Raccomandazioni nel PTV contouring e nel set up nei tumori polmonari

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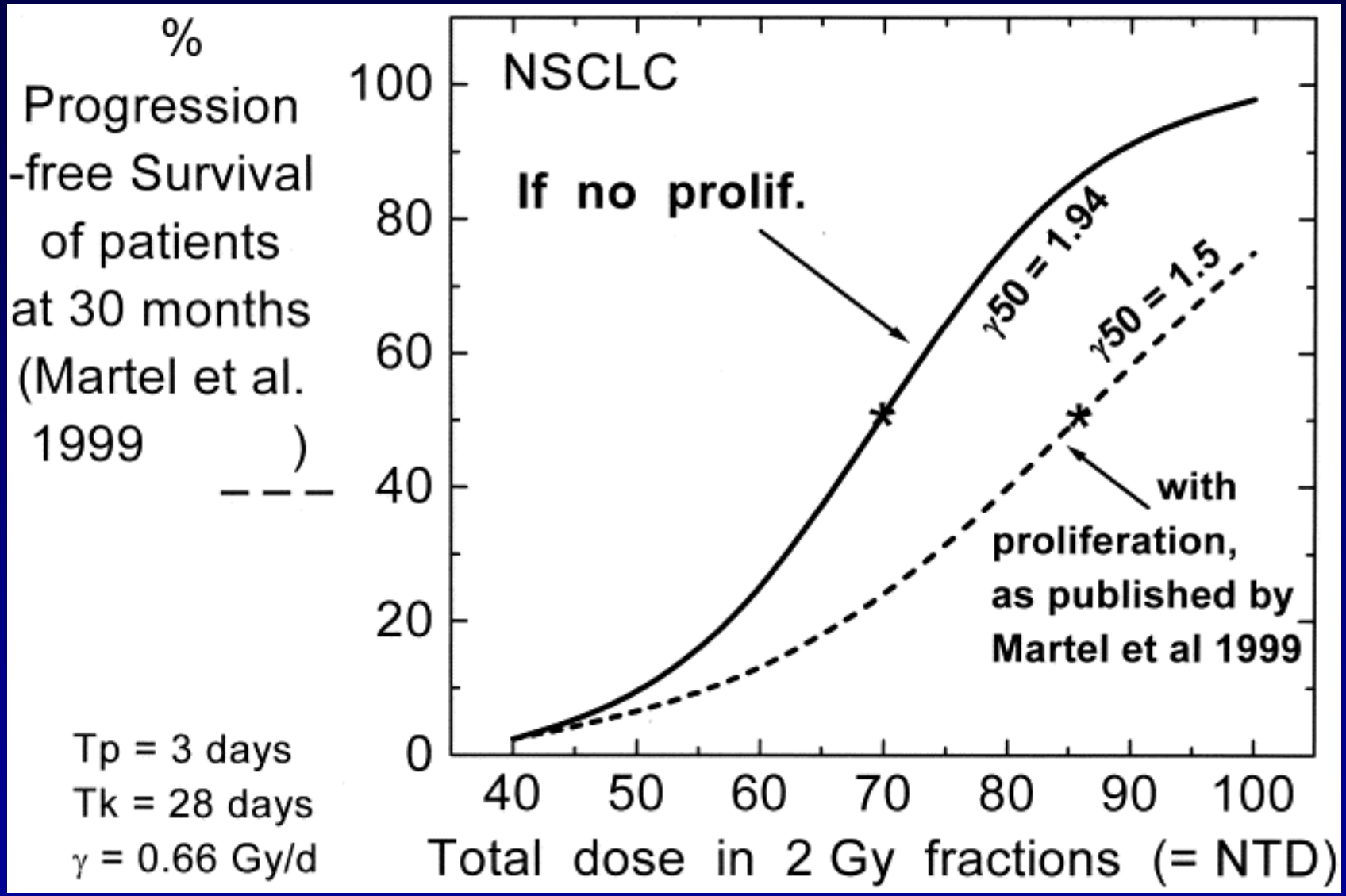
Introduzione

- La RT con finalità radicale nel NSCLC continua ad essere una sfida. Studi di dose escalation o di associazione RT-CT hanno portato ad un miglioramento dei risultati ma a prezzo di una non trascurabile tossicità. Al fine di migliorare il controllo locale e ridurre la tossicità è fondamentale una sempre più accurata identificazione dei volumi bersaglio (GTV, CTV, PTV).

- La radioterapia dei tumori polmonari è particolarmente difficile a causa
  - della sovente importante estensione di malattia sia parenchimale che linfonodale
  - della immediata prossimita di organi critici a tolleranza limitata (polmoni, esofago, midollo, cuore)
  - della mobilità degli organi intratoracici



Fowller,IJROBP, 2004

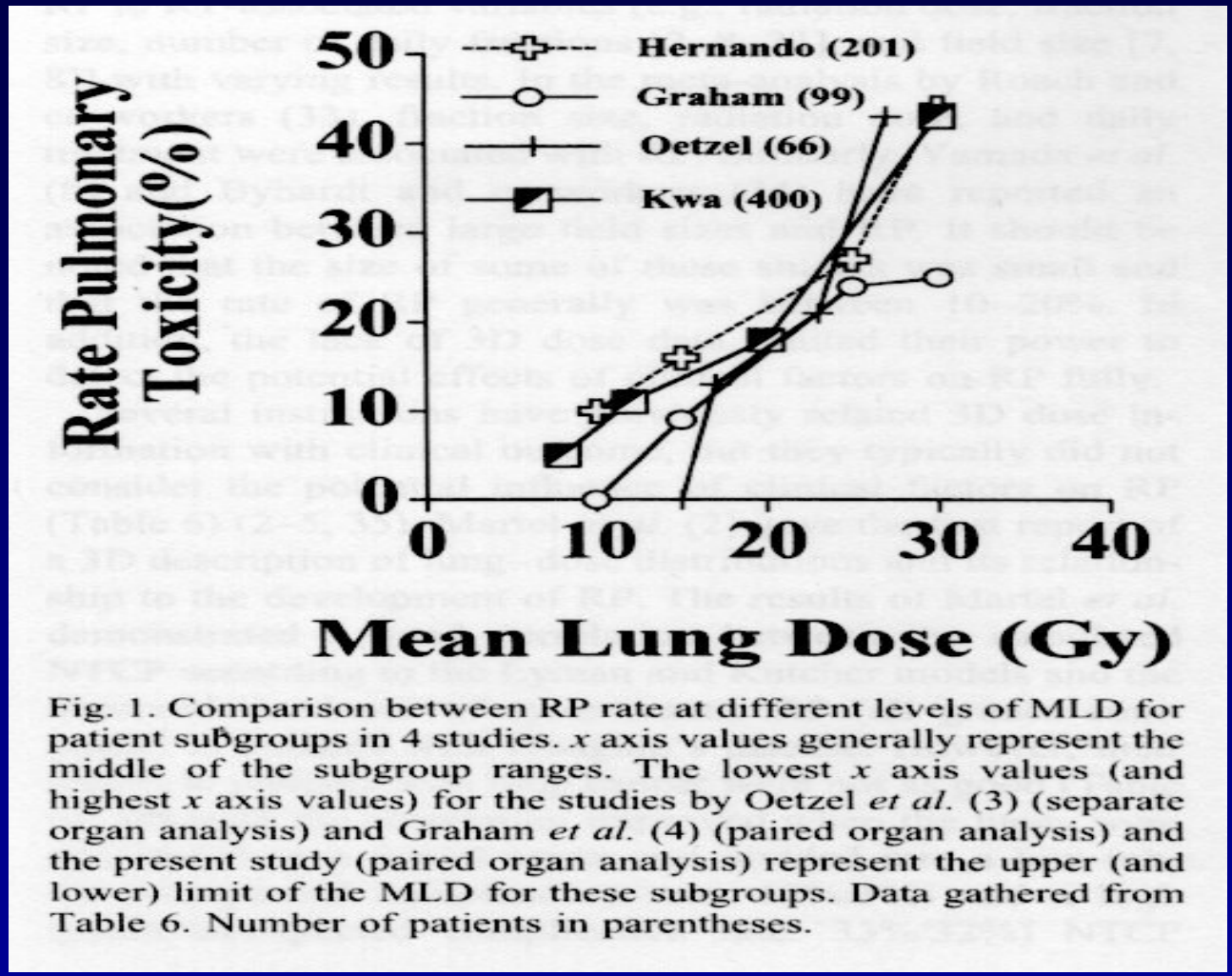


Fig. 1. Comparison between RP rate at different levels of MLD for patient subgroups in 4 studies. *x* axis values generally represent the middle of the subgroup ranges. The lowest *x* axis values (and highest *x* axis values) for the studies by Oetzel *et al.* (3) (separate organ analysis) and Graham *et al.* (4) (paired organ analysis) and the present study (paired organ analysis) represent the upper (and lower) limit of the MLD for these subgroups. Data gathered from Table 6. Number of patients in parentheses.

From: Hernando, M.L., IJROBP, 2001

Radioterapia e tumore del polmone

- Per migliorare il modesto controllo locale, è necessario somministrare dosi elevate (dose escalation).

- L'organo critico dose-limitante è rappresentato in genere dai polmoni. La tossicità tardiva polmonare è correlata alla distribuzione di dose. E' pertanto necessario limitare il volume di polmone esposto a dosi medio-basse (es:V20).

- Una migliore definizione del CTV, della riproducibilità del set-up ed una riduzione della mobilità degli organi interni che consenta una riduzione dei margini da CTV a PTV, permette una diminuzione dei volumi irradiati con conseguente riduzione del rischio di tossicità tardiva

ICRU Report 62

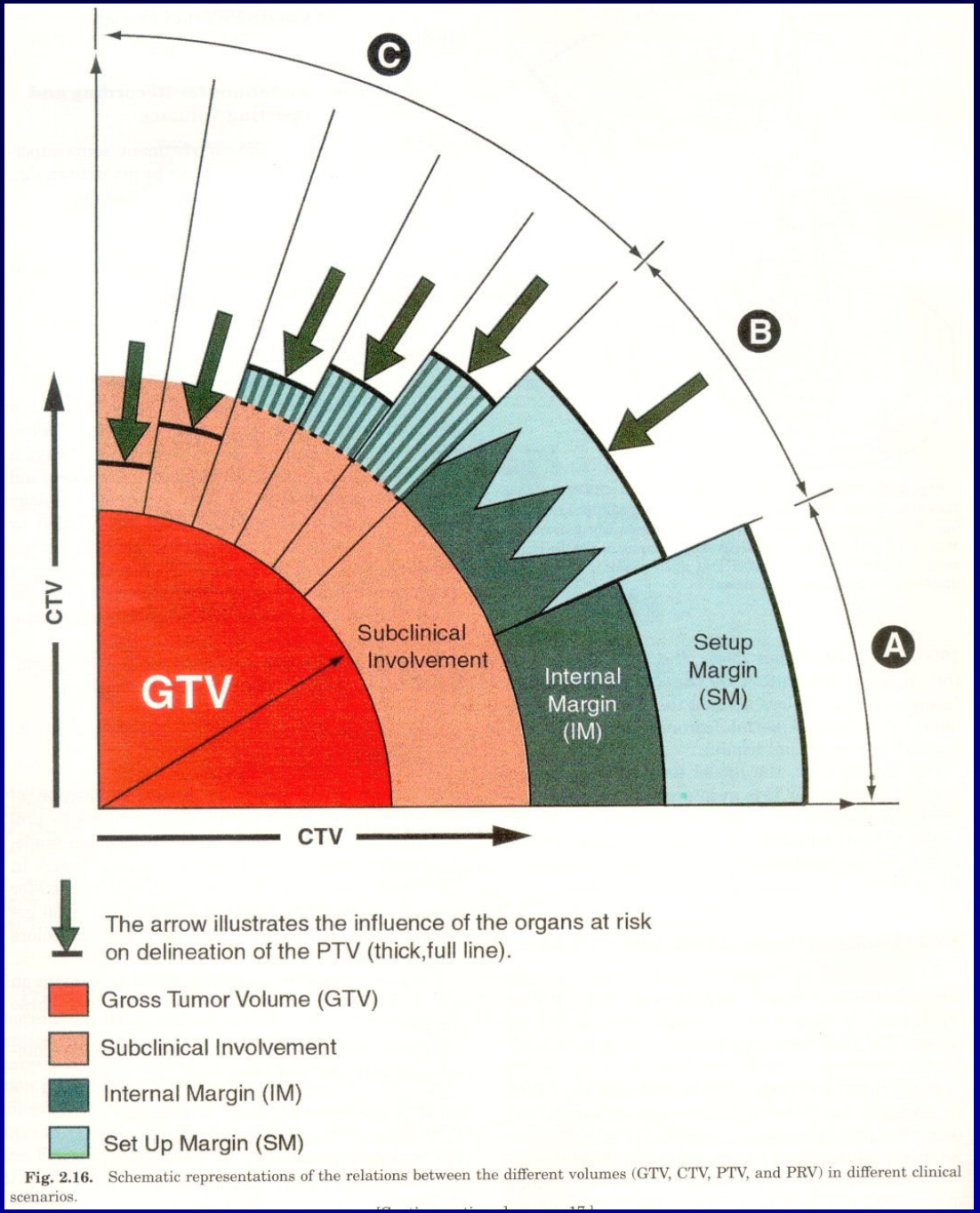
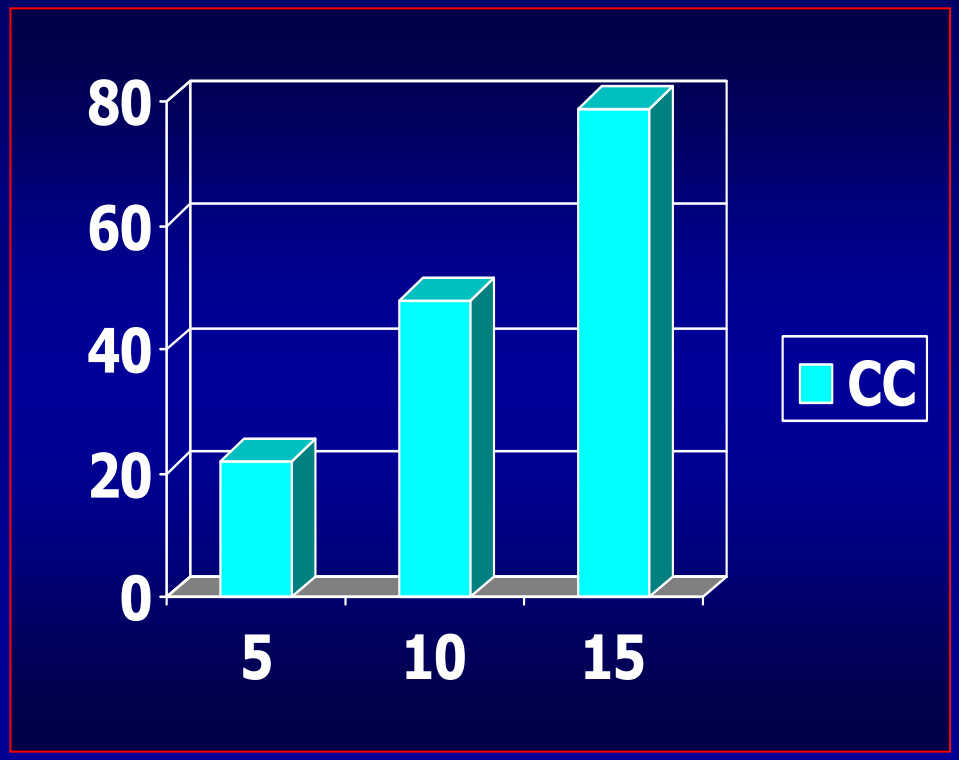


Fig. 2.16. Schematic representations of the relations between the different volumes (GTV, CTV, PTV, and PRV) in different clinical scenarios.

The determination of internal margin and set up margin, and the presence of OAR in the proximity of the target contribute to determine the " safety margin " around the CTV

Nell'espansione da GTV a PTV, ogni millimetro di margine ha un impatto significativo sul volume di polmone sano irradiato !



Diametro	Volume Polmone sano
50 mm	65 cc
+ 5 mm	87 cc (+22 cc)
+ 10 mm	113 cc (+48 cc)
+ 15 mm	144 cc (+79 cc)

Institut S. Catherine- Avignone

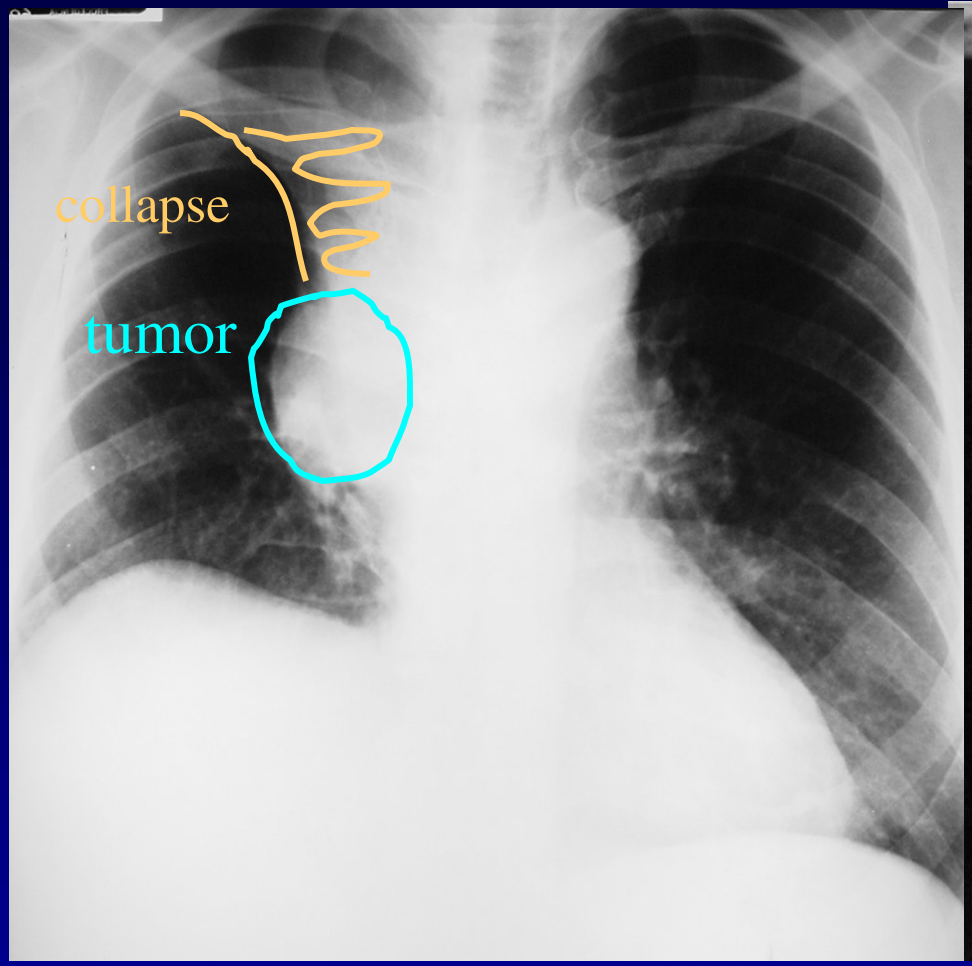
SOMMARIO

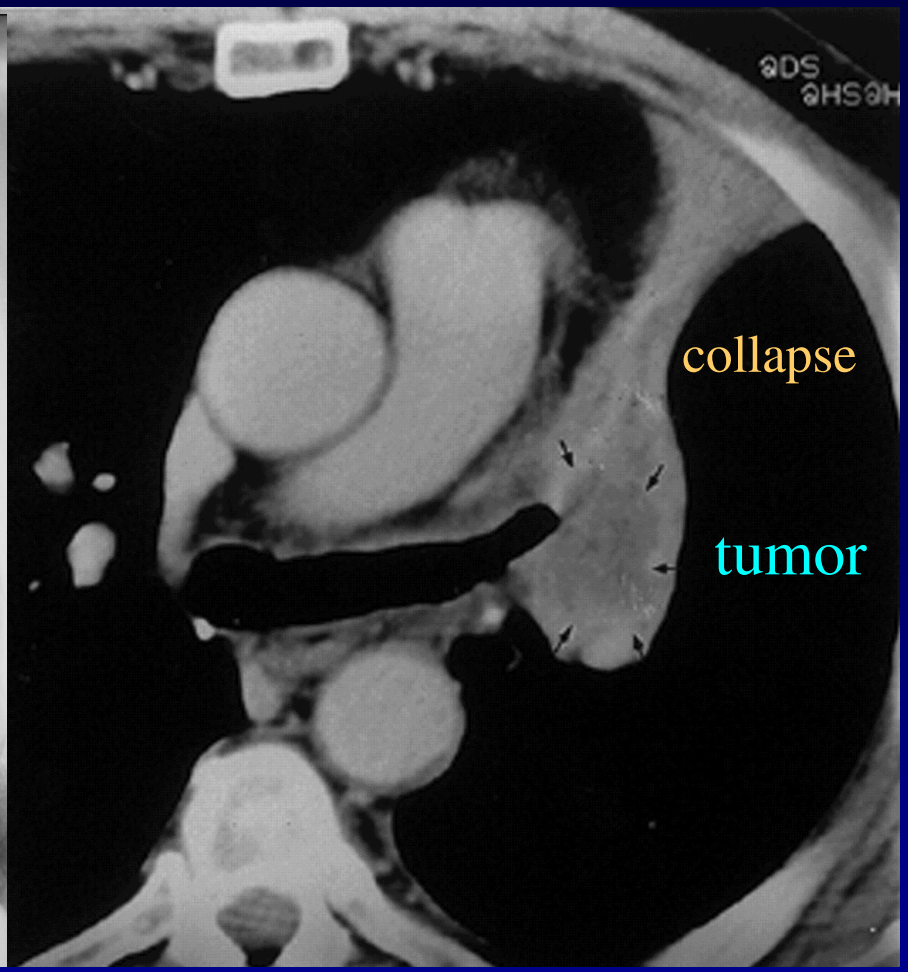
- ✓ Definizione GTV-CTV
- ✓ Definizione di CTV rappresentativo in caso di target mobile: implicazioni nella fase di impostazione del trattamento
- ✓ Definizione di PTV rappresentativo in caso di target mobile: implicazioni nella fase di esecuzione del trattamento (internal margin)
- ✓ Problemi di riproducibilità del trattamento (set up margin)
- ✓ Image guided radiotherapy

DEFINIZIONE GTV-CTV

- ✓ E' necessario definire con precisione
  - Lo stadio di malattia alla diagnosi
  - La probabile estensione infraclinica
  - L' interessamento parietale
  - L' estensione mediastinica (TC)
  - L' estensione endobronchiale (broncoscopia)

- ✓ E' necessario differenziare il volume bersaglio tumorale dai:
  - fenomeni infiammatori peritumorali
  - l'atelettasia





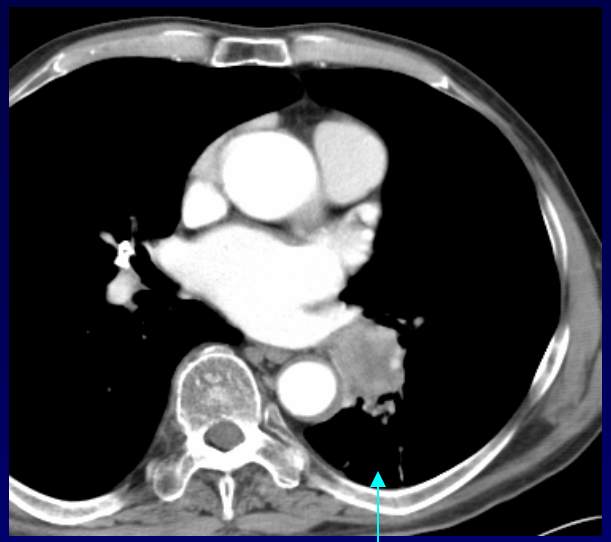
The Golden "S" sign¨:

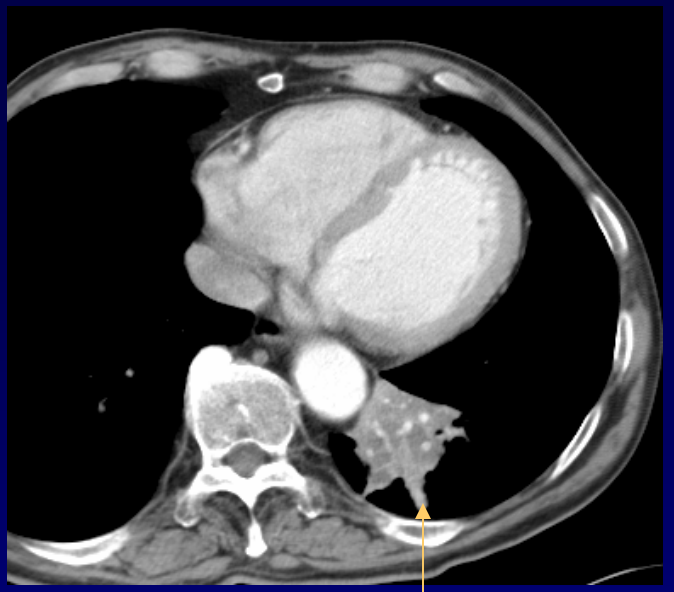
- tumor: bulging convexe border
- distal collapse: concave border

Definizione GTV-CTV (Tumore Primitivo)

- Migliore concordanza fra valore misurato su TC e diametro e volume reale con W=1600 HU, L= -600 HU per il parenchima polmonare e W=400 HU, L=20 HU per il mediastino (Radiother Oncol 2004, vol 71, 2, pp 139-146)

- Per distinguere l'atelettasia dal tumore, W=150 HU, L=50 HU (Liver Window). (IJROBP 2002, vol 53, 3, pp 566-573)





tumore

atelettasia

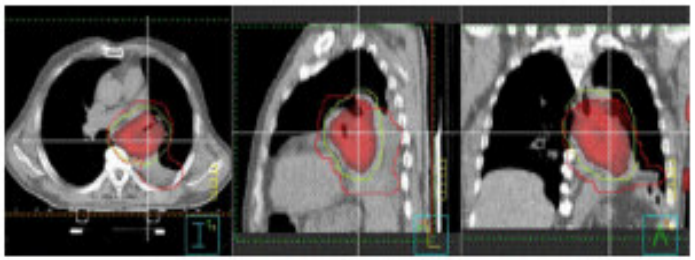
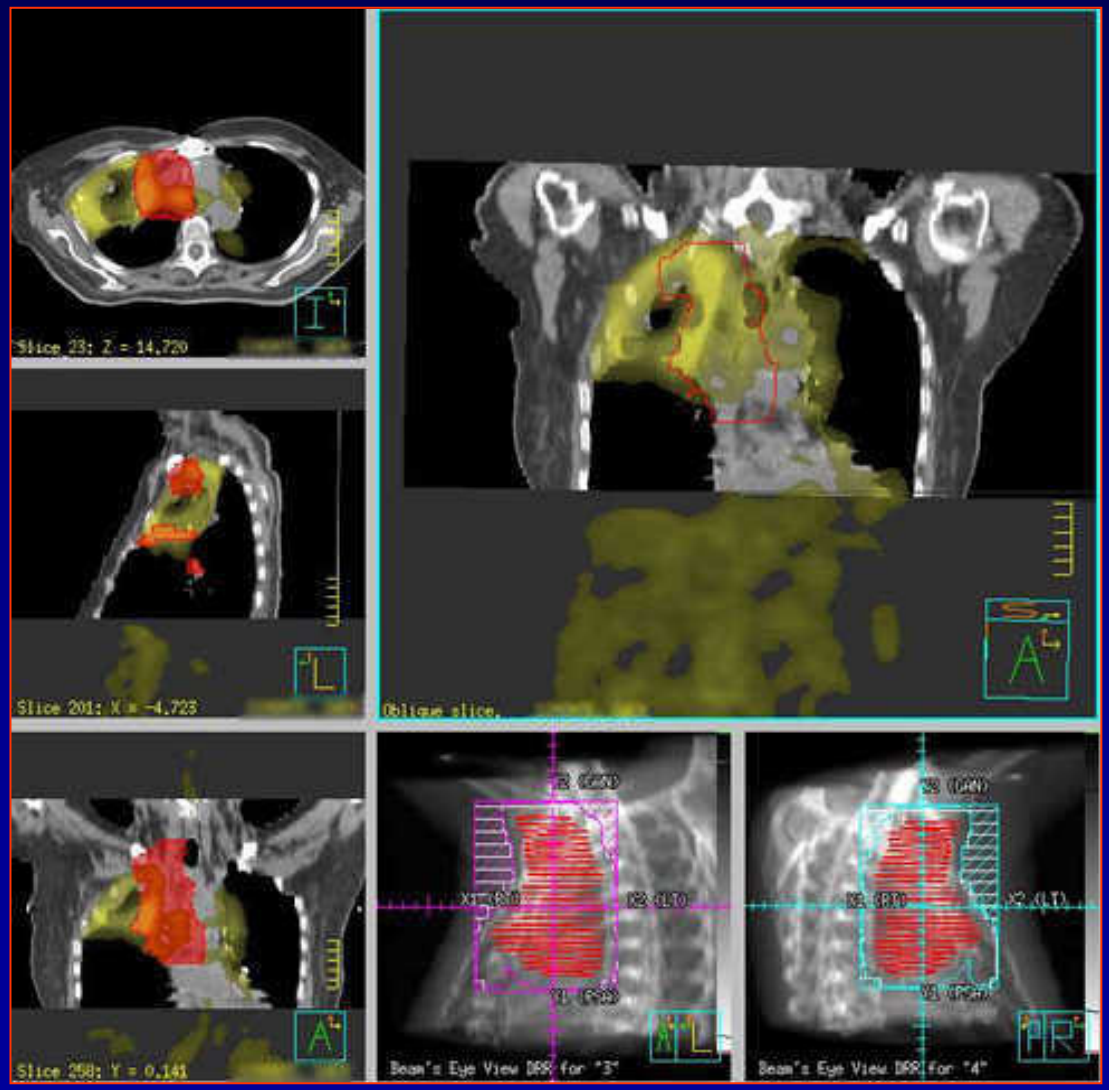


Fig. 6. FDG-PET-CT fusion images of patient with [^{18}F]-FDG-negative atelectasis. Pink structure: GTV derived from PET (source-background algorithm). Red contour: GTV derived from CT.

