



# Brachytherapy – treatment of the future

**Prof. Janusz Skowronek, MD, PhD**

Brachytherapy Department, Greater Poland Cancer Centre, Poznań, Poland

<http://www.wco.pl/zb/?m=7>



Journal of Contemporary **BRACHYTHERAPY**

Journal of Polish Brachytherapy Society // Published by Termedia sp. z o.o.

# Brachytherapy

Derived from ancient Greek words for short distance (**brachios**) and treatment (**therapy**) and refers to the therapeutic use of encapsulated radionuclides within or close to a tumor.

It is sometimes called seed implantation and is an outpatient procedure used in the treatment of different kinds of cancer.

# Brachytherapy

The efficacy of brachytherapy, as compared with the efficacy of external beam alone,  
is attributable  
to the ability of radioactive implants to deliver a  
higher concentrated radiation dose more precisely to  
tissues,  
which contributes to improved local control,  
provided that the tissue is clinically delimitable and  
accessible.  
At the same time, the surrounding healthy tissues are  
spared irradiation.

# Brachytherapy

## Kinds of brachytherapy

- a. characterized by the duration of the irradiation:

there are 2 different kinds of brachytherapy:  
**permanent**, when the seeds remain inside of the body,  
and **temporary**, when the seeds are inside of the body and then removed.

# Brachytherapy

**b. characterized by the positioning of the radionuclides:**

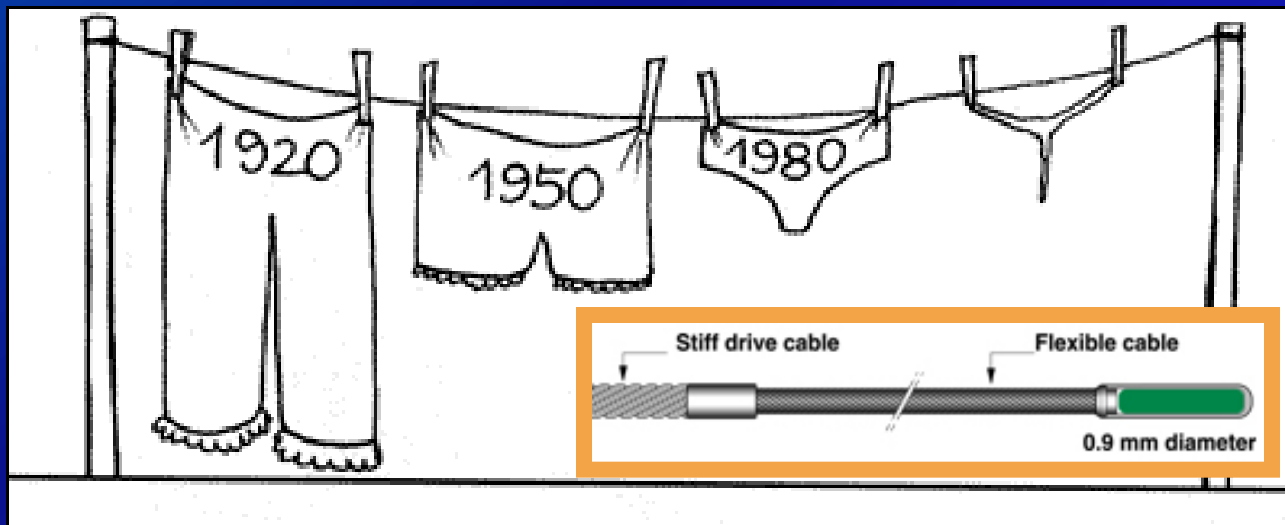
- **interstitial** brachytherapy: radioactive sources are inside the tumour,
  - **contact** brachytherapy or **plesiobrachytherapy**: radioactive sources are close to the tumour,
- Contact brachytherapy is divided into **four different kinds** of brachytherapy:
  - **intracavitary,**
  - **intraluminal,**
  - **endovascular,**
  - **surface brachytherapy**

# Brachytherapy

c. characterized by the dose rate (ICRU definitions):

- low dose rate (LDR) 0.4 - 2.0 Gy/h
- pulsed dose rate (PDR) 0.5 - 1.0 Gy/h
- medium dose rate (MDR) 2 - 12 Gy/h (history in EU,US)
- high dose rate (HDR)  $> 12$  Gy/h

# Evolution in brachytherapy...



Ra

Cs /  
Co

Ir

? Homeopathy...

# **Brachytherapy curative**

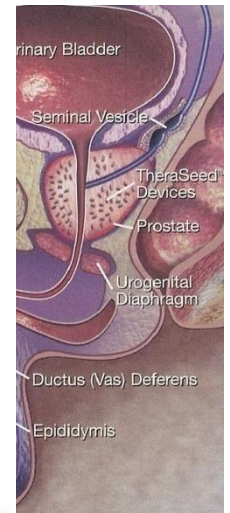
**Prostate cancer as example**



# Greatest problems...

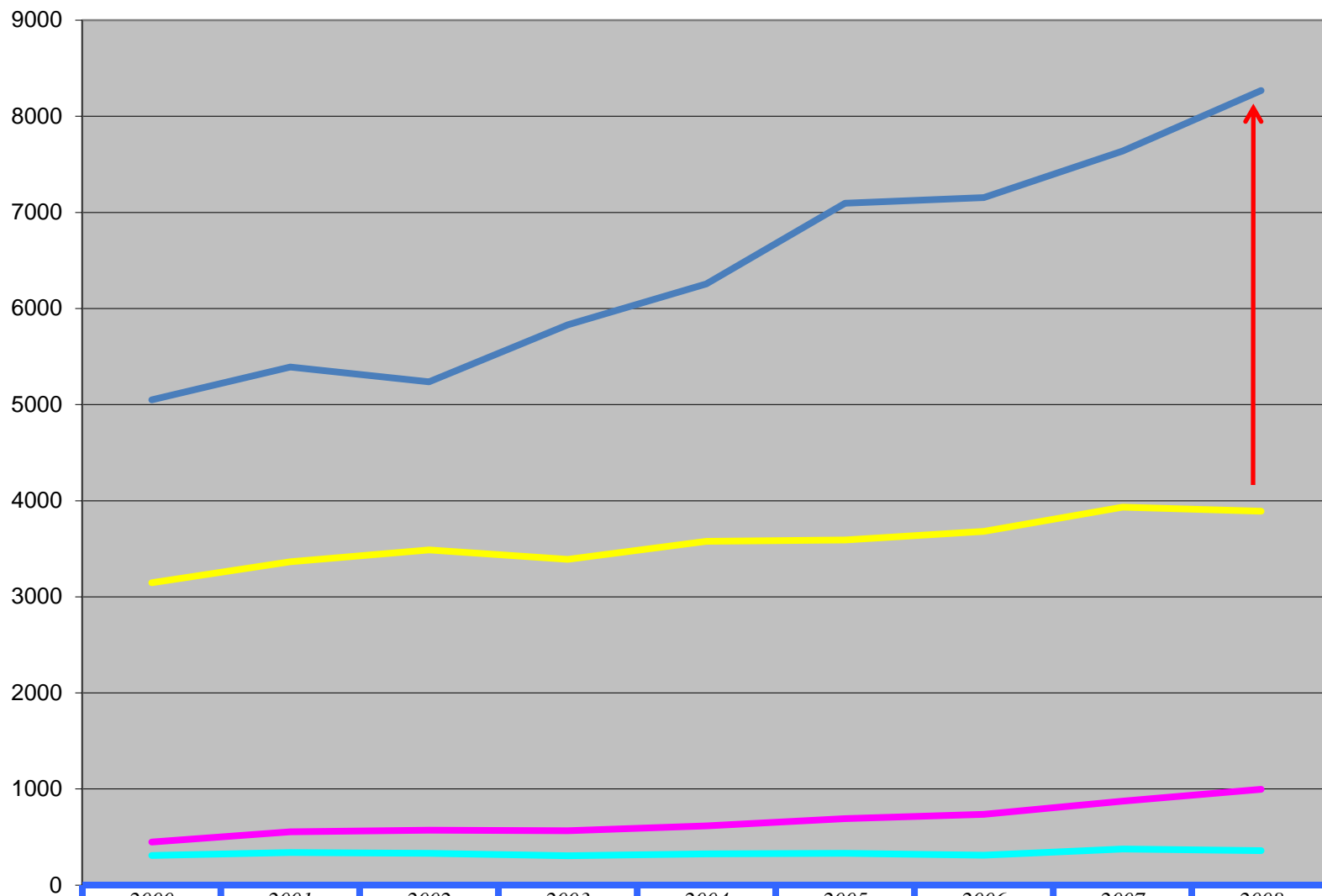
Impotence

Urinary incontinence



# Prostate cancer - morbidity, mortality in Poland

Number of patients



	2000	2001	2002	2003	2004	2005	2006	2007	2008
Morbidity - Poland	5049	5391	5236	5832	6257	7095	7154	7638	8268
Morbidity - Greater Poland	448	555	573	565	617	691	737	874	997
Mortality - Poland	3147	3365	3488	3390	3578	3592	3681	3932	3892
Mortality - Greater Poland	308	338	331	305	325	330	310	377	360

## Patterns of care for brachytherapy in Europe: Updated results

Ferran Guedea, Jack Venselaar, Peter Hoskin, Taran Paulsen Hellebust, Didier Peiffert, Bradley Londres, Montse Ventura, Jean-Jacques Mazon, Erik Van Limbergen, Richard Pötter, Gyorgy Kovacs

*Radiotherapy and Oncology 97 (2010) 514–520*

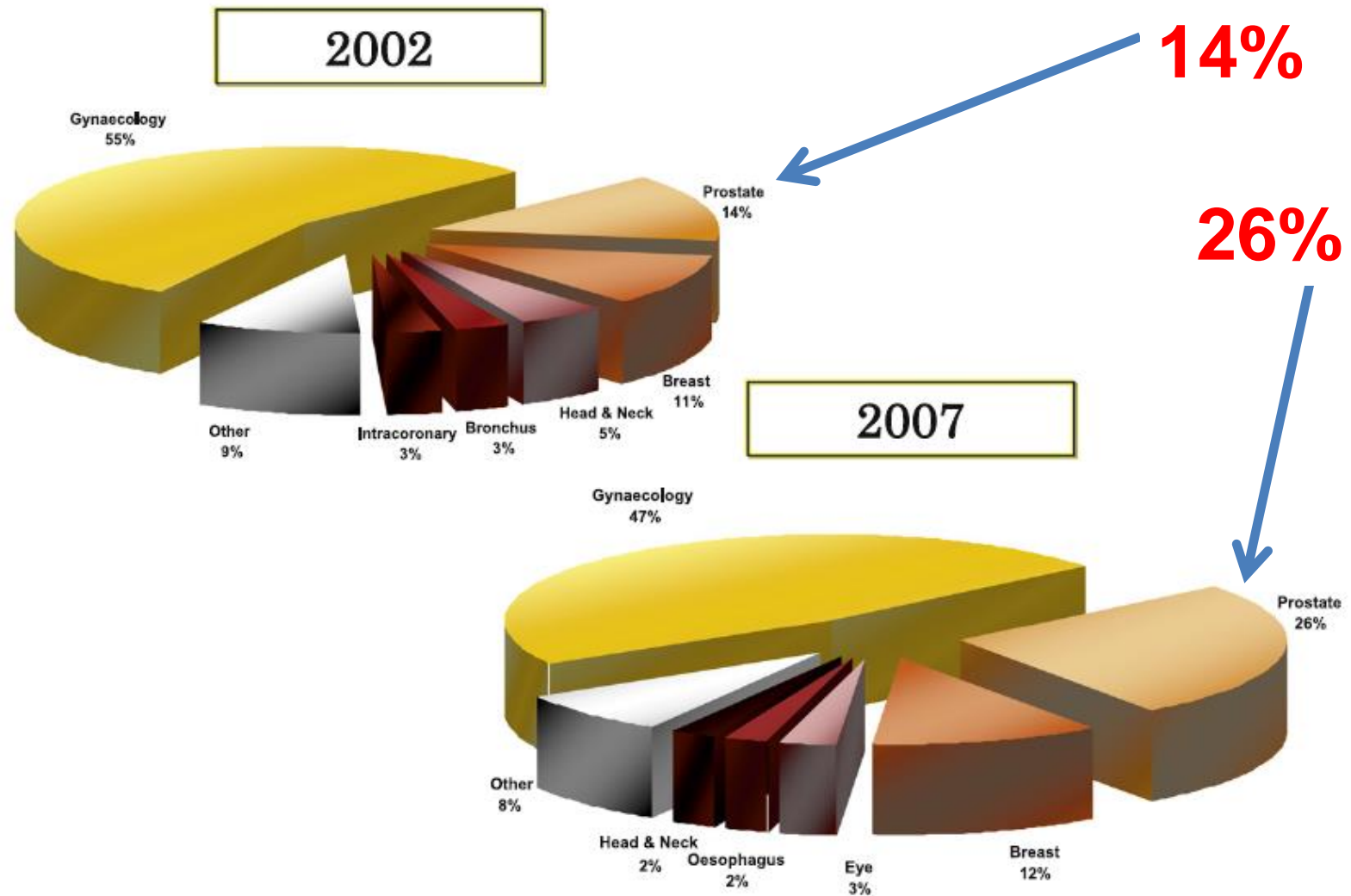


Fig. 3. Most common treatment localizations, group I (2002 vs. 2007).

**> 20 YEARS AGO**

**Radical prostatectomy**

**or**

**External beam irradiation**

# **10 - 20 YEARS AGO**

**Radical prostatectomy**

**or**

**Conventional external beam**

**or**

**Conformal external beam**

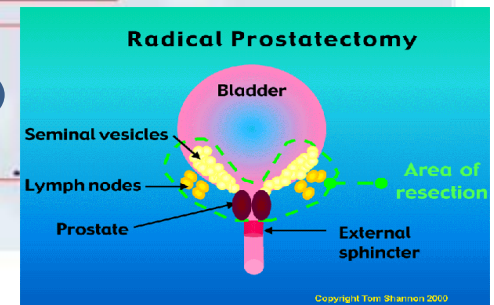
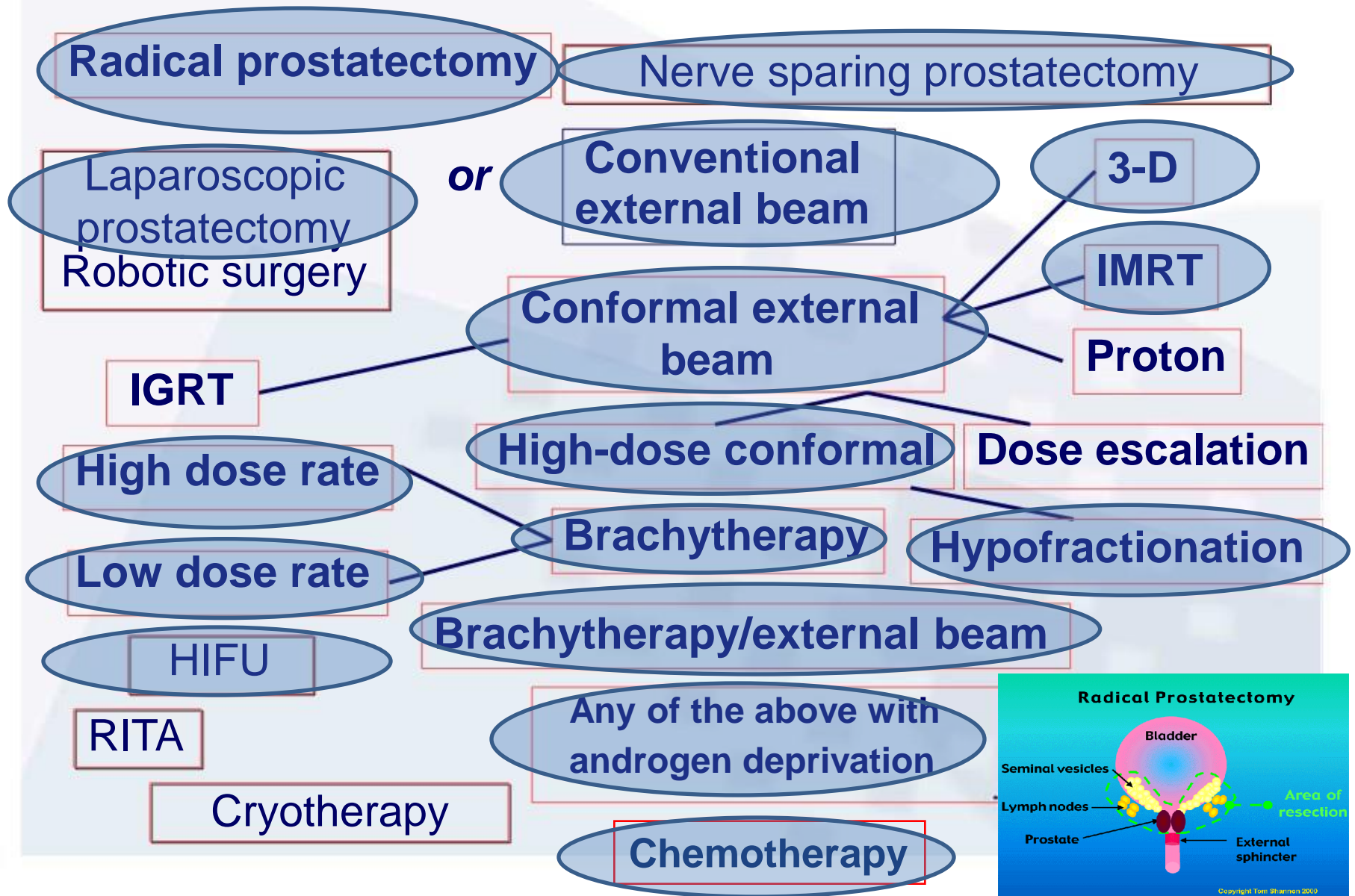
**or**

**Brachytherapy**

**or**

**Brachytherapy/external beam**

# Today - Poland







PII S0360-3016(97)00231-9

## ● Clinical Investigation

### AMERICAN BRACHYTHERAPY SOCIETY (ABS) CONSENSUS GUIDELINES FOR BRACHYTHERAPY OF ESOPHAGEAL CANCER

LAURIE E. GASPAR, M.D.,\* SUBIR NAG, M.D.,† ARNOLD HERSKOVIC, M.D.,‡  
RAO MANTRAVADI, M.D.,§ BURTON SPEISER, M.D.¶ AND THE CLINICAL  
RESEARCH COMMITTEE, AMERICAN BRACHYTHERAPY SOCIETY, PHILADELPHIA, PA



PII S0360-3016(00)01534-0

## CLINICAL INVESTIGATION

## Sarcoma

### THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR BRACHYTHERAPY OF SOFT TISSUE SARCOMAS

SUBIR NAG, M.D.,\* DANIEL SHASHA, M.D.,† NORA JANJAN, M.D.,‡ IVY PETERSEN, M.D.,§ AND  
MARCO ZAIDER, PH.D.¶ for the American Brachytherapy Society



PII S0360-3016(99)00351-X

## PHYSICS CONTRIBUTION

### THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR PERMANENT PROSTATE BRACHYTHERAPY POSTIMPLANT DOSIMETRIC ANALYSIS

SUBIR NAG, M.D.,\*† WILLIAM BICE, PH.D.,\*‡ KEITH DEWYNGAERT, PH.D.,\*§  
BRADLEY PRESTIDGE, M.D.,\*¶ RICHARD STOCK, M.D.,\*¶ AND YAN YU, PH.D.\*#



Brachytherapy 6 (2007) 34–37

American Brachytherapy Society recommends no change for prostate permanent implant dose prescriptions using iodine-125 or palladium-103

Mark J. Rivard<sup>1,\*</sup>, Wayne M. Butler<sup>2</sup>, Phillip M. Devlin<sup>3</sup>, John K. Hayes Jr.<sup>4</sup>, Robert A. Hearn<sup>5</sup>, Eugene P. Lief<sup>6</sup>, Ali S. Meigooni<sup>7</sup>, Gregory S. Merrick<sup>2</sup>, Jeffrey F. Williamson<sup>8</sup>



PII S0360-3016(01)01567-X

## CLINICAL INVESTIGATION

## Head and Neck

### THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR HIGH-DOSE-RATE BRACHYTHERAPY FOR HEAD-AND-NECK CARCINOMA

SUBIR NAG, M.D.,\* ELMER R. CANO, M.D.,† D. JEFFREY DEMANES, M.D.,‡  
AJMEL A. PUTHAWALA, M.D.,§ AND BHADRASAIN VIKRAM, M.D.,¶ FOR THE AMERICAN  
BRACHYTHERAPY SOCIETY



PII S0360-3016(99)00069-3

## CLINICAL INVESTIGATION

## Prostate

### AMERICAN BRACHYTHERAPY SOCIETY (ABS) RECOMMENDATIONS FOR TRANSPERINEAL PERMANENT BRACHYTHERAPY OF PROSTATE CANCER

SUBIR NAG, M.D.,\*† DAVID BEYER, M.D.,\*‡ JAY FRIEDLAND, M.D.,\*§ PETER GRIMM, D.O.,\*¶ AND  
RAVINDER NATH, PH.D.\*#



PII S0360-3016(00)00555-1

## RAPID COMMUNICATION

### AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR CLINICAL IMPLEMENTATION OF NIST-1999 STANDARDS FOR <sup>103</sup>PALLADIUM BRACHYTHERAPY

DAVID BEYER, M.D.,\* RAVINDER NATH, PH.D.,† WAYNE BUTLER, PH.D.,‡ GREGORY MERRICK, M.D.,‡  
JOHN BLASKO, M.D.,§ SUBIR NAG, M.D.,¶ AND COLIN ORTON, PH.D.† FOR THE AMERICAN  
BRACHYTHERAPY SOCIETY, OAKBROOK, IL



PII S0360-3016(00)00497-1

## CLINICAL INVESTIGATION

## Cervix

### THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR HIGH-DOSE-RATE BRACHYTHERAPY FOR CARCINOMA OF THE CERVIX

SUBIR NAG, M.D.,\* BETH ERICKSON, M.D.,† BRUCE THOMADSEN, M.D.,‡ COLIN ORTON, PH.D.,§  
JEFFREY D. DEMANES, M.D.,¶ AND DANIEL PETEREIT, M.D.,‡ FOR THE AMERICAN BRACHYTHERAPY SOCIETY



# CLINICAL INVESTIGATION

# Endometrium

## THE AMERICAN BRACHYTHERAPY SOCIETY RECOMMENDATIONS FOR HIGH-DOSE-RATE BRACHYTHERAPY FOR CARCINOMA OF THE ENDOMETRIUM

SUBIR NAG, M.D.,\* B.  
NILENDU GUPTA, Ph.D.  
F



ESTRO/EAU/EORTC

Daniel Ash<sup>a,\*</sup>, Ant



# ASTRO GUIDELINE

AMERICAN SOCIETY OF  
COLLEGE OF RADIOLOGISTS  
OF I

BETH A. ERICKSON, M.

JOHN K. HAYES, M.D.,<sup>†</sup> I-CHOW J. HSU, M.D.,<sup>†</sup> DAVID E. MORRIS, M.D.,<sup>†</sup>  
RACHEL A. RABINOVITCH, M.D.,<sup>†</sup> JONATHAN D. TWARD, M.D., Ph.D.,<sup>\*\*</sup> AND SETH A. ROSENTHAL, M.D.<sup>††</sup>



# ASTRO GUIDELINE

## AMERICAN SOCIETY FOR RADIATION ONCOLOGY (ASTRO) AND AMERICAN COLLEGE OF RADIOLOGISTS (ACR) PRACTICE GUIDELINE FOR THE TRANSPERINEAL PERMANENT BRACHYTHERAPY OF PROSTATE CANCER

SETH A. ROSENTHAL, M.D.,\* NATHAN H. J. BITTNER, M.D., M.S.,<sup>†</sup> DAVID C. BEYER, M.D.,<sup>‡</sup>  
D. JEFFREY DEMANES, M.D.,<sup>§</sup> BRIAN J. GOLDSMITH, M.D.,\* ERIC M. HORWITZ, M.D.,<sup>¶</sup>  
GEOFFREY S. IBBOTT, Ph.D.,<sup>||</sup> W. ROBERT LEE, M.D.,<sup>¶</sup> SUBIR NAG, M.D.,<sup>\*\*</sup> W. WARREN SUH, M.D.,<sup>††</sup>  
AND LOUIS POTTERS, M.D.<sup>‡‡</sup>



GEC-ESTRO recommendations

GEC-ESTRO recommendations for brachytherapy for head and neck squamous cell carcinomas

Int. J. Radiation Oncology Biol. Phys., Vol. 76, No. 4, pp. 963–972, 2010

Copyright © 2010 Elsevier Inc.

