TERMOABLAZIONE DEI TUMORI POLMONARI

Gianpaolo Carrafiello

Radiologia Diagnostica e Interventistica,
Ospedale San Paolo
Dipartimento di Scienze della Salute,
Universita degli Studi di Milano

- Since the first pulmonary resections in the early 20th century, pneumonectomy and lobectomy were considered the standard operations for lung cancer;
- Sublobar resection emerged as attractive option – three-fold local recurrence (Lung Cancer Study Group);
- Sublobar resections (wedge resection or segmentectomy): for patients at increased risk for morbidity and mortality after lobectomy that can still tolerate a smaller pulmonary resection.
- Best chance of cure in early stage disease
- Benefitial in limited pulmonary metastases

Churchill ED, et al. J Thoracic Cardiovasc Surgery 1950;20:349-65
Ginsberg RJ, et al. Ann Thorac Surg 1995;60(3):613-22
Warren WH. J Thorarc Cardiovsc Surg 1994;107(4):1087-1093
Landreneau RJ. J Thorac Cardiovasc Surg 1997; 113(4):691-8
Abbas G, et al. J Surg Oncol 2009; 100:645-50

Termoablazione dei tumori polmonari

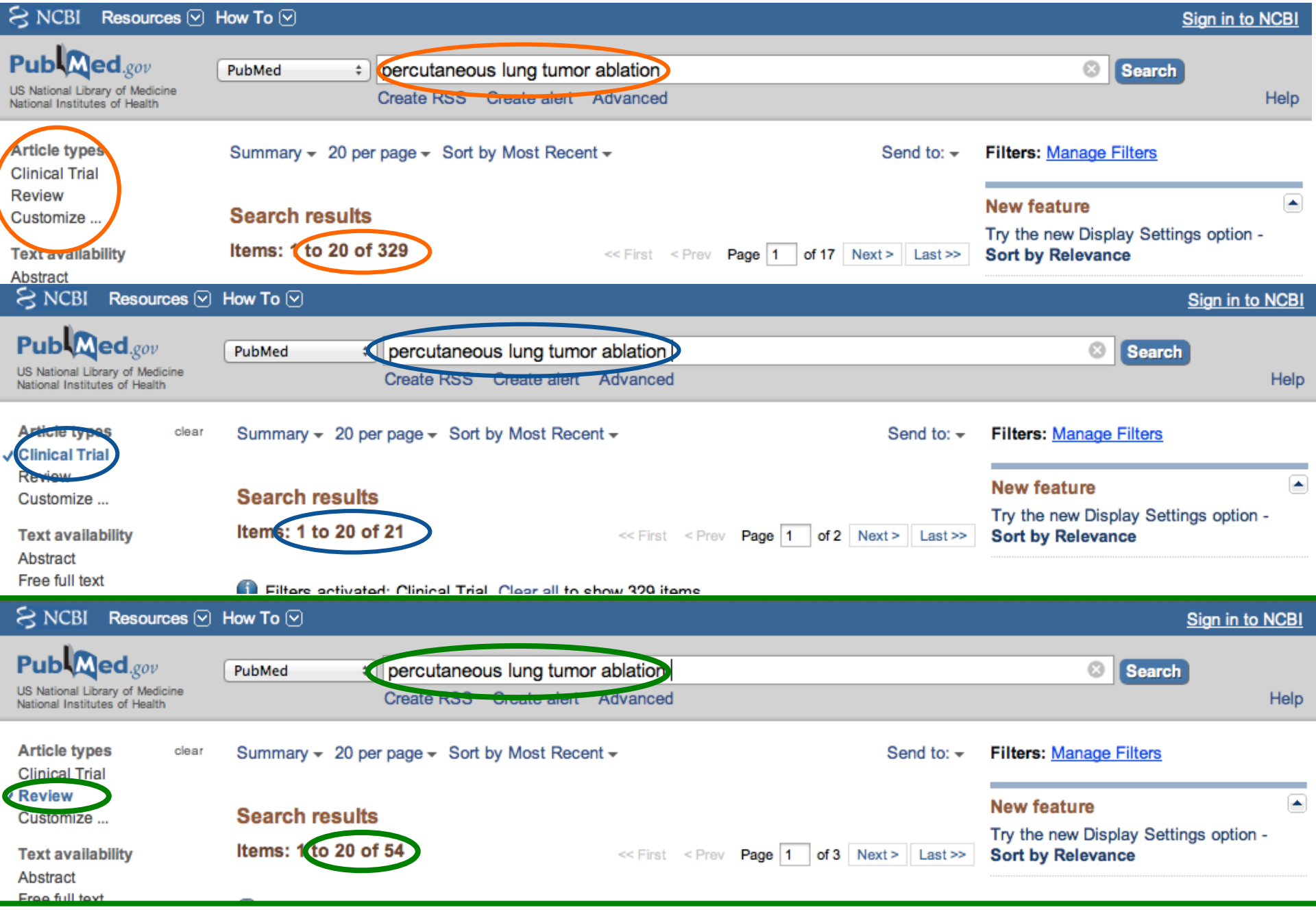
- Despite the availability of surgical resection and advances in minimally invasive surgical many patients with thoracic malignancies have little recourse other than the modest therapeutic benefits of chemotherapy and/or RT;

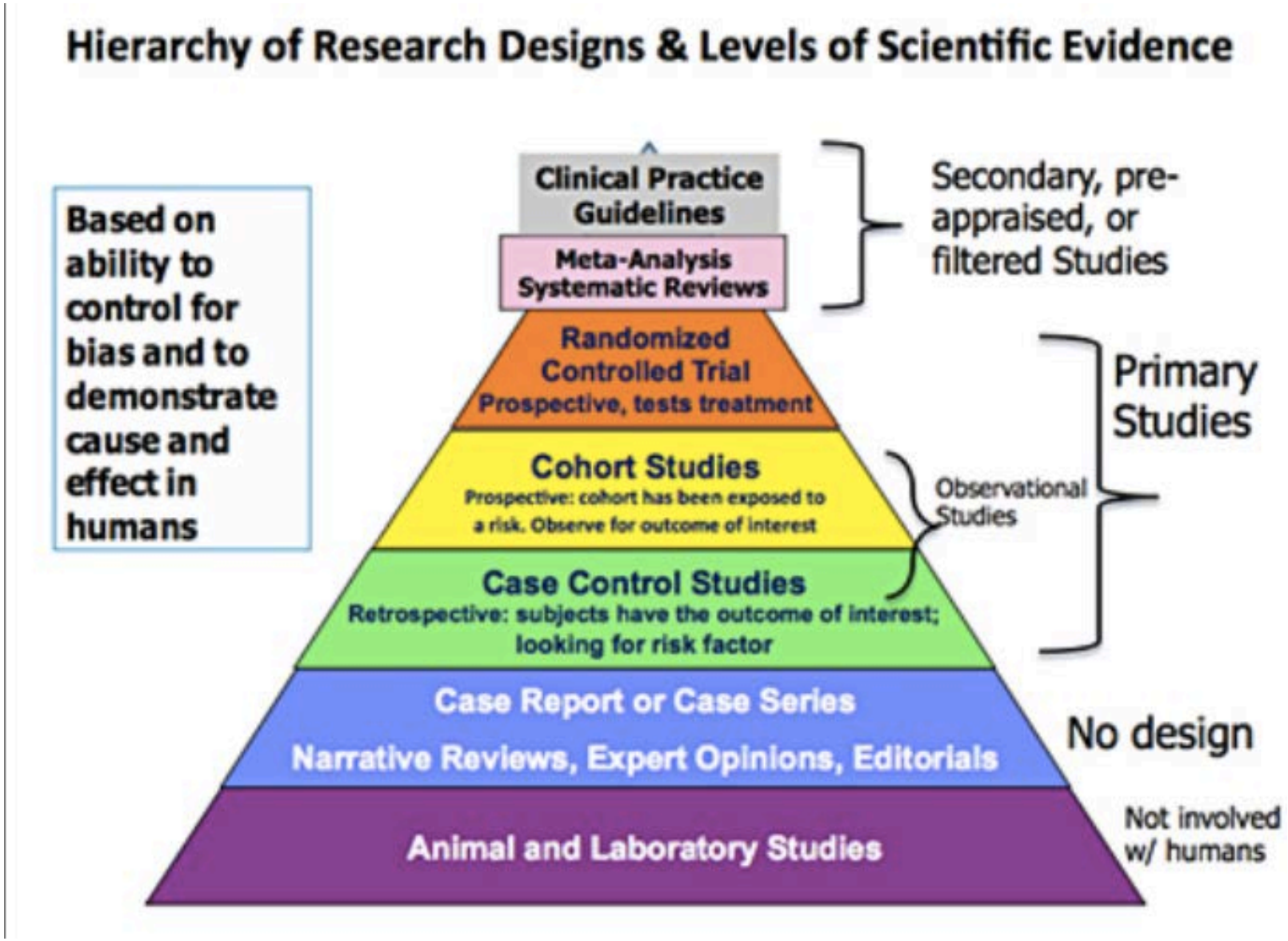
- Many of these patients are not surgical candidates because of their poor cardiopulmonary function, advanced age, or other medical comorbidities.

- Percutaneous ablations treatments are now proving to be an important tool in the treatment of primary and secondary lung neoplasms.

- Image-guided thermal ablation offers clinicians and patients a repeatable, effective, low-cost, and safe treatment for effective palliation and, in some cases, cure of both primary and metastatic thoracic malignancies either before or concurrently with systemic therapy and RT

Termoablazione dei tumori polmonari




Hierarchy of Research Designs & Levels of Scientific Evidence
Based on ability to control for bias and to demonstrate cause and effect in humans
Clinical Practice Guidelines
Meta-Analysis Systematic Reviews
Secondary, pre-appraised, or filtered Studies
Randomized Controlled Trial
Prospective, tests treatment
Cohort Studies
Prospective: cohort has been exposed to a risk. Observe for outcome of interest
Observational Studies
Case Control Studies
Retrospective: subjects have the outcome of interest; looking for risk factor
Primary Studies
Case Report or Case Series
Narrative Reviews, Expert Opinions, Editorials
No design
Animal and Laboratory Studies
Not involved w/ humans

Termoablazione dei tumori polmonari

Acad Radiol. 1995 Sep;2(9):776-84.

Radiofrequency tissue ablation in the rabbit lung: efficacy and complications.

Goldberg SN[1], Gazelle GS, Compton CC, McLoud TC.

Author information

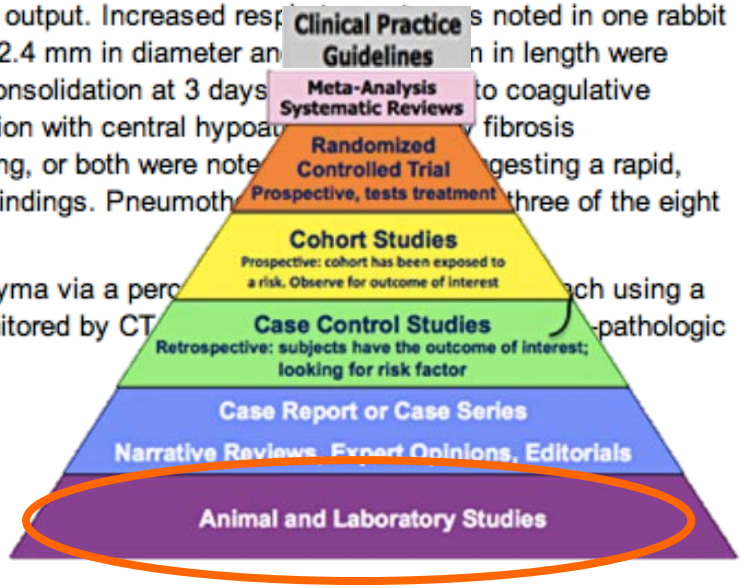
Abstract

RATIONALE AND OBJECTIVES: We assessed the feasibility and safety of performing percutaneous radiofrequency ablation of pulmonary tissue in rabbits.

METHODS: Using an aseptic technique and computed tomography (CT) guidance, insulated 19-gauge aspiration biopsy needles were inserted into the right lower lobe of eight New Zealand White rabbits. Radiofrequency was applied via a coaxial electrode for 6 min at 90 degrees C. Probe-tip temperature, tissue impedance, and wattage were recorded at baseline and at 60-sec intervals throughout the procedure. CT scanning was used to assess tissue destruction and the presence or absence of pneumothorax immediately after the procedure and at 24 hr, 3 days, 10 days, 21 days, and 28 days. Three rabbits were sacrificed immediately, and the remaining rabbits were euthanized at 24 hr and at 3 days. 10 days, and 28 days (two rabbits). Gross and microscopic pathology were obtained and correlated with CT findings.

RESULTS: The mean initial tissue impedance was 509 +/- 197 omega, marked changes in tissue impedance were found during the procedure (240-1380 omega). Rigid temperature control required continuous manual fine-tuning of generator output. Increased resp s noted in one rabbit during the first 30 sec of radiofrequency application. Homogeneous, ovoid opacities 8.4 +/- 2.4 mm in diameter an n in length were found by CT scanning immediately after the procedure. These opacities showed maximal consolidation at 3 days to coagulative necrosis and a peripheral acute inflammatory reaction. At 10 days, peripheral hyperattenuation with central hypoa fibrosis surrounding degenerating blood products) was seen. Minimal residual fibrosis, pleural scarring, or both were note gesting a rapid, near-total recovery from the procedure. Lesion sizes were within 2 mm of gross pathologic findings. Pneumoth three of the eight rabbits (37.5%).

CONCLUSION: Radiofrequency tissue ablation was safely performed in pulmonary parenchyma via a perc ch using a coaxial needle technique. Tissue response to thermal injury was predictable and easily monitored by CT -pathologic correlation.



Pulmonary Thermal Ablation: Comparison of Radiofrequency and Microwave Devices by Using Gross Pathologic and CT Findings in a Swine Model[1]

Christopher L. Brace, PhD
J. Louis Hinshaw, MD
Paul F. Laeseke, PhD
Lisa A. Sampson, CVT
Fred T. Lee, Jr, MD

Purpose: To compare the performance of equivalently sized radiofrequency and microwave ablation applicators in a normal porcine lung model.

Materials and Methods: All experiments were approved by an institutional animal care and use committee. A total of 18 ablations were performed in vivo in normal porcine lungs. By using com-

Termoablazione dei tumori polmonari

January 2000, Volume 174, Number 1

Technical Innovation

« Previous Article | Next Article »

Percutaneous Radiofrequency Ablation of Malignancies in the Lung

Damian E. Dupuy[1], Ronald J. Zagoria[2], Wallace Akerley[1], William W. Mayo-Smith[1], Peter V. Kavanagh[2] and Howard Safran[3]

Affiliations: 1 Department of Diagnostic Imaging, Rhode Island Hospital, Brown University School of Medicine, 593 Eddy St., Providence, RI 02903.

2 Department of Radiology, Wake Forest University School of Medicine, Medical Center Blvd., Winston-Salem, NC 27157.

3 Department of Oncology, Rhode Island Hospital, Brown University School of Medicine, Providence, RI 02903.

Citation: American Journal of Roentgenology. 2000;174: 57-59. 10.2214/ajr.174.1.1740057

Citation | Full Text | Figures | References | PDF | PDF Plus | Add to Favorites | Permissions | Download Citation

Choose

Radiofrequency (RF) ablation is a minimally invasive technique that is used for the treatment of primary and secondary liver tumors [1]. Early results indicate that tumor reduction and eradication can be achieved with this percutaneous imaging-guided procedure. For the most part, RF ablation can be performed under conscious sedation in the outpatient setting with a low incidence of side effects [1]. Malignant tumors in bone [2], head and neck [3], and bronchi [4] have also been treated with RF ablation with early results showing promise. A 30% 3-year survival has been shown in the RF ablation of colorectal hepatic metastases [5], but long-term results in extrahepatic malignancies are not available. The percutaneous technique has not been validated in the treatment of lung tumors. The technique has been applied to a lung tumor model in animals [6] but, to our knowledge, has not been reported in humans. This report describes the successful application of RF ablation in three patients with lung malignancies.

Materials and Methods

Choose

The first patient is a 45-year-old man who in 1996 was diagnosed with stage IV bronchogenic adenocarcinoma, with a left infrahilar mass, mediastinal lymphadenopathy, and a solitary T4 bone lesion. Aggressive treatment with paclitaxel (Taxol; Bristol-Myers Squibb, Princeton, NJ) and external beam radiation effected a complete response of 2-years' duration. On follow-up chest CT, a new 2.5-cm mass was revealed within the radiation field in the left infrahilar region (Fig. 1A, Fig. 1B, Fig. 1C, Fig. 1D). Analysis of the biopsy sample confirmed recurrent adenocarcinoma. Bone scan and MR imaging of the spine were normal. The patient was not considered a candidate for surgery because of the extent of disease at the time of diagnosis. Additional radiation therapy was contraindicated to some extent because of the location of the nodule within the prior radiation field. Therefore, percutaneous RF ablation was considered the best option for attempting local tumor eradication.

Termoablazione dei tumori polmonari

October 2011, Volume 197, Number 4

Vascular and Interventional Radiology
Original Research

« Previous Article | Next Article »

Complications After 1000 Lung Radiofrequency Ablation Sessions in 420 Patients: A Single Center's Experiences

Masataka Kashima[1], Koichiro Yamakado[1], Haruyuki Takaki[1], Hiroshi Kodama[1], Tomomi Yamada[2], Junji Uraki[1] and Atsuhiro Nakatsuka[1]

Share

Affiliations: 1 Department of Radiology, Mie University Graduate School of Medicine, 2-174 Edobashi, Tsu-city, Mie 14-8507, Japan.