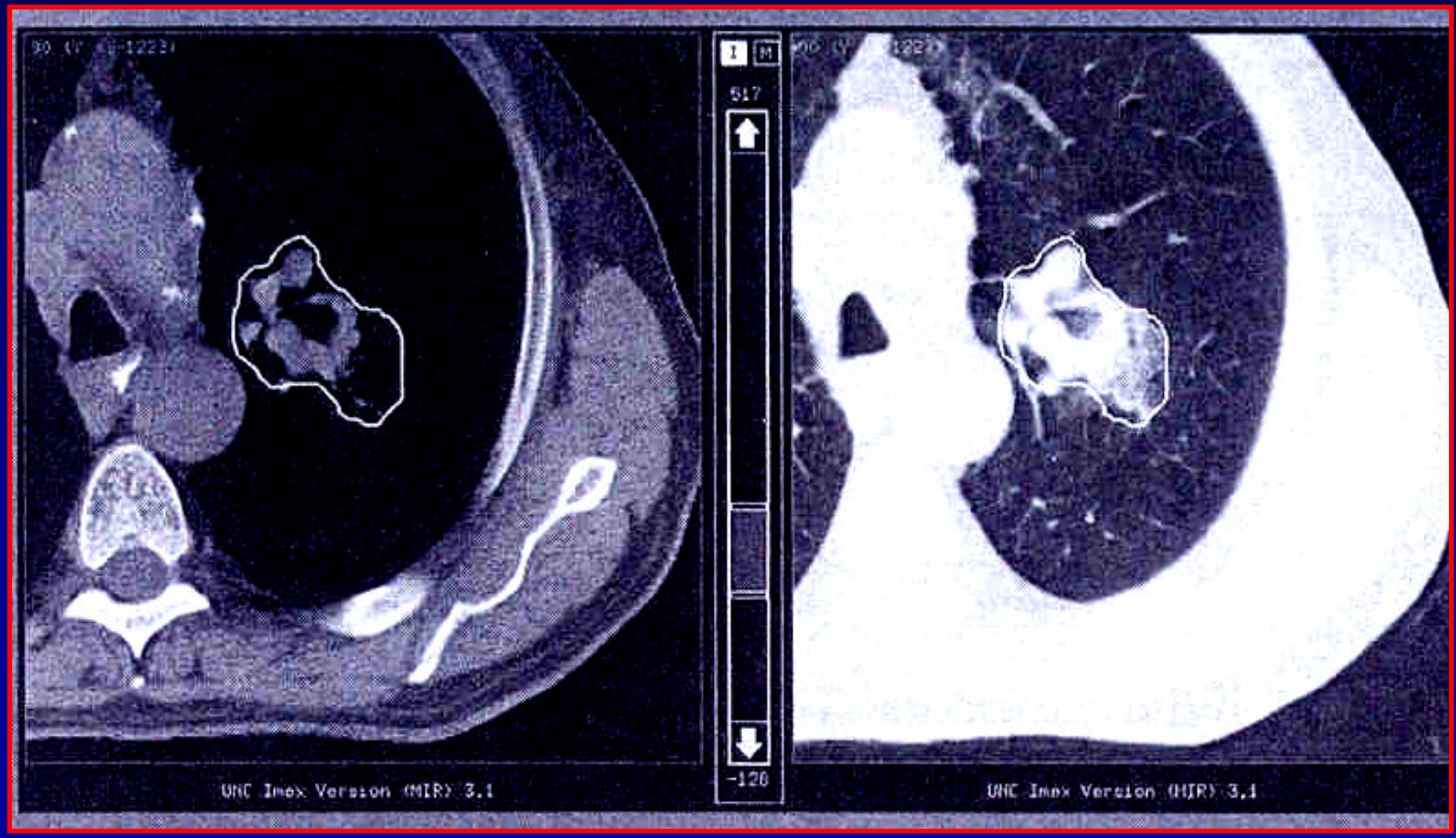
Estensioni parenchimatose
Nestle et al, IJROBP 1999



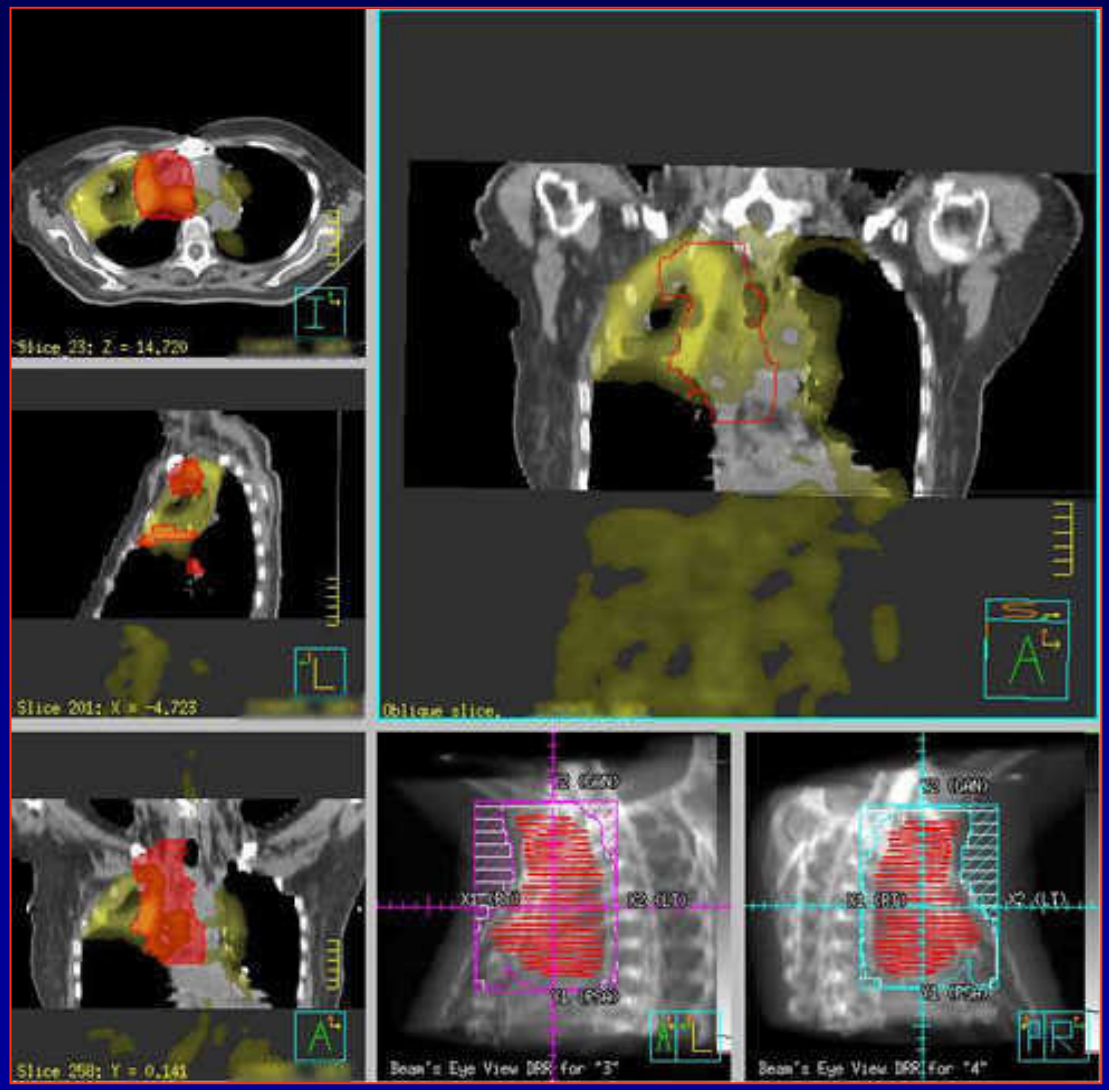
In questa analisi retrospettiva le informazioni apportate dalla FDG-PET hanno determinato una sostanziale riduzione del volume bersaglio. In particolare nei Pazienti con tumore associato ad importante atelettasia.

Estensioni parenchimatose

Seminars in radiation oncology, 2004



Estensioni parenchimatose
Nestle et al, IJROBP 1999



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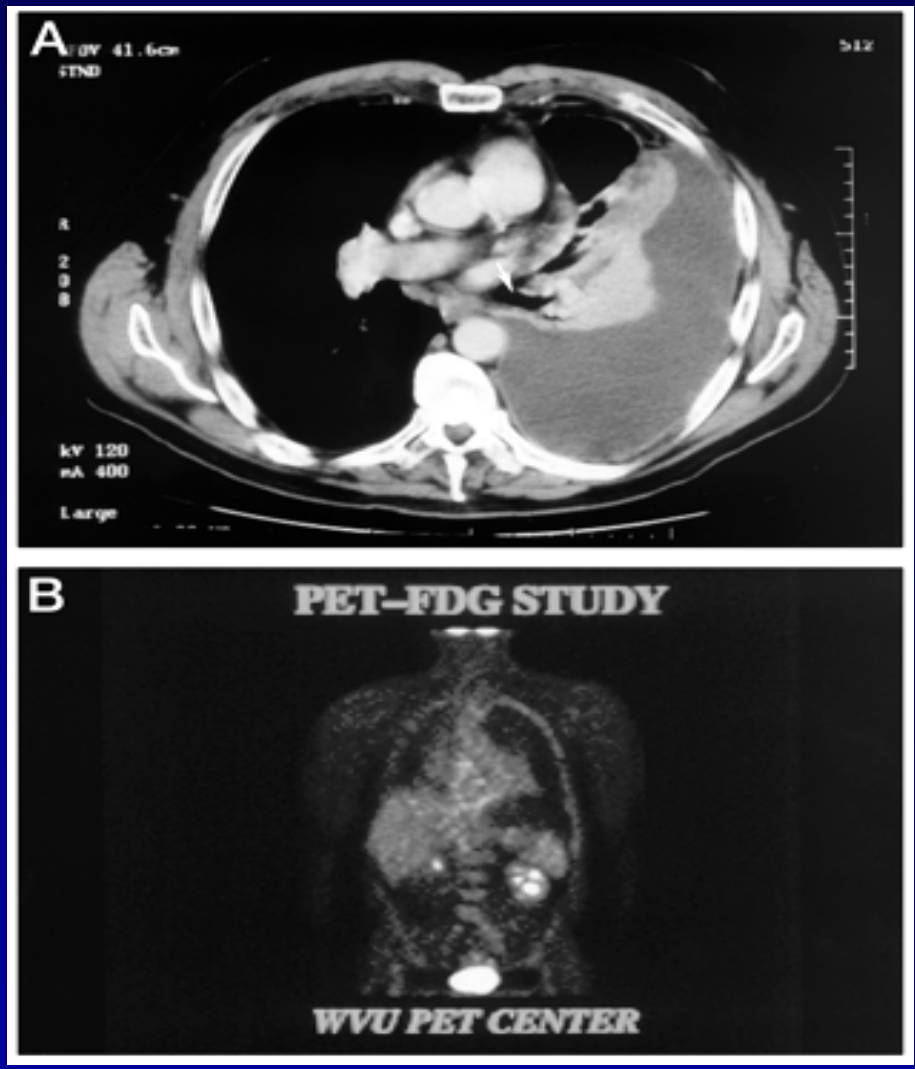
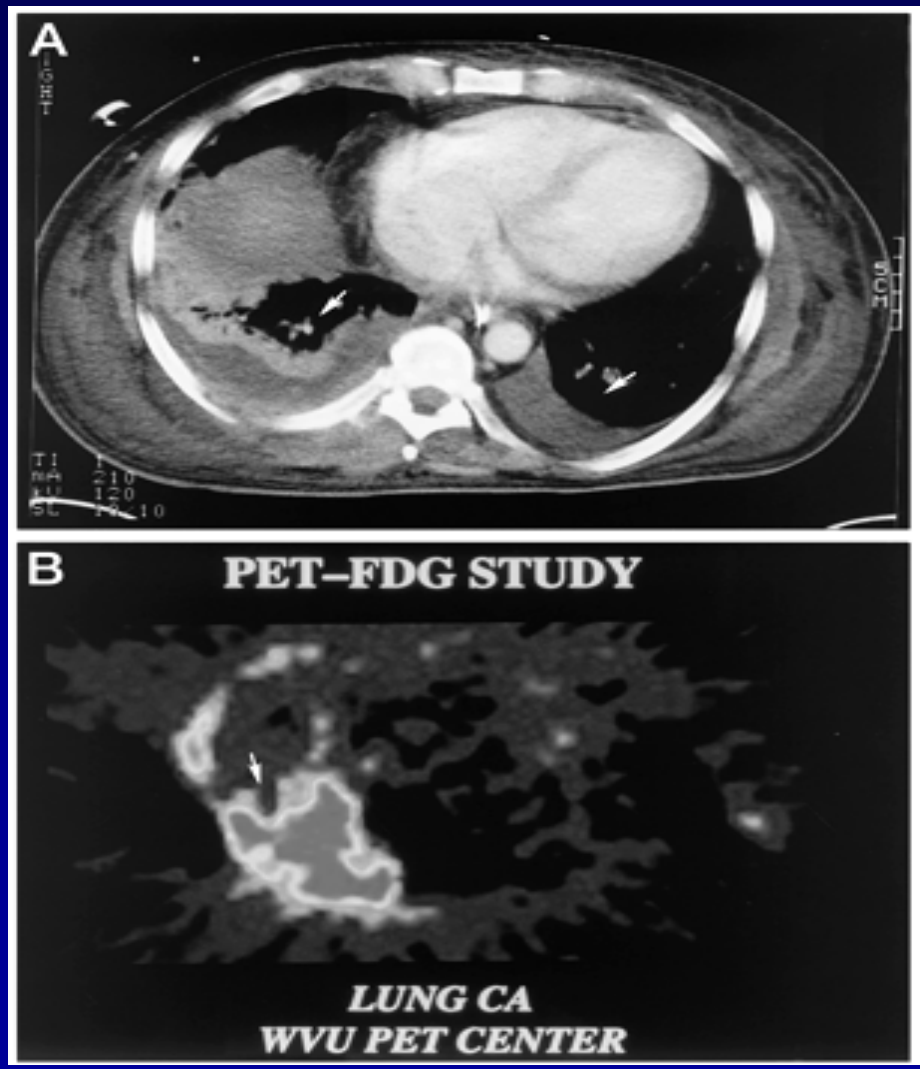
Estensioni pleuriche
Interesse della PET-FDG





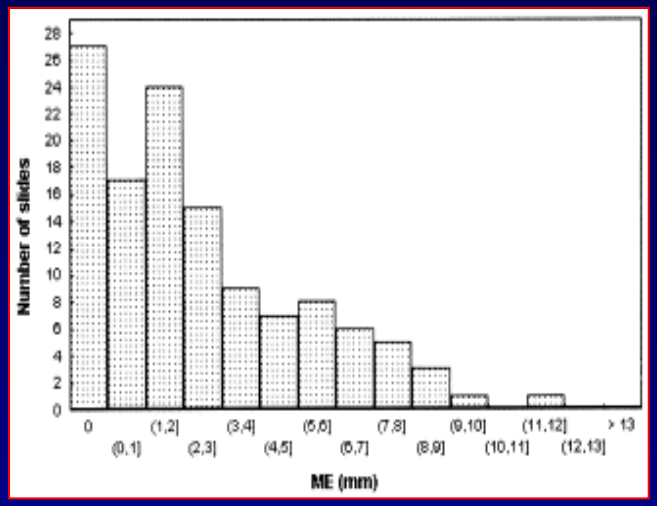
Definizione GTV-CTV (Tumore Primitivo)

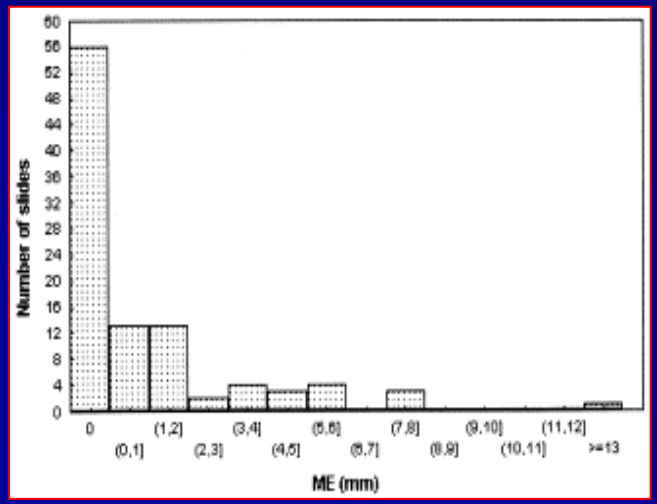
- ✓ L'uso della PET nella delineazione del GTV riduce le variazioni inter osservatore. E' di ausilio soprattutto nei casi con componente atelettasica o con versamento pleurico (riduzione del volume).

- ✓ Dubbi se presenza di flogosi.

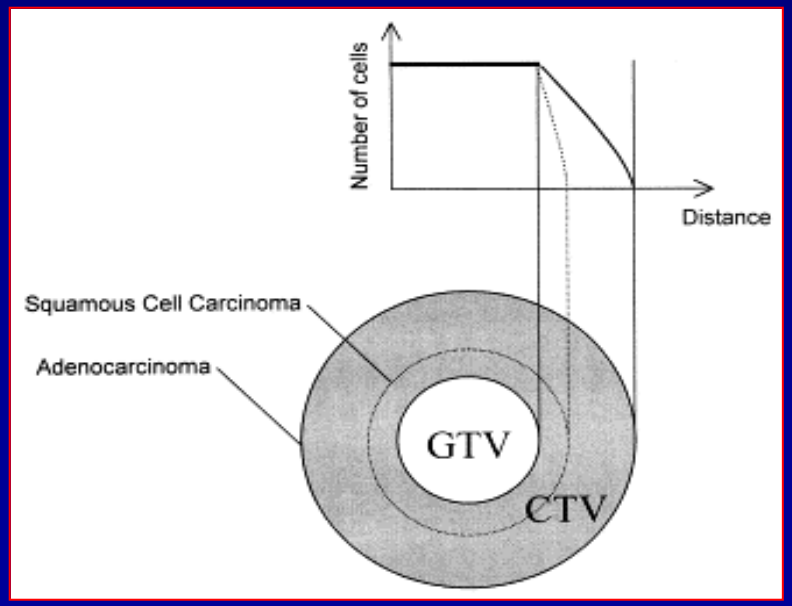
- ✓ Mancanza ancora di chiara correlazione fra posività PET e riscontro anatomo-patologico (soglia di positività nel riconoscimento dell'estensione microscopica).

Estensioni infracliniche
Giraud et al, IJROBP 2000





Microscopic extension in adenocarcinoma and in squamous cell carcinoma.



Volume trattato

- CTV = GTV

Recidive locali = 8/31 (26%)

- CTV = GTV+ 6-8 mm

NO recidive locali

"SRT for Lung Tumors"

Fujino et al, IJROBP 57, 2, S 415-2003

Staging TC mediastinico

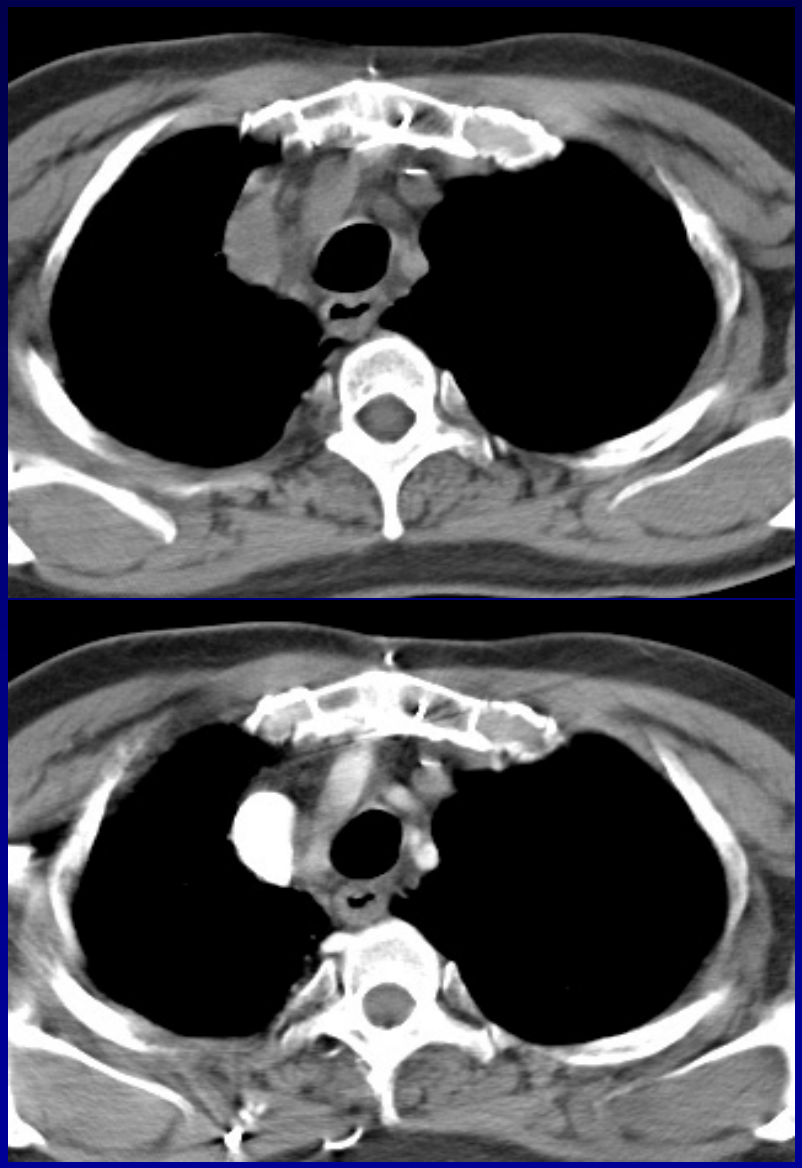
- Linfoadenopatie: aspetto solido, forma rotonda, nodulare.

- E' molto utile una buona conoscenza della normale anatomia mediastinica e delle normali varianti che potrebbero simulare la presenza di malattia.