Printed in the USA. All rights reserved

0360-3016/10/\$-see front matter

doi:10.1016/j.ijrobp.2009.10.068

ics<sup>d</sup>, Peter Levendag<sup>e</sup>,

RADIO THERAPY  
& ONCOLOGY  
JOURNAL OF THE EUROPEAN SOCIETY FOR  
THERAPEUTIC RADIOLOGY AND ONCOLOGY

elsevier.com/locate/radonline

chytherapy  
cer

mer<sup>d</sup>,  
Bertermann<sup>g</sup>

Vol. 74, No. 4, pp. 987–1001, 2009  
ncology. Published by Elsevier Inc.  
Printed in the USA.  
0360-3016/09/\$-see front matter

EMENT FROM  
STRO)

HOLZ, M.D.,<sup>†</sup>  
GH, M.D.,<sup>¶</sup>  
R, Ph.D.,<sup>‡</sup>

JENNIFER Y. WO, M.D.,<sup>||||</sup>

FRANK A. VICINI, Ph.D.,<sup>†</sup> TIMOTHY J. WHELAN, Ph.D.,<sup>†</sup> JULIA WHITE, Ph.D.,<sup>†</sup> JENNIFER Y. WO, M.D.,<sup>||||</sup>  
AND JAY R. HARRIS, M.D.<sup>¶¶</sup>

Practical Radiation Oncology (2011) 1, 60–71

# Special Article

## Palliative thoracic radiotherapy in lung cancer: An American Society for Radiation Oncology evidence-based clinical practice guideline

George Rodrigues MD, MSc<sup>a,\*</sup>, Gregory M.M. Videtic MD, CM, FRCPC<sup>b</sup>,  
Ranjan Sur MD, PhD<sup>c</sup>, Andrea Bezjak MD, FRCPC<sup>d</sup>, Jeffrey Bradley MD<sup>e</sup>,  
Carol A. Hahn MD<sup>f</sup>, Corey Langer MD<sup>g</sup>, Keith L. Miller MD<sup>h</sup>,  
Benjamin J. Moeller MD, PhD<sup>i</sup>, Kenneth Rosenzweig MD<sup>j</sup>, Benjamin Movsas MD<sup>k</sup>

practical radiation oncology  
**pro**  
www.pmonlineadonc.org



# ESTRO/EAU/EORTC recommendations on permanent seed implantation for localized prostate cancer

Daniel Ash<sup>a,\*</sup>, Anthony Flynn<sup>a</sup>, Jan Battermann<sup>b</sup>, Theodoros de Reijke<sup>c</sup>,  
Paulo Lavagnini<sup>d</sup>, Leo Blank<sup>e</sup>

<sup>a</sup>Department of Clinical Oncology and Medical Physics, Cookridge Hospital, Leeds, UK

<sup>b</sup>Department of Radiotherapy, Academisch Ziekenhuis, Utrecht, Germany

<sup>c</sup>Department of Urology, Academisch Medisch Centrum, Amsterdam, The Netherlands

<sup>d</sup>Istituto Tumori, Genoa, Italy

<sup>e</sup>Department of Radiotherapy, Free University, Amsterdam, The Netherlands

Received 18 September 2000; accepted 27 September 2000

	Recommended Do well	Optional Fair	Investigational Do poorly
PSA (ng/ml)	< 10	10-20	>20
Gleason score	5-6	7	8-10
Stage	T1c-T2a	T2b-T2c	T3
IPSS	0-8	9-19	>20
Prostate volume (g)	<40	40-60	>60
Q <sub>max</sub> ml/s	>15	15-10	<10
Residual volume cm <sup>3</sup>			>200
TURP $\pm$			+

**National Comprehensive Cancer Network 1.2009 [www.nccn.org](http://www.nccn.org)**  
**Risk categories (N0 M0) – Clinically localized**

	<b>Low</b>	<b>Intermediate</b>	<b>High</b>	<b>Very high, locally advanced</b>
<b>T</b>	1-2a	2b, 2c	3a	3b, 4
<b>PSA</b>	< 10	10-20	>20	Any
<b>Gleason score</b>	< 7	7	>7	any

**Metastatic:**  
**any T, N1 M0**  
**any T, any N, M1**

# Contraindications

*ESTRO/EAU/EORTC RECOMMENDATIONS ON PERMANENT SEEDIMPLANTATION FOR LOCALISED PROSTATE CANCER*

- 1.** expected survival time < 5 years,
- 2.** metastasis,
- 3.** TURP in the past with considerable damage to the prostate,
- 4.** persistent hematuria, the regular use of aspirin or anticoagulants,
- 5.** prostate volume > 60 cm cc.

# **Brachytherapy**

**Temporary - HDR**



ELSEVIER

Radiotherapy and Oncology 74 (2005) 137–148

RADIOOTHERAPY  
& ONCOLOGY

JOURNAL OF THE EUROPEAN SOCIETY FOR  
THERAPEUTIC RADIOLOGY AND ONCOLOGY

[www.elsevier.com/locate/radonline](http://www.elsevier.com/locate/radonline)

## GEC/ESTRO-EAU recommendations on temporary brachytherapy using stepping sources for localised prostate cancer

György Kovács<sup>a,\*</sup>, Richard Pötter<sup>b</sup>, Tillmann Loch<sup>c</sup>, Josef Hammer<sup>d</sup>,  
Inger-Karine Kolkman-Deurloo<sup>e</sup>, Jean J.M.C.H. de la Rosette<sup>f</sup>, Hagen Bertermann<sup>g</sup>

<sup>a</sup>*Interdisciplinary Brachytherapy Centre, University Hospital Schleswig-Holstein Campus Kiel, Arnold Heller Str 9, D-24105 Kiel, Germany*

<sup>b</sup>*University Clinic for Radiotherapy and Radiobiology, Vienna General Hospital, Vienna, Austria*

<sup>c</sup>*Department of Urology, University of the Saarland, Homburg, Germany*

<sup>d</sup>*Department of Radiotherapy, Barmherzige Schwestern Hospital and St Vincenc Clinic, Linz, Austria*

<sup>e</sup>*Division of Clinical Physics, Department of Radiation Oncology, Erasmus MC, Daniel Den Hoed Cancer Center, Rotterdam, The Netherlands*

<sup>f</sup>*Department of Urology, AMC, Amsterdam, The Netherlands*

<sup>g</sup>*Department of Urology, City Hospital, Kiel, Germany*

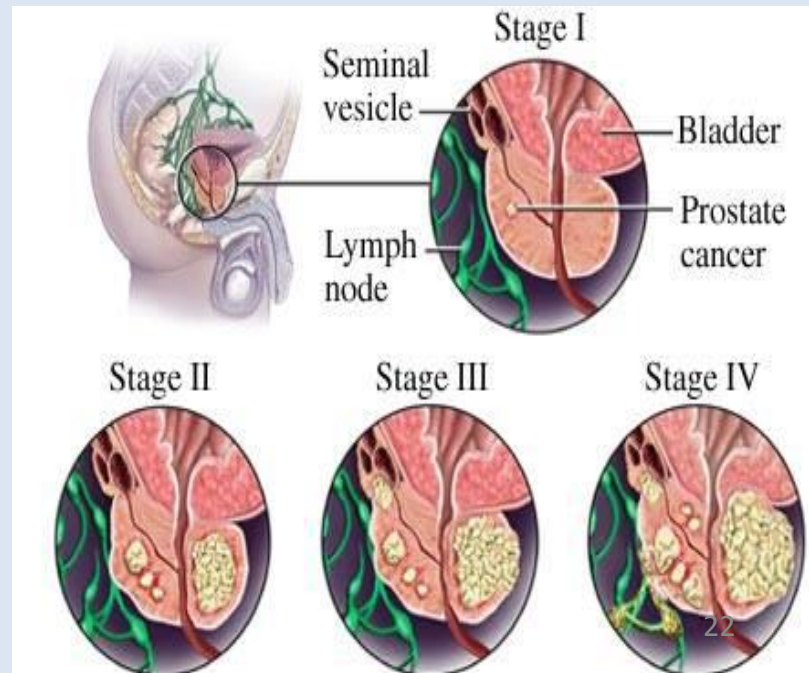
Received 3 August 2004; accepted 2 September 2004

Available online 22 October 2004

# Monotherapy (ABS, GEC-ESTRO)

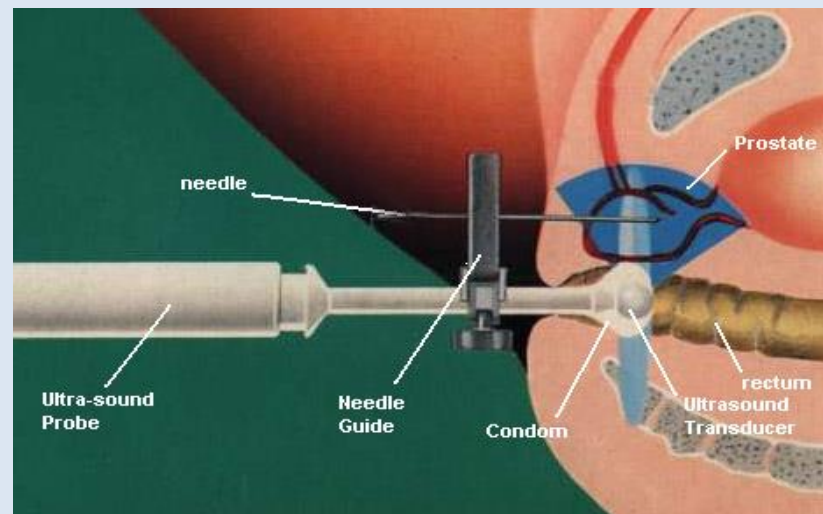
1. T1 i T2,
2. N0,
3. M0,
4. PSA <10, Gleason  $\leq$ 6,
5. > 5 years life expectancy

↑  
?????????



# HDR brachytherapy: diagnostic, equipment, team

➡ similar to seeds



# Team



## Experience in:

- TRUS (done by radiotherapist),
- dosimetry, treatment planning (physicist and radiotherapist),
- needles (seeds) implantation (radiotherapist and physicist),
- radiotherapy knowledge.

## Team:

- radiotherapist,
- urologist, radiologist or radiotherapist with ultrasound skills,
- physicist,
- 2-3 nurses,
- anesthetist,
- nurse anesthetic,
- X-ray technician.



# Brachytherapy - equipment

**High quality - image guided source placement - SWIFT**

- High quality digital TRUS with template software,
- X-ray/CT for post-implant dosimetry,
- Stepper, stepping unit,
- Treatment planning system.

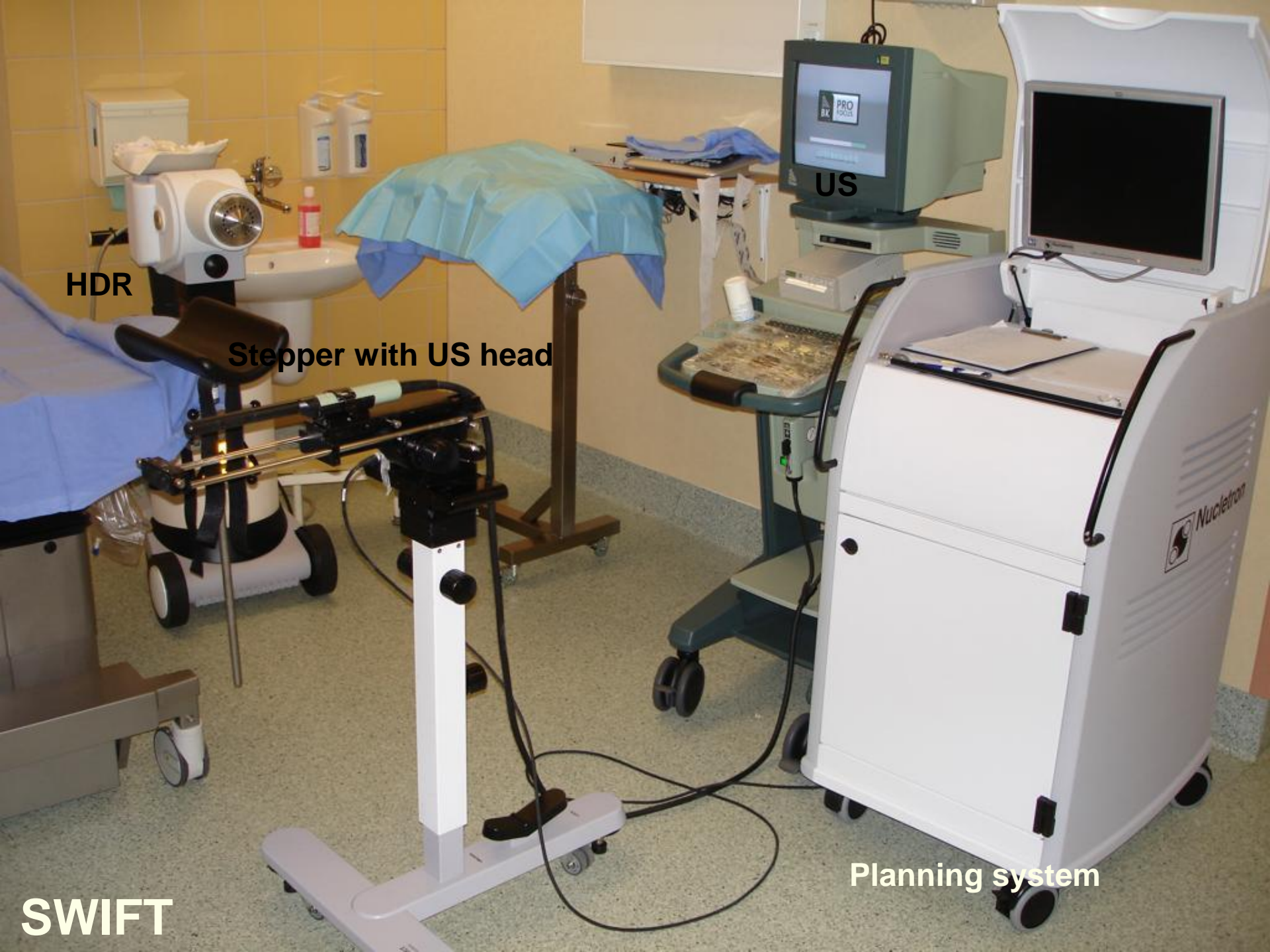
HDR

Stepper with US head

US

Planning system

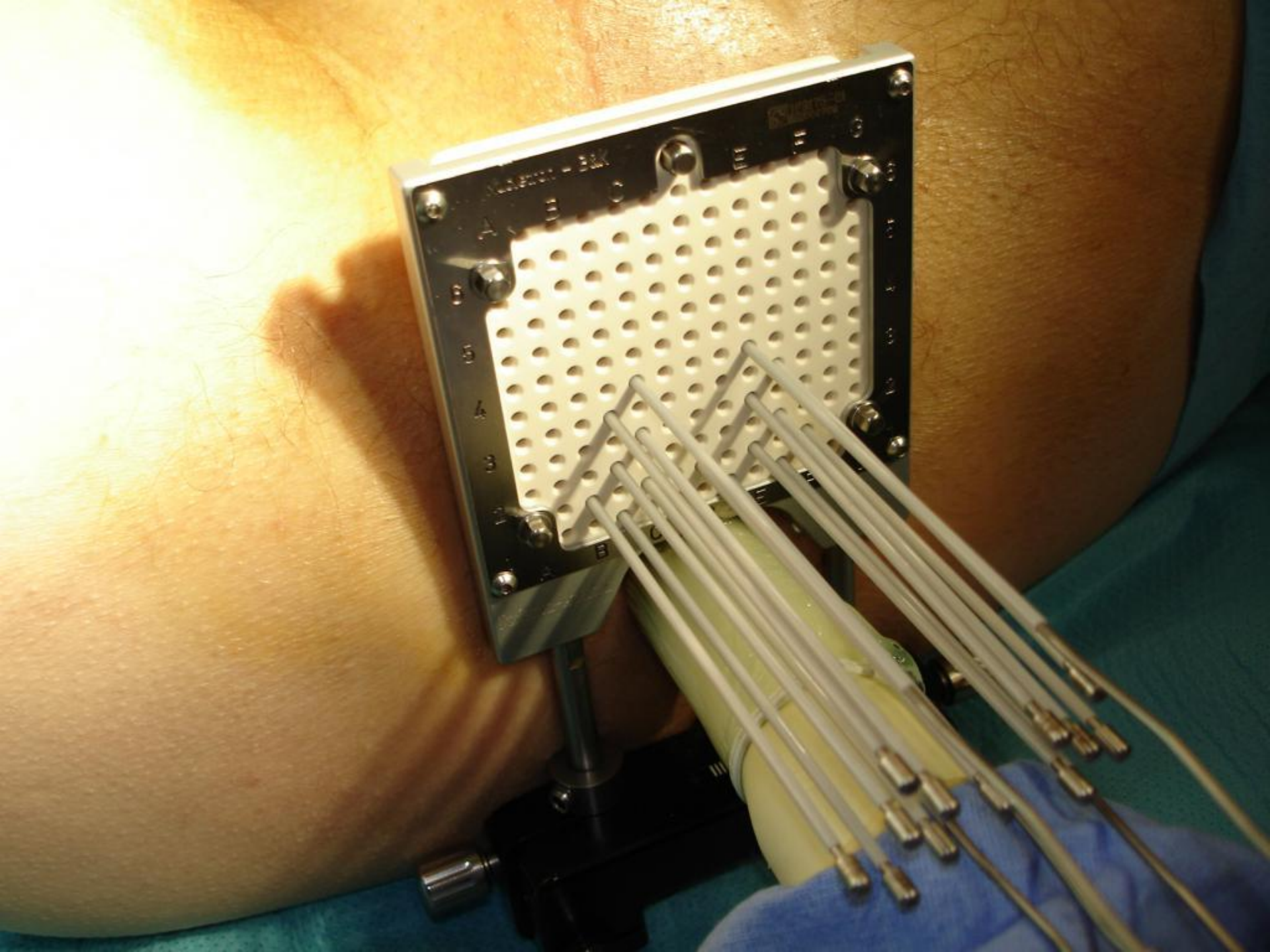
SWIFT

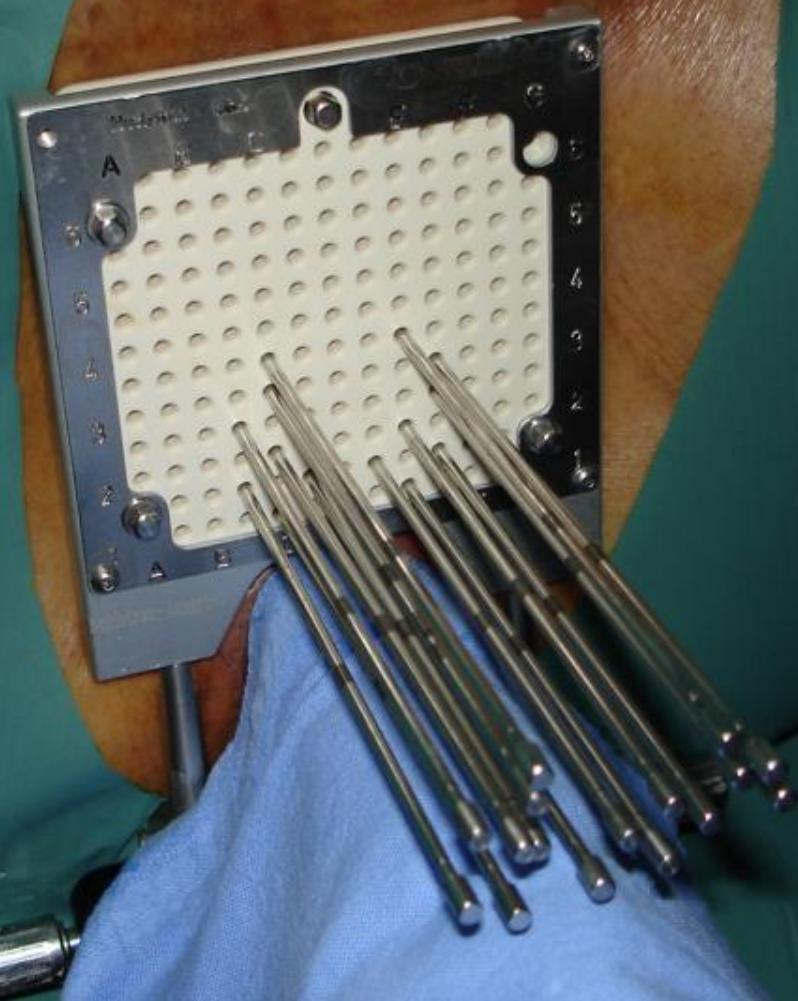




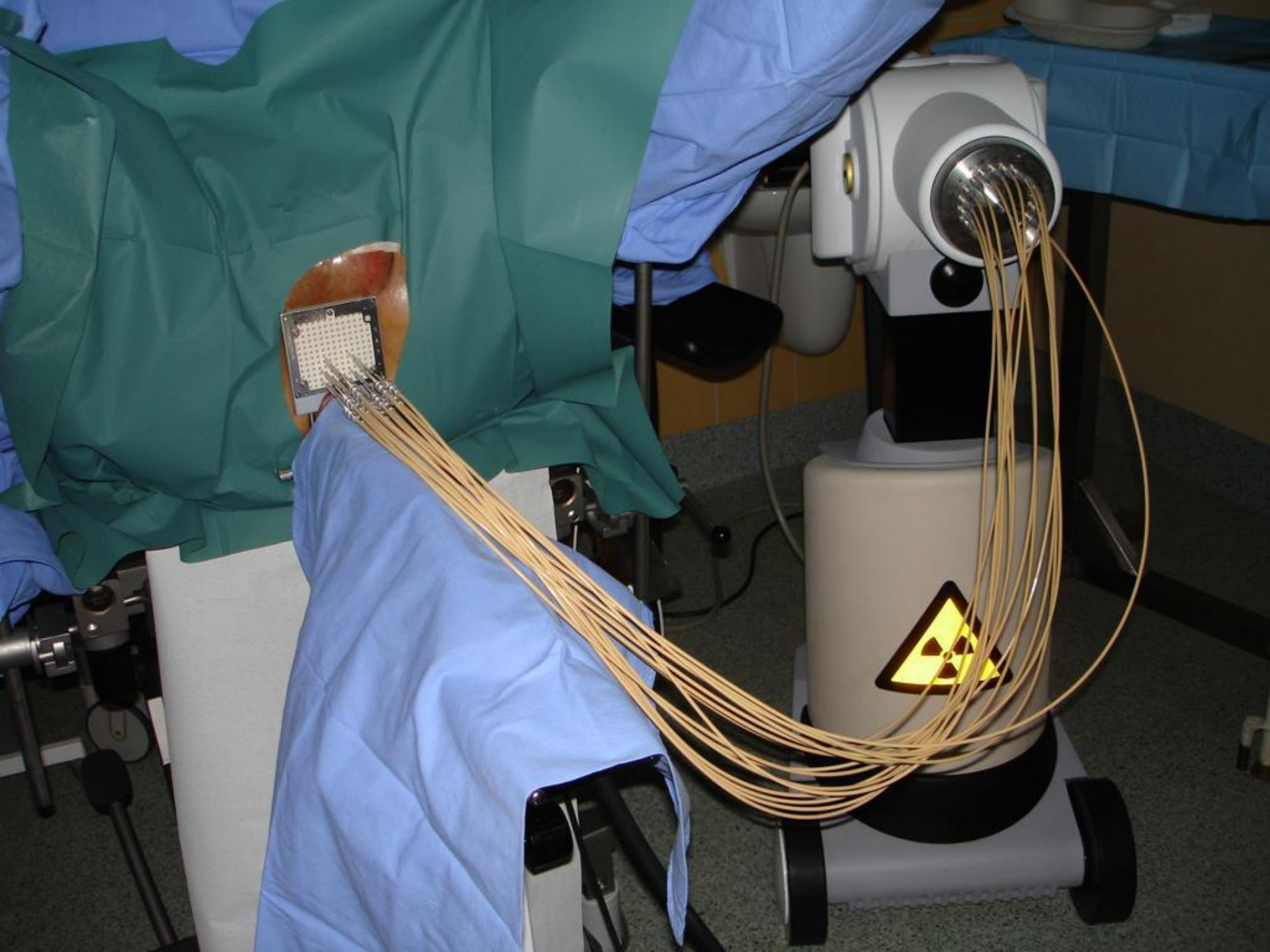
C 05	b 15
E 35	cu 15
C 3	d 1.5
e 3	e 1.5
b 25	C 1
e 15	D 1
C 2*	E 1
E 2*	
F 2	