2 Department of Translational Medical Science, Mie University Graduate School of Medicine, Mie, Japan.

Citation: American Journal of Roentgenology. 2011;197: W576-W580. 10.2214/AJR.11.6408

Radiol med (2012) 117:1320–1332
DOI 10.1007/s11547-012-0849-z

CHEST RADIOLOGY
RADIOLOGIA TORACICA

Radiofrequency ablation for single lung tumours not suitable for surgery: seven years' experience

Ablazione con radiofrequenza dei tumori polmonari solitari non operabili: esperienza di sette anni

G. Carrafiello • M. Mangini • F. Fontana • D. Laganà • E. Cotta • A. Di Massa • F. Piacentino
A. Ianniello • C. Floridi • A.M. Ierardi • C. Fugazzola

Research Reporting Standards for Percutaneous Thermal Ablation of Lung Neoplasms

Steven C. Rose, MD, Damian E. Dupuy, MD, Debra A. Gervais, MD, Steven F. Millward, MD, Daniel B. Brown, MD, John F. Cardella, MD, and Michael J. Wallace, MD, for the Technology Assessment Committee of the Society of Interventional Radiology

J Vasc Interv Radiol 2009; 20:S474–S485

Abbreviations: FGD = [^{18}F]fluorodeoxyglucose, NSCLC = non–small-cell lung cancer, PET = positron emission tomography, RF = radiofrequency, SIRTAC/IWGIGTA = Society of Interventional Radiology Technology Assessment Committee and International Working Group on Image-Guided Tumor Ablation

Cardiovasc Intervent Radiol (2012) 35:247–254
DOI 10.1007/s00270-012-0340-1

INVITED SUBMISSION: CIRSE STANDARDS OF PRACTICE GUIDELINES

Standards of Practice: Guidelines for Thermal Ablation of Primary and Secondary Lung Tumors

Philippe L. Pereira · Masala Salvatore

Received: 24 February 2011 / Accepted: 3 January 2012 / Published online: 21 January 2012

LUMIRA TRIAL

RFA vs MWA

Radiofrequency ablation versus microwave ablation in the treatment of primary and secondary neoplasms of the lung: randomized trial

- **COORDINATING CENTER:**
  - Università dell'Insubria ed A.O. Ospedale di Circolo e Fondazione Macchi ,Varese ***, Prof. Gianpaolo Carrafiello.***

LUMIRA TRIAL

RFA vs MWA

ONGOING TRIAL

Radiofrequency ablation versus microwave ablation in the treatment of primary and secondary neoplasms of the lung: randomized trial

- **ITALY**
- Galliera Hospital, Genova - *Prof. Giovanni De Caro, Prof. Alessandro Valdata, Dr. Francesco Pinna*
- Oncology Hospital A. Businco, Cagliari - *Dr. Claudio Pusceddu*
- Garibaldi Hospital, Catania - *Dr. Antonio Basile*
- Camposampiero Hospital, Padova - *Prof. Fernando Gaion, Dr. Ernesto Bissoli*
- University Campus Bio-Medico, Rome - *Dr. Francesco Grasso Rosario.*
- Policlinico di Milano Hospital - *Prof. Luigi Santambrogio, Dr. Mario Nosotti*
- PistoiaHospital, Pistoia - *Dr. Luca Carmignani*
- Azienda Ospedaliera Sant'Anna e San Sebastiano, Caserta - *Prof. Giuseppe Belfiore*
- Azienda Ospedaliera Santa Croce e Carle,Cuneo - *Dr. Maurizio Grosso*
- Cariggi Hospital, Firenze - *Dr. Ernesto Mazza*

- **U.K.**
- Royal Brompton and Harefield NHS Foundation Trust, Harefield Hospital, *Dr. Paras Dalal.*

- **THE NETHERLANDS**
- Netherlands Cancer Institute-Antoni van Leeuwenhoek, Hospital Plesmanlaan, Amsterdam, *Dr. Warner Prevo.*

- **GERMANY**
- Goethe University Hospital,Francoforte, ***Prof. Thomas J Vögl.***

- **FRANCE**
- Centre Leon Berard, Lyon, *Dr. Bertrand Richioud*

- **GREECE**
- Attikon Hospital,*Dr. Dimitrios Filippiadis*

Termoablazione dei tumori polmonari

- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Termoablazione dei tumori polmonari

- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Patient selection

Research Reporting Standards for Percutaneous Thermal Ablation of Lung Neoplasms

Steven C. Rose, MD, Damian E. Dupuy, MD, Debra A. Gervais, MD, Steven F. Millward, MD, Daniel B. Brown, MD, John F. Cardella, MD, and Michael J. Wallace, MD, for the Technology Assessment Committee of the Society of Interventional Radiology

J Vasc Interv Radiol 2009; 20:S474–S485

"inclusion criteria are set to define the population believed most likely to benefit from the experimental therapy and therefore eligibile for treatment under the research protocol"

Patient selection

Journal of
Cancer Therapeutics & Research
ISSN 2049-7962

HOAJ
Herbert Open Access Journals

Database Open Access

Patient selection - clinical and imaging criteria - for percutaneous lung malignancies ablation: a single centre experience and a literature review

Carrafiello G[1]*, Nocchi Cardim L[1], Floridi C[1], Piacentino F[1], Di Massa A[1], Ierardi AM[1] and Fugazzola C[1]
Correspondence: gcarraf@gmail.com
[1]Department of Radiology, Vascular and Interventional Radiology, University of Insubria, Varese, Italy.

Abstract

Purpose: To settle the most important clinical and radiological selection criteria for percutaneous ablation in patients with pulmonary tumours.

Materials and Methods: A retrospective analysis of pulmonary thermal ablations performed in our Centre with special "focus" on clinical and radiological selection criteria for thermal ablation. The criteria employed in our Centre were then compared with those of 24 studies chosen from Literature that fit the issue and described their patient selection criteria for lung tumours thermal ablation.

Results: From May 2008 until May 2011, thermal ablation was indicated as an alternative to conventional treatment for

Conclusion: Thermal ablation is a rational alternative for conventional therapy in an adequately selected group of patients. A randomized controlled study with a control group submitted to conventional therapies to define with precision the candidable patients to thermal ablative therapy would be necessary.

Keywords: selection criteria, lung malignancies, ablation techniques, microwave ablation, radiofrequency ablation, pulmonary cancer, therapy.

Tecnology ***LEVEL of EVIDENCE***

Literature Review

REVIEW ARTICLE

Therma

Thomas Schneide

Conclusion

Percutaneous thermal ablation broadens the range of treatment options for patients who are not candidates for surgery. However, the local control that can currently be achieved must be measured against that achieved by stereotactic radiotherapy. Tumor ablation should always be indicated on the basis of interdisciplinary consensus through a tumor board (including pulmonologists, oncologists, thoracic surgeons, radiotherapists, and radiologists in line with the certification guidelines of the German Cancer Society [Deutsche Krebsgesellschaft] for lung cancer facilities) and after all treatment options have been weighed.

ler et al.: eReferences

LC: primary lung cancer; Met.: metastasis, usually of extrathoracic malignancies; y: years; m: months

Biop.: histology confirmed by biopsy; Rad.: ablation due to suspected tumor on radiological examination;

Patient selection

PERCUTANEOUS ABLATIONS
Criteria

- Clinical
- Imaging

Patient selection

PERCUTANEOUS ABLATIONS

Clinical Criteria

- 3 scenarios

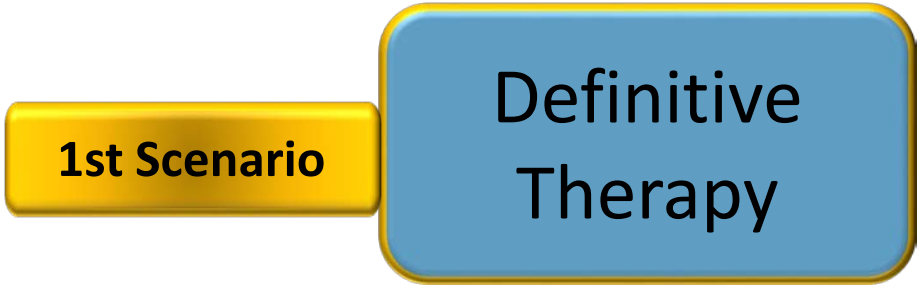
Definitive Therapy

Palliation

Complementary to Other Therapies

Patient selection

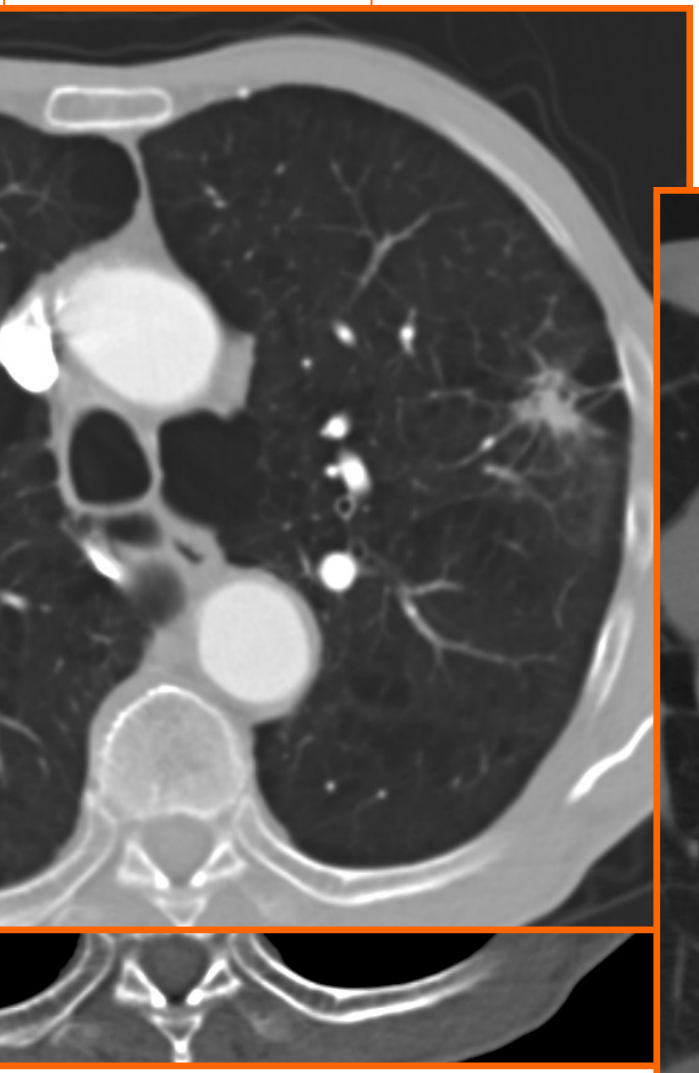
Clinical Criteria



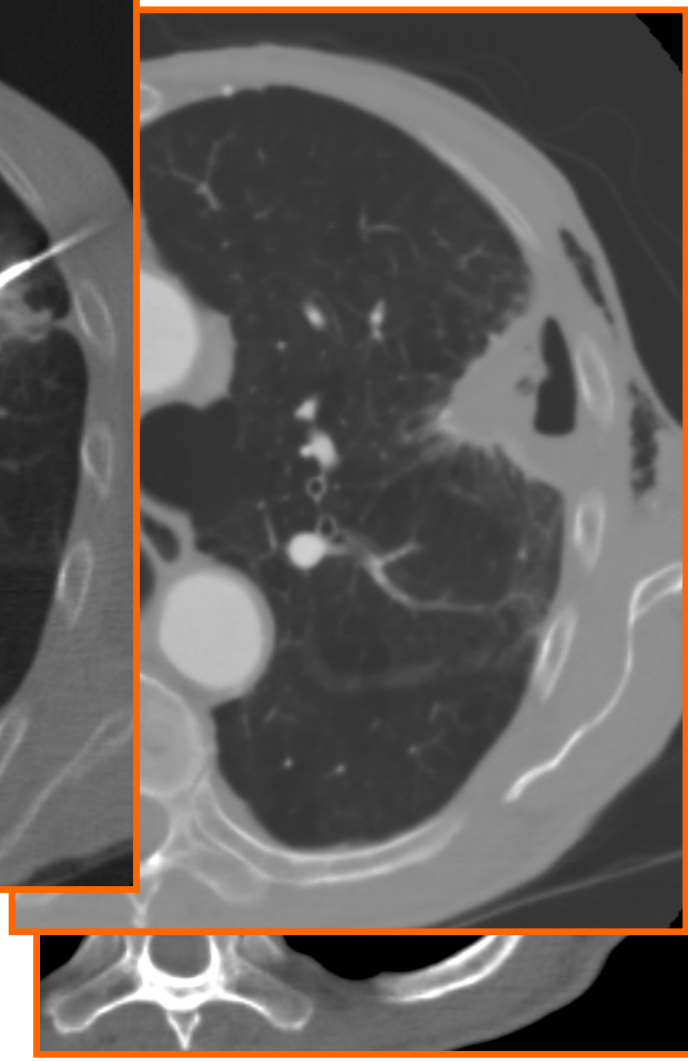
- Stages I or II with clinical comorbidities
  - RFA can guarantee survival comparable to surgery for Stage I
- Stages I or II when the patient refuses Surgery
- Limited number of metastases

Hiraki T, et al. BioMed Research Int 2014
Vogl TJ, Eur J Radiol 2011;77(2):346-57
Casal RF, et al. Clin Chest Med 2010;31:151-163
De Baère T, et al. Cardiovasc Intervent Radiol 2010;34(2):241-51
Kim SR. Eur J Radiol. 2012 Feb;81(2):395-9

Patient selection



Definitive Therapy



Patient selection

Criteria for Metastases

- More favorable in:
  - Solitary rather than multiple metastases
  - Metachronous rather than syncronous metastases
  - Colorectal rather than other primary tumors
    - Safe and minimally invasive
    - Local progression rate is particularly high for tumors > 3 cm
    - Better survival for small metastasis, low carcinoembryonic antigen levels, and/or no extrapulmonary metastasis

Fergusin J, et al. EJSO 2015
Hiraki T, et. World J Gastroenterol 2014; 20(4):988-96
Vogl TL. Eur J Radiol 2011; 77: 346-57

Patient selection

Clinical Criteria

2nd Scenario

Complementary to Other Therapies

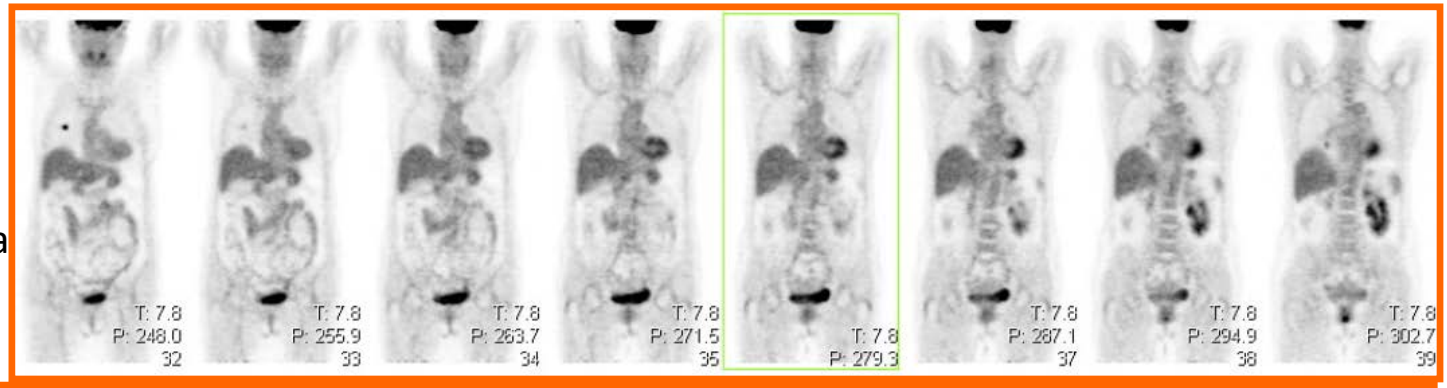
- Persistent, solitary, peripheral focus after definitve Radiation and Chemotherapy

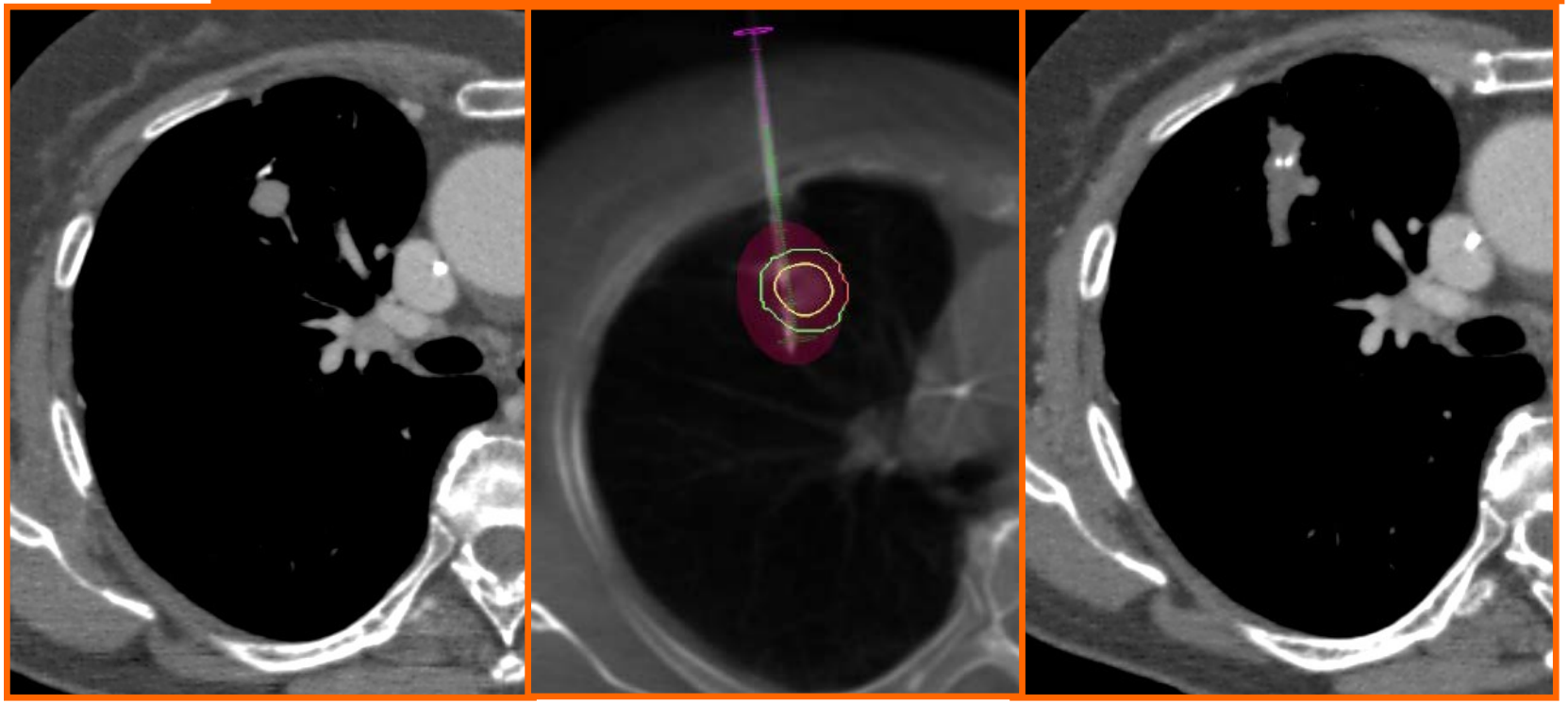
Wei Z, et al. Cardiovasc Interv Radiol 2014 May 9 [Epub ahead of print]
Li X, et al. AJR Am J Roentgenol 2013; 201(6):1362-7
Abbas G, et al. Surg Oncol 2009;100(8):645-50

