text{Sb}(\alpha,2n)^{123}\text{I}$	$^{124}\text{Te}(p,n)^{124}\text{I}$	$^{124}\text{Xe}(n,\gamma)^{125}\text{Xe}$ $^{125}\text{Xe} \rightarrow ^{125}\text{I}$	$^{99}\text{Mo} \rightarrow ^{99\text{m}}\text{Tc}$

- 排泄: 尿液 (predominant route), 粪便 (some)

甲狀腺癌：乳突癌&濾泡癌. 甲狀腺全切除術

治療前 I-131/I-123/I-124 WBS. $\uparrow$ TSH ($>30 \mu\text{IU/mL}$)

- 低碘飲食: 1-2 weeks
- 停用甲狀腺素: 4 weeks or 5 days
- 肌肉注射基因重組人類甲促素(rhTSH; Thyrogen): 0.9 mg *2 days

AJCC TNM期別
ATA復發風險

治療 碘I-131 ($^{131}\text{I-NaI}$; radioactive iodine; RAI)

- 甲狀腺殘餘組織: 30 ~ 150 mCi
- 頸部淋巴結轉移: 30 ~ 150 mCi
- 遠處轉移 (肺/骨): 150 ~ 200 mCi



治療後

- 甲狀腺素(TSH $\downarrow$)
- 甲狀腺球蛋白(Tg $<2 \text{ ng/ml}$). 抗甲狀腺球蛋白抗體(ATA)
- 超音波. I-131/I-123 whole body scan. I-124/F-18 FDG PET/CT.
Cancer work-up (Tc-99m MIBI. Tl-201)

手術治療



甲狀腺素治療



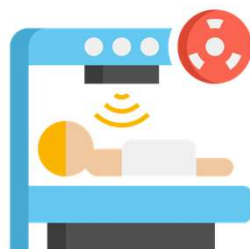
放射碘治療



標靶治療



放射治療



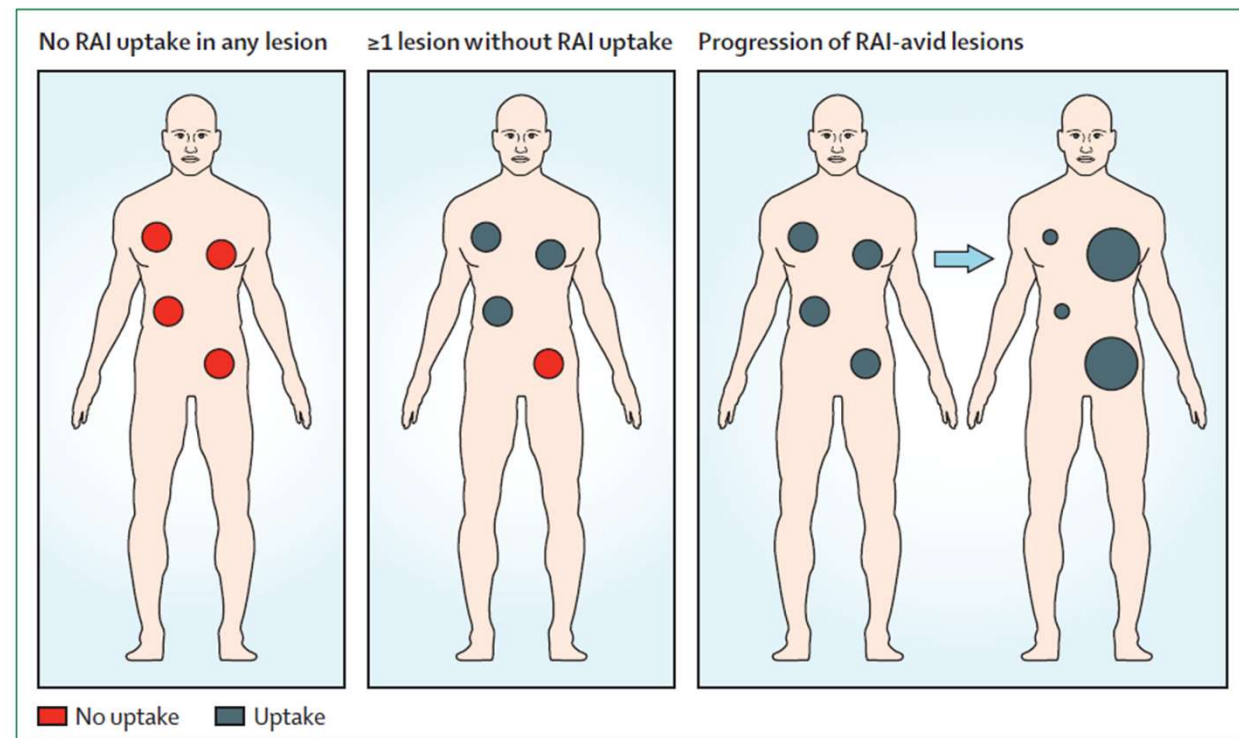
免疫治療



放射碘難治分化型甲狀腺癌

(rrDTC: radioiodine refractory differentiated thyroid cancer)

- No ^{131}I uptake is present on a diagnostic ^{131}I scan
- No ^{131}I uptake is present on a ^{131}I scan performed several days after ^{131}I therapy
- ^{131}I uptake is only present in some but not other tumor foci
- DTC metastasis(es) progress despite ^{131}I uptake
- DTC metastasis(es) progression despite a cumulative ^{131}I activity of >600 mCi



治療前事前準備

- 低碘飲食(1-2週)

- $<50 \mu\text{g/day}$

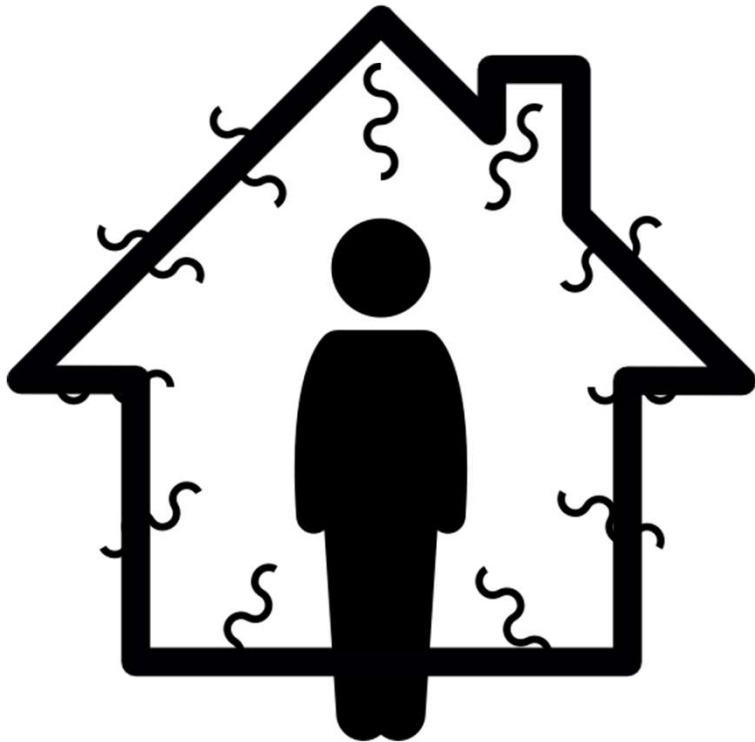
- 停用甲狀腺素(4週或5天)

- 施打人類甲促素(2天)



食物或藥物	建議停用時間
甲狀腺素	3-4 wk for T4, 10-14 d for T3
海帶,石花菜,藻類提取物, Lugol solution	2-3 wk (根據碘含量)
綜合維他命(含碘)	7-10 d
Thionamide medications (propylthiouracil, methimazole, carbimazole)	3 d
Amiodarone	3-6 mo or longer
飽和的碘化鉀溶液(SSKI)	2-3 wk
外用碘酒(手術皮膚準備)	2-3 wk
顯影劑(水溶性)	6-8 wk (假設正常腎功能)
顯影劑(親油性)	1-6 mo

一定要住院隔離嗎？



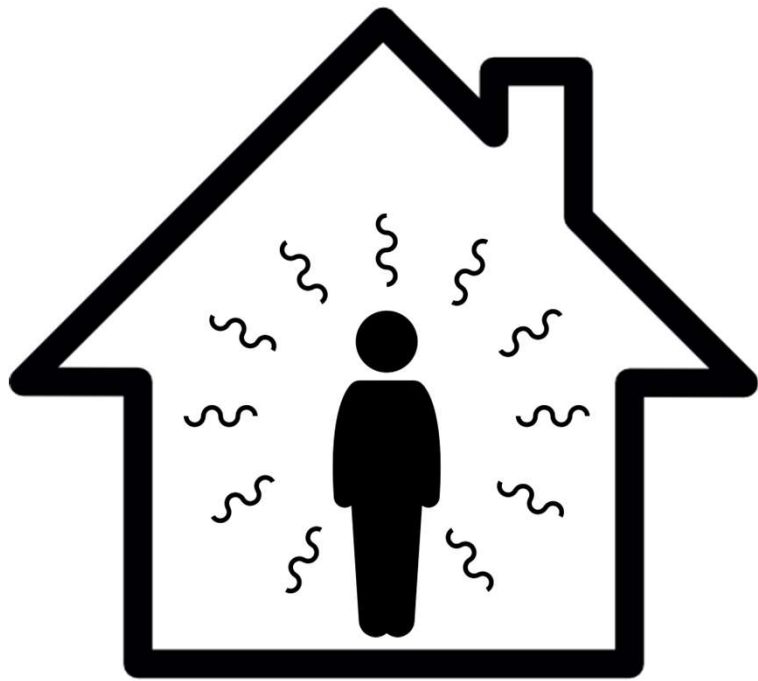
<醫用放射性物質與可發生游離輻射設備輻射安全檢查項目及其作業規定>第四條第八項：

以大劑量做治療時或使用之放射性物質活度超過一·一一拾億貝克（GBq），應設治療室，治療室外對一般人員或工作人員之劑量應符合游離輻射防護安全標準之規定。



醫療機構對病人接受放射碘-131治療活度大於30毫居禮(mCi)者，應安排其於專用病房住院隔離。

何時可以出院？



- 1.<國際原子能總署(IAEA)第63號報告>及
<國際放射防護委員會(ICRP)第155號報告>：
對於照護者的**輻射總曝露不超過劑量約束值
或劑量限制值**時，病人即可外釋。
- 2.<游離輻射防護安全標準>第12條：
輻射作業造成**一般人**之年劑量限度，有效劑
量不得超過一毫西弗。



醫療機構應對住院病人量測確認距離其軀幹體
表一公尺處之**輻射劑量率低於每小時70微西弗
($\mu\text{Sv/h}$)**時，始准其出院。

照護者要穿防護衣嗎？



<游離輻射防護安全標準>

1. 第7條：輻射工作人員職業曝露之劑量限度，每連續五年週期之有效劑量不得超過一百毫西弗，且任何單一年內之有效劑量不得超過五十毫西弗。
2. 第18條：設施經營者應盡合理之努力，使接受緊急曝露人員之劑量符合規定：為搶救生命，劑量儘可能不超過單一年劑量限度之十倍。除前款情況外，劑量儘可能不超過單一年劑量限度二倍。



住院中：要穿防護衣
出院後：不穿防護衣

防護衣要怎麼穿？



(外)手套、腳套、拋棄式防水性隔離衣

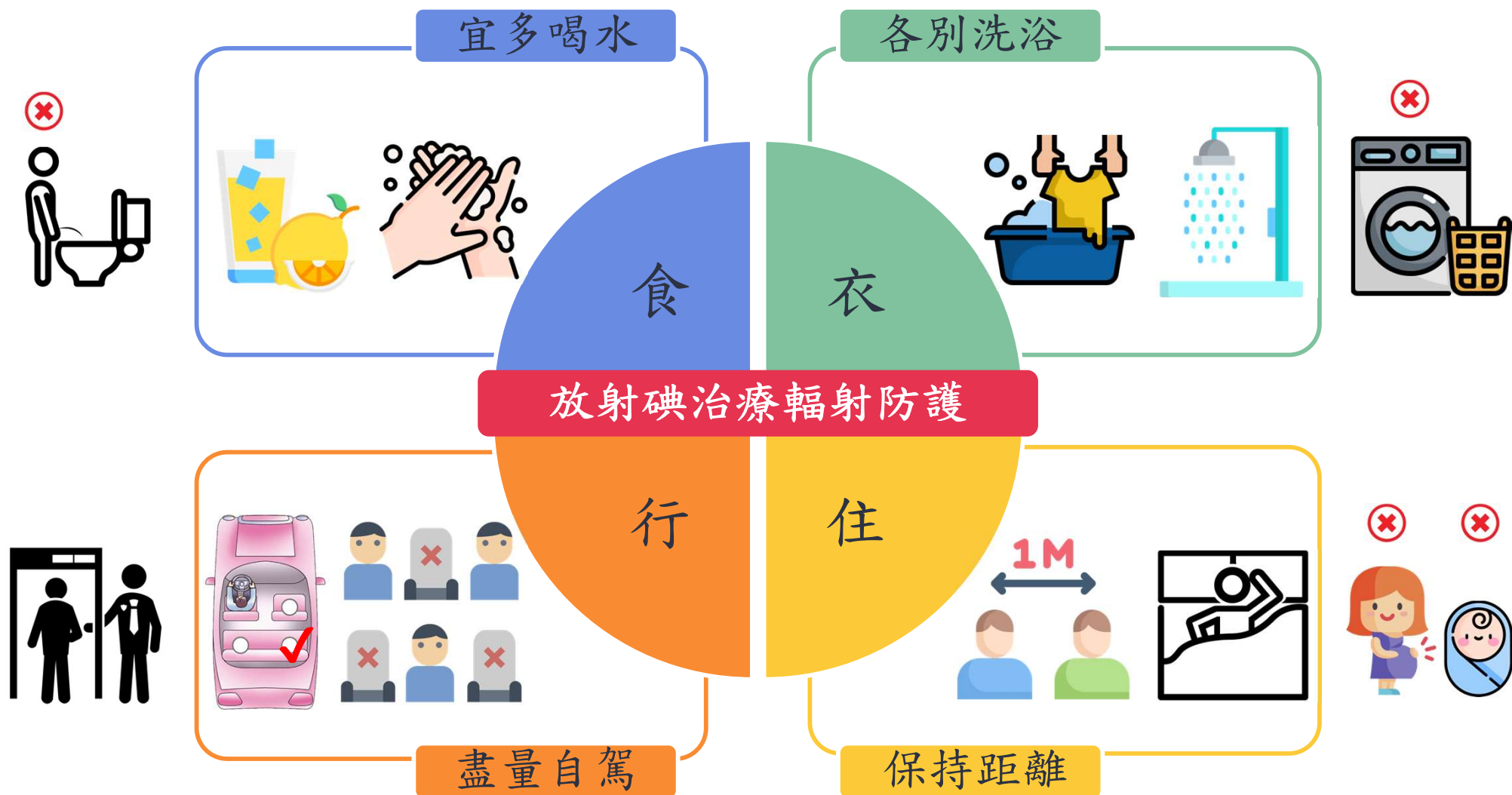
(中)鉛裙、鉛衣、鉛頸、鉛手套/眼鏡

(內)個人偵檢器/膠片佩章

- 恢復正常飲食/甲狀腺素: 門診治療後2-3天或出院
- 懷孕: 6-12 months
- 再次治療: 6-12 months
 - 肺纖維化 (pulmonary fibrosis): 600 mCi
 - 骨髓抑制 (bone marrow suppression): 800 mCi
 - 繼發性腫瘤 (secondary tumor: leukemia, bladder & breast): 800 mCi

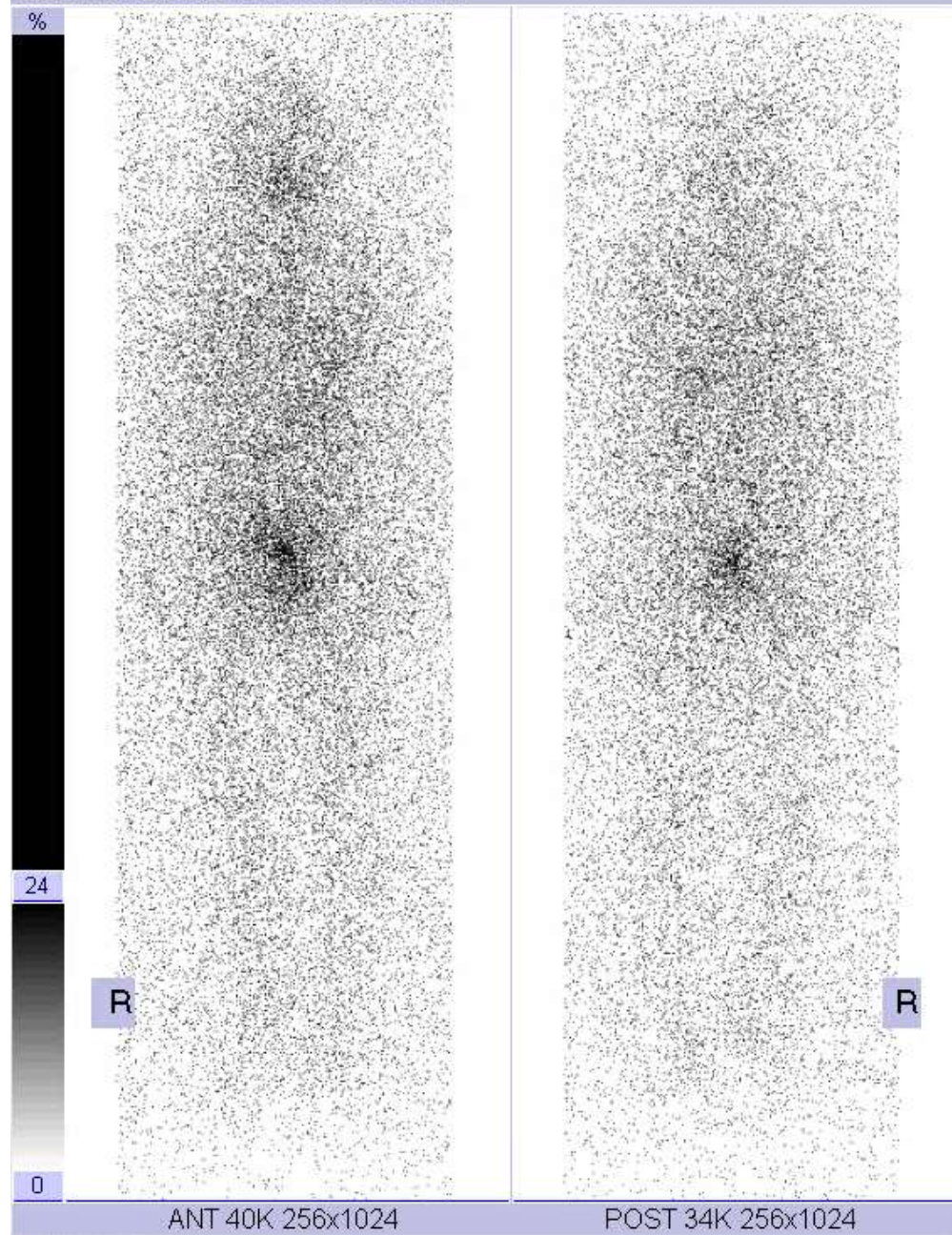
早期副作用(短暫,輕微)	晚期副作用
1. 口腔黏膜炎	1. 不孕
2. 噁心(rare)	2. 永久性唾液腺損傷:
3. 嘔吐 (occasional)	口乾.過度齧齒
4. 唾液腺炎	唾液腺結石.溢淚
5. 喪失味覺	味覺障礙.結膜乾燥
6. 味覺改變(金屬味)(unusual)	3. 癌症: 膀胱癌.胃癌
7. 甲狀腺炎(脖子疼痛&腫脹)	大腸癌.唾液腺癌
8. 白血球/血小板↓ → ↑感染or出血	白血病.黑色素瘤