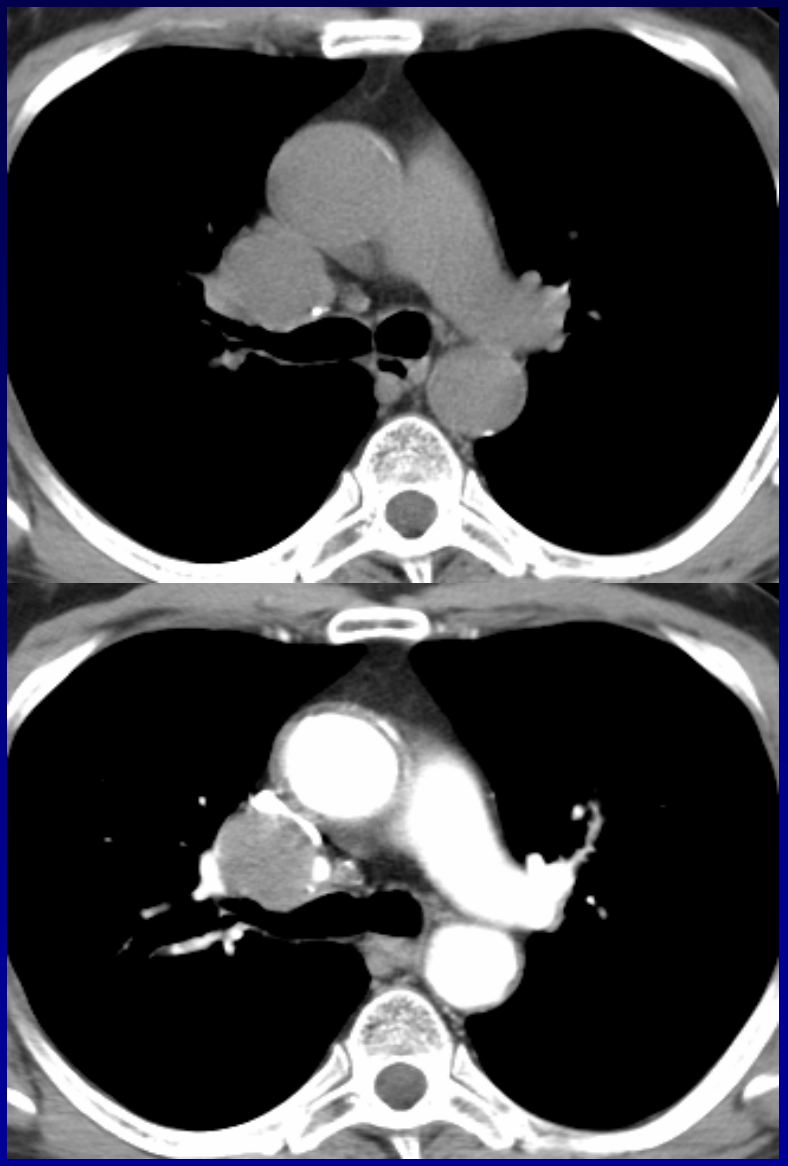
- Seguire l'andamento della lesione lungo scansioni TC contigue può essere utile per distinguere i linfonodi dai vasi

- L'utilizzo di mdc ev è essenziale

L'utilizzo di mdc ev è essenziale



strutture vascolari



linfoadenopatie

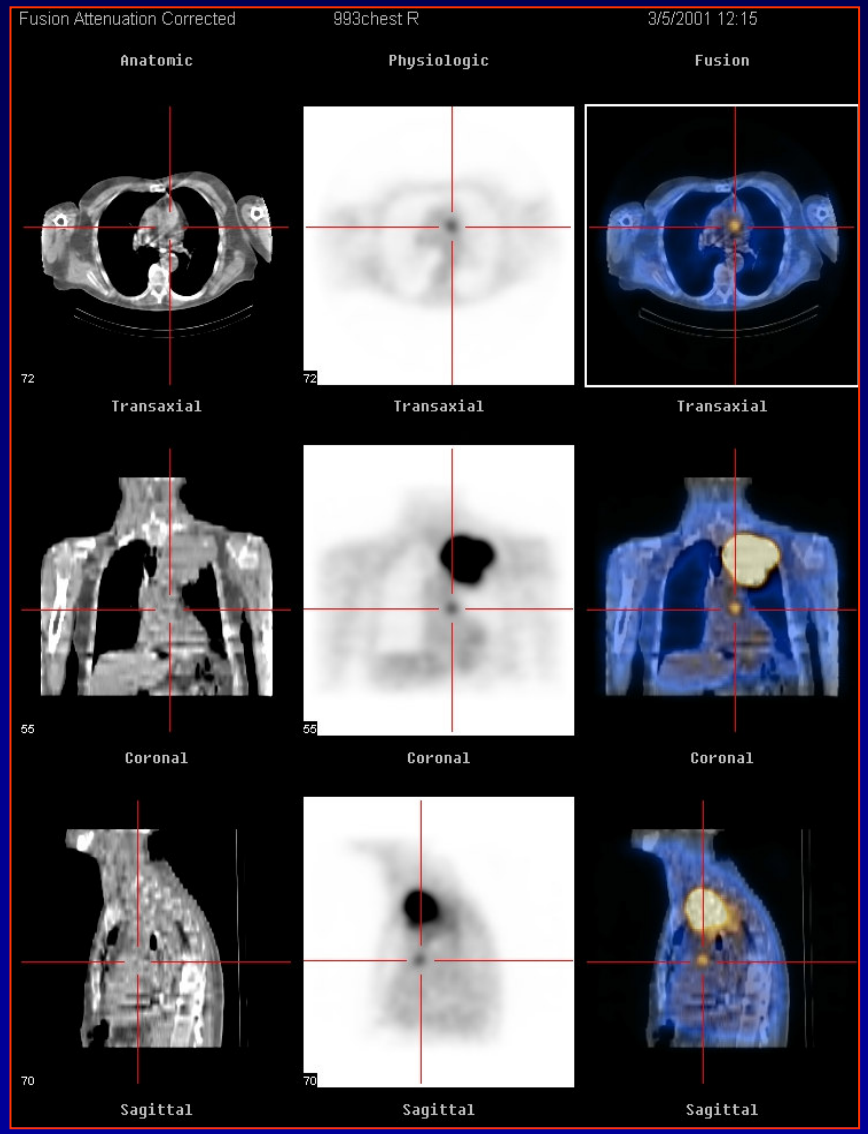
Definizione GTV-CTV
(Malattia linfonodale)

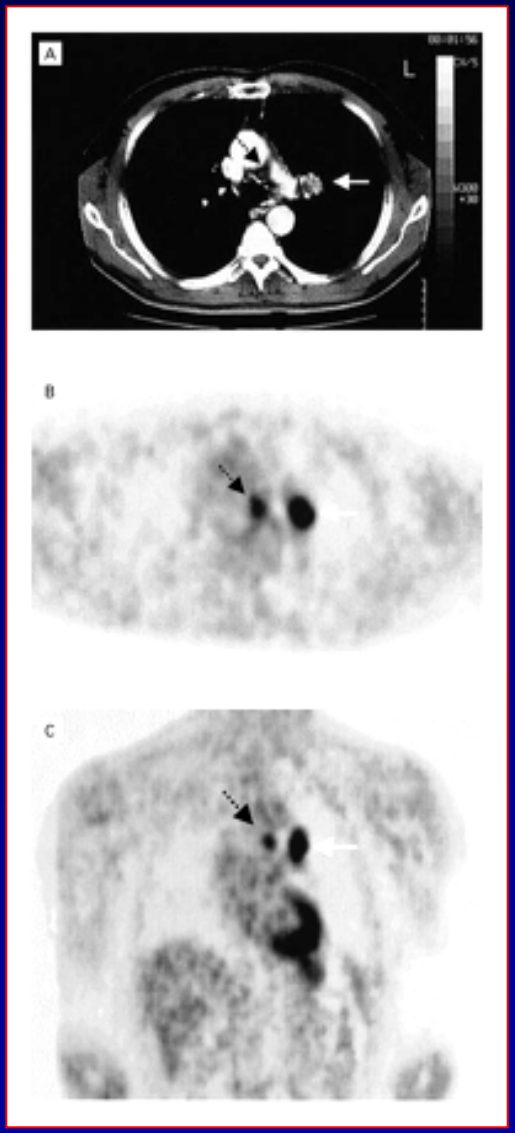
STAGING NON INVASIVO

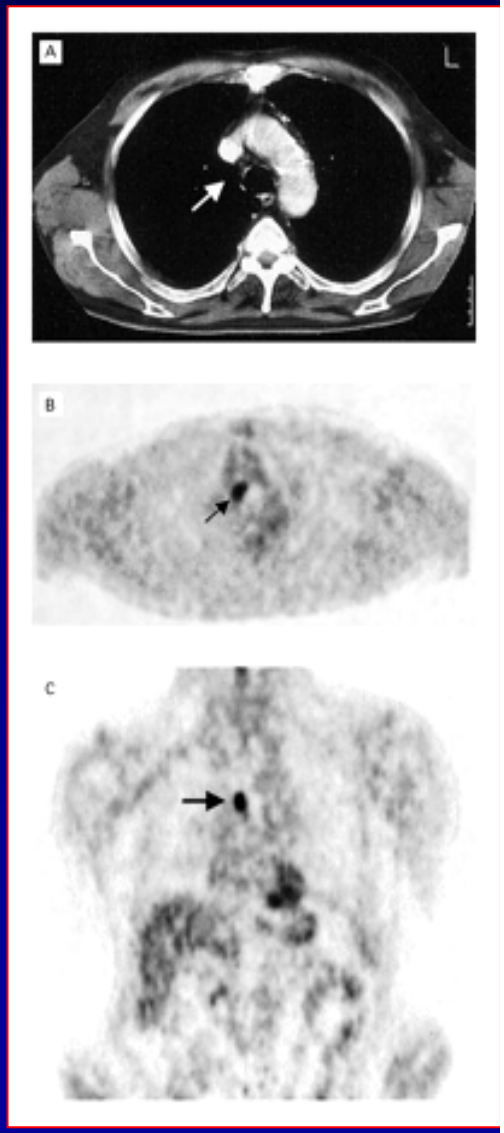
• CT SCAN (criteri anatomico-dimensionali). Sono considerati patologici gli N con asse minore > 10 mm (12 mm se N sottocarenali). Affidabilità modesta (elevata % sia di FP che di FN).

• FDG-PET. Elevato VPN (>90%). 24% FP. (Toloza, Chest 2003, 123, pp 137-146). Limitata risoluzione spaziale. Utile correlazione visiva con CT o eventuale (meglio) fusione d'immagini CT-PET. Se discordanza fra TC e PET, utile staging invasivo (mediastinoscopia e/o broncoscopia con FNA).

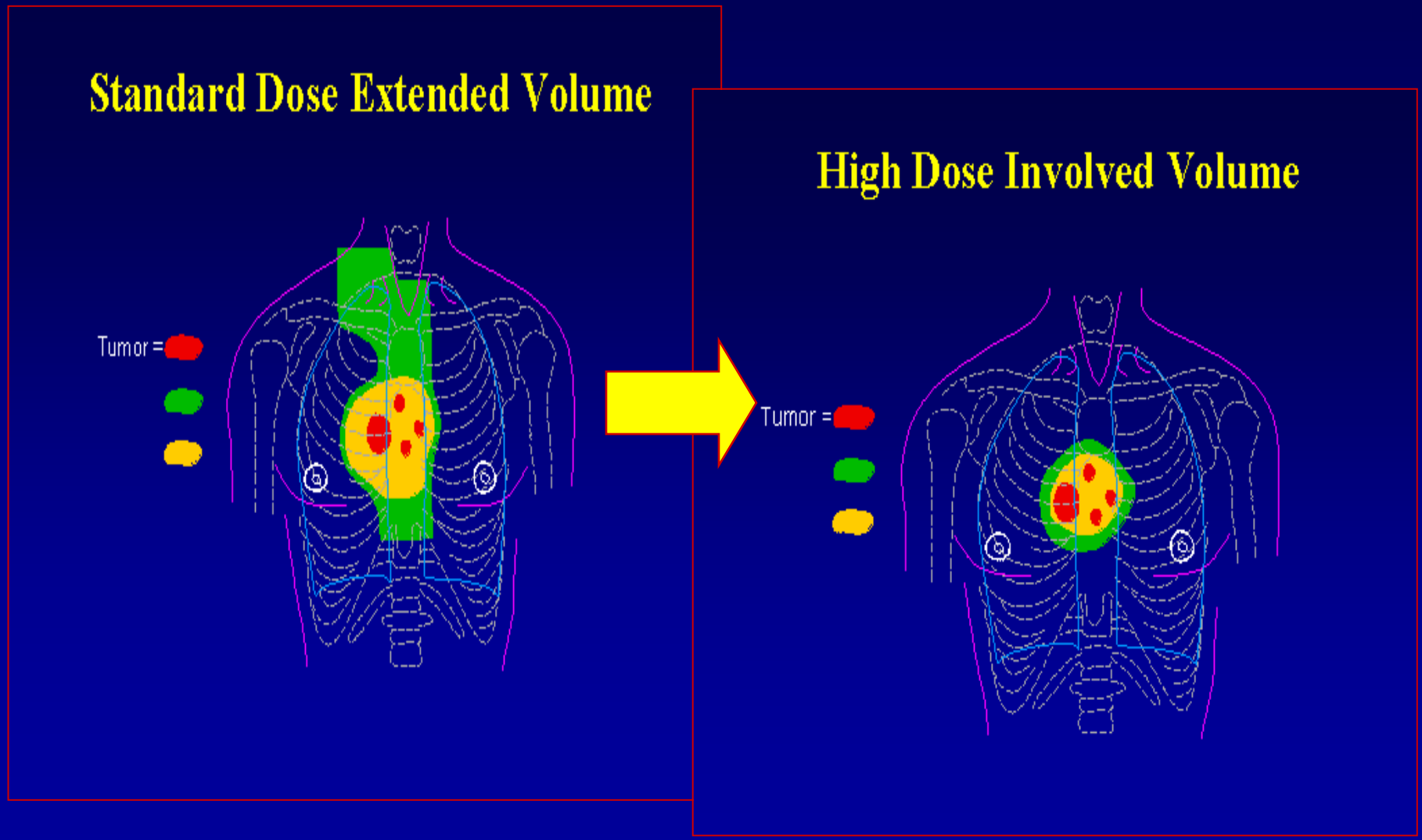
Staging mediastinico
Interesse della FDG-PET

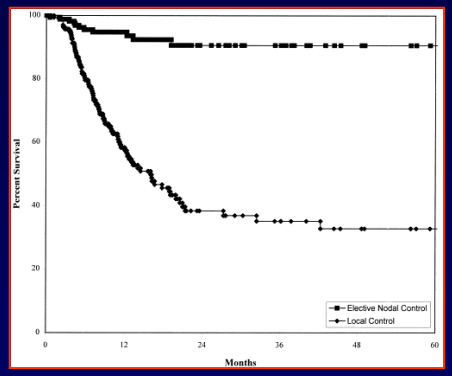






Evoluzione dei volumi bersaglio





Elective nodal irradiation in the treatment of non–small-cell lung cancer with three-dimensional conformal radiation therapy Rosenzweig et al, IJROBP 2001

171 patients treated with 3D-CRT. Only lymph node regions initially involved with tumor either by biopsy (55%) or radiographic criteria (node 15 mm in the short axis on CT) were included in the clinical target volume. Elective nodal failure was defined as a recurrence in an initially uninvolved lymph node in the absence of local failure. Only 11 patients (6.4%) with elective nodal failure were identified. With a median follow-up of 21 months in survivors, the 2-year actuarial rates of elective nodal control and primary tumor control were 91% and 38%, respectively. In patients who were locally controlled, the 2-year rate of elective nodal control was 85%. The median time to elective nodal failure was 4 months (range, 1–19 months). Most patients failed in multiple lymph node regions simultaneously. Local control remains one of the biggest challenges in the treatment of non–small-cell lung cancer. Most patients in our series developed local failure within 2 years of radiation therapy. **The omission of elective nodal treatment did not cause a significant amount of failure in lymph node regions not included in the clinical target volume. Therefore, we will continue our policy of treating mediastinal lymph node regions only if they are clinically involved with tumor.**

Can elective nodal irradiation be omitted in stage III non-small-cell lung cancer? analysis of recurrences in a phase II study of induction chemotherapy and involved-field radiotherapy
Senan et al, IJROBP 2002

Fifty patients were treated with either two or four cycles of induction CHT, followed by once-daily involved-field RT to 70 Gy, delivered using three-dimensional treatment planning. Elective nodal failure was defined as recurrence in the regional nodes outside the clinical target volume, in the absence of in-field failure.

No elective nodal failure was observed when only nodes of at least 1 cm were included in the GTV. Omitting elective mediastinal irradiation did not result in isolated nodal failure. Future studies of concurrent CHT and RT for Stage III non-small-cell lung cancer should use involved-field RT to limit toxicity.

Definizione dei volumi bersaglio: da GTV a CTV

La variabilità interosservatore nel definire GTV e CTV è il principale fattore d'incertezza nella pianificazione del trattamento.

→ istruzioni esplicite comuni

Definizione del GTV mediante contornamento manuale

- Tumore + adenopatie
- Ottimizzazione tecniche d'imaging (mdc ev, finestra per il parenchima polmonare/ mediastino/ atelettasia; ev TC/PET con fusione d'immagini)
- Stretta collaborazione con il Radiologo e il Medico Nucleare

Definizione del CTV: espansione automatica + valutazione clinica

- Estensione microscopica

Substantial range of motion of a lung tumor is seen in the image at left without Active Breathing Coordinator™ use, while the image at right shows how breathing control arrests lung motion. (photos courtesy of The Royal Marsden)

2. Generazione di CTV rappresentativo in caso di Target mobile:implicazioni nella fase di pianificazione

Generazione di GTV rappresentativo in caso di Target mobile

- E' pratica comune ricavare il GTV da un singolo CT scan ed utilizzare margini per i movimenti d'organo e le altre incertezze, POPULATION-BASED. Si assume che venga catturata la posizione media del target. TAC spirale rapida potrebbe generare errori di posizione (distribuzione di dose pianificata non corrispondente a quella reale). Non chiara correlazione fra sede del T e sua mobilità.

- Necessità quindi di introdurre margini individuali PATIENT-BASED

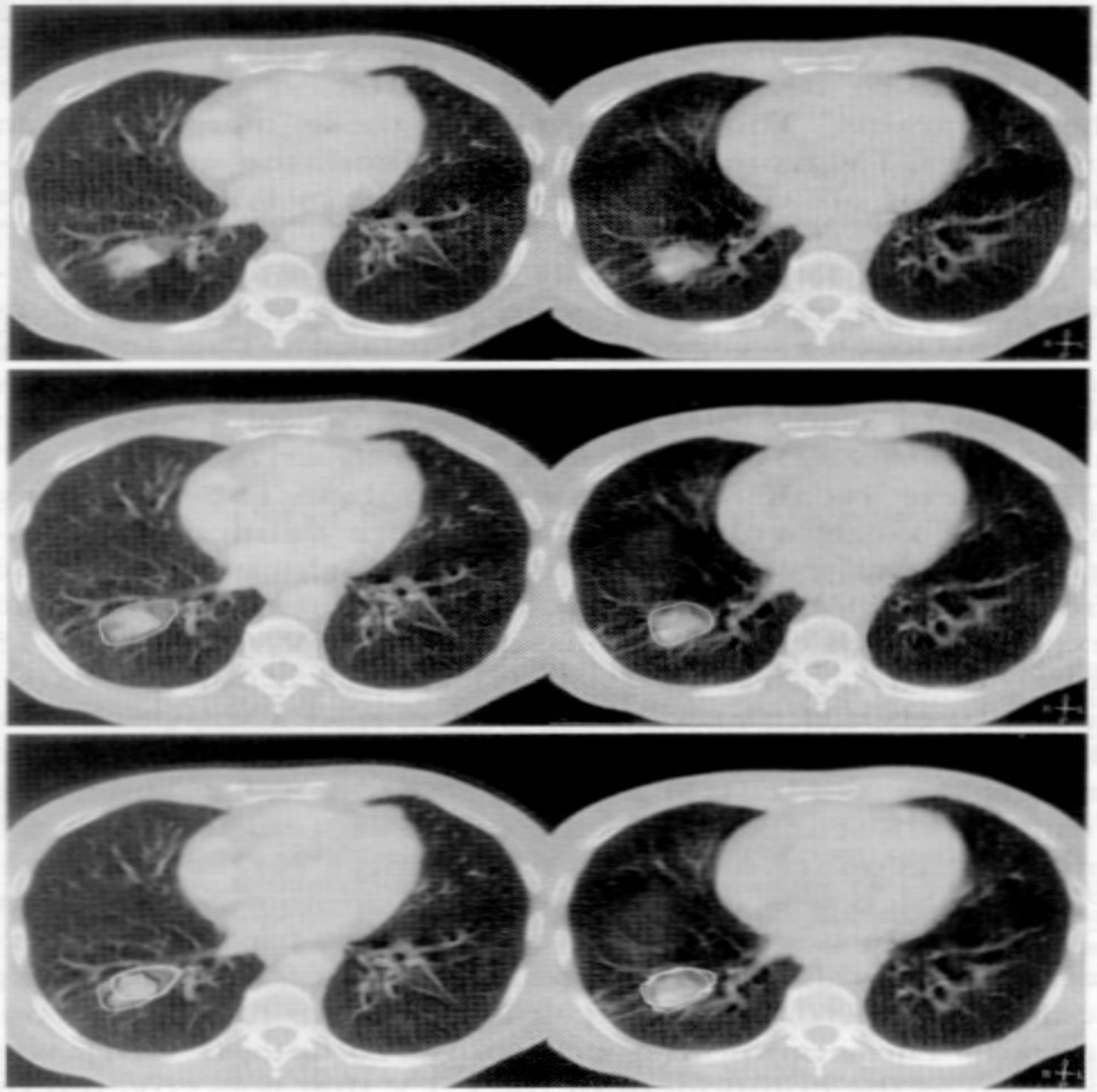
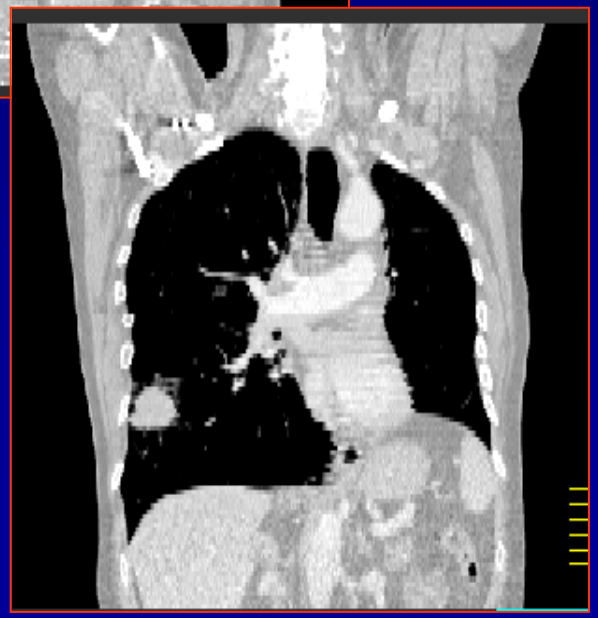
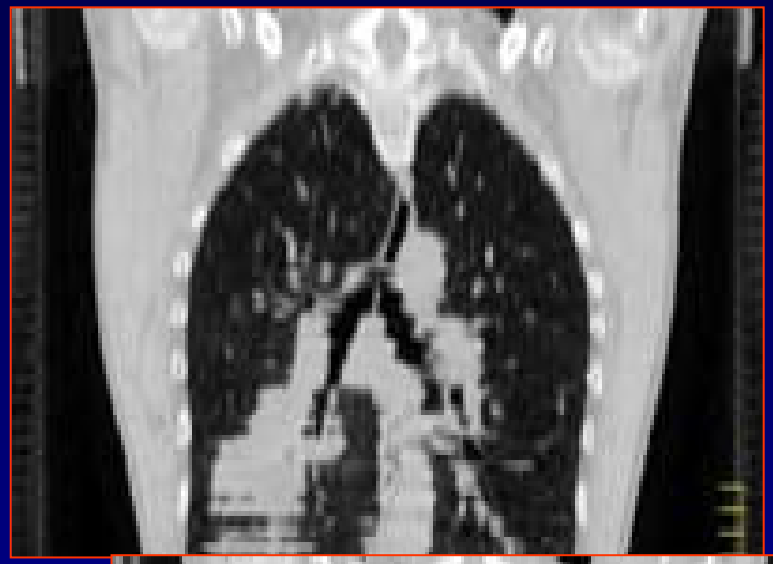


Fig. 1. Upper panel: Coregistered rapid (left) and slow CT scans (right). Blurring of the edges of mobile structures such as vessels and the heart are obvious on the slow scan. Middle panel: CT scans showing the corresponding contoured GTVs. Lower panel: Projection of all contoured GTVs on each type of scan.