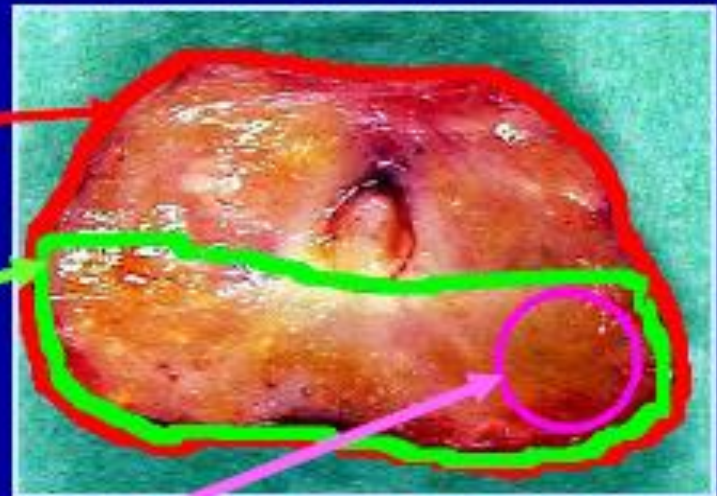
# Dose Prescription: IMBRT

## Different Target and Treatment Philosophies:

CTV 1 → Prostate Capsule

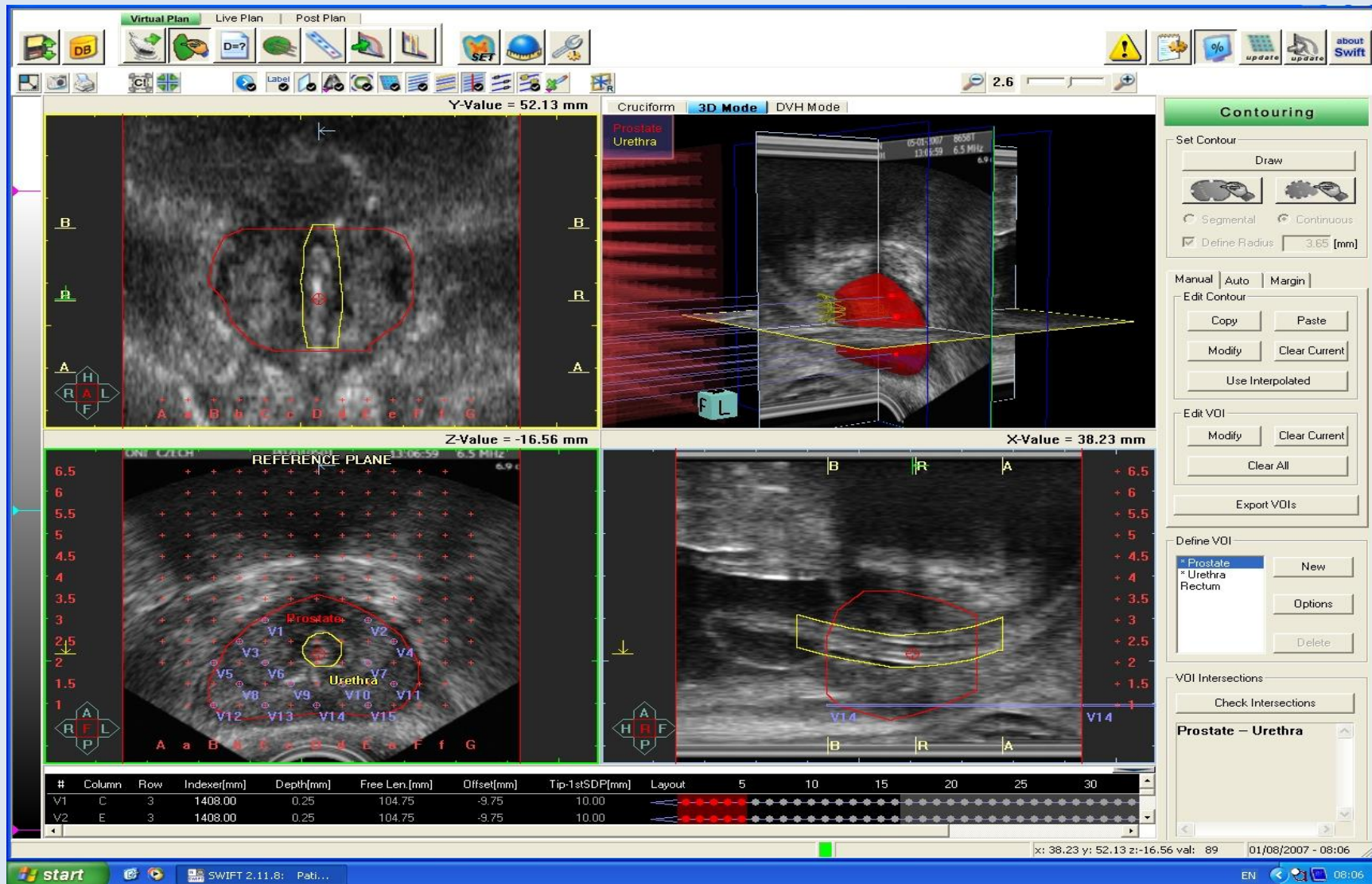
CTV 2 → Peripheral Zone

CTV 3 → Visible Tumor Infiltration





# „Virtual planning”



The screenshot displays the Swift 2.11.8 software interface for radiation therapy planning. The main window shows a 3D dose distribution for a prostate cancer treatment. The top-left panel displays a cross-section of the prostate with dose contours (75.0% to 200.0%) and a DVH curve. The DVH curve shows the cumulative dose distribution for the Prostate and Urethra. The interface includes various toolbars, a 'Dose Settings' panel on the right, and a 'Layout' panel at the bottom showing a grid of treatment points.

**Dose Settings Panel:**

- TG 43 Dosimetry Protocol
- Line Source (selected) / Point Source
- Dose Calculation: On Slices (selected) / On Volume
- Calculate button
- Dose Grid Resolution: High (selected) / Medium / Preview
- Dose Colors: Visualize 2D (checked) / Visualize 3D (unchecked)
- Colorwash (checked) / Mixing: 0.5
- 2D / 3D checkboxes
- Abs. [Gy] / Rel. [%] color scale

**Layout Panel:**

#	Column	Row	Indexer[mm]	Depth[mm]	Free Len.[mm]	Offset[mm]	Tip-1stSDP[mm]	Layout
L8	b	2	1408.00	3.87	96.04	-6.13	10.00	[Icon]
L9	d	2	1408.00	3.87	96.07	-6.13	10.00	[Icon]
L10	e	2	1408.00	3.20	96.78	-6.80	10.00	[Icon]
L11	F	2	1408.00	3.87	96.06	-6.12	10.00	[Icon]
L12	B	1.5	1408.00	4.71	95.13	-5.29	10.00	[Icon]
L13	C	1.5	1408.00	5.04	94.92	-4.96	10.00	[Icon]
L14	D	1.5	1408.00	6.05	93.91	-3.94	10.00	[Icon]
L15	E	1.5	1408.00	4.04	95.96	-5.96	10.00	[Icon]

# Conclusions

**Remote temporary afterloading brachytherapy has several advantages:**

- accurate positioning of the source by first implanting non-active guide needles,
- possibility to choose the source positions over the length of the needle,
- no target movement during radiation,
- stepping source technology allowing for dose and volume adaptation due to adjustment of source dwell locations and times according to 3D imaging based individual dose prescription before irradiation,
- shortening the time and costs.

**CLINICAL INVESTIGATION**

**Prostate**

**AMERICAN BRACHYTHERAPY SOCIETY (ABS) RECOMMENDATIONS FOR  
TRANSPERINEAL PERMANENT BRACHYTHERAPY OF PROSTATE CANCER**

SUBIR NAG, M.D.,\*<sup>†</sup> DAVID BEYER, M.D.,\*<sup>‡</sup> JAY FRIEDLAND, M.D.,\*<sup>§</sup> PETER GRIMM, D.O.,\*<sup>||</sup> AND  
RAVINDER NATH, PH.D.\*<sup>¶</sup>

\*Prostate Brachytherapy Quality Assurance Group, Clinical Research Committee, American Brachytherapy Society, Reston, VA;

<sup>†</sup>The Ohio State University, Columbus, OH; <sup>‡</sup>Arizona Oncology Services, Phoenix, AZ; <sup>§</sup>Moffitt Cancer Center, Tampa, FL;

<sup>||</sup>Swedish Medical Center, Seattle, WA; and <sup>¶</sup>Yale University, New Haven, CT

## **Brachytherapy as a Boost to EBRT:**

- T2b, T2c or
- Gleason 8-10 or
- PSA > 20 ng/ml

## **Other possible indications for Brachytherapy as a Boost to EBRT:**

- Perineural invasion,
- Multiple positive biopsies, bilateral positive biopsies,
- MRI positive for capsular penetration.

## **Brachytherapy (including Boosting EBRT) in Conjunction with Androgen Deprivation:**

- Patients with initially large prostate (>60 cc) that have downsized sufficiently

# Brachytherapy

**Permanent**



PII S0360-3016(99)00069-3

## CLINICAL INVESTIGATION

## Prostate

# AMERICAN BRACHYTHERAPY SOCIETY (ABS) RECOMMENDATIONS FOR TRANSPERINEAL PERMANENT BRACHYTHERAPY OF PROSTATE CANCER

SUBIR NAG, M.D.,<sup>\*†</sup> DAVID BEYER, M.D.,<sup>\*‡</sup> JAY FRIEDLAND, M.D.,<sup>\*§</sup> PETER GRIMM, D.O.,<sup>\*||</sup> AND  
RAVINDER NATH, PH.D.<sup>\*¶</sup>

<sup>\*</sup>Prostate Brachytherapy Quality Assurance Group, Clinical Research Committee, American Brachytherapy Society, Reston, VA;

<sup>†</sup>The Ohio State University, Columbus, OH; <sup>‡</sup>Arizona Oncology Services, Phoenix, AZ; <sup>§</sup>Moffitt Cancer Center, Tampa, FL;

<sup>||</sup>Swedish Medical Center, Seattle, WA; and <sup>¶</sup>Yale University, New Haven, CT



ELSEVIER

Radiotherapy and Oncology 57 (2000) 315–321

---

RADIOTHERAPY  
& ONCOLOGY

JOURNAL OF THE EUROPEAN SOCIETY FOR  
THERAPEUTIC RADIOLOGY AND ONCOLOGY

---

[www.elsevier.com/locate/radonline](http://www.elsevier.com/locate/radonline)

# ESTRO/EAU/EORTC recommendations on permanent seed implantation for localized prostate cancer

Daniel Ash<sup>a,\*</sup>, Anthony Flynn<sup>a</sup>, Jan Battermann<sup>b</sup>, Theodoros de Reijke<sup>c</sup>,  
Paulo Lavagnini<sup>d</sup>, Leo Blank<sup>e</sup>

<sup>a</sup>*Department of Clinical Oncology and Medical Physics, Cookridge Hospital, Leeds, UK*

<sup>b</sup>*Department of Radiotherapy, Academisch Ziekenhuis, Utrecht, Germany*

<sup>c</sup>*Department of Urology, Academisch Medisch Centrum, Amsterdam, The Netherlands*

<sup>d</sup>*Istituto Tumori, Genoa, Italy*

<sup>e</sup>*Department of Radiotherapy, Free University, Amsterdam, The Netherlands*

Received 18 September 2000; accepted 27 September 2000



**Example of seed**





# Seeds - producers

## **Greatest:**

1. McMaster University's Reactor (Canada),
2. National Research Universal (NRU) Reactor (Canada)

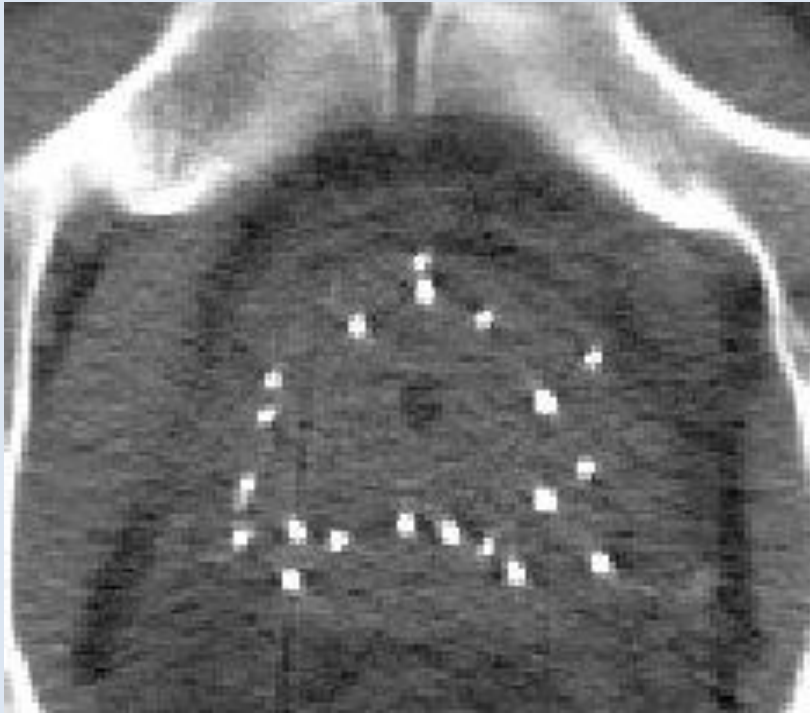
1. IsoRay Medical™, Cesium-131
2. Best Medical International, Inc.  
Best Industries Iridium (Ir 192)
3. Theragenics TheraSeeds  
Iodine-125, Palladium-103
4. Amersham Healthcare Iodine (I-125)

1. IBt Bebig
2. Nucletron
3. Varian VariSeed
4. Oncura RAPID Strand
5. BARD ProSeed
6. IsoAid

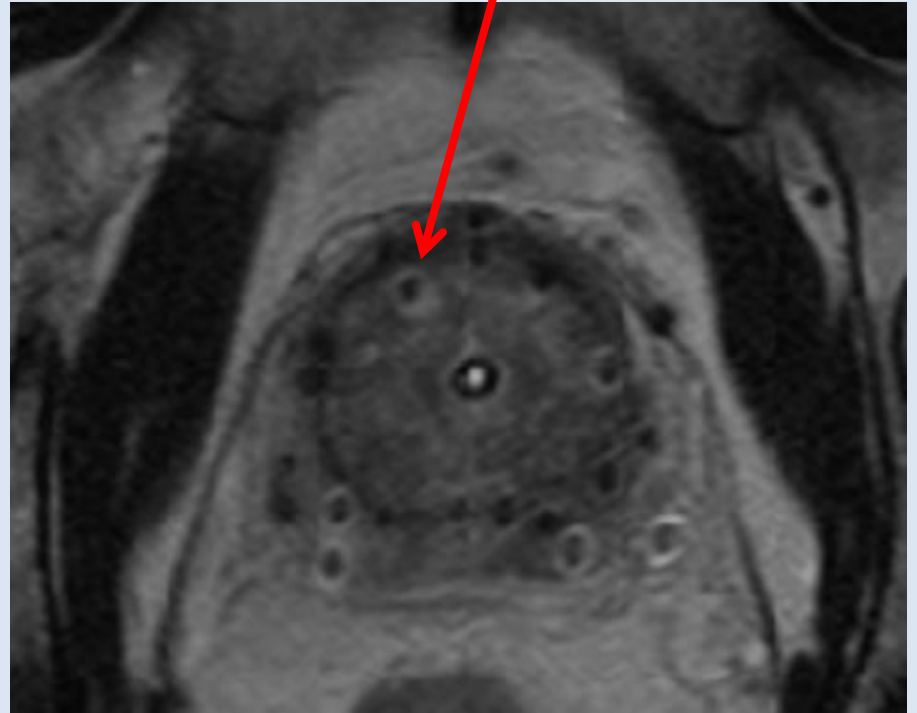


- Low Morbidity ✓
- Cost Effective ✓
- Outpatient Procedure ✓
- One Day Procedure ✓

In **CT** imaging the high contrasts leads to absorption artefacts which can be handled using a soft tissue filter for image reconstruction on the CT device.



I25.S17 seeds also provide a unique quality in **MRI** imaging. While normal seeds only appear as dark dots in the image, similar to a blood vessel, S17 seeds show a bright **halo** around the dark dot, this allows you to clearly identify the seeds.







21 11:13

# Doses:

---

**I-125 monotherapy      140-160 Gy (144-145 Gy)**

**I-125 + 40-50 Gy EBRT      100-120 Gy**

---

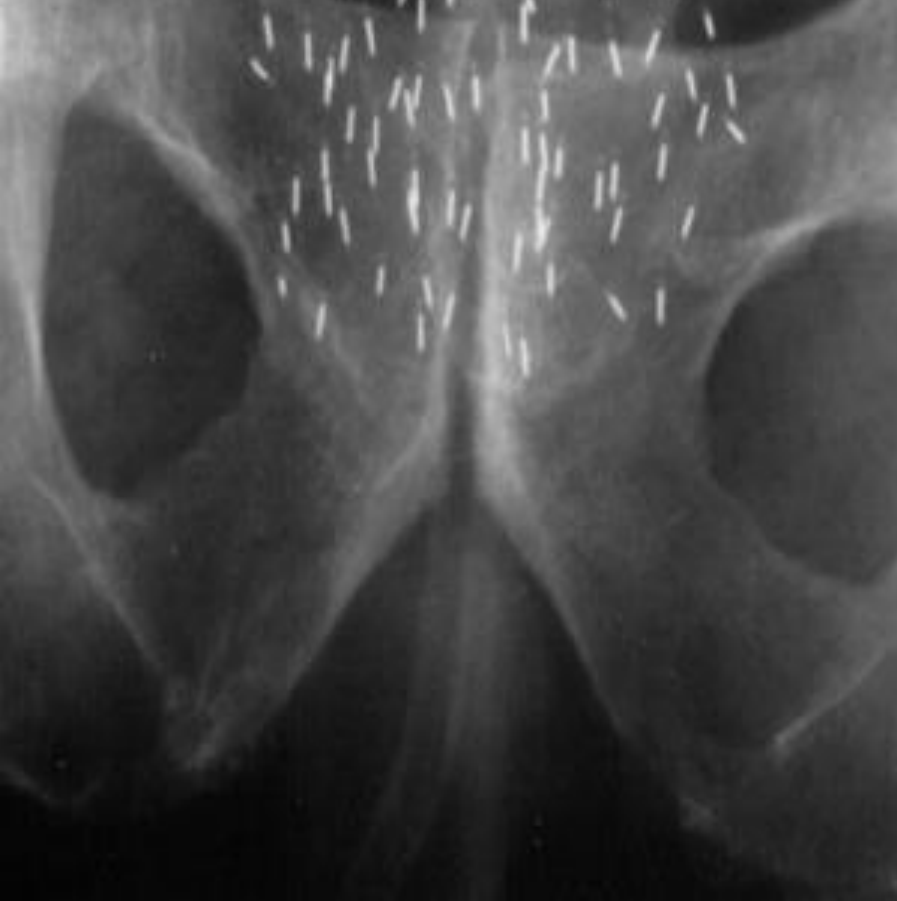
**Pd-103 monotherapy      110-120 Gy (125 Gy)**

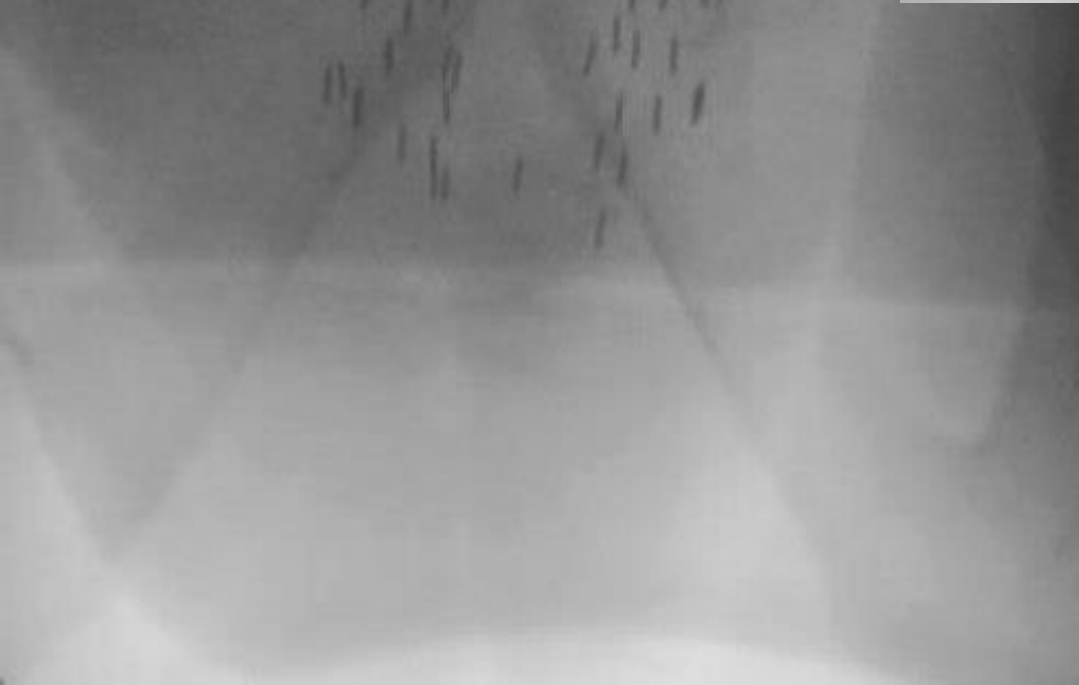
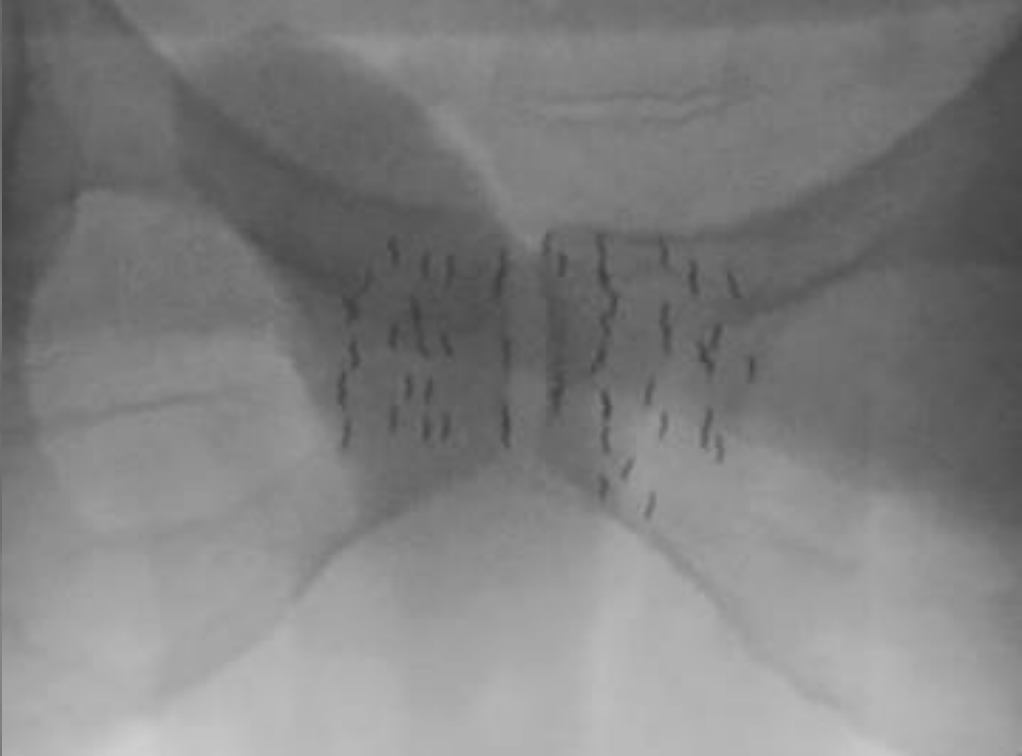
**Pd-103 + 50 Gy EBRT      60-90 Gy**