Patient selection

Complementary to Other Therapies: Resection

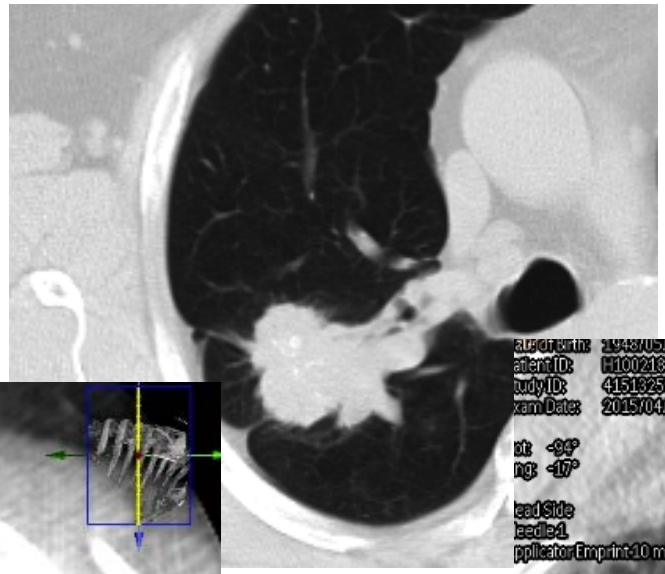
Metastasis
Recurrence from
Cholangiocarcinoma

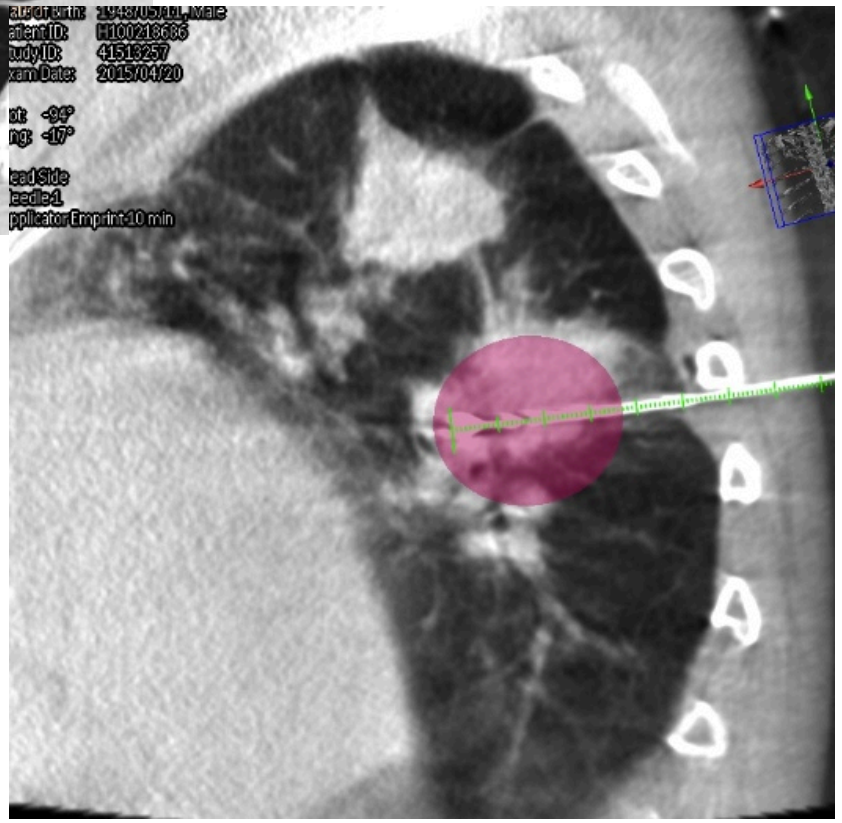




Patient selection

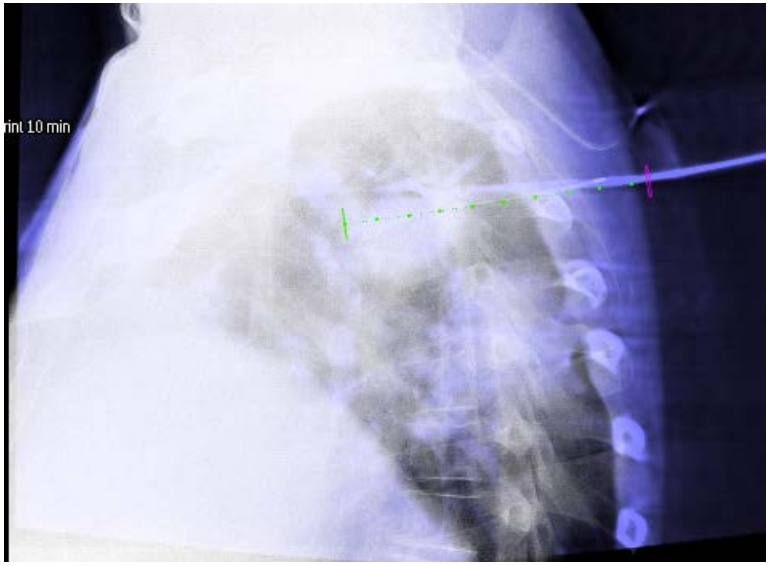
Complementary to Other Therapies: Chemotherapy

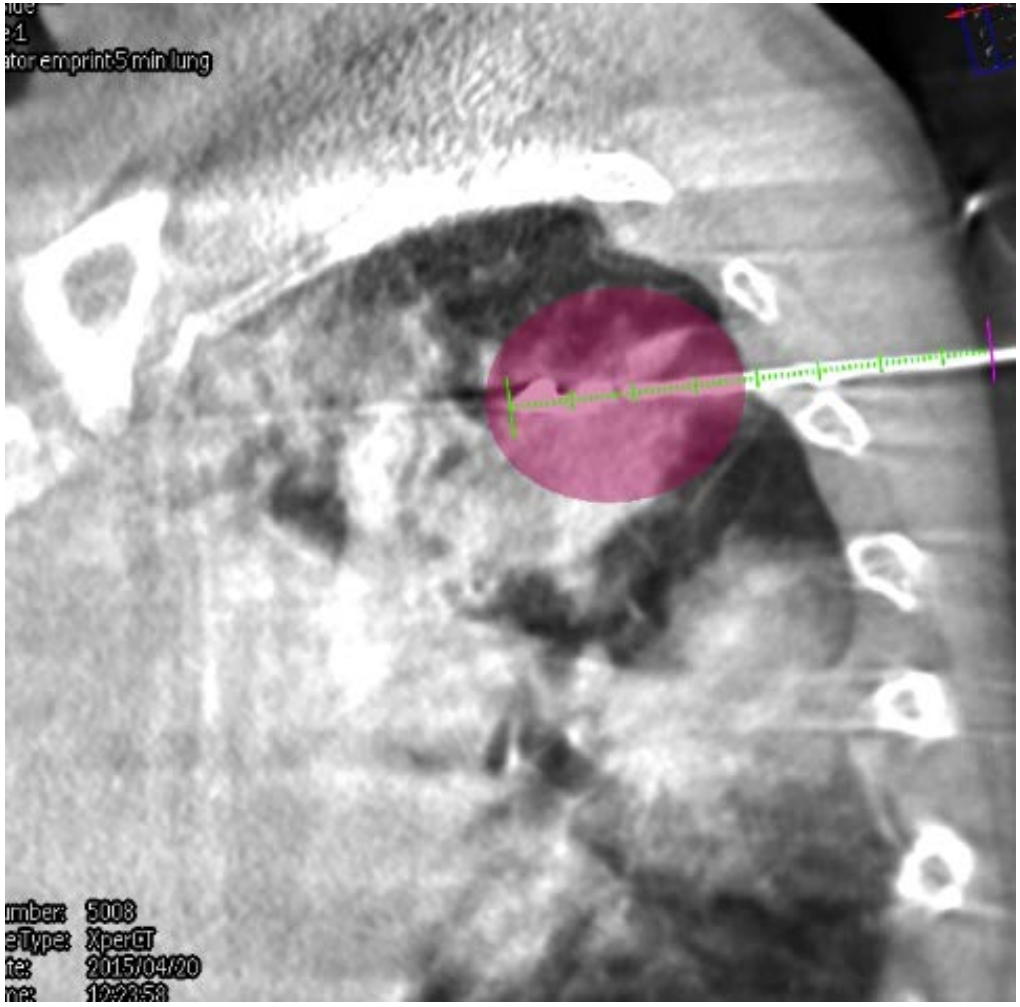




Patient selection

Complementary to Other Therapies: Chemotherapy





Patient selection

Clinical Criteria

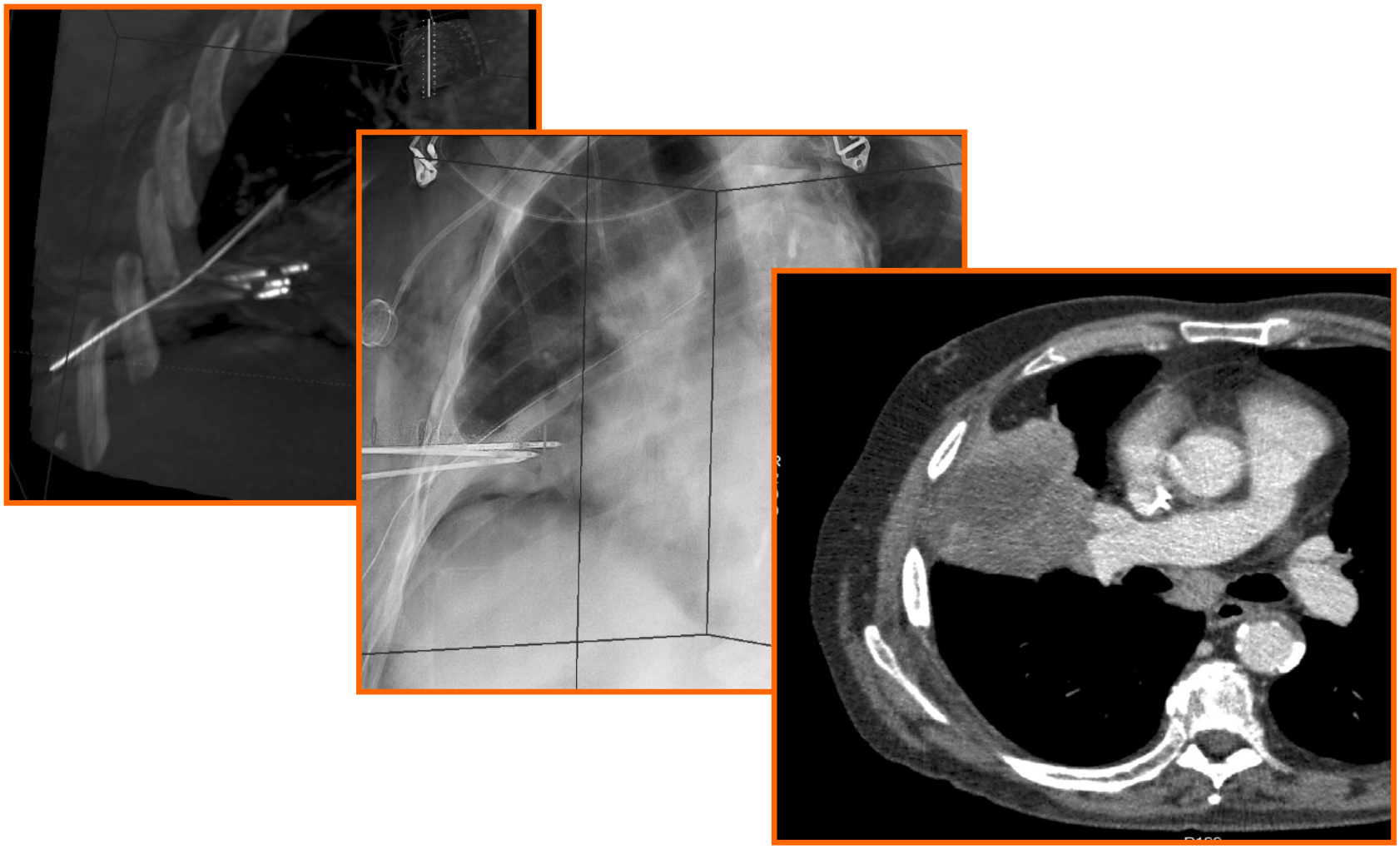
3rd Scenario → Palliation

- Chest wall pain
- Plexus Involvement
- Hemoptysis
- Dyspnea

Hamamoto S, et al.BMC Research Notes 2014; 7:765
Simon CJ, et al. Radiology 2007;243(1):268-75
VanSonnenberg E, et al. AJR Am L Roentgenol 2005;184(2):381-90

Patient selection

Palliation for Pain Reduction



Patient selection

Clinical Criteria: Exclusion

- Relative contraindications:
  - Poor lung function: FEV1<1L – respiratory failure is much more likely to occur
  - Pacemaker: electrical current can result in thermal injury; feasible if lesion is remote from the wires and the pacemaker is switched off during the procedure
  - Presence of a coagulopathy: the procedure should not be performed if INR>1.8 and platelets < $50x10^3/\mu L$
  - Single lung: higher risk for post-ablation pneumonia (sominstrate steroids)

Sofocleus CT, et al. Radiol Med 2014; 119:541-48.
Roy AM. Curr Probl Diagn Radiol 2009;38(1):44-52.
Dupuy DE. Radiology 2011; 260(3): 633-55.
Sofocleous CT, et al. AJR 2011; 197: W581-89

Patient selection

Clinical Criteria: Exclusion

- Contraindications:
  - Pulmonary hypertension
  - Malignant Effusion

Abbas G, et al. Surg Oncol 2009;100(8):645-5

Patient selection

Imaging Criteria

1) Lesion Size
2) Lesion Localization
3) Maximum number of lesions/lung

Feasibility
Predictivity

Patient selection

Imaging Criteria

1) Size

- Lesion maximum diameter
  - <5 cm; < 7 cm; it's accepted that is not possible to achieve complete ablation for lesions > 3,5 cm with RFA, even with mutiple ablations
  - < 3cm – ideal diameter
  - MWA – to prefer for lesions > 3 cm (multiple antenna

Smith S.L., et al. BJR 2015
Carrafiello G, et al. Int J Surg 2008;6:65-9
Vogl TJ, et al. Eur J Radiol 2011;77(2):346-57
De Baère T, et al. Cardiovasc Intervent Radiol 2010;34(2):241-51
Roy AM. Curr Probl Diagn Radiol 2009;38(1):44-52
Gillams AR. BMJ 2007;334(7602):1056-7
Gillams AR. Cancer Imaging 2008;8 Spec No A:S1-5

Patient selection

Imaging Criteria

2) Localization

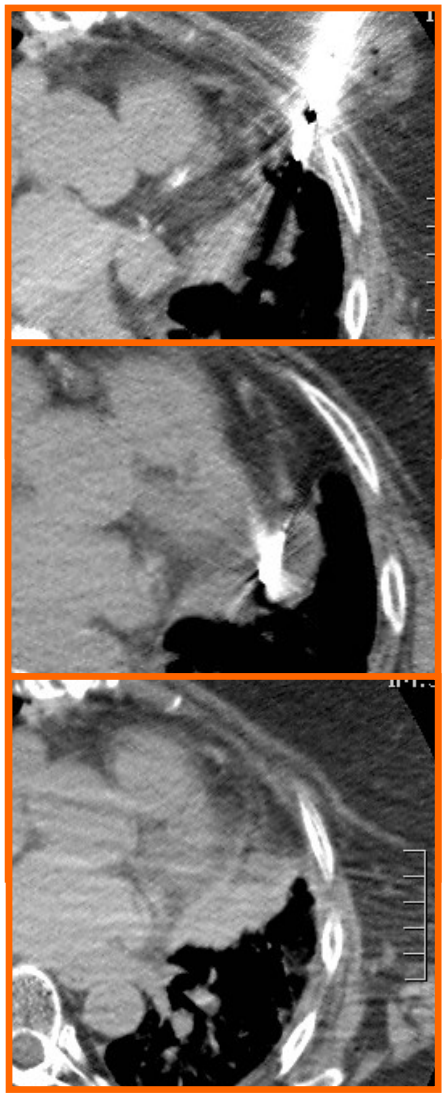
- Careful with lesions close to large vessels, heart or trachea
  - To avoid lesions < 1cm from hilum
  - Iguchi et al. – 42 cases at < 10 mm from heart or aorta without any complications
  - MWA is better in those cases
- Care in single lung: higher risk in developing postablation polmonitis (steroid administration during procedure)

LeVeen RF. Semin Inter Radiol 1997; 14:313-24
Wolf F et al Radiology 2008;247:871-79
Gómez FM, et al. Clin Transl Oncol 2009;11(1):28-34
Lee JM, et al. Eur Radiol 2003;13: 2540-7
Gillams AR, et al. Cardiovasc Intervent Radiol 2005;28:476-80
Vogl T, et al Eur J Radiol 2011;77:346-57

