Emerging technologies for small and smaller lesions – Update on ablation

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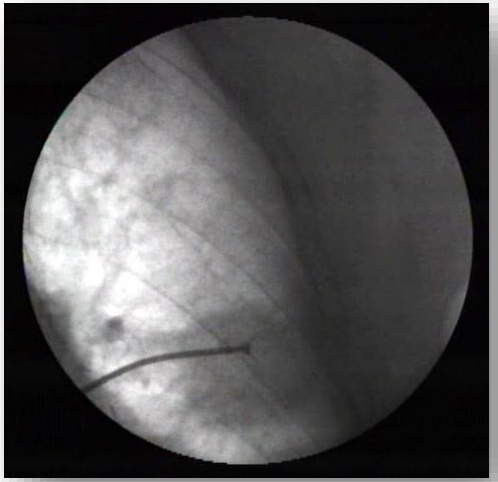
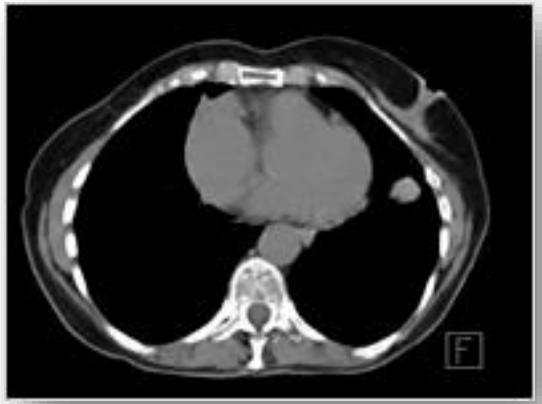
Definition of SPN

A *solitary pulmonary nodule (SPN)* or coin lesion is a mass in the lung smaller than 3 centimeters in diameter. It can be an incidental finding found in up to 0.2% of chest X-rays and around 1% of CT scans.





https://en.wikipedia.org/wiki/Solitary_pulmonary_nodule

Fluoroscopic guided TBB

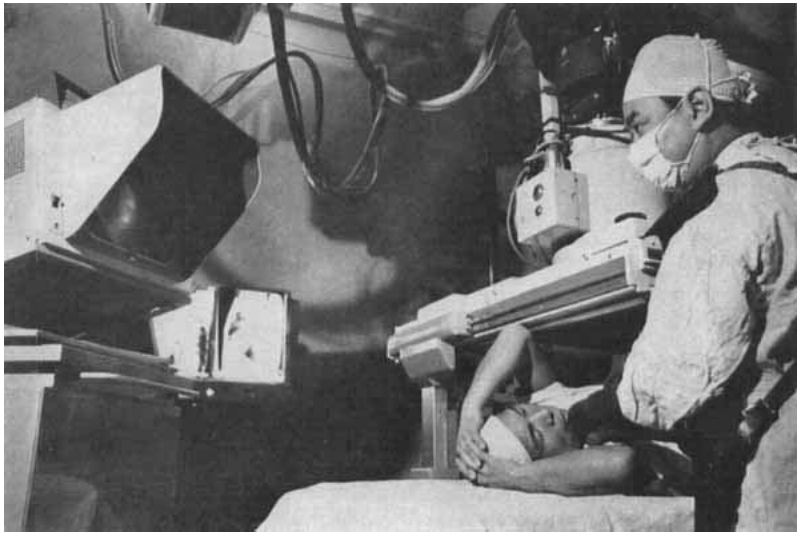
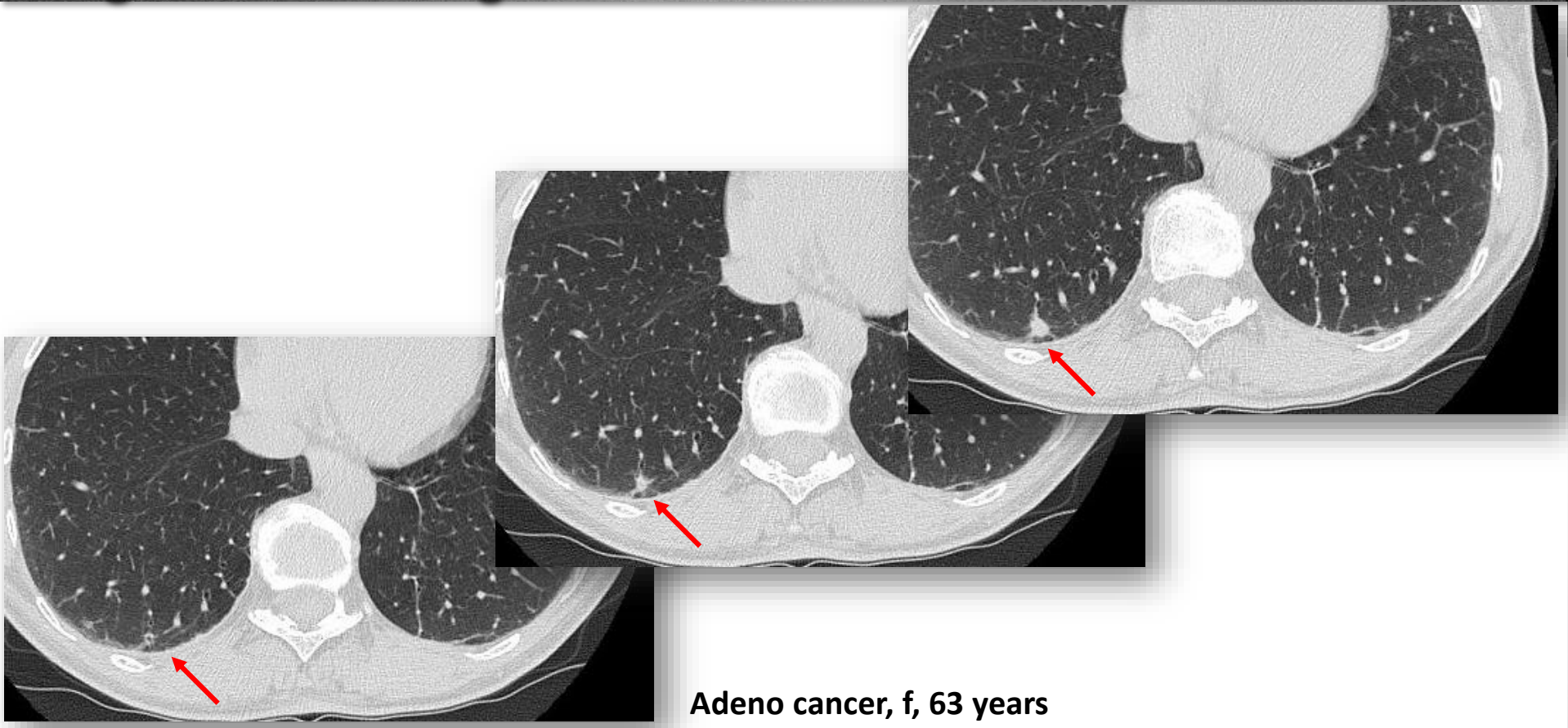


TABLE 5. Result of Transbronchial Biopsy on Metastatic Pulmonary Tumors

Tumor diameter (cm)	No. of cases	Positive	Negative	Accuracy
–2.0	8	1	7	
2.1–3.0	6	1	5	
3.1–	10	5	5	
TOTAL	24	7	17	29.1%

Tsuboi et al., Cancer 1967

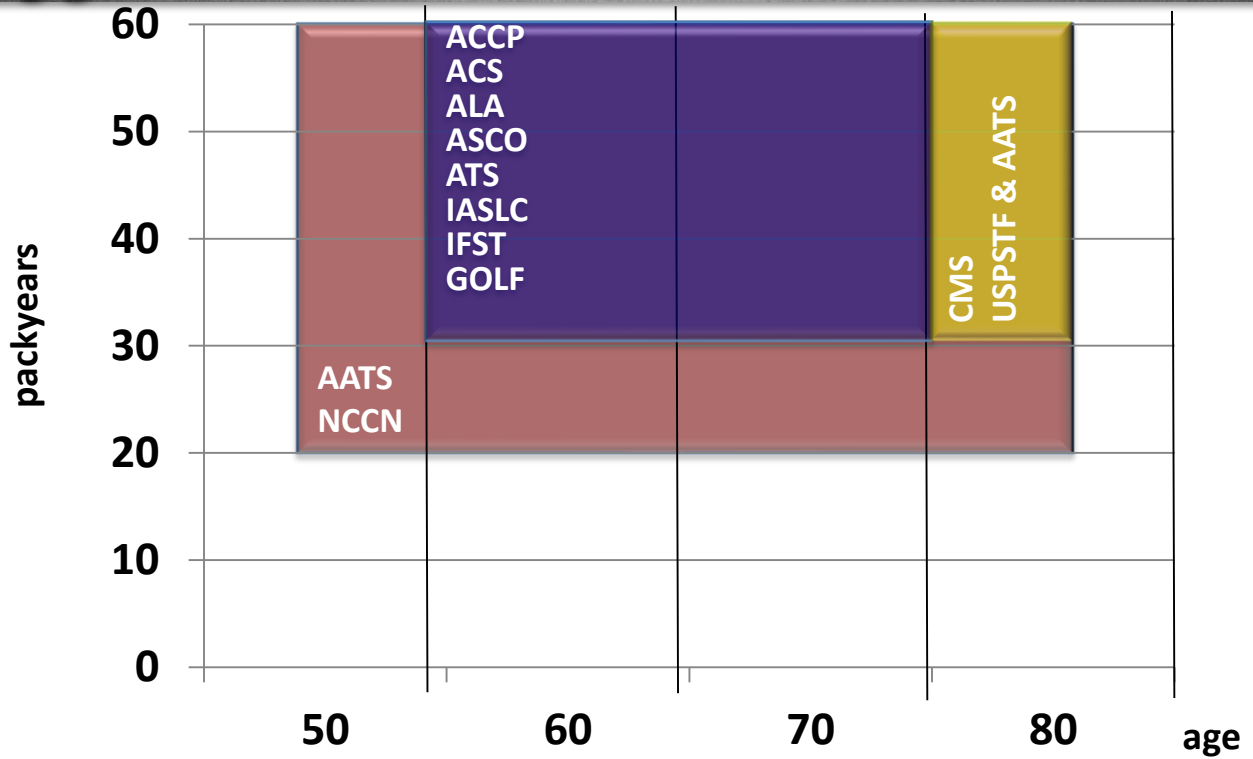
Lung cancer screening



Adeno cancer, f, 63 years

Courtesy of CP. Heussel, Thoraxklinik Heidelberg

LC screening guidelines



AATS: American Association for Thoracic Surgery
NCCN: National Comprehensive Cancer Network
CMS: Centers for Medicare & Medicaid Services
IFST: Cancer Network
GOLF: Cancer Care
USPSTF: US Preventive Services Task Force

ACCP: American College of Chest Physicians
ACS: American Cancer Siociety
ALA: American Lung Association
ASCO: American Society of Clinical Oncology
ATS: American thoracic Society
IASLC: International association of Study of Lung Cancer

Lung cancer screening

trial	SPN	thereof malignant	SPN size
NLST (n= 53.454)	6466	3.6 %	1.3 cm
DANTE (n=2472)	672	4.1 %	1.1 cm
DLCST (n=4104)	983	0.7 %	1.2 cm
Nelson (n=15,822)	2507	8 %	1.4 cm
LUSI (n=4052)	540	1.6 %	1.5 cm

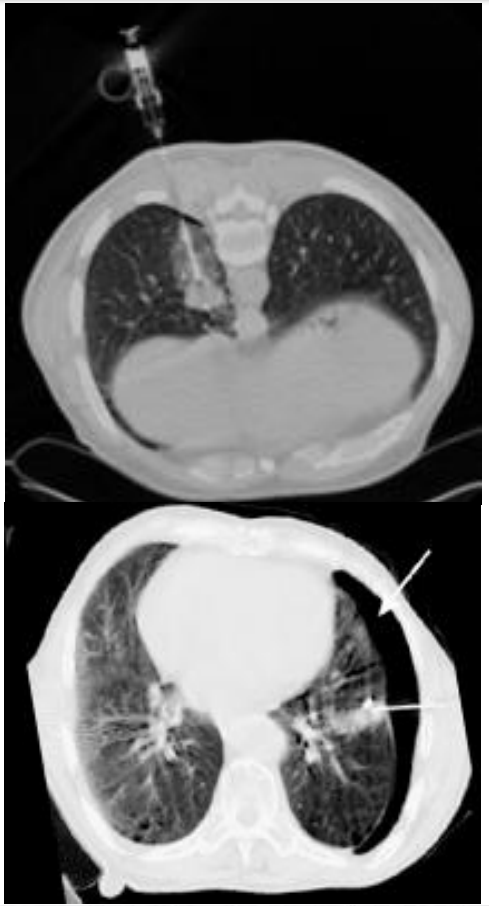
Access to SPN

Dx Options for Peripheral Nodules < 3 cm - comparison

Diagnosis Option	Modality	Yield	Details
Chest x-ray or CT	Radiographic	N/A	Good early indicator, but not definitive
Transbronchial biopsy under fluoro guidance	Bronchoscopic	~30%	Very difficult to localize and access intraparenchymal nodules
TBB w/Navigation	Bronchoscopic	60-80%	Addition of navigation increases yield by 30-50% Avoids issues associated with TTNA
Transthoracic sampling (TTNA)	CT Guided	90%	Although this technique has a higher yield, it is difficult to reach nodules close to vessels, risk of pneumothoraces, chest tube placement
Thoracotomy, Thoracoscopy	Surgery	90%+	Surgery is invasive, expensive, painful, long patient recovery time