治療後注意事項

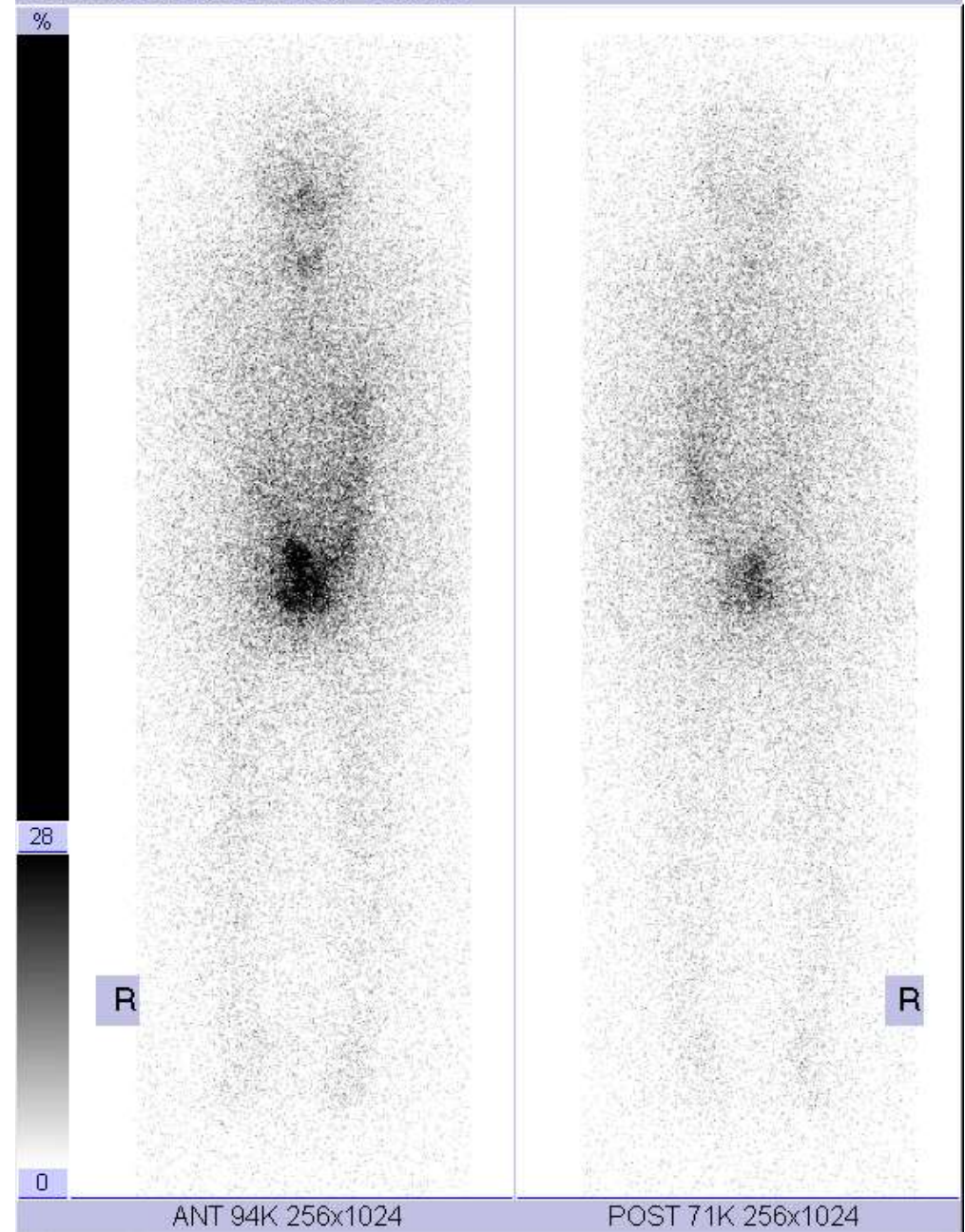


I-131 whole body scan (2.5 mCi)

I-131 Whole body scan 3days 4/12/2013

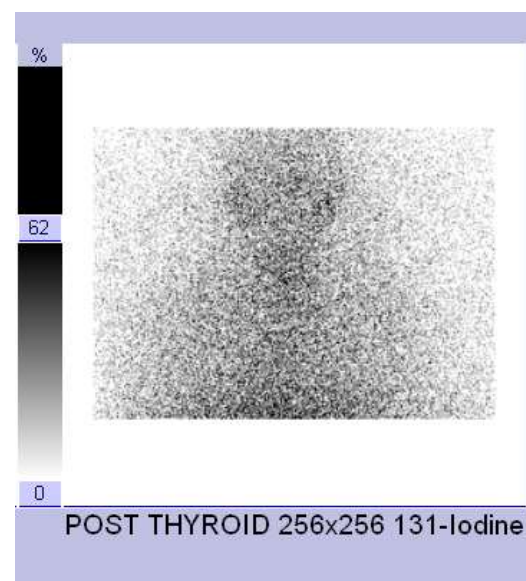
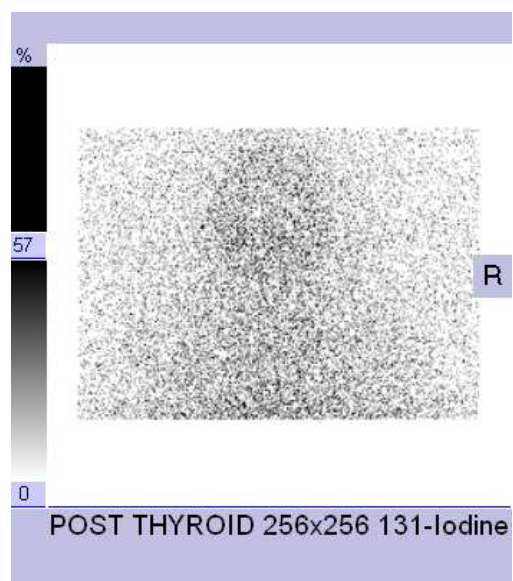
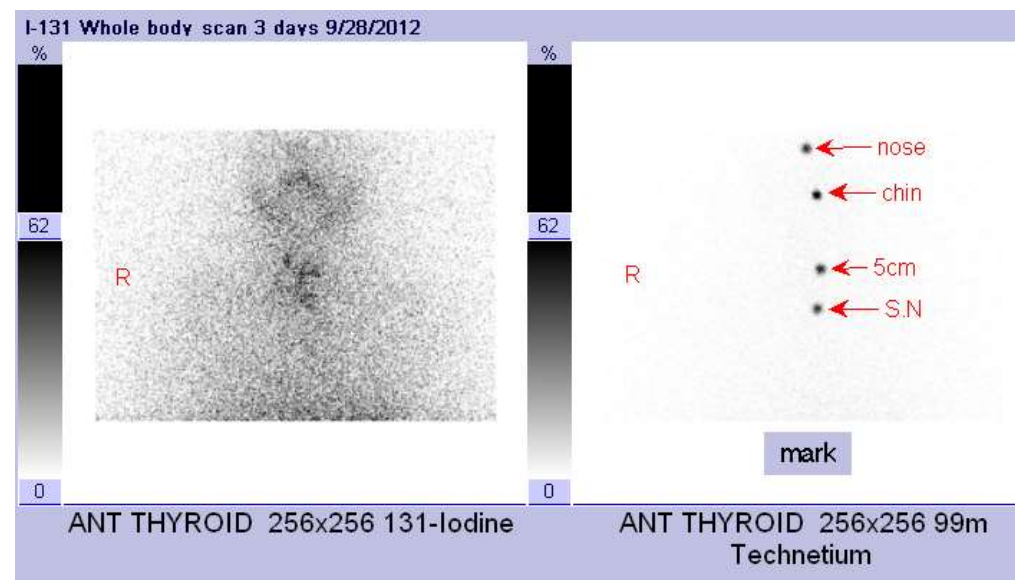
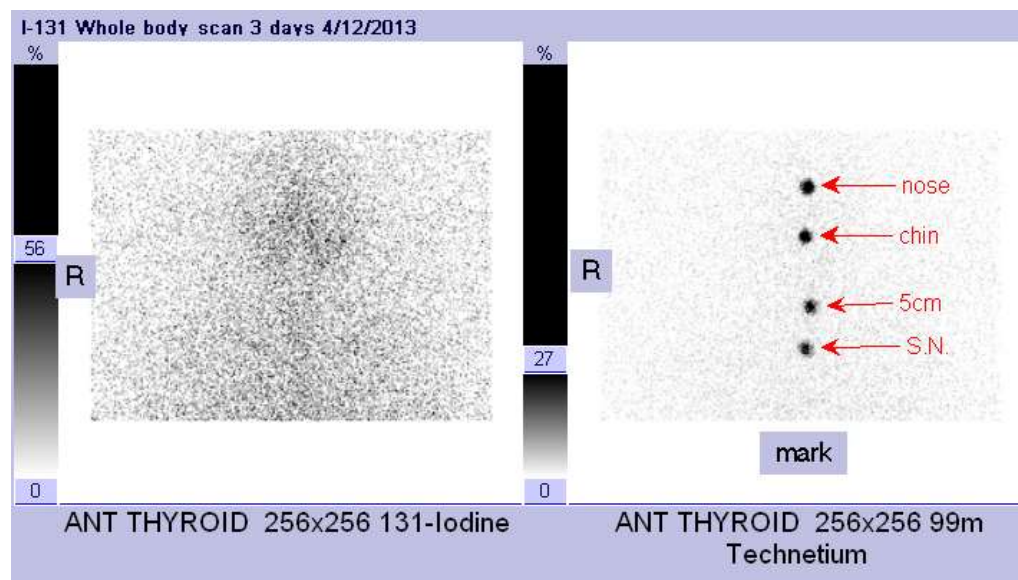


I-131 Whole body scan 3days 9/28/2012



正常

殘存組織

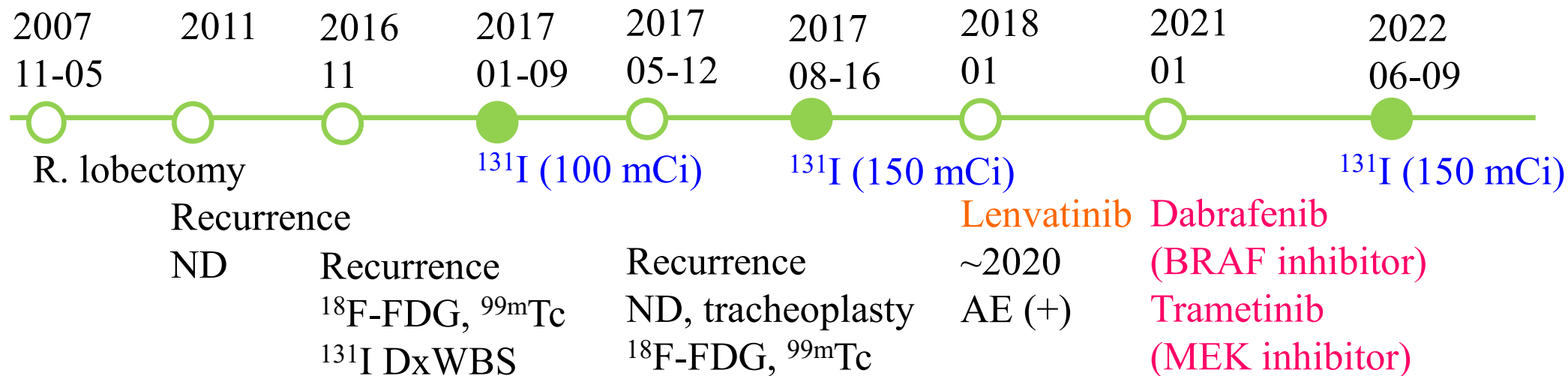


45 y/o man
PTC

rrDTC

標靶
治療

再分化
治療



2017-01-11 I-131

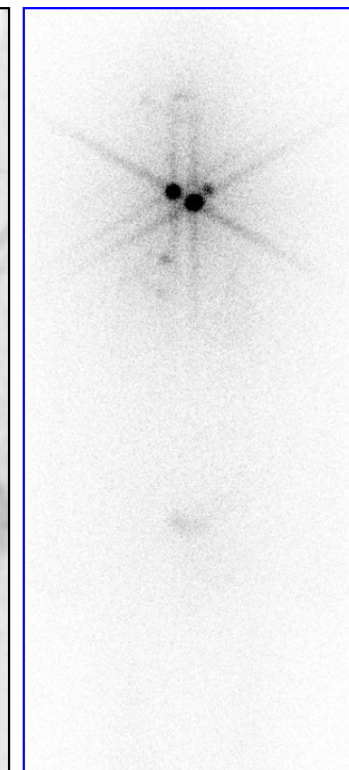
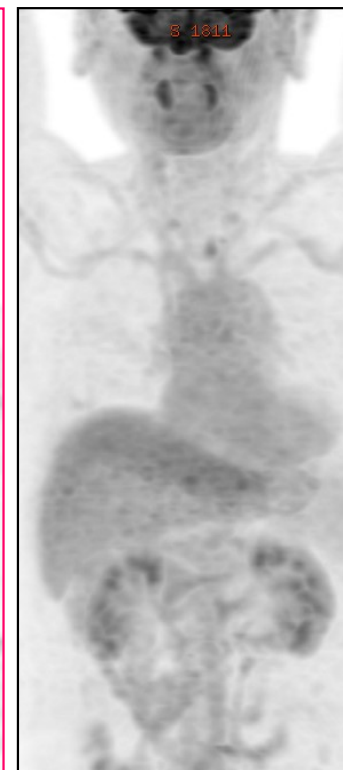
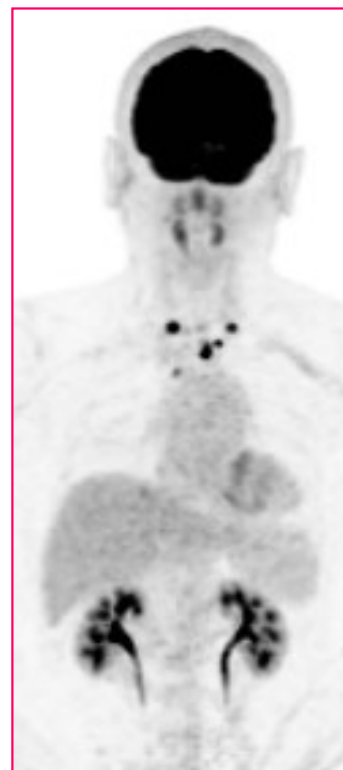
2017-08-15 FDG

2017-08-18 I-131

2020-12-08 FDG

2022-05-19 FDG

2022-06-13 I-131



甲狀腺機能亢進/甲狀腺腫大

治療前 I-131/I-123/Tc-99m uptake & scan

- 低碘飲食: 7 days
- 停用抗甲狀腺藥物3-7天(不用停Propranolol)
- SONO

甲狀腺大小
是否有功能性結節
甲狀腺碘吸收能力

治療 碘I-131 ($^{131}\text{I-NaI}$; radioactive iodine; RAI)

- 80-220 $\mu\text{Ci/g}$
- Graves disease: 10-15 mCi
- Nodular goiter: 20-30 mCi

治療後

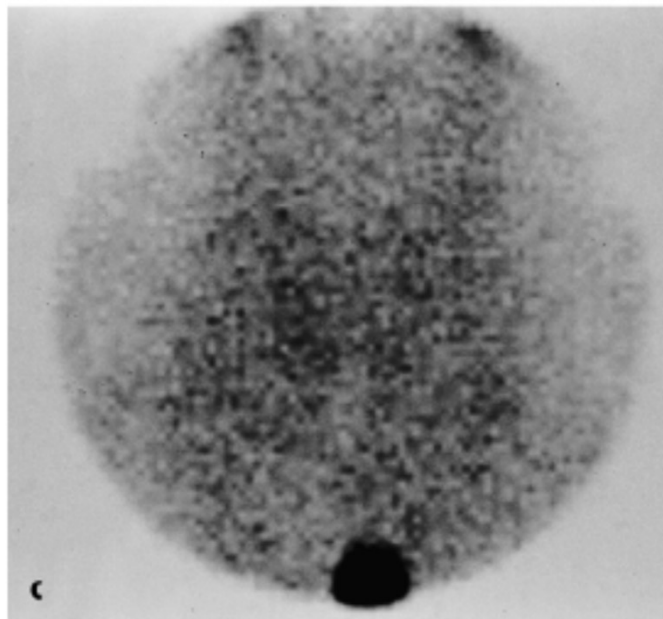
- T3, T4, free T4, TSH, anti TSH receptor Ab, Anti-TPO Ab, ATA
- 甲狀腺素(甲狀腺功能低下)



結節性甲狀腺腫
Multinodular goiter



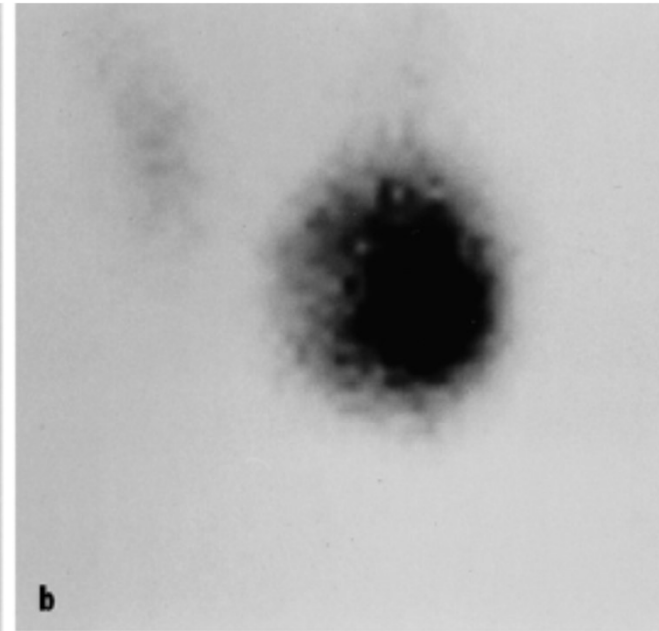
a



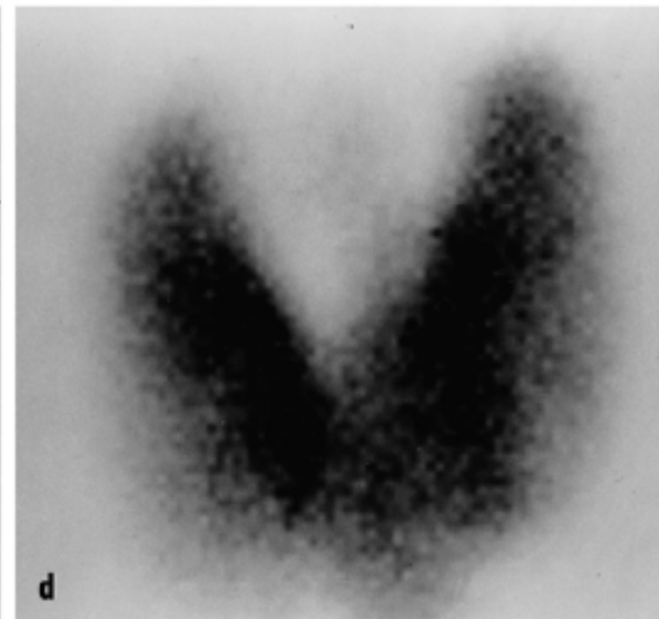
c

甲狀腺炎
Thyroiditis

孤立性高功能甲狀腺結節
Solitary hyperfunctioning thyroid nodule



b



d

葛瑞夫茲氏病
Graves' disease



- 治療後

副作用	無證據顯示
1. 甲狀腺功能低下	1. 增加甲狀腺癌或其他癌症風險
2. 甲狀腺炎(脖子疼痛&腫脹)(1-5%)	2. 增加不孕症風險
3. 喉返神經麻痺(very common)	3. 增加出生缺陷風險
4. 味覺障礙(very common)	
5. Graves' disease 眼病加劇	