---

**Cs-131 monotherapy      115 Gy**







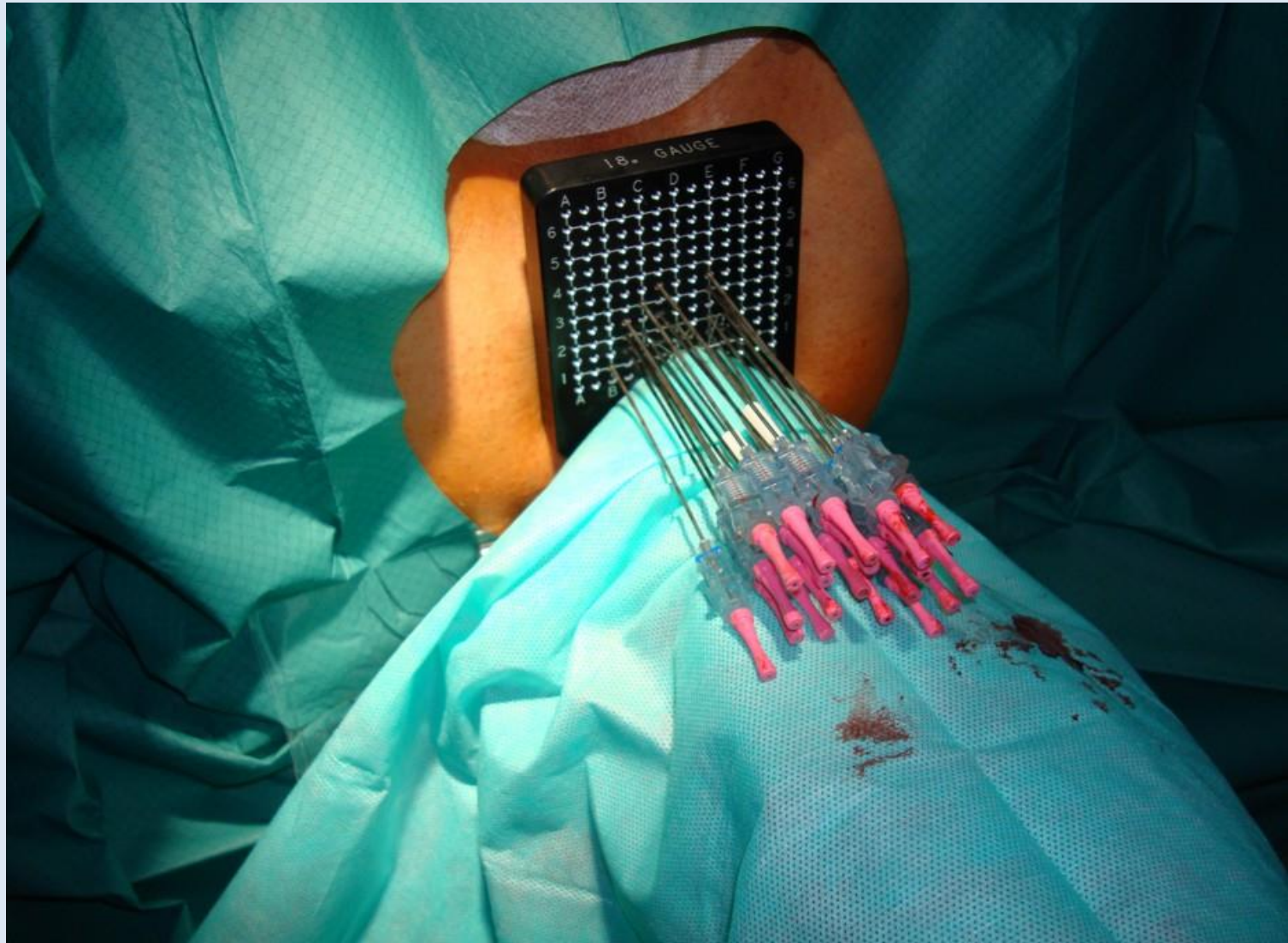
# Post implant dosimetry

It is usual to perform the CT scan  $4\pm 6$  weeks after implantation when oedema has settled.

**It is recommended that the following indices are recorded for all patients:**

1. The volume implanted.
2. The number of seeds.
3. The number of needles used.
4. The total activity implanted.
5. The prescribed dose.
6. The **D90**, that is the dose that covers 90% of the prostate volume as defined from post implant imaging.
7. The **V100**, that is the percentage of the prostate volume that has received the prescribed dose.
8. **V150**, the volume that has received 50% more than the prescribed dose.

# Utrecht technique – used in 2008-2009





**External beam  
radiotherapy  
(\$59,455)**

**Radical  
prostatectomy  
(\$36,888)**

**Brachytherapy  
(\$35,143)**

**Cumulative treatment costs over five and a half years  
for patients with newly-diagnosed prostate cancer.<sup>14</sup>**

# Seeds

## Sole LDR brachytherapy:

### Advantages

- good treatment results (similar to surgery) <sup>1,2</sup>
  - relatively small rate of complications
  - short treatment time (1-3 days)

### Disadvantage

- in the past – seed migration possibility
  - small risk of relative irradiation
  - costs

1) Sylvester, J. E., P. D. Grimm, et al. (2010). "Fifteen-Year Biochemical Relapse-Free Survival, Cause-Specific Survival, and Overall Survival following I(125) Prostate Brachytherapy in Clinically Localized Prostate Cancer: Seattle Experience." Int J Radiat Oncol Biol Phys

2) Ragde, H., L. J. Korb, et al. (2000). "Modern prostate brachytherapy. Prostate specific antigen results in 219 patients with up to 12 years of observed follow-up." Cancer **89**(1): 135-41.



# HDR

## Advantages

- good treatment results (similar to seeds) <sup>1,2</sup>
  - possibility of dose verification
  - complications similar to <sup>1)</sup>
    - positive radiobiology
  - no staff exposure to radiation

## Disadvantage

- different fractionation schemas
- in monotherapy – small trial's number

1) Demanes, D. J., A. A. Martinez, et al. (2011). "High-Dose-Rate Monotherapy: Safe and Effective Brachytherapy for Patients with Localized Prostate Cancer." Int J Radiat Oncol Biol Phys.

2) Mark, R. J., P. J. Anderson, et al. (2010). "Interstitial High-Dose-Rate Brachytherapy as Monotherapy for Early Stage Prostate Cancer: Median 8-Year Results in 301 Patients " Brachytherapy **9**(Supplement 1): S76.

# **Brachytherapy palliative**

**Lung cancer as example**

# Radical treatment (<5 -10% of BT patients): Indications

## 1. Curative intent as a „boost” to EBRT – T<sub>1-2</sub> N<sub>0-1</sub> M<sub>0</sub>

-  LC
- before EBRT- remission of atelectasis, reclassification.

## 2. Alone - definitive brachytherapy for small tumors - T<sub>1-2</sub> N<sub>0</sub> M<sub>0</sub>

- in patients with occult carcinoma or tumors potentially resectable, with diameter < 2 cm, disqualified for surgery or EBRT (Japan, USA).

## 3. Postoperative brachytherapy of the bronchial stump after resection with positive resection margins (R<sub>2</sub>).

## 4. As a boost for minor residual disease within a combined non-surgical radical approach.

# Palliative treatment (>90 % of BT patients): Indications

1. The main indication is treatment of life-threatening complications such a dyspnea, obstructive pneumonia or atelectasis, cough or haemoptysis resulting from endobronchial or endotracheal tumour growth.
2. Treatment of endobronchial or endotracheal recurrent tumour growth in previously irradiated areas or in combination with EBRT for metastatic lung cancers.

# Brachytherapy treatment schemas - indications, doses

Indications for brachytherapy	I phase	II phase	III phase	IV phase
<b><u>Radical combined treatment: schema I;</u></b> clinical stage T1-3 N1-3 M0	EBRT: total dose 44 Gy in 22 fr. aa 2 Gy (2 a-p fields)	1 fr. x 6 Gy, ref. point 0.5 - 1 cm	EBRT 16 Gy in 8 fr. (changed fields)	1 fr. x 6 Gy, ref. point 0.5 - 1 cm
<b><u>Radical combined treatment: schema II;</u></b> clinical stage T1-3 N1-3 M0	EBRT: total dose 44 Gy in 22 fr. aa 2 Gy (2 a-p fields)	EBRT 16 Gy in 8 fr. (changed fields)	HDR-BT - in 1, 3 and 5 weeks of EBRT – 3 x 10 Gy.	
<b><u>Radical sole treatment, radiologically occult cancer T1-2N0</u></b>	Total dose 36 - 42 Gy in 6 - 7 fr. with interval of 4 - 7 days between fractions			
<b><u>Radical treatment after surgery, R2</u></b>	After EBRT with total dose of 50 - 60 Gy	To consider increasing the total use using HDR-BT HDR. Fr. dose from 1 x 6 Gy till 3 fr. x 6 Gy (18 Gy), depending on EBRT dose		
<b><u>Radical treatment: stump infiltration</u></b>	Sole brachytherapy: 4 fr. of 7.5 - 10 Gy with interval of 4 - 7 days between fractions			
<b><u>Palliative treatment</u></b>	3 Gy in 3 fr. of 6 Gy with interval of 4 -7 days – in patients treated earlier with EBRT – dose > 50 Gy			
	22,5 Gy in 3 fr. of 7,5 Gy Gy with interval of 4 -7 days – in patients not irradiated or treated earlier with EBRT – dose < 50 Gy			
	1 x 10 Gy in case of WHO scale > 2	Sometimes dose can be repeated after few weeks, in cases with clinical remission or visible during bronchoscopy		

Poznań

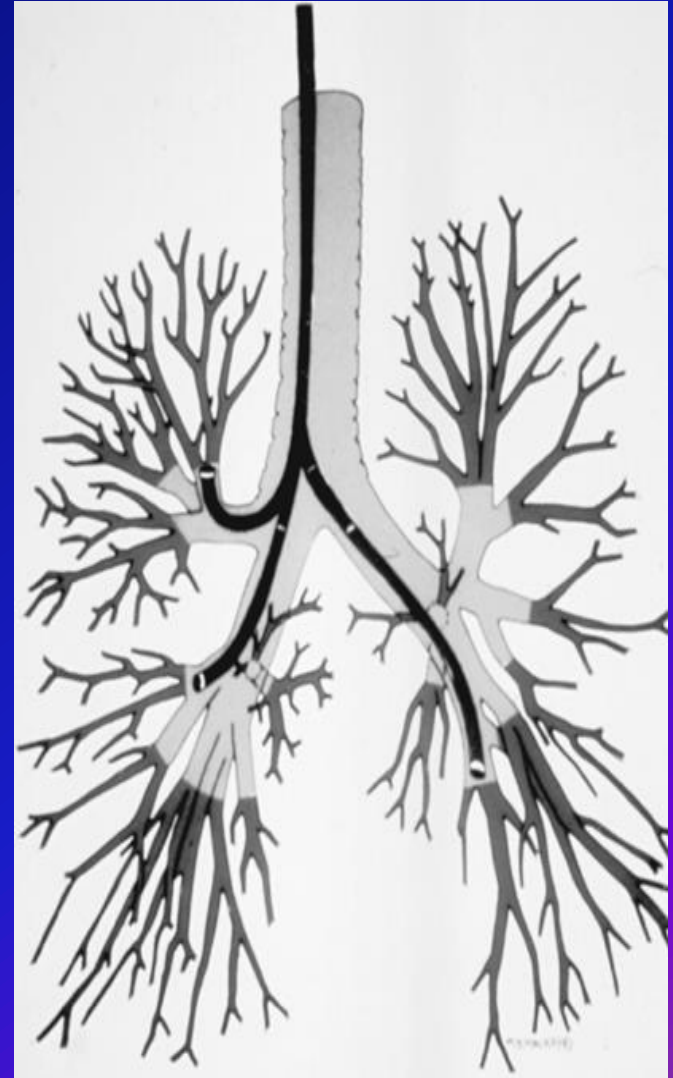
Poznań

# Contraindications:

1. peripheral location of the tumor,
2. Pancoast tumor (?),
3. pressure - location outside of bronchii,
4. contraindication to bronchoscopy (**relative**).



# Bronchofiberscope, endobronchial catheter French 5-6, applicator adapter





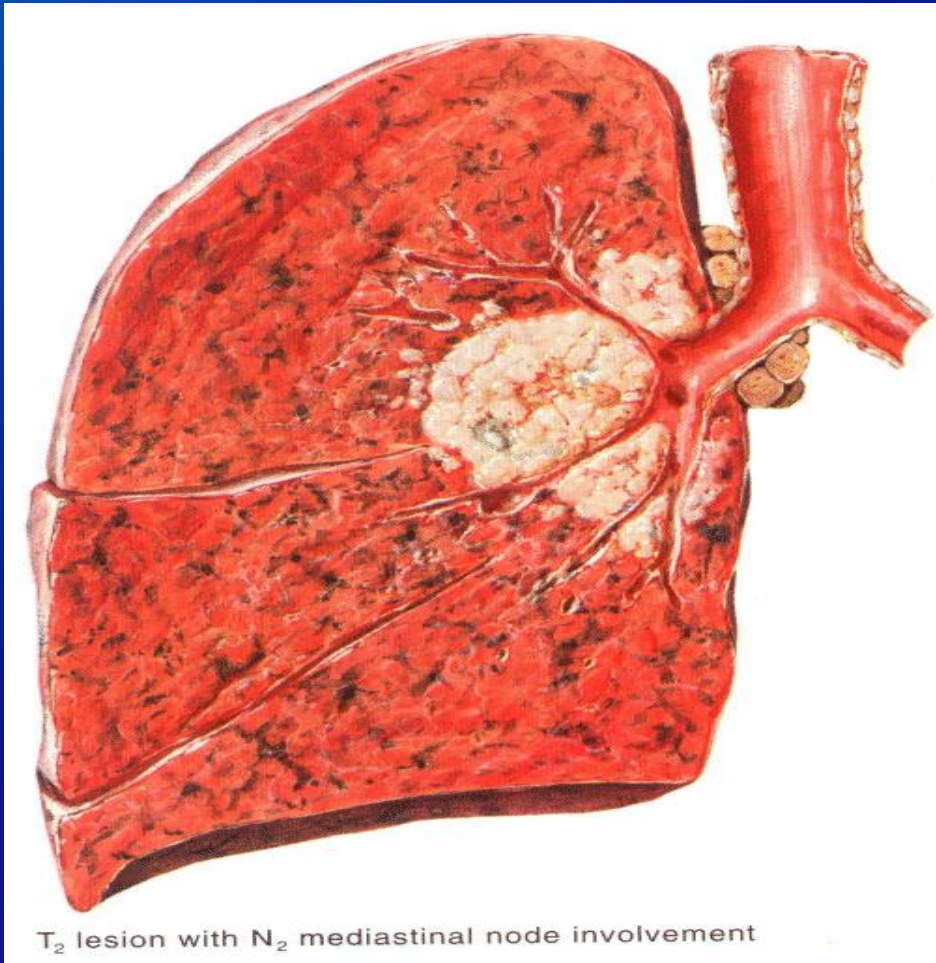
**Lumencath Applicator Set**

**Fritz Adjustable Intraluminal Applicator Set**



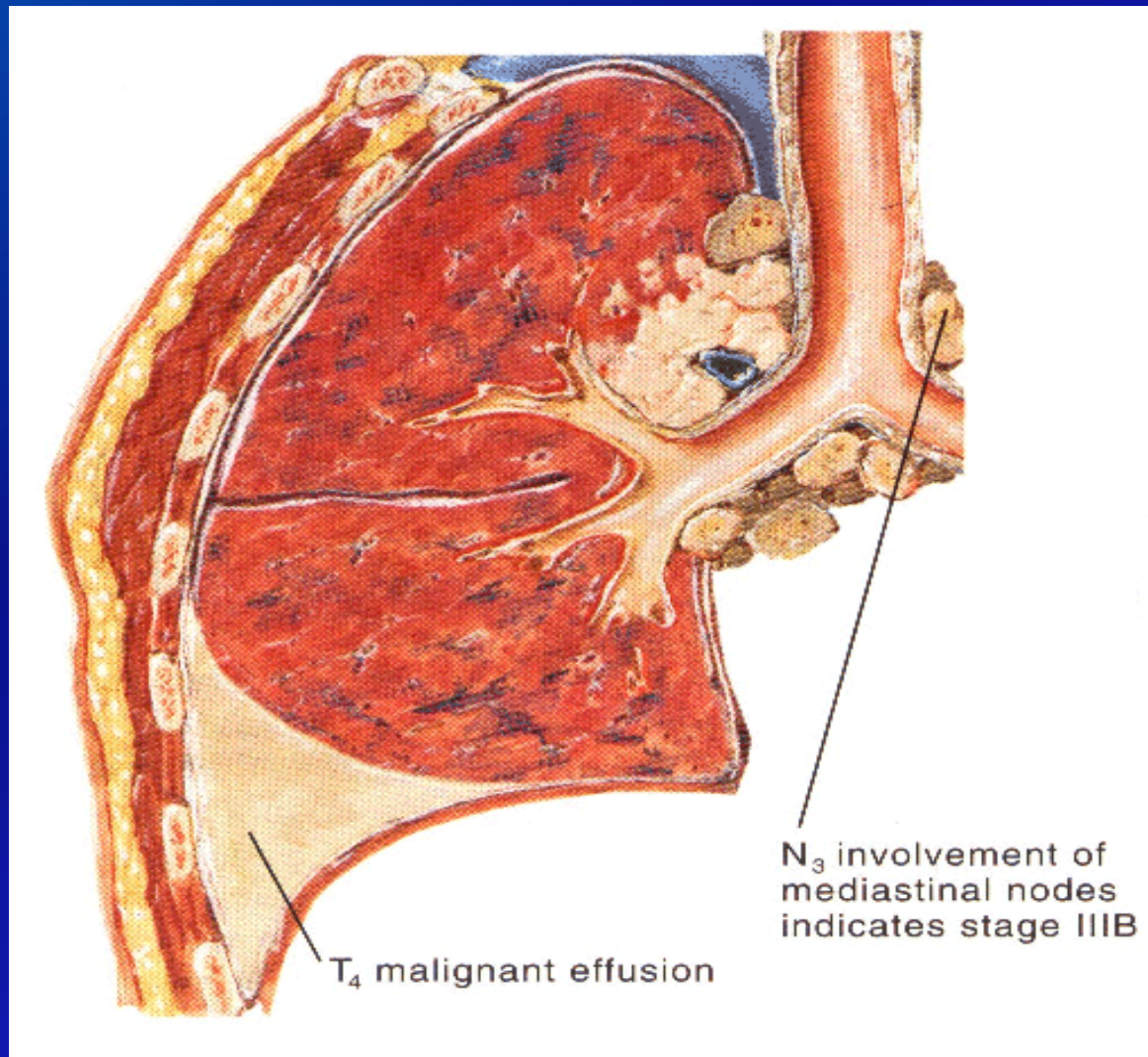
**Very rarely**

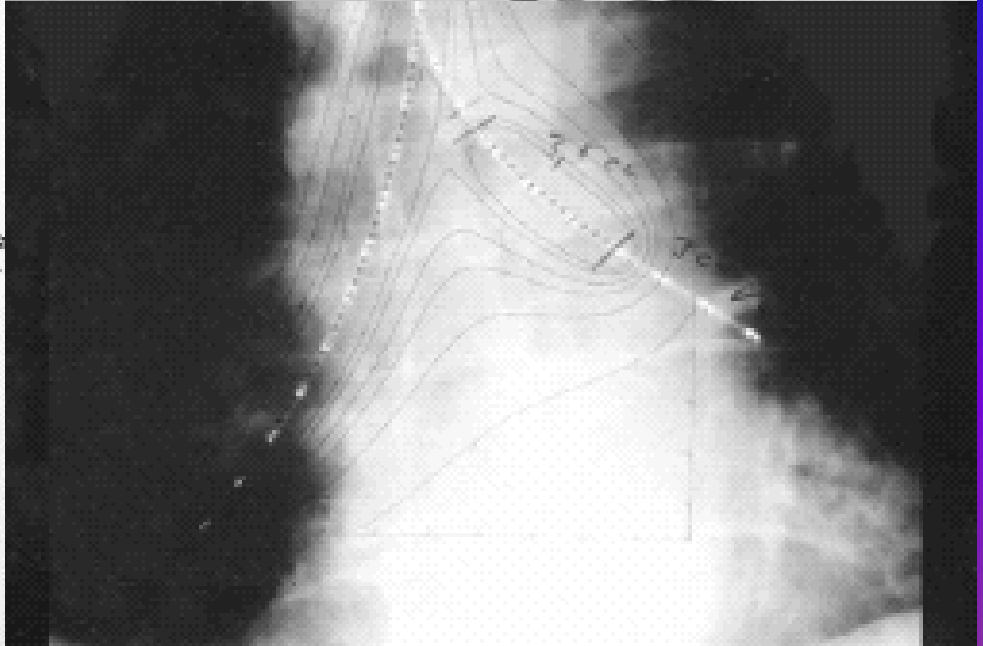
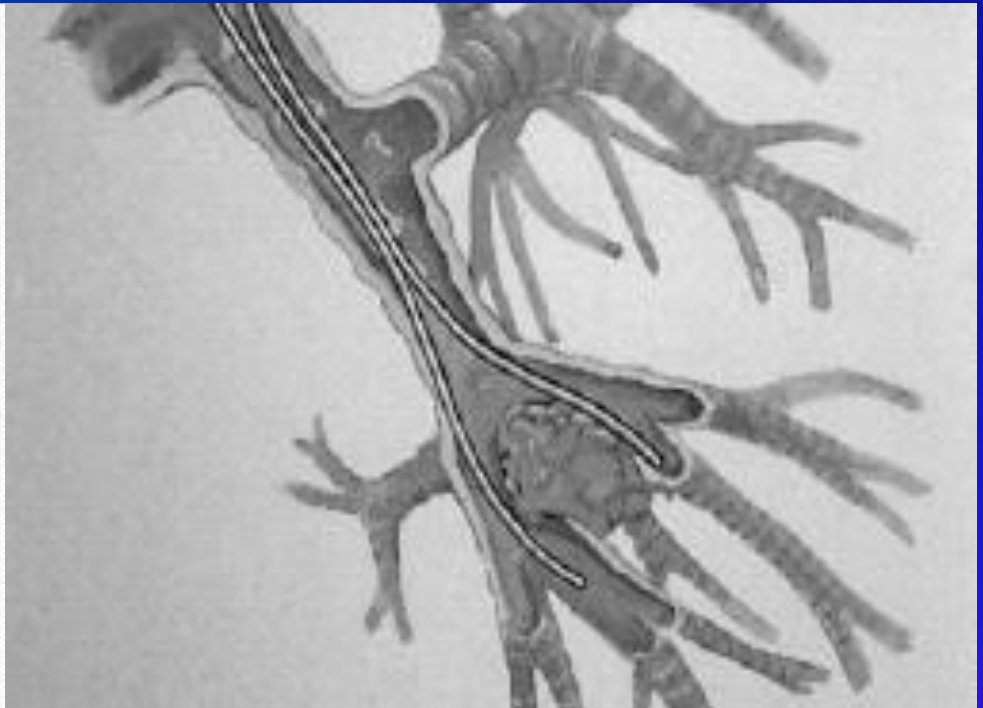
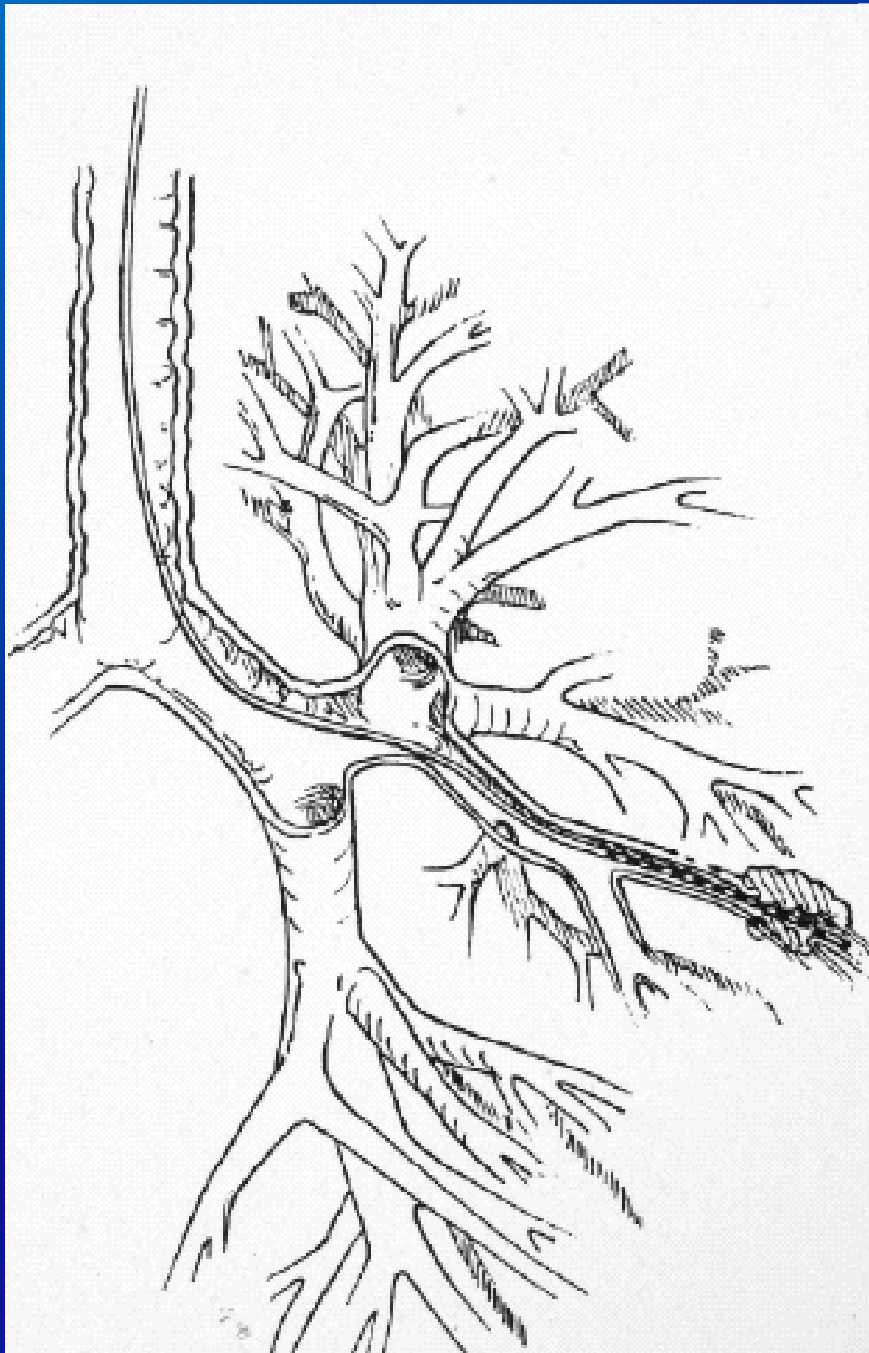
# Location of the tumor for brachytherapy