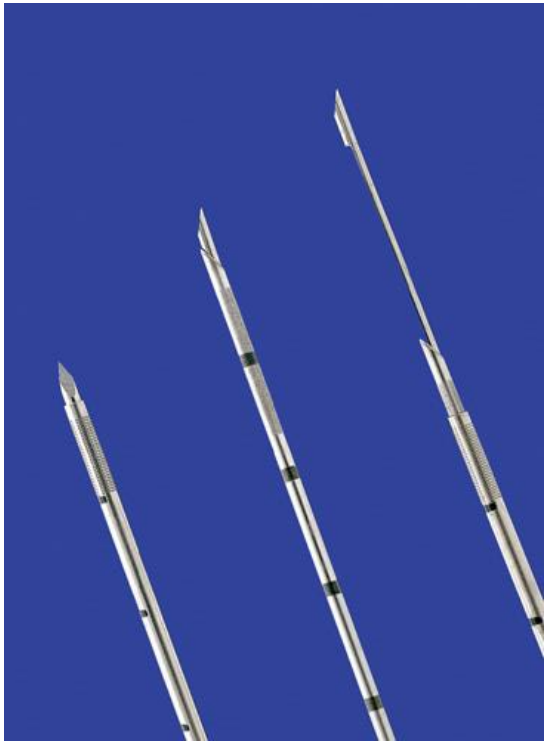
Transthoracic needle aspiration

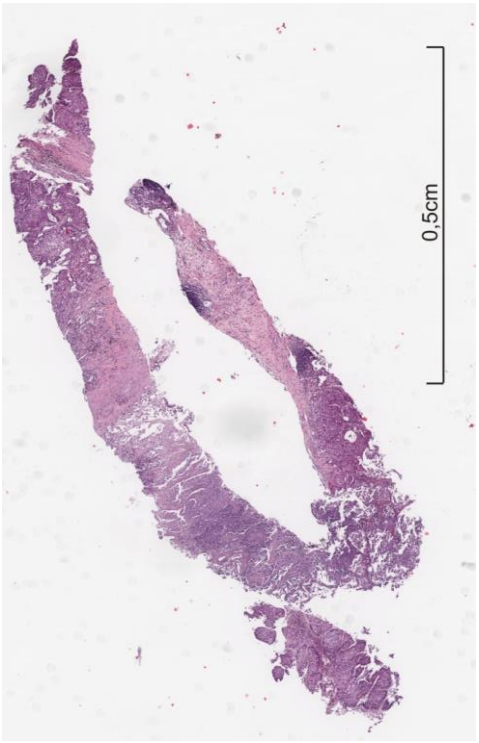
- “Über infectiöse Pneumoniae”
  - Leyden O, Dtsch. Med. Wochenschr 1893
- Sensitifity for malignancy
  - 72 % - 90 %
- Complications:
  - Pneumothorax up to 50%
  - 10-25 % drainage needed



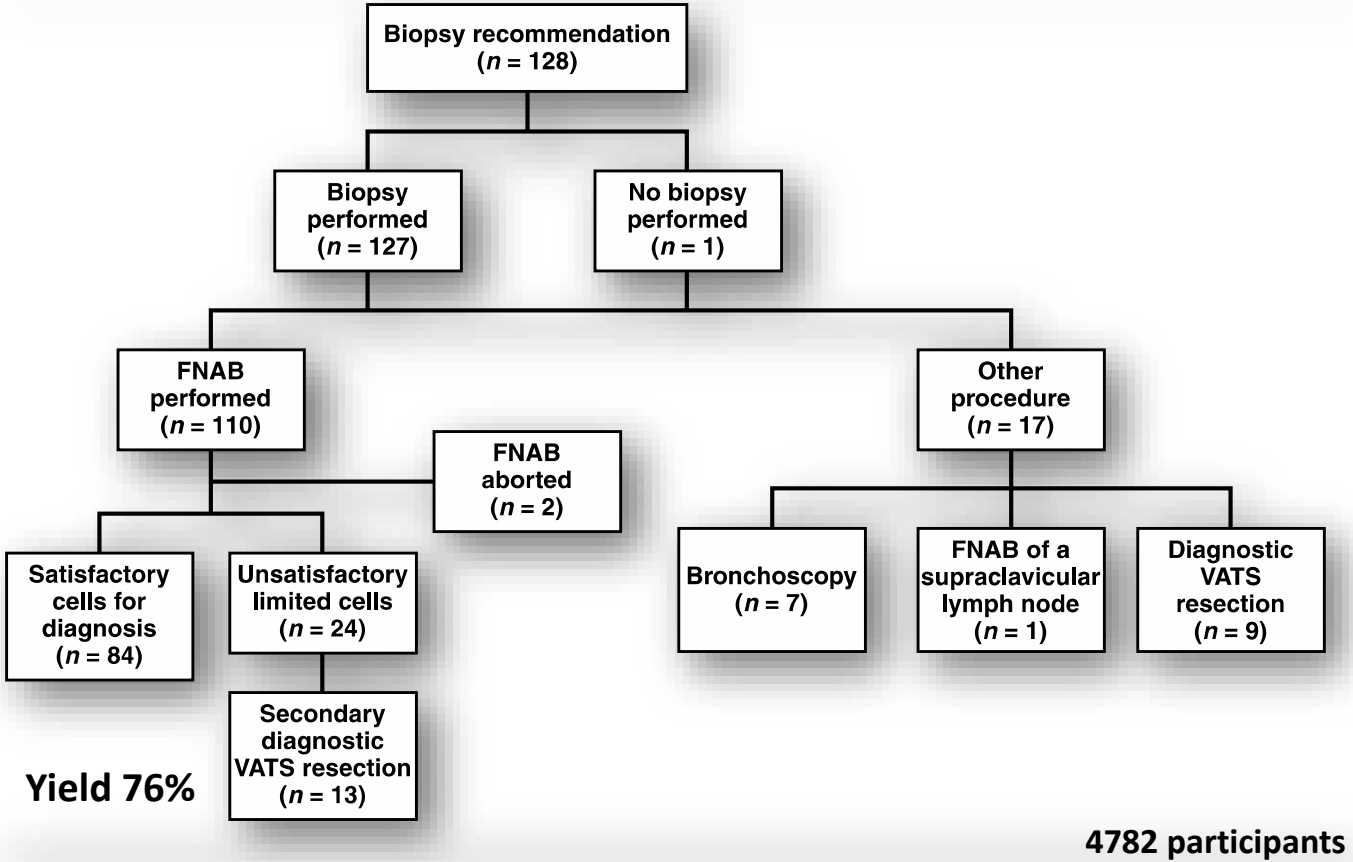
Manhire A et al. Guidelines for radiologically guided lung biopsy. Thorax 2003
Rivera MP et al., Establishing the Diagnosis of Lung Cancer , Chest 2013

CT guided NA





I-ELCAP – Toronto subtrial



Wagnetz et al., AJR 2012; 198:351–358

I-ELCAP – Toronto subtrial

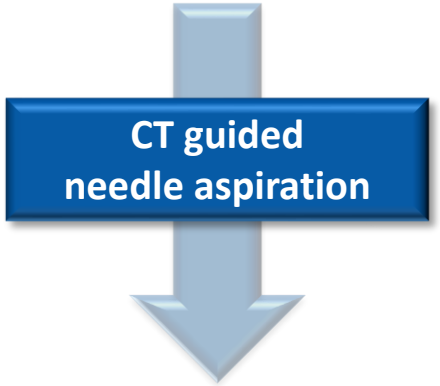
complications

- **44 % asymptomatic pneumthoraces**
- **13 % Pneu with drainage**

=> pneumo rate 57%

CT guided needle aspiration

248 patients
SPN < 20 mm



yield
complications

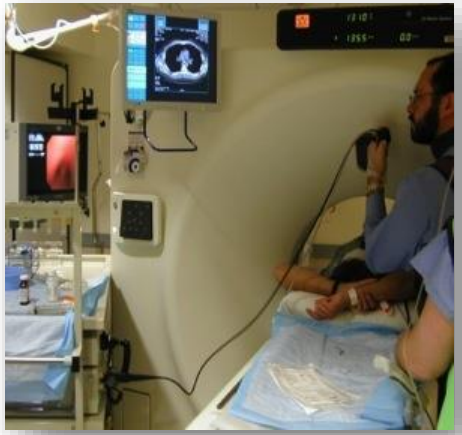
Characteristics	N	Pneumothorax rate (%)
Age, years		
>60	120	15.0
≤60	128	17.2
Sex		
Male	144	19.4
Female	104	15.4
Size of pulmonary nodule		
≤10 mm	108	15.7
>10 mm and < 20 mm	140	16.4
Needle path length, mm		
≤30	86	10.5
31–50	124	16.9
>50	38	26.3
Number of punctures		
1	213	13.6
2	35	31.4

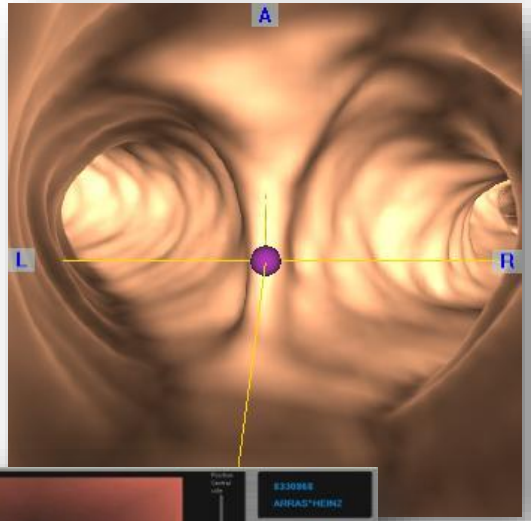
yield: 93 %, pneumorate 24%

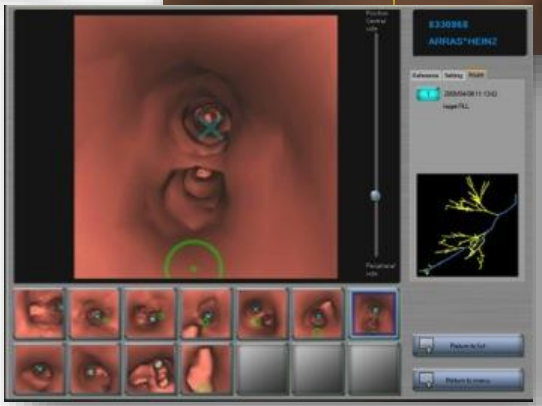
Fluoroscopic guided TBB

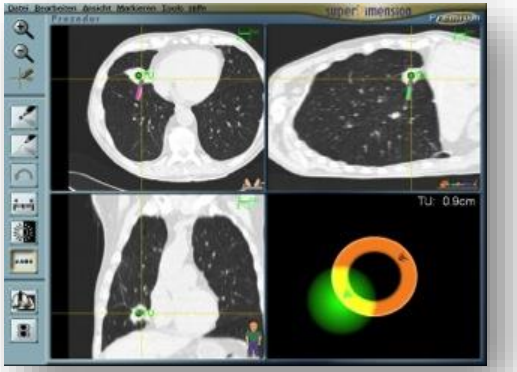
All Methods:		< 2 cm LESION				> 2 cm LESION			
First Author	**Year**	**N**	**Pos**	**Neg**	**Sens**	**N**	**Pos**	**Neg**	**Sens**
Gasparini[110]	1995	195	82	113	**42**	300	169	131	**56**
Hattori[76]	1971	17	13	4	**76**	182	150	32	**82**
Baaklini[88]	2000	16	4	12	**25**	135	93	42	**69**
Wallace[122]	1982	65	3	62	**5**	78	24	54	**31**
Bandoh[130]	2003	25	8	17	**32**	72	50	22	**69**
Radke[106]	1979	21	6	15	**29**	76	49	27	**64**
Naidich[121]	1988	15	4	11	**27**	46	26	20	**57**
Trkanjec[129]	2003	17	9	8	**53**	33	27	6	**82**
McDougall[105]	1981	9	1	8	**11**	36	21	15	**58**
Stringfield[107]	1977	3	1	2	**33**	26	13	13	**50**
Summary		383	131	252	**34**	984	622	362	**63**