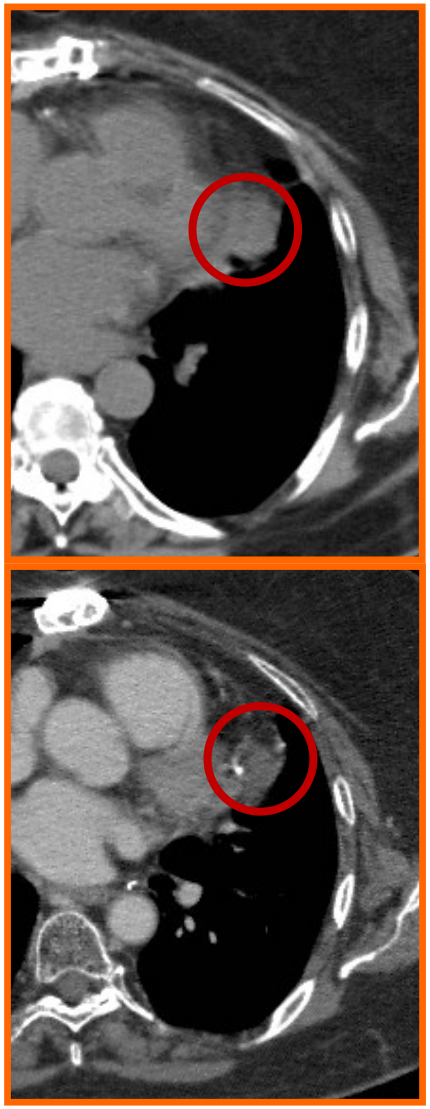
Patient selection

Close to heart

Pre



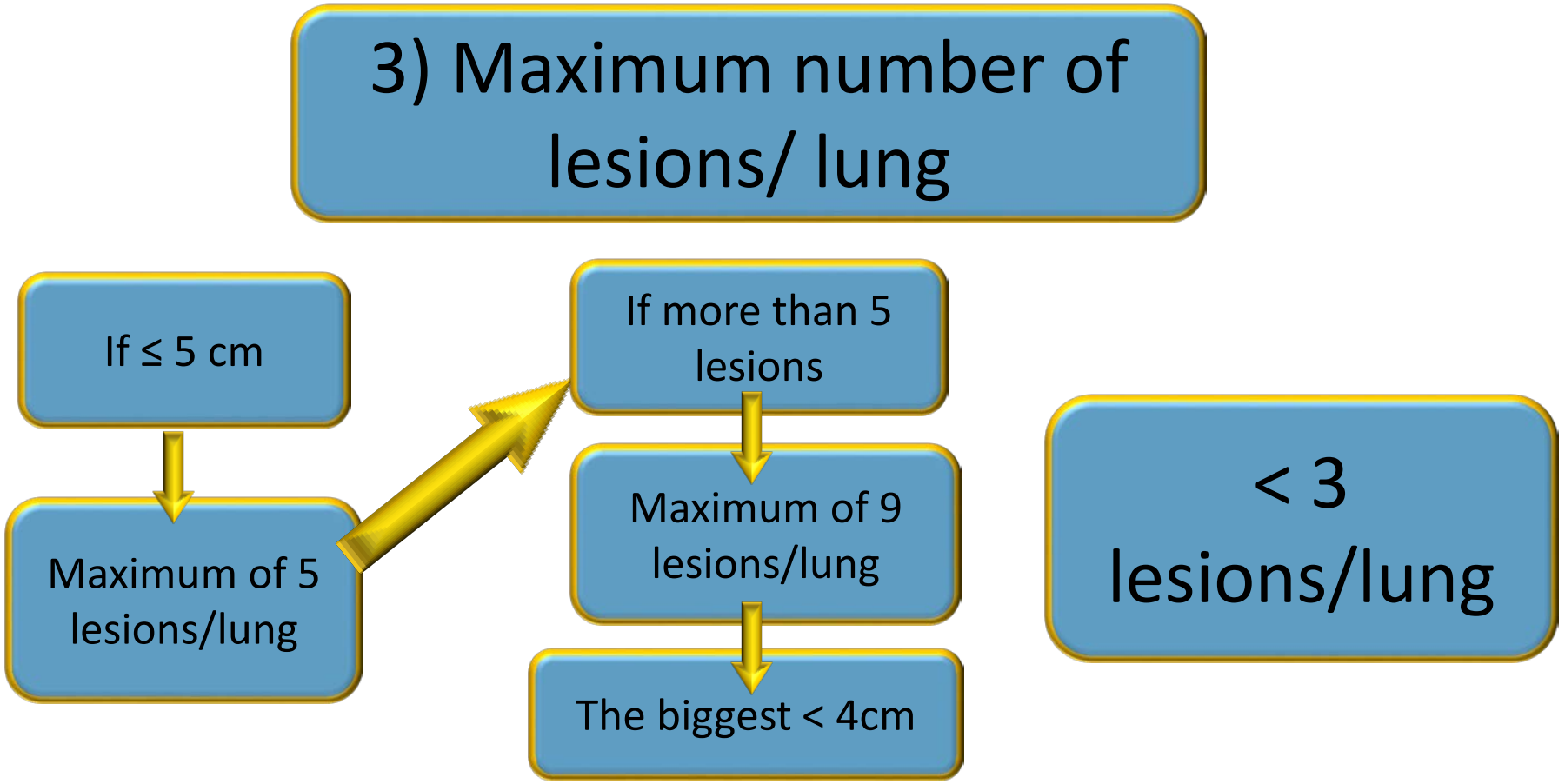
During



5 months follow-up

Patient selection

Imaging Criteria

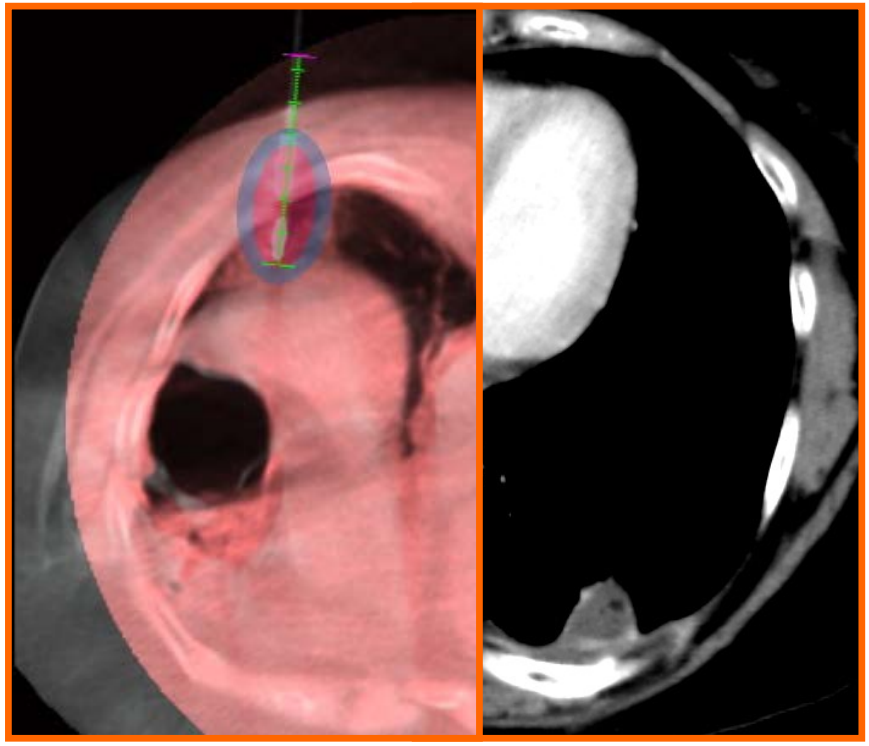


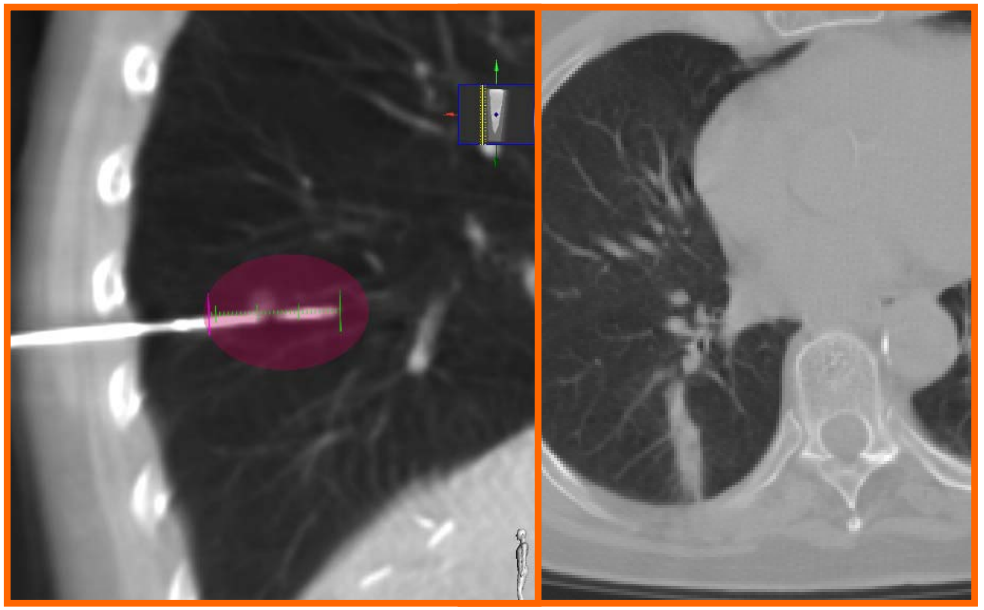
Abbas G, et al. J Surg Oncol 2009; 100:645-50

Patient selection

Multiple Lesions: Metastases

- Primary Cancer controlled. No extrapulmonary disease.



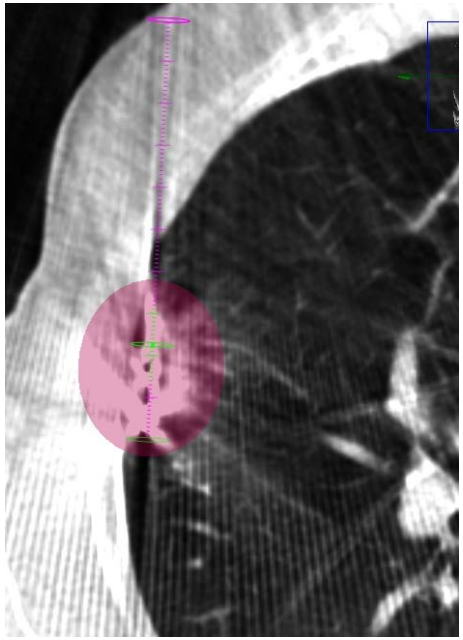


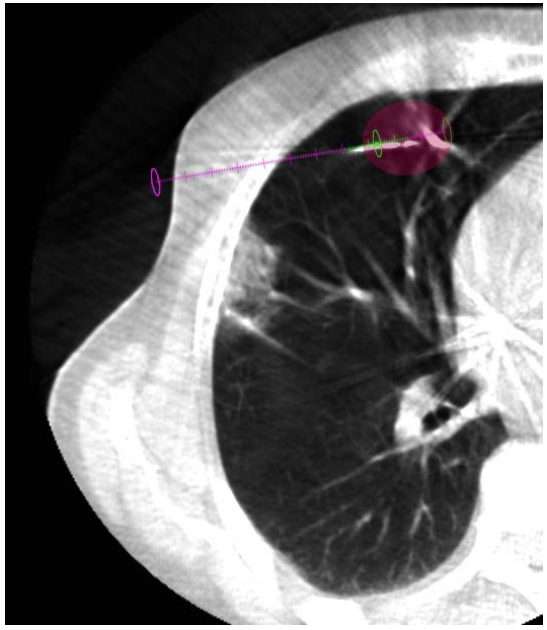
Bilateral RCC metastases

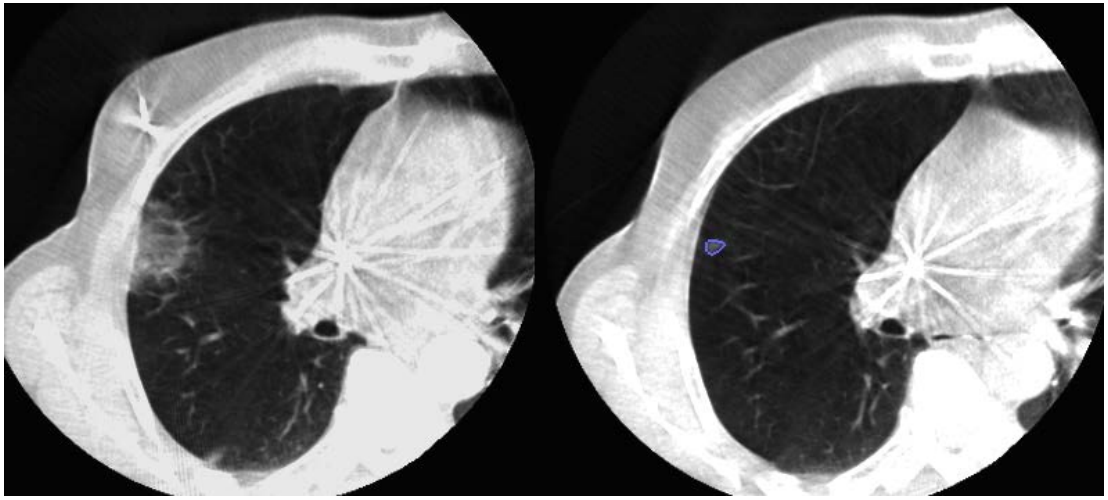
Patient selection

Multiple Lesions: Metastases

- Primary Cancer controlled. No extrapulmonary disease.







Before treatment
Cea 124
C.A 19.9 51

24/03/2015
Cea 7
C.A. 19.9 28

Patient selection

The Ideal Candidate

- High-risk surgical candidates with early stage lung cancer
- Small oligonodular tumor or favorably located metastases
- Without any hilar, mediastinal nodal or extrathoracic involvement

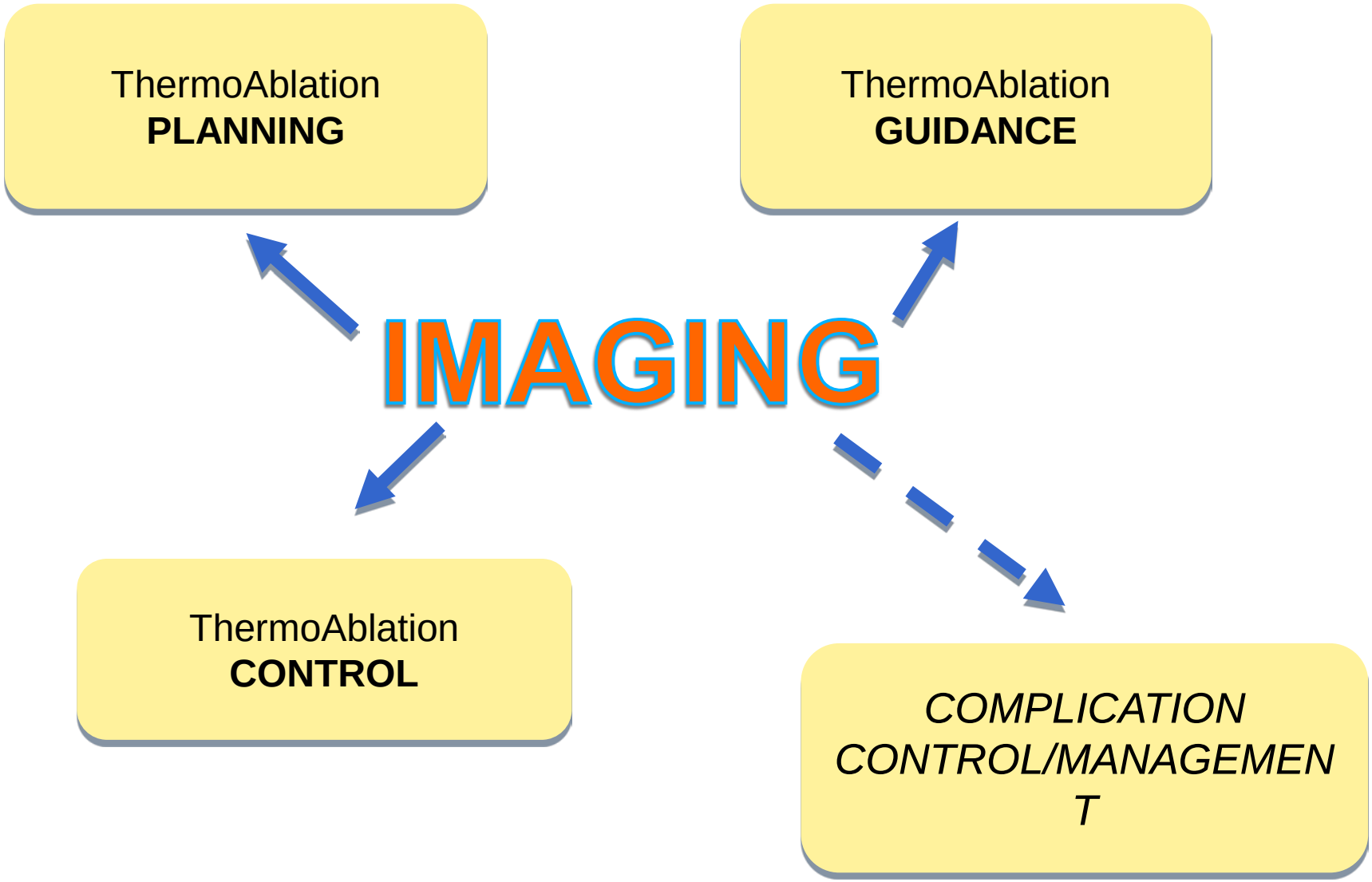
- Patients seeking for palliative measures for tumor-related symptoms or who have a recurrent thoracic malignancy within appropriate treatment fields

Alexander ES, et al. Semin Interv Radiol 2013; 30:141-50
Alexander ES, et al. J Vasc Interv Radiol 2012; 23(9):1236-40

Termoablazione dei tumori polmonari

- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Imaging Guidance



Imaging Guidance

The lungs provide a unique environment for ablation under computed tomographic (CT) guidance.