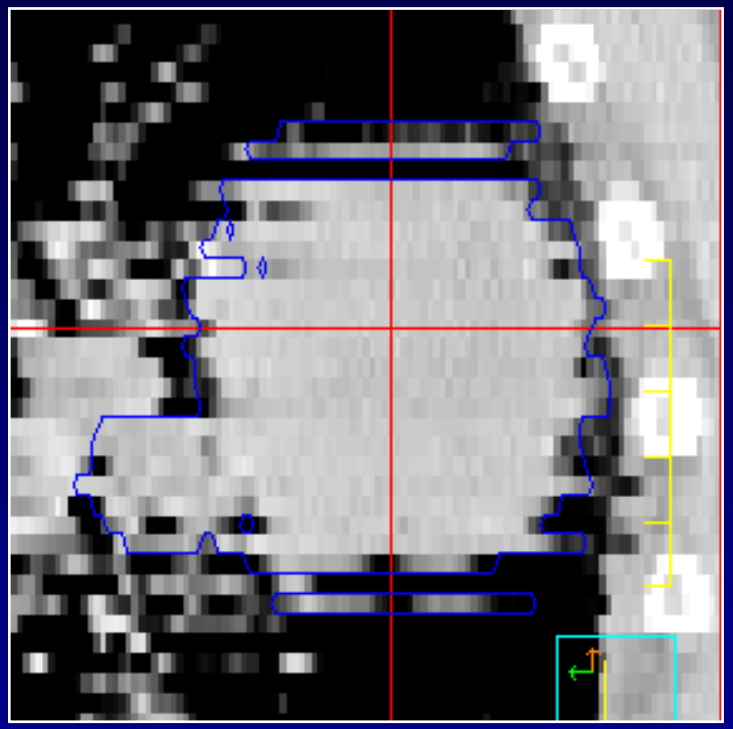
"SLOW" O "FAST" CT SCANS DEL TORACE POSSONO DARE UNA DIVERSA RAPPRESENTAZIONE DELLA FORMA E DIMENSIONE DEL GTV

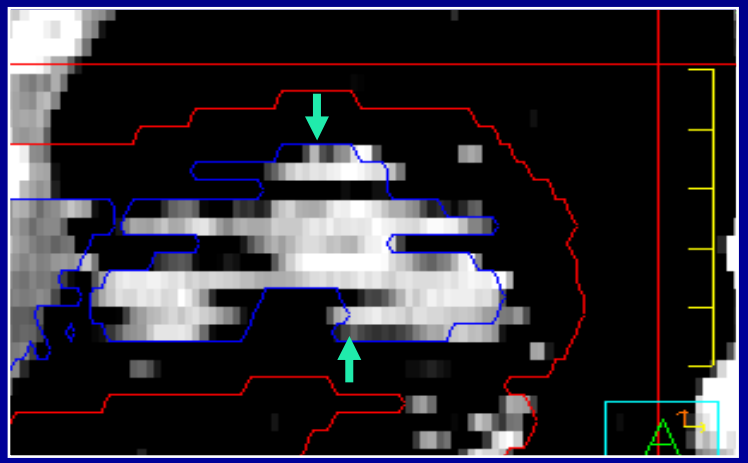
Visualizzazione del tumore





Difficoltà di contouring





Generazione di GTV rappresentativo in caso di Target mobile

Tecniche d'imaging standard mancano di informazioni relative al fattore tempo. Possibili approcci per ovviare a ciò:

1. completa caratterizzazione ed incorporazione di ogni forma di mobilità interna
2. restrizione della mobilità respiratoria durante le procedure di preparazione (acquisizione imaging) e durante l'erogazione della RT
3. uso di respiratory gated planning CT scan e di Gated RT
4. uso di real time tumor tracking RT (Cyberknife)

La scelta è in base alla tecnologia disponibile

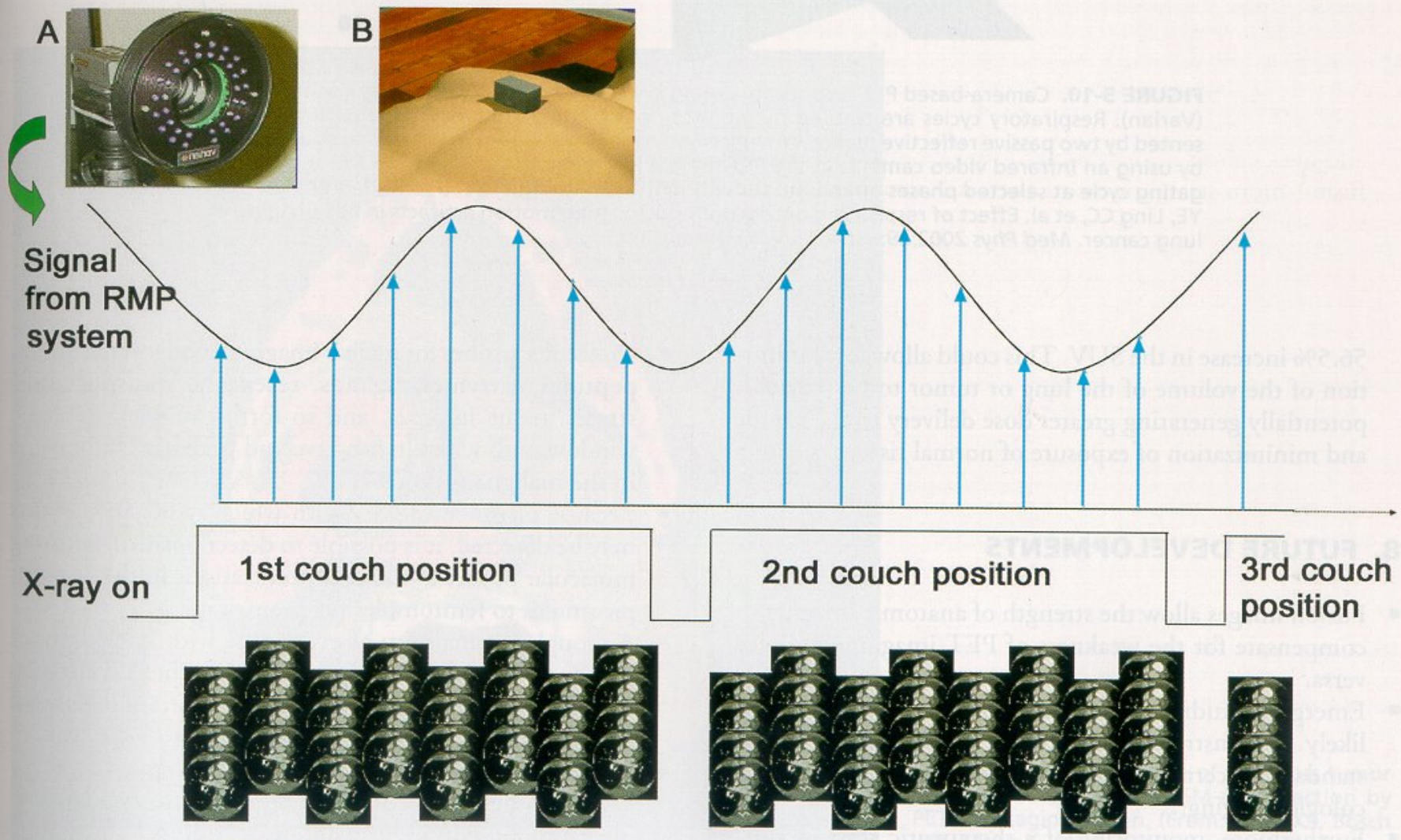


FIGURE 5-9. Four dimensional (4D)-CT respiratory motion tracking with retrospective gating. Respiratory motion is tracked by following a block mounted on the patient's chest **(B)** with a Varian (Cary, NC, USA) real-time position management (RPM) optical monitor **(A)**. CT images are acquired at end-tidal inspiration and expiration over complete respiratory cycles.

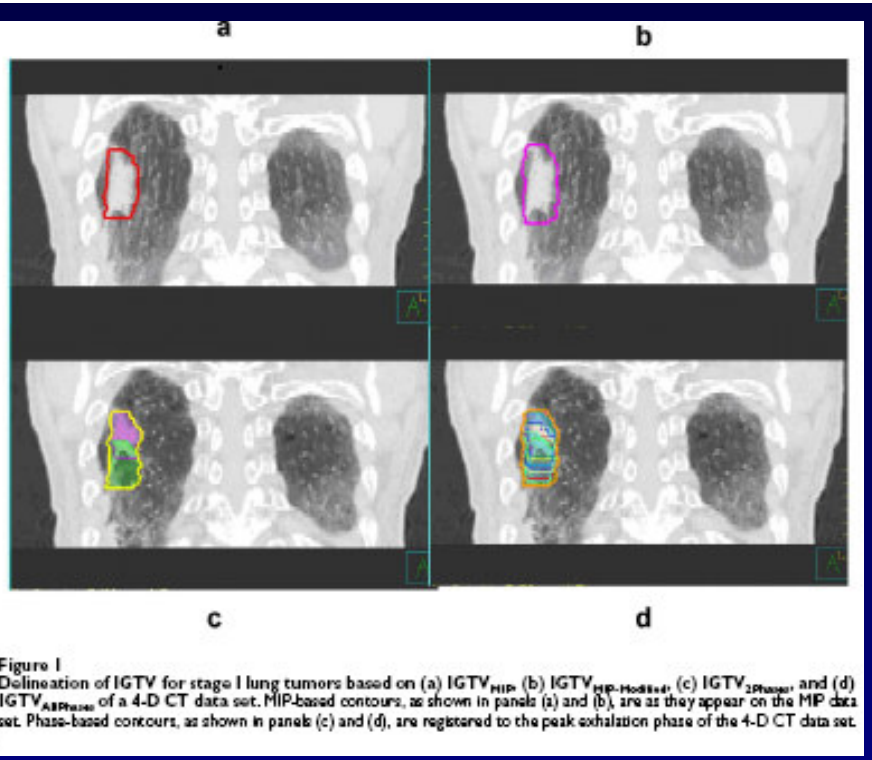


Figure 1
Delineation of IGTV for stage I lung tumors based on (a) $IGTV_{MIP}$, (b) $IGTV_{MIP\text{-}Modified}$, (c) $IGTV_{2Phase}$, and (d) $IGTV_{All Phase}$ of a 4-D CT data set. MIP-based contours, as shown in panels (a) and (b), are as they appear on the MIP data set. Phase-based contours, as shown in panels (c) and (d), are registered to the peak exhalation phase of the 4-D CT data set.

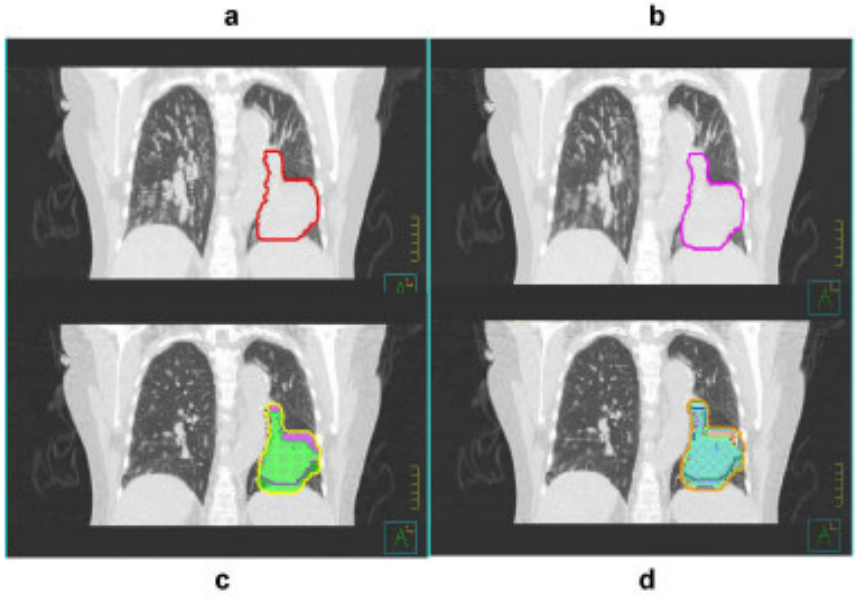


Figure 2
Delineation of IGTV for stage III lung tumors based on (a) $IGTV_{MIP}$, (b) $IGTV_{MIP\text{-}Modified}$, (c) $IGTV_{2Phase}$, and (d) $IGTV_{All Phase}$ of a 4-D CT data set. MIP-based contours, as shown in panels (a) and (b), are as they appear on the MIP data set. Phase-based contours, as shown in panels (c) and (d), are registered to the peak exhalation phase of the 4D-CT data set.

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Determination of patient-specific internal gross tumor volumes for lung cancer using four-dimensional computed tomography

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* Corresponding author

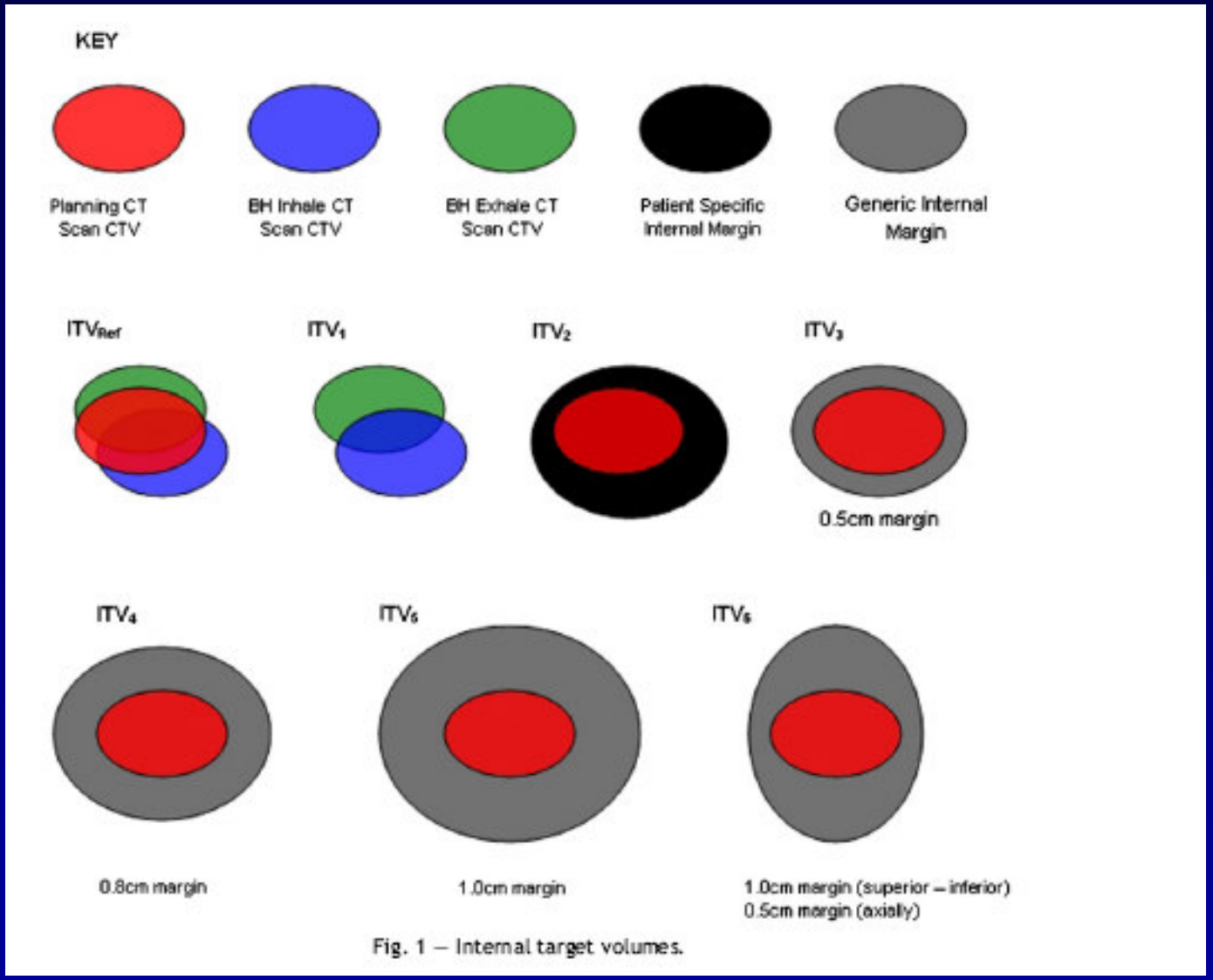
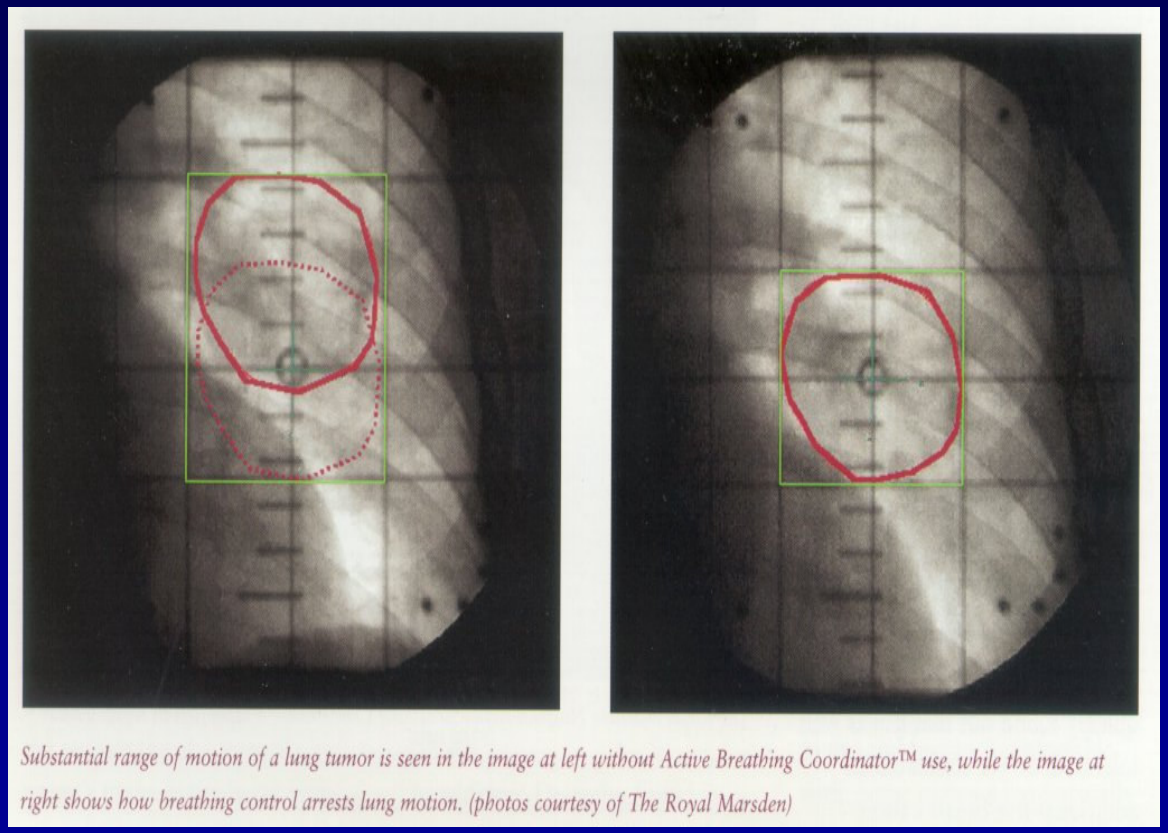


Fig. 1 – Internal target volumes.

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV



Substantial range of motion of a lung tumor is seen in the image at left without Active Breathing Coordinator™ use, while the image at right shows how breathing control arrests lung motion. (photos courtesy of The Royal Marsden)

Implicazioni nella fase di trattamento: Internal Margin

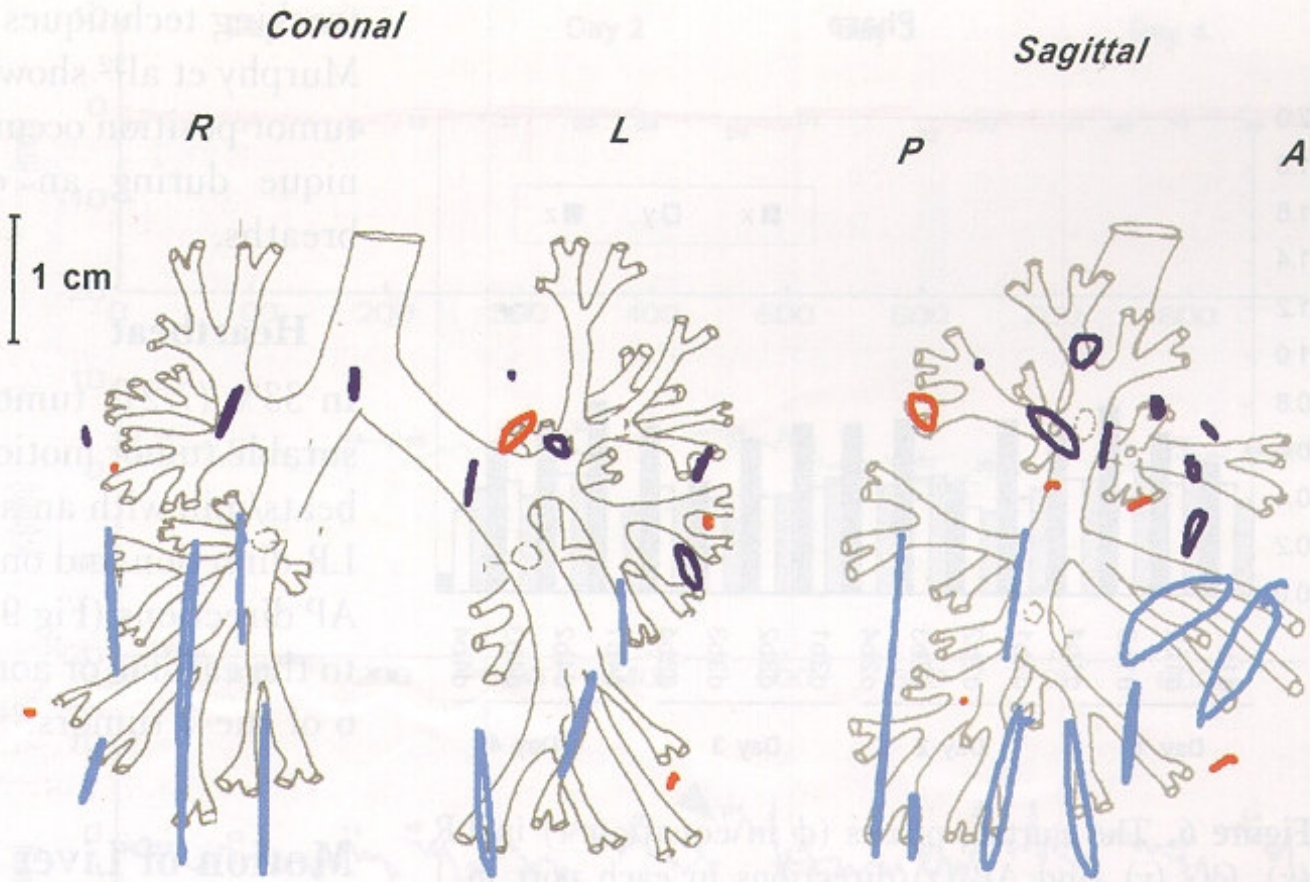
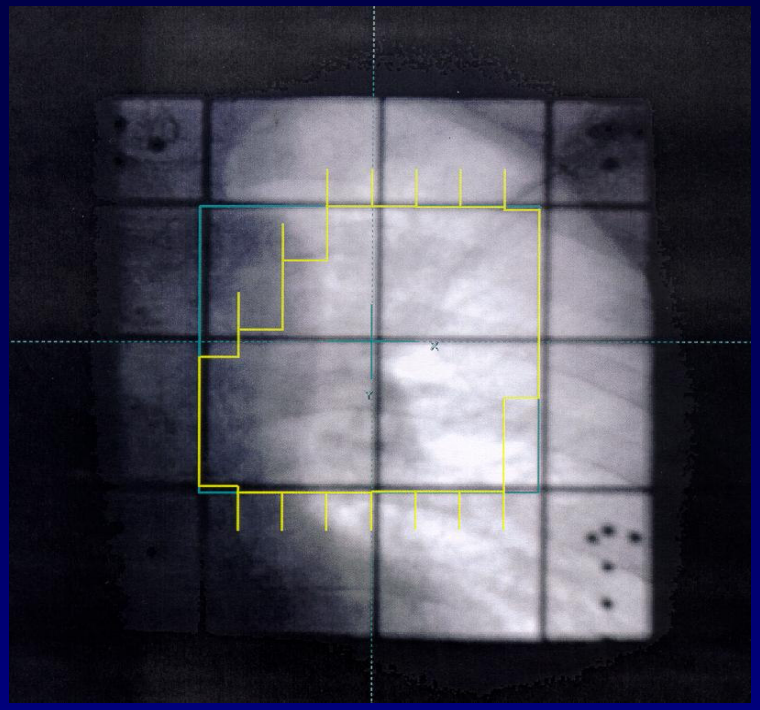
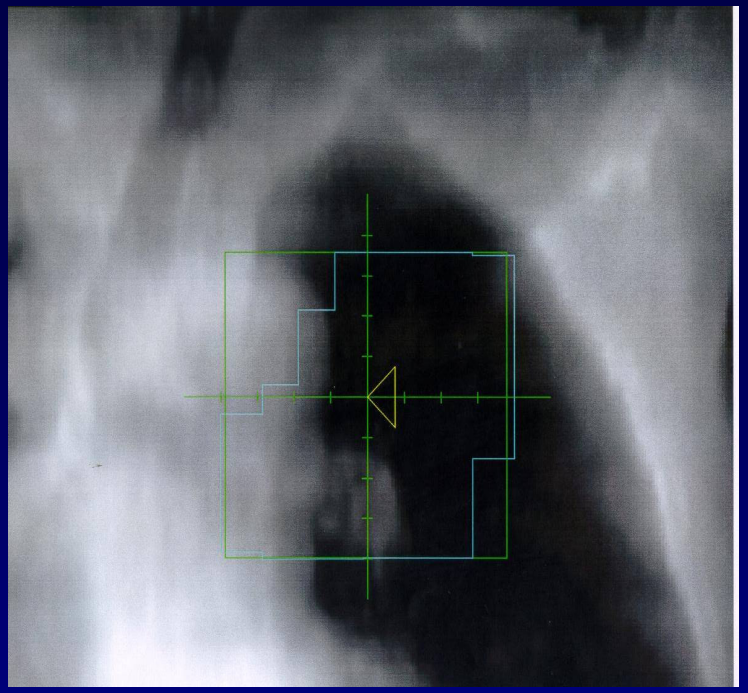


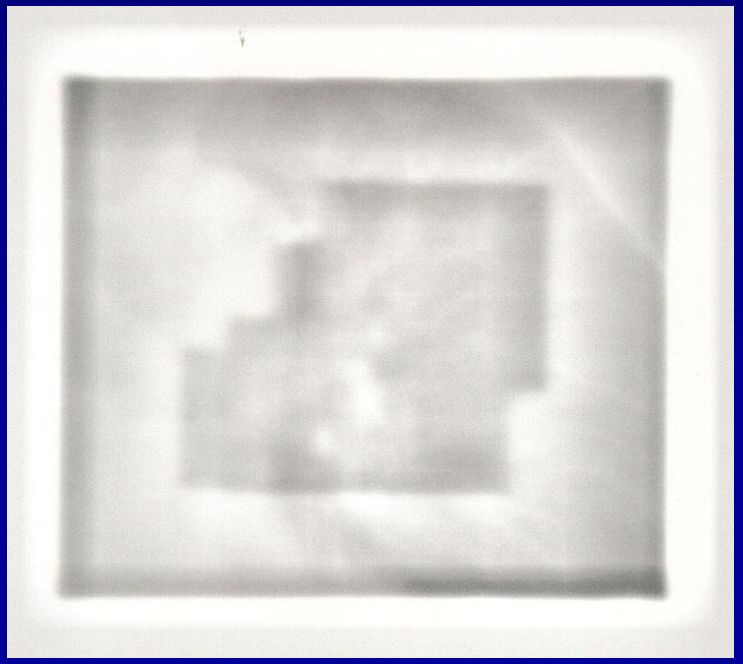
Figure 5. Orthogonal projections of the 3D trajectories of the 21 tumors on the coronal and the sagittal plane. The tumors are displayed at the approximate position. Tumors that were attached to bony structures are colored red; lower-lobe tumors are colored light blue. (Modified with permission.[24])

3D trajectories of 21 tumors in the coronal and sagittal plane
Lower lobe tumors are colored light blue



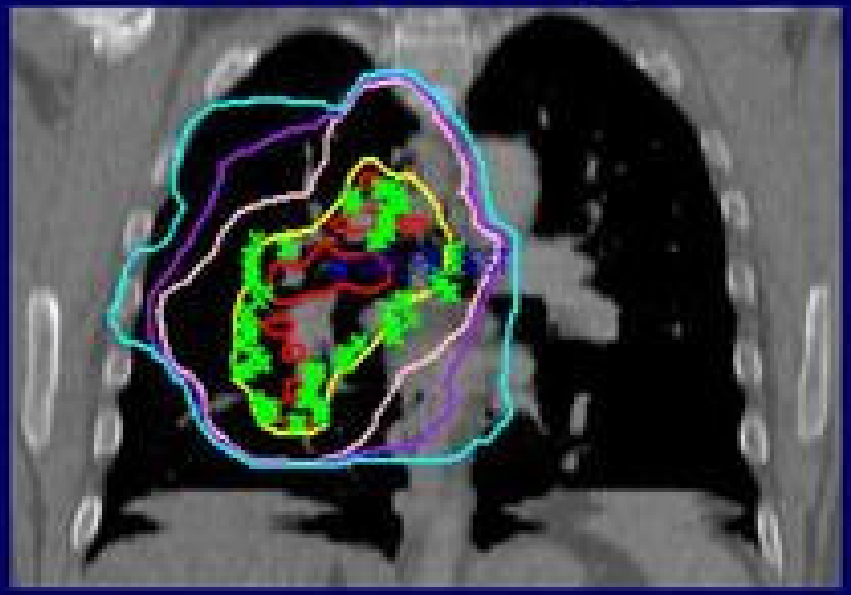


Necessità di margini adeguati a comprendere il CTV indipendentemente dalle escursioni respiratorie



Comparison of Free Breathing and Respiratory Gated Treatment Plans

Free breathing



Gated - inspiration

- Less lung within the radiation field with gating on inspiration
- NTCP decreased from 30% to 19% with gating technique

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

How to limit motion?