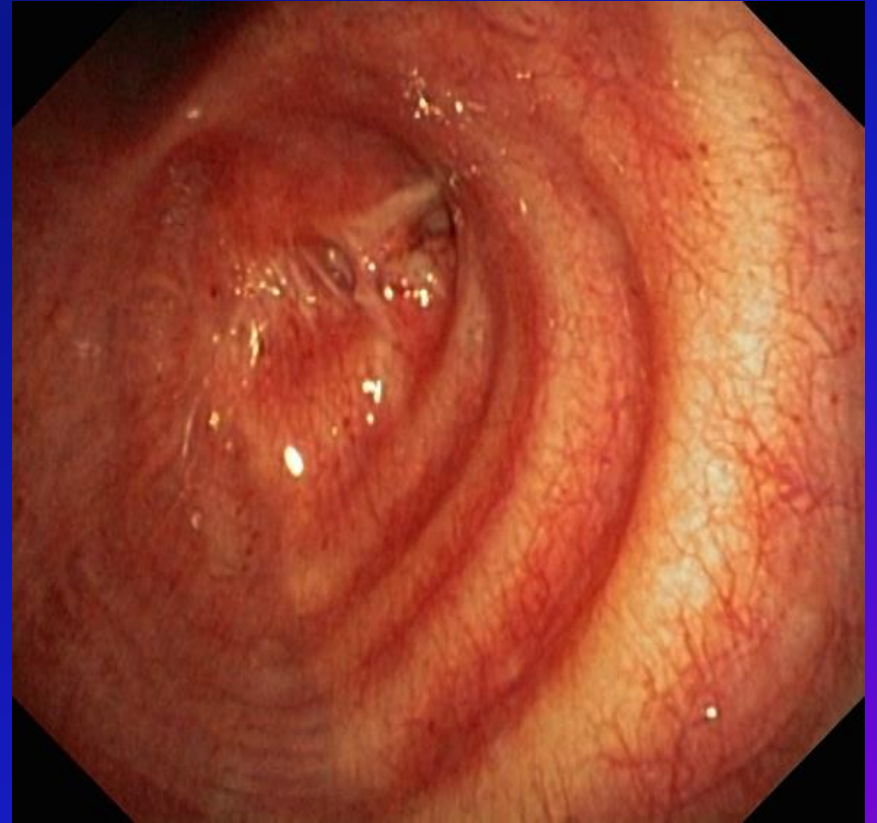
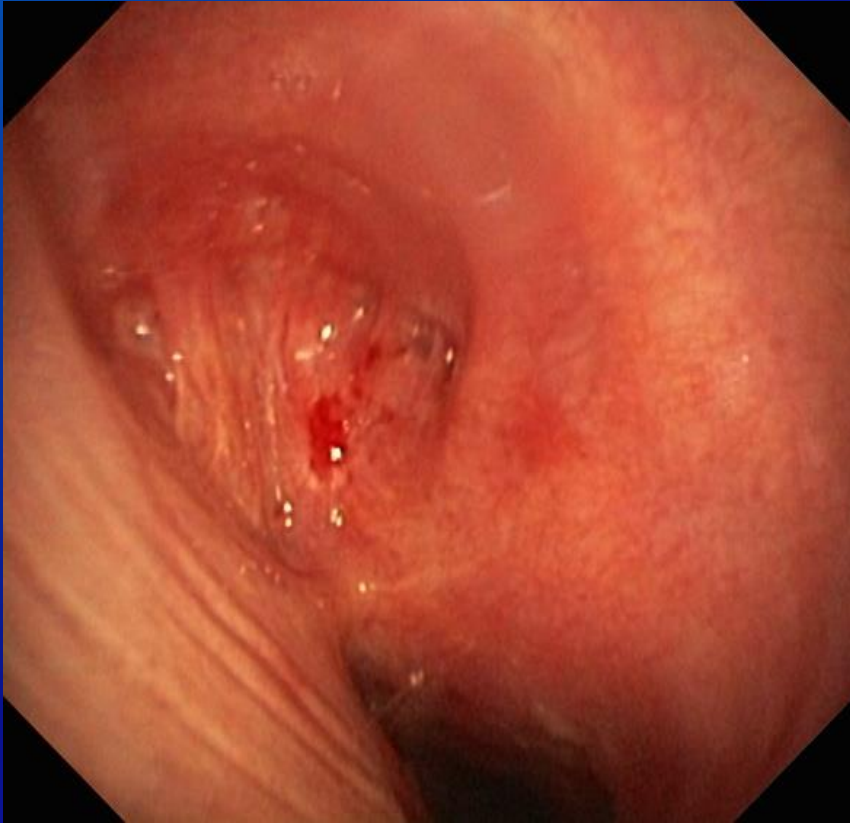


# Lack of indications for brachytherapy



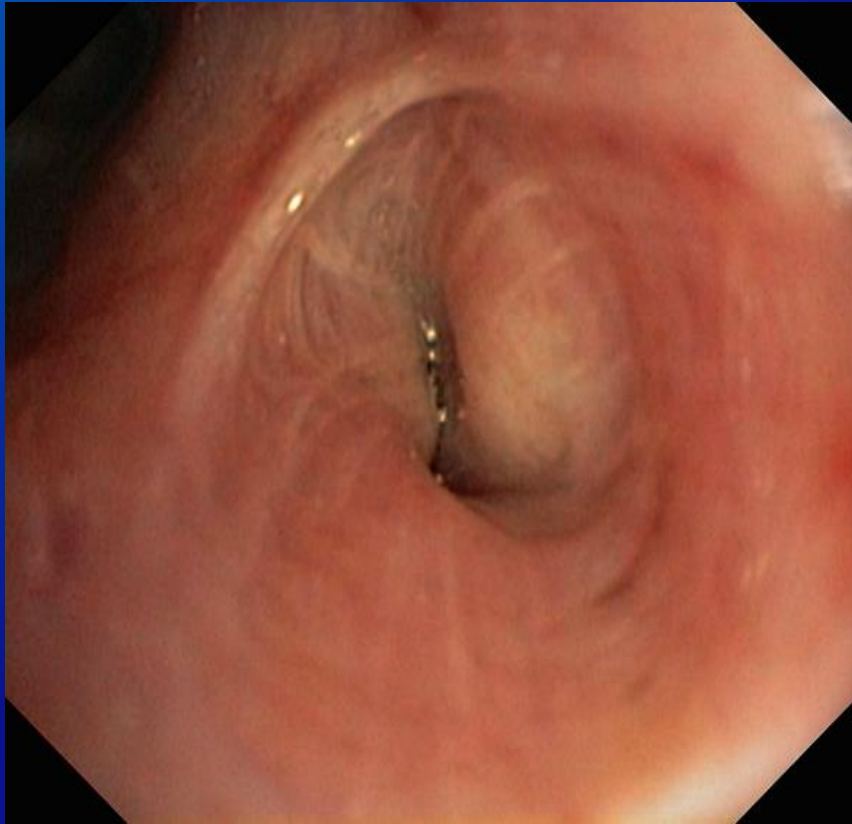


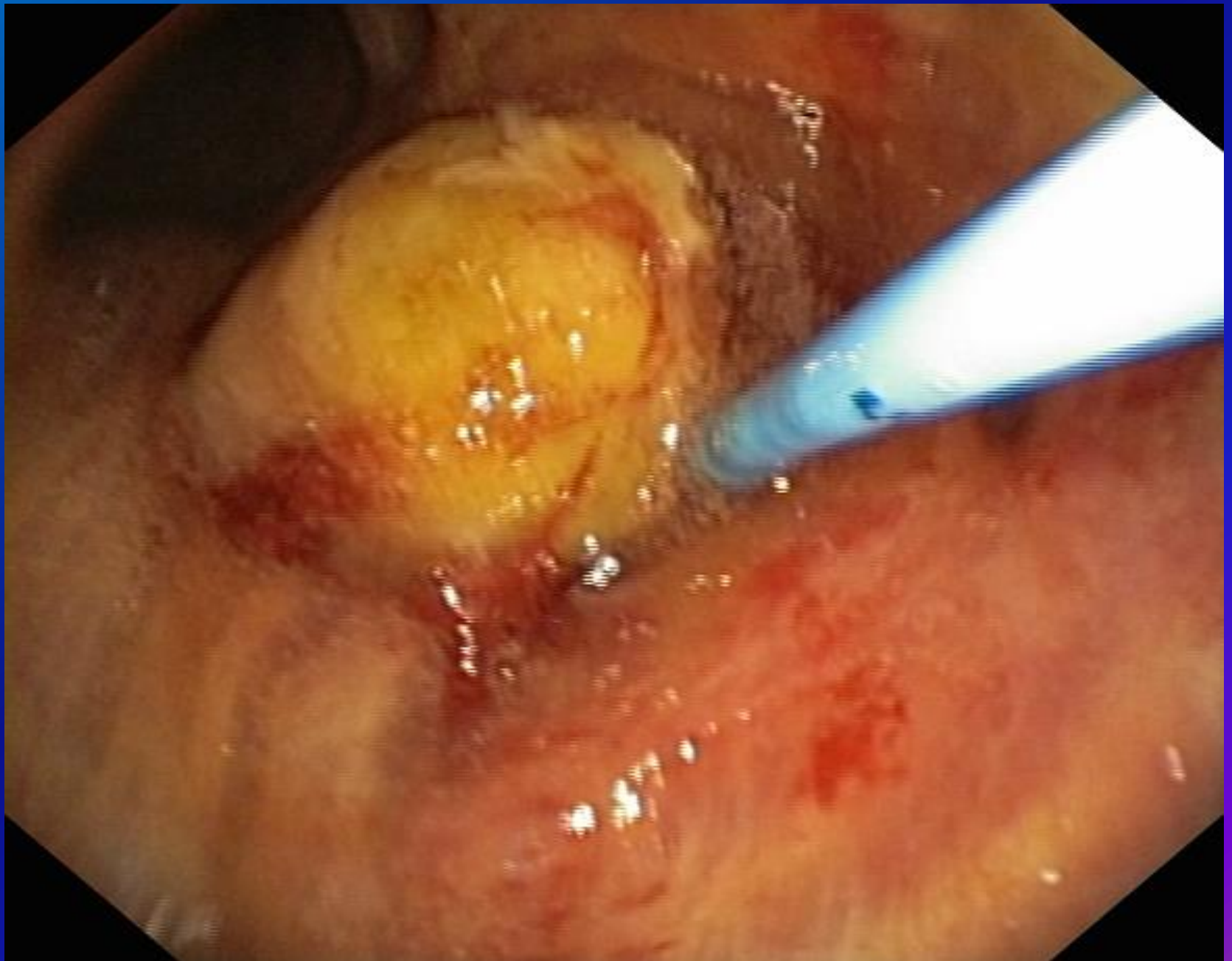
# Stump

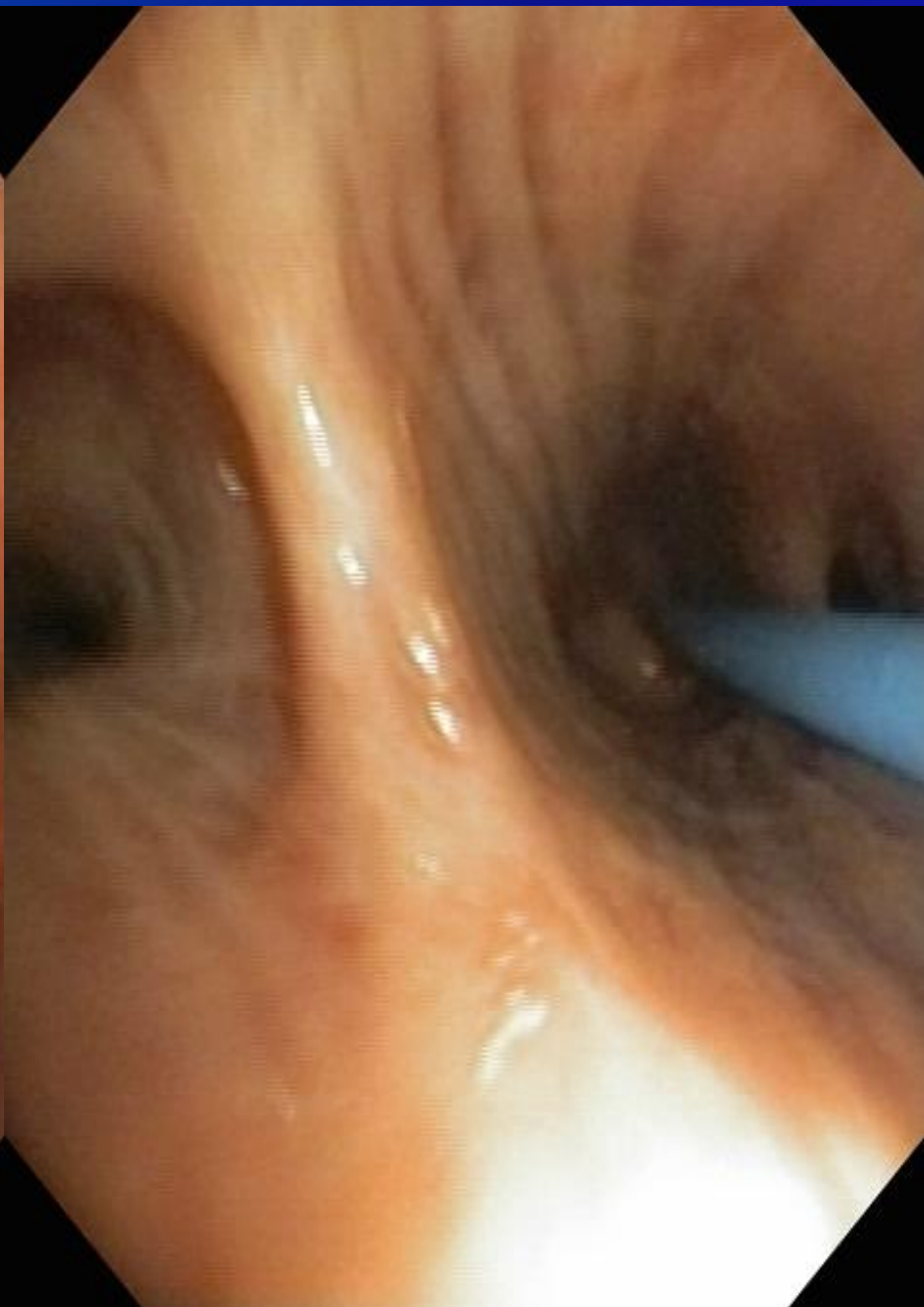




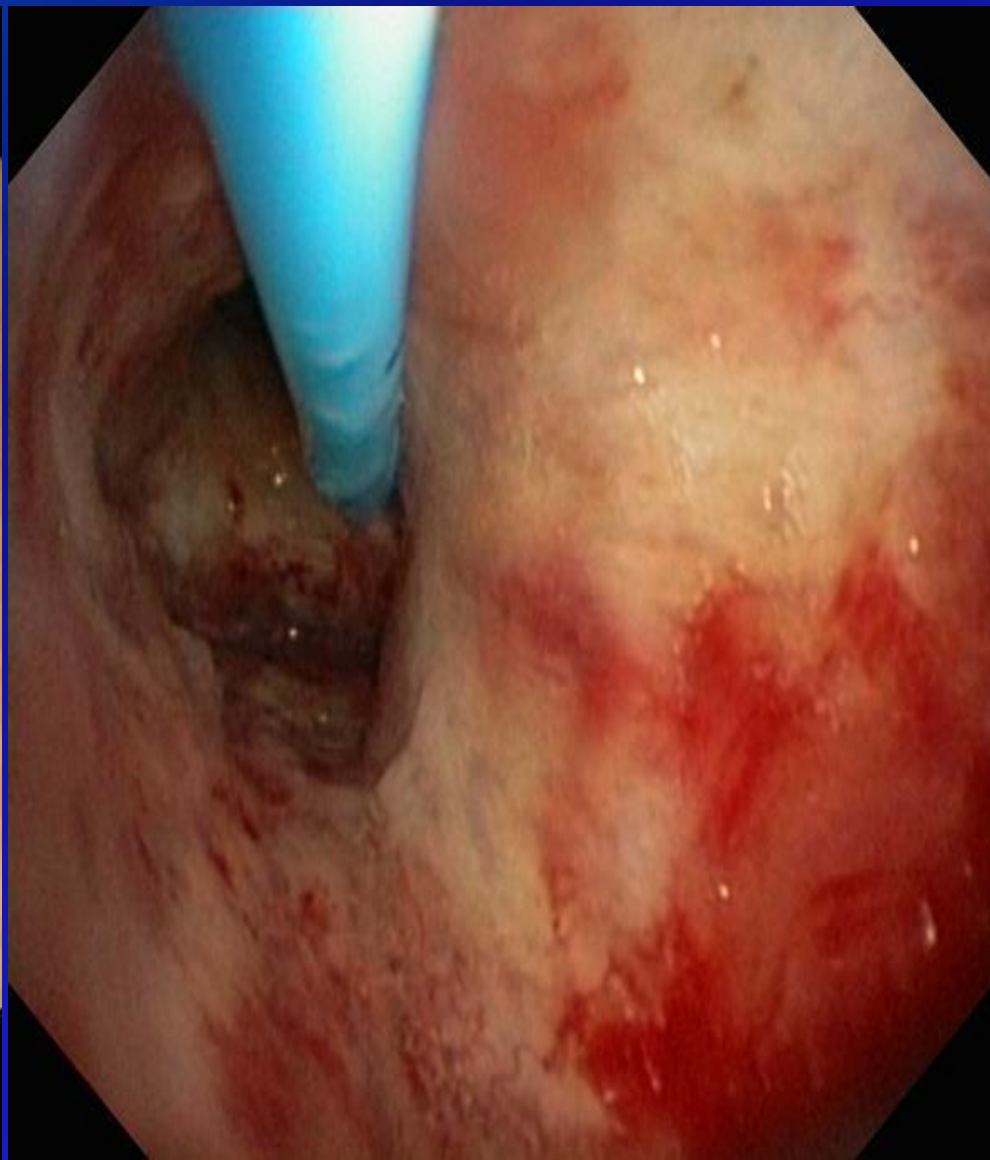
# Stump

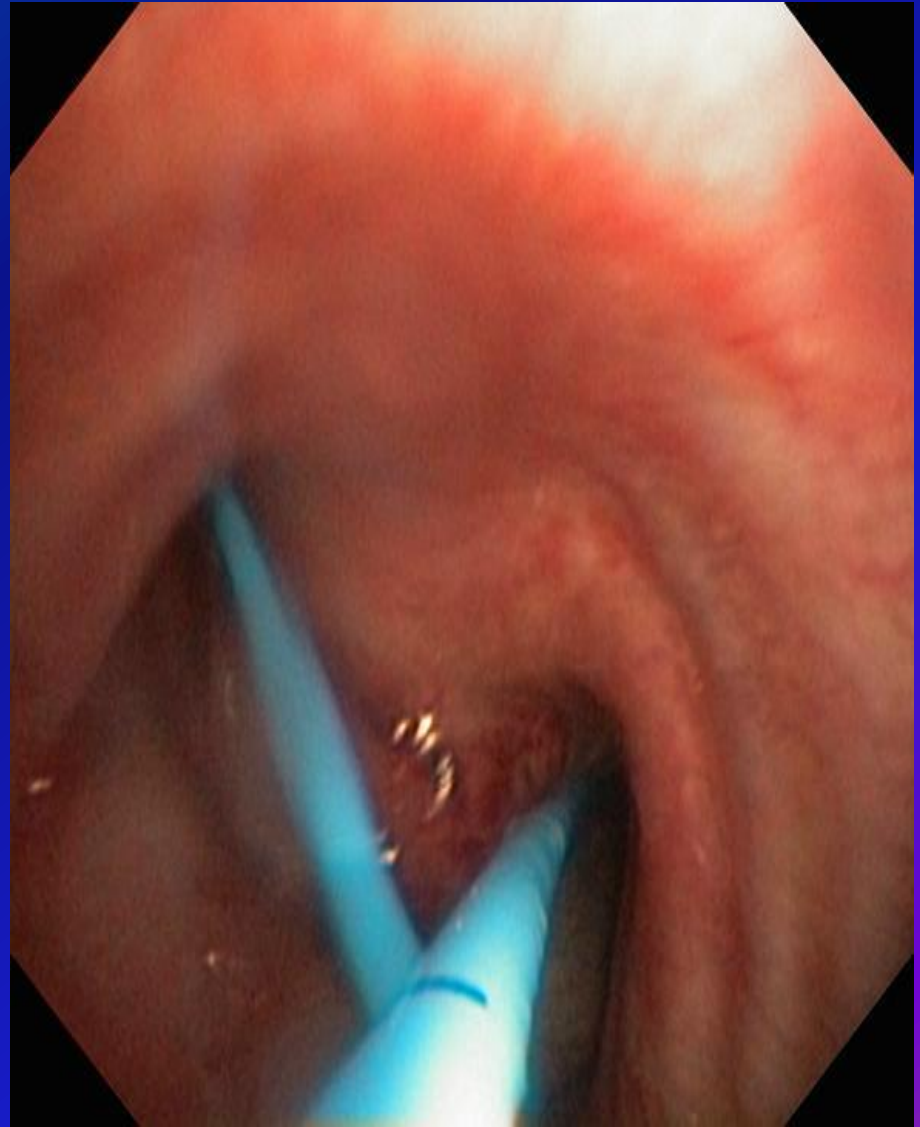
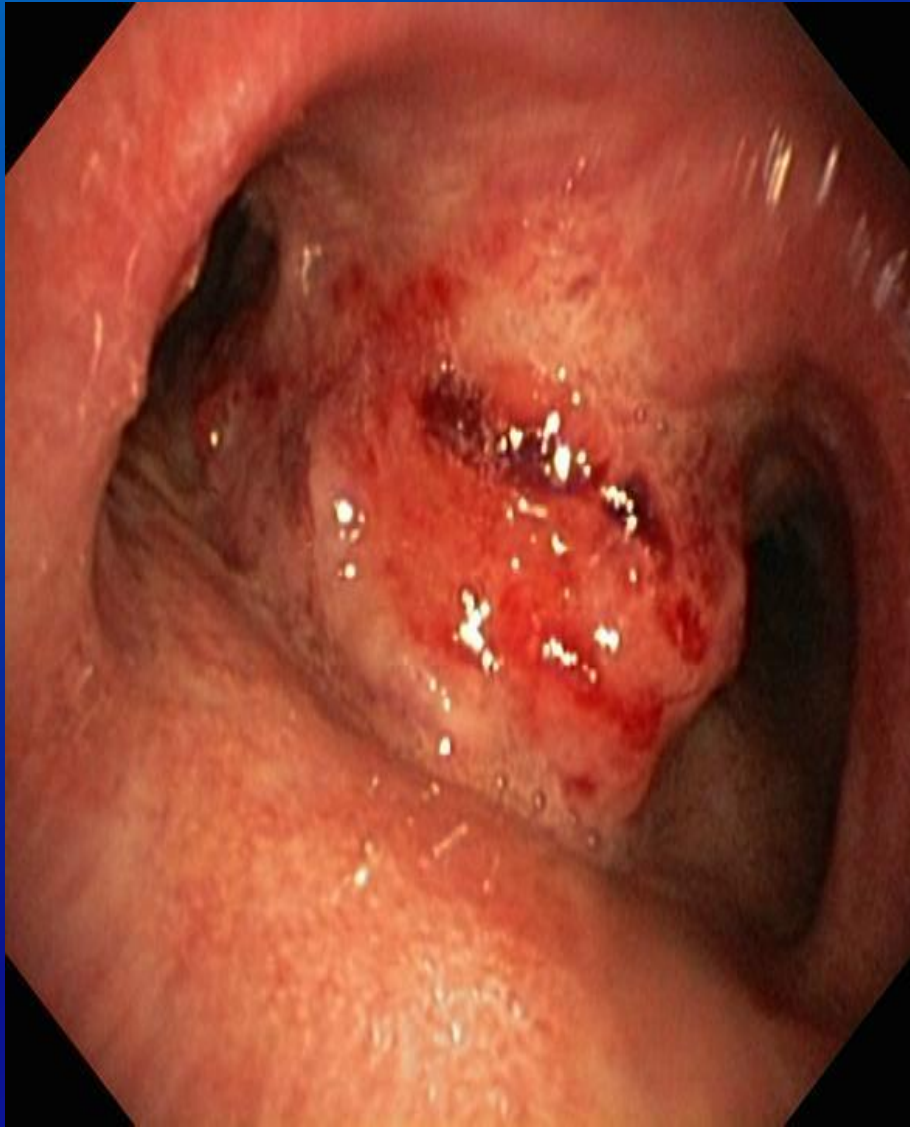