Bronchoscopic Navigation techniques

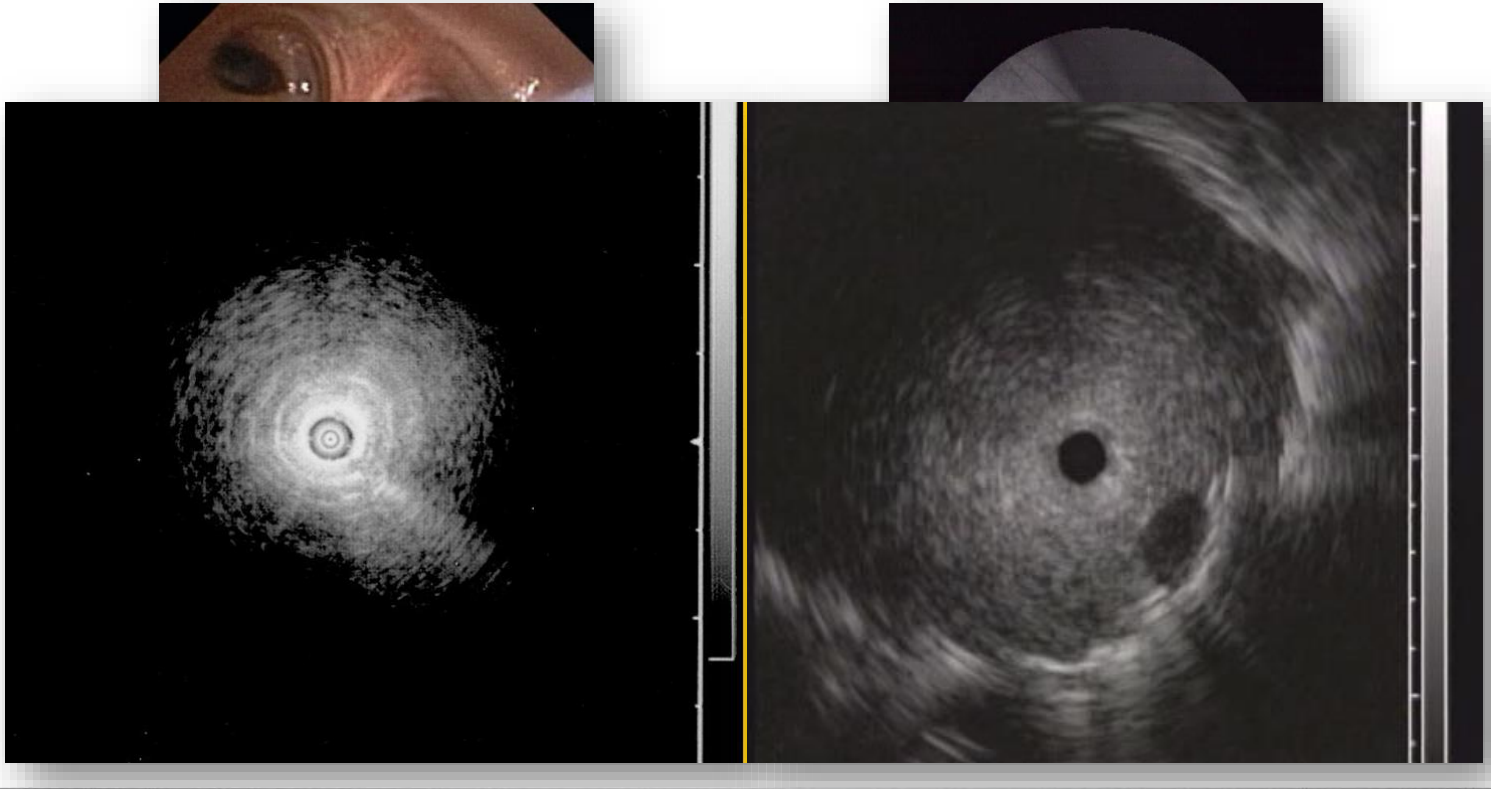








EBUS guided TBB



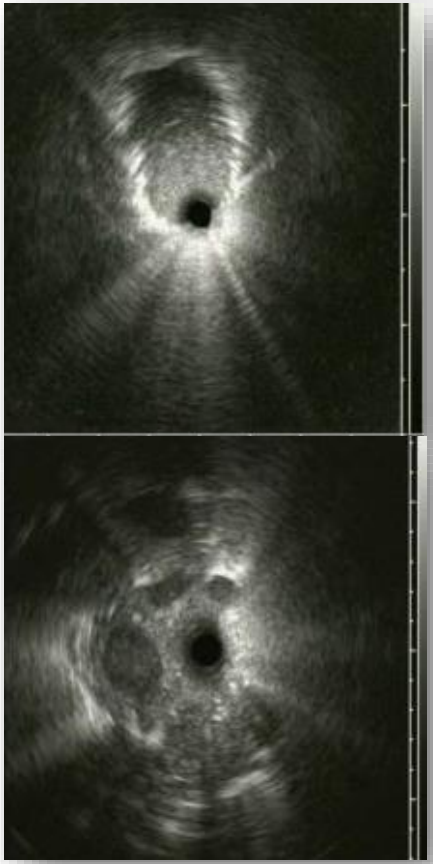
EBUS TBB

Pro´s

- improved yield
- with/without fluoroscopy 69 - 75 %

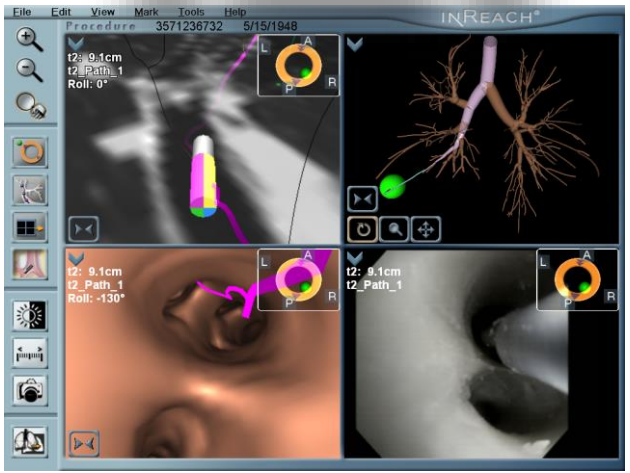
Con´s

- try and error technique
- no steerability
- additional procedure costs (probe, guide sheath)
- yield drops below SPN < 2 cm



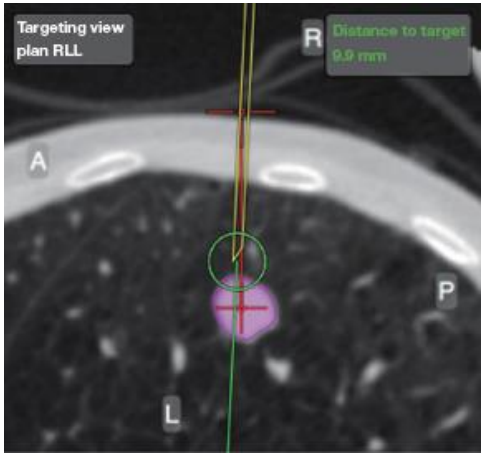
Schwarz Y et al. Chest 2006, Gildea TR et al. Am J Respir Crit Care Med 2006, Eberhardt R et al. Chest 2007, Makris D et al. Eur Respir J 2007, Eberhardt R et al. Am J Respir Crit Care Med 2007, Eberhardt et al., Respiration, 2010

Electromagnetic navigation bronchoscopy (ENB)



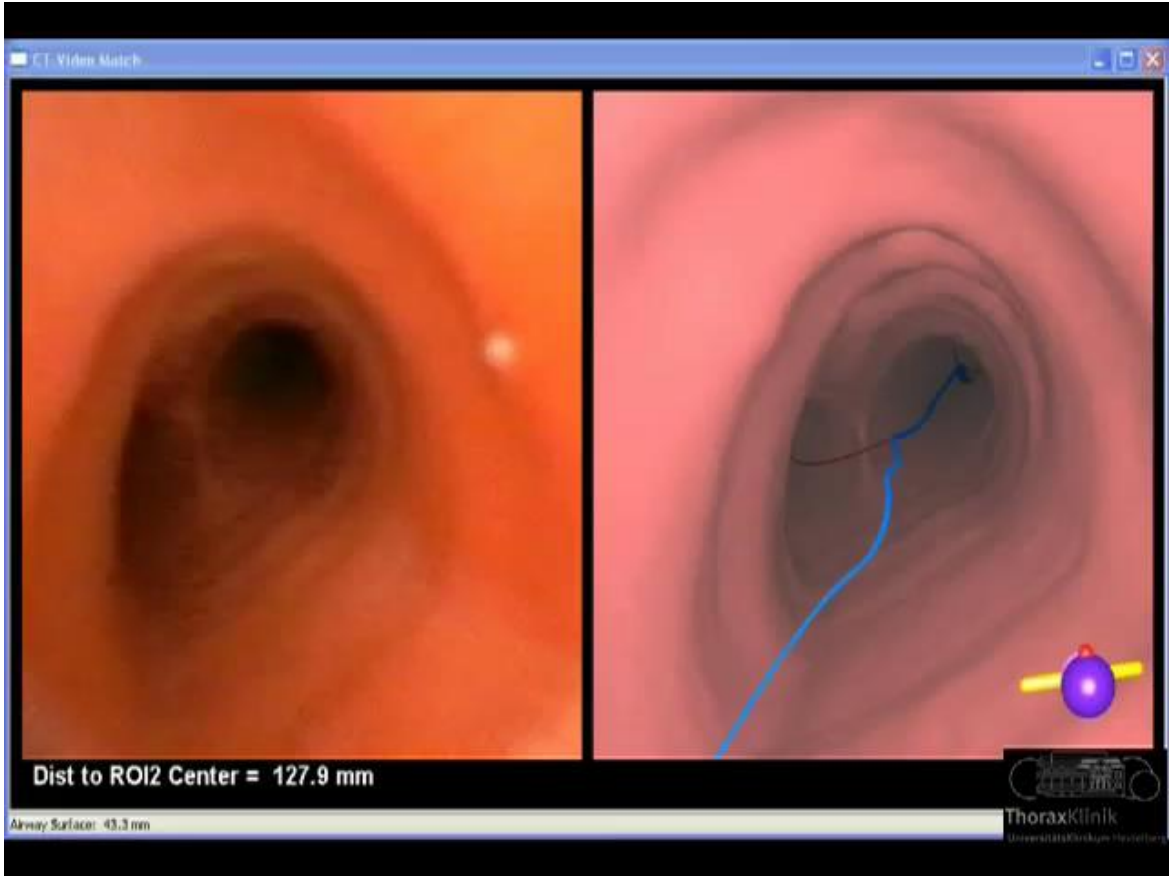
i-Logic© (Medtronic)

SPiNDrive© (Veran)



- virtual CT-reconstruction
- elektromagnetic field
- steerable probes/instruments
- extended working channel

Lungpoint AR Navigation Procedure Video



LungPoint® Navigation - a approach to SPN

feasibilty and safety trial

- SPN < 40 mm
  - mean 28 mm
- definitive diagnosis 80%
- 1 small pneumothorax

Eberhardt R et al., Respiration 2010

- 68 SPN < 30 mm
  - mean 22 mm (R 10–30 mm)
- diagnostic yield 77.9%

Tamiya et al., Respirology 2013

Navigated bronchoscopy

Pro´s

- **NB improves yield**
- **with fluoroscopy 69 - 75 %**
- **without fluoro 62 – 77 %**

Con´s

- **no real-time control**
- **virtual reality**
- **additional procedure costs (Medtronic, Veran, steerable catheter)**
- **yield drops below SPN < 2 cm**

Schwarz Y et al. Chest 2006, Gildea TR et al. Am J Respir Crit Care Med 2006, Eberhardt R et al. Chest 2007, Makris D et al. Eur Respir J 2007, Eberhardt R et al. Am J Respir Crit Care Med 2007, Eberhardt et al., Respiration, 2010

ENB – EBUS combination

120 patients
SPN 10-32 mm

EBUS
vs.
EMN
vs.
EBUS + EMN

yield
complications

	EBUS n (%)	ENB n (%)	EBUS and ENB n (%)
Overall diagnostic yield	27/39 (69)	23/39 (59)	35/40 (88)
Yield by lesion size:			
≤ 20 mm	7/9 (78)	3/4 (75)	9/10 (90)
20 - 30mm	16/23 (70) p=0.80	11/22 (50) p=0.50	21/24 (88) p=0.99
> 30 mm	4/7 (57)	9/13 (69)	5/6 (83)
Yield by lobar location:			
Bilateral upper lobes	16/27 (59)	17/22 (77)	17/20 (85)
Right middle lobe	3/3 (100) p=0.18	2/3 (67) p=0.01†	2/2 (100) p=0.99
Bilateral lower lobes	8/9 (89)	4/11 (29)	16/18 (89)
Yield for malignant disease:			
Sensitivity	23/32 (72)	16/29 (55)	28/31 (90)
Specificity	7/7 (100)	10/10 (100)	9/9 (100)
Positive predictive value	23/23 (100)	16/16 (100)	28/28 (100)
Negative predictive value	7/16 (44)	10/23 (44)	9/12 (75)
Yield for benign disease:			
Sensitivity	4/7 (57)	7/10 (70)	7/9 (78)
Specificity	32/32 (100)	29/29 (100)	31/31 (100)
Positive predictive value	4/4 (100)	7/7 (100)	7/7 (100)
Negative predictive value	32/35 (91)	29/32 (91)	31/33 (94)
Pneumothorax rate	2/39 (5)	2/39 (5)	3/40 (8)