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

鐳Ra-223.骨轉移

治療後

造影追蹤.副作用

週 期 表

說明

原子序
元素符號
元素名稱
原子量

1H
1008
氫

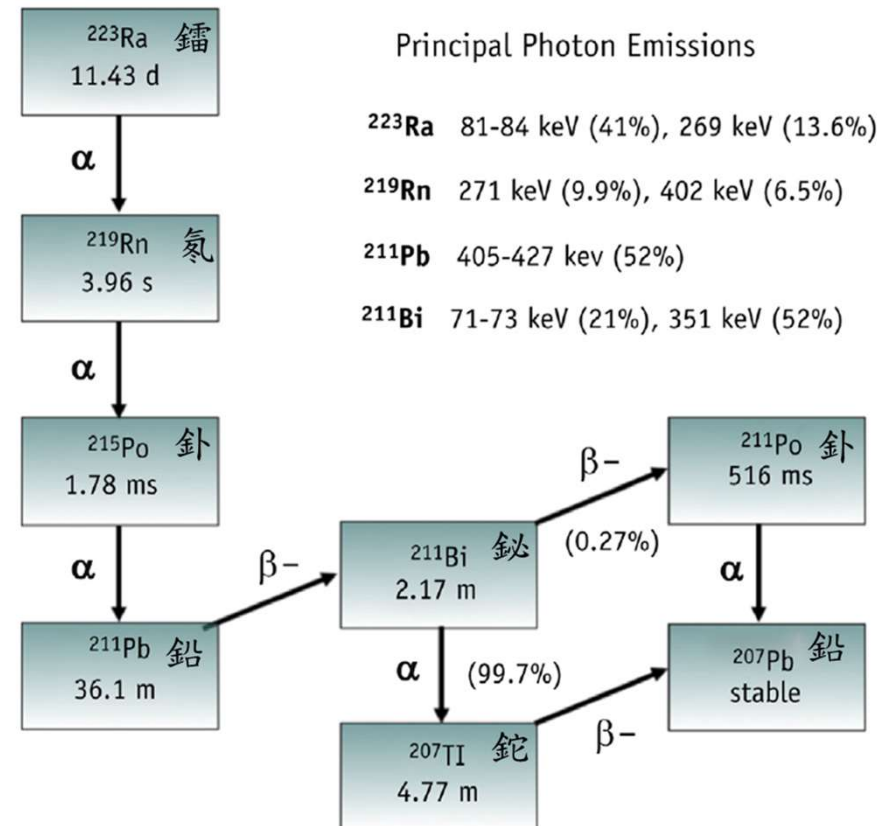
氣體
液體
固體
人造元素

惰性氣體
18
VIII A

金屬										非金屬							
1 IA	2 II A	過 渡 元 素										13 III A	14 IV A	15 VA	16 VI A	17 VII A	18 VIII A
1 氫 1008																	2He 4003
2 3Li 6941 鋰	4Be 9012 鈹											5B 1081 硼	6C 1201 碳	7N 1401 氮	8O 1600 氧	9F 1900 氟	10Ne 2018 氖
3 11Na 2299 鈉	12Mg 2431 鎂	3 III B	4 IV B	5 VB	6 VIB	7 VIIB	8 VIIIB	9 VIIIB	10 VIIIB	11 IB	12 IIB	13Al 2698 鋁	14Si 2809 矽	15P 3097 磷	16S 3207 硫	17Cl 3545 氯	18Ar 3995 氬
4 19K 3910 鉀	20Ca 4008 鈣	21Sc 4496 釷	22Ti 4788 鈦	23V 5094 鈮	24Cr 5200 鉻	25Mn 5494 錳	26Fe 5585 鐵	27Co 5893 鈷	28Ni 5869 鎳	29Cu 6355 銅	30Zn 6539 鋅	31Ga 6972 鎵	32Ge 7259 鍺	33As 7492 砷	34Se 7896 硒	35Br 7990 溴	36Kr 8380 氪
5 37Rb 854 銣	38Sr 8762 銻	39Y 8891 鈾	40Zr 9122 鈷	41Nb 9291 鈮	42Mo 9594 鉬	43Tc 9891 鎝	44Ru 1011 鈷	45Rh 1029 銠	46Pd 1064 鈀	47Ag 1079 銀	48Cd 1124 鎘	49In 1148 銦	50Sn 1187 錫	51Sb 1218 銻	52Te 1276 碲	53I 1269 碘	54Xe 1313 氙
6 55Cs 1329 銫	56Ba 1373 鋇	57-71 鐳系元素	72Hf 1785 鈷	73Ta 1809 鉭	74W 1839 鎢	75Re 1862 銿	76Os 1902 銱	77Ir 1922 銲	78Pt 1951 鉑	79Au 1970 金	80Hg 2006 汞	81Tl 2044 鉍	82Pb 2072 鉛	83Bi 2090 鉍	84Po (210) 釷	85At (210) 砒	86Rn (222) 氡
7 87Fr (223) 銣	88Ra (226) 鐳	89-103 鐳系元素	104Unq (261) 鈾	105Unp (262) 鈾	106Unh (263) 鈾	107Uus (264) 鈾	108Uno (265) 鈾	109Uue (266) 鈾									
鐳系元素		57La 1389 鐳	58Ce 1401 鈰	59Pr 1409 鐮	60Nd 1442 釷	61Pm 1449 鉕	62Sm 1504 鈾	63Eu 1520 鈰	64Gd 1573 鈱	65Tb 1589 鈷	66Dy 1625 鐳	67Ho 1649 鈱	68Er 1673 鉕	69Tm 1689 釷	70Yb 1730 鐳	71Lu 1750 鐳	
鈾系元素		89Ac (227) 鈾	90Th 2320 鈾	91Pa (231) 鐳	92U 2380 鈾	93Np (237) 鈾	94Pu 2391 鈾	95Am 2431 鋂	96Cm 2471 鋂	97Bk 2471 鈾	98Cf 2521 鈾	99Es 2521 鈾	100Fm 2571 鈾	101Md 2561 鈾	102No 2591 鈾	103Lr 2601 鈾	

1. 鐳 Radium-223 ($^{223}\text{RaCl}_2$; Xofigo)

- Half-life: 11.4 d
- γ emission or X-ray (154 keV, 1.1%)
- β emission (3.6%)
- α emission (95.3%)
- Maximum energy: 5.78 MeV (average)
- Maximum range: $<10\mu\text{m}$
- Usual administered activity: 50-200 kBq/kg
- Typical response time: <10 d
- Typical response duration: ?
- Retreatment interval: ?
- Actinium-227 generator (鈾)
- Excretion is predominantly via the gastrointestinal tract.
- Tumor-to-marrow ratio: 30:1



骨轉移

治療前 Tc-99m MDP / F-18 NaF bone scan

- 起始: $ANC \geq 1.5 \times 10^9/L$. $PLT \geq 100 \times 10^9/L$. $Hb \geq 10 \text{ g/dL}$
- 後續: $ANC \geq 1.0 \times 10^9/L$. $PLT \geq 50 \times 10^9/L$

治療 鐳Ra-223 ($^{223}\text{RaCl}_2$; Xofigo)

- 55 kBq/kg 靜脈注射(>1 min)
- 每隔4週給予.共6劑

Primary
Container
Closure
System



Primary
Container
Closure
System with
Top and
Bottom Cap
and Wrapping
film



Primary
Container
Closure
System
placed in the
Shielding
Container



Type A
shipping
box

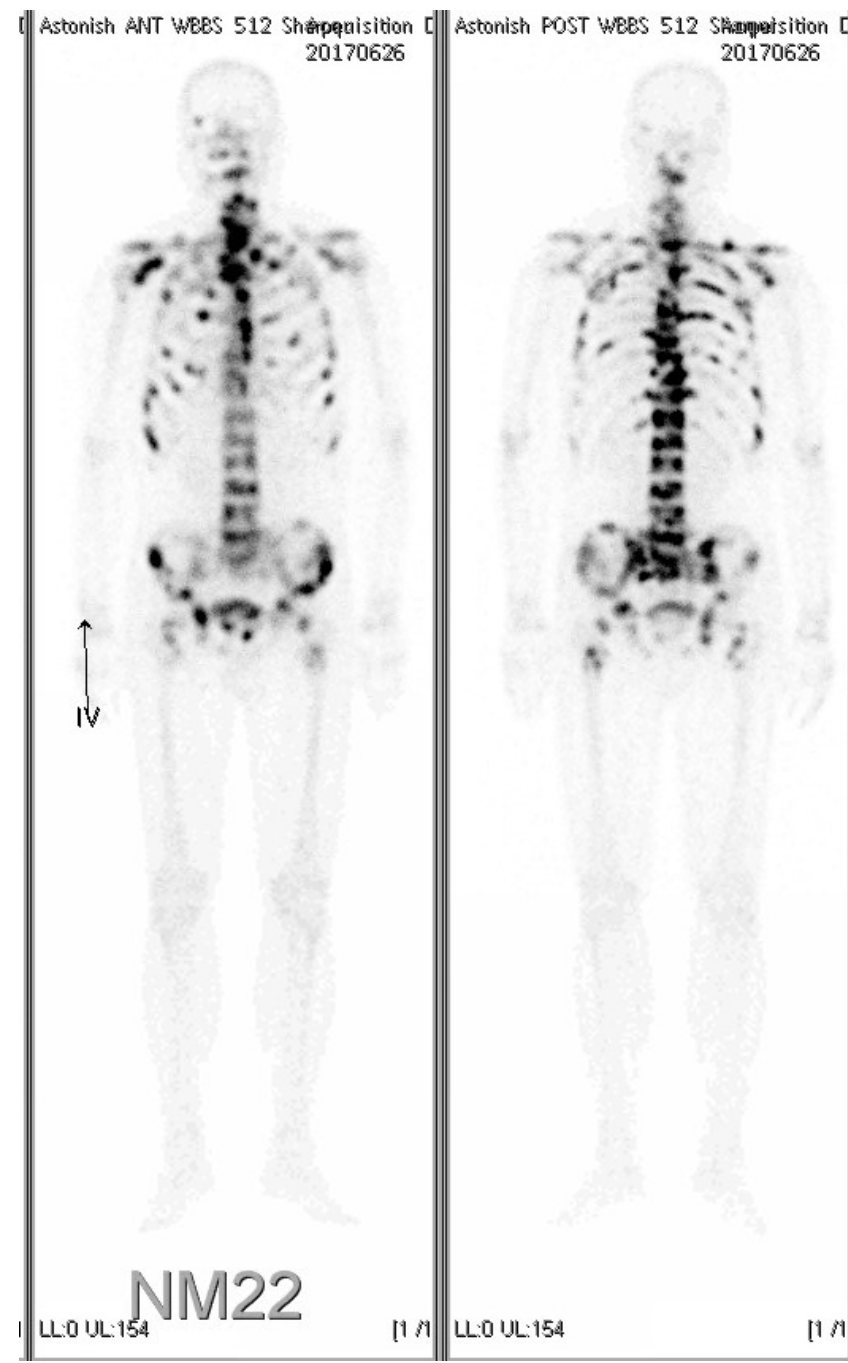
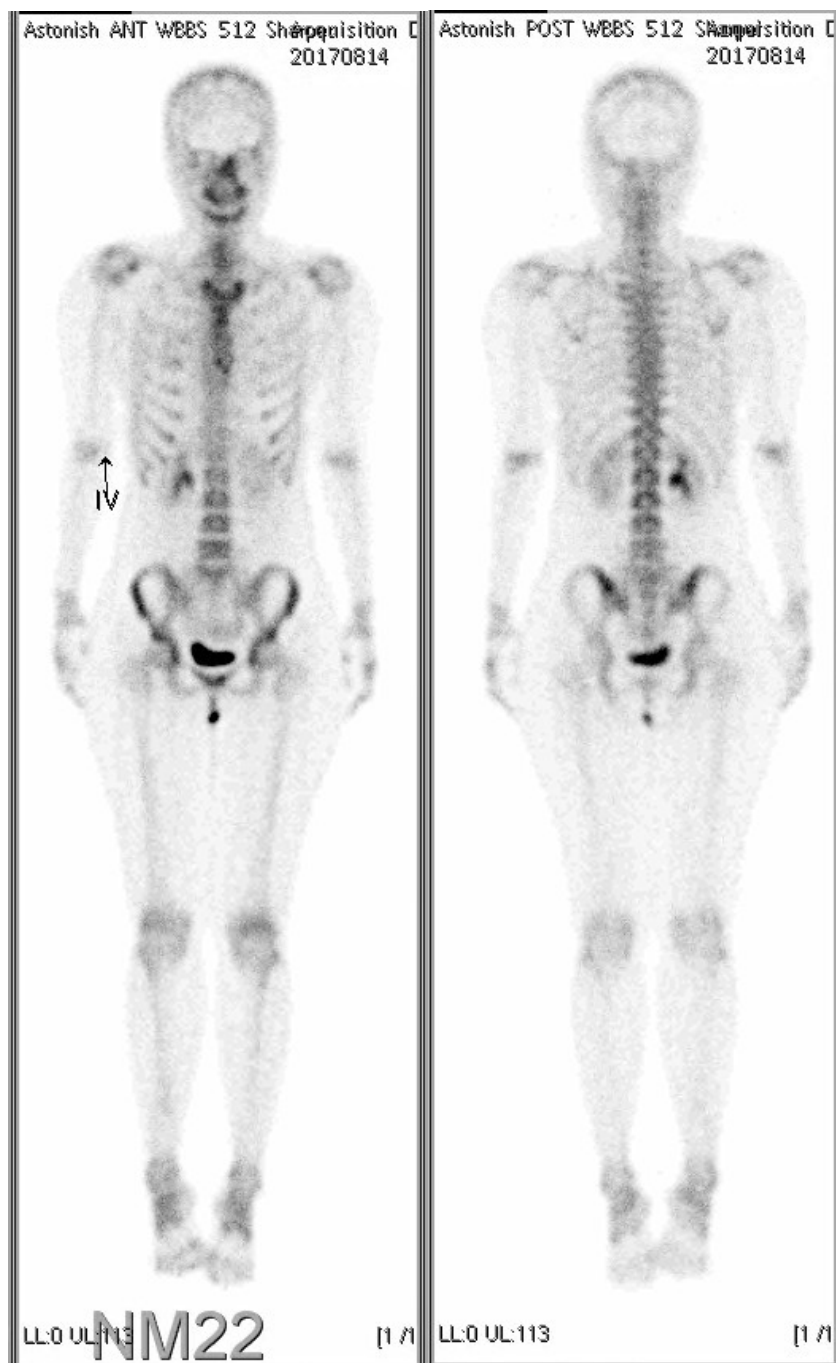


治療後

- 血液學副作用: 嗜中性白血球低下.血小板低下.貧血
- 非血液學副作用: 腹瀉.噁心.嘔吐

正常

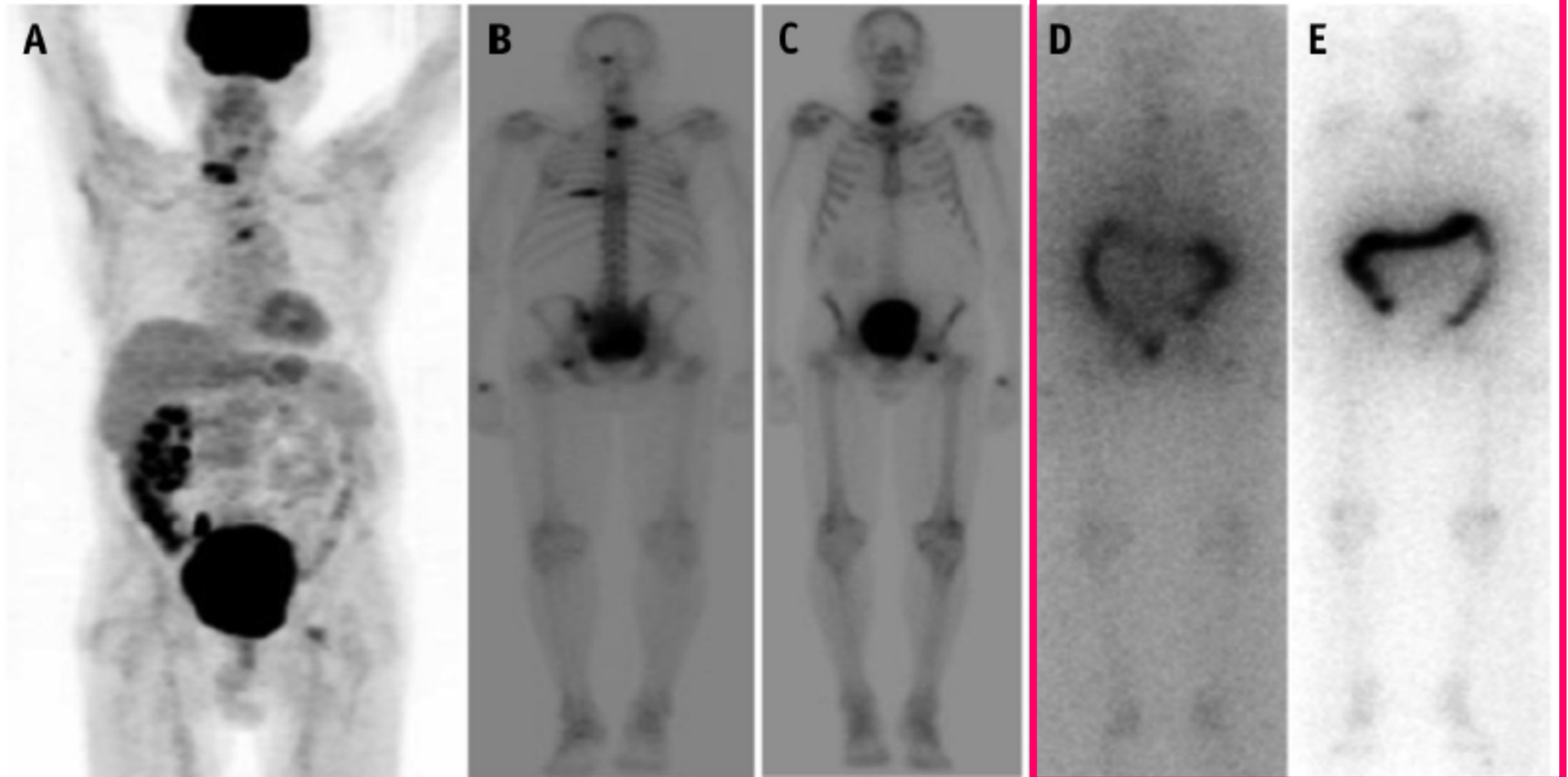
骨轉移 



(A) FDG PET scan

(BC) MDP bone scan

(DE) $^{223}\text{RaCl}_2$ scan
24hr after injection



2. 鍶 Strontium-89 ($^{89}\text{SrCl}_2$; Metastron)

※ Half-life: 50.5 d (最長)

※ No γ emission

- β emission
- Maximum energy: 1.4 MeV; Mean energy: 0.583 MeV
- Maximum range: 7 mm
- Usual administered activity: 148 MBq
- Typical response time: 14-28 d (最長)
- Typical response duration: 12-26 wk (最長)
- Retreatment interval: >3 mo

※在正常骨骼與癌症轉移病灶的代謝(turnover)速率比值約10:1

- Excretion is predominantly renal.
- The toxicity of treatment is limited to temporary myelosuppression, which typically occurs 6 wk after therapy.