- Abdominal compression
- Deep inspiration breathing training
- Active Breath Control
- Target tracking

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

How to limit motion?

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- Target tracking

Controlled compression of of abdominal wall was emploied only when fluoroscopy showed a motion of the target of > +/- 7 mm

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Patient	Without abdominal compression (mm)	With abdominal compression (mm)
A	20.0	10.0
B	16.0	11.0
C	15.0	10.0
D	15.0	8.0
E	15.0	7.0
F	10.0	5.0
G	7.0	5.0

From: Negoro, Y., IJROBP, 2001

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

How to limit motion?

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- Deep inspiration breathing training
- Active Breath Control
- Target tracking

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Deep inspiration breathing training

- Deep inspiration breath holding: most reproducible position
- Increased lung volume: lower percentage of total lung volume receiving > 20 Gy
- Decreased lung density
- Tumor imobilization: PTV margin reduction

Barnes, EA et al : Int J Radiat Oncol Biol Phys, 2001

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Supero inferior motion during free breathing (FB) or deep inspiration breath holding (DIBH)

Patient	Tumor location	FB SI motion (mm)	DIBH SI motion (mm)
A	RLL	31,9	1,4
B	RLL	22,5	3,8
C	Mediastinum	2,0	1,0
D	RUL	7,1	3,5
E	LLL	9,4	2,2
F	RML	10,0	2,5
G	LLL	10,0	2,1
H	RML	10,7	3,3
Mean		12,9	2,8

Barnes EA, et al: Int J Radiat Oncol Biol Phys, 2001

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

V 20 variations

Patient	Free breathing + margins	DIBH + margins	Decrease in V > 20 Gy (%)
A	13.9	5.2	62.6
B	19.5	11.0	43.6
C	14.5	14.7	- 1.4
D	11.7	7.6	35.0
E	16.8	15.5	7.7
F	13.3	8.4	36.8
G	6.3	4.5	28.6
H	6.0	3.2	46.7
Mean	12.8	8.8	32.5

Barnes EA, et al: Int J Radiat Oncol Biol Phys, 2001

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Deep inspiration breathing training

- Self gating at DIBH is an inexpensive, easily performed method of reducing the total lung volume receiving high dose irradiation
- The dosimetric benefit is patient specific and due to both the increased lung volume achieved at deep inspiration and the PTV margin reduction allowed through tumor imobilization
- Not all patients are suitable for this technique

Barnes, EA et al : Int J Radiat Oncol Biol Phys, 2001

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

How to limit motion?

- Abdominal compression
- Deep inspiration breathing training
- Active Breath Control
- Target tracking

Active breath control

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Active breath control

- The patient's breathing is monitorized continuously
- At a preset lung volume airflow of the patient is temporarily blocked immobilizing breathing motion
- The duration of the active breath hold is that which is comfortably mantained by each patient
- Radiation will be turned on and off during this period

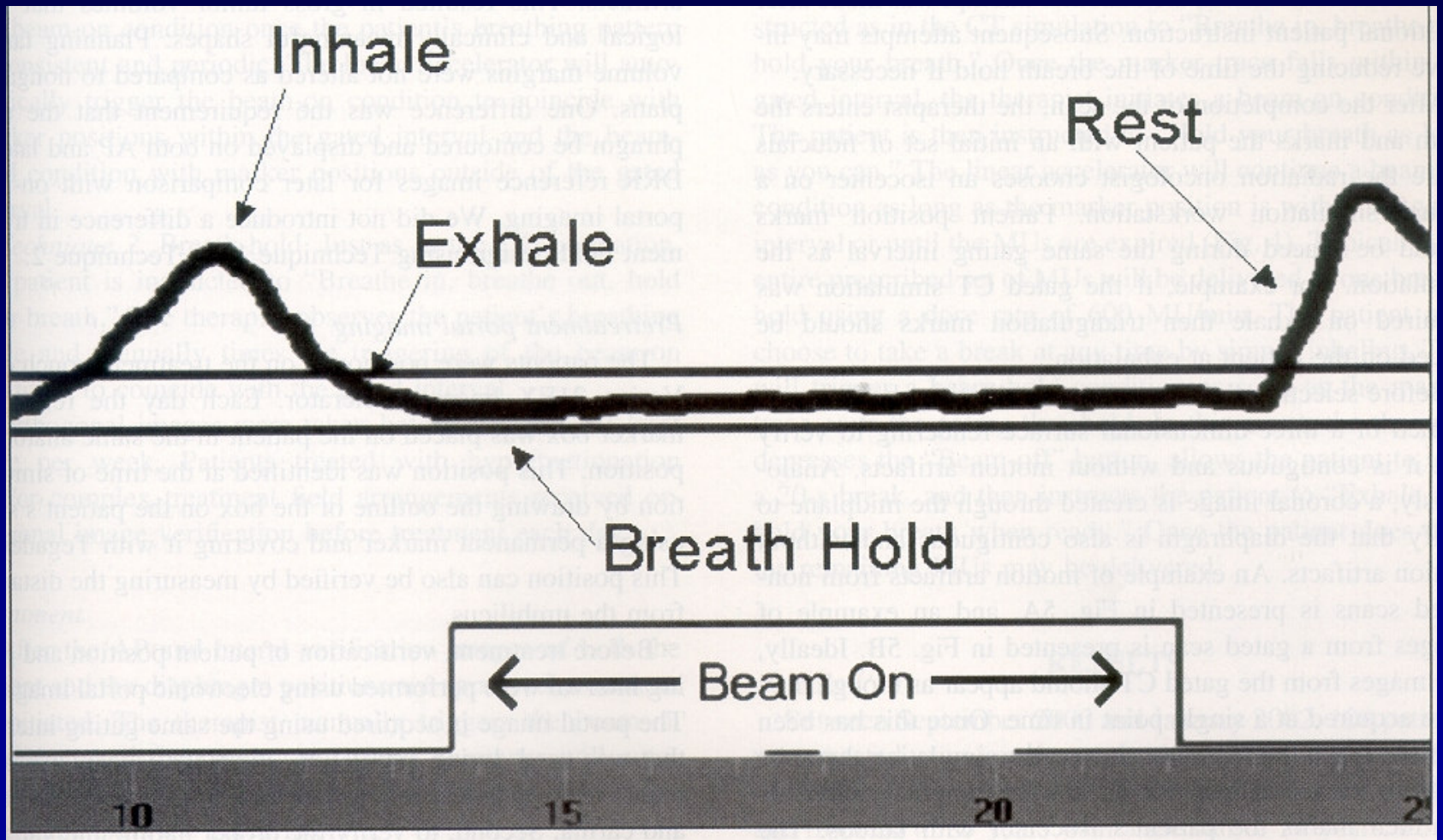

Fig. 4. Part of the respiratory gating software user interface. The wave represents the patient's respiration during a breath hold on exhalation. The beam-on condition corresponds to the amplitude-gated exhalation.

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Active breath control

Average excursions beetween edge profiles of 2 ABC CT scan

Region	n Data points	Intrafraction (mm)	Interfraction (mm)
Diaphragm	60	1.5+/-1.8	4.0+/-3.3
Mid thorax	20	2.1+/-1.7	3.9+/-3.1
Apex	36	2.6+/-2.0	2.0+/-2.2

Wong, JW: Int J Radiat Oncol Biol Phys, 1999

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

How to limit motion?

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- Deep inspiration breathing training
- Active Breath Control
- Target tracking

RADIATION THERAPY IN THE TREATMENT OF LUNG TUMORS: UNCERTAINTIES IN TARGETING PTV

Real time tumor tracking (RTRT): automatic repositioning of the beam relative to the tumor target

- Shift the patient using a remotely controlled couch
- Shift the beam by physically repositioning the radiation source (CyberKnife)
- Redirect the beam electromagnetically (for charged particle beams)
- Shift the aperture of a remotely controlled colimator
- Gating the beam to tumor motion

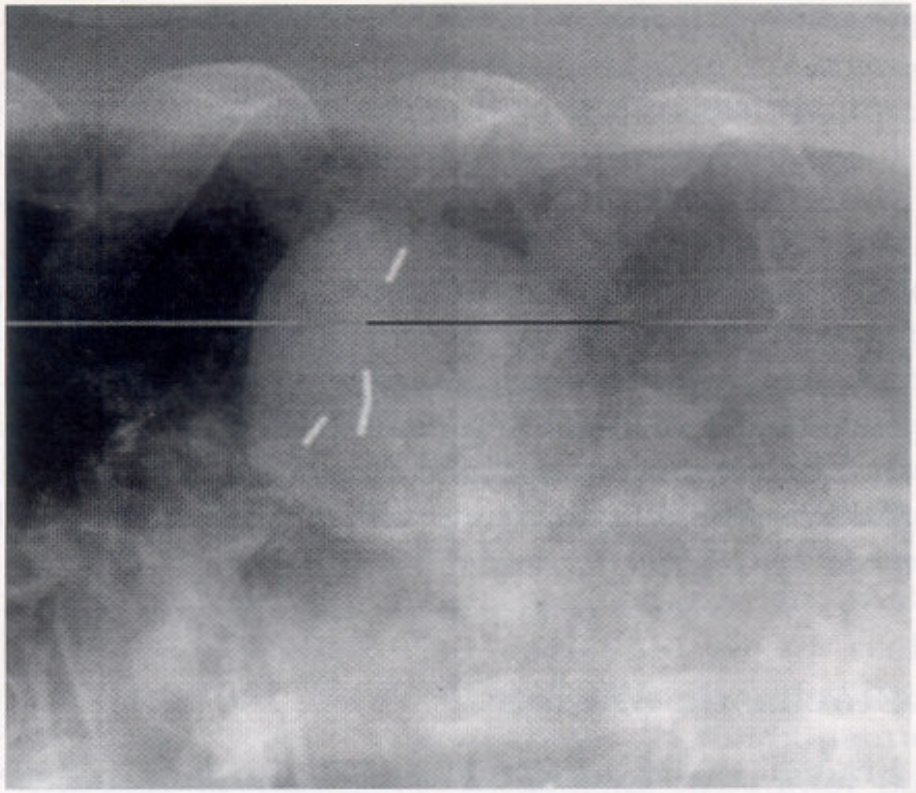


Figure 1. A radiographic image of a lung tumor containing 4 gold fiducials, taken with a real-time amorphous silicon imaging system during a CyberKnife lung radiosurgery treatment.

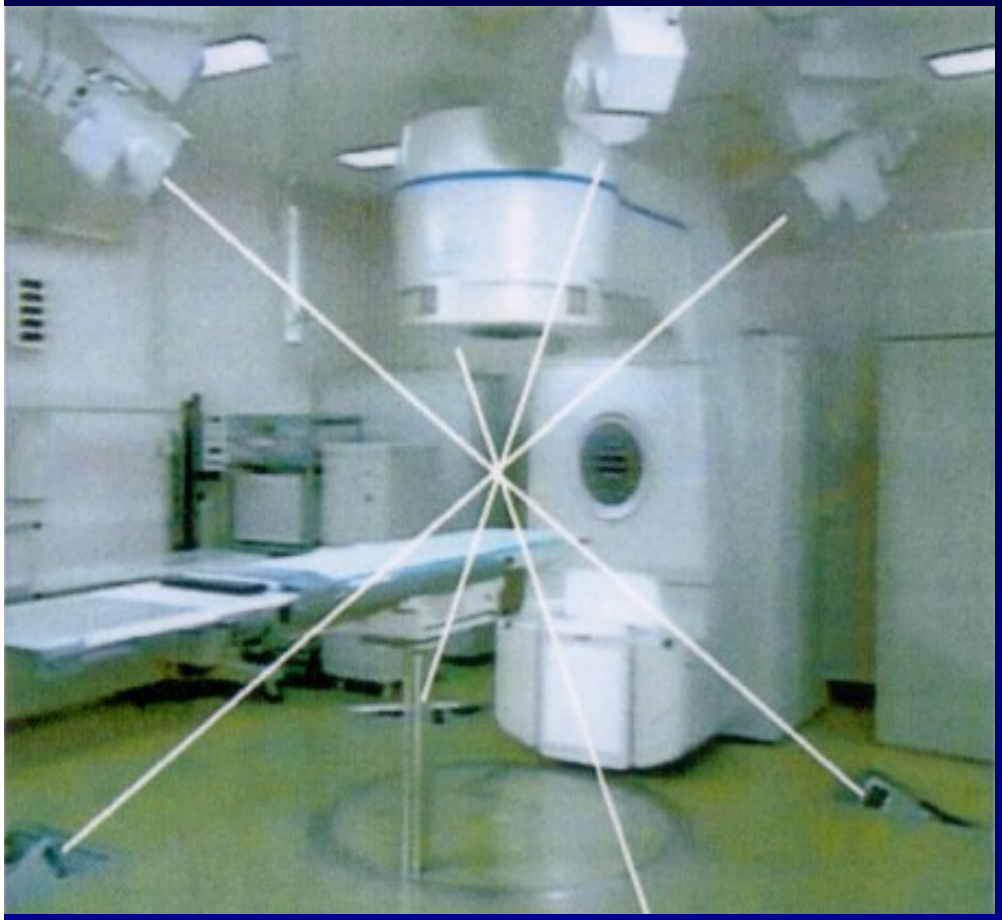
4 ways to locate the target:

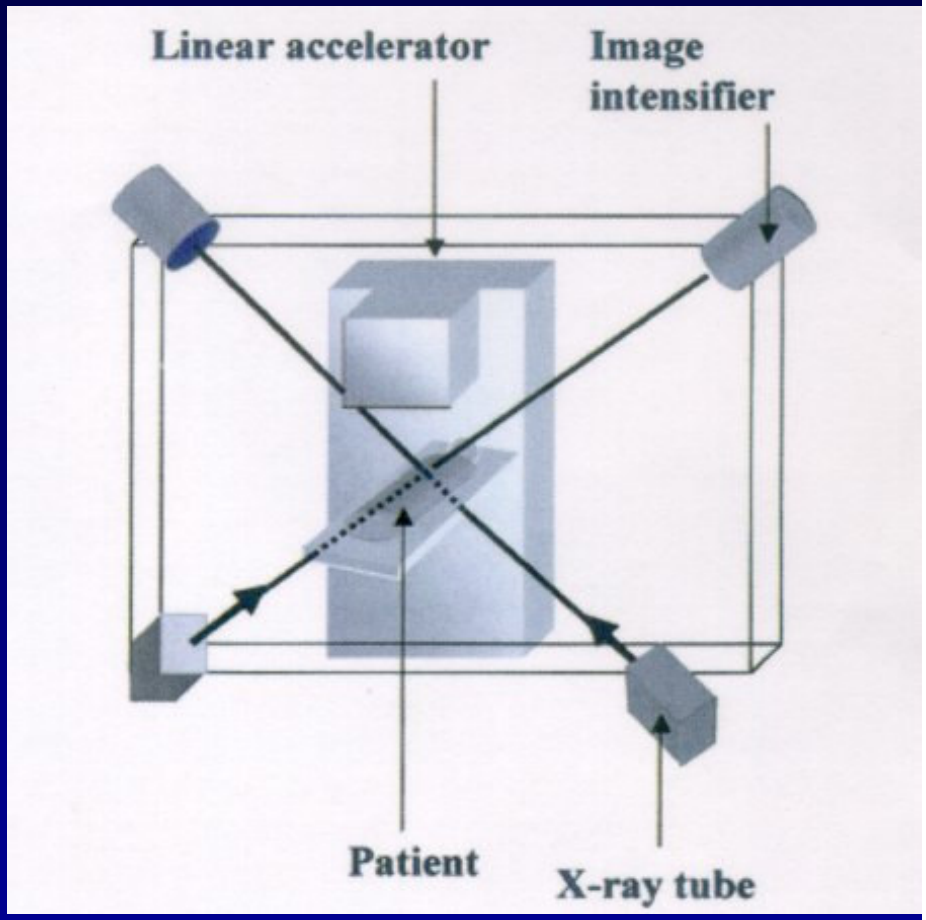
- Image the tumor
- Image anatomical structures rigidly connected to the tumor
- Detect artificial fiducials implanted in the tumor
- Track surrogate organs that move in synchrony with the tumor

Tumor motion measured via radiographic imaging

Measure the target position on a time scale faster than the motion itself

Fiducial based guidance has the advantage that the fiducials are easily located with automatic image processing tools and the time needed to make a position determination is short (50 msec)





Determination of 3D coordinates of tumor markers by mean of fluoroscopic digitized images

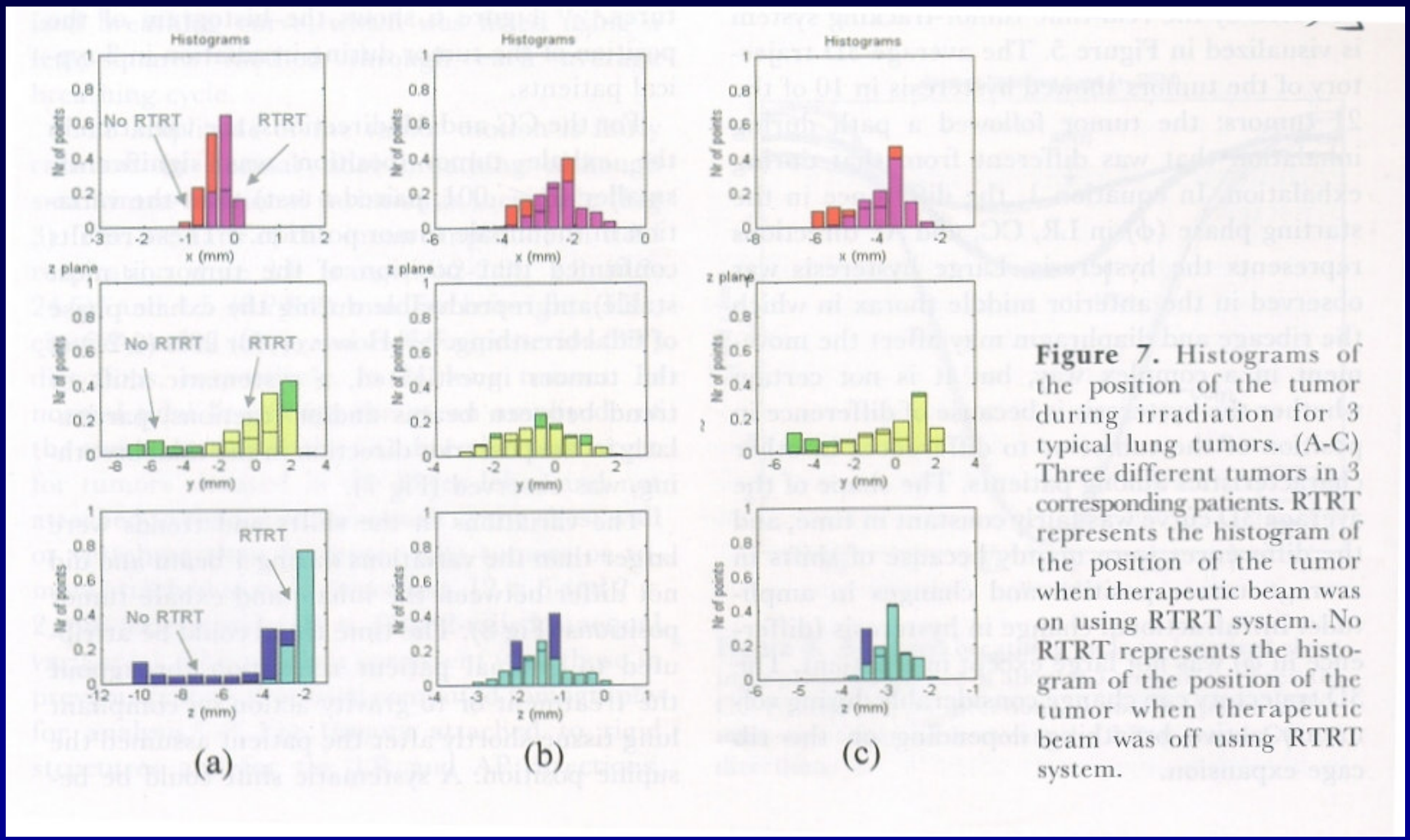


Figure 7. Histograms of the position of the tumor during irradiation for 3 typical lung tumors. (A-C) Three different tumors in 3 corresponding patients. RTRT represents the histogram of the position of the tumor when therapeutic beam was on using RTRT system. No RTRT represents the histogram of the position of the tumor when therapeutic beam was off using RTRT system.

Real time tumor tracking: gating the beam to target motion. If the 3D coordinates of tumor markers are within predetermined limits the system allows the Linac to irradiate the patient

Shirato, H: Sem Radiat Oncol, 2004

Interventions to reduce organ motion effects in radiation planning and treatment of lung cancer

Conclusions

- Methods of reducing the adverse effect of organ motion occurring during a radiation treatment of lung tumors are many (abdominal compression, treating during voluntary or controlled breath hold, tracking radiation with tumor motion)
- Interventions to reduce organ motion must be patient specific, with individual studies of organ motion and reproducibility of intervention
- Reduction of organ motion must ensure an adequate representation of CTV extension during planning procedures
- Reproducibility of organ position must be good enough to permit a reduction in PTV margins

SET UP MARGIN

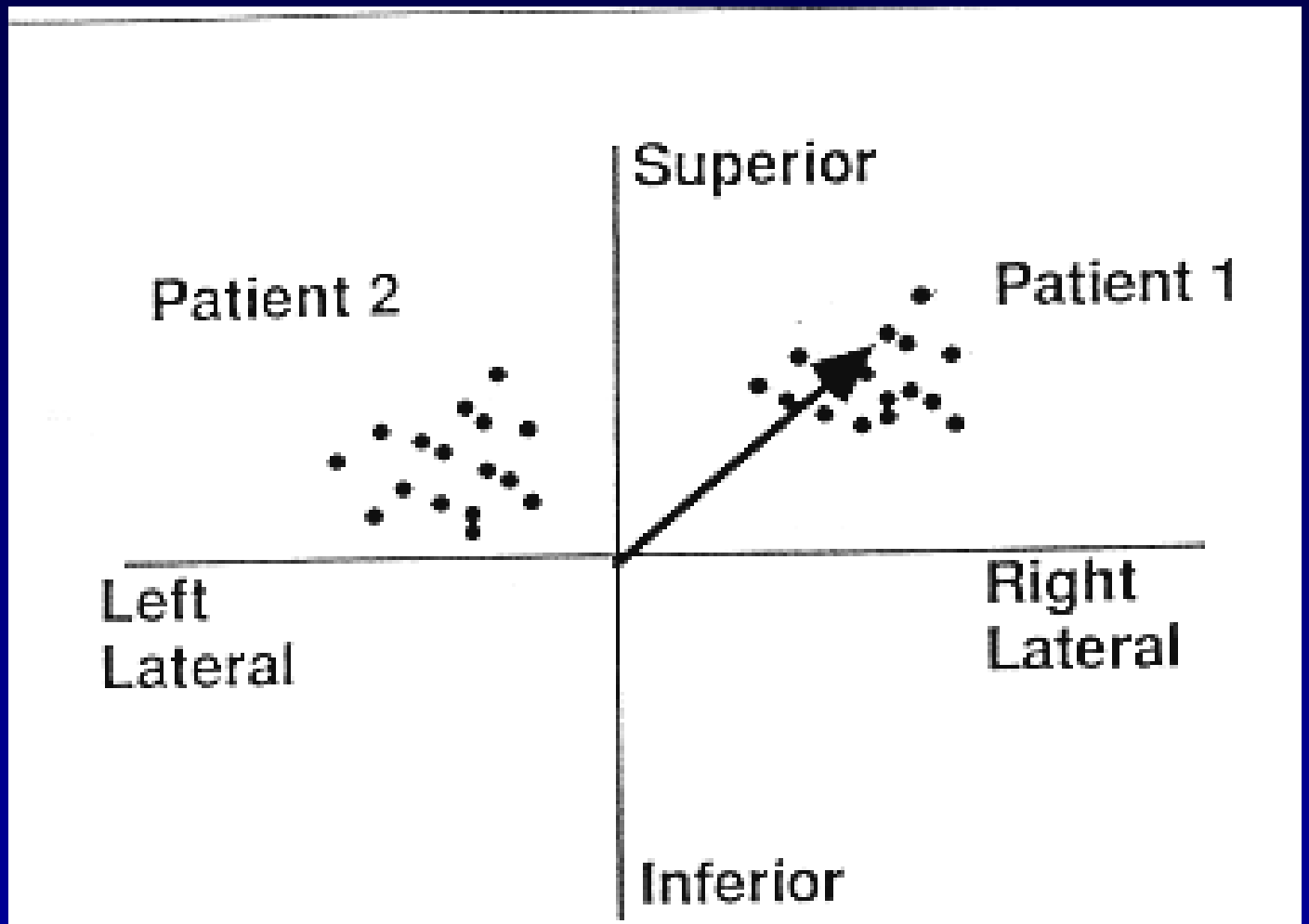
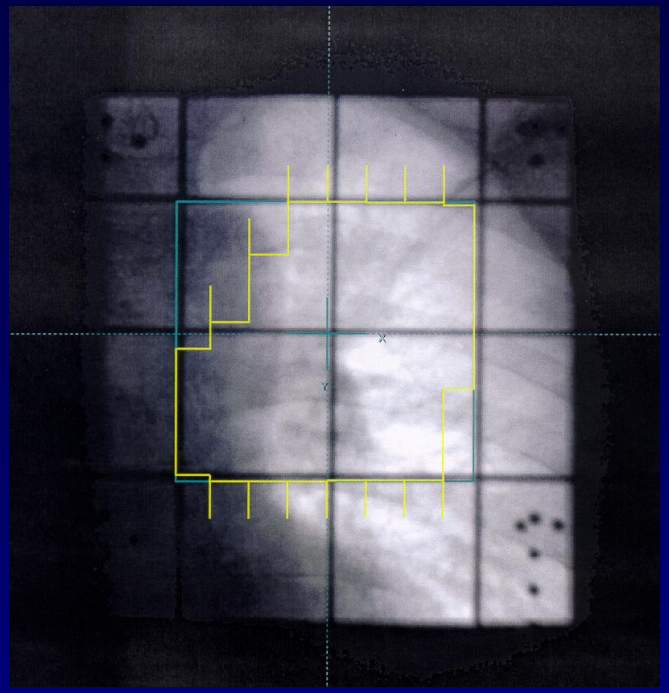