VBN and rEBUS

199 patients
SPN 10-30 mm

VBN + rEBUS
vs.
classical bronch + rEBUS

yield
complications

Table 3 Diagnostic yield according to lesion size in the per-protocol population

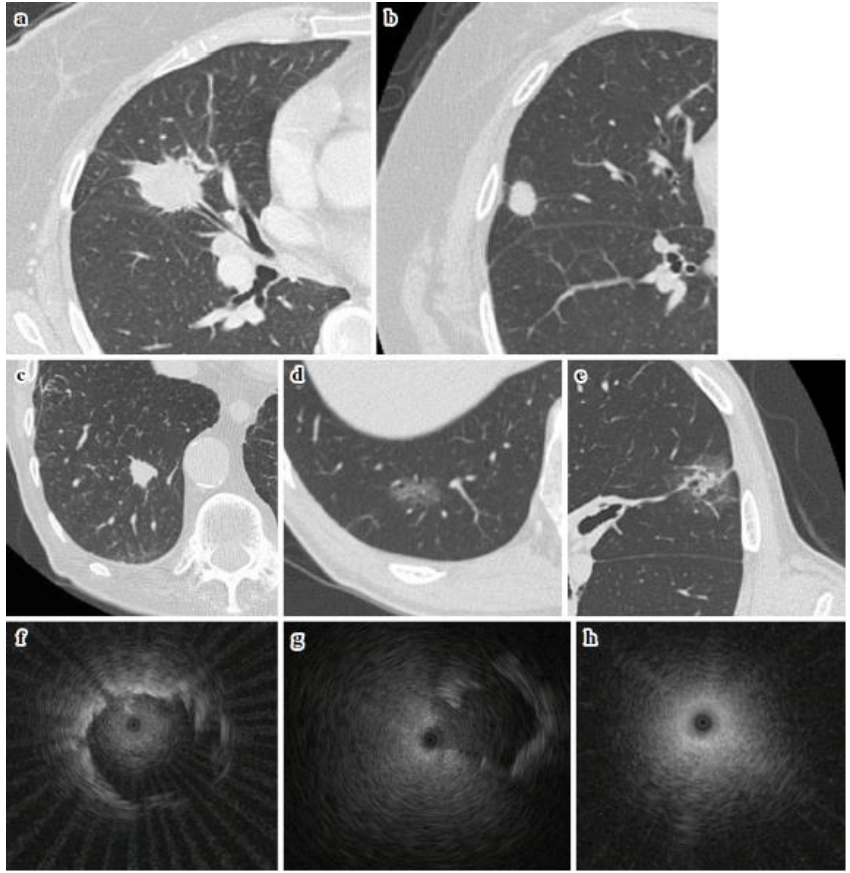
Lesion size	Bronchoscopic diagnosis		p Value
	VBNA	NVBNA	
<20 mm	44/58 (75.9)	35/59 (59.3)	0.056
20–30 mm	36/41 (87.8)	29/36 (80.6)	0.382
Total	80/99 (80.8)	64/95 (67.4)	0.032

Ishida T et al., Thorax 2011

Review Navigation

	Study	Year	# > 20mm	dx > 20mm	Yield > 20mm (%)	# ≤ 20mm	dx ≤ 20mm	Yield ≤ 20mm (%)
1	Kikuchi[26]	2004	9	6	66.7	15	8	53.3
2	Kurimoto[27]	2004	69	57	83	81	59	73
3	Asahina[30]	2005	12	11	91.7	18	8	44.4
4	Schwarz[33]	2006	11	8	72.7	2	1	50
5	Gildea[34]	2006	23	17	73.9	31	23	74.1
6	Asano[35]	2006	12	10	83.3	26	21	80.8
7	Dooms[38]	2007	39	32	82.1	11	2	18.2
8	Makris[39]	2007	20	15	75	20	10	50
9	Eberhardt[20]	2007	30	20	67	9	7	78
10	Tachihara[40]	2007	19	18	94.7	77	42	54.5
11	Yoshikawa[41]	2007	86	78	90.7	37	28	75.7
12	Eberhardt[42]	2007	57	40	63	35	22	70
13	Yamada[43]	2007	84	65	77.4	74	41	55.4
14	Asano[45]	2008	17	16	94.1	15	11	73.3
15	Oki[47]	2008	75	55	73.3	23	13	56.5
16	Lamprecht[48]	2009	9	7	77.8	4	3	75
17	Eberhardt[51]	2009	0	0		100	46	46
18	Bertoletti[52]	2009	46	37	80.4	7	3	42.9
19	Oki[54]	2009	57	44	77	14	5	36
20	Iwano[55]	2009	92	74	80.4	30	22	73.3

SPN navigation factors of success



Bronchus sign

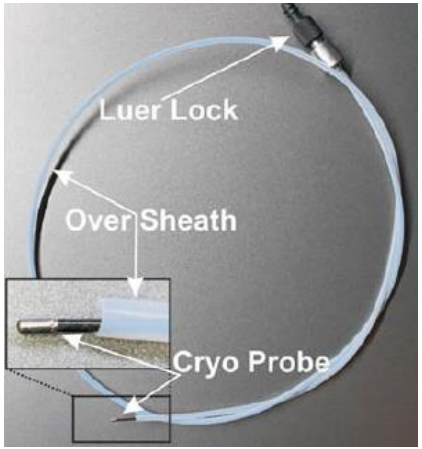
+ size

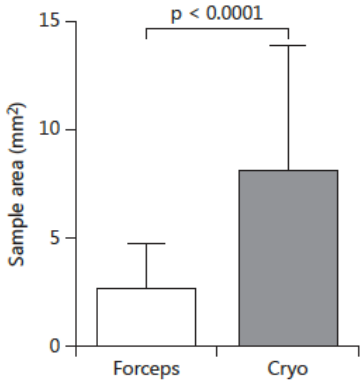
Solid vs GGO

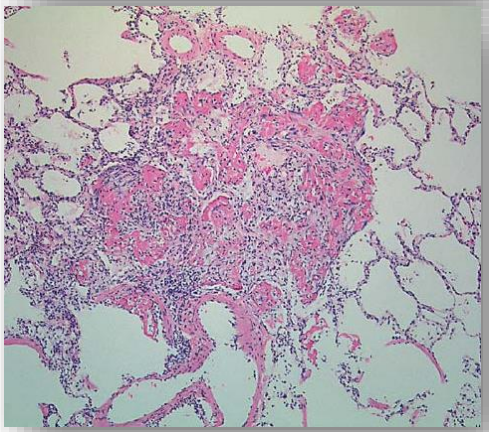
+ location

Probe placement

Influence of biospy tools - Cryoprobes



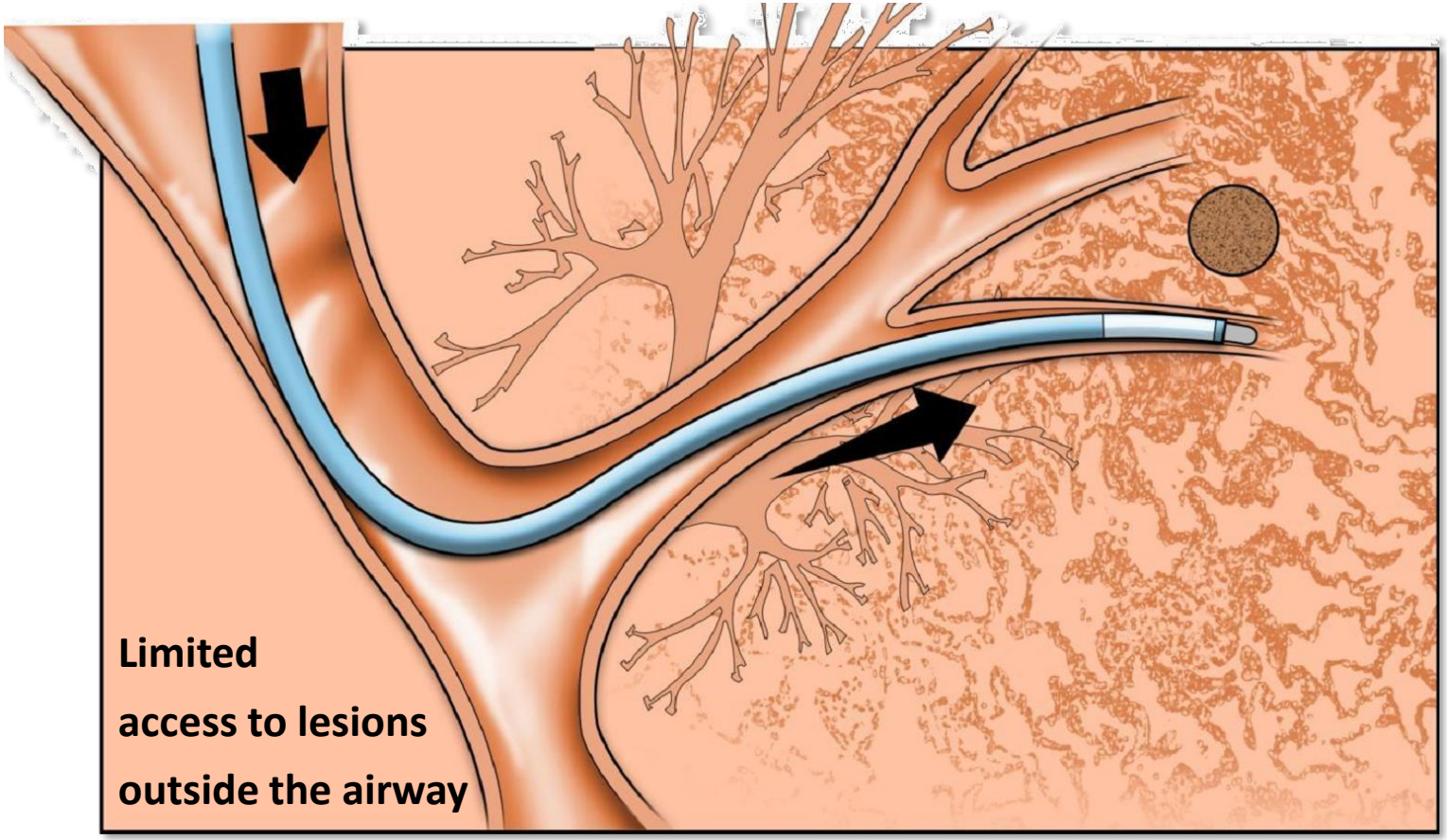




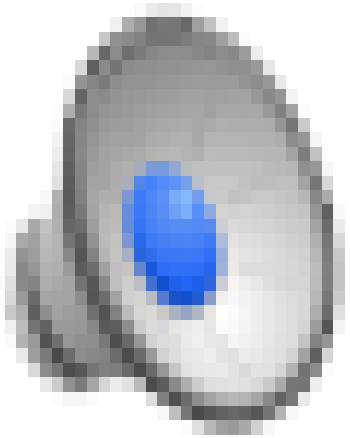
Solitary Pulmonary Nodule (SPN)

Pulmonary nodules < 2 cm …
a diagnostic dilemma !!!

Biopsy limitation



Trans-Parenchymal Nodule Access



Trans-Parenchymal Nodule Access: First in human data

Site	Size (mm)	Visible at fluoroscopy	Procedure planning time (min)	Nodule access time (min)	Fluoroscopy time (min)	Intra-procedural adverse events	Tunnel length (mm)
LUL	40	Yes	10	40	11.6	None	10
Lingula	20	Yes	15	Data not recorded	7.09	None	50
LLL	25	No	30	30	5.18	None	60
LUL	31	Yes	18	No sample taken	5	Sheath could not be directed along optimal path	–
RML	22	No	15	26	6.7	None	50
LLL	22	No	12	13	3	None	30
RLL	30	No	25	30	1.8	None	30
RLL	18	Yes	15	17	3.6	None	60
RLL	20	No	30	12	4.2	None	90
RML	28	Yes	15	13	9.8	None	70
LUL	17	No	14	No sample taken	N/A	Sheath could not be directed along optimal path	–
LUL	31	No	10	15	2.1	None	20

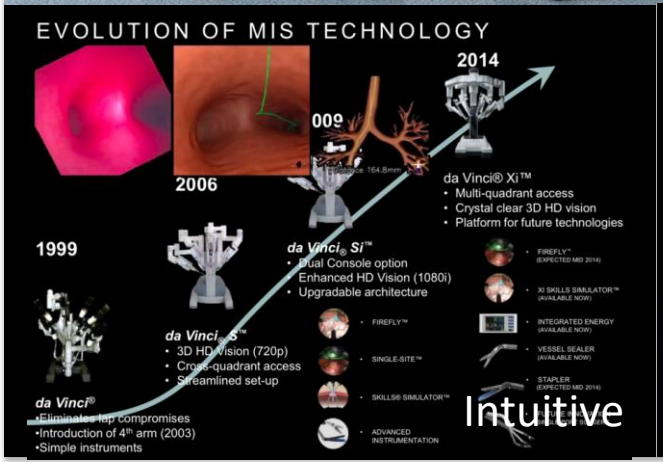
Herth FJF et al., Thorax 2015

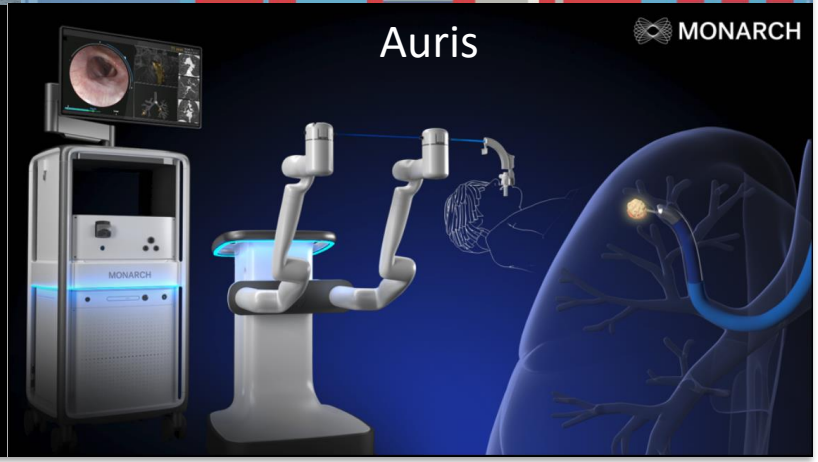
Non-Bronchus Sign SPN's - Results

Lesion Size	Diagnostic Yield	SPN Major Axis Mean (mm)	Closest Distance to Pleura Based on Biopsy Angle Mean (mm)
<20.0mm	83.8%	12.3 ± 4.2	21.3 ± 13.2
≥20.0mm	83.8%	23.8 ± 2.5	19.0 ± 18.7