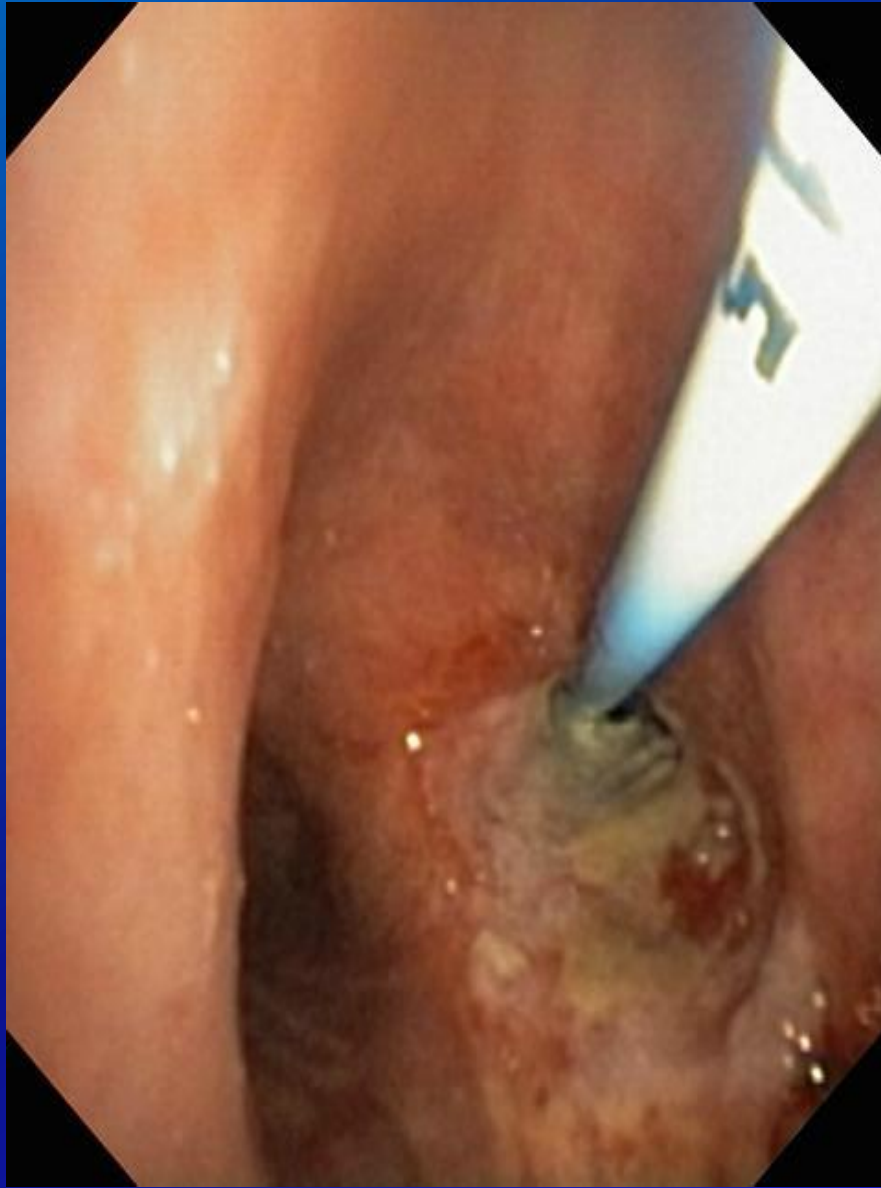




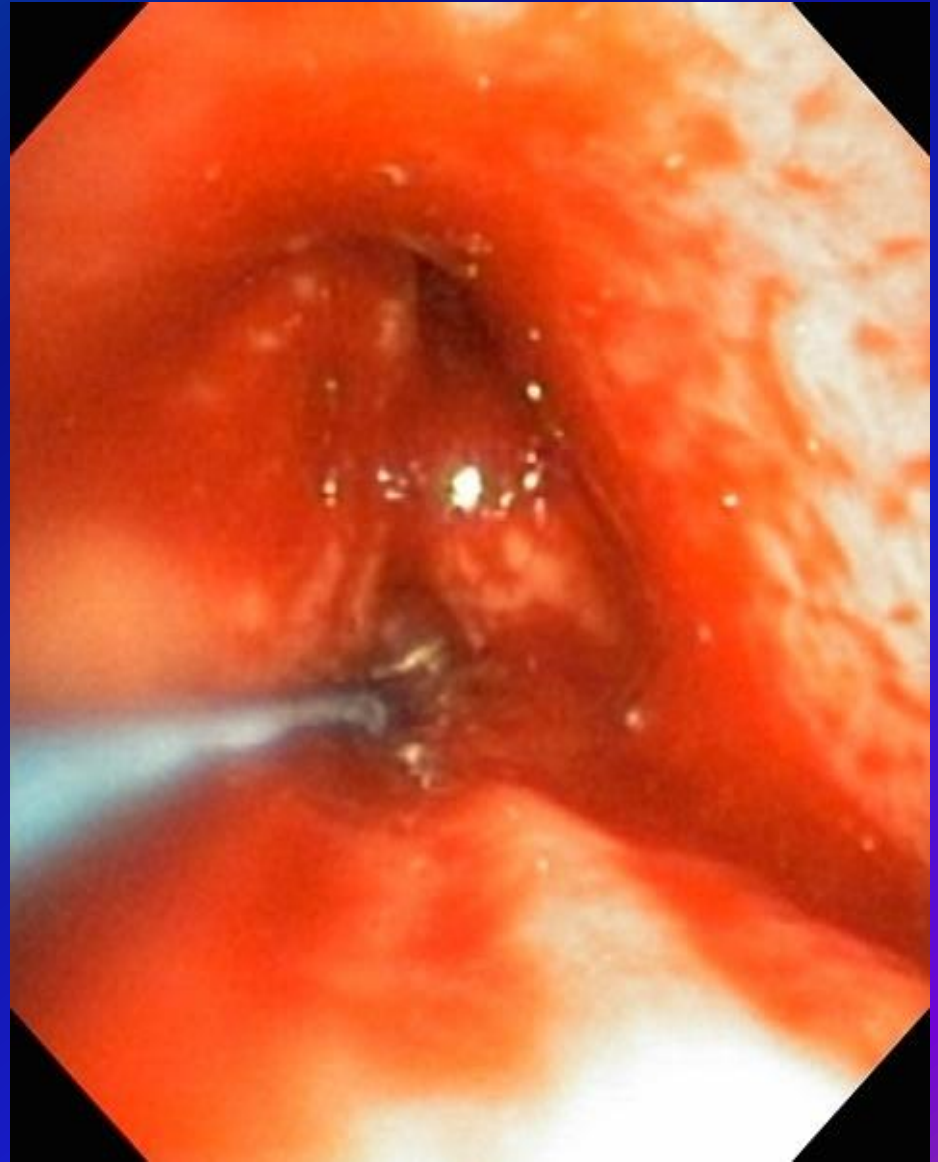
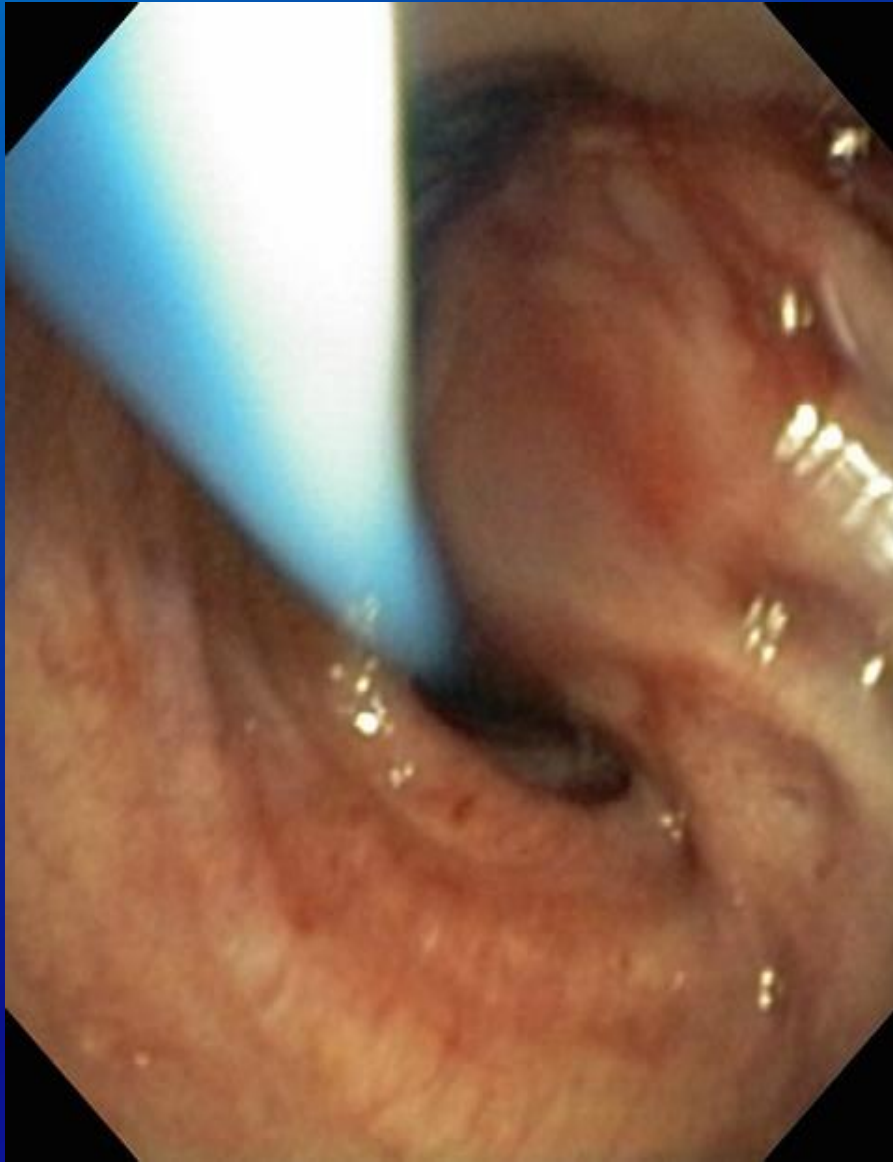


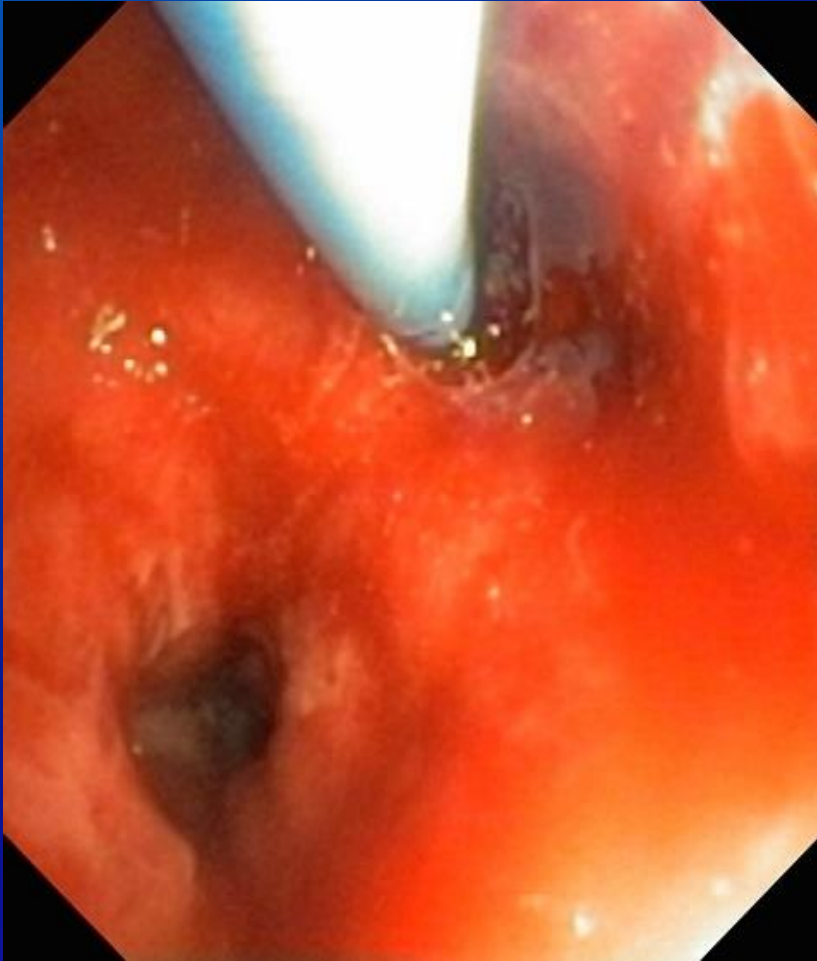










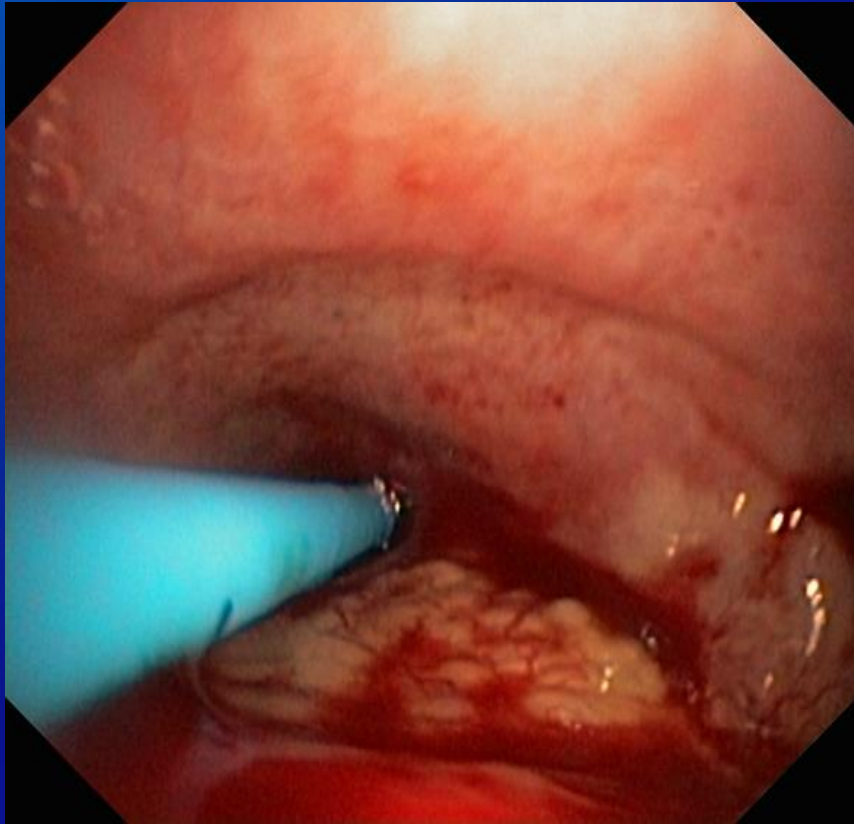




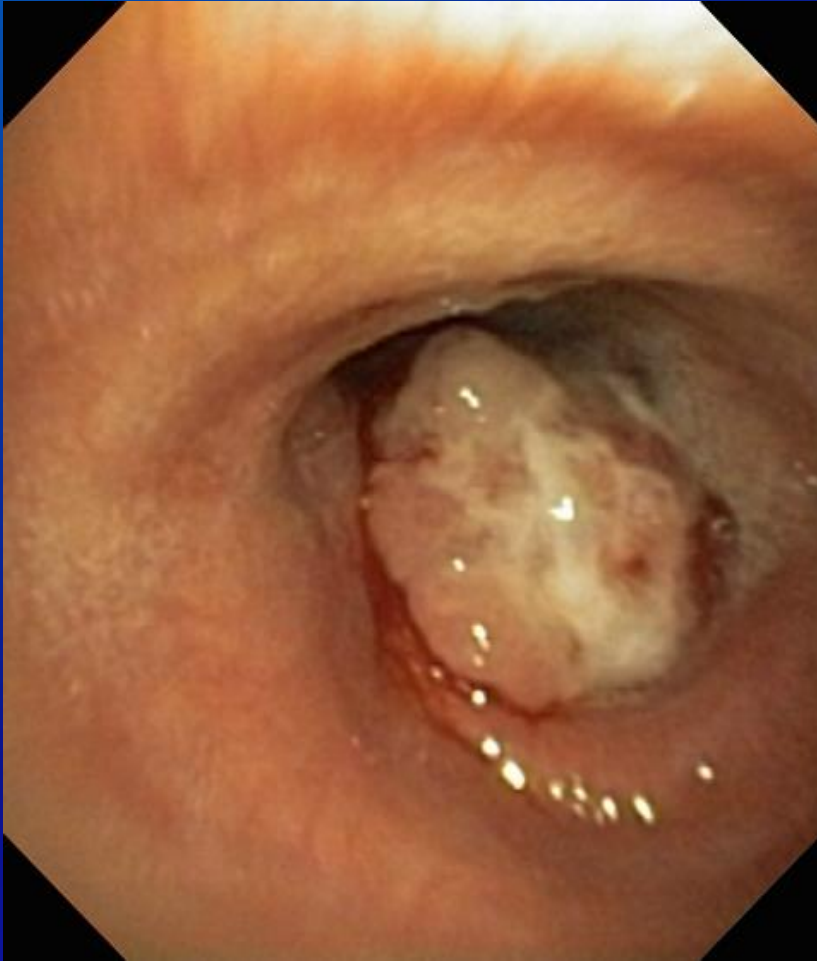




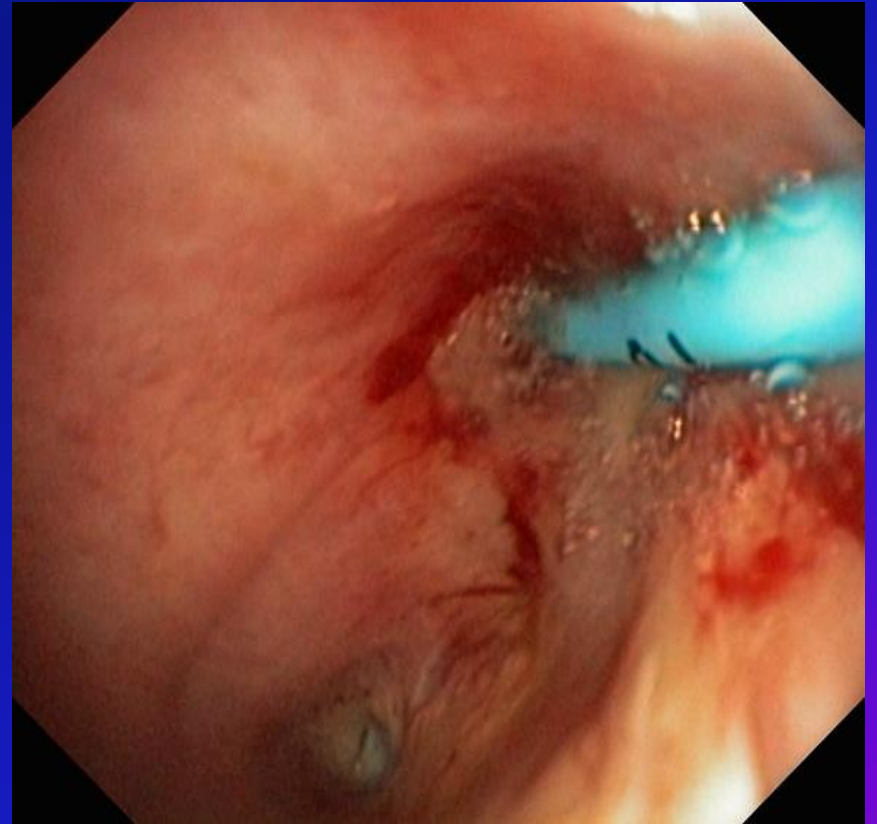
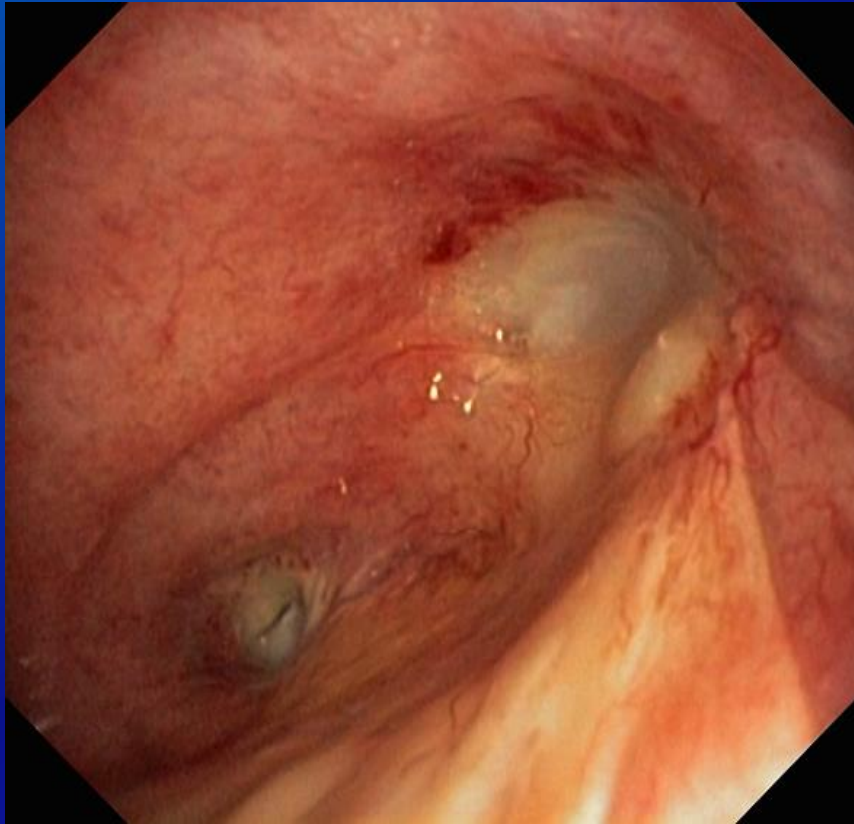