- there is an excellent contrast ratio between tissue of the targeted tumor, aerated lung, and the metal of the needle, which is enhanced by the ability to provide multiplanar imaging for accurate evaluation of needle placement and electrode deployment

De Baere et al. Semin Intervent Radiol 2013;30:151–156

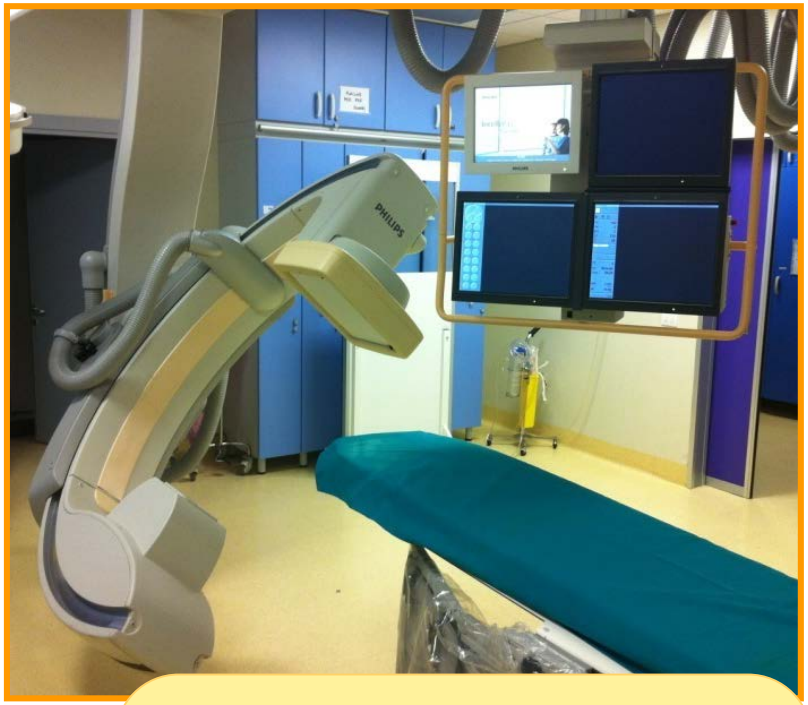
Imaging Guidance

- **CT: no real time imaging**
- **FLUORO CT: more similar to real time imaging, opportunity of electrode repositioning, BUT high operator dose radiation**

Imaging Guidance: ***UPDATE***

Advantages C-arm Cone Beam CT Guidance

- Pathway Guidance
- Prediction of Ablation Area
- Evaluation of Ablation Area
- Immediate CT control
- Immediate Problem Solving



- **XperCT (Dualphase)**
- **Xperguide**
- **Predictability software**
- **Overlay**

Imaging Guidance: ***UPDATE***

Acta Radiologica
0(0) 1–9

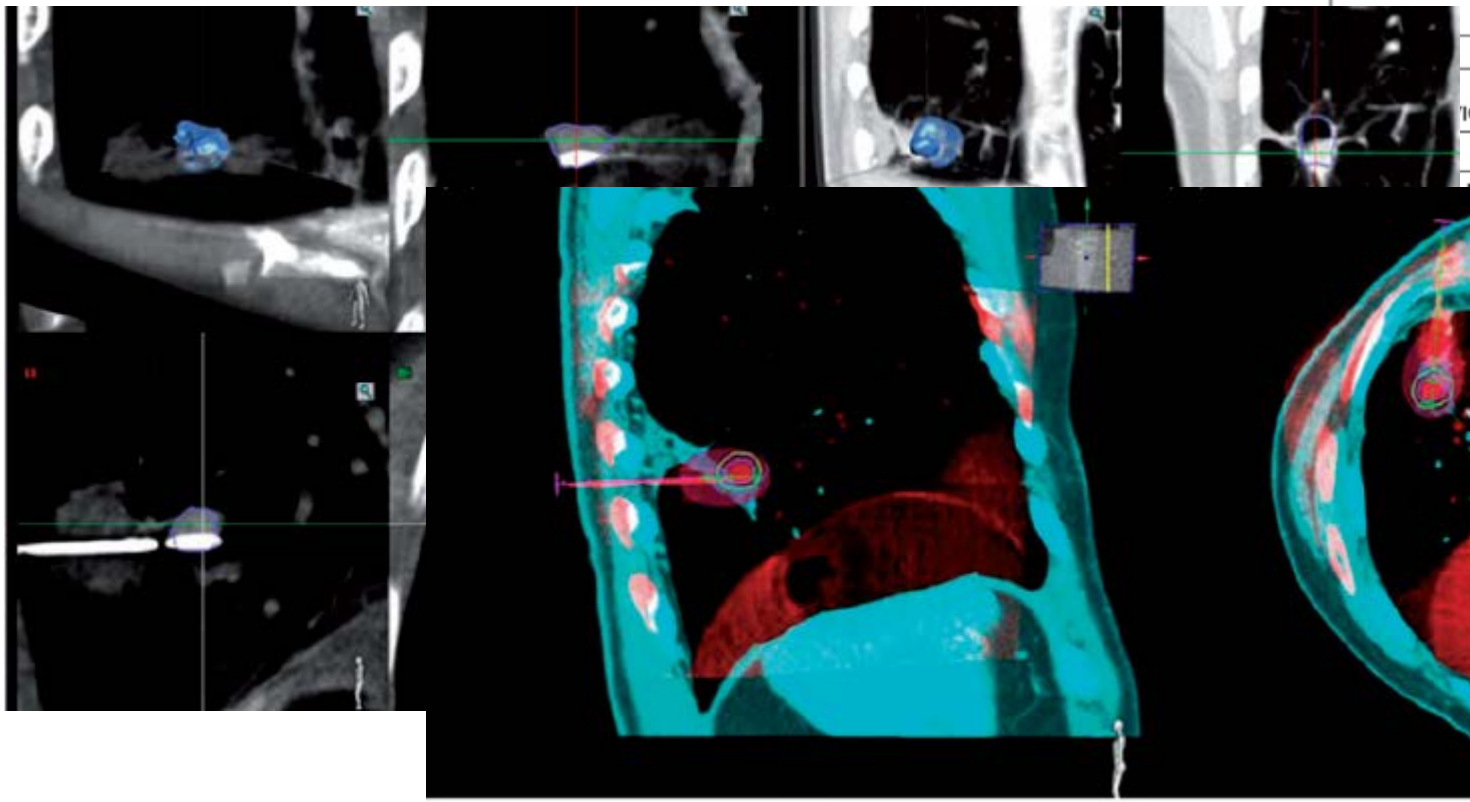
DOI: 10.1177/0284185115574874
acr.sagepub.com
SAGE

Cone beam computed tomography images fusion in predicting lung ablation volumes: a feasibility study

Anna Maria Ierardi[1], Mario Petrillo[2], Genti Xhepa[1], Domenico Laganà[1], Filippo Piacentino[1], Chiara Floridi[1], Ejona Duka[1], Carlo Fugazzola[1] and Gianpaolo Carrafiello[1]

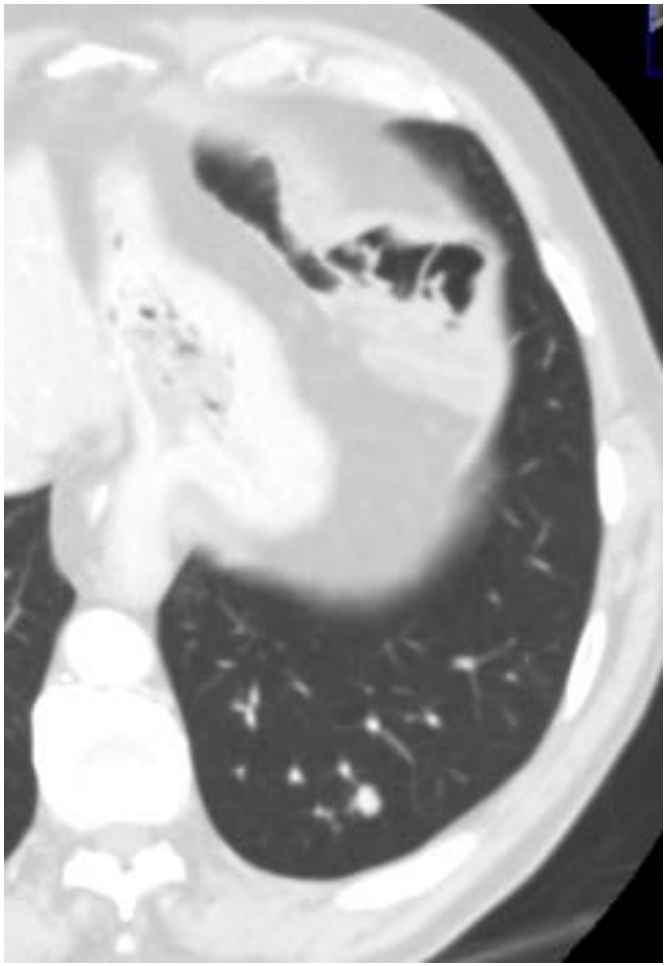
Cone beam computed tomography images fusion in predicting lung ablation volumes: a feasibility study

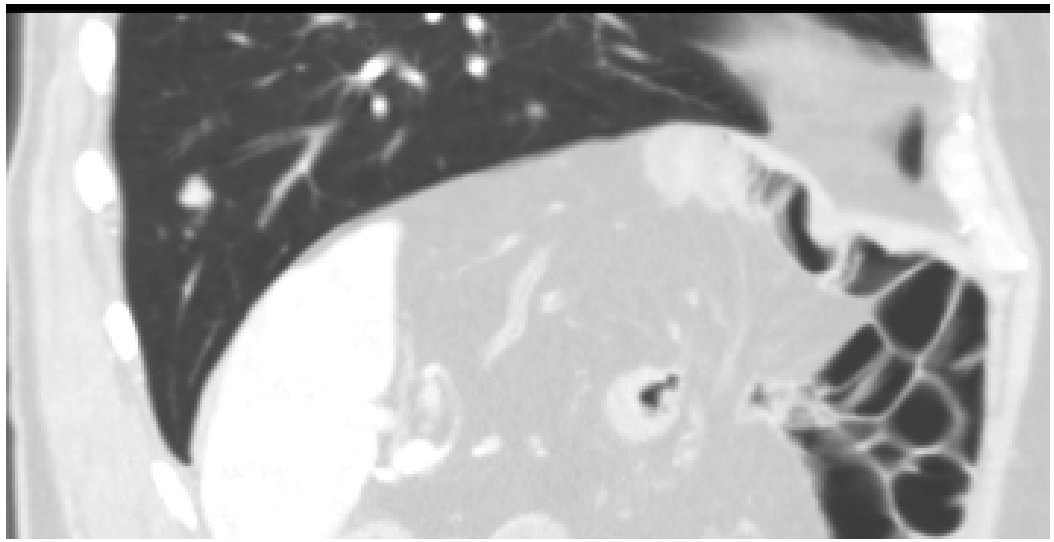
Pre-procedural CBCT
⇩
PLANNINNG (Xpeguide/Ablation Software)
Lesion Segmentation
N°/Trajectory devices
⬇
Fluoroscopy
ICE POSITIONIG (Xpeguide)
⬇



Conclusion: Use of pre-procedural 3D CBCT fusion imaging could be useful to define expected ablation volumes.

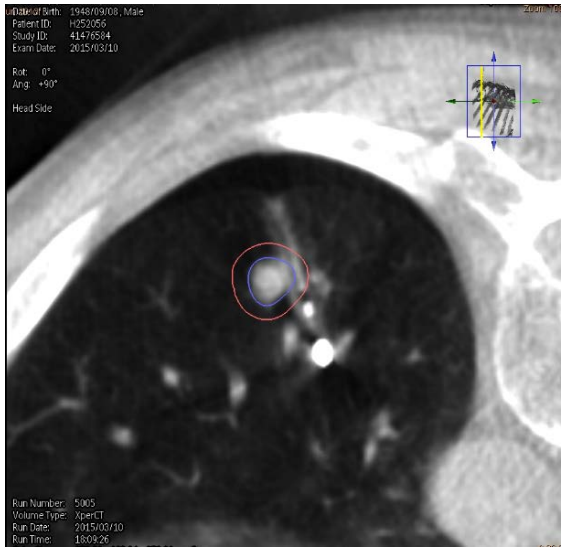
Imaging Guidance: ***UPDATE***

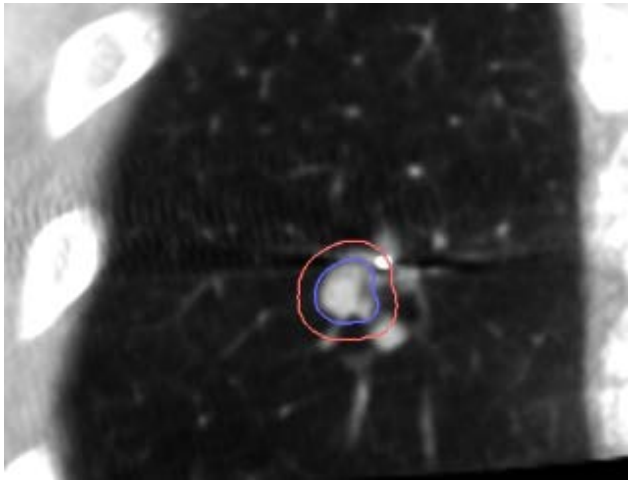


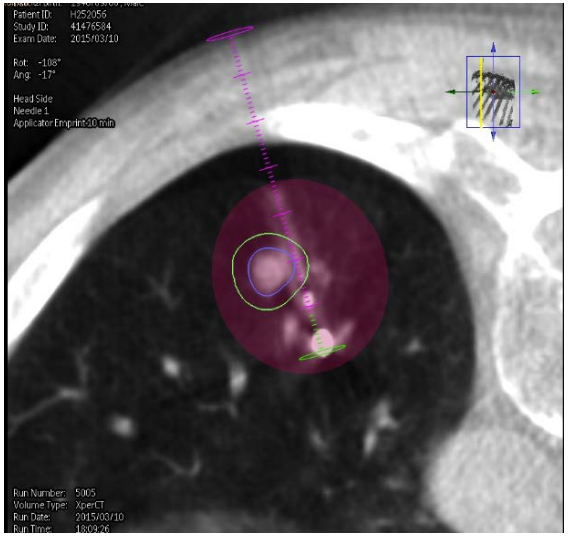


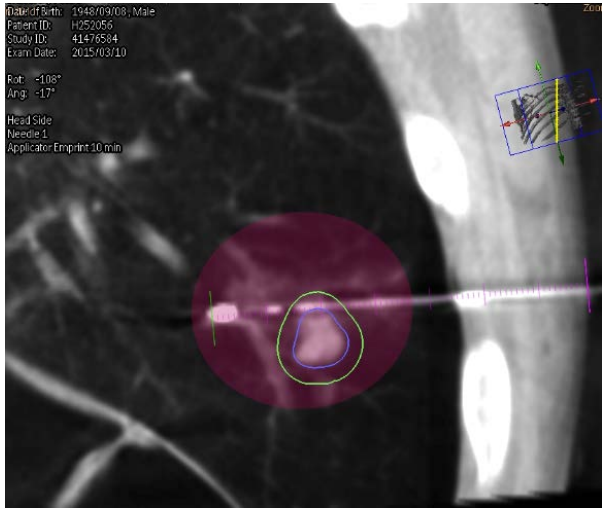
Termoablazione dei tumori polmonari

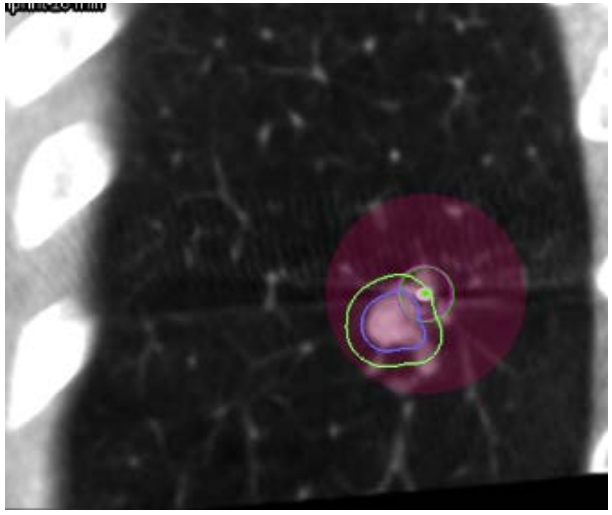
Imaging Guidance: *UPDATE*





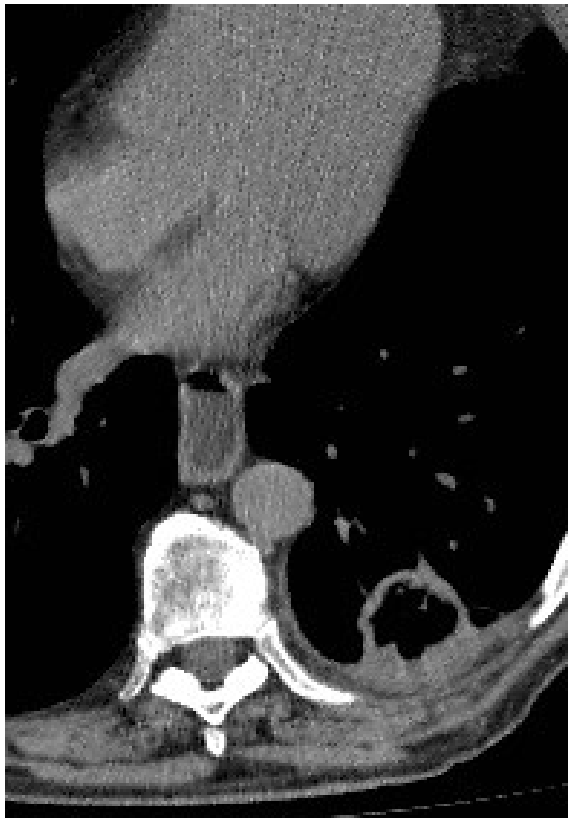


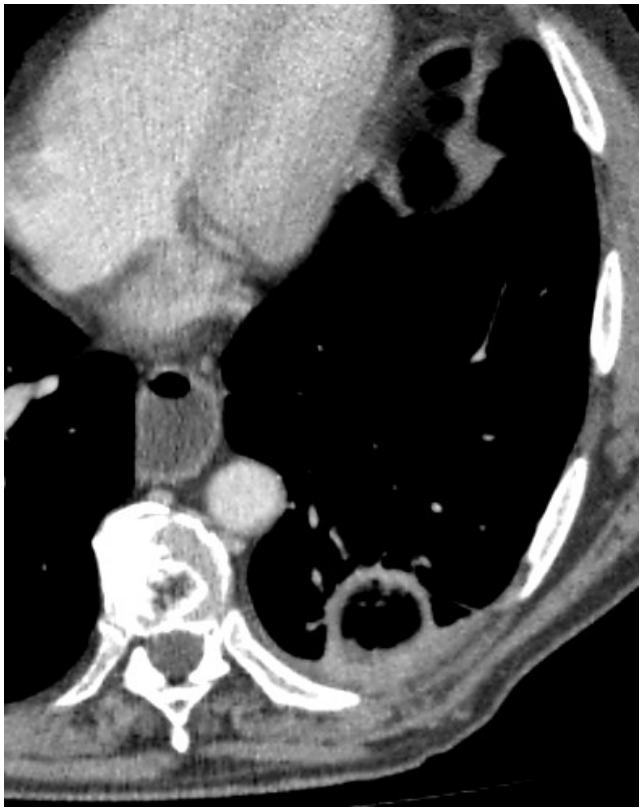


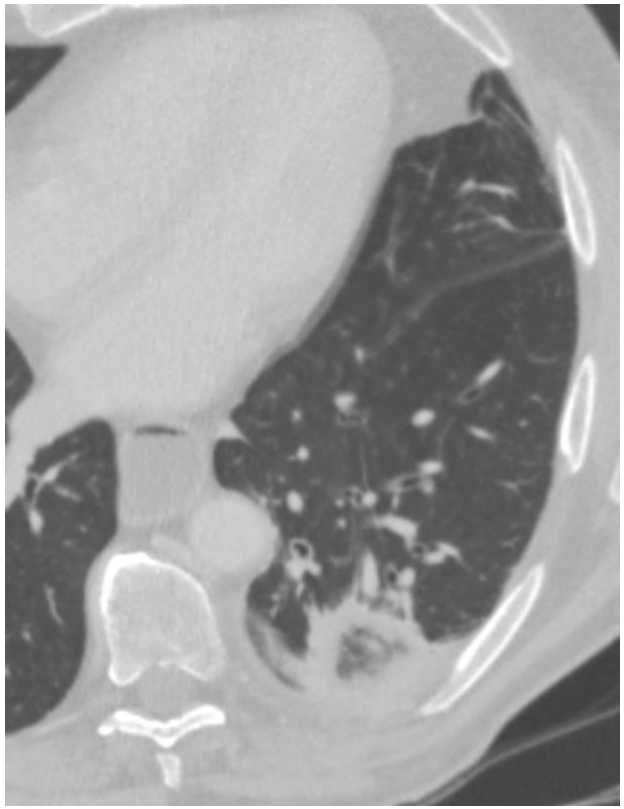


Termoablazione dei tumori polmonari

Imaging Guidance: ***UPDATE***







Termoablazione dei tumori polmonari

- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Tecnology

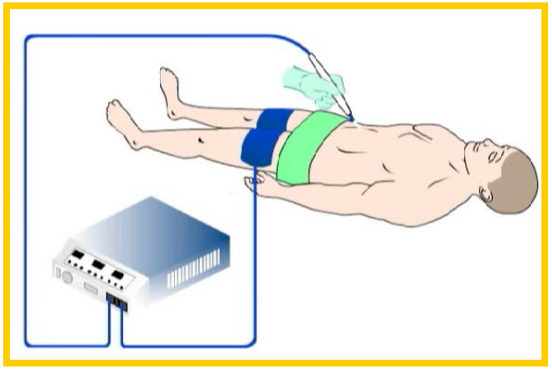
- Site-specific differences favor lung tumors for energy deposition due to heat insulation and low electric conductivity provided by aerated lung around the tumor.