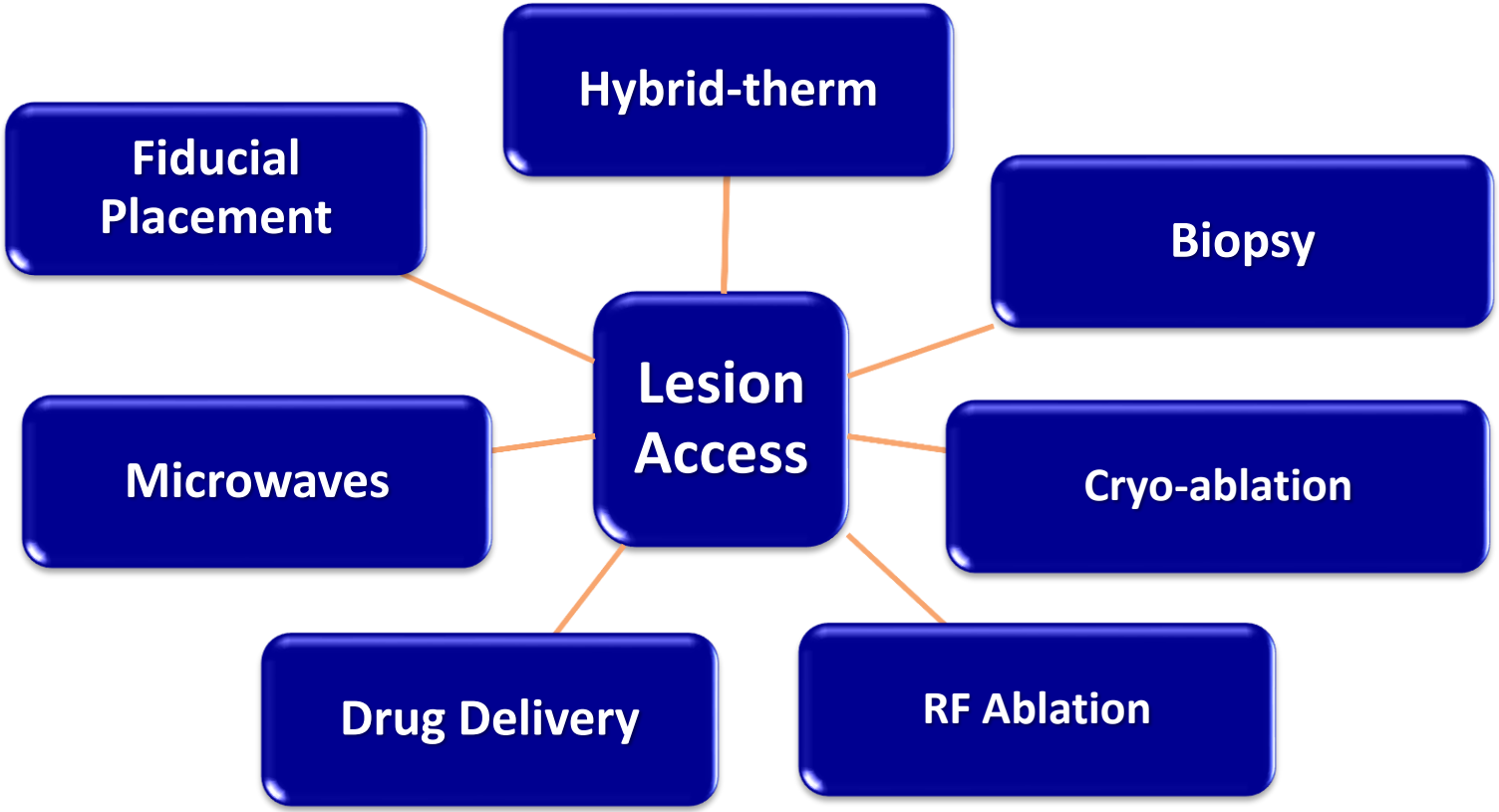
Overall diagnostic yield was 83,8% on SPNs with a mean major axis of 18.1 ± 6.8 mm

Robotic bronchoscopy

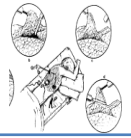
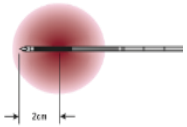
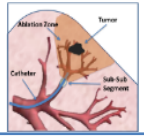




Option for therapy



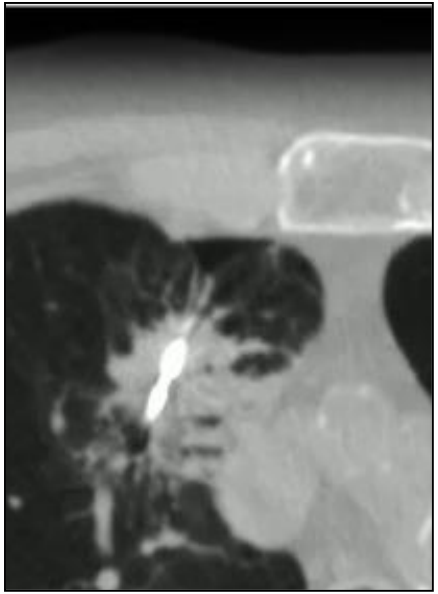
Lung Cancer Treatment Options

Surgery	SBRT	RF/MW/Cryo	Vapor
			
Effective	Complete kill difficult to achieve and determine	Complete kill difficult to achieve and determine	Effective (Anticipated)
30 – 90 minutes	20 min beam on, 3 times over 2 wks	8 – 30 minutes per ablation	8-10 seconds per ablation
Surgeon	Radiation Oncologist	Interventional Radiologist	Interventional endoscopist
In OR	In dedicated suite	In CT gantry	bronchoscopy lab
38% major complications	Stroke, myocardial infarction, aggravation emphysema	Pneumothorax	Substantially safer
Wide margin resected	Fiducials, tattoos, immobilization	Probe must be in center of lesion	Easy placement in proximal airway
Pulmonary function impact	Toxicity build up	Repeatable, but slow	Easily repeatable in other areas

RF-Ablation of Lung Tumors

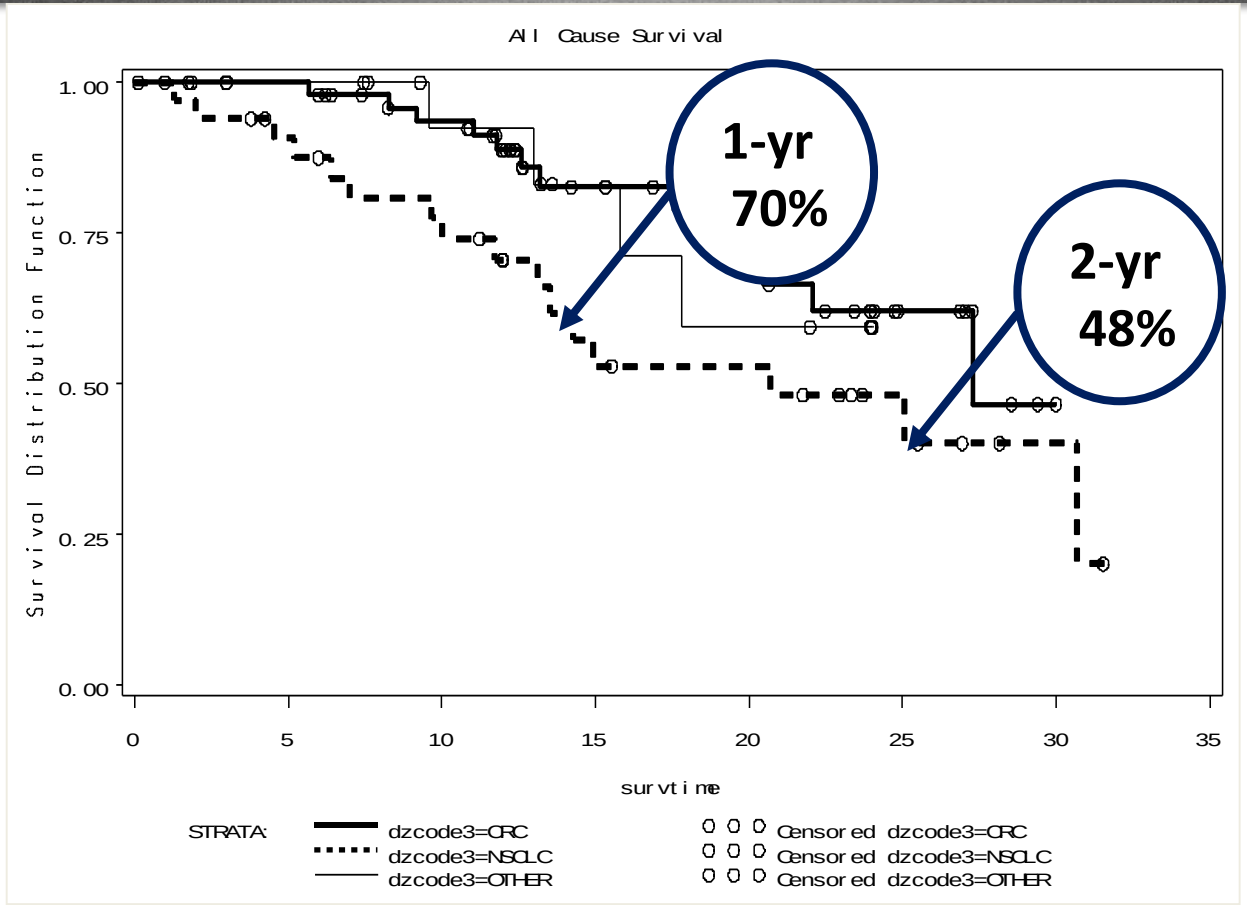
Pre - Ablation

Peri - Ablation



Post - Ablation

RAPTURE: Overall Survival

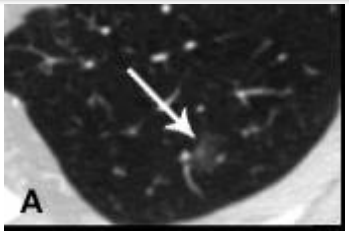


Lencioni et al. Lancet Oncol 2008; 9:621-628

RFA of Lung Cancer

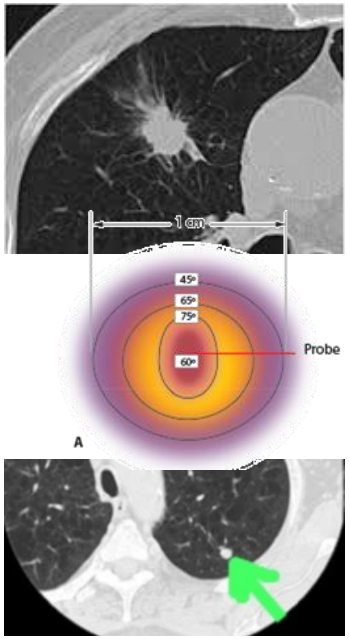
Relies on thermal conductivity of tumor to ablate

- **Semi-solid tumors have regions of low thermal conductivity**
- **Ground glass opacities (GGO) have very low thermal conductivity**



Relies on a small surface area to volume ratio (SA to V ratio)

- **Majority of malignant early stage tumors are spiculated**
- **Spiculations are "tentacle like" outgrowths**