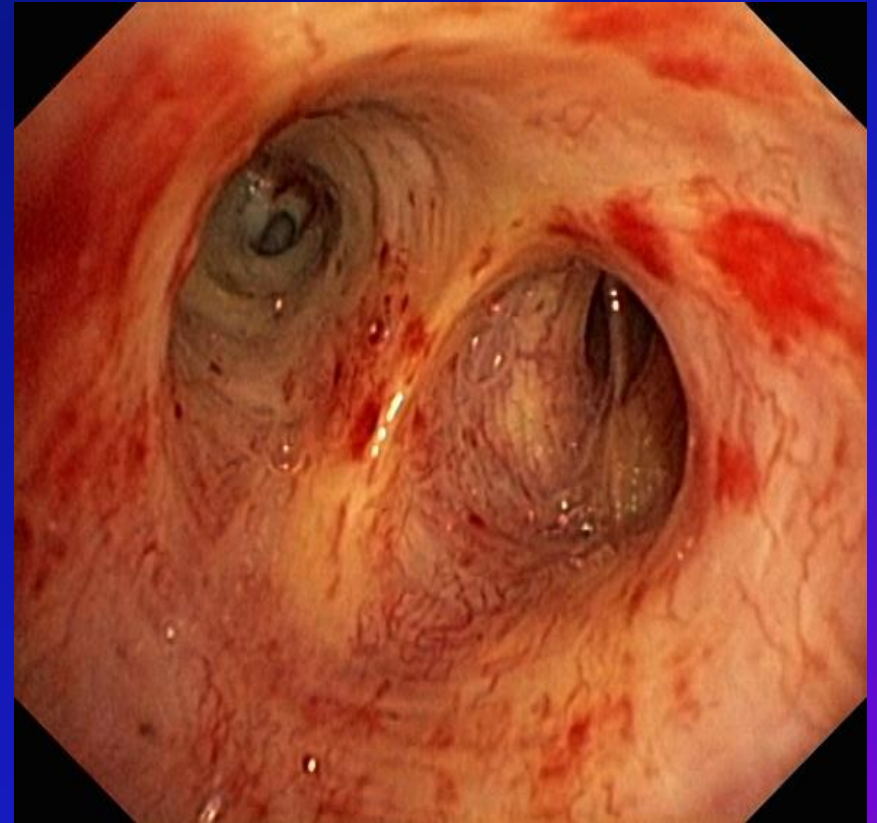




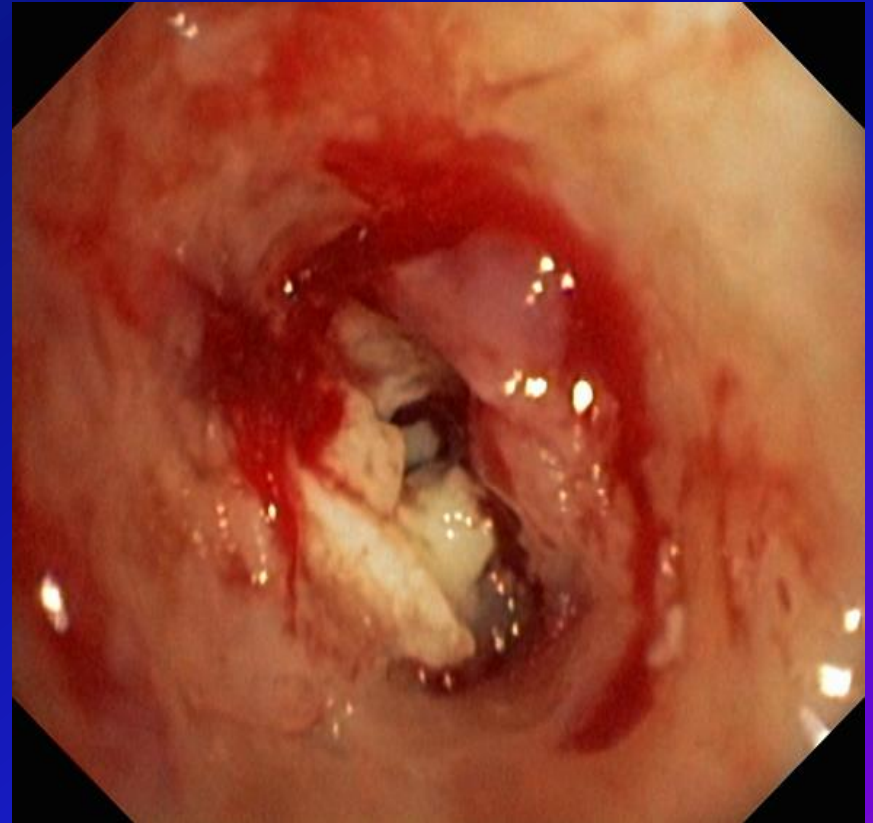
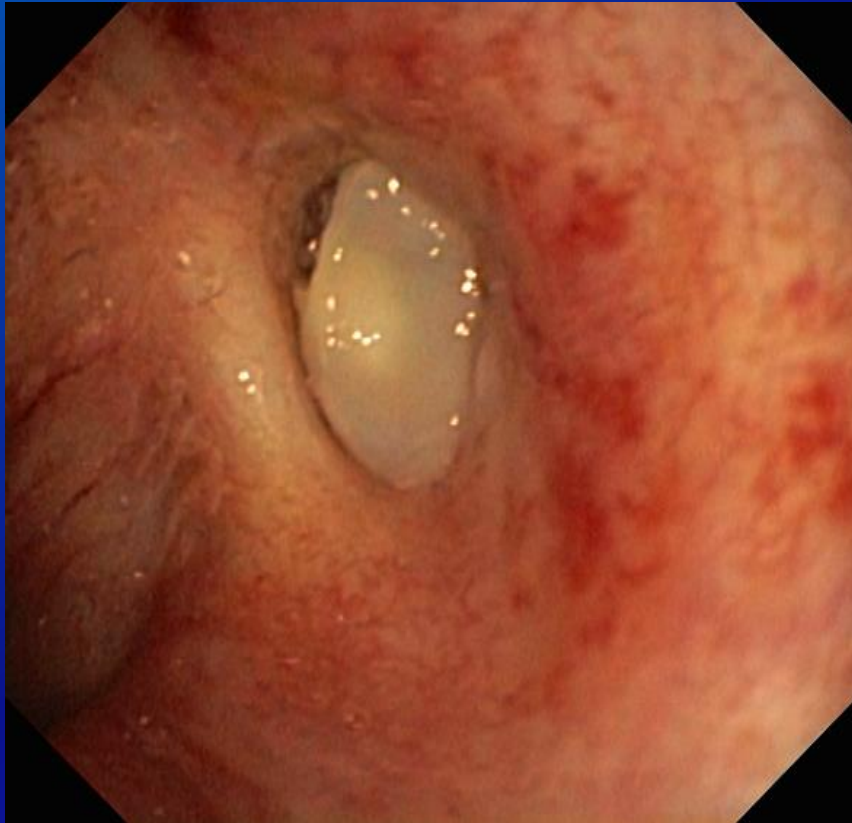