- It has been demonstrated that a given quantity of radiofrequency current produces a larger volume of ablation in the lung than in subcutaneous tissues or in kidney.

Tecnology

RFA

- Tumoral tissue heating (60 to 100° C)
- Cell death (thermocoagulation necrosis)



- Closed circuit (current flow through the patient)
- Heat production by current flow within the needle-electrode

Molecules ionic collisions

↓

Heat production
(coagulative necrosis)

HEAT SINK EFFECT:
Heat disspation by tissue perfusion

Carrafiello G. Int J Sur 2008

Tecnology ***LEVEL of EVIDENCE***

RFA & NSCLC

Lung

Thierry de

[1] Department c
Villejuif, Franc

MD, Department of
ssy, 114 rue Edouard
e@igr.fr).

Semin Interve

Table 2 Summary

Study	OS 5 y (%)
Simon et al[31]	27
Grieco et al[41]	–
Lencioni et al[10]	–
Palussière et al[33]	–
Kodama et al[32]	55.7
Simon et al[34]	20.7

Abbreviations: OS, ove
*Combination of radio

Conclusion

RFA is a promising treatment for small size NSCLC in nonsurgical candidates. Treatment of tumors >3 cm might require the use of other ablative techniques still in evaluation today.

In the future, RFA should be compared with stereotactic body radiation therapy, which also demonstrates a high local control rate. Whether RFA can be compared with surgery in very early stage NSCLC remains to be evaluated.

Today RFA is mostly used as a standalone technique, with the main objective of complete destruction of tumor cells in the targeted volume. Future treatment strategies should investigate combination therapies with radiation therapy[41] or systemic therapies; improved tumor control with RFA by combining with targeted therapies has already been demonstrated in animal studies.[42]

Tecnology ***LEVEL of EVIDENCE***

RFA & MTS

N.J.R. Lyons et al. / EJSO 41 (2015) 1447–1455

Review

Percutaneous management of pulmonary metastases arising from colorectal cancer; a systematic review

N.J.R. Lyons [a,*], S. Pathak [a], I.R. Daniels [a], A. Spiers [b], N.J. Smart [a]

Morbidity rates and progression of disease.

Author	Year	Chest drain insertion (%)	Major complications (%)	Minor complications (%)	Pneumothorax (%)	Local progression (%)	Disease free survival (%)	Died from disease (%)e	New extra pulmonary disease (%)	New pulmonary disease (%)
Gilliams et al.	2013	15	8	–	32	19	20	–	50	46
Petre et al.	2013	33	4	33	33	13	54	–	22	24
Matsui et al.	2015	17	4	7	70	21	–	29	–	–
Yamakado et al.	2007	21.4	0	31	37	17	–	21	–	30
Yamakado et al.	2009	14	2	17	40	14	–	28	–	–
Ferguson et al.	2015	18.6	0.5	–	53.8	11.5	69.4	–	–	–
Lencioni et al.	2008	13	–	–	–	9	–	–	–	–
Baere et al.	2015	–	–	–	–	–	–	–	–	–

Mortality, survival rates and overall survival rates.

Author	Year	Design	No. pts	Mean age	Tumours per patient (mean)	Tumour size	Duration of follow up (months)	Extra pulmonary disease (%)	Mortality (%)	1 year survival (%)	2 year survival (%)	3 year survival (%)	5 year survival (%)	OS months
Gilliams et al.	2013	Pro	122	68∼	3.3	1.7 cm (*)	–	20	0	–	–	57	–	41∼
Petre et al.	2013	Pro	45	63∼	1.5	0.4–3.5 cm	18∼	47	0	95	72	50	–	–
Matsui et al.	2015	Retro	84	65∼	2.0	1.2 cm∼	37.5∼	15	0	95		65	–51.6	67*
Yamakado et al.	2007	Retro	71	64*	2.2	2.5 cm*	19*	42	0	84	62	46	–	31∼
Yamakado et al.	2009	Retro	78	78*	2.5	2.0*	25*	10	0	84	56	35	–	38∼
Ferguson et al.	2015	Retro	157	63		–	33	–	0.6	89	–	44	19.9	36∼
Lencioni et al.	2008	Pro	53	63*	2.2	1.4*	–	29	0	89	66	–	–	–
Baere et al.	2015	Retro	293	65.8*	1.8	1.58*	–	23	–	93		72	54	–

Legend: * for mean values, ∼ for median.

Tecnology ***LEVEL of EVIDENCE***

RFA & NSCLC

STUDY	ABLATION MODALITY	No. of patients	Mean size (cm)	1- year survival	3-year survival	5-year survival
Ridge [19]	RFA	29	1.4	NA	60%	14%
Kodama [20]	RFA	33	3.0 cm	82%	NA	NA
Simon [21]	RFA	75	3 (1-7.5)	78%	36%	27%
Palussiere [22]	RFA	87	2.1 (1-5.4)	91.1	66.1	58.1
Hiraki [23]	RFA	50	1.4	94	74	51
Huang [24]	RFA	237	NA	80	45.8 (2y)	24.3
Ambrogi [25]	RFA	57	2.6	89	59	40
Lanuti [26]	RFA	45	2.1	NA	31	NR
Lencioni [27]	RFA	33	2.2	70%	48%	NR
Liu [28]	RFA	29	3 (1.4-4.8)	87.5 - 92.3	58.7-87.5 (Stage Ia vs Ib)	NR

Carrafiello et al. CVIR in press

Tecnology

MWA

International Journal of Surgery 6 (2008) S65–S69

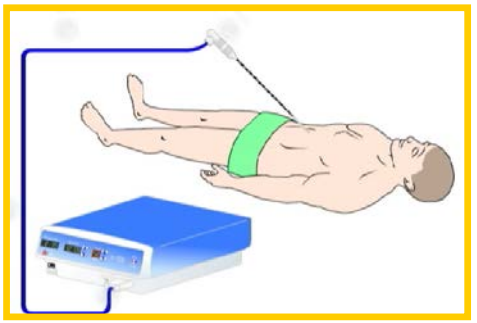
Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.theijs.com

Microwave tumors ablation: Principles, clinical applications and review of preliminary experiences

Gianpaolo Carrafiello [a,*], Domenico Laganà [a], Monica Mangini [a], Federico Fontana [a], Gianlorenzo Dionigi [c], Luigi Boni [c], Francesca Rovera [c], Salvatore Cuffari [b], Carlo Fugazzola [a]



- Tumoral tissue heating (65-160° C)
- Cell death (thermocoagulation necrosis)

- **Antenna creates an electromagnetic field (Frequency 900-2450 MHz)**
- **NO** current flow through the patient **(no grounding pad)**

Agitation of water molecules

↓

Friction force caused by ater molecules collision

↓

Heat generation

Tecnology ***LEVEL of EVIDENCE***

MWA

STUDY	ABLATION MODALITY	No. of patients	Mean size (cm)	1- year survival	3-year survival	5-year survival
Wolf (30)	MWA	30	3.5	65(for all)	45 (for all)	NA
Lu (31)	MWA	48	2.2	75	29.2	NA
Belfiore (32)	MWA	45	3	69 (for all)	49 (for all)	
Liu (33)	MWA	15	2.4	69	NA	NA
Yang (34)	MWA	47	3.5	89	43	16
Wei (35)	MWA	46	3.7	NA	NA	NA
Wei (36)	MWA and CHT	39	3.84	65 (stage III or IV)	45	NA
Xu (37)	MWA with RT or CHT	51	NA	74 (stage III)	56	NA

Carrafiello et al. CVIR in press

Tecnology

MWA VS RFA: MWA Advantages

- Higher intra-tumoral temperatures
- Superior ablation volumes
- Smaller ablation times
- Possibility of using multiple antennas
- Optimal heating of cystic masses
- Doesn’t require grounding pad
- Less intraprocedural pain
- No heat sink effect

Carrafiello et al. Int J Surg. 2008;6 Suppl 1:S65-9.

Tecnology ***LEVEL of EVIDENCE***

The role of percutaneous image-guided ablation for lung tumors

Elena N. Petre · Stepl
Constantinos T. Sofoc

In summary, ablation of pulmonary malignancies is an established treatment for those patients that cannot undergo surgery or have recurrences after surgery, radiation or chemothrapy. It is also a unique option for patients with compromised pulmonary function. The current oncologic outcomes after ablation support the use of this treatment, especially for relatively small tumors that can be ablated with sufficient margins. Recent experience suggests comparable 3-year survival between sublobar resection, SBRT, and ablative therapies [32, 33]. However, larger randomized controlled trials with longer follow-up are needed to make more educated conclusions regarding the value of ablation with regard to surgery and/or SBRT in different disease settings. This may lead to an increased use of these minimally invasive procedures in patients with pulmonary malignancies.

Table 1 Outcomes of imag

References	Ablation modality	GY	3-year survival	5-year survival
Ridge [38]	RFA		60 %	14 %
Hiraki [61]	RFA		74 %	51 %
Huang [37]	RFA		45.8 % (2-year)	24.3 %
Ambrogi [62]	RFA		40 %	25 %
Lanuti [63]	RFA		31 %	NR
Lee [64]	RFA		80 %	NR
Fernando [65]	RFA		83 %	83 %
Simon [66]	RFA		36 %	27 %
Lencioni [7]	RFA		48 %	NR
Wolf [67]	MWA		45 %*	NR
Liu [26]	MWA		NR	NR

*Rates reported for the entire group that included primary and metastatic pulmonary tumors

Tecnology

Cryoablation

- Freezing temperature (-20° C) destroying tissue
- alternative cycles of freezing and thawing

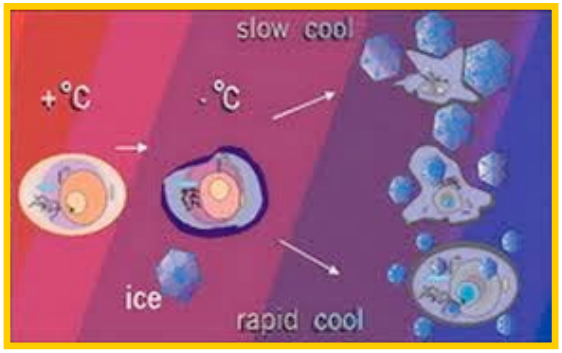
Water diffuses from the intracellular space into the extracellular space

↓

Cell shrinking and cell membranes damaging + vascular injury

↓

Thawing (20-40° C) → Hypotonic condiction + Hyperemic response



↓

Cell rupture

↓

Aggregation of platelets + Thrombosis → Uniform necrosis of the tissue

Chen, et al. J Chin Med Assoc 2013; 76:303-11
Hoffmann NE, et. Urology 2002;60:40e9

Termoablazione dei tumori polmonari

Tecnology ***UPDATE***

Updates Surg (2015) 67:39–45
DOI 10.1007/s13304-015-0288-1

ORIGINAL ARTICLE

A new system of microwave ablation at 2450 MHz: preliminary experience

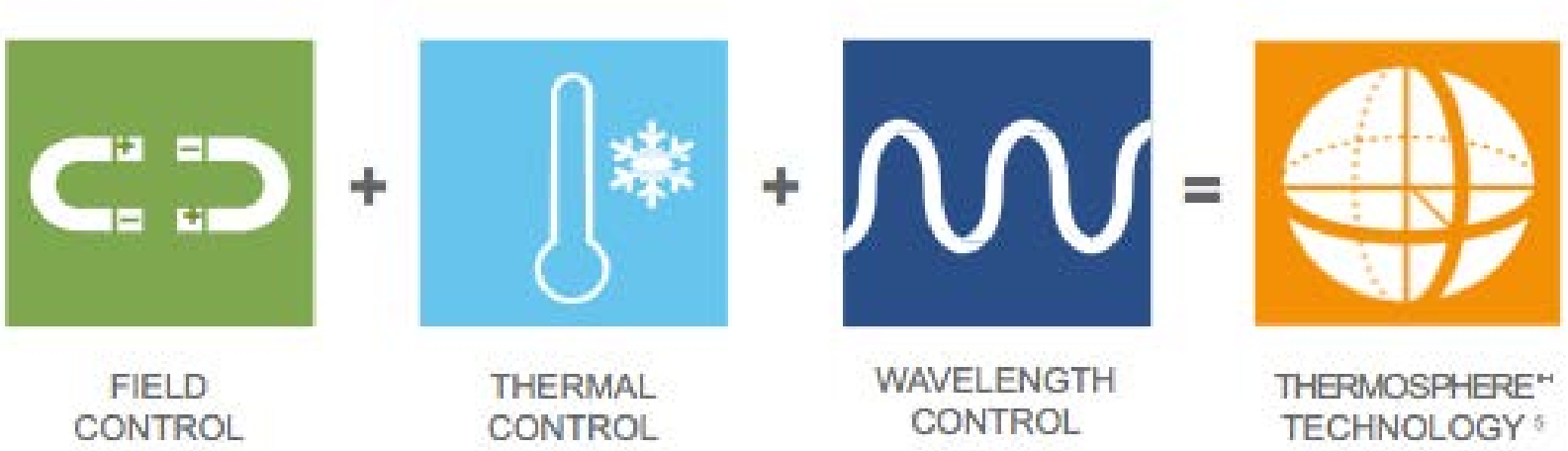
Anna Maria Ierardi · Alberto Mangano · Chiara Floridi · Gianlorenzo Dionigi · Antonio Biondi · Ejona Duka · Natalie Lucchina · Georgios D. Lianos · Gianpaolo Carrafiello

$$\frac{\text{Long axis area}}{\text{Short axis area}} > 1$$

$$\frac{\text{Long axis area}}{\text{Short axis area}} = 1$$

Tecnology ***UPDATE***

The Thermosphere system achieves this by being the first and only ablation system **to employ three kinds of control** to **maintain a precise, predictable, spherical ablation zone** throughout procedures.