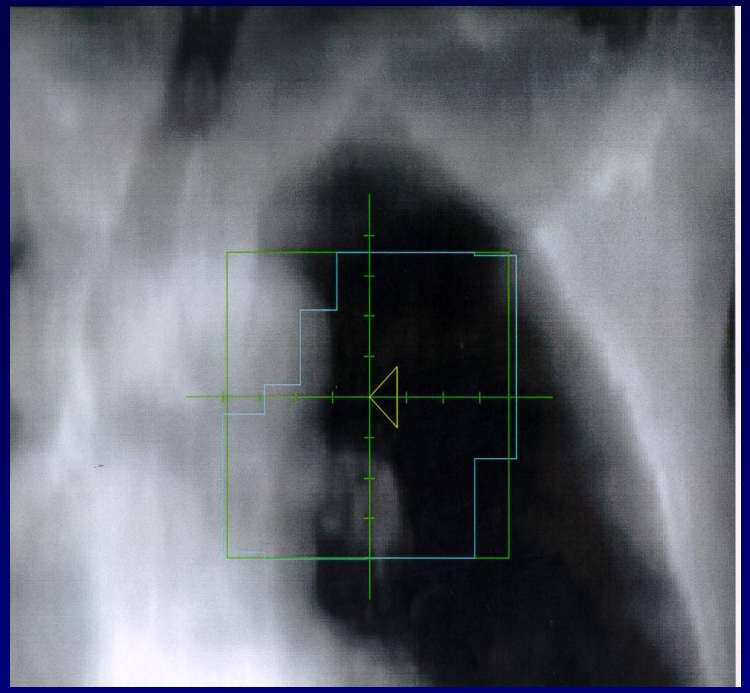
Figure 1. Random and systematic errors for two pa-

PROCESSO DI ANALISI

scopo:

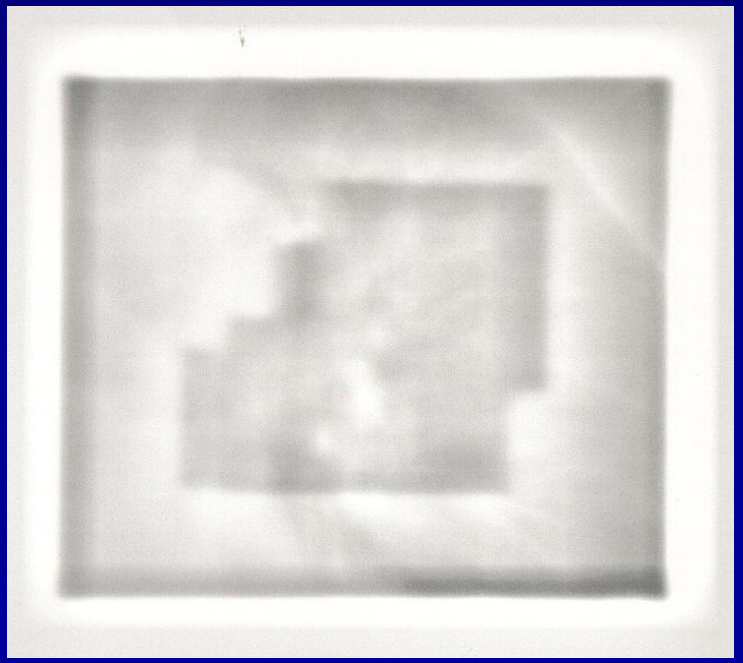
- comprendere l'effetto degli errori sistematici e casuali
- derivare i margini fra CTV e PTV





Confronto tra immagine portale e immagine di riferimento:

- ✓ Simulazione
- ✓ DRR



Risultati
(21 pazienti per 118 misurazioni)

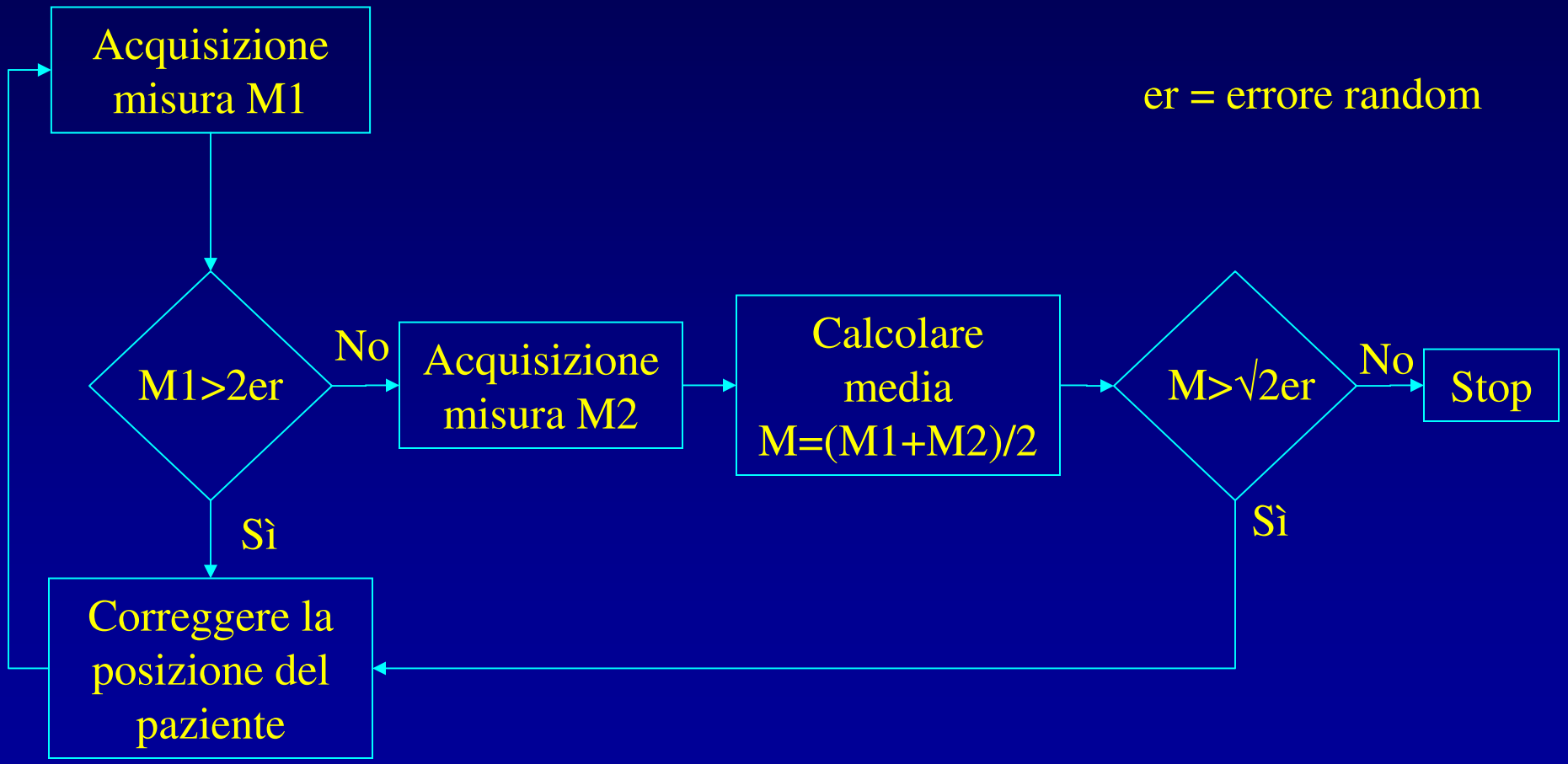
I° Gruppo: ***T – bar***
(11pz)

	c-c	lat	p-a
Errore sistematico (mm)	1.5 ± 3.5	0.3 ± 2.4	-1.1 ± 3.8
Errore random (mm)	2.1	2.1	2.3
Errore complessivo (mm)	3.7	2.8	3.7

II° Gruppo: ***cuscino a vuoto d'aria (10 pz)***

	c-c	lat	p-a
Errore sistematico (mm)	0.7 ± 3.8	0.0 ± 4.8	1.3 ± 5.9
Errore random (mm)	3.7	4.1	3.1
Errore complessivo (mm)	5.3	6.0	6.3

Diagramma di flusso del protocollo di intervento



er = errore random

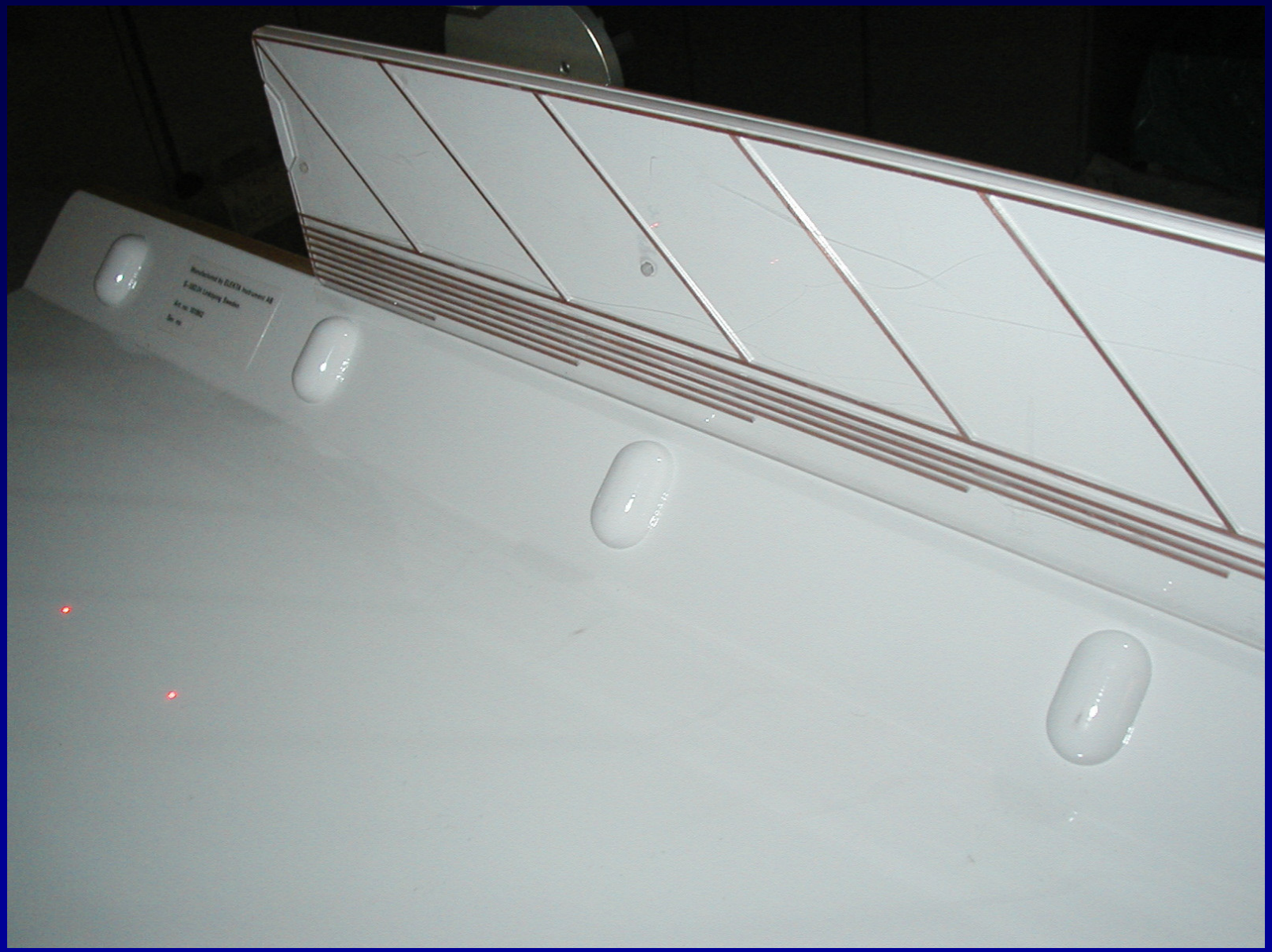
Numero medio di misure previste per paziente: 3.2

Numero medio di correzioni previste per paziente: 0.9

RADIATION THERAPY IN LUNG TUMORS

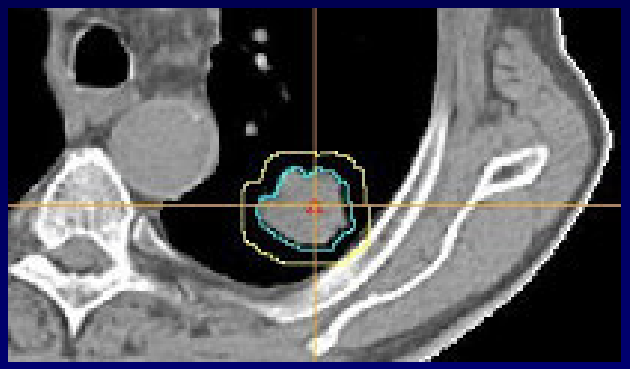
CTV - PTV

SISTEMI DI IMMOBILIZZAZIONE PER TRATTAMENTI IPOFRAZIONATI CON LOCALIZZAZIONE STEREOTASSICA

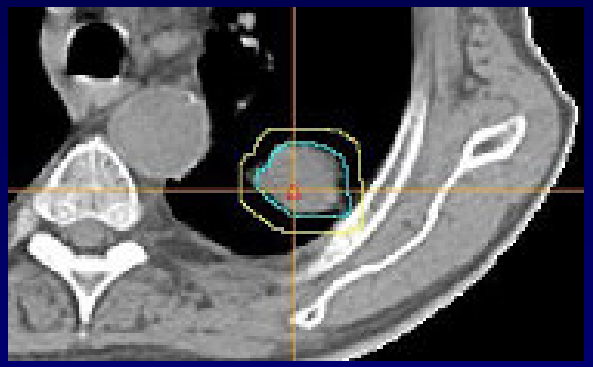


Variabilità del riposizionamento del CTV rispetto all'isocentro

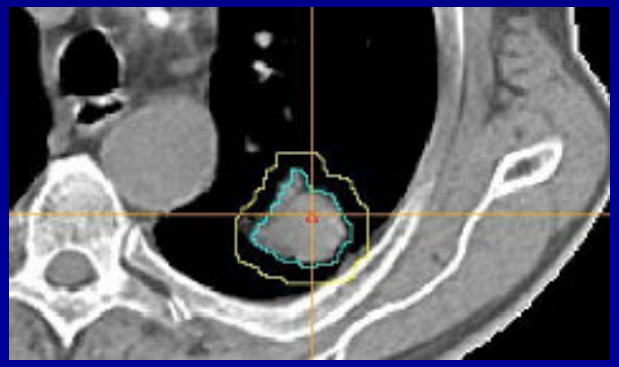
piano di trattamento



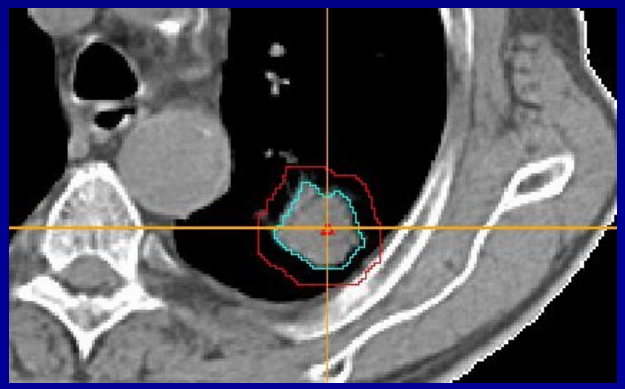
1° frazione



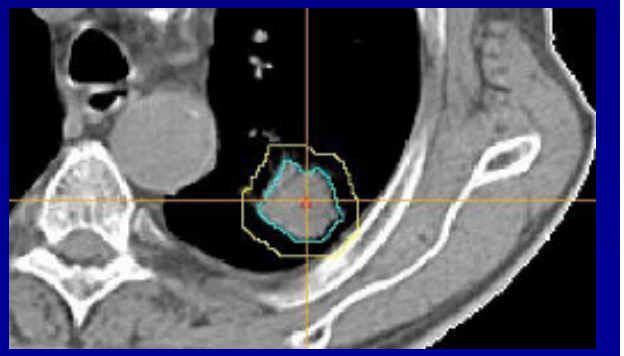
2° frazione



3° frazione

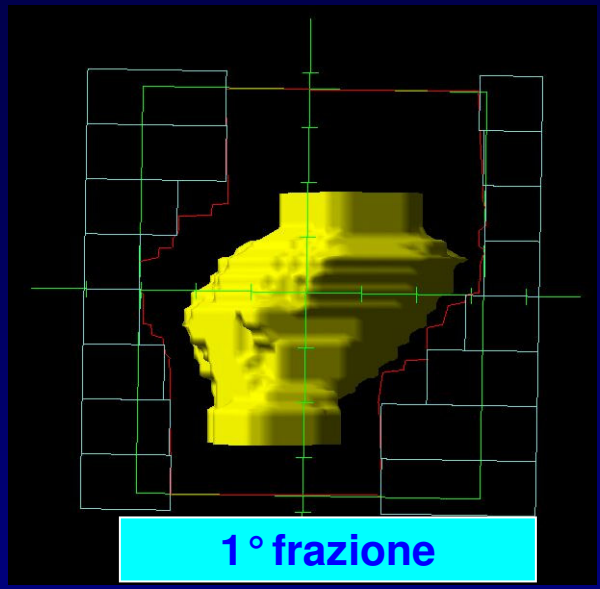


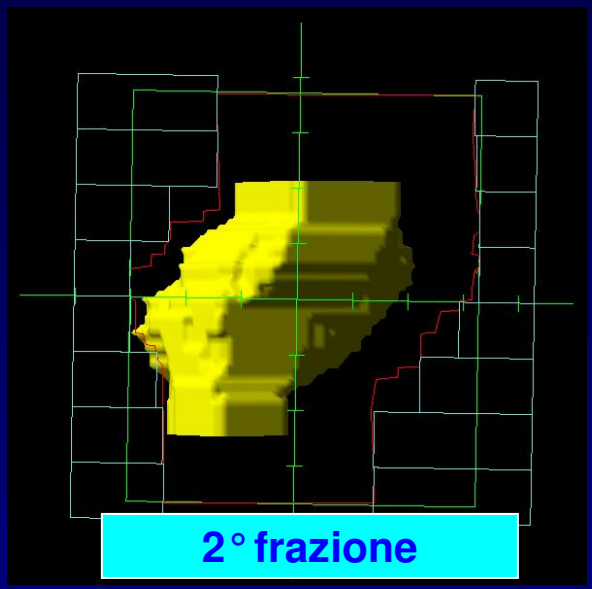
4° frazione

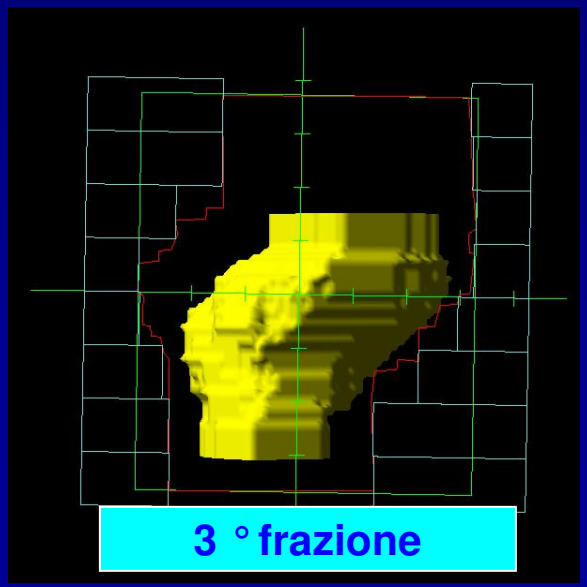


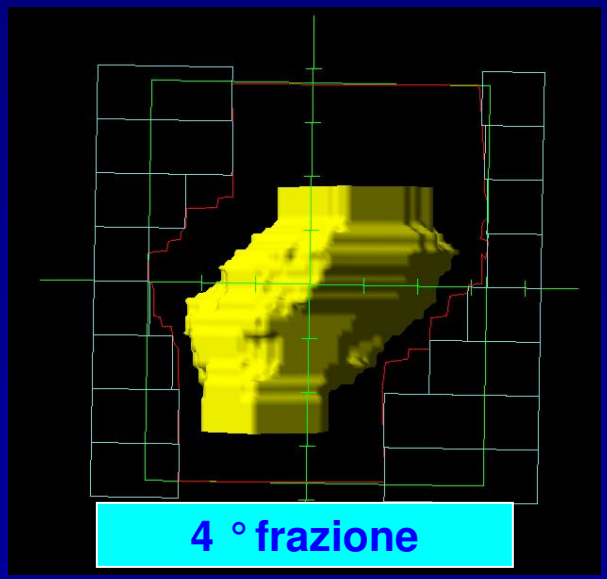
5° frazione

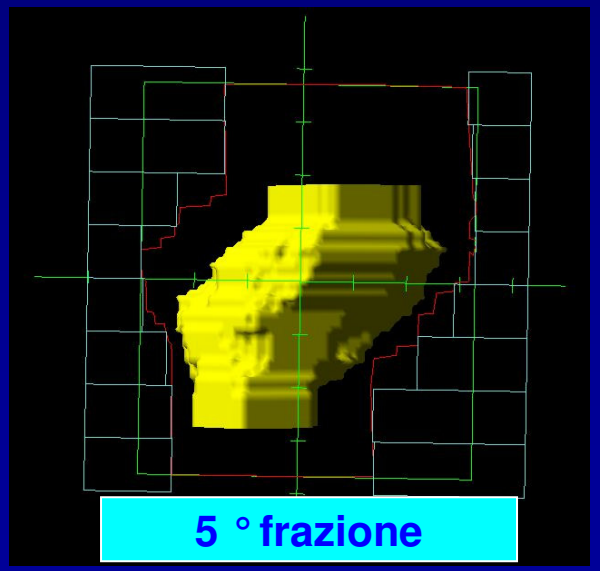
Variabilità del riposizionamento del CTV rispetto al singolo fascio