3. 釷 Samarium-153 (^{153}Sm -EDTMP; Quadramet)

- Half-life: 1.9 d
- γ emission (103 keV)
- β emission
- Maximum energy: 0.81 MeV; Mean energy: 0.229 MeV
- Maximum range: 4 mm

- Usual administered activity: 37 MBq/kg
- Typical response time: 2-7 d (快)
- Typical response duration: 8 wk
- Retreatment interval: >2 mo

※ 可同步用於全身造影

- Tumor-to-normal bone ratio: 4:1-7:1
- Pain flare is rare (~10%)

4. 銻 Rhenium-186 & 188 (^{186}Re -HEDP & ^{188}Re -HEDP)

- | | |
|--|--|
| ■ Half-life: 3.7 d | ※ Half-life: 16.9 h (最短) |
| ■ γ emission (137 keV) | ※ γ emission (155 keV, 10% abundance) |
| ■ β emission | β emission |
| ■ Maximum energy: 1.07 MeV | Maximum energy: 2.1 MeV |
| ■ Mean energy: 0.362 MeV | Mean energy: 0.764 MeV |
| ■ Maximum range: 5 mm | Maximum range: 10 mm (最長) |
| ■ Usual administered activity: 1.3 GBq | Usual administered activity: 1.3-4.4 GBq |
| ■ Typical response time: 2-7 d (快) | Typical response time: 2-7 d (快) |
| ■ Typical response duration: 8-10 wk | Typical response duration: 8 wk |
| ■ Retreatment interval: >2 mo | Retreatment interval: ? |
| ■ Clearance is predominantly renal. | ^{188}W generator |
| ■ Toxicity is limited to temporary myelosuppression. | Toxicity was limited to activity-dependent, temporary myelosuppression with a nadir at 6 wk. |

5. 錫 Stannum-117m (^{117m}Sn -DTPA)

- Half-life: 13.6 d
- γ emission (159 keV)
- Conversion electrons
- Maximum energy: 0.13 & 0.16 MeV
- Maximum range: $<1\mu\text{m}$ (最短)

- Usual administered activity: 2-10 MBq/kg
- Typical response time: 5-19 d
- Typical response duration: 12-16 wk
- Retreatment interval: >2 mo

6. 磷 Phosphorus-32 (^{32}P -sodium orthophosphate)

- Half-life: 14.3 d
- ※ No γ emission
- β emission
- Maximum energy: 1.7 MeV; Mean energy: 0.695 MeV
- Maximum range: 8.5 mm

- Usual administered activity: 444 MBq (fractionated)
- Typical response time: 14 d
- Typical response duration: 10 wk
- Retreatment interval: >3 mo

- ※ The main disadvantage of ^{32}P therapy is dose-limiting myelosuppression with reversible pancytopenia (血球減少) maximal at 5-6 wk after administration.
- ※ 可治療真性紅血球增多症 (polycythemia vera) ($74\text{--}111\text{ MBq/m}^2$; $2\text{--}3\text{ mCi/m}^2$)

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

釷Y-90微球體.肝癌/肝轉移

治療後

造影追蹤.副作用

週 期 表

說明

原子序
元素符號
元素名稱
原子量

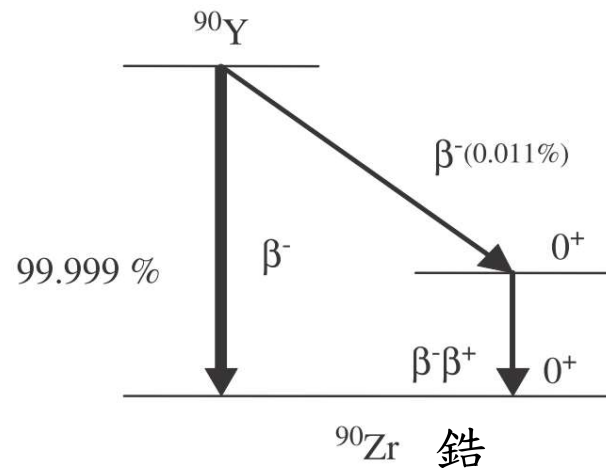
1H
1008
氫

氣體
液體
固體
人造元素

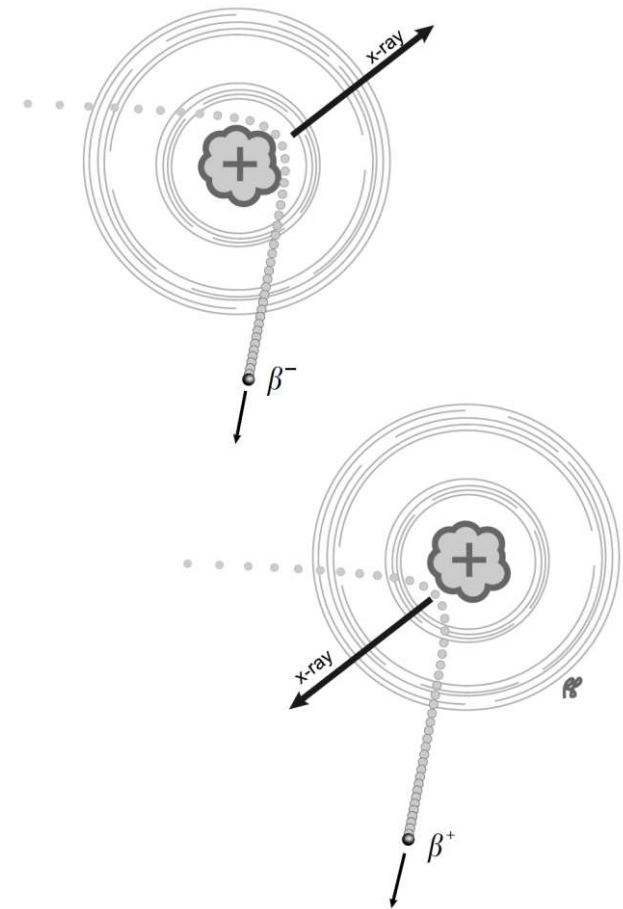
説明																		元素名稱		原子量		金属		非金属		稀有气体																																									
1																		2		13																		14		15		16		17		18																					
IA																		IIA		IIIA																		IVA		VA		VIA		VIIA		VIIIA																					
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18	
1																		2		3																		4		5		6		7		8		9		10		11		12													

釔 Yttrium-90

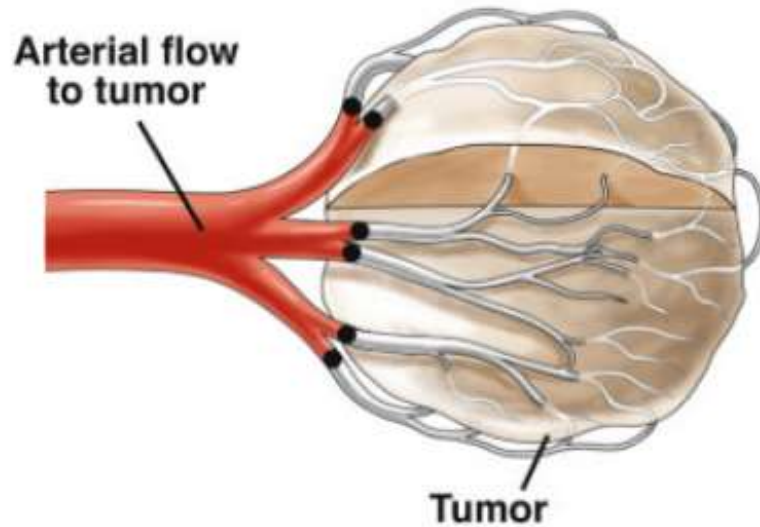
- Half-life: 64 h (2.7 d)
- β emission, No γ emission
- Maximum energy: 2.281 MeV
- Mean energy: 0.933 MeV
- Path length of 5 mm in soft tissue (about 100-200 cell diameters)
- $^{89}\text{Y}(n,\gamma)^{90}\text{Y}$, $^{90}\text{Sr}/^{90}\text{Y}$ generator



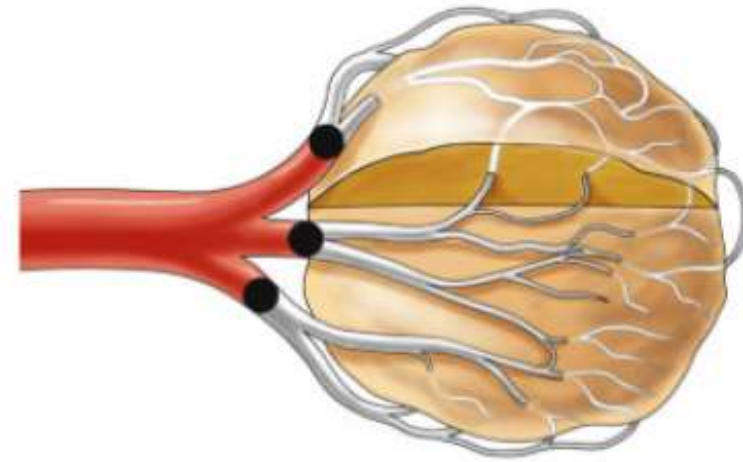
- 制動輻射(Bremsstrahlung): 50-390 keV
- 內成對發生效應: 511 keV



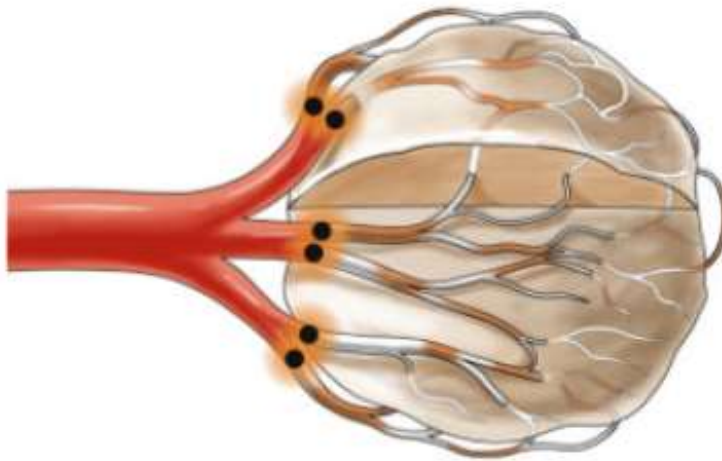
動脈栓塞
Arterial embolization
(TAE) 100-300 μm



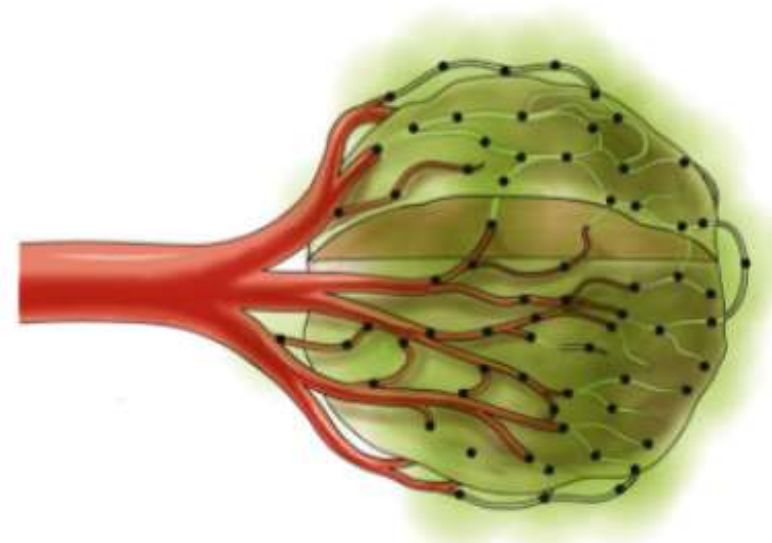
化學栓塞療法
Conventional chemoembolization
(cTACE) 300-500 μm



Drug-eluting bead chemoembolization
(DEB-TACE) 100-300 μm



Radioembolization
(TRE) 20-60 μm
放射性栓塞



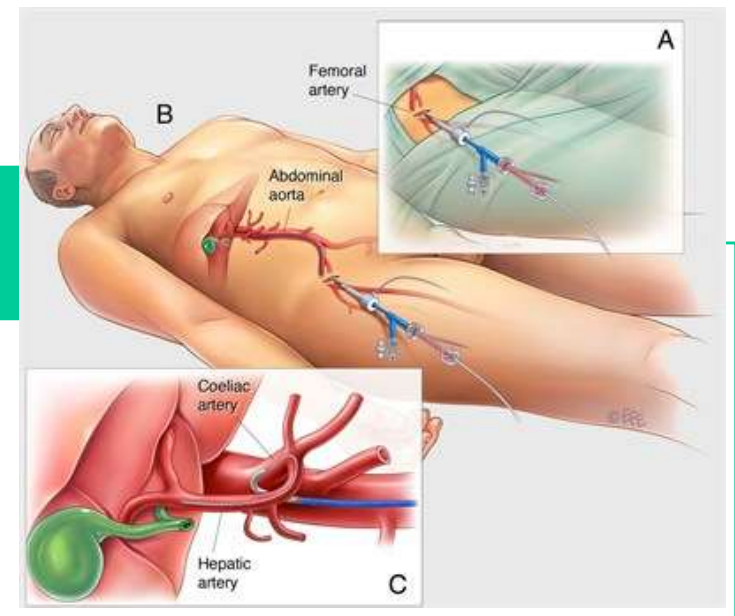
產品名稱	SIR-Spheres	TheraSphere
生產廠商、城市、國家	Sirtex Medical, Sydney, Australia	MDS Nordion, Ottawa, Canada
成份	樹脂	玻璃
Y-90微球生產	與樹脂結合，附著在球體表面	嵌入玻璃基質中
球體大小(μm)	20-60 (32.5 ± 2.5)	20-30 (25 ± 5)
每個微球活性(Bq)	40-70	2,500 (在參考時間)
每GBq的球體數量(百萬)	20 (平均)	0.4 (在參考時間)
保存期限(shelf-life)	1天	12天
比重(specific gravity)	低 (1.6 g/cc)	高 (3.6 g/cc)
栓塞效果	中等	輕微
可用活性(GBq)	3	3, 5, 7, 10, 15, 20
每瓶藥的球體數量(百萬)	40-80	1.2-8 (在校準時)

產品名稱	SIR-Spheres	TheraSphere
適應症	•美國：肝癌；美國以外(特別是歐洲和澳洲)：無法切除的肝臟腫瘤(肝癌和轉移) •大腸直腸轉移伴有肝內氟尿苷(floxuridine)等化學藥物治療效果不佳	•美國：大腸直腸癌；美國以外(特別是歐洲和澳洲)：肝癌和轉移 •肝癌伴有適當擺位的導管
配藥	需要	不需要
一藥瓶給兩個以上患者	可能	不可能
顯影劑導引藥物注射	需要	不需要
劑量計算	•Empirical •BSA •Partition or multi-compartmental method	•Mono-compartmental MIRD (partitional)
給藥途徑	經肝動脈導管 Hepatic ports (罕見)	經肝動脈導管
離院時的特殊輻防措施	可能有尿液汙染	無

肝癌/肝轉移

治療前 Tc-99m MAA

- 禁忌症: 肺分流 >20%. 門靜脈栓塞
- 胃腸分流: 胃. 十二指腸. 膽囊
- 腫瘤正常組織吸收比(T/N ratio)



治療 釷Y-90微球體

- 動脈導管. 緩慢注射
- 樹脂 SIR-Spheres: 3 GBq/81 mCi in 5-mL vial
- 玻璃 TheraSphere: 1.5-2.5 GBq/40-70 mCi

樹脂: 20-60 μm

玻璃: 20-30 μm

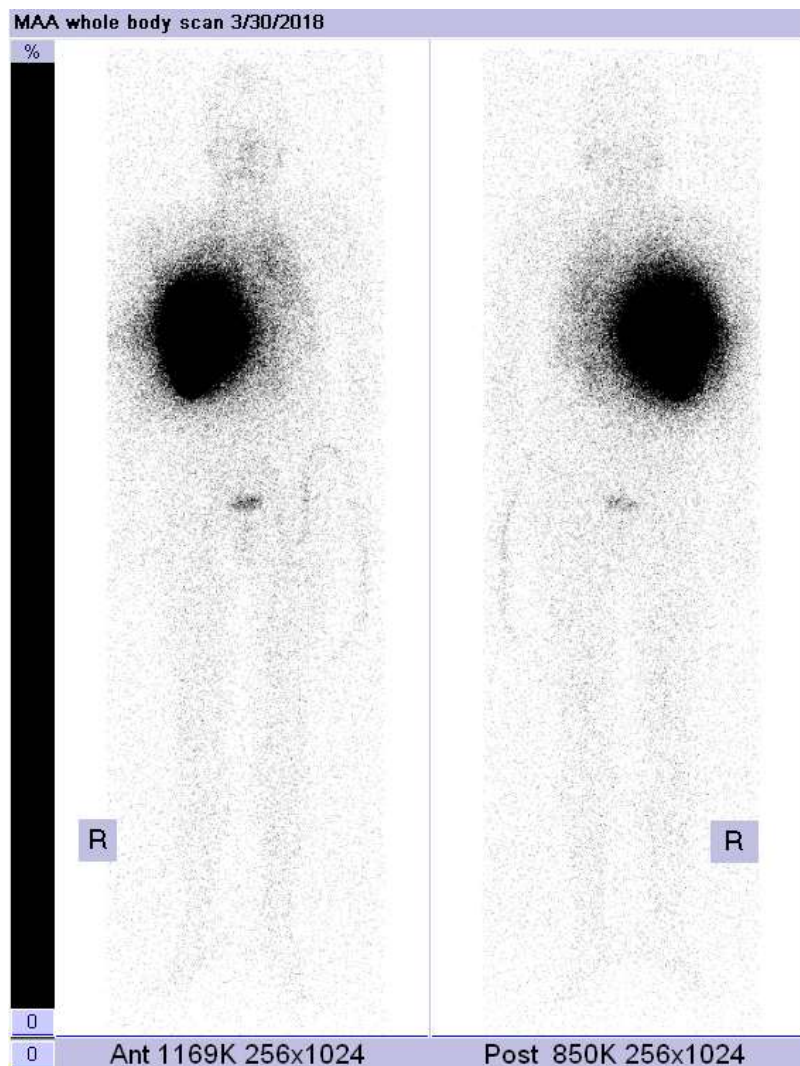
MAA: 10-90 μm

Sulfur colloid: 0.1-1 μm

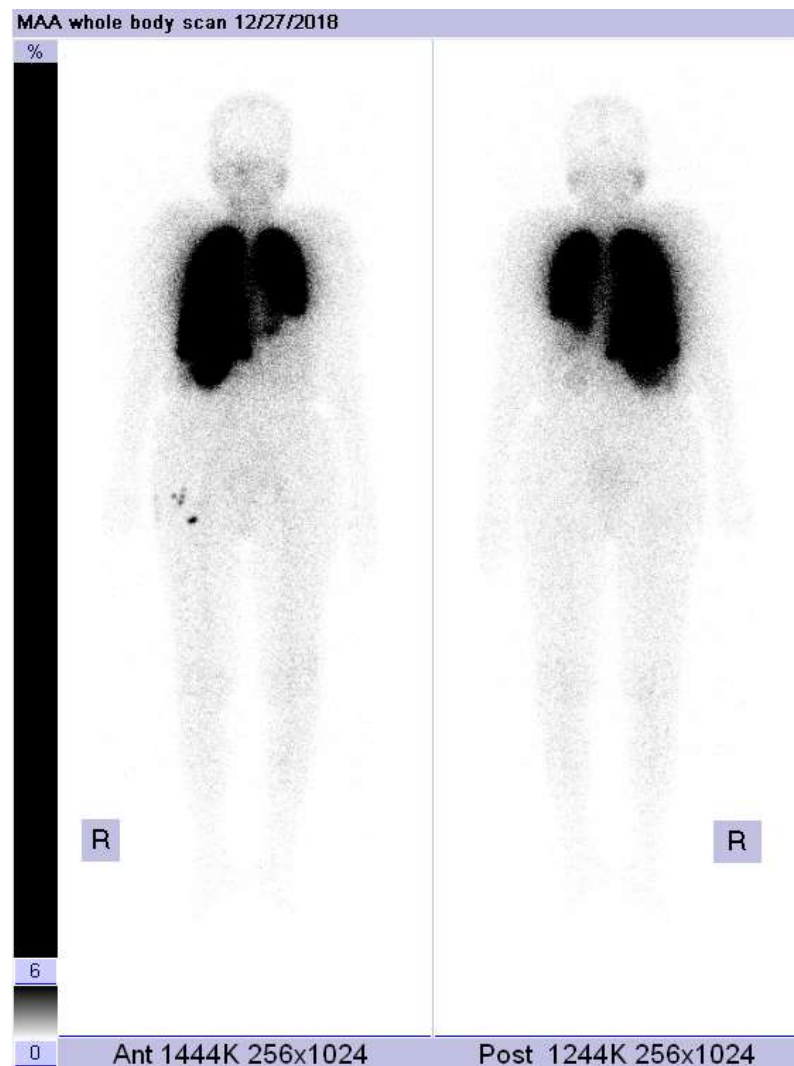
治療後

- 當天或隔天: SPECT/CT (制動輻射). PET/CT (內成對發生效應)
- 副作用: 噁心. 腹痛. 食慾降低. 疲累. 發燒

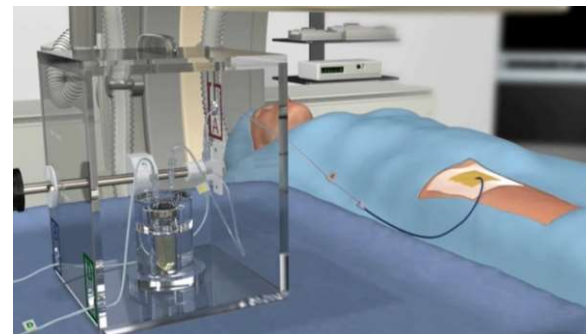
✓ 肺分流 1.52%



肺分流 >20% (59.75%)