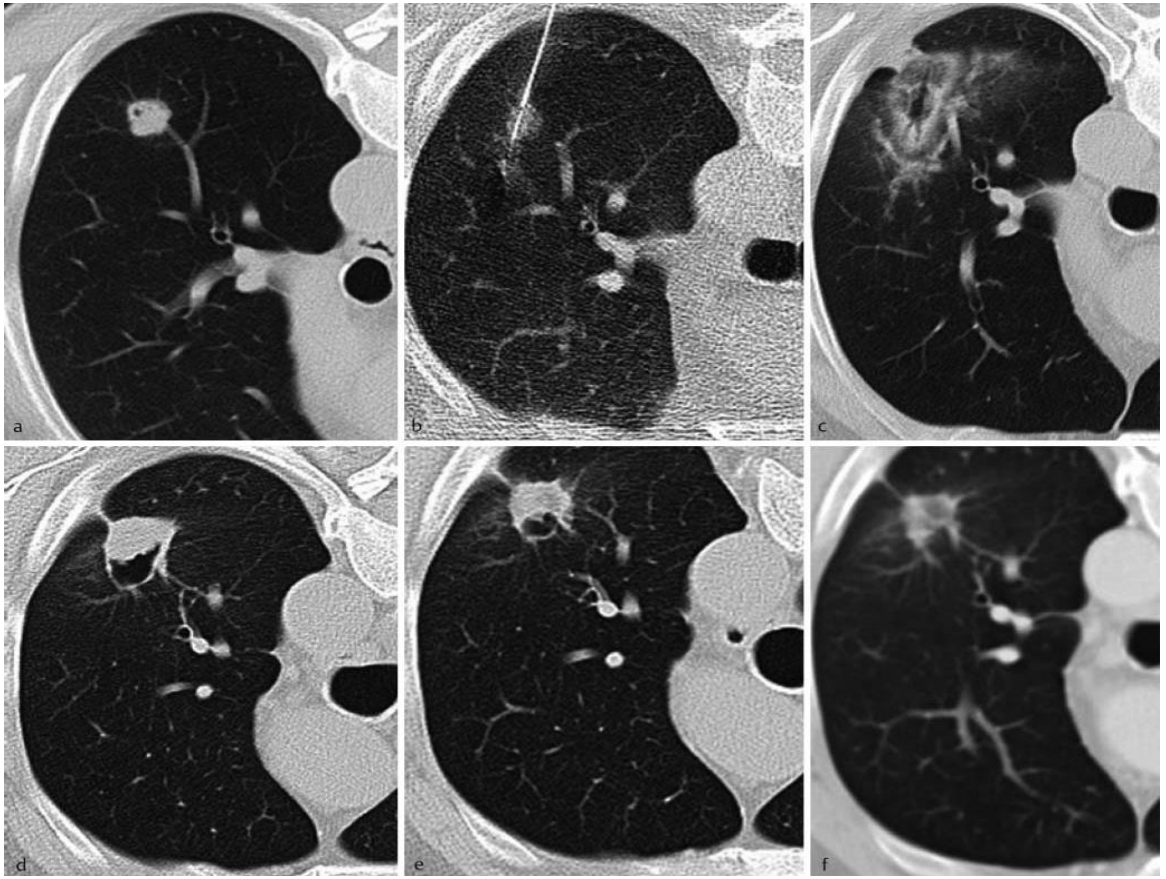
Often desiccates and chars tissue

- **Causes incomplete ablation of tumor by forming insulative sleeve around probe**

Good in solid, non-spiculated tumors <u>≤</u> 2cm

Microwave Ablation

Microwave



Microwave - results

author, year of publication	patient number (n)	pathology (number of ablated lesions)	follow-up (months)	LTP (%)	overall survival (OS) (%) cancer-specific survival (CSS) (%)				
					1 year	2 years	3 years	4 years	5 years
Wolf, 2008 [1]	50	NSCLC: 27 SCLC: 3 Met: 20	Mean: 10	26	OS: 65 CSS: 83	55 73	45 61		
Vogl, 2011 [2]	80	Met: 130	Mean: 9	27	OS: 91	75			
Lu, 2012 [3]	69	NSCLC (I-IV): 56 Met: 37	Median: 18	16	OS NSCLC: 75 OS Met: 47	54 24	29 14		
Belfiore, 2013 [8]	56	NSCLC: 44 Met: 25	N/A	0	CSS: 69	54	49		
Carrafiello 2014 [9]	24	NSCLC (I-IV): 14 Met: 11 Microcytoma: 1	Mean: 9.9	23	OS: 75	55			
Liu, 2013 [10]	15	NSCLC (I): 15	Median: 12	31					
Yang, 2014 [12]	47	NSCLC (I): 47	Median: 30	27	OS: 89	63	43		16
Han, 2015 [15]	28	NSCLC (I+ IIA): 28	Median: 22	32	OS: 80.5 CSS: 95	74 74	22 65	22 65	
Sun, 2015 [18]	29	NSCLC (I-IV): 15 Met: 14	Median: 25	34	OS: 91	86			
Egashira, 2016 [22]	44	Met: 87	Median: 15	2					

Vogl et al., Rofo 2017

Microwave - complications

author, year of publication	patient number (n)	procedure-related deaths (%)	pneumothorax (%)	severe pneumothorax (%)	hemorrhage(H) hemptysis (P) hemothorax (T) (%)	skin burns (B) pain (P) (%)	pneumonia (%)	pleural effusion (%)
Wolf, 2008 [1]	50	1.5	39	12	6 (P)	3 (B) 2 (P)	3	–
Vogl, 2011 [2]	80	0	8.5	0.8	6 (H) 4.6 (P)	0.8 (B) 9 (P)	–	–
Lu, 2012 [3]	69	0	18.8	7.2	7.2 (P) 2.9 (T)	2.9 (P)	–	–
Belfiore, 2013 [8]	56	0	32	14	–	17.8 (P)	–	–
Carrafiello 2013 [9]	24	0	37.5	0	3.8 (P)	–	–	3.8
Wei, 2015 [11]	39	0	30.8	7.7	15.3 (T)	–	18	18
Yang, 2014 [12]	47	0	63.8	13.5	31.9 (P)	27.6 (P)	14.9	34
Zheng, 2014 [13] (major complications)	184	0.5	–	15.7	–	–	0.5 (abscess)	2.9
Han, 2015 [15]	28	0	50	28.5	3.5 (P)	–	3.5	7.1
Ni, 2015 [16]	35	0	20.5	7.7	5.1 (H) 2.6 (P)	23.1 (P)	5.1	15.4
Splatt, 2015 [17] (major complications)	51	1.4	–	12.9	2.9 (H)	1.4 (B)	2.9	5.7
Egashira, 2016 [22]	44	0	–	13	6.9 (H)	–	–	–

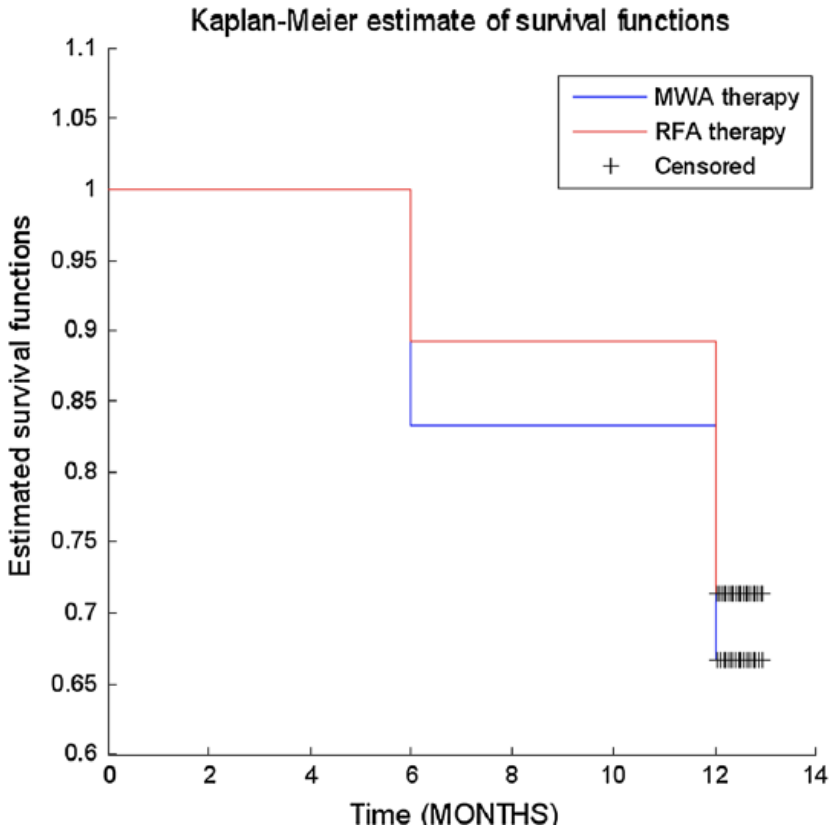
Vogl et al., Rofo 2017

RFA vs. MWA

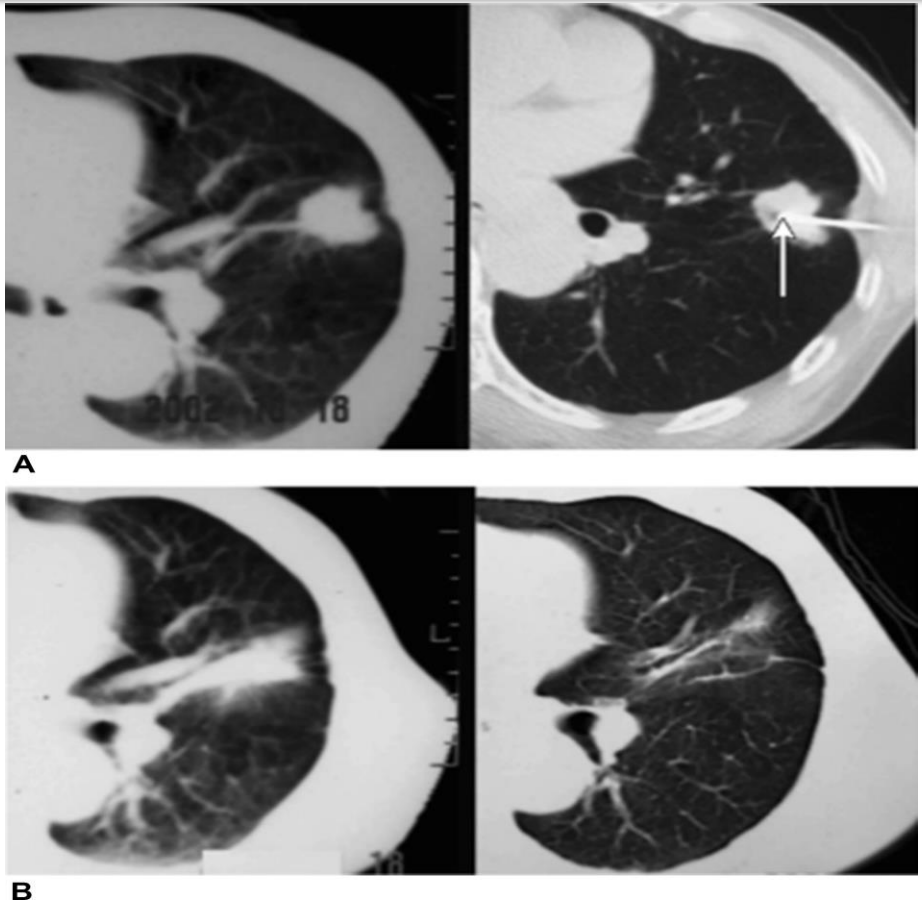
52 patients
non-surgical
RT

MWA (n=24)
Vs.
RFA (n=28)

effectivness
complications



Cryoablation



CHEST 2017 151, 674-685DOI: (10.1016/j.chest.2016.05.025)

Cryoablation

Study group and year	Number of patients	Tumor data	Tumor size* (mm)	Indications	Freeze/thaw cycle	Follow-up	LCR	Survival
Wang et al. [17], 2005	187: 165 NSCLC (5 stage I, 17 stage II, 80 stage III, and 63 stage IV), 22 metastasis	234 tumors: 196 primary cancer and 38 metastasis	43 ± 2 in peripheral locations and 64 ± 3 in central locations	Local control and palliation	Double	NA	NA	NA
Kawamura et al. [18], 2006	20: all metastasis	35	Mean tumor size, 13.3	Local control	Triple	9 to 28 months (median, 21 months)	LCR: 80%	1 y OS: 89.4%
Zemlyak et al. [35], 2010	27: all NSCLC (27 stage I)	27	NA	Local control	NA	Mean, 33 months	LCR: 89%	3 y OS/cancer-specific survival/cancer-free survival rate: 77.0%/90.2%/45.6%, respectively
Yamauchi et al. [28], 2011	24: all metastasis	55	13 ± 7	Local control	Triple	Median, 40 months	1 /3 y LCR: 90.8% and 59%, respectively, 3 y LCR of tumors <15 mm and >15 mm: 79.8% and 28.6%, respectively ($P = 0.001$)	1 /3 y OS: 91%/59.6%, respectively
Zhang et al. [14], 2012	46: all NSCLC (12 stage I, 19 stage II, and 15 stage III)	46	32 ± 11	Local control	Double	24 months	2 y LCR: 83.7%.	2 y OS: 93.5%.
Pusceddu et al. [19], 2013	32: 11 NSCLC (4 stage I, 3 stage II, 3 stage III, and 1 stage IV), 21 metastasis	34 tumors: 11 primary cancer and 23 metastasis	26 ± 12	Local control	Double or triple	6 months	1 /3 /6 mo technical success: 82%/97%/91%, respectively	NA
Yamauchi et al. [8], 2012	22: all NSCLC (22 stage I)	34	14 ± 6	Local control	Triple	12 to 68 months (median, 23 months)	LCR of 97%	2 /3 y OS: 88%/88%, respectively
Yashiro et al. [27], 2013	71 (patients characteristics were not reported)	210 tumors: 11 primary cancer and 199 metastasis	Mean tumor size, 12.8	Local control	Triple	79 to 2467 days (median, 454 days)	1 /2 /3 y LCR: 80.4%/69.0%/67.7%, respectively	NA