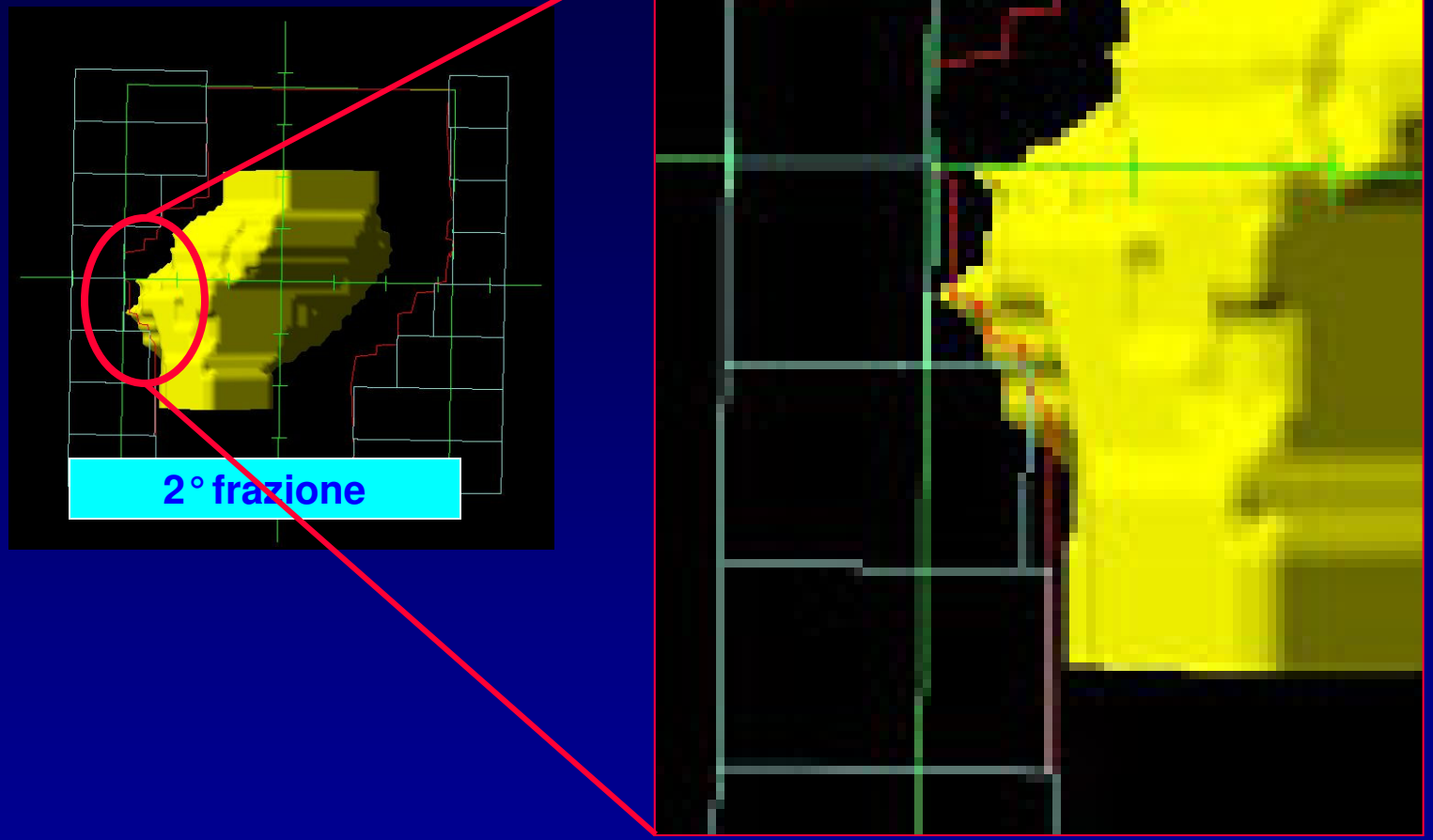




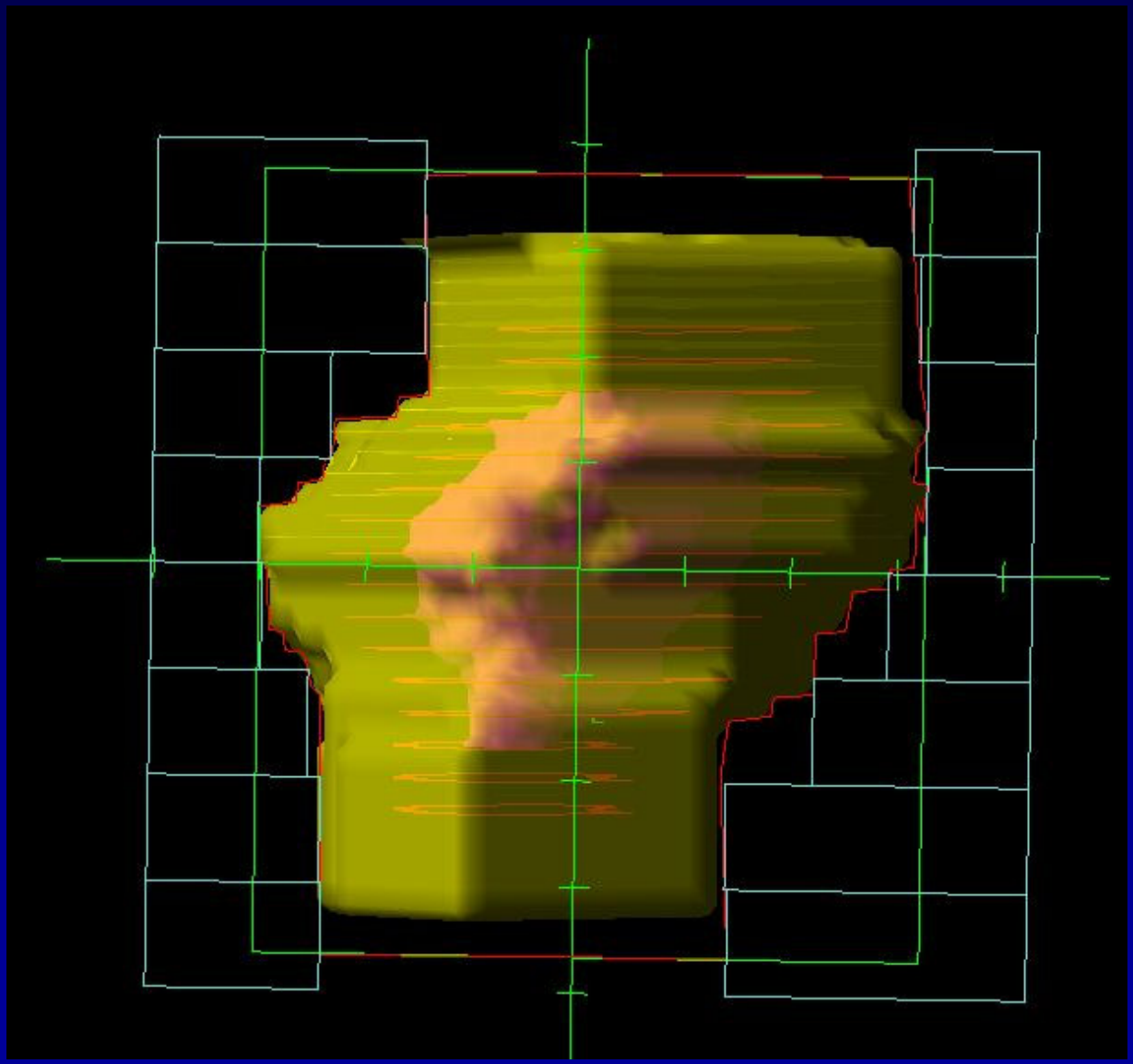


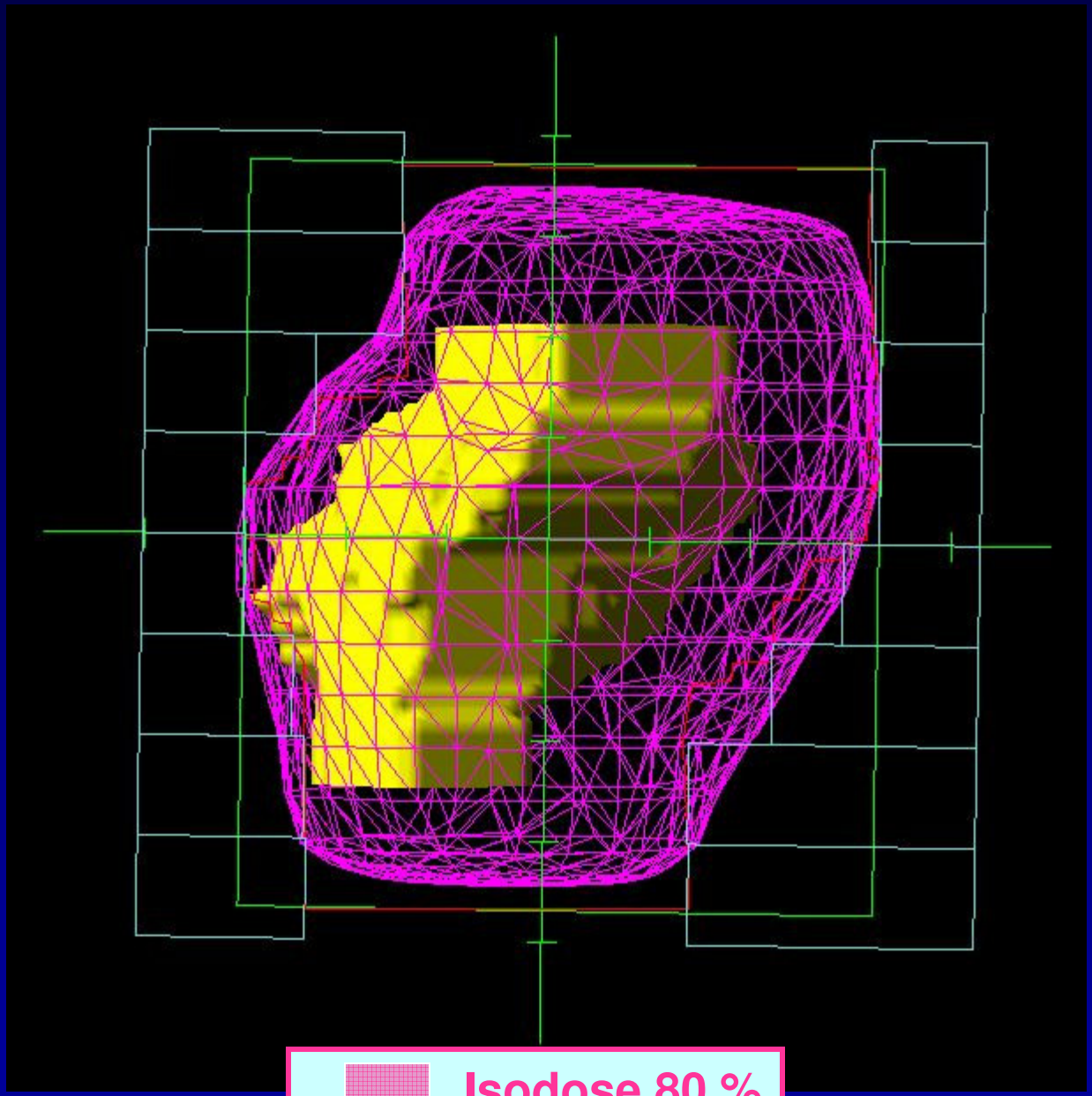


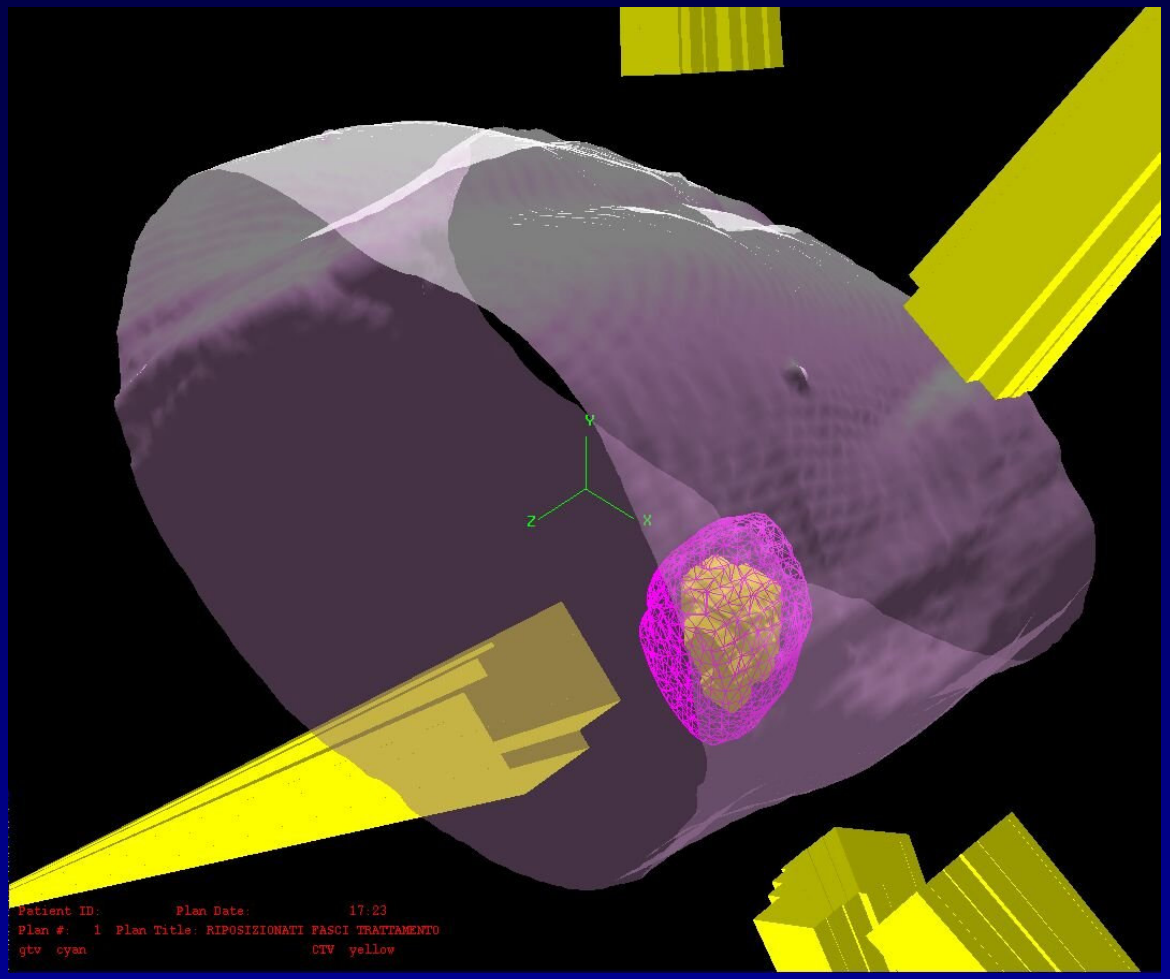


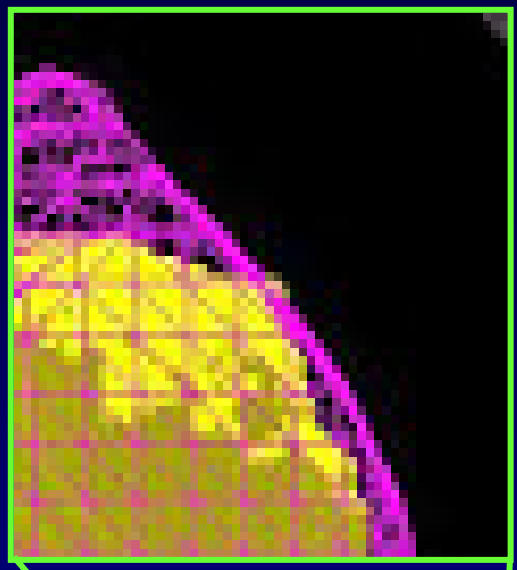

2° frazione

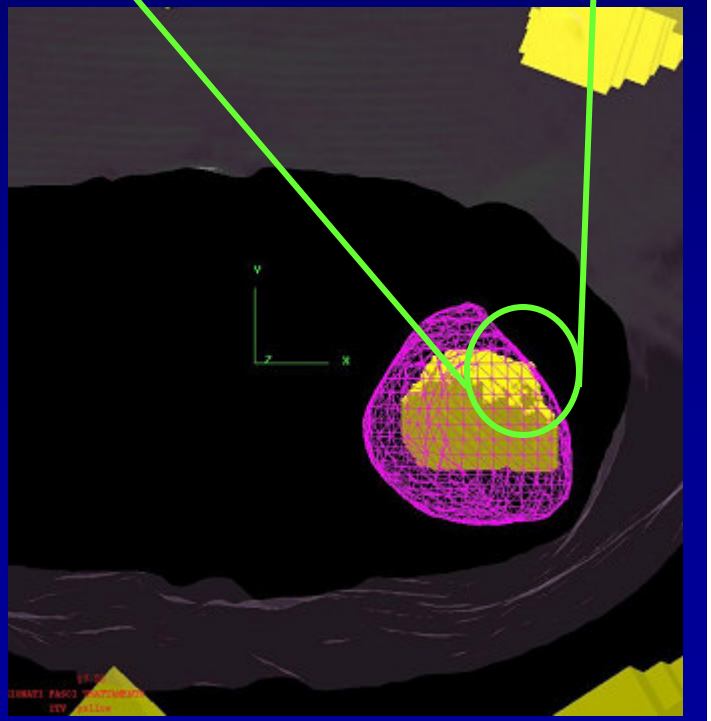
PTV CTV GTV




Isodose 80 %


Patient ID: Plan Date: 17:23
Plan #: 1 Plan Title: RIPOSIZIONATI FASCI TRATTAMENTO
gtv cyan CTV yellow

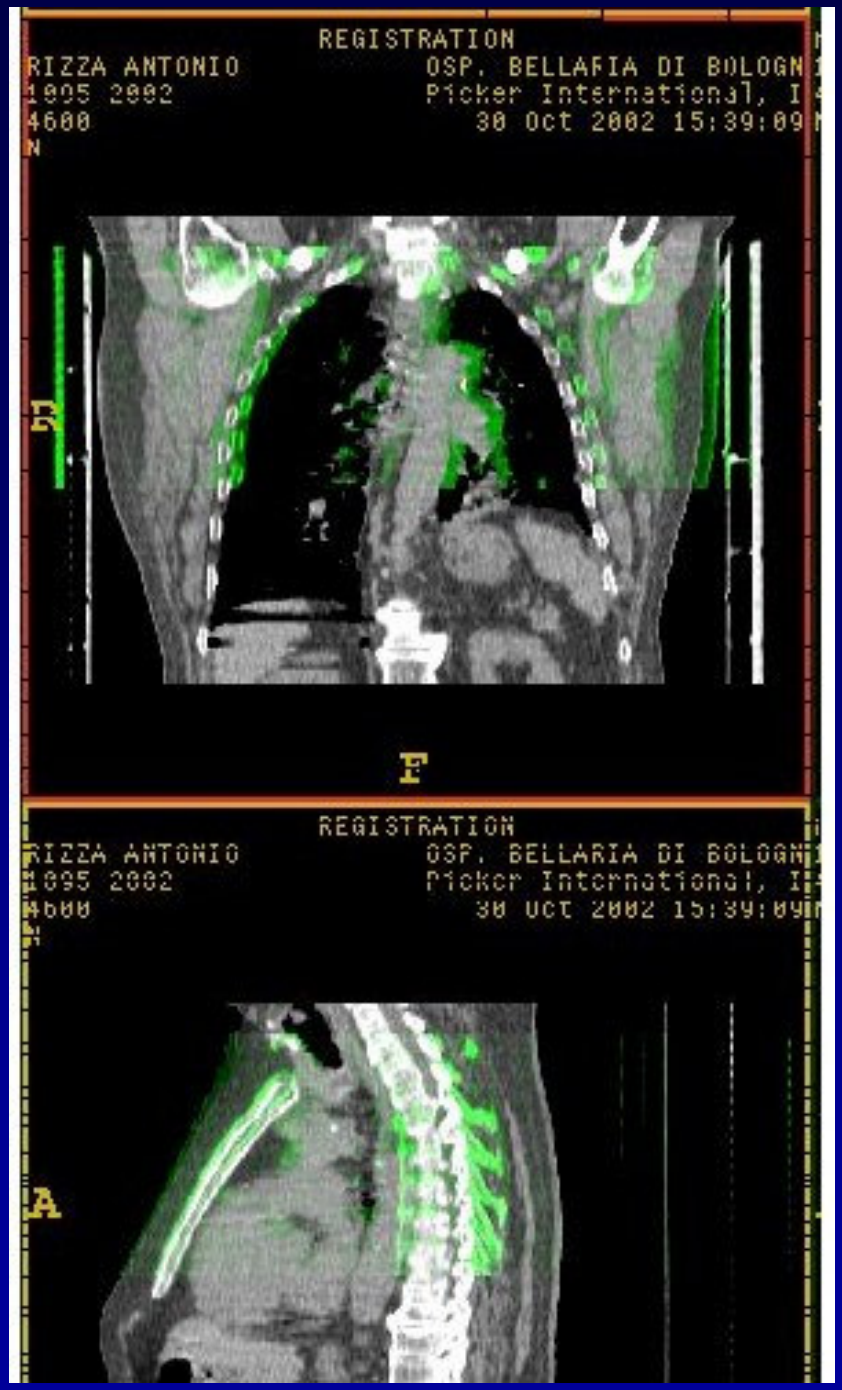


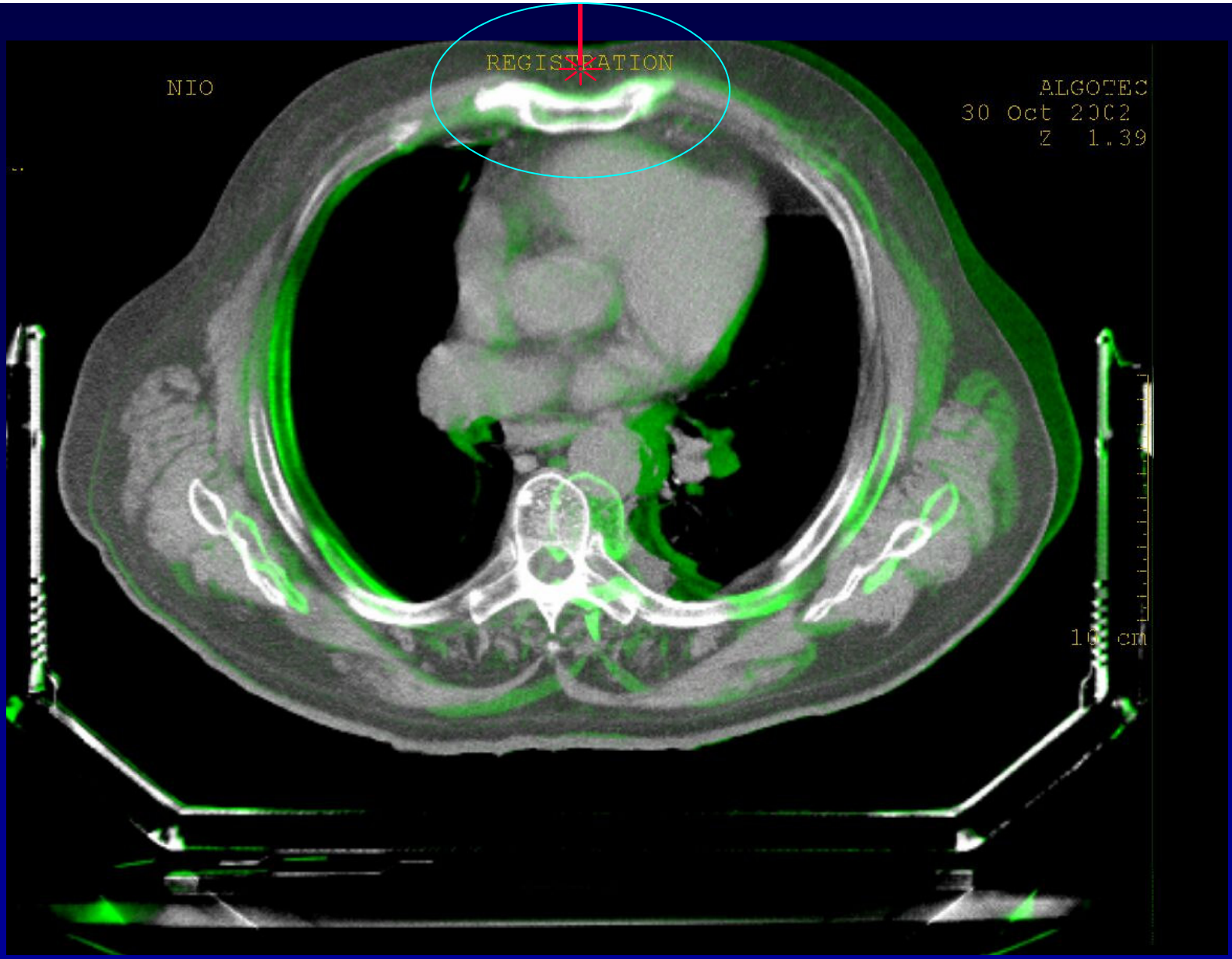


Isodose 80 %

Impatto dosimetrico della variabilità del riposizionamento

	Volume a dose 80%	Volume a dose 90%	Volume a dose 100 %
fraz. 1	100 %	100 %	95 %
fraz. 2	99.98 %	99.83 %	78 %
fraz. 3	100 %	99.98 %	88 %
fraz. 4	100 %	100 %	95 %
fraz. 5	100 %	100 %	94 %


REGISTRATION
RIZZA ANTONIO
1005 2002
4600
N
OSP. BELLARIA DI BOLOGN
Picker International, I
30 Oct 2002 15:39:09
F
REGISTRATION
OSP. BELLARIA DI BOLOGN
Picker International, I
30 Oct 2002 15:39:09
A



Presence of <u>rotation and traslation</u> of the patients with respect to SBF

Radiotherapy and Oncology 66 (2003)

"Impact of target reproducibility on tumor dose in stereotactic radiotherapy of target in the lung and liver"

J. Wulf et al (Univ. Of Würzburg)

TC (Target Coverage)

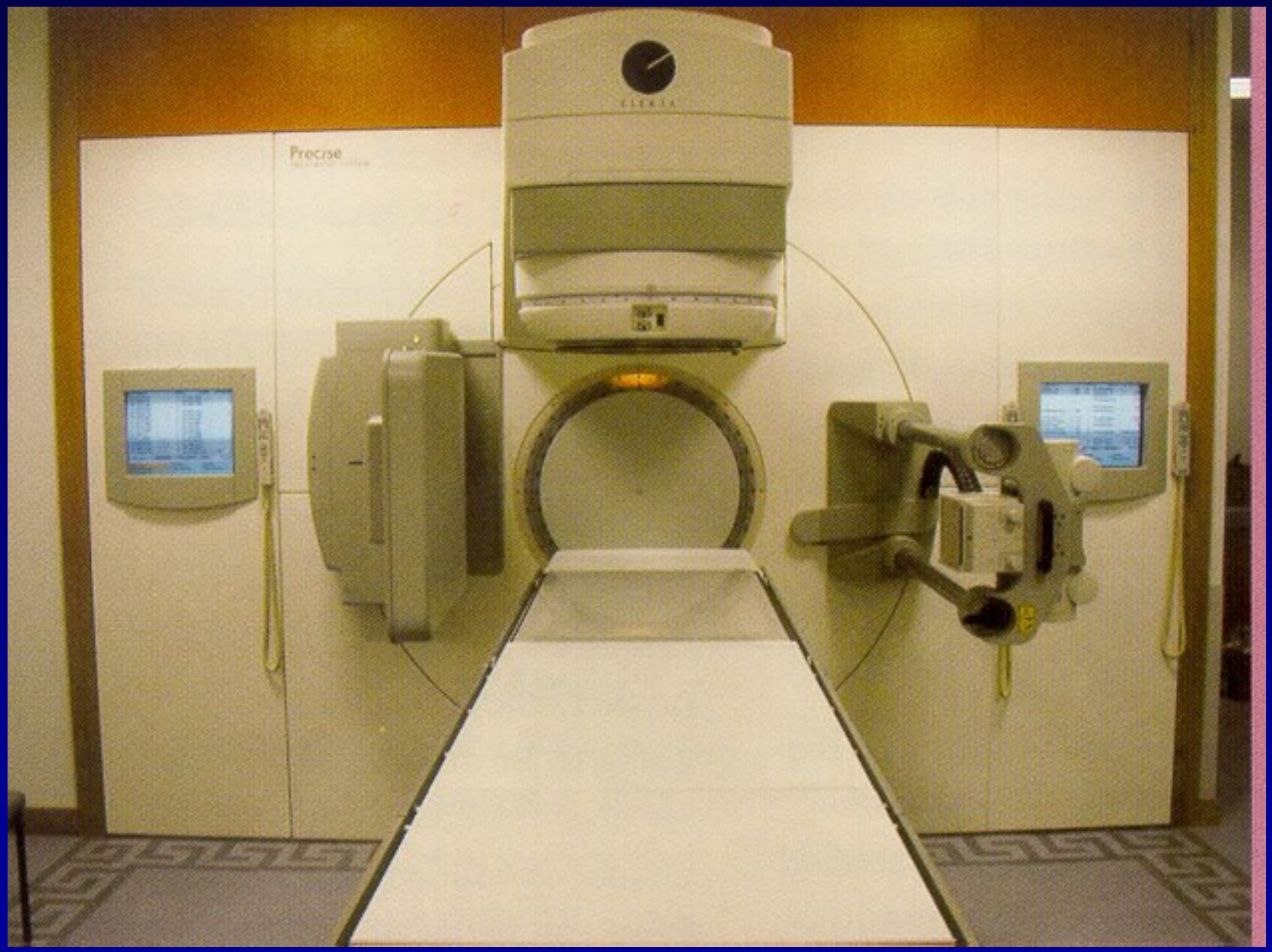
TC = % of CTV all'interno della isodose di riferimento