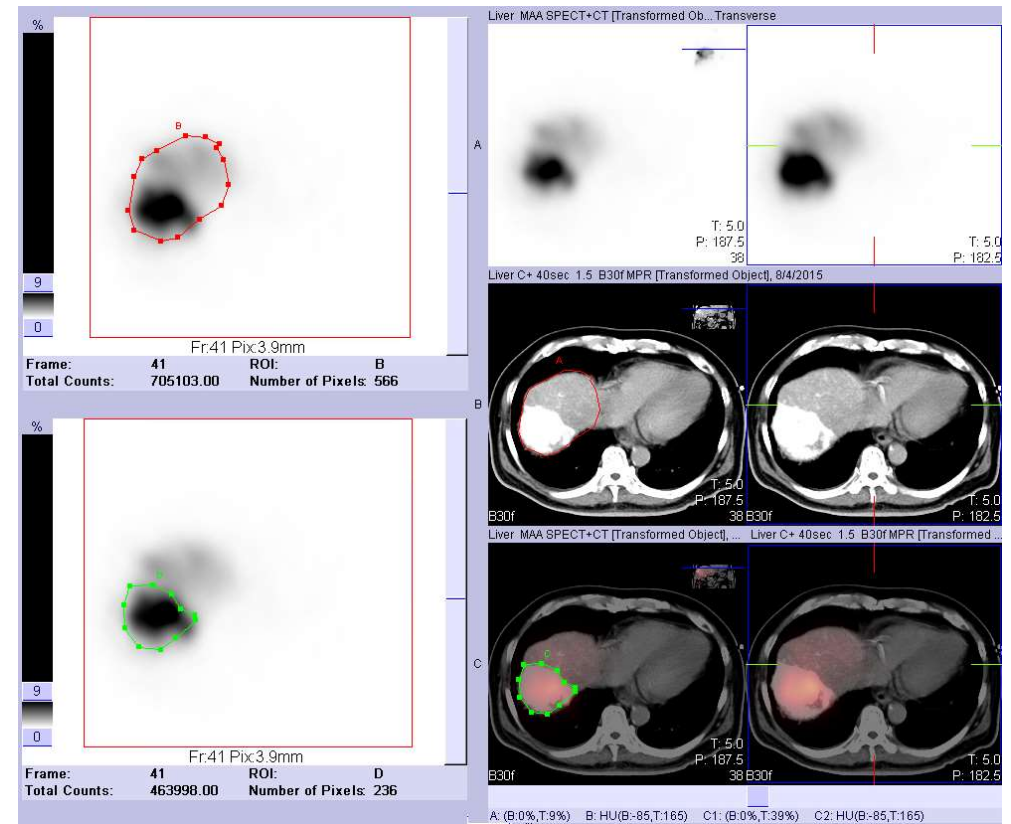
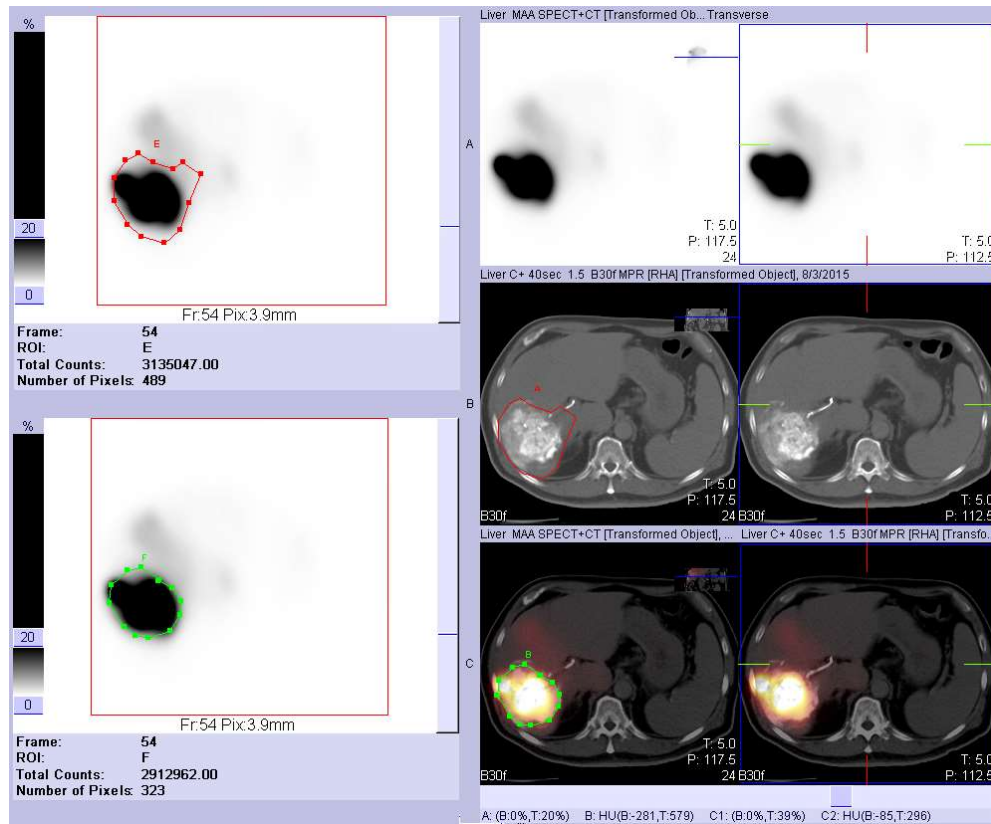
將樹脂微球由運送瓶取出(左)，以壓克力圓柱型套筒將樹脂微球由瓶內抽取出來，再置入執行治療瓶中(右)。



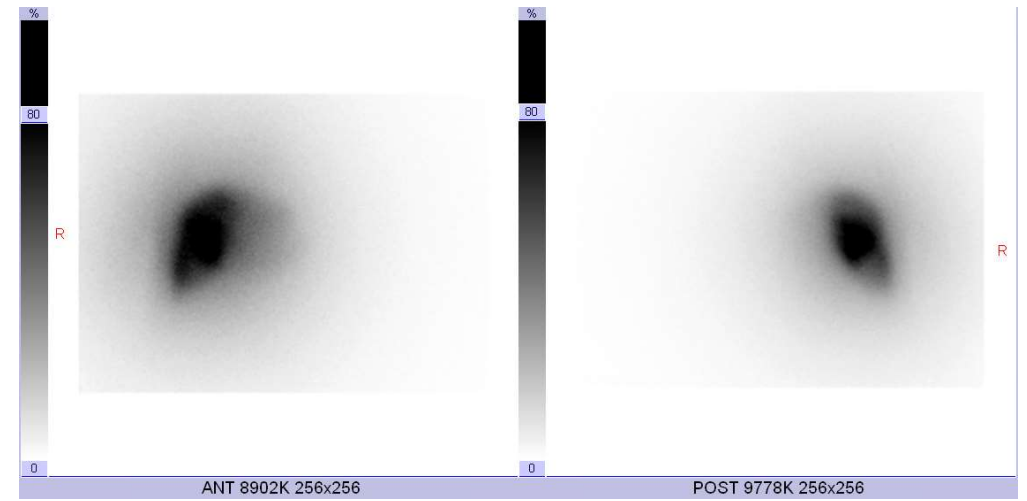
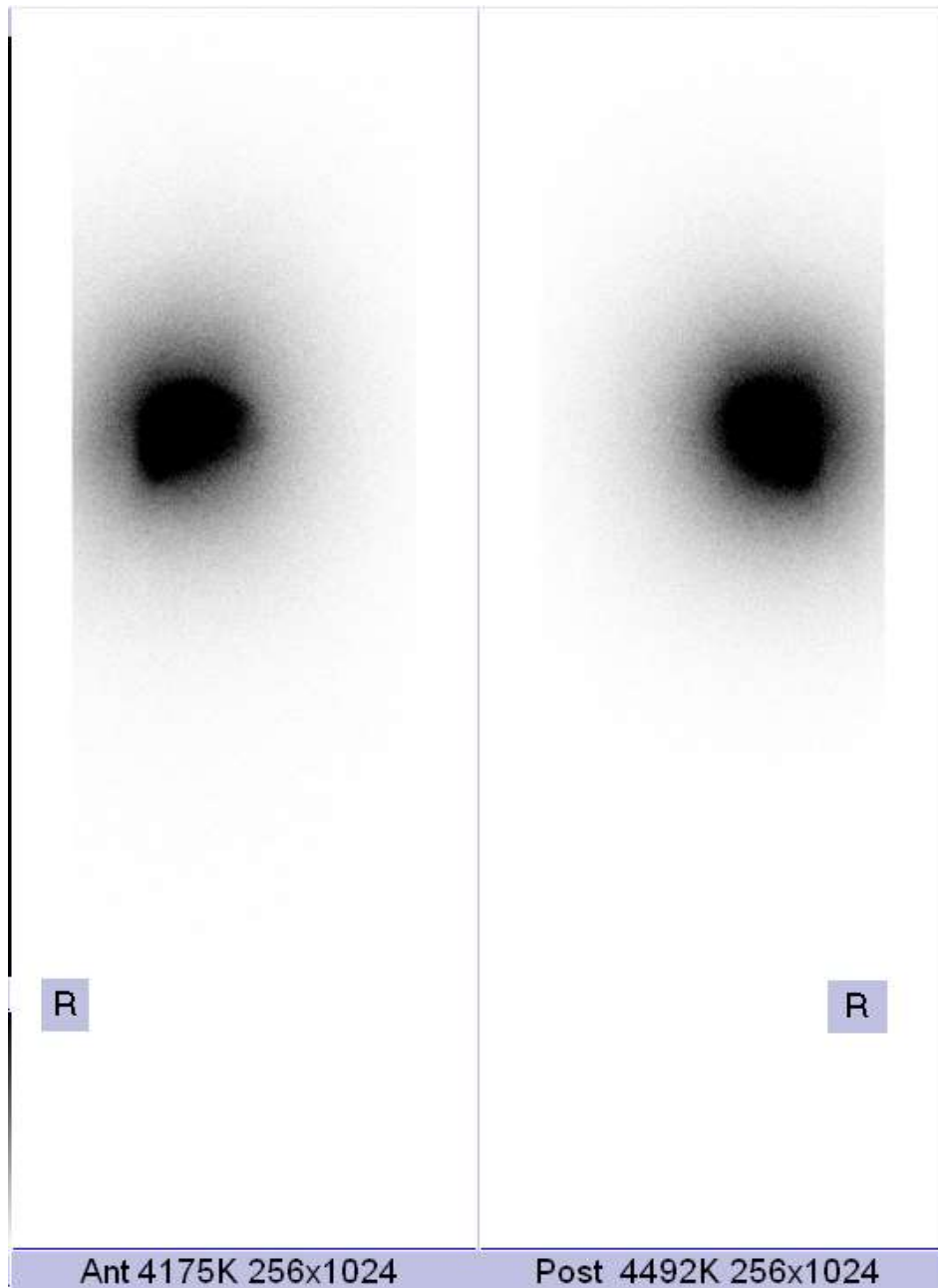
透過器械與生理食鹽水注射，將釷-90樹脂微球經由動脈導管注射進入肝臟腫瘤。

3.5 mCi

1.5 mCi

 $^{99m}\text{Tc-MAA}$ 

制動輻射(bremsstrahlung radiation)



制動輻射(bremsstrahlung radiation)

腫瘤正常組織吸收比(T/N ratio)

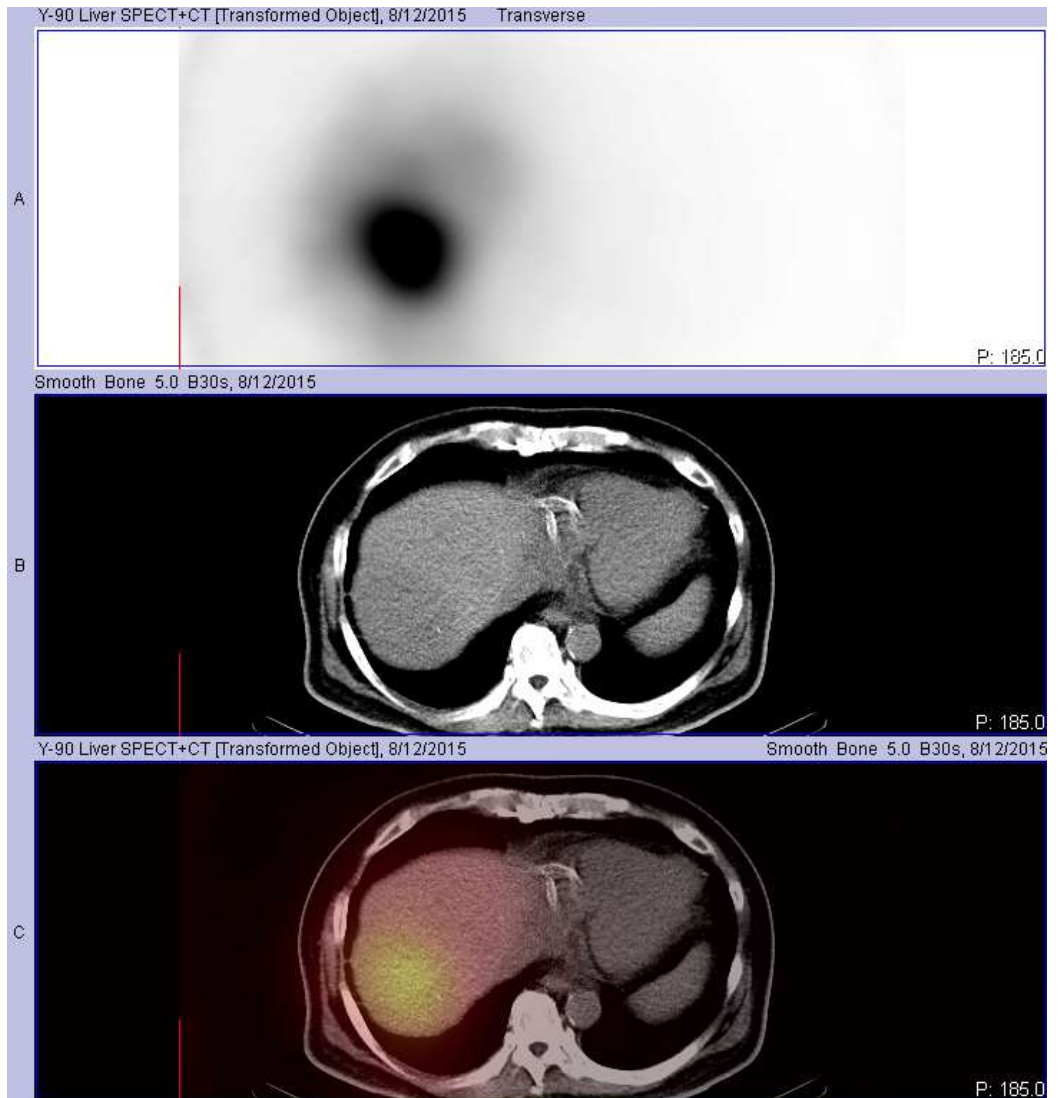
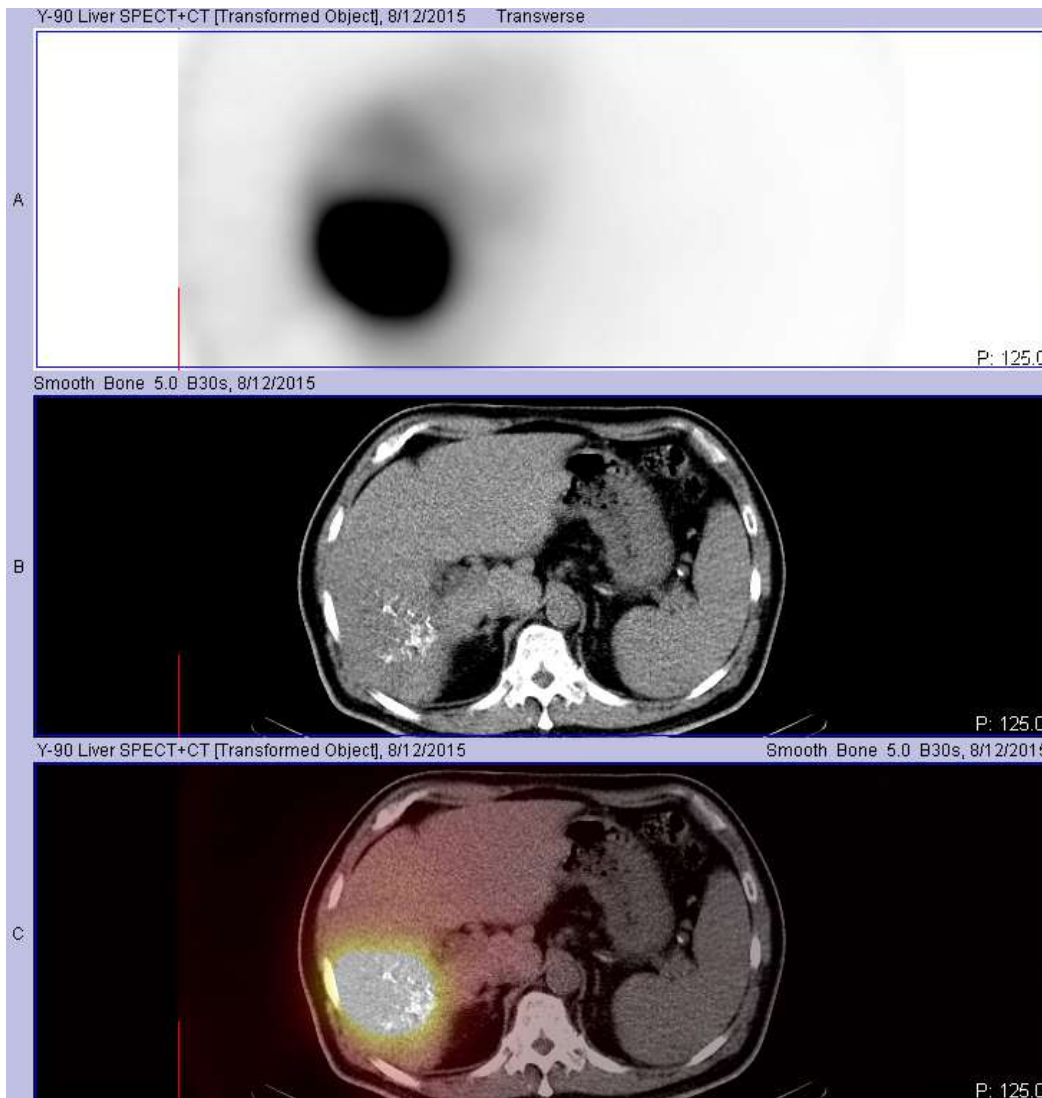
6.17 in RHA territory