Tecnology ***UPDATE***

Technology Improvements

- **PRECISE**
- **PREDICTABLE**
- **SPHERICAL**

ABLATION ZONE

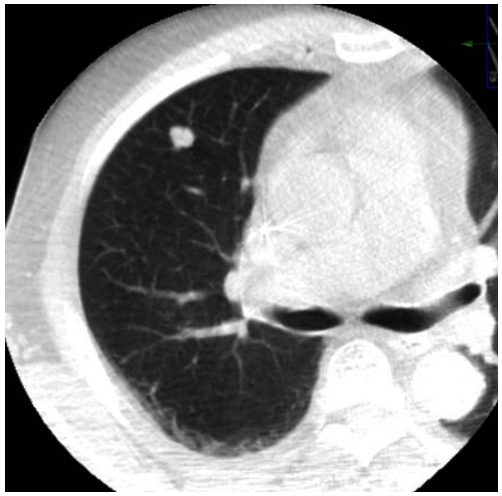
→ SAFER MARGINS

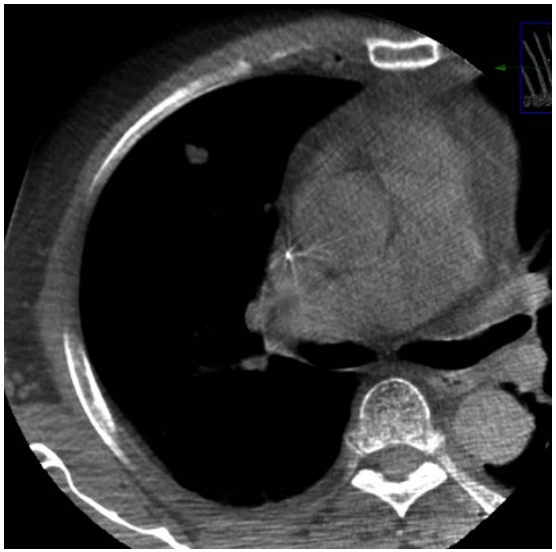
↓

- less recurrences
- less complications

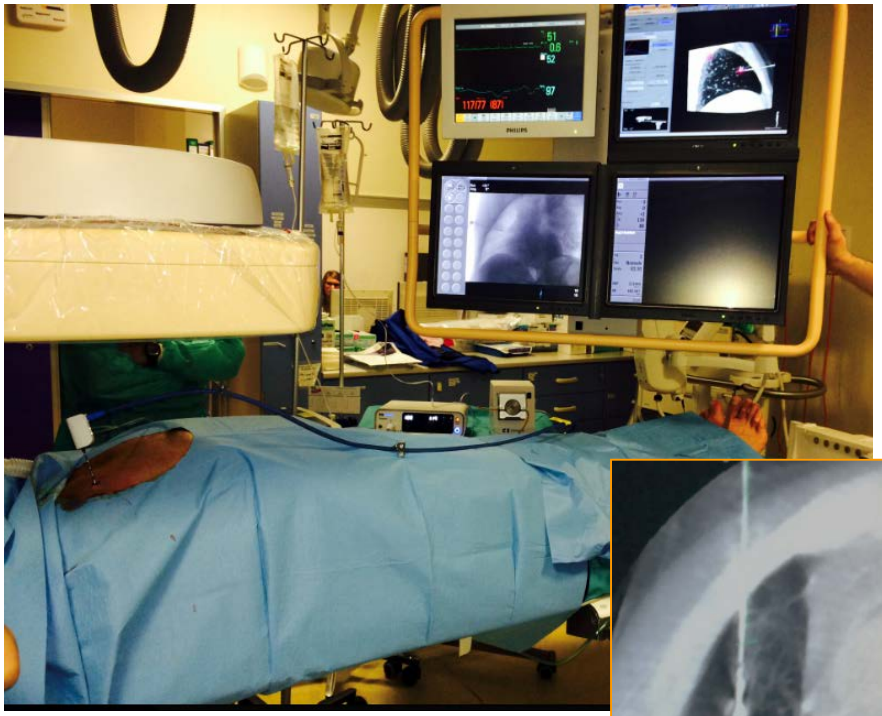
Termoablazione dei tumori polmonari

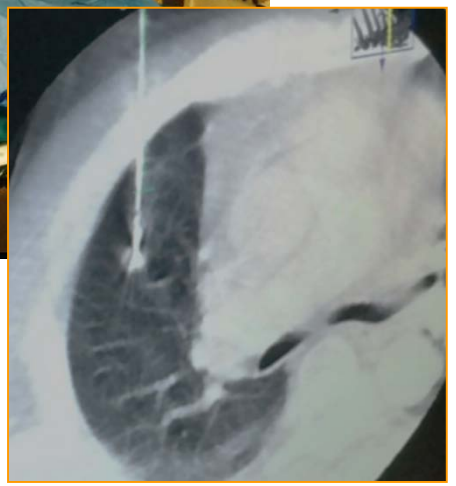
Tecnology ***UPDATE***





- Male, 67 yo
- Lung; Right Upper Lobe
- CRC Metastasis
- Extension of Disease

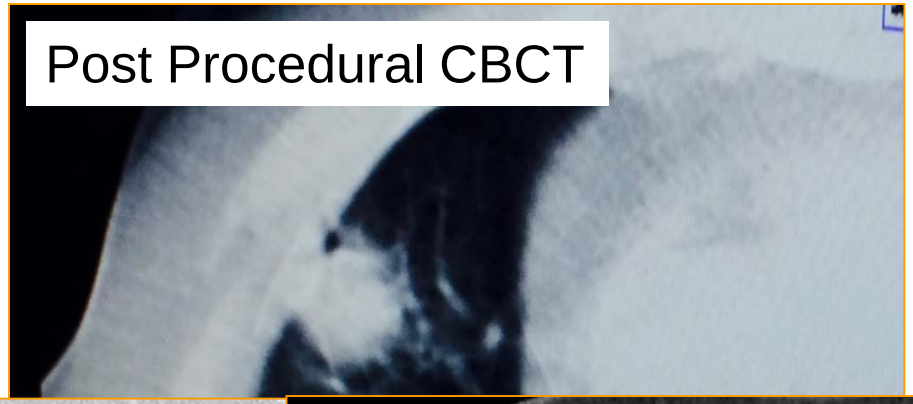


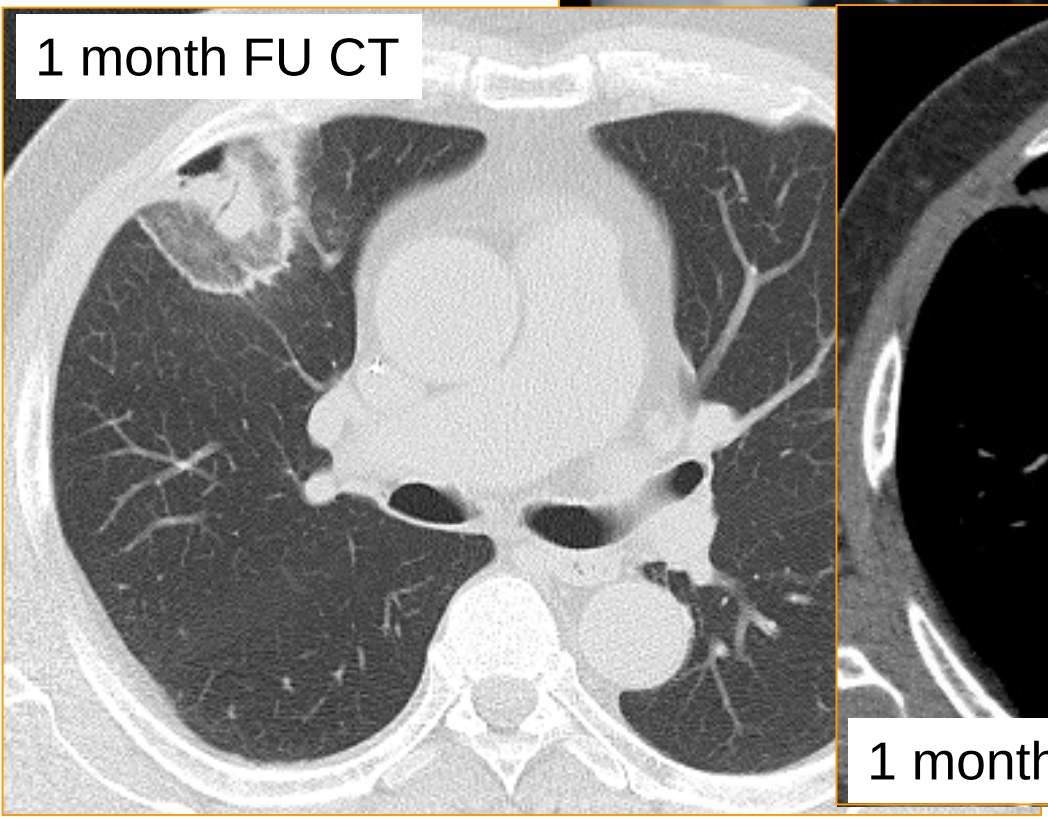


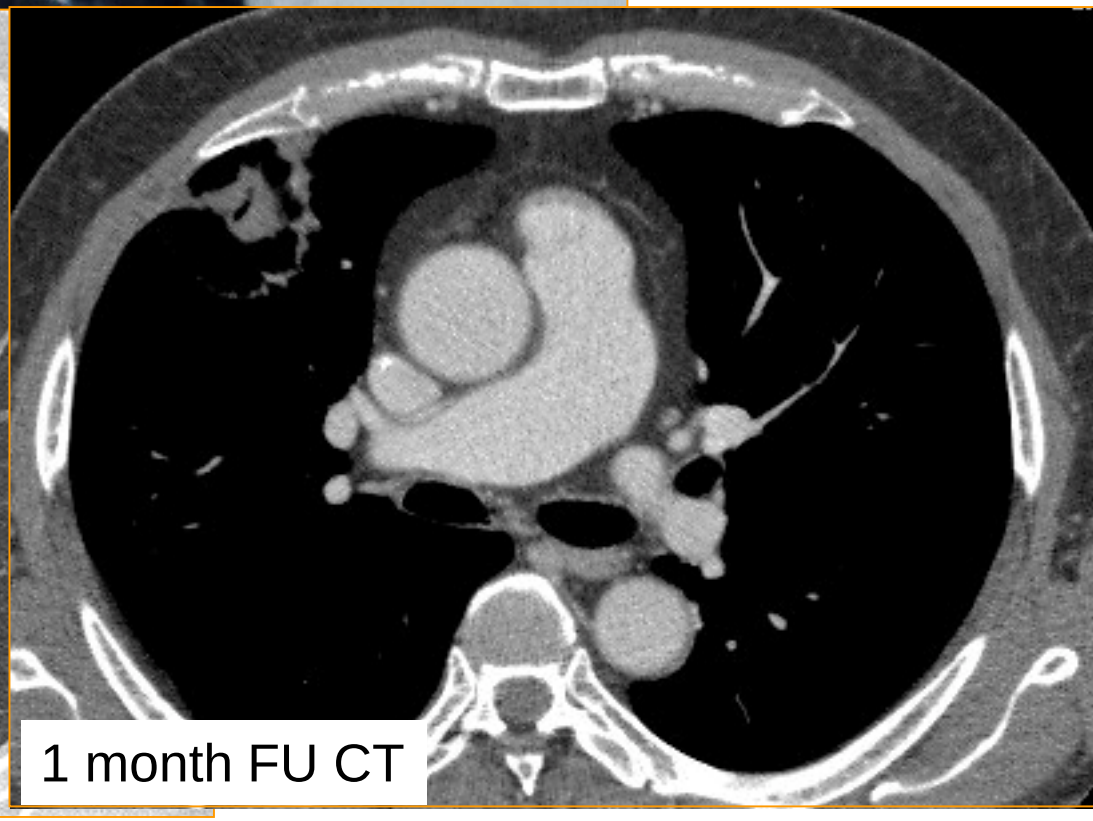
100 Watt	2:30	30mm

Termoablazione dei tumori polmonari

Tecnology ***UPDATE***



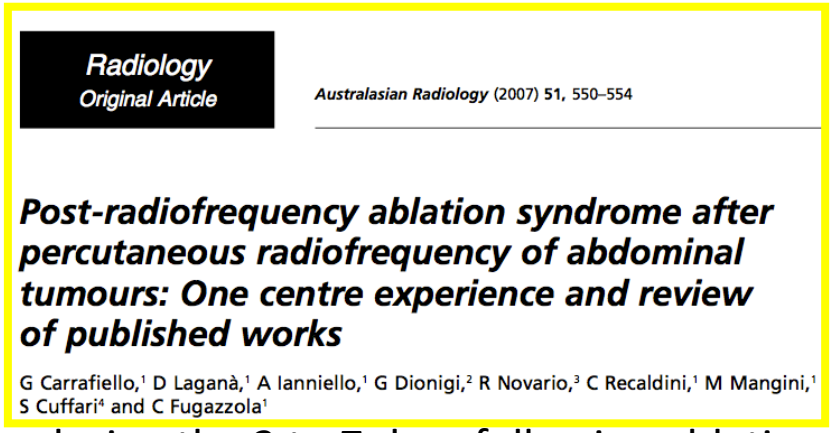




- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Complications

COMPLICATIONS


Radiology
Original Article

Australasian Radiology (2007) 51, 550–554

Post-radiofrequency ablation syndrome after percutaneous radiofrequency of abdominal tumours: One centre experience and review of published works

G Carrafiello,[1] D Laganà,[1] A Ianniello,[1] G Dionigi,[2] R Novario,[3] C Recaldini,[1] M Mangini,[1] S Cuffari[4] and C Fugazzola[1]

- Mild o moderate post procedural pain
- Mild dyspnea
- Fever < 38° C

} during the 2 to 7 days following ablation

- Most common complication: **Pneumothorax**
  - Occurs > 50% of procedures (11-52%)
  - Chest tube placement required in 6-29% of the cases
- Pleural effusion 6-19%
- Parenchymal hemorrhage – hemoptysis in 3-9%
- Others:
  - Bronchopleural fistula
  - Pulmonary artery pseudoaneurysm
  - Needle Tract Seeding
  - Thermal injuries to nearby structures
  - Pneumonitis
  - Systemic Air Embolism

Post-ablation Syndrome

- Fever (<38,5° C)
- Fatigue
- General malaise
- Nausea
- Vomiting

Yang X, et al. J Surg Oncol 2014 Jun 25. [Epub ahead of print]
Hiraki T, et al. World J Gastroenterol 2014; 20(49):988-96
Hiraki T, et al. Semin Intervent Radiol 2013; 30:169-75
Carrafiello G, et al. Radiol Med 2012;117:201–13
Alexander ES, et al. J Vasc Interv Radiol 2012; 23(9):1236-40
Mali B, et al. Med Biol Eng Comput 2008;46(8):745–57

Complications

COMPLICATIONS

Radiol med (2012) 117:201–213
DOI 10.1007/s11547-011-0741-2

CHEST RADIOLOGY
RADIOLOGIA TORACICA

Complications of microwave and radiofrequency lung ablation: personal experience and review of the literature

Complicanze della termo-ablazione polmonare con microonde e radiofrequenza: esperienza personale e revisione della letteratura

G. Carrafiello • M. Mangini • F. Fontana • A. Di Massa • A.M. Ierardi • E. Cotta • F. Piacentino
L. Nocchi Cardim • C. Pellegrino • C. Fugazzola

Table 2 Systematic review of radiofrequency ablation complications in pulmonary tumours

Literature	Patients (tumours), n	Major complications, %	Minor complications, %
Suzuki et al. [20]	14 (18)	16.7	41.2
Pennathur et al. [21]	100 (100)	27	7%
Thanos et al. [22]	35 (48)	4.1	8.3
Shu Yan Huo et al. [23]	9 (23)	24.4	33.3
Dequanter and Lothaire [24]	10 (15)	33.3	13.3
Soga et al. [25]	39 (39)	17.9	<5
Pennathur et al. [26]	22 (22)	30	Not available
Lanuti et al. [27]	31 (31)	32.2	67.7
Nomura et al. [28]	130 (130; 327 sessions)	18.4	29
Okuma et al. [11]	57 (57; 112 sessions)	35.7	46
Hiraki et al. [29]	20 (20; 23 sessions)	4.3	69.6
Cariati et al. [30]	11 (11)	36.4	27.3
Sano et al. [31]	137 (366; 221 sessions)	14	43.4
Simon et al. [2]	153 (189; 183 sessions)	12	23.5

Table 3 Systematic review of microwave ablation complications in pulmonary tumours

Literature	Cases	Minor complications	Major complications
Durick et al. [32]	8 swine (24 ablation zones)	–	–
Brace et al. [33]	3 swine (18 ablation zones)	–	–
Carrafiello et al. [34]	9 patients (10 tumours)	–	30%
Wolf et al. [12]	50 patients (82 tumours; 66 sessions)	~ 10%	~30%

- Safety evaluation shows that the 30-day mortality rate (0%) after MWA is markedly lower than after RFA (3.9%) or after surgery (2.0%)
- MWA appears to be associated with a lower complication rate than RFA.
- Further studies with larger patient populations and more treatments should be done in order to confirm our preliminary results.

Complications

PNEUMOTHORAX
Manual aspiration

Cardiovasc Intervent Radiol (2012) 35:247–254
DOI 10.1007/s00270-012-0340-1

INVITED SUBMISSION: CIRSE STANDARDS OF PRACTICE GUIDELINES

Standards of Practice: Guidelines for Thermal Ablation of Primary and Secondary Lung Tumors

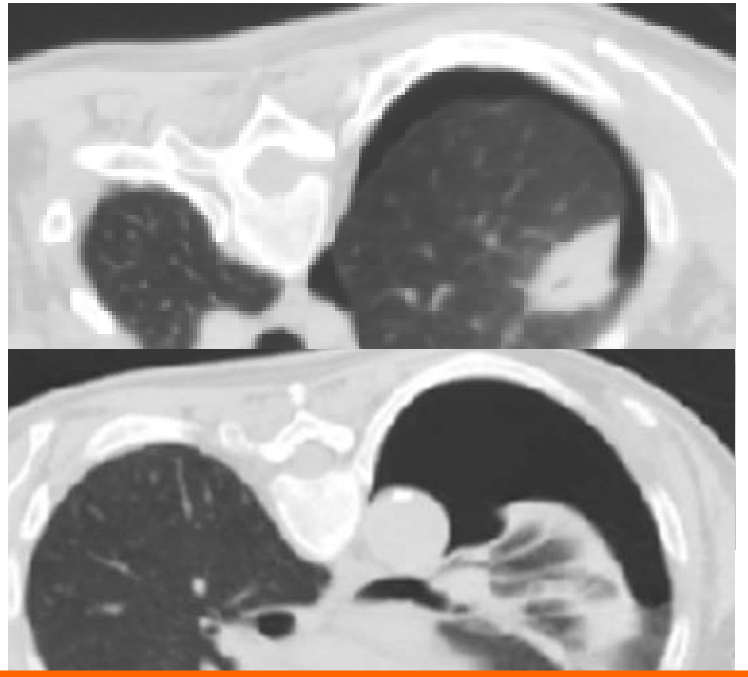
Philippe L. Pereira · Masala Salvatore

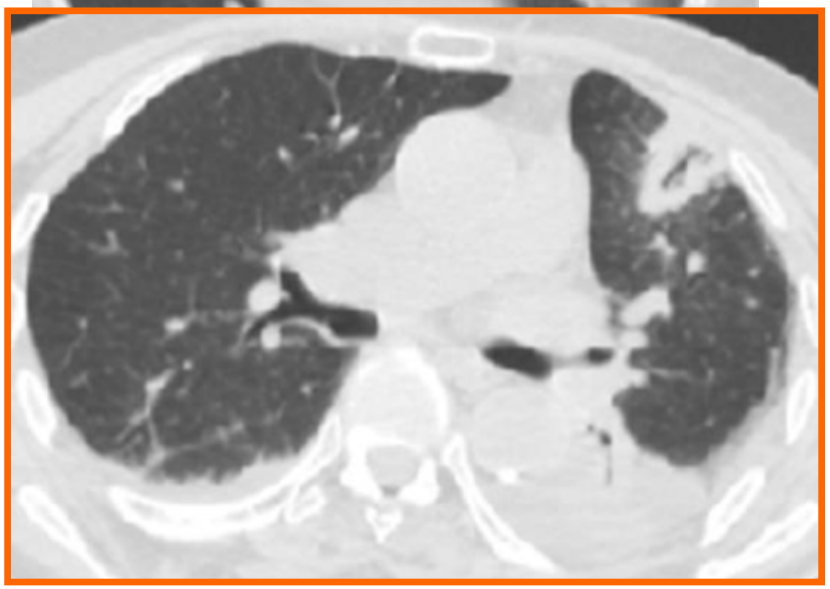
- **Manual aspiration** during ablation should be considered as a valuable option for thin pneumothoraces to avoid excessive coagulation of atelectatic lung parenchyma during energy application.

Complications

PNEUMOTHORAX

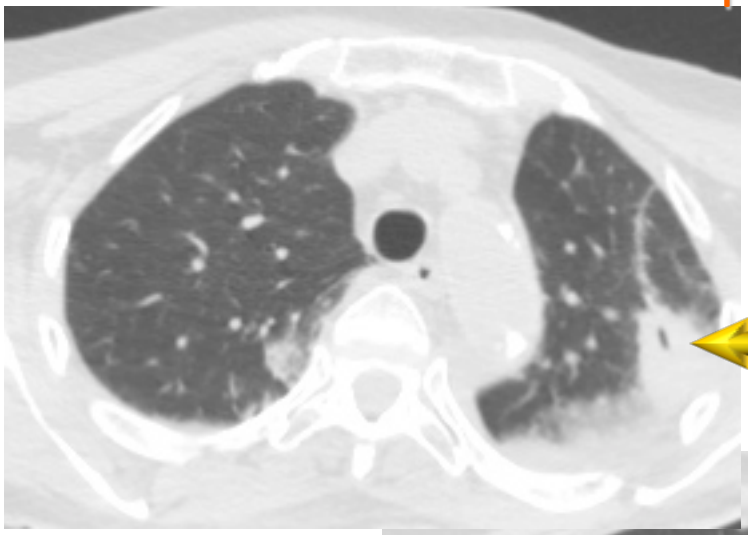
Manual aspiration

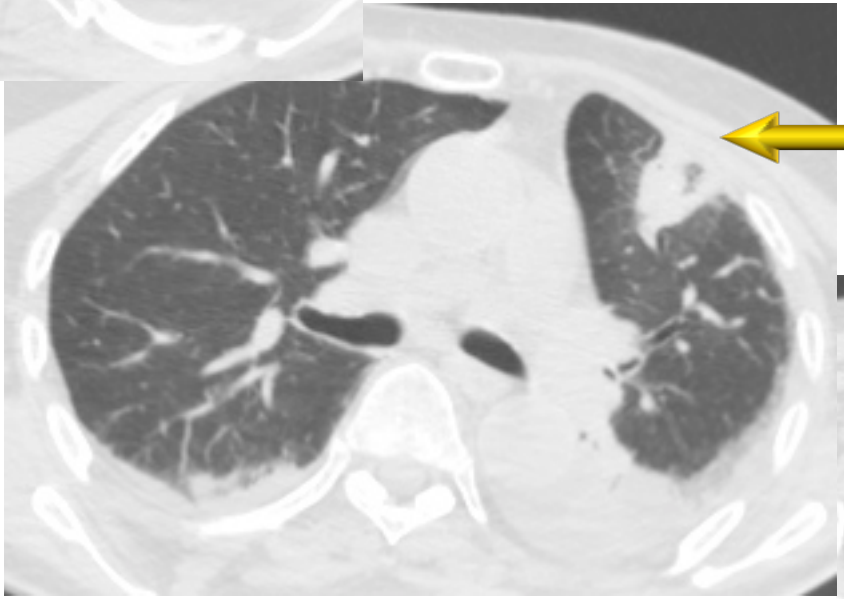


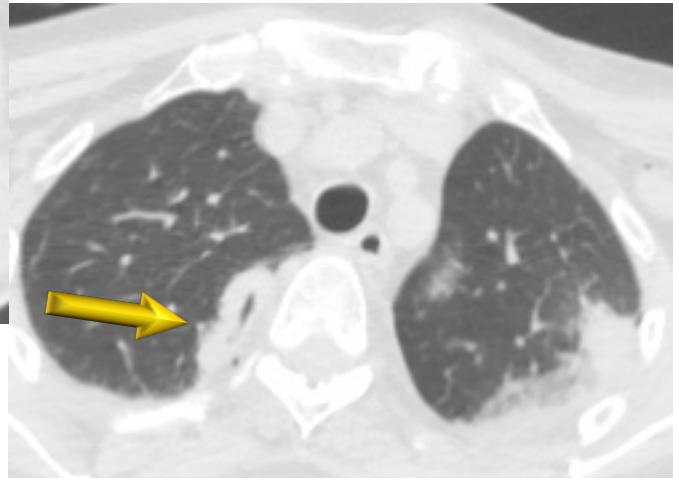


Complications

PNEUMOTHORAX







Complications

HEMORRHAGE

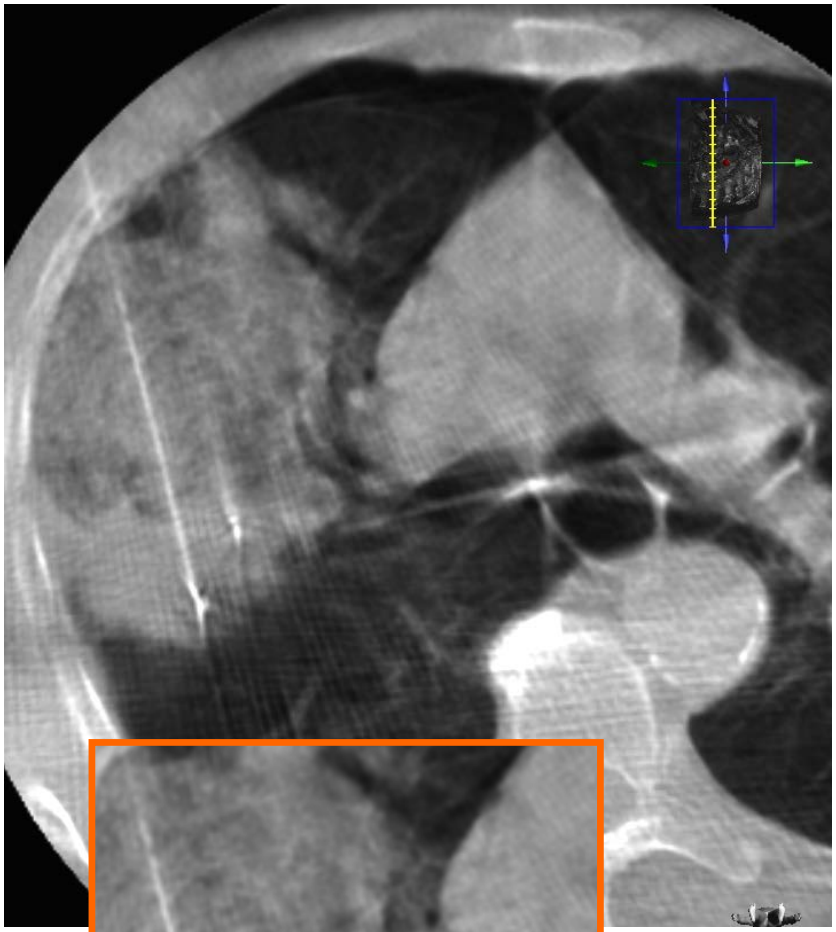
Nour-Eldin A. Nour-Eldin
Nagy N. N. Naguib
Martin Mack
John E. Abskharon
Thomas J. Vogl

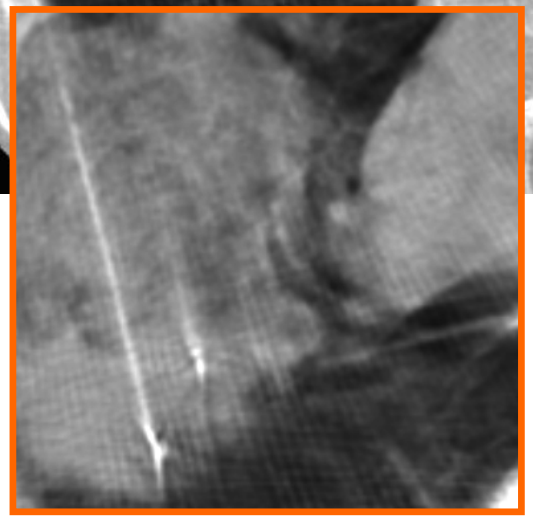
Pulmonary hemorrhage complicating radiofrequency ablation, from mild hemoptysis to life-threatening pattern

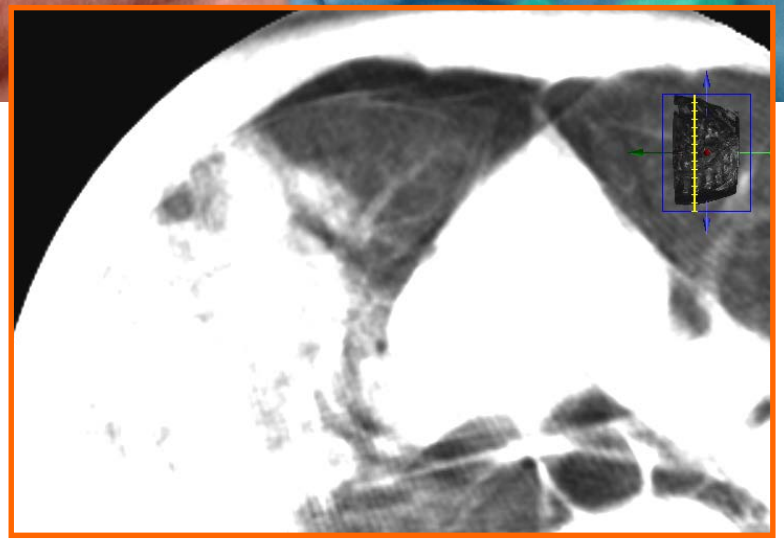
- Incidence of **intraparenchymal pulmonary hemorrhage**, **pleural effusion** and **hemoptysis** were 17.7% (44/248 sessions), 4% (8/248 sessions), and 16.1% (40/248 sessions), respectively;
- Death because of massive bleeding occurred in one session (0.4%).

Eur Radiol 2011;21:197-204

COMPLICATION: HEMORRHAGE







Complications

HEMORRHAGE

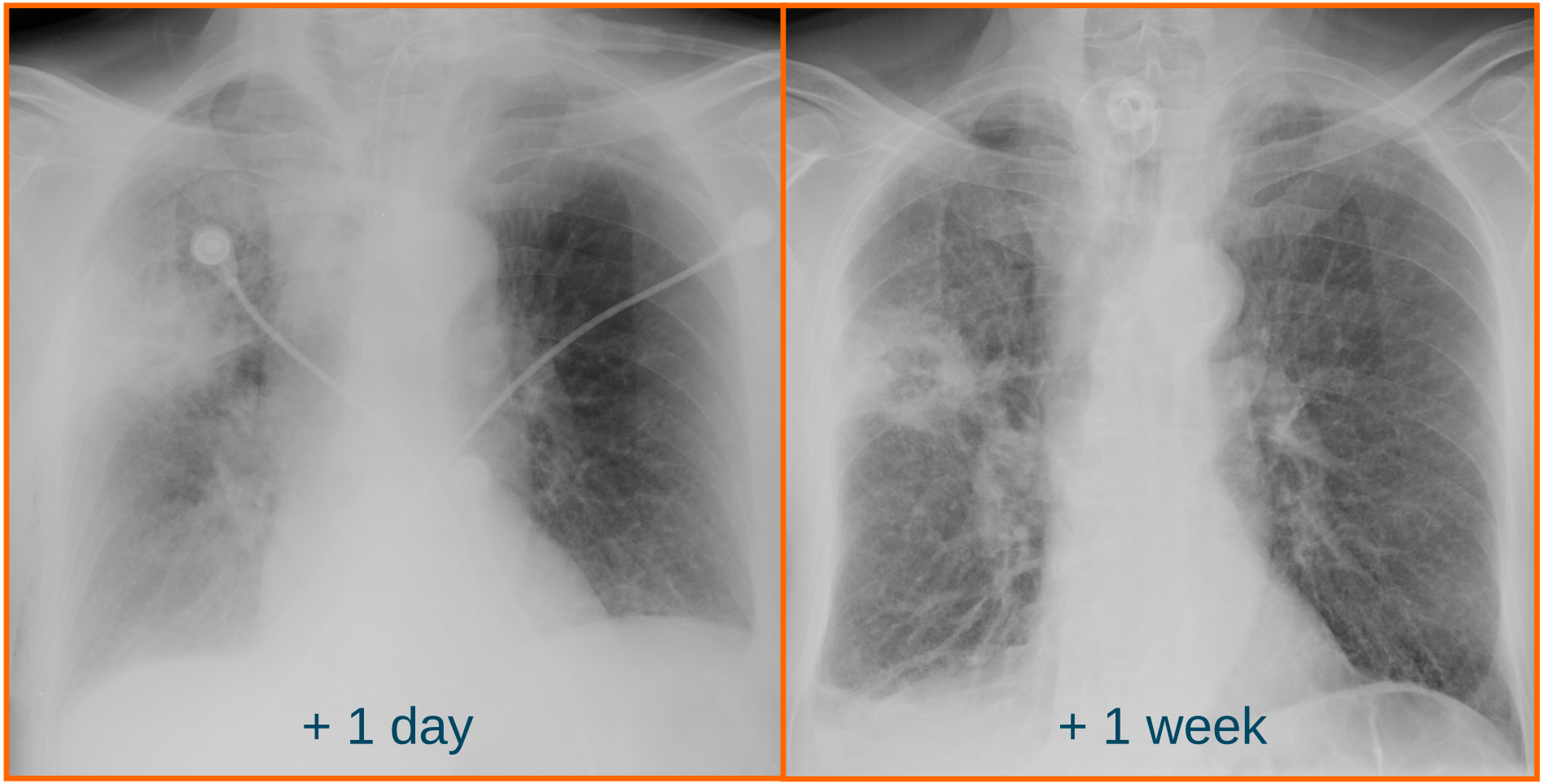
Ablation

= ***than just…***

Coagulation

Pai M, et al. Dig Surg 2012;29(1):43-7

COMPLICATION: HEMORRHAGE



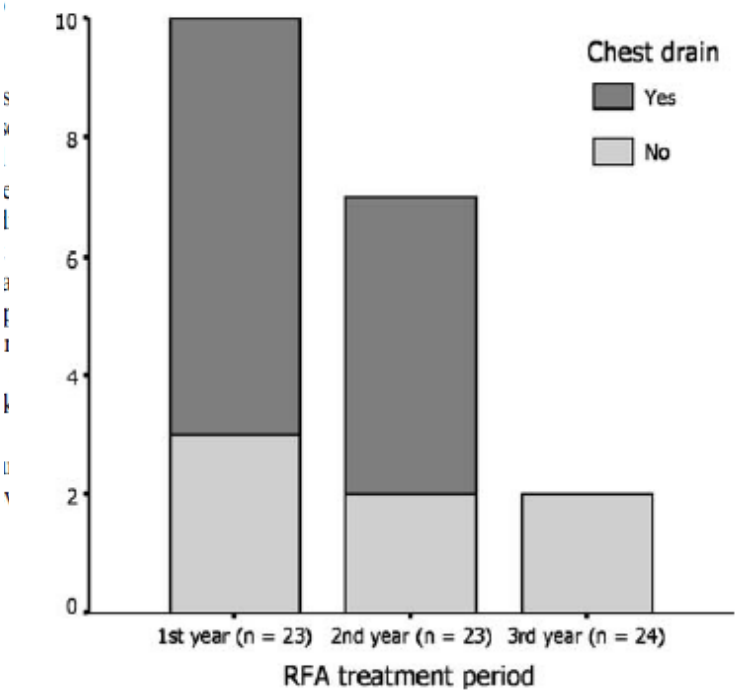
Complications

Learning Curve for Percutaneous Radiofrequency Ablation of Pulmonary Metastases From Colorectal Carcinoma: A Prospective Study of 70 Consecutive Cases

Tristan D. Yan, BSc (Med) MBBS,[1] Julie King, MPH,[1] Adrian Sjarif, MBBS,[1] Derek Glenn, MBBS,[2] Karin Steinke, MD,[1,2] and David L. Morris, MD, PhD[1]

Background: Percutaneous radiofrequency ablation (RFA) for inoperable colorectal pul

Variable	Group 1 (n)	Group 2 (n)	*P* value
Total	35	35	–
Overall morbidity	18	7	.025
Intraprocedural adverse events	6	0	.025
Intrapulmonary bleeding	5	0	.027
Coughing	1	0	–
Pleuritic chest pain	1	0	–
Postprocedural adverse events	16	7	.044
Pneumothorax	14	5	.030
Pneumothorax necessitating chest drain	10	2	.023
Pleural effusion	4	3	–
Pleural effusion necessitating chest drain	1	0	–
Pleuritic chest pain	2	2	–



Annals of Surgical Oncology, 13(12):1588–1595
DOI: 10.1245/s10434-006-9010-3

Termoablazione dei tumori polmonari

- Patient selection
- Imaging Guidance
- Technology
- Complication Management
- Follow up

Complications

CT Scan

RFA

Immediate

- Ground-glass opacificacion
- Wrinkling of tumor edges
- Vaporization
- “Cockade phenomenon”
- Cavitation (25%) – related to areas that vastly exceed the pretreatmenr tumor size

1 month

- Lesion consolidated and/or nodular with diamater > preablation size; cavitations or bubble lucencies

2-6 months

- No change or size increseament (for CR)
- PR = CR
- Pleural thickening
- CR = decrease in contrast enhancement

MWA

Immediate

- Hazy ground-glass opacificacion, extended
- Wrinkling of tumor edges
- Vaporization
- “Cockade phenomenon”
- Cavitation (25%) – related to areas that vastly exceed the pretreatmenr tumor size

1, 3, 6 months

- Ablation zone increases in size (thermal changes to the surrounding lung tissue)
- Follows a persistent reduction in lesion diameter, consistent with consolidation
- Cavitary changes (inverse relationship to cancer-specific mortality)
- Pleural thickening

Alexander ES, et al. Semin Interv Radiol 2013; 30:141-50
De Baère T, et al. Radiology 2006;240(2):587–596
Gadaleta C, et al.AJR Am J Roentgenol 2004;183(2):361–368

Complications

PET Scan

RFA and MWA

- Decrease or complete absence of PET activity – CR
- Residual or recurrent tumors tend to exhibit PET uptake (peripheralmargins of the tumor)
- False-positive PET uptake within the first 6 months of ablation (inflammatory reaction)

Alexander ES, et al. Semin Interv Radiol 2013; 30:141-50
De Baère T, et al. Radiology 2006;240(2):587–596
Gadaleta C, et al.AJR Am J Roentgenol 2004;183(2):361–368

Termoablazione dei tumori polmonari
Take Home Messages

- Correct Patient Selection
- Pre and Intra Procedural Assessment
- Best Operator Imaging
- Technology: evaluation of lesion caractheristics
- Complications: ability to manage
  (learning curve to avoid them!)
- Correct Timing and technique of Imaging Follow up


Thank you