Biomed Res Int. 2014;2014:521691

Comparison of the different options

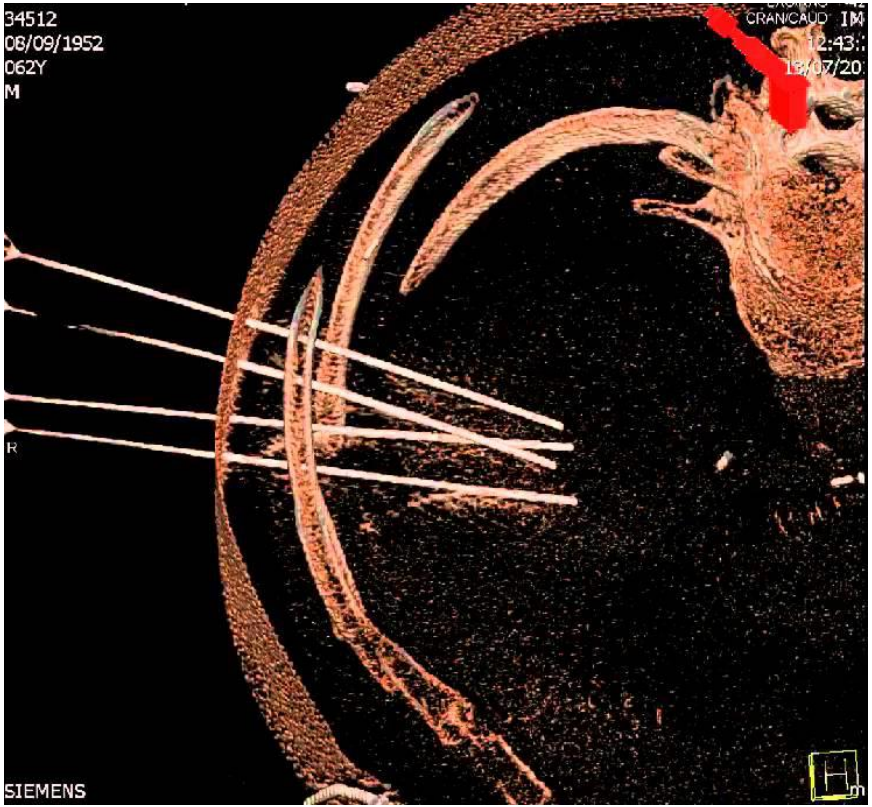
Table 1 Characteristics of the different ablation techniques.

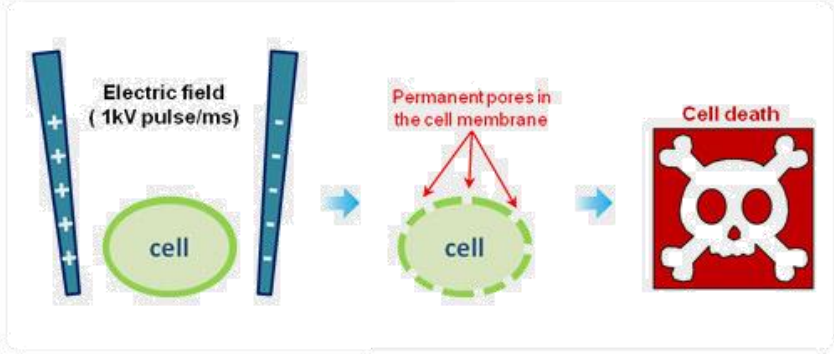
	Ablation technique	Ablation effect	Treatment effect			
			Lung tumors	Liver tumors	Kidney tumors	Bone tumors
RFA	Application of a high-frequency oscillating electric field	Resistive heating surrounding the electrode tip and tissue hyperthermia	+++	+++	+++	+++
MWA	Application of a propagating electromagnetic energy	Tissue hyperthermia by dielectric hysteresis	+	+++	±	+ +
Cryoablation	Application of liquid nitrogen or argon gas	Crystal formation and osmotic shock	+ +	–	+++	+++
IRE	Application of electric pulses	Irreversible cell membrane disruption	±	+ +	±	±

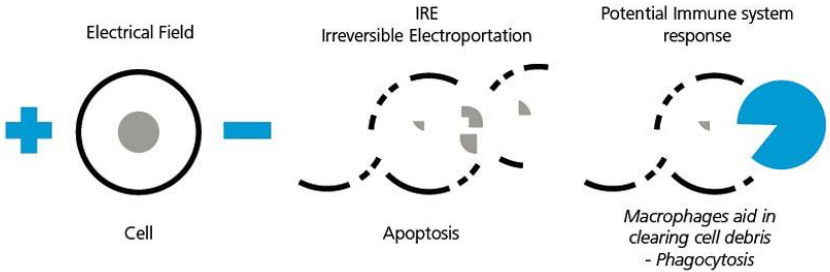
RFA: radiofrequency ablation; MWA: microwave ablation; IRE: irreversible electroporation.

Diagn Interv Imaging. 2017; 98(9):609-617

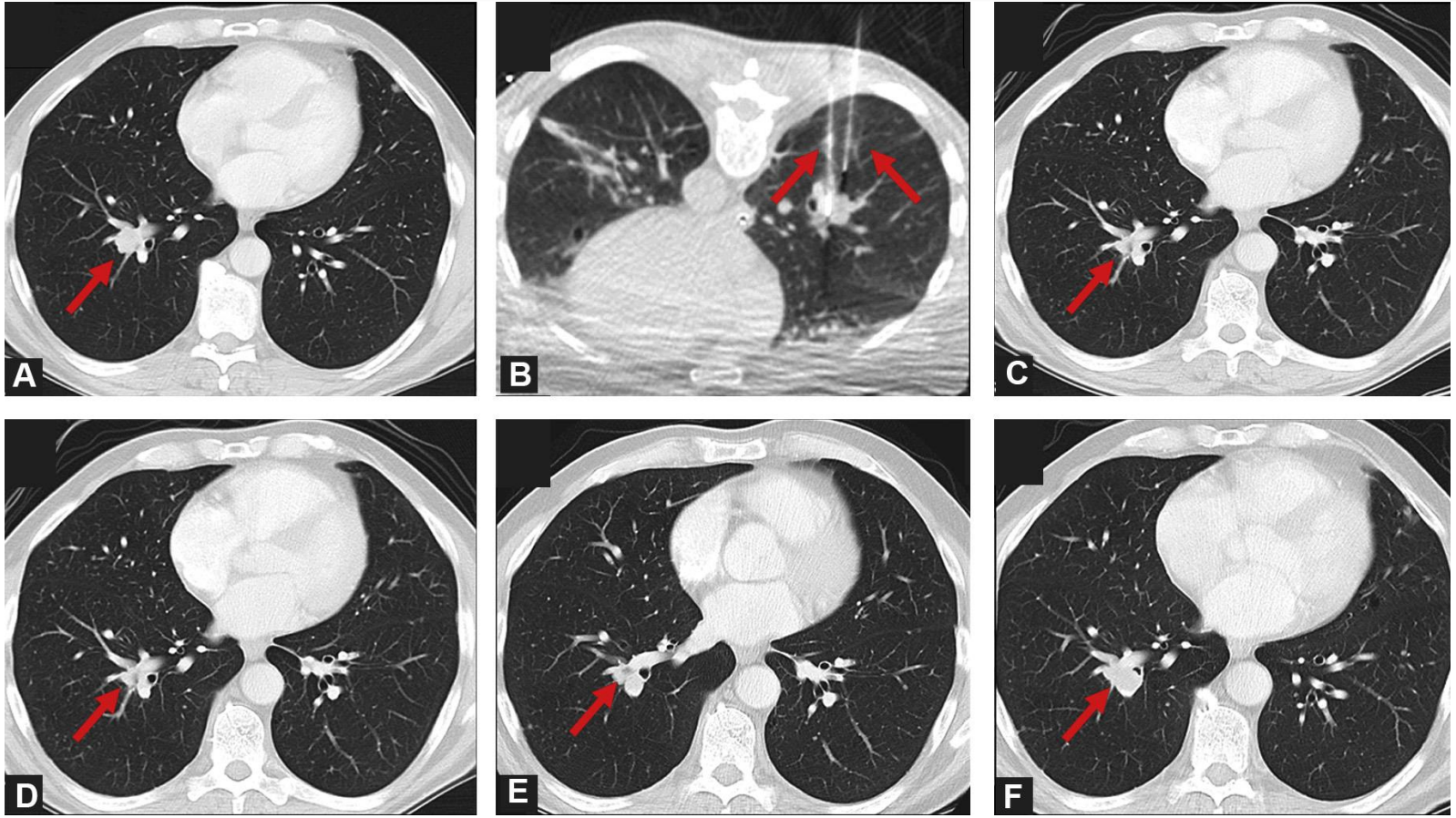
Nanoknife - Irreversible Electroporation (IRE)



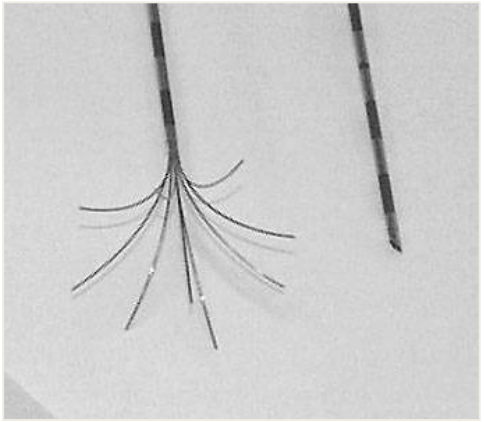


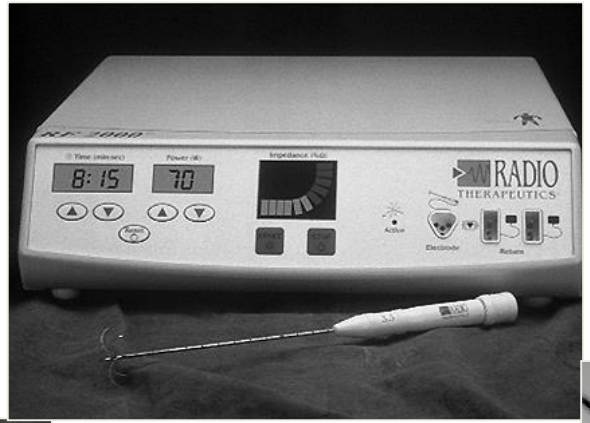


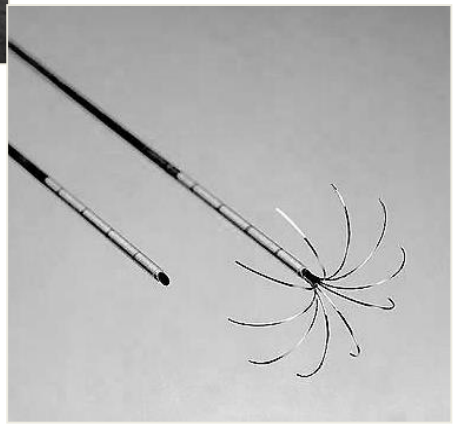
Nanoknife - Irreversible Electroporation (IRE)



Broncoscoipoic RFA Electrode and Device Types







Endoscopic RFA

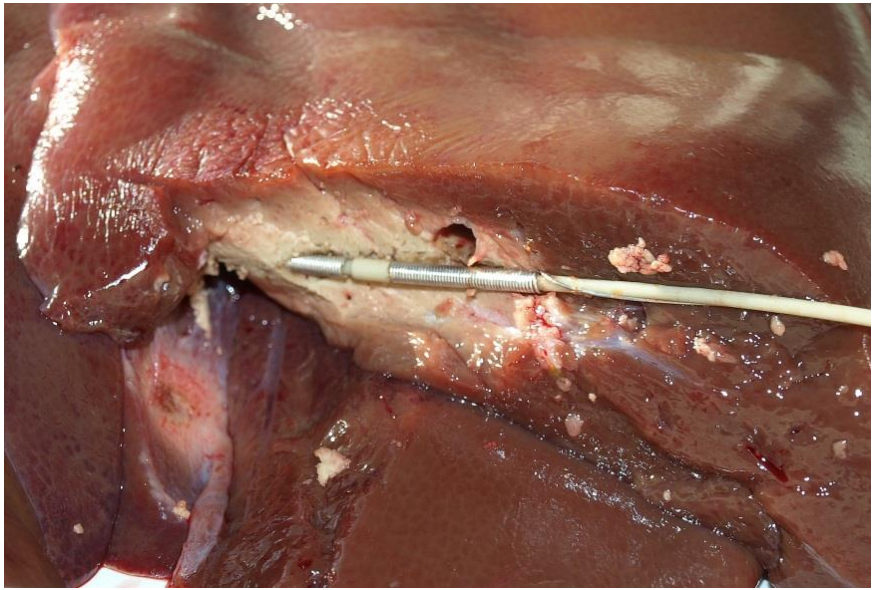
10 patients
T1N0M0
3 different RFA probes