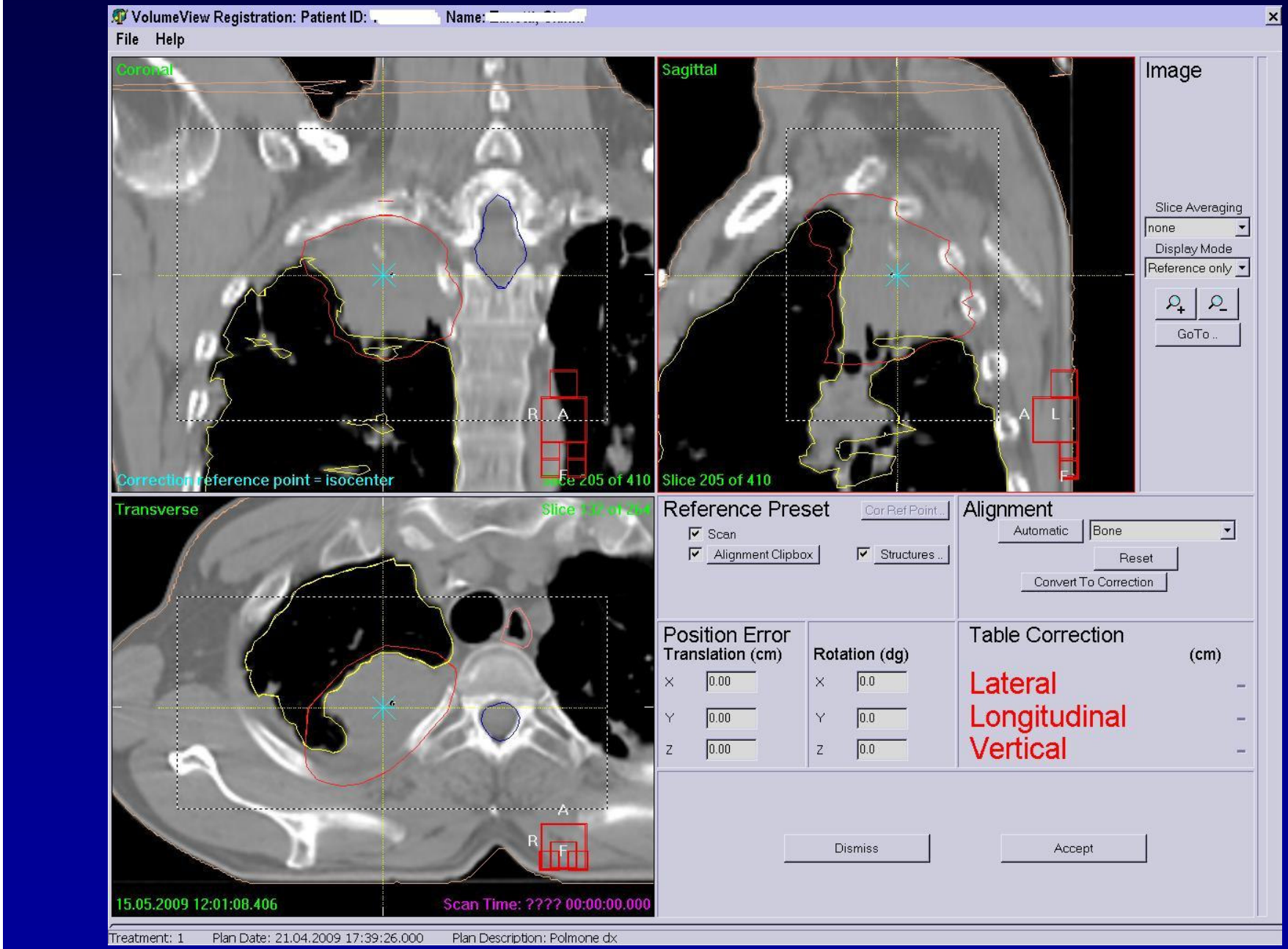
N° 93/99 targets with $TC^{sim} \geq 95\%$

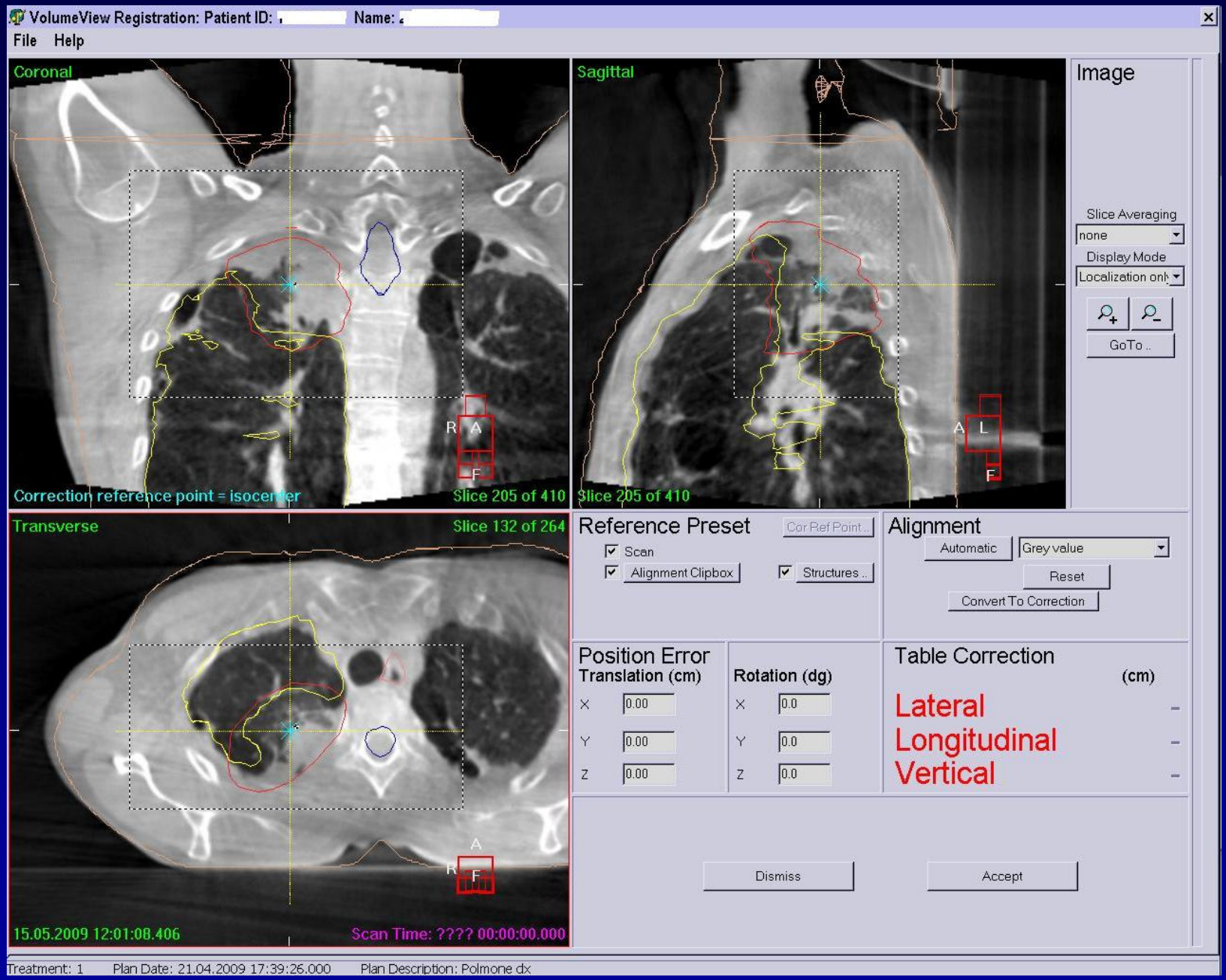
N° 98/99 targets with $TC^{sim} \geq 85\%$

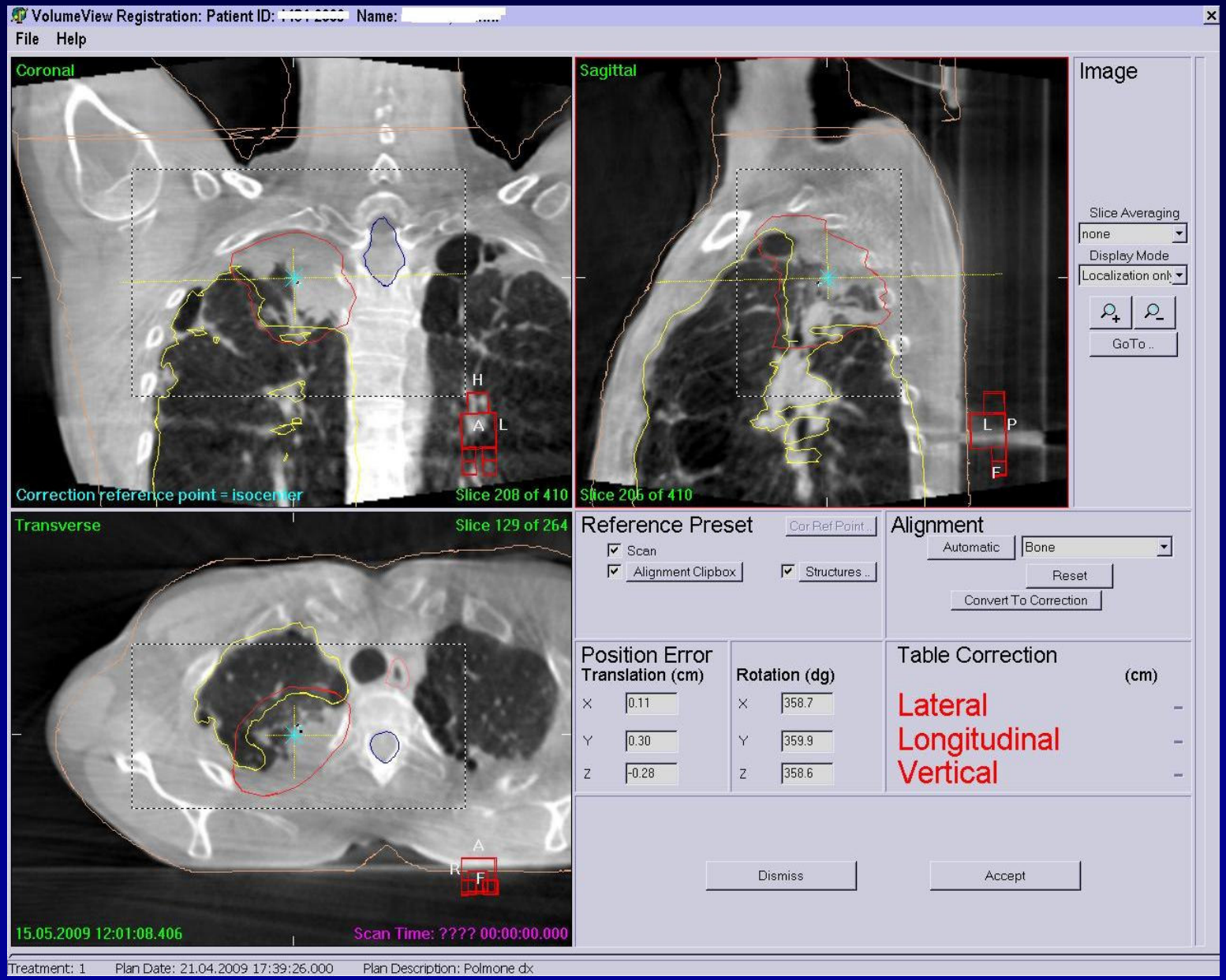
TC^{sim}_{mean}	0,958
TC^{sim}_{median}	0,996
TC^{sim}_{min}	0,682
Tc^{sim}_{max}	1,000
SD_{TCsim}	0,084

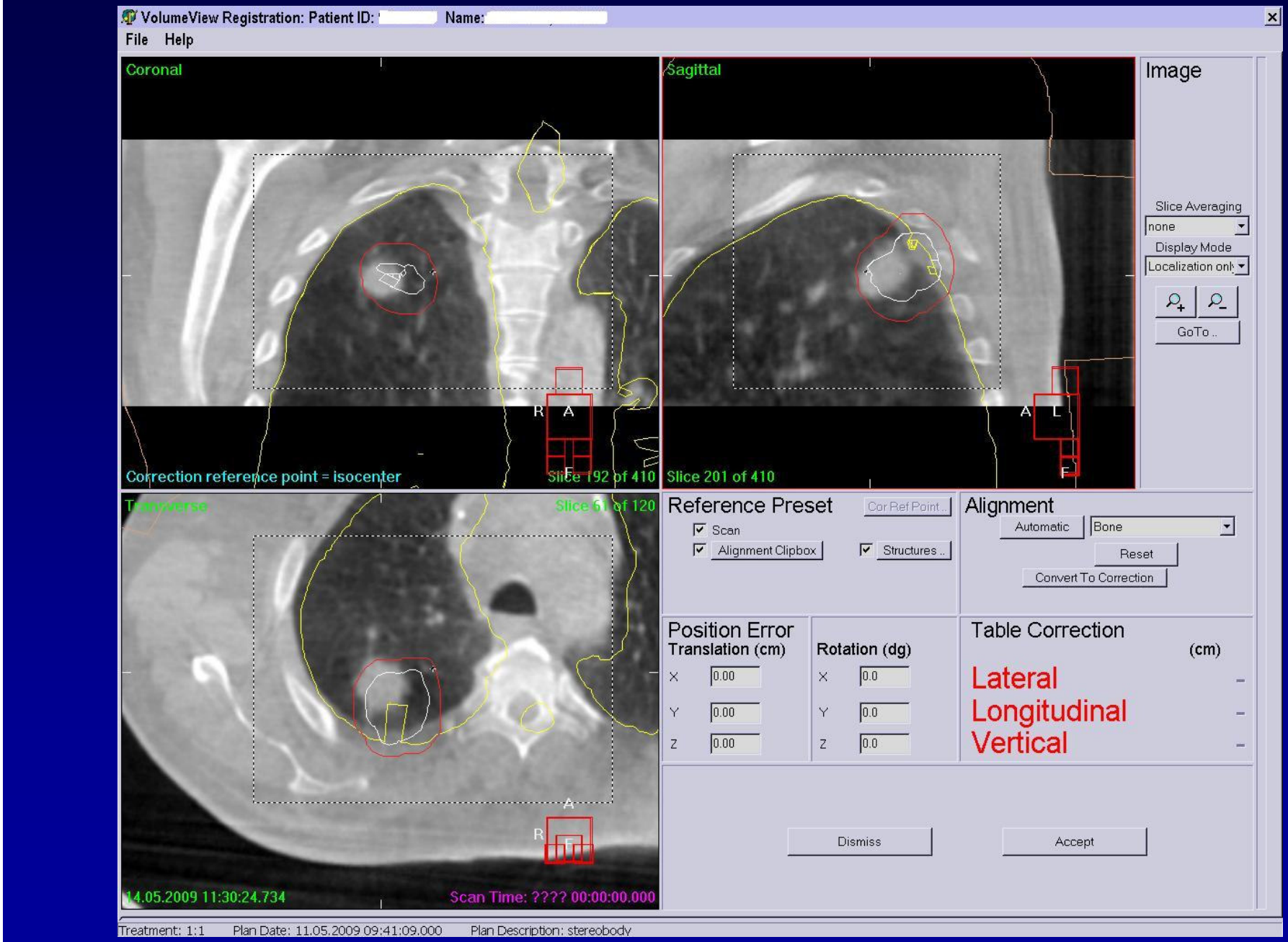
IMAGE GUIDED RADIATION THERAPY


Precise

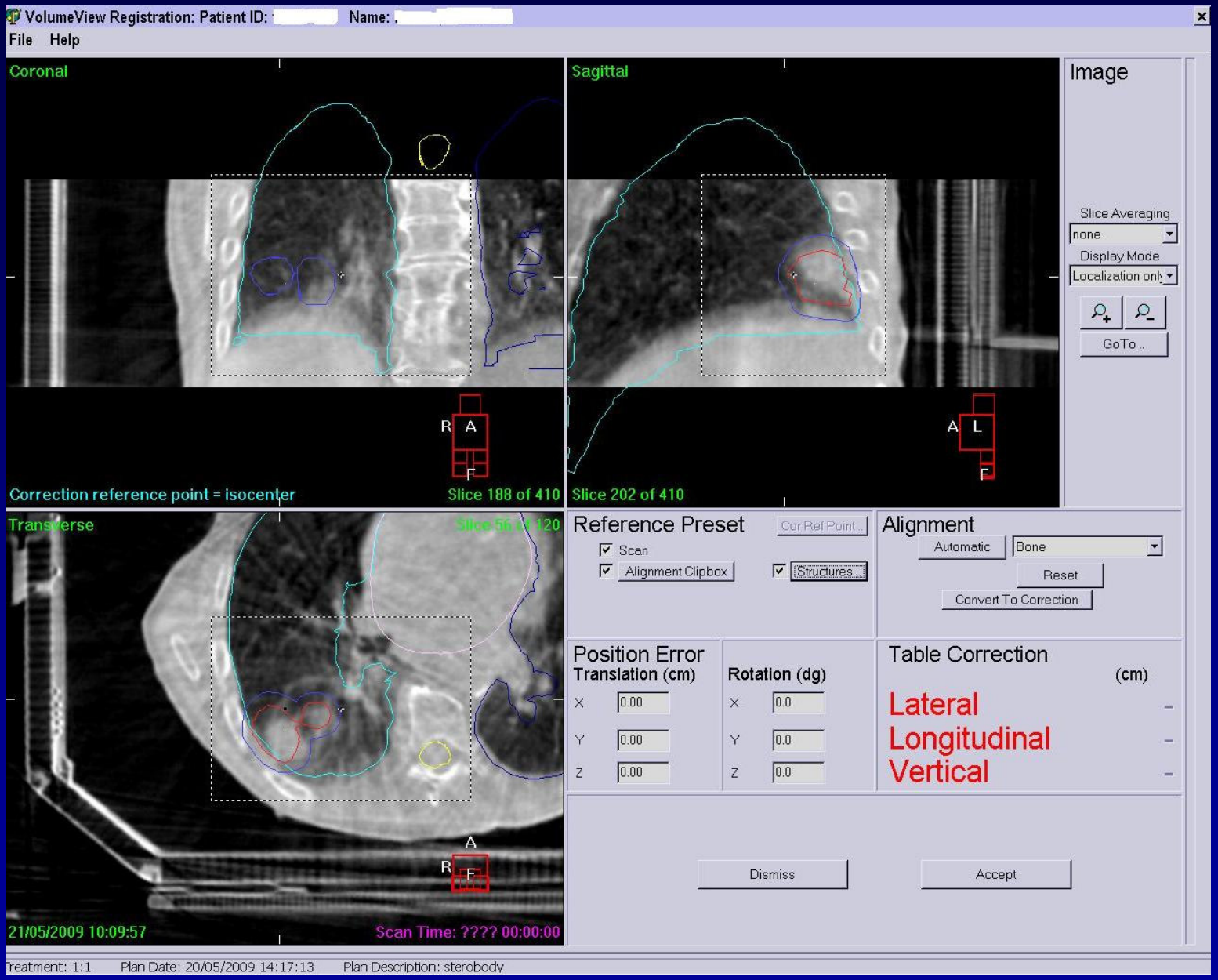

VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
Correction reference point = isocenter
Slice 205 of 410
Sagittal
Slice 205 of 410
Image
Slice Averaging
none
Display Mode
Reference only
GoTo ..
Transverse
15.05.2009 12:01:08.406
Scan Time: ???? 00:00:00.000
Reference Preset
Cor Ref Point..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Bone
Reset
Convert To Correction
Position Error
Translation (cm)
Rotation (dg)
X 0.00
Y 0.00
Z 0.00
X 0.0
Y 0.0
Z 0.0
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
Treatment: 1
Plan Date: 21.04.2009 17:39:26.000
Plan Description: Polmone dx

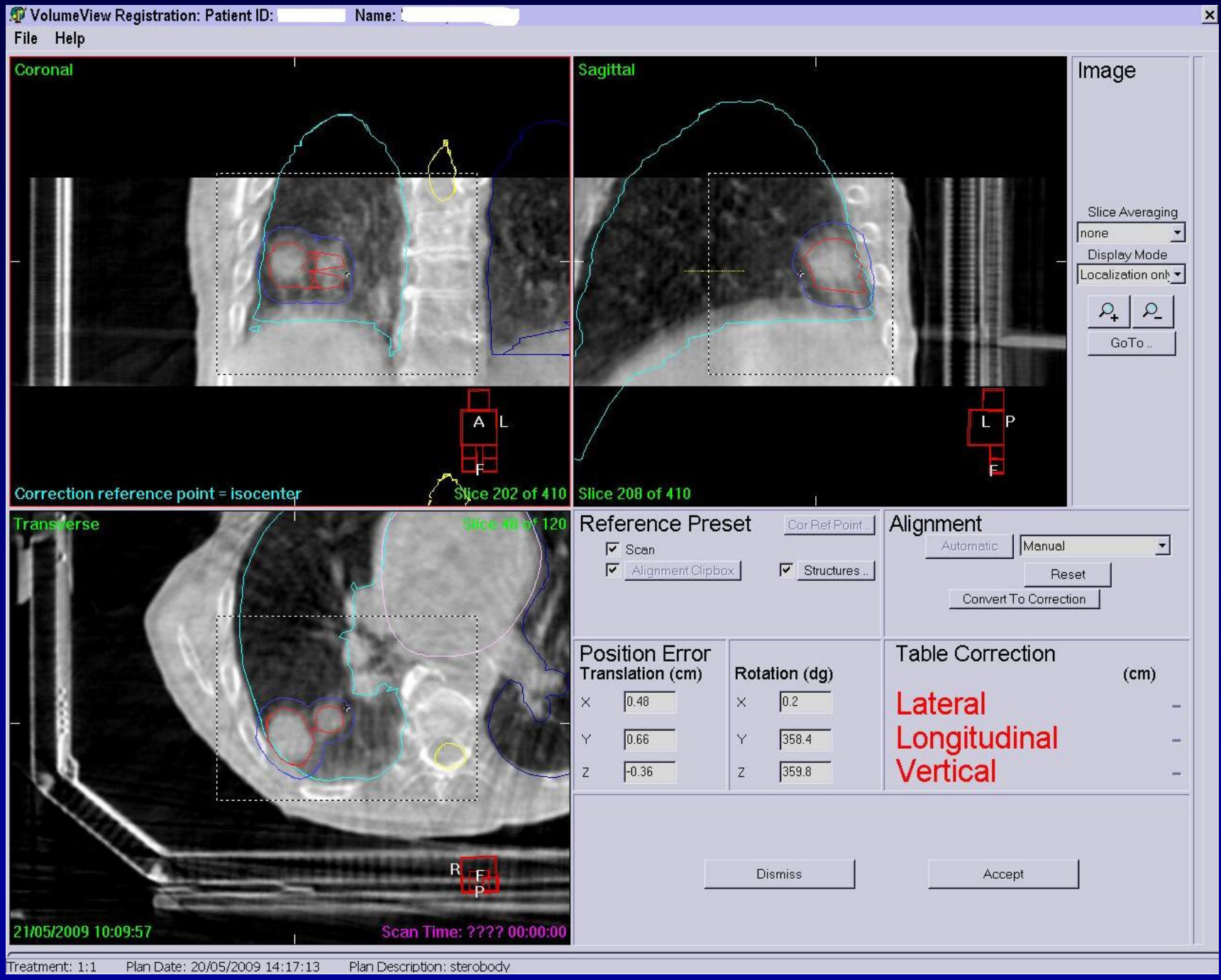

VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
Correction reference point = isocenter
Slice 205 of 410
Sagittal
Slice 205 of 410
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
Transverse
Slice 132 of 264
15.05.2009 12:01:08.406
Scan Time: ???? 00:00:00.000
Reference Preset
Cor Ref Point ..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Grey value
Reset
Convert To Correction
Position Error
Translation (cm)
Rotation (dg)
X 0.00
Y 0.00
Z 0.00
X 0.0
Y 0.0
Z 0.0
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
Treatment: 1
Plan Date: 21.04.2009 17:39:26.000
Plan Description: Polmone dx


VolumeView Registration: Patient ID: Name:
File Help
Coronal
Correction reference point = isocenter
Slice 208 of 410
Sagittal
Slice 205 of 410
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
Transverse
Slice 129 of 264
15.05.2009 12:01:08.406
Scan Time: ???? 00:00:00.000
Reference Preset
Cor Ref Point..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Bone
Reset
Convert To Correction
Position Error
Translation (cm)
X 0.11
Y 0.30
Z -0.28
Rotation (dg)
X 358.7
Y 359.9
Z 358.6
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
Treatment: 1
Plan Date: 21.04.2009 17:39:26.000
Plan Description: Polmone dx


VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
Correction reference point = isocenter
Slice 192 of 410
Sagittal
Slice 201 of 410
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
Transverse
Slice 61 of 120
14.05.2009 11:30:24.734
Scan Time: ???? 00:00:00.000
Reference Preset
Cor Ref Point ..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Bone
Reset
Convert To Correction
Position Error
Translation (cm)
Rotation (dg)
X 0.00
Y 0.00
Z 0.00
X 0.0
Y 0.0
Z 0.0
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
Treatment: 1:1
Plan Date: 11.05.2009 09:41:09.000
Plan Description: stereobody


VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
Sagittal
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
H
R
A
Correction reference point = isocenter
Slice 192 of 410
Slice 201 of 410
Transverse
Slice 61 of 120
Reference Preset
Cor Ref Point..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Manual
Reset
Convert To Correction
Position Error
Translation (cm)
Rotation (dg)
X
-0.75
359.6
Y
-0.05
1.3
Z
0.88
358.9
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
14.05.2009 11:30:24.734
Scan Time: ???? 00:00:00.000
Treatment: 1:1
Plan Date: 11.05.2009 09:41:09.000
Plan Description: stereobody


VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
Sagittal
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
R A F
A L F
Correction reference point = isocenter
Slice 188 of 410
Slice 202 of 410
Transverse
Slice 56 of 120
Reference Preset
Cor Ref Point ..
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Bone
Reset
Convert To Correction
Position Error
Translation (cm)
Rotation (dg)
X 0.00
Y 0.00
Z 0.00
X 0.0
Y 0.0
Z 0.0
Table Correction
(cm)
Lateral -
Longitudinal -
Vertical -
A R F
21/05/2009 10:09:57
Scan Time: ???? 00:00:00
Dismiss
Accept
Treatment: 1:1
Plan Date: 20/05/2009 14:17:13
Plan Description: sterobody


VolumeView Registration: Patient ID:
Name:
File
Help
Coronal
A
L
F
Correction reference point = isocenter
Slice 202 of 410
Sagittal
L
P
F
Slice 208 of 410
Image
Slice Averaging
none
Display Mode
Localization onl
GoTo ..
Transverse
Slice 40 of 120
R
F
P
21/05/2009 10:09:57
Scan Time: ???? 00:00:00
Reference Preset
Cor Ref Point
Scan
Alignment Clipbox
Structures ..
Alignment
Automatic
Manual
Reset
Convert To Correction
Position Error
Translation (cm)
X 0.48
Y 0.66
Z -0.36
Rotation (dg)
X 0.2
Y 358.4
Z 359.8
Table Correction
(cm)
Lateral
Longitudinal
Vertical
Dismiss
Accept
Treatment: 1:1
Plan Date: 20/05/2009 14:17:13
Plan Description: sterobody

Conclusioni

- L'errore di set up può essere ridotto mediante l'uso di dispositivi di immobilizzazione adeguati e di protocolli di intervento (errore sistematico)
- L'impiego sempre più frequente di trattamenti ipofrazionati rende necessario evidenziare anche l'errore casuale, in quanto in grado di determinare significative variazioni della dose assorbita
- L'uso sistematico di sistemi di imaging volumetrico "on board", consentendo una correzione quotidiana dell'errore di set up permette l'impiego di un set-up margin più ristretto e consente così di ridurre il volume di OAR irradiato.