1.9 GBq

Y-90 microsphere

3.26 in LHA territory

1.13 GBq



大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

釷Y-90/碘I-131單株抗體.淋巴瘤

治療後

造影追蹤.副作用

週 期 表

說明

原子序
元素符號
元素名稱
原子量

1H
1008
氫

氣體
液體
固體
人造元素

1 IA																		2 IIA										3 IIIB										4 IVB										5 VB										6 VIB										7 VIIB										8 VIIIB										9 VIIIB										10 VIIIB										11 IB										12 IIB										13 IIIA										14 IVA										15 VA										16 VIA										17 VIIA										18 VIIA																																																																																																																																											
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55										23 Zn 65.39										24 Ga 69.72										25 Ge 72.59										26 As 74.92										27 Se 78.96										28 Br 79.90										29 Kr 83.80										30 Xe 131.3										31 Rn (222)									
1 H 1.008																		2 Li 6.941										3 Na 22.99										4 K 39.10										5 Rb 85.47										6 Cs 132.9										7 Fr (223)										8 Be 9.012										9 Mg 24.31										10 Ca 40.08										11 Sr 87.62										12 Ba 137.3										13 Ra (226)										14 Sc 44.96										15 Ti 47.88										16 V 50.94										17 Cr 52.00										18 Mn 54.94										19 Fe 55.85										20 Co 58.93										21 Ni 58.69										22 Cu 63.55																																																																																																			

治療前 In-111 ibritumomab tiuxetan/I-131 tositumomab

- Ritumomab / **SSKI** + Tositumomab
- Y-90 ibritumomab tiuxetan: $\text{ANC} \geq 1.5 \times 10^9/\text{L}$. $\text{PLT} \geq 100$ or $150 \times 10^9/\text{L}$
- I-131 tositumomab: $\text{PLT} \geq 100$ or $150 \times 10^9/\text{L}$

治療 釷Y-90/碘I-131單株抗體

- 靜脈注射
- 釷 Y-90 ibritumomab tiuxetan (Zevalin): 0.3 or 0.4 mCi/kg (>10 min)
- 碘 I-131 tositumomab (Bexxar): 65 or 75 cGy

治療後

- 血小板低下/嗜中性白血球低下(90%)
- 無力(35%).噁心(25%).顫抖(20%)

- ^{111}In -ibritumomab tiuxetan (Zevalin) dosimetry images (72-hour postinjection)

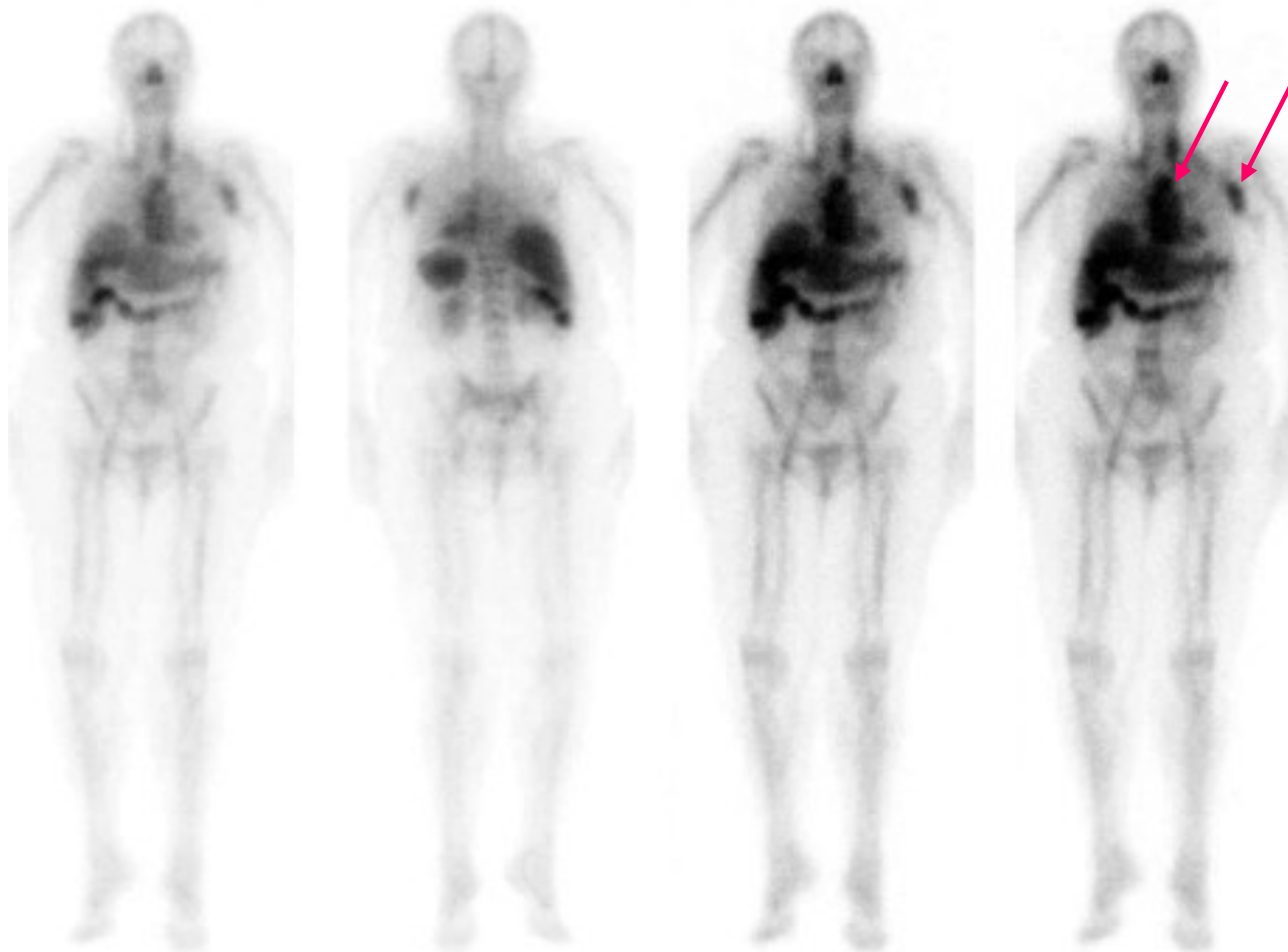
1. **Tumor activity**

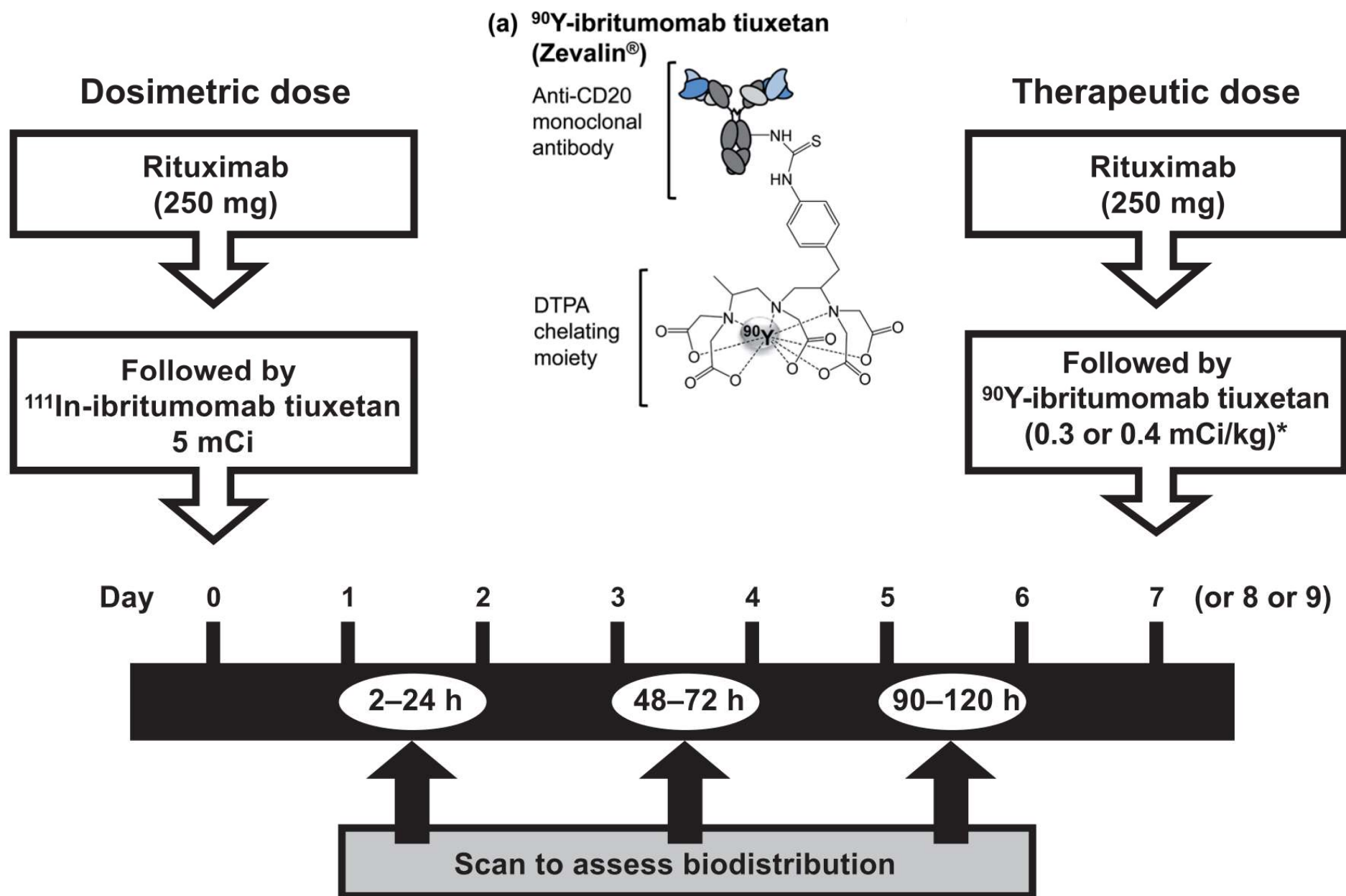
2. Expected activity: (1) moderately high: liver/spleen

- (2) low or very low: kidneys/bladder/bowel

3. **Unacceptable activity:** (1) diffuse lung $>^{D1}$ cardiac blood pool

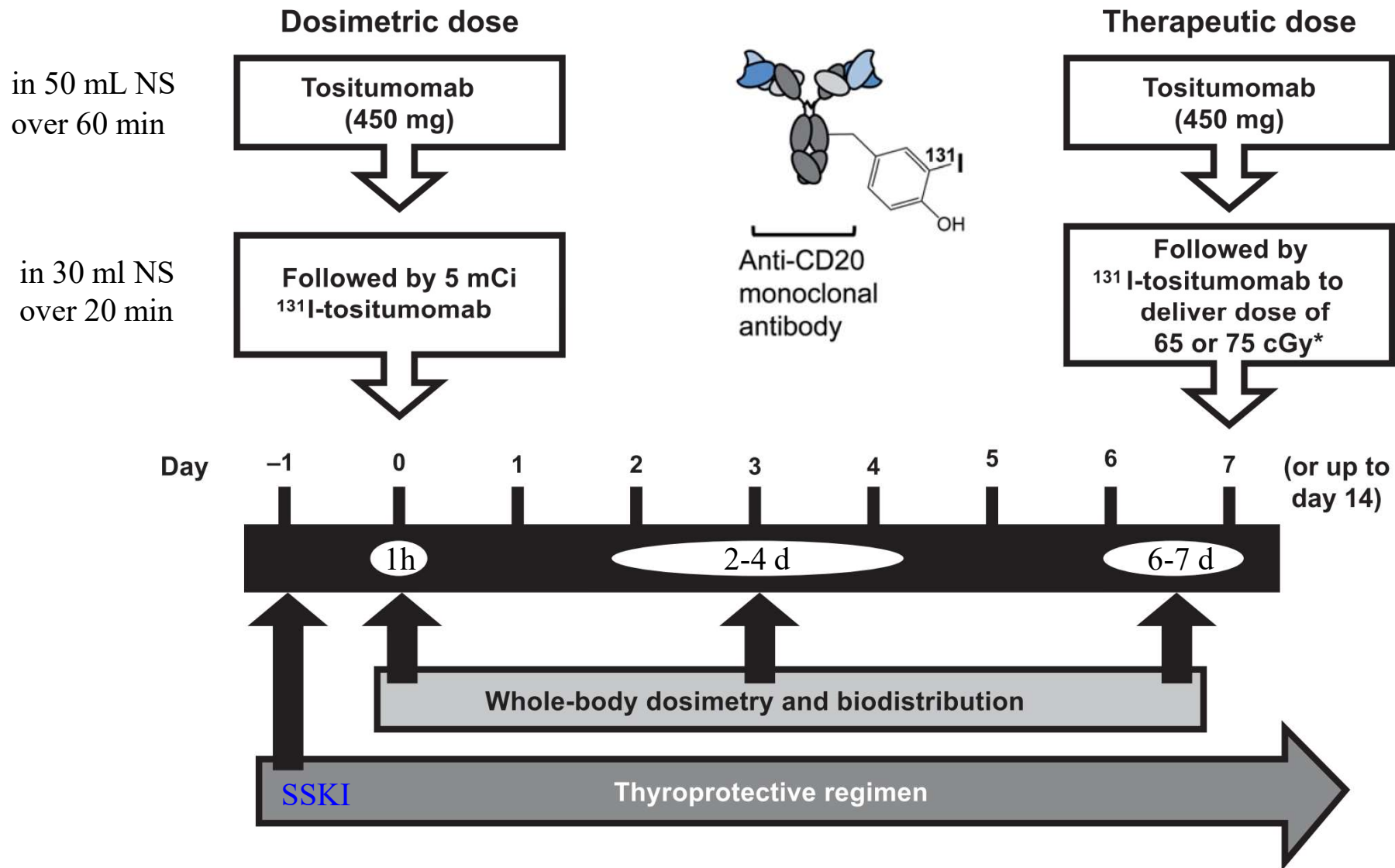
- (2) diffuse lung/kidney/intense bowel $>^{D2/3}$ liver





* 0.4 mCi/kg in patients with a platelet count $\geq 150 \times 10^9/\text{L}$ or 0.3 mCi/kg with a platelet count 100×10^9 to $149 \times 10^9/\text{L}$. Maximum total dose is 32 mCi.

**(b) ^{131}I -tositumomab
(Bexxar[®])**



* 75 cGy in patients with a platelet count $\geq 150 \times 10^9/\text{L}$ or 65 cGy with a platelet count $100 \times 10^9/\text{L}$ to $149 \times 10^9/\text{L}$.

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

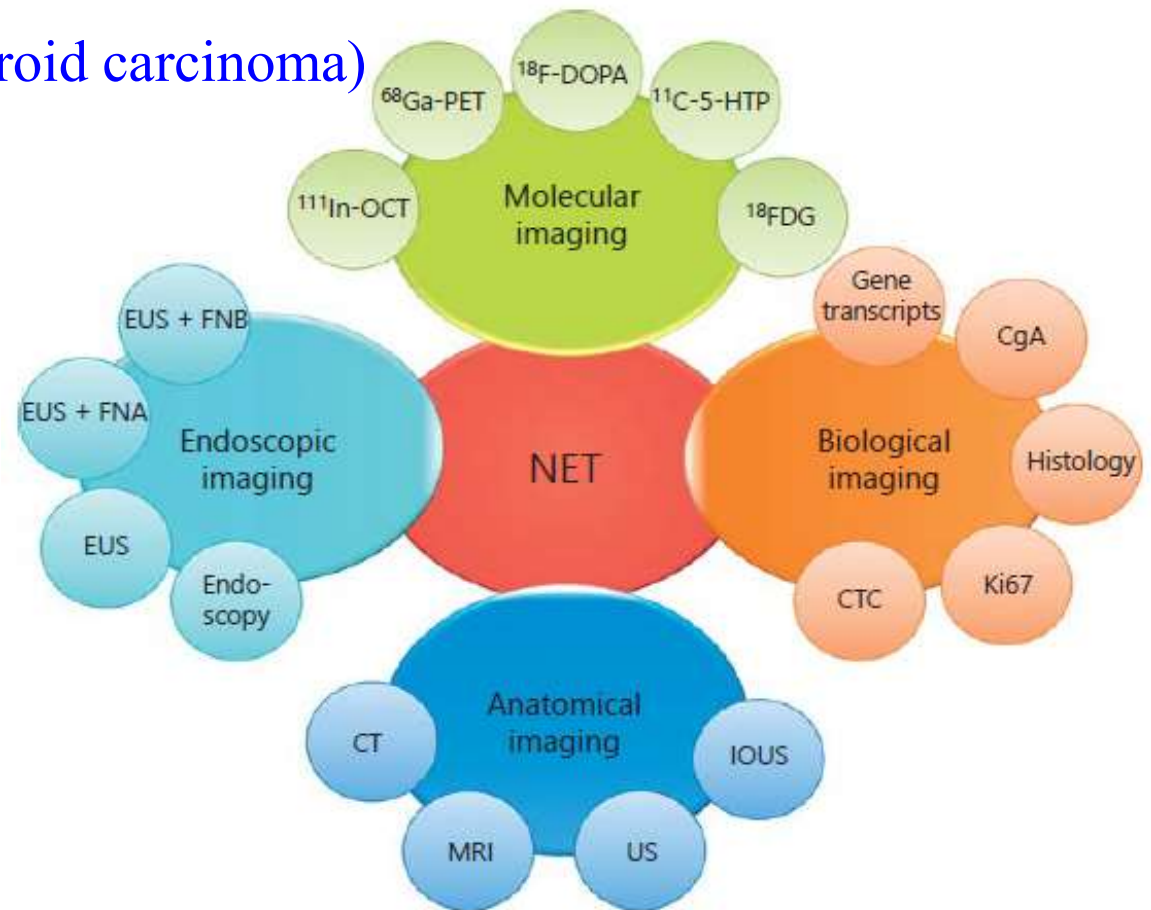
碘I-131 MIBG/鎳Lu-177 DOTA-TATE.神經內分泌瘤

治療後

造影追蹤.副作用

神經內分泌瘤 (neuroendocrine tumor, NET)

- 嗜鉻性細胞瘤 (pheochromocytoma)
- 神經母細胞瘤 (neuroblastoma)
- 副神經節瘤 (paraganglioma)
- 類癌瘤 (carcinoid tumor)
- 甲狀腺髓質癌 (medullary thyroid carcinoma)



週 期 表

說明

原子序
元素符號
元素名稱
原子量

1H
1008
氫

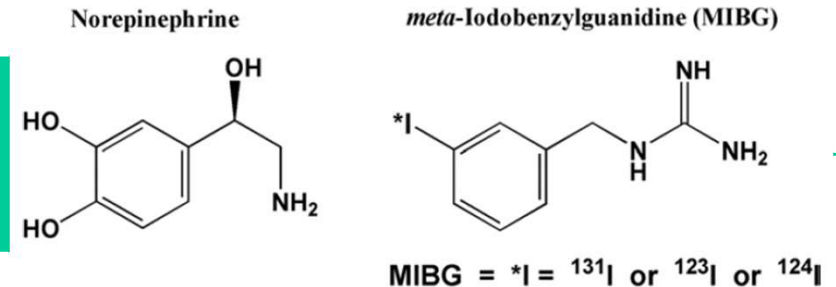
氣體
液體
固體
人造元素

説明																		元素名稱		原子量		金屬		非金屬		惰性氣體																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
1 IA		2 IIA		過渡元素										13 IIIA		14 IVA		15 VA		16 VIA		17 VIIA		18 VIIIA																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
1 氫 1008		2 鋰 6941	3 鈹 9012																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															</

神經內分泌瘤

治療前 I-131/I-123 MIBG (腎上腺髓質)

- Lugol's solution 或 SSKI (治療前2-3天)
- 1.2-2.2 mCi/10.8 mCi. 緩慢靜脈注射(>5 min). 48 hr & 72 hr 造影



治療 I-131 MIBG (Azedra/Generic)

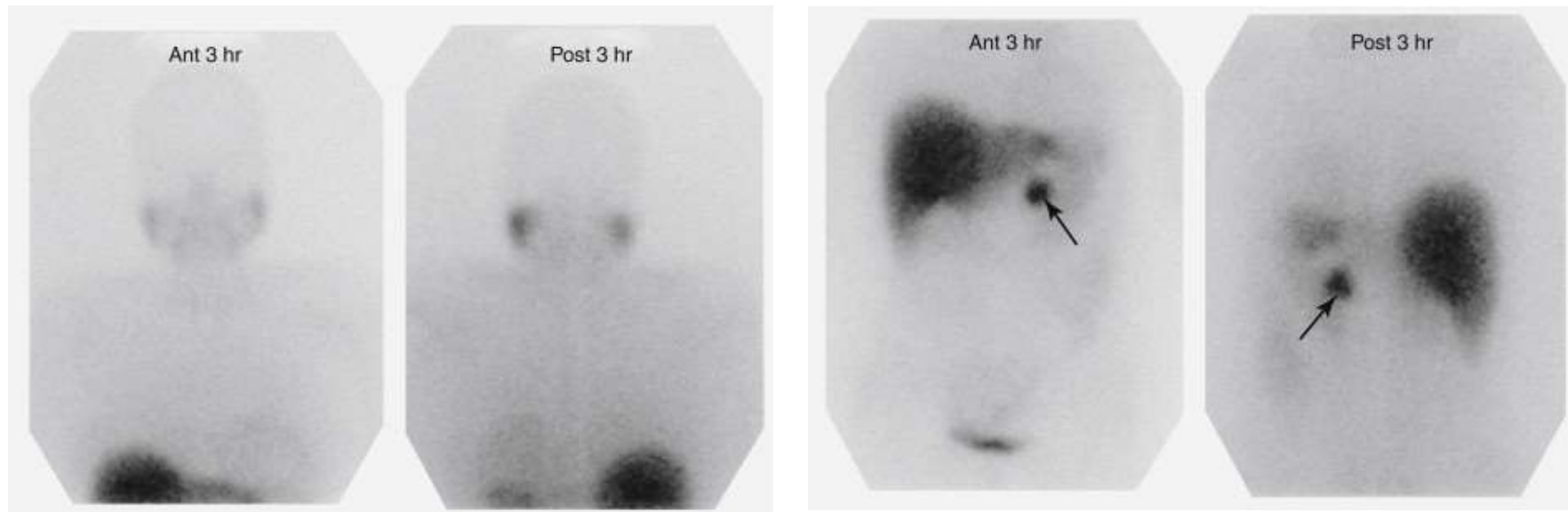
- 100-300 mCi
- 緩慢靜脈注射(45 min ~ 4 hr)

Norepinephrine analog
正腎上腺素類似物

治療後

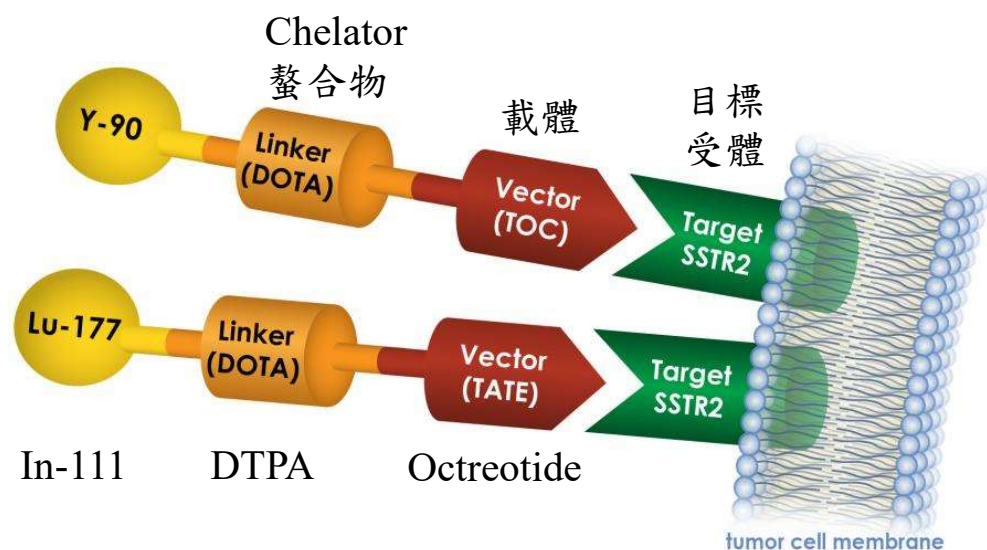
- 早期副作用: 噁心. 嘔吐. 短暫骨髓抑制. 腎功能變差. 血壓不穩定
- 晚期副作用: 甲狀腺功能低下. 持續骨髓抑制. 白血病或其他癌症

^{123}I -MIBG (造影)



鎳 Lutetium-177

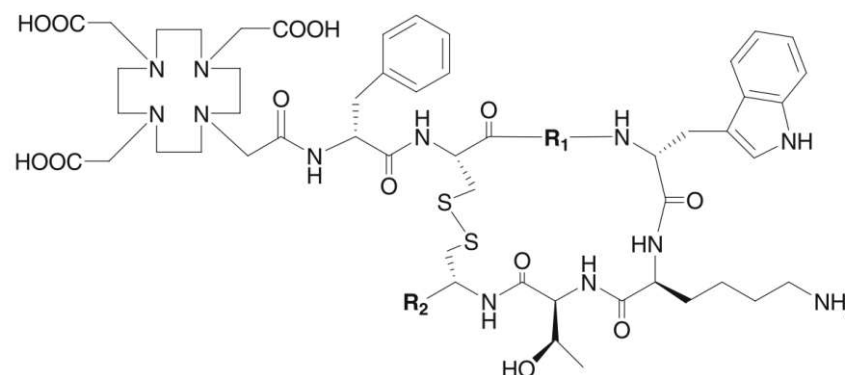
- Half-life: 6.647 days
- γ emission
113 keV (6.2%), 208 keV (11%)
- β emission (79.3%)
- Maximum energy: 0.497 MeV
- Mean energy: 0.13 MeV



胜肽受體放射性核種治療
Peptide receptor radionuclide therapy (PRRT)

Somatostatin analogs (體抑素類似物)

Somatostatin receptor (SSTR)



<i>Compound</i>	R₁	R₂
DOTA-OC	Phe	Thr(ol)
DOTA-TOC	Tyr	Thr(ol)
DOTA-TATE	Tyr	Thr
DOTA-NOC	Nal-1	Thr(ol)
DOTA-NOC-ATE	Nal-1	Thr
DOTA-BOC	BzThi	Thr(ol)
DOTA-BOC-ATE	BzThi	Thr

治療前 **In-111 pentetreotide. Ga-68 DOTA-TATE. Ga-68 DOTA-TOC**

- ANC <2000/mm³, PLT <75x10³/mm³, Hb <8 g/dl
- Albumin <30 g/L, Bilirubin >upper limit x3, CCr <50 ml/min

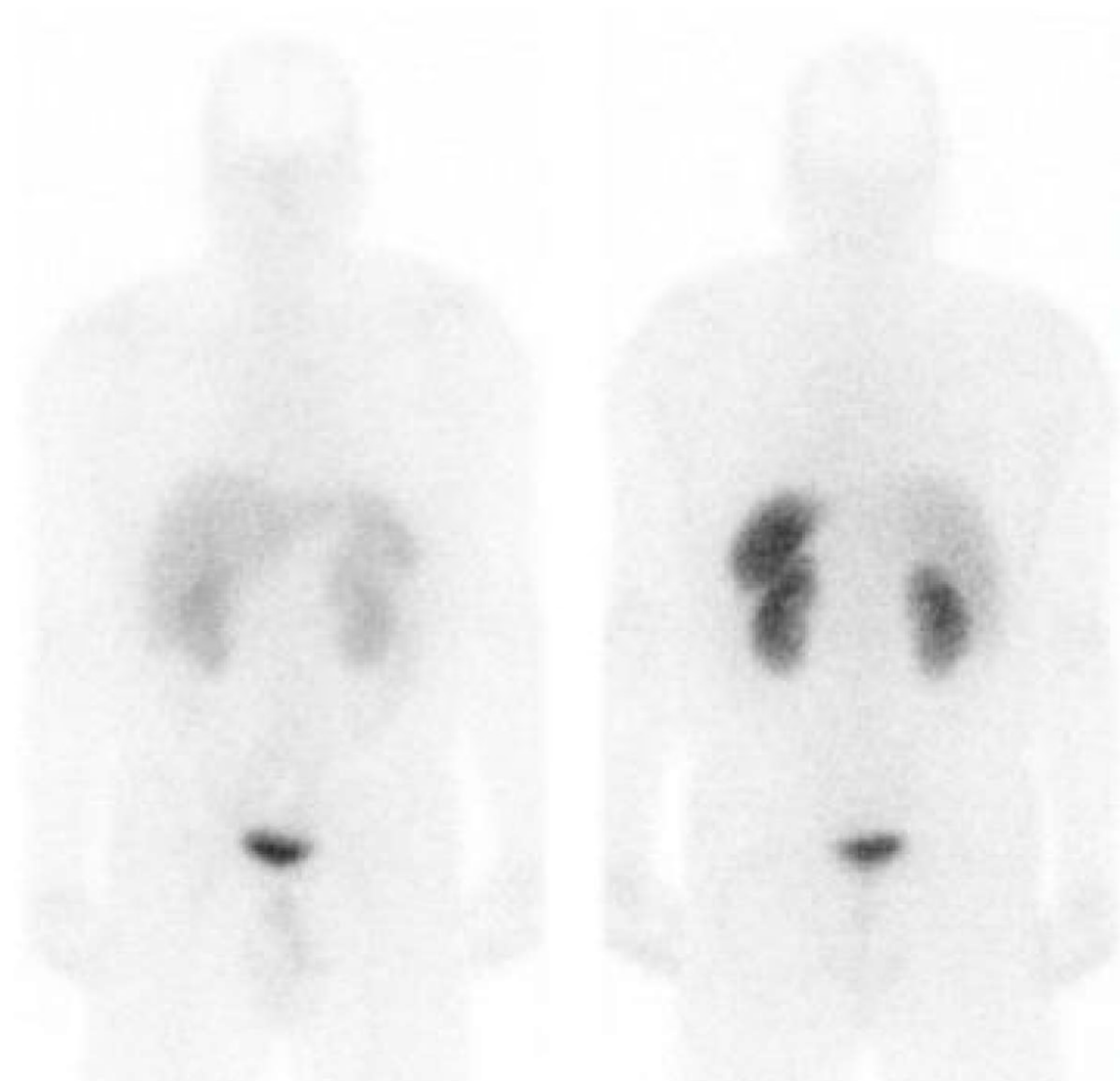
治療 **Lu-177 DOTA-TATE (Lutathera)**

- 200 mCi
- 靜脈注射.每隔8週給予.共4劑

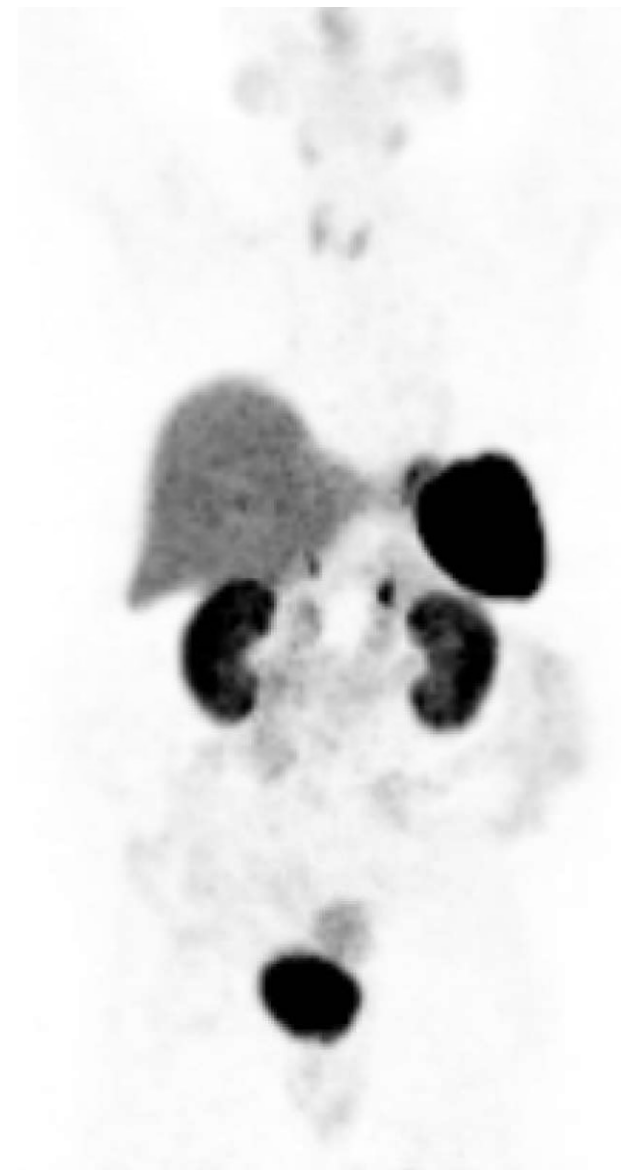
治療後

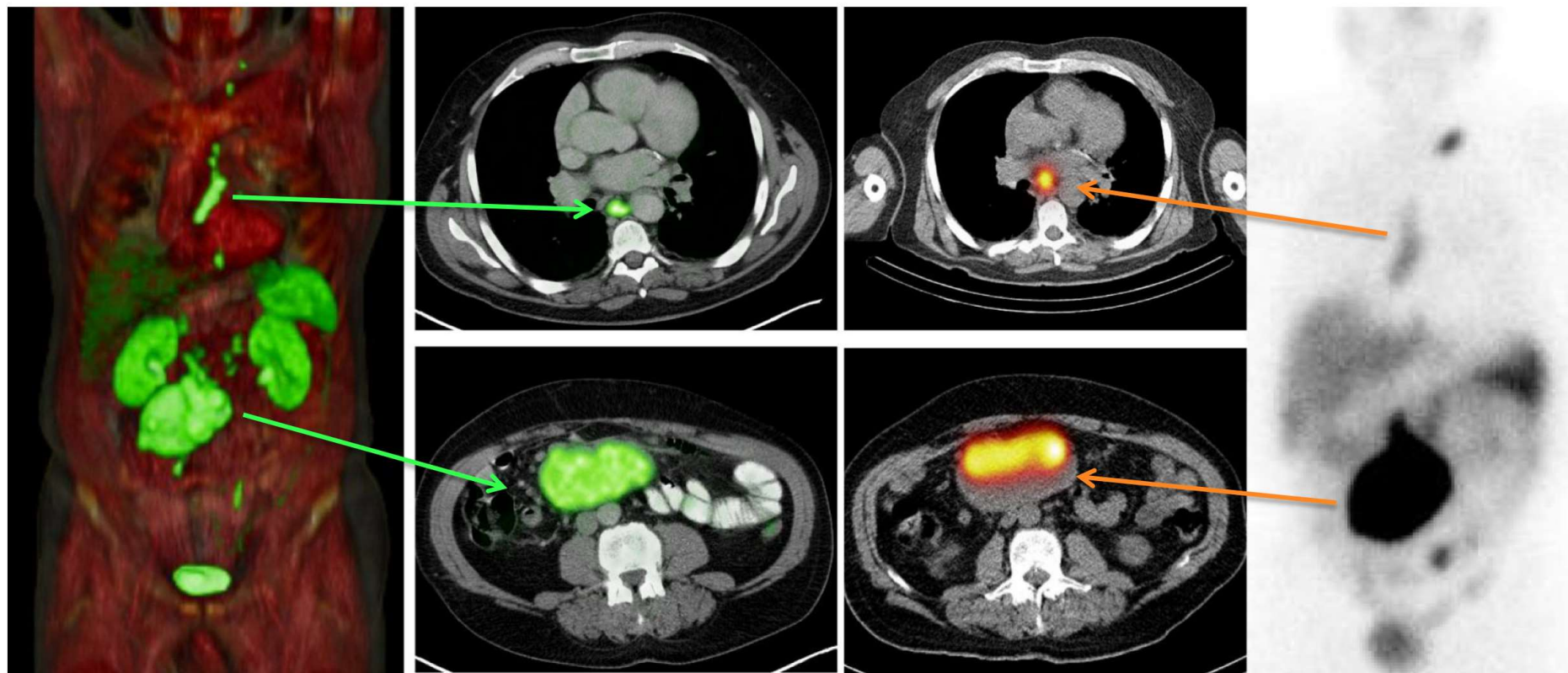
- 血小板低下(25%).淋巴球低下(22.3%).貧血(13.4%).全血球減少(10.2%)
- 無力(27.7%).食慾降低(13.4%)

In-111 pentetreotide (OctreoScan)
2 day protocol (4hr & 24 hr)



Ga-68 DOTA-TATE (NETSPOT)
1 day protocol (2hr)





^{68}Ga -DOTATOC
Diagnosis



^{177}Lu -DOTATOC
Therapy

(SomaKit TOC)

17 y/o man

2016嗜鉻性細胞瘤→手術

2020副神經節瘤→手術

多處轉移(骨頭,淋巴,肝臟)→R/T, C/T, Lu-177 DOTATATE

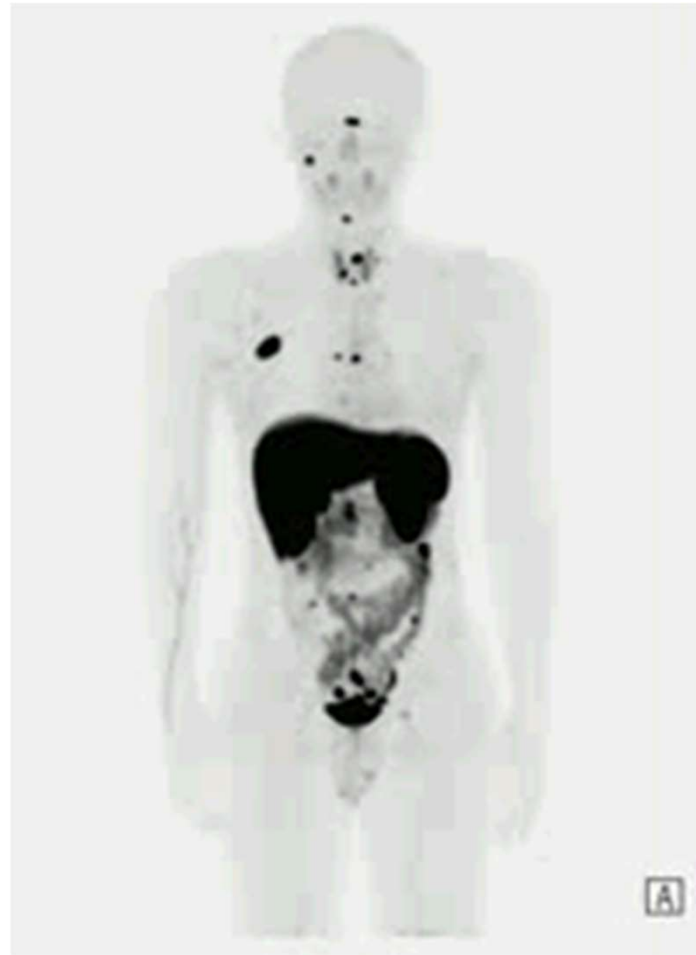
2021-08-19

F-18 FDG PET/CT



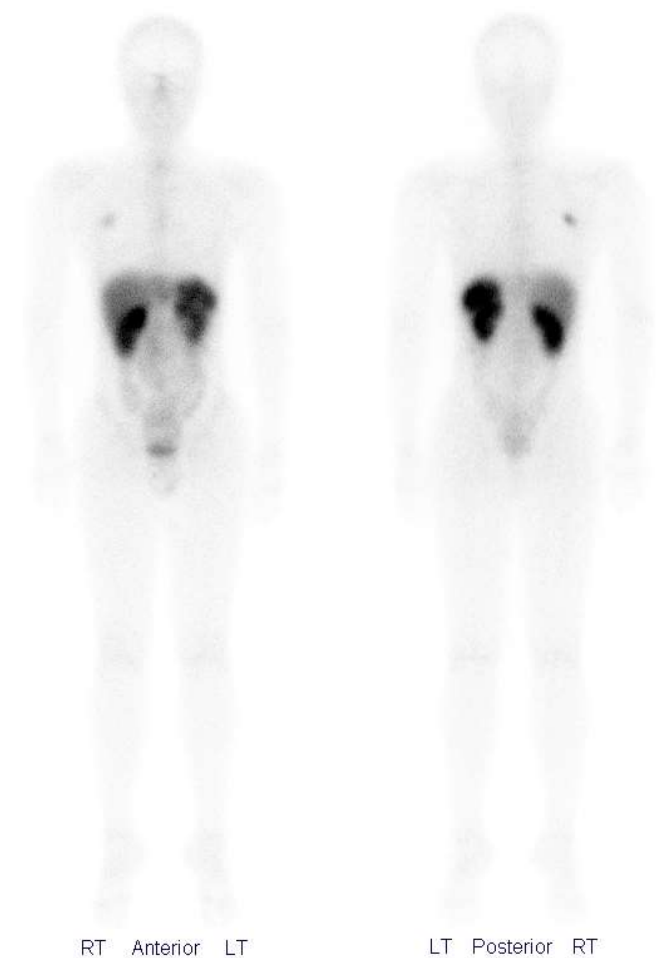
2021-09-15

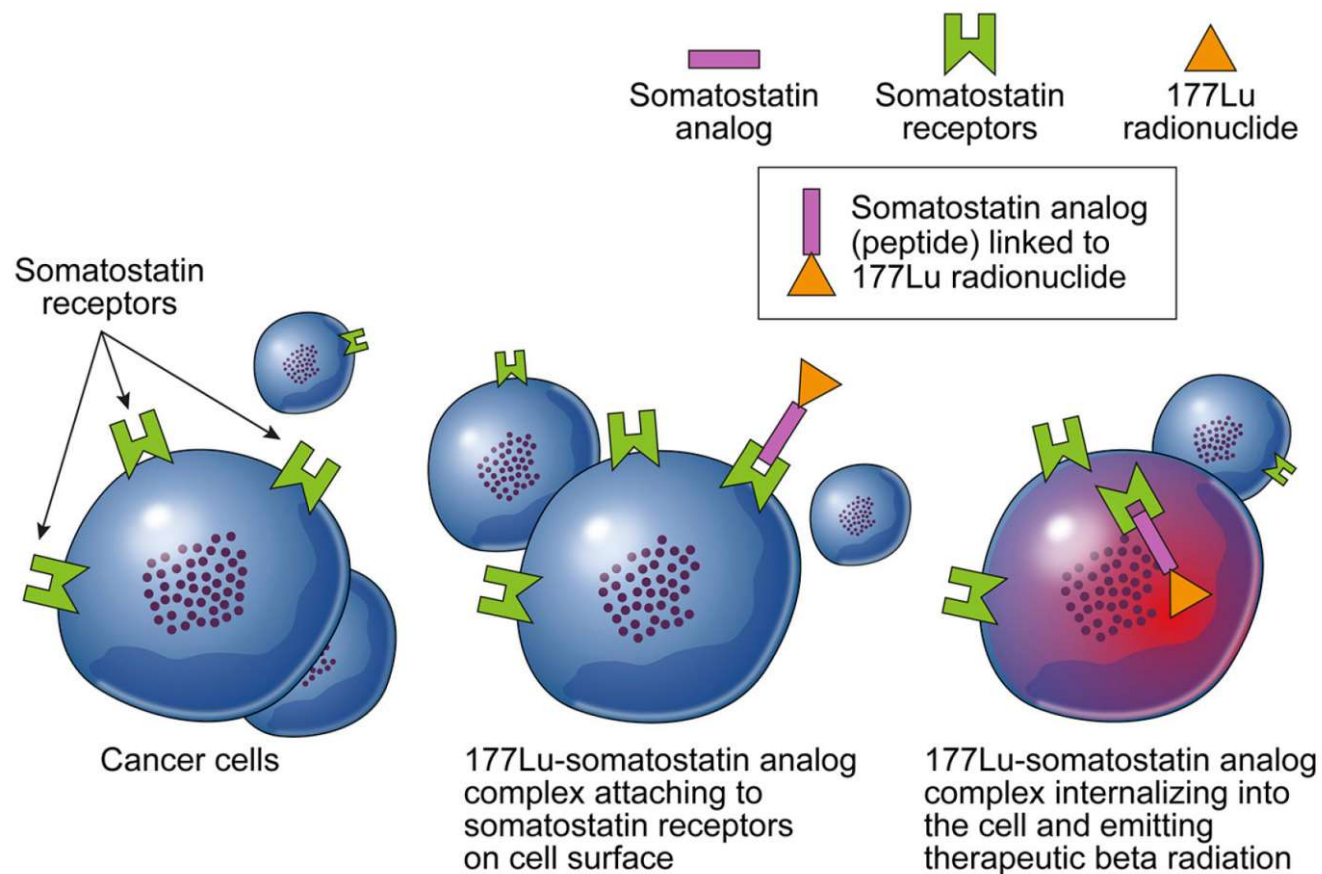
Ga-68 DOTATOC



2021-11-23

Lu-177 DOTATATE





Administered agents	Start time (min)	Infusion rate (mL/h)	Duration
Antiemetic	0	-	bolus
Amino acid solution, either extemporaneously compounded (1 L) or commercial (1.5 L to 2.2 L)	30	250 – 550 (not < 320 mL/h for commercial solutions)	4 hours
Lutathera with sodium chloride 9 mg/mL (0.9%) solution for injection	60	400	20 to 30 minutes

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

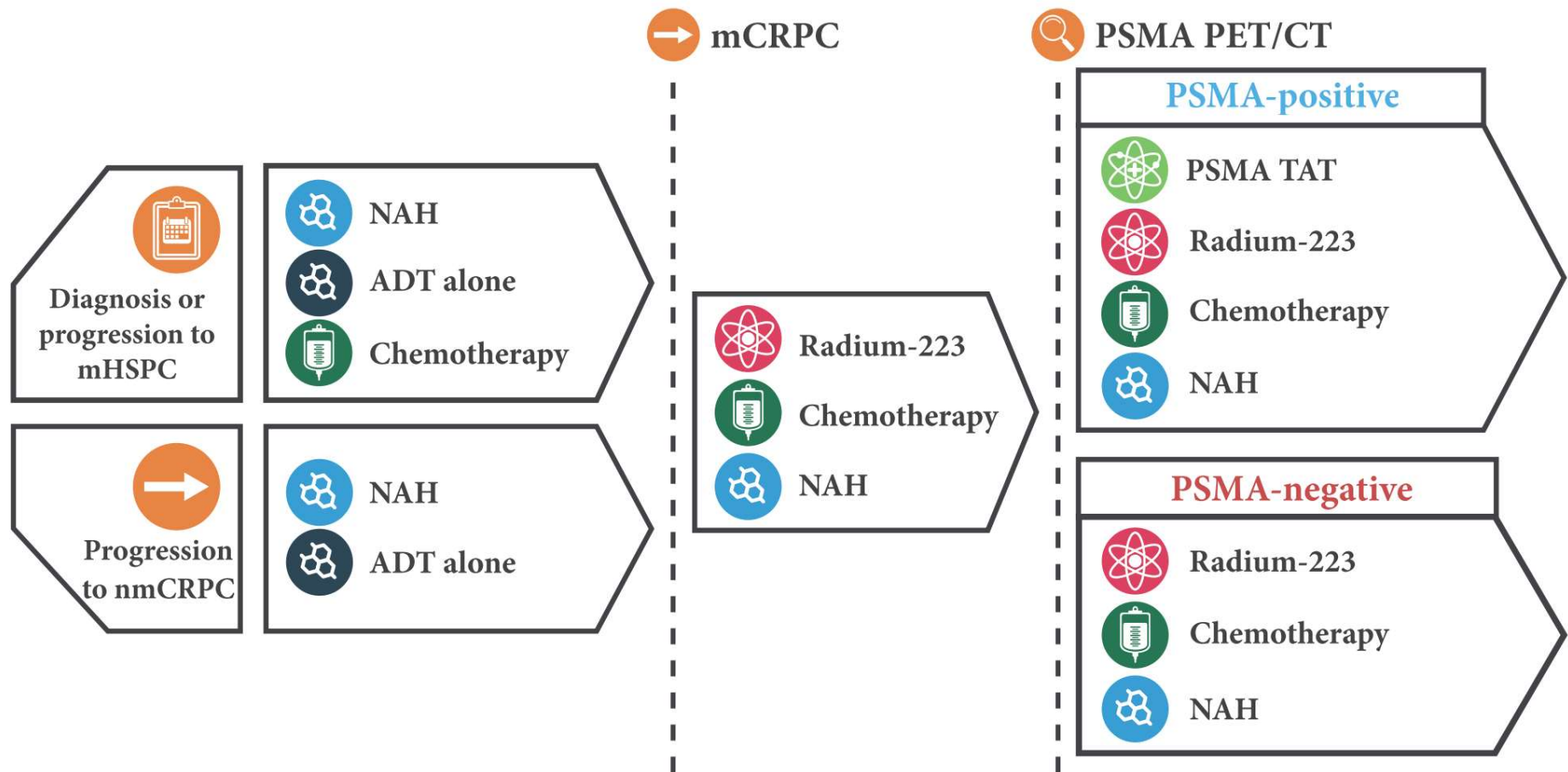
造影評估.準備

治療

放射核種.疾病

治療後

造影追蹤.副作用



治療前 Ga-68 PSMA-11 (gozetotide, Locametz)

- Ga-68 PSMA I&T
- F-18 DCFPyL (Piflufolastat, Pylarify), rhPSMA-7.3, PSMA-1007
- [F-18 Fluciclovine (FACBC, Axumin)]

治療 Lu-177 PSMA (Pluvicto)

- 200 mCi.靜脈注射.每隔6週給予.共6劑
- Bi-213 PSMA-617, Ac-225 PSMA-617
- At-211 PSMA-pentanedioic acid, Th-227 PSMA-IgG1

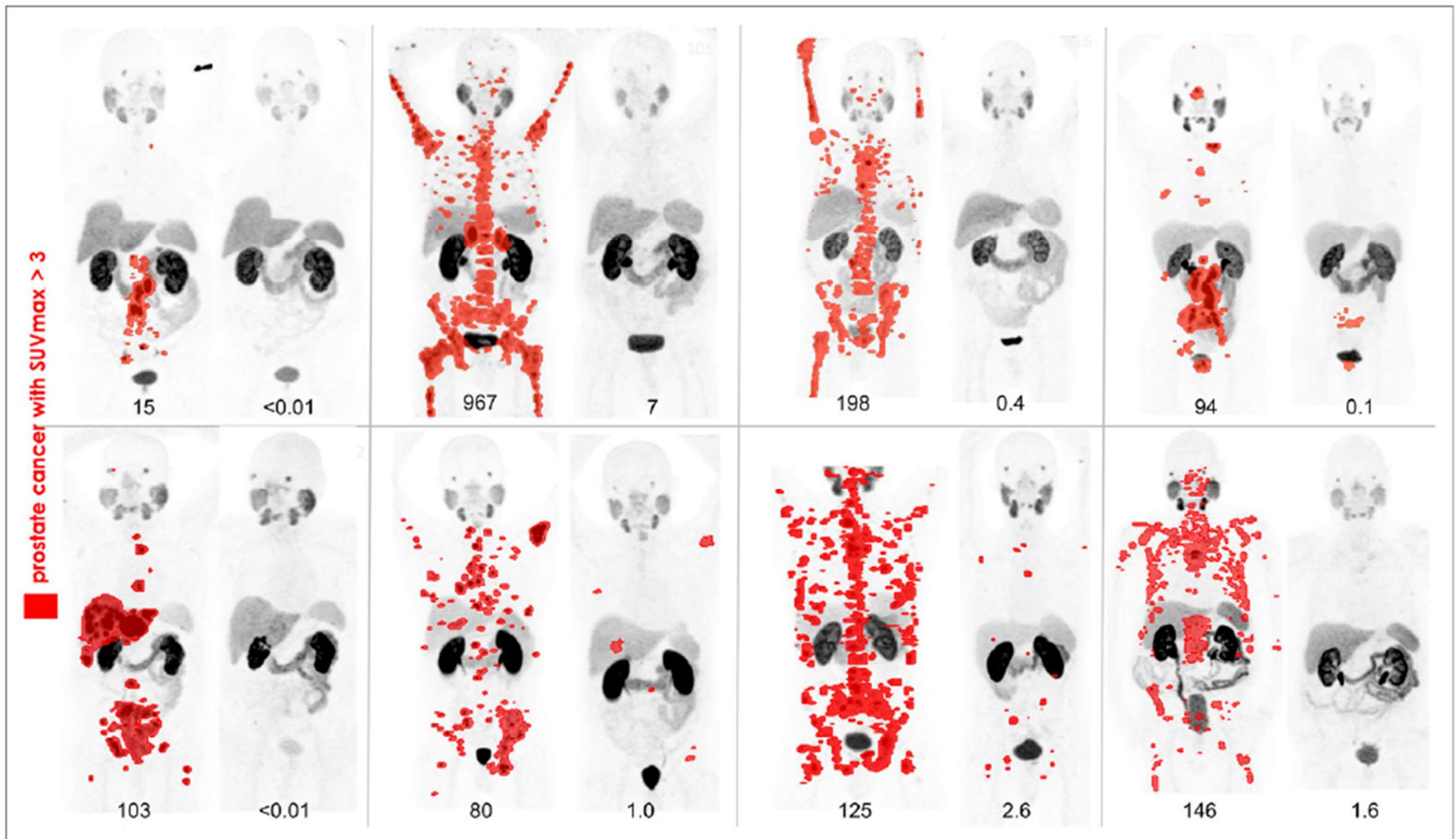
治療後

- PSA



Fig. 1 Normal body distribution of PSMA-ligands. [^{68}Ga]Ga-PSMA-11, [^{68}Ga]Ga-PSMA-I&T, [^{18}F]F-DCFPyL, and [^{18}F]F-rhPSMA-7.3 applications lead to notable kidney uptake. Bladder retention is high for [^{68}Ga]Ga-PSMA-11, [^{68}Ga]Ga-PSMA-I&T, and [^{18}F]F-DCFPyL and lower for [^{18}F]F-rhPSMA-7.3. Reference organs for ligands with kidney-dominant excretion are liver and parotid

gland. [^{18}F]F-PSMA-1007 leads to high liver uptake due to hepatic excretion. Reference organs for ligands with liver excretion are spleen and parotid gland. Focal uptake in the pelvic bone is noted on the [^{18}F]F-rhPSMA-7.3 PET corresponding to metastatic disease. [^{68}Ga]Ga-PSMA-I&T subpart was modified with permission from [130]



2018 SNMMI Image of the Year: PET imaging before and after ^{177}Lu -PSMA617 therapy for metastatic prostate cancer. ^{68}Ga -PSMA11 PET maximum-intensity projection images at baseline and 3 months after ^{177}Lu -PSMA617 treatment in 8 patients who experienced prostate-specific antigen declines of $\geq 98\%$ in a prospective phase II study. Red = disease with SUV > 3. Used with permission from Hofman et al. from the Peter MacCallum Cancer Centre (Melbourne, Australia).

大綱

簡介

1. 甲狀腺疾病
2. 骨骼疾病
3. 肝臟疾病
4. 淋巴疾病
5. 神經內分泌疾病
6. 攝護腺癌

總結

治療前

造影評估.準備

治療

放射核種.疾病

治療後

造影追蹤.副作用

1. 甲狀腺癌/機能亢進/腫大 (Thyroid cancer & hyperthyroidism)

- 碘 I-131

2. 骨轉移 (Bony metastasis)

- 鐳 Ra-223, 銻 Sr-89, 釷 Sm-153, 釷 Re-186/Re-188, 錫 Sn-117m
- 磷 P-32: 真性紅血球增多症(polycythemia vera)

3. 肝癌/肝轉移 (Hepatoma & liver metastasis)

- 釷 Y-90 微球體 (SIR-Spheres/TheraSphere)

4. 淋巴瘤 (Lymphoma)

- 釷 Y-90 ibritumomab tiuxetan (Zevalin)
- 碘 I-131 tositumomab (Bexxar)

5. 神經內分泌瘤 (Neuroendocrine tumor)

- 碘 I-131 MIBG
- 釷 Y-90 DOTA-TOC & 鐳 Lu-177 DOTA-TATE (Lutathera)

6. 攝護腺癌 (Prostate cancer)

- 鐳 Lu-177 PSMA (Pluvicto)