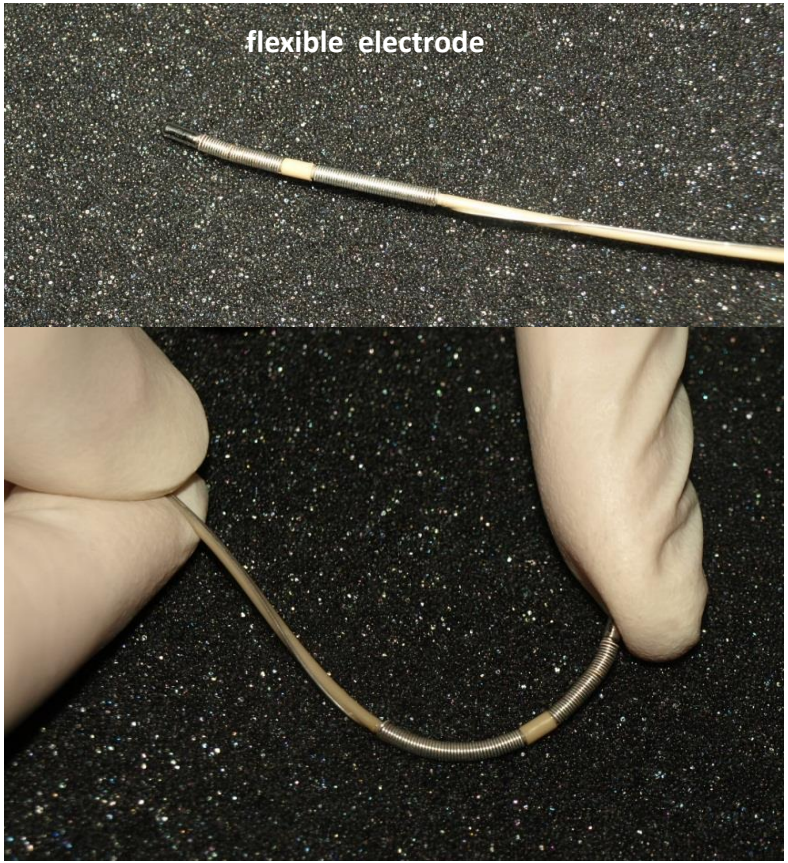
Endoscopic RFA followed by VATS

effectivness

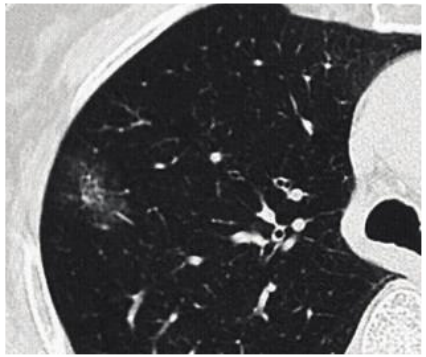
Length of Tip, mm	Size of Tumor, mm (Area of Tumor, mm²)	Size of RFA Lesion, mm (Area of RFA Lesion, mm²)
5	20 × 5 (78.5)	5 × 1 [10.2)
5	30 × 15 (353.3)	15 × 2 (17.3)
5	16 × 10 (125.6)	10 × 5 (33.6)
8	23 × 15 (270.8)	11 × 9 (105.6)
8	25 × 20 (392.5)	12 × 5 (46.2)
8	10 × 10 (78.5)	8 × 8 (49.0)
10	28 × 20 (439.6)	16 × 12 (188.8)
10	21 × 15 (247.3)	13 × 8 (57.6)
10	16 × 11 (138.2)	14 × 9 (78.5)
10	14 × 10 (145.1)	12 × 10 (126.9)

Flexible RFA probe

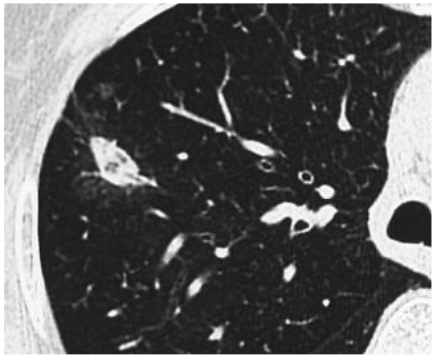




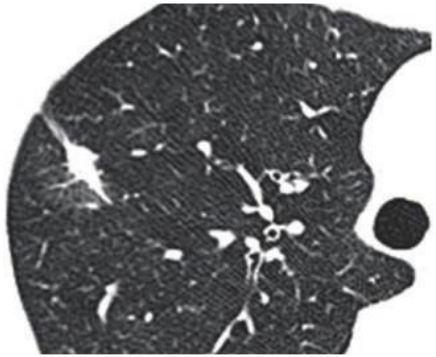
Clinical Experience of Bronchoscopy-Guided Radiofrequency Ablation



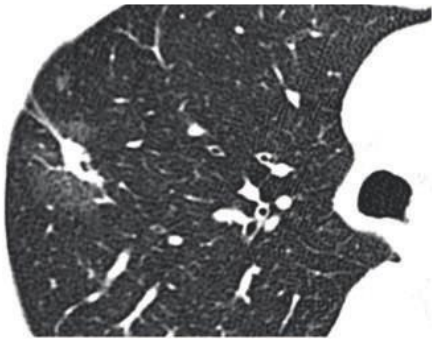
Before RFA



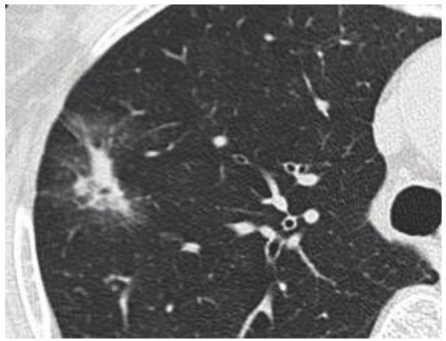
One month



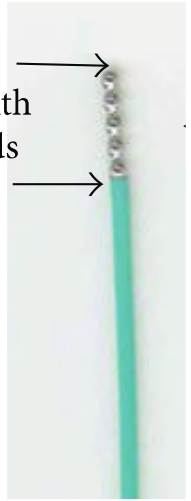
12 months



48 months



60 months



Bronchoscopy-Guided Radiofrequency Ablation

Case	Response	Relapse to initial RFA	Time of retry, months	PFI, months	OS, months	Outcome	Other therapies after RFA
1	PR	+	64	60	87	alive	retry
2	SD	+	40	35	93	alive	retry
3	SD	+	21	17	73	alive	retry, SBRT
4	PR	+	26	20	65	alive	retry
5	PD	+	13, 19	6	40.5	dead (lung cancer)	retry
6	PR			34	34	dead (pneumonia)	
7	SD	+		35	50	dead (lung cancer)	
8	PR	+		55	79.5	alive	RT
9	PR	+		60	71	alive	
10	PD	+		4	27.5	dead (lung cancer)	SBRT
11	PR			65.5	65.5	alive	
12	SD			23	23	dead (other malignancy)	
13	PR	+		19.5	30.5	alive	RT
14	SD			30	30	alive	
15	SD			25.5	25.5	alive	BRT for another lesion
16	SD			24	24	alive	
17	PR			23.5	23.5	alive	
18	PR			23	23	alive	
19	PD			3	5	dead (pneumonia)	
	PD			3			
20	SD	+		24	71	alive	chemotherapy
	PR			71			
	PR	+		24			

PR = Partial response; SD = stable disease; PD = progressive disease; retry = repeat therapy; BRT = body radiation therapy; RT = standard radiation therapy.

Response rate 47.8%

Local progression in 12 lesions

Local tumour control 82.6%

Retreatment in 5 lesions

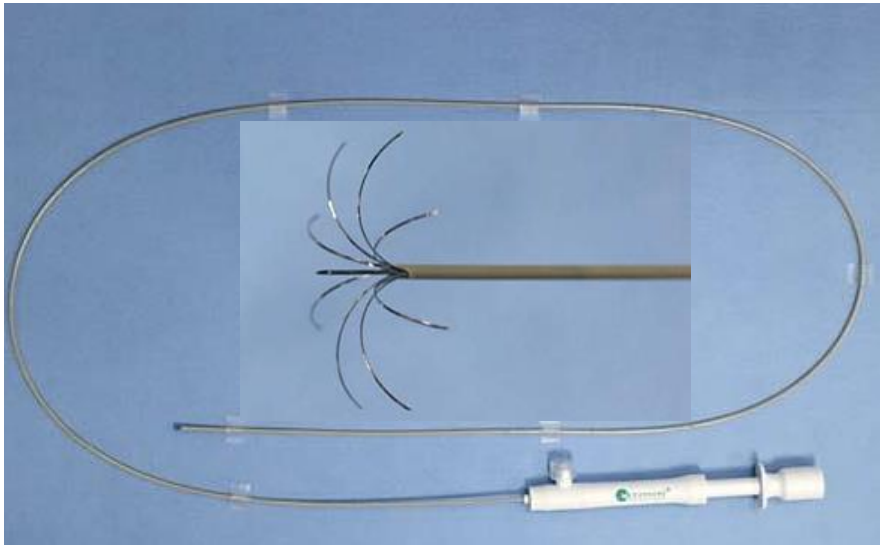
Koizumi et al., Respiration 2015

Radiofrequency Ablation for Nonsurgical SPN

3 patients
non-surgical
SPN 14 mm

Navigation, radial
EBUS, biopsy
RFA

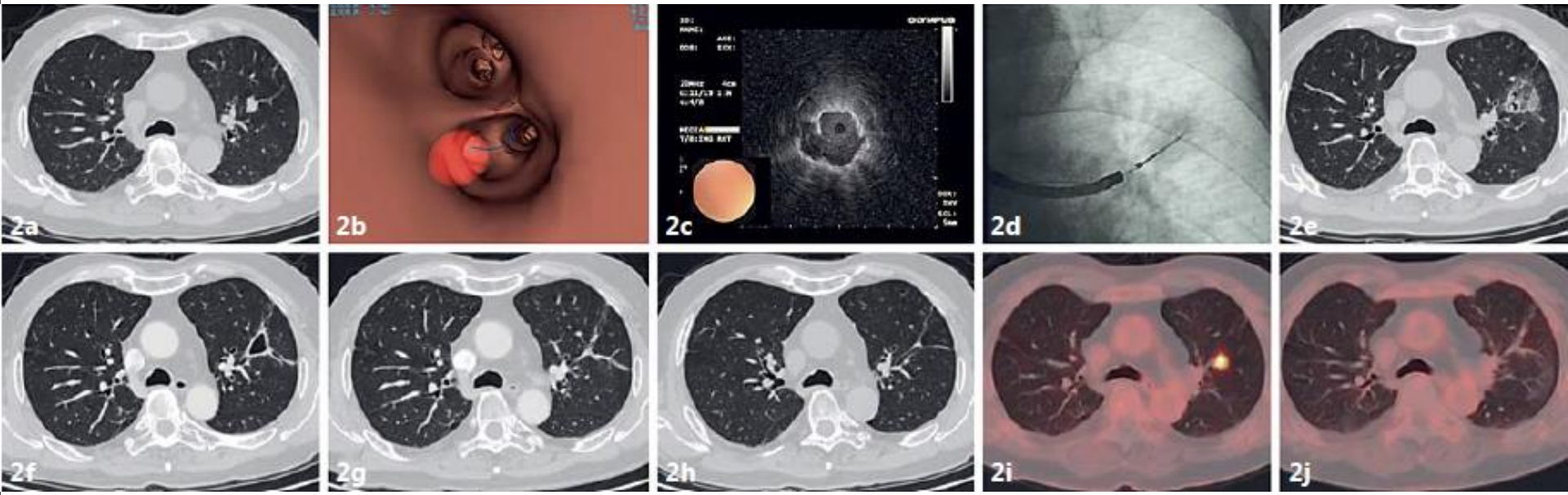
effectivness
complications



Xie F et al., Respiration 2017 epub ahead

Radiofrequency Ablation for Nonsurgical SPN

before



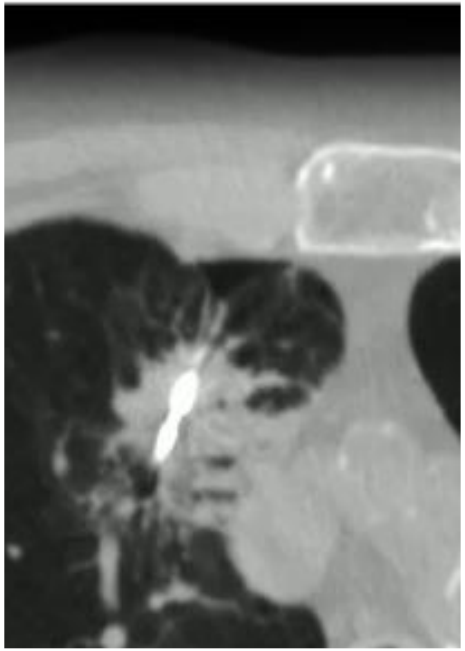
1 m after RFA | 3 m after RFA | 12 m after RFA | before | 3 m after RFA

No complications
2 pts stable > 1 year

Ablation of Lung Tumors (in-vivo)

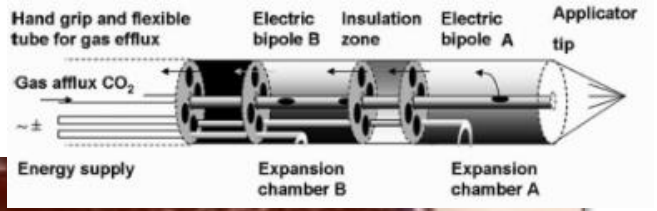
Pre - Ablation