# Late radiation injury



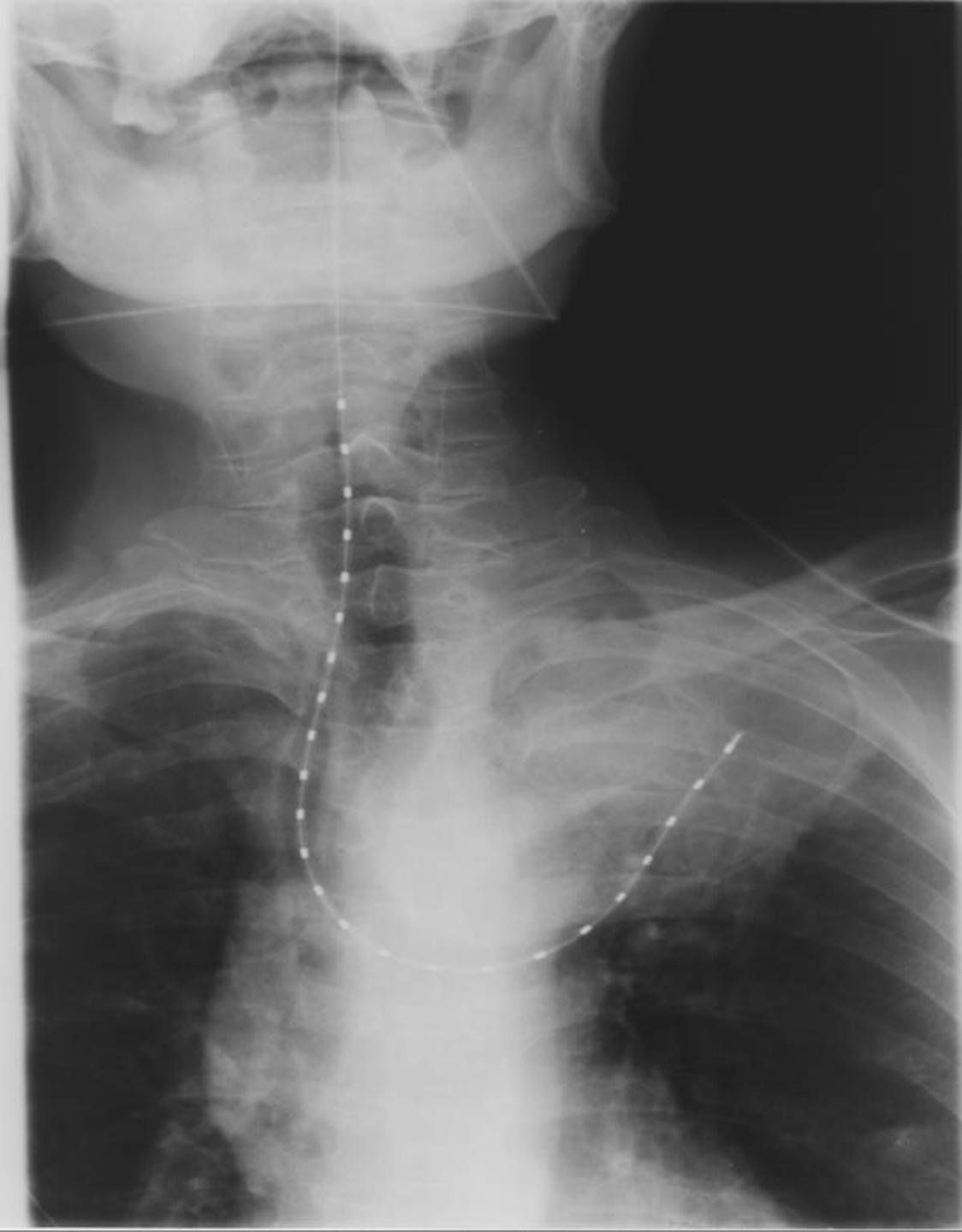
# Late radiation injury



# Late radiation injury







Radcliffe

295601  
1330



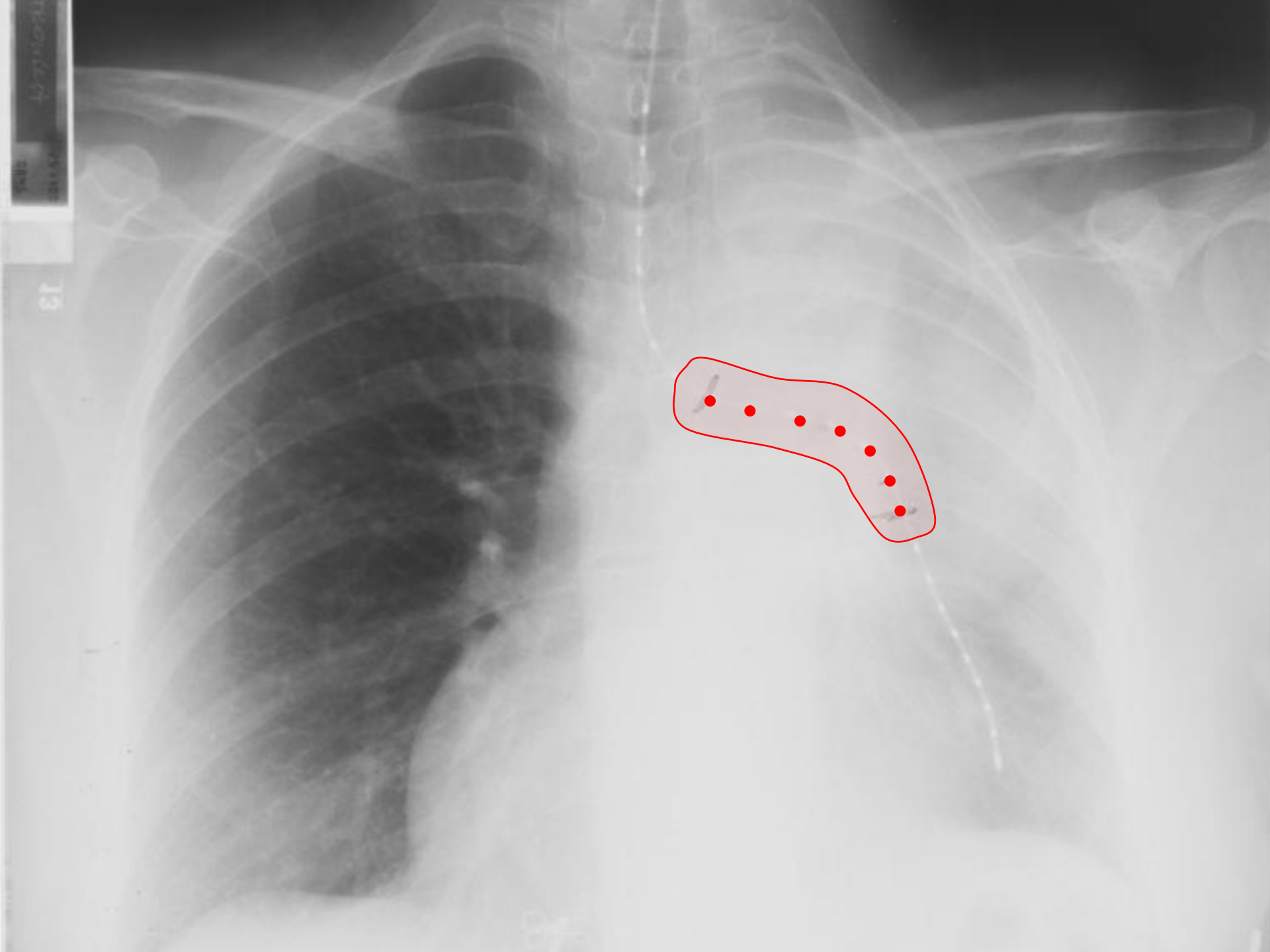


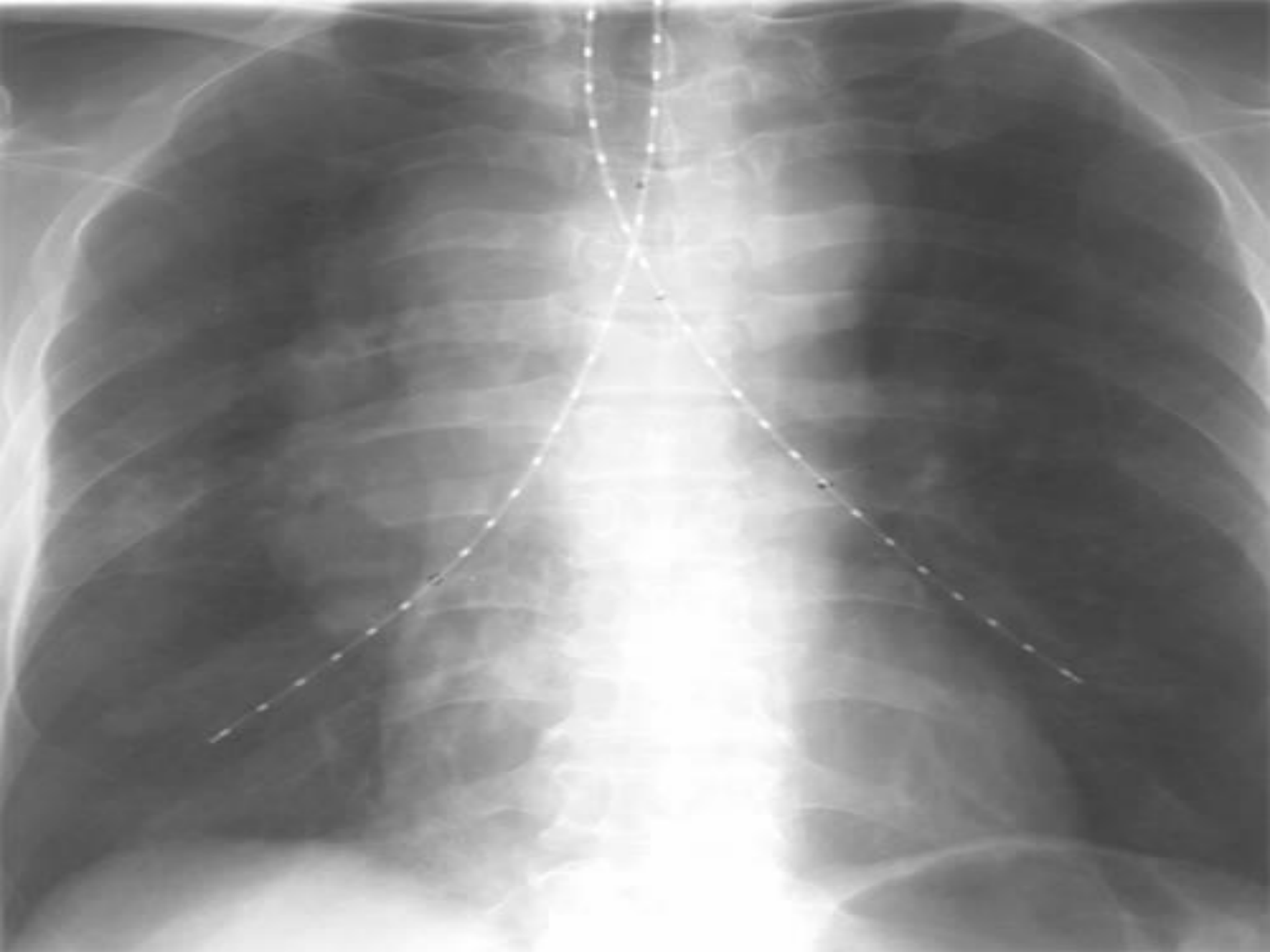
Matthews

25 11 2007  
08:56

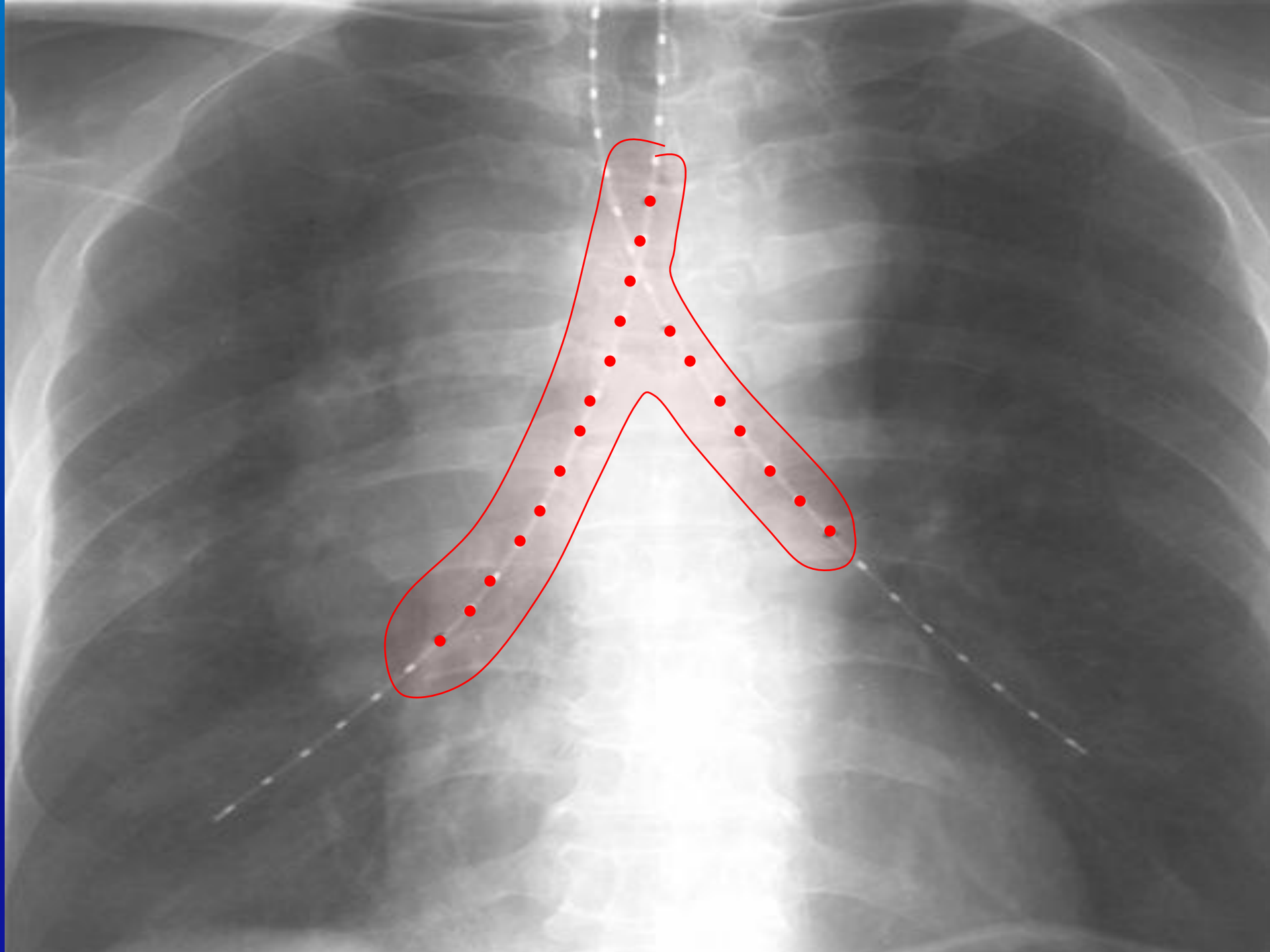
13

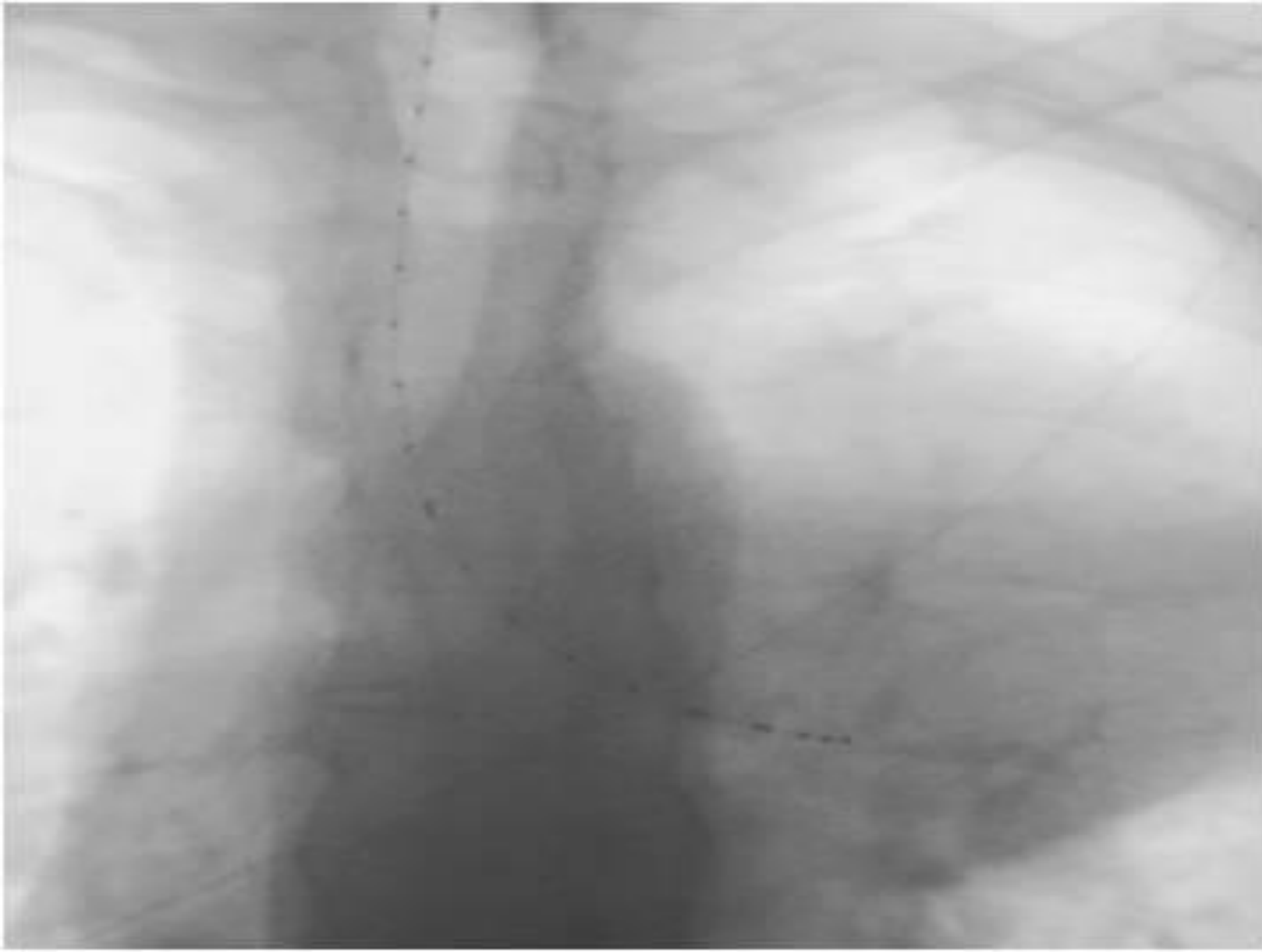




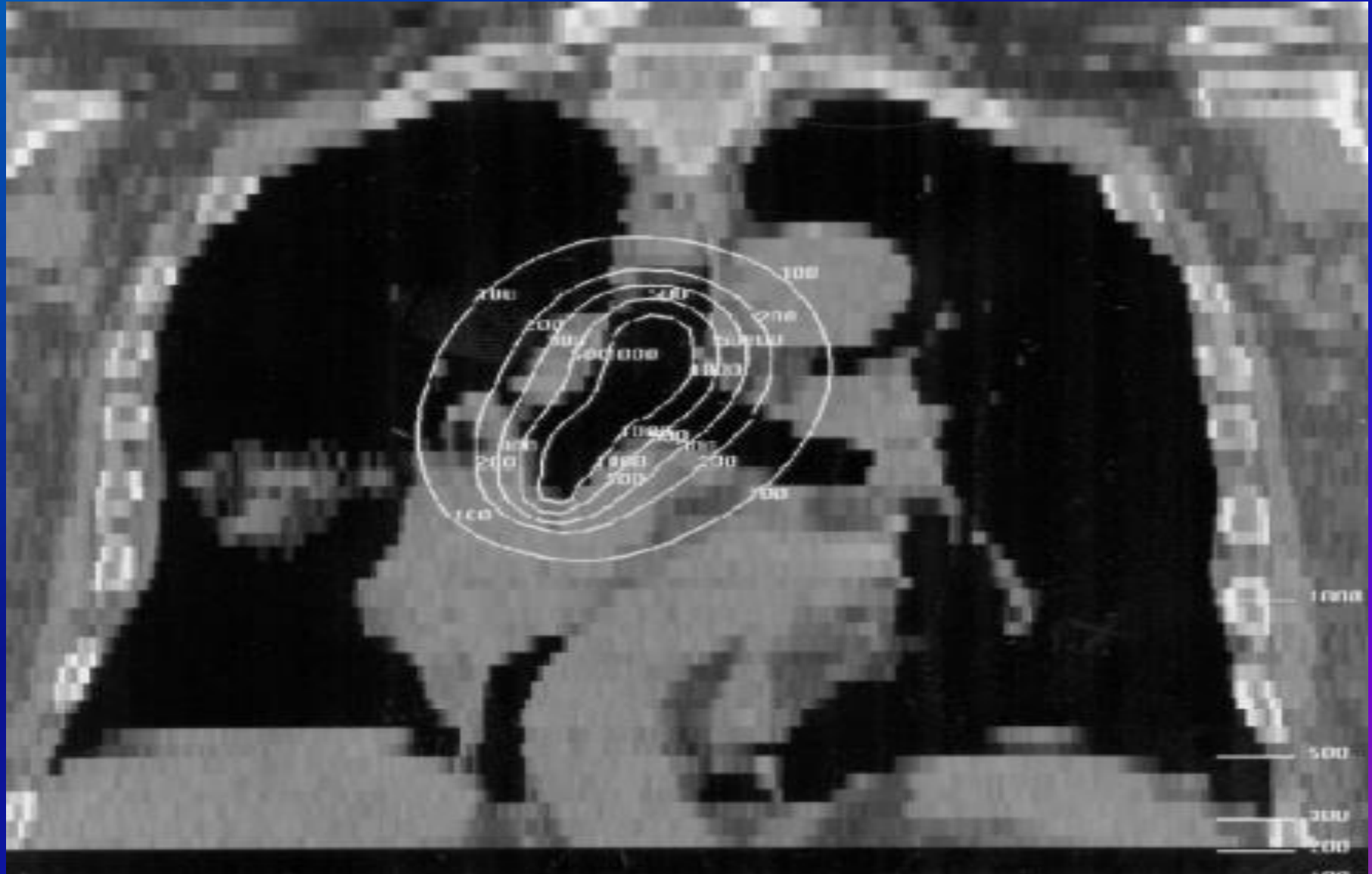






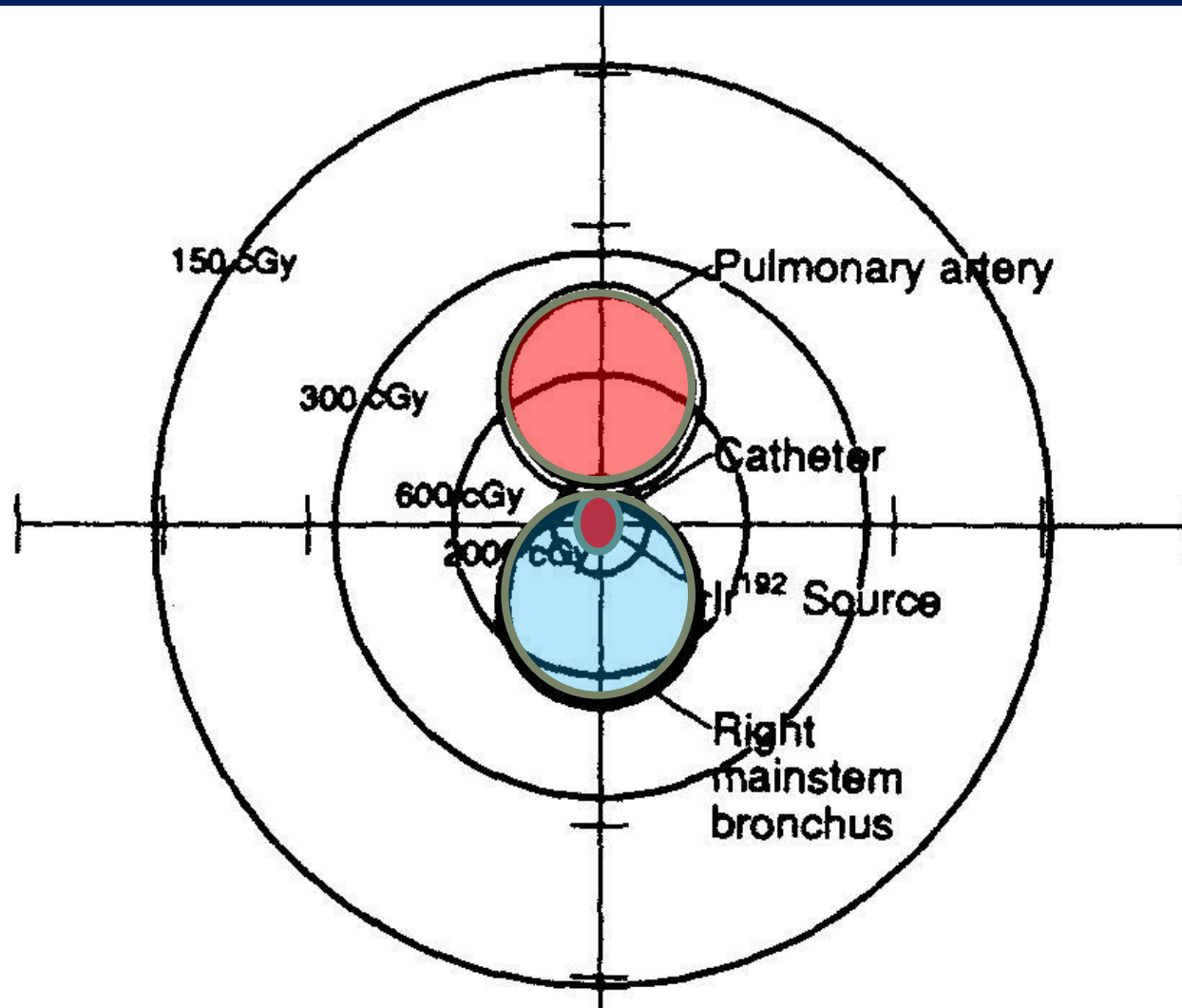


Coronal reconstruction plane with superimposed dose distribution achieved with dose prescription relative to the mucosa. Rapid dose-fall visible



Isodoses placed on schematically situated right main bronchus and pulmonary artery. Catheter with inserted isotope  $\text{Ir}^{192}$  is located nearby artery wall. In this case irradiation dose, growing constantly with shortening of distance to source, is very high and greater in artery wall than in tumor.

The risk of bronchus and artery wall damage and haemorrhage is great



# Permanent implants (seeds)

## Requirements

1. adequate performance status,
2. T<sub>1-2</sub>, No Mo,
3. easy postero - lateral access to the tumor.



# Brachytherapy of inoperable tumors

1. Inoperable tumors, peripheral location,
2. Steel or elastic applicators used for seeds,
3. Primary or single metastasis with diameter  $< 2-3$  cm,
4. Total dose 100 – 160 Gy, 0,5 – 1,0 cm outside target,

# Brachytherapy after surgery

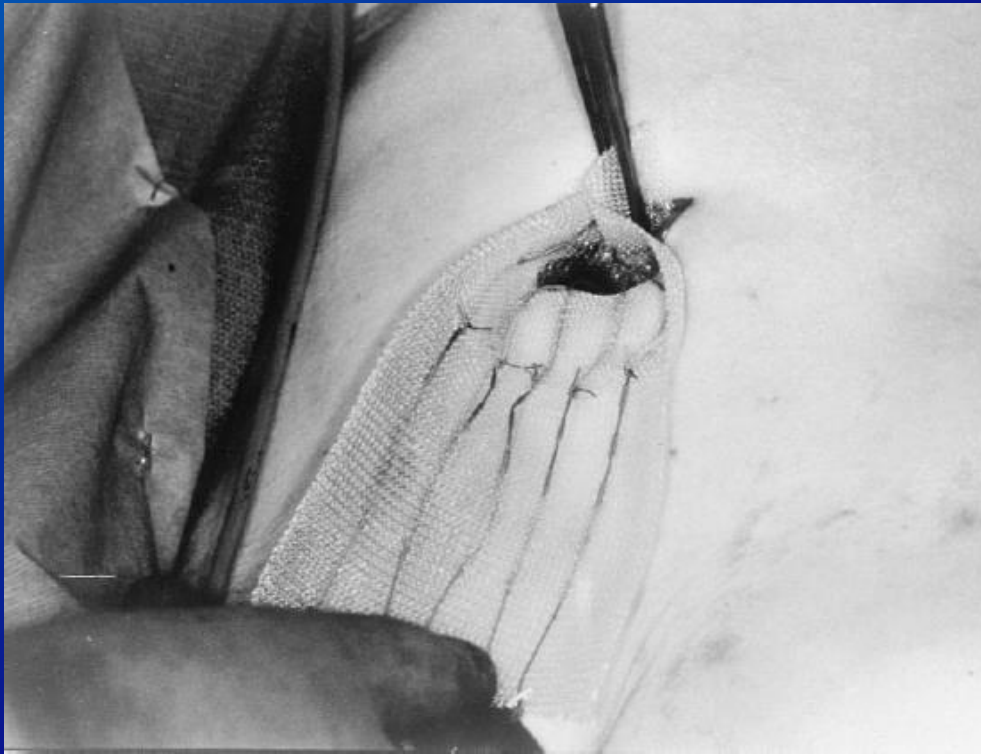
after resection, non radical, using elastic needles  
seeds are implanted

# Convenient location

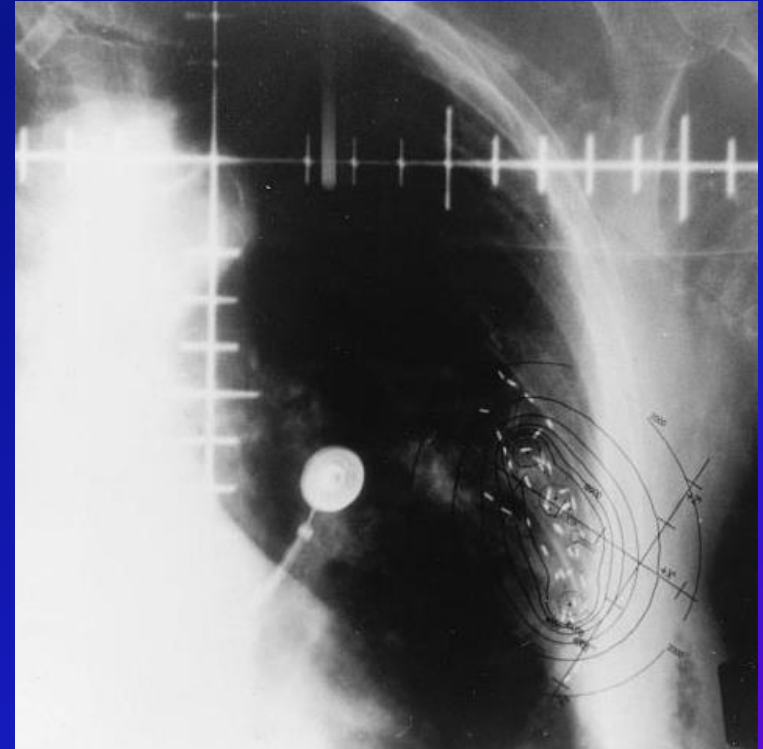


Clinical appearance of T<sub>1</sub>N<sub>0</sub>M<sub>0</sub> lesion

**Intraoperative brachytherapy for Stage I lung cancer c A. CHEN *et al.***  
**Int. J. Radiation Oncology Biol. Phys., Vol. 44, No. 5, pp. 1057–1063, 1999**



**Insertion of the  $^{125}\text{I}$  seeds through the thoracoscopy port with video assistance.**

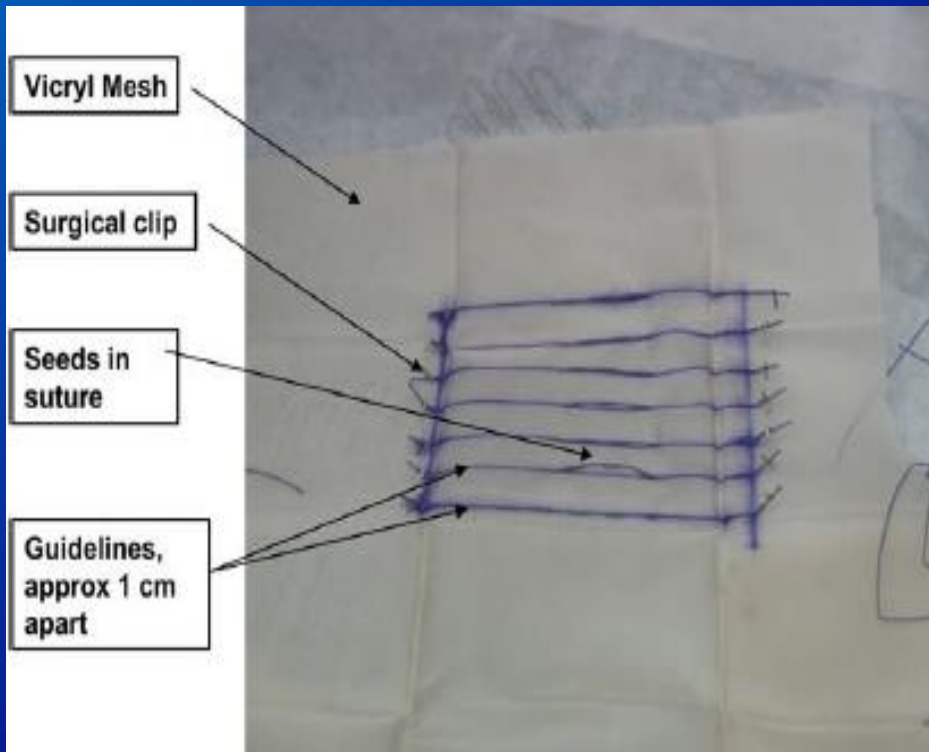


**Postoperative orthogonal simulation film with isodose curves.**



# A.J. Stewart et al.

Brachytherapy 8 (2009) 63-69



- (A) Planar implant made using  $^{125}\text{I}$  seeds in suture within a Vicryl mesh. (B) Completed implant being placed into mediastinum using long-handled tools. The seeds will be straightened to give optimal dosimetry before lung reinflation.

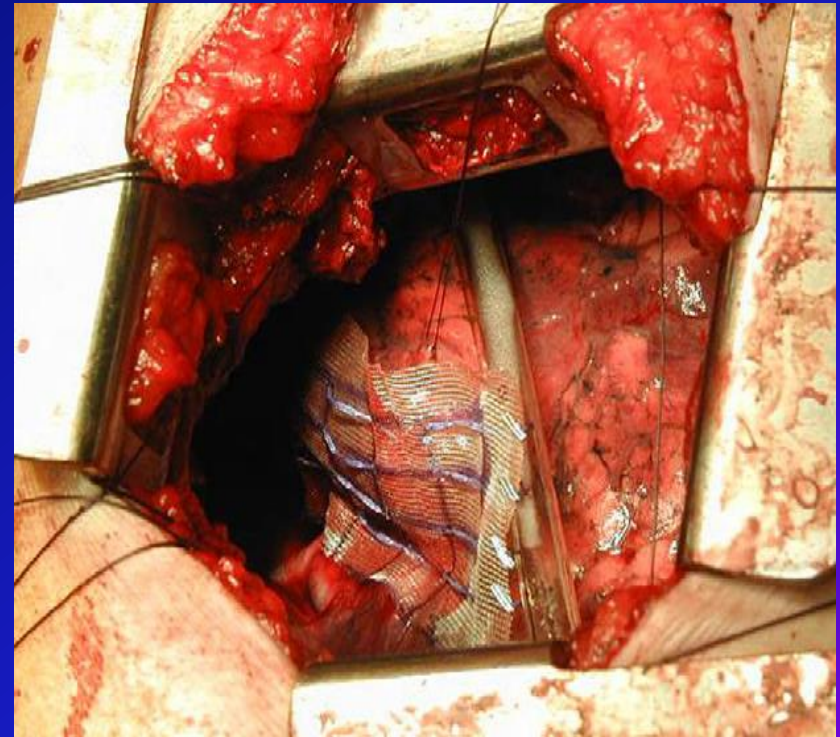


**Tolerance of the aorta using intraoperative iodine-125 interstitial  
brachytherapy in cancer of the lung**

**Mark G. Trombetta, Athanasios Colonias, Daryl Makishi, Robert Keenan, E. Day Werts, Rodney  
Landreneau, David S. Parda;  
Brachytherapy 7 (2008) 50-54**



**125-I Vicryl mesh implant**



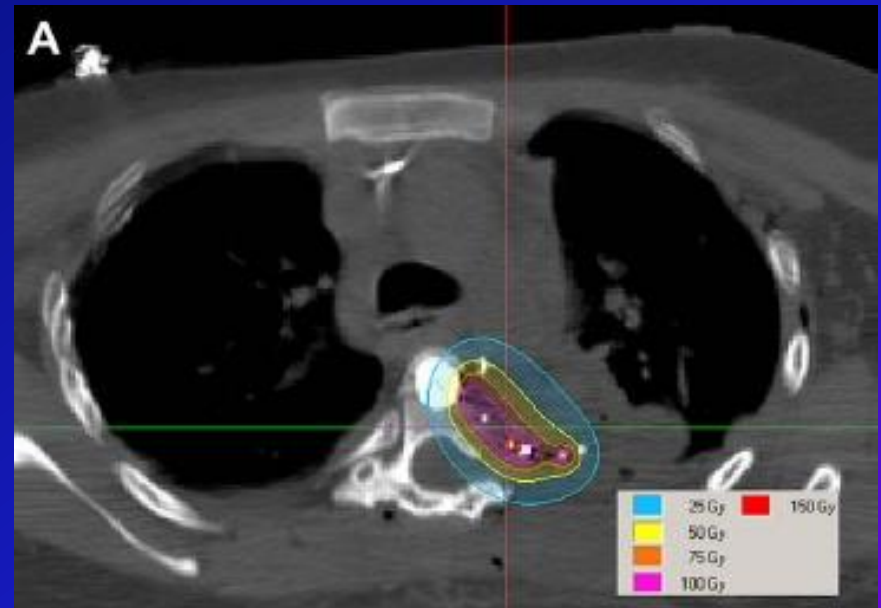
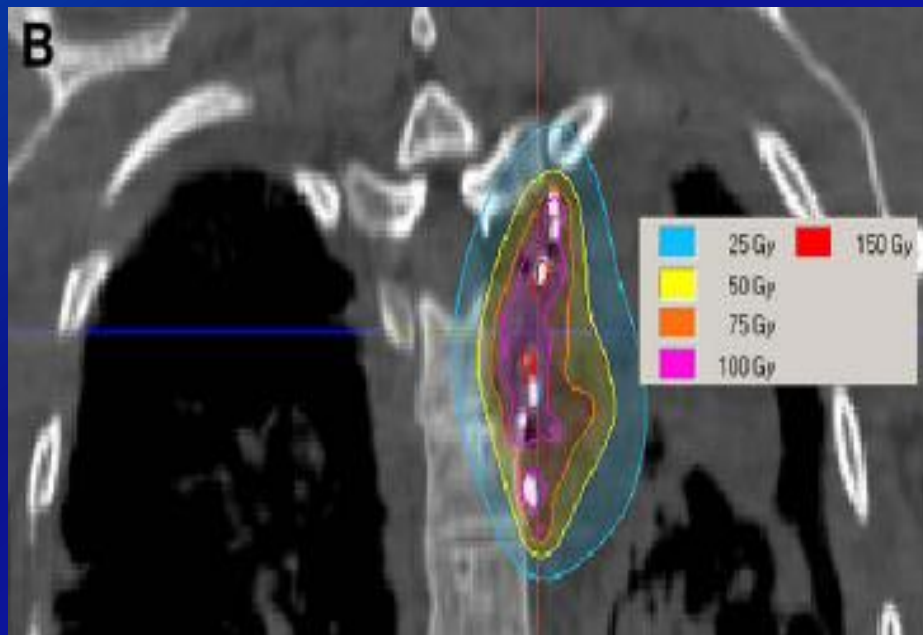
**Placement of the 125I implant  
along the sublobar resection  
staple  
line.**

# Intraoperative seed placement for thoracic malignancy: A review of technique, indications, and published literature

Alexandra J. Stewart, Subhakar Mutyala, Caroline L. Holloway, Yolonda L. Colson, Phillip M. Devlin *Brachytherapy* 8 (2009) 63-69

Intraoperative  $^{125}\text{I}$  seed placement has been used in conjunction with sublobar resection in patients with lung cancer who are medically unfit for lobar resection. This technique is currently being evaluated in the USA in a multi-institution randomized prospective trial

by the American College of Surgeons Oncology Group (ACOSOG) Z4032



Axial (A) and sagittal (B) isodose distributions for a planar permanent  $^{125}\text{I}$  paraspinal implant.



**Thank you  
for your  
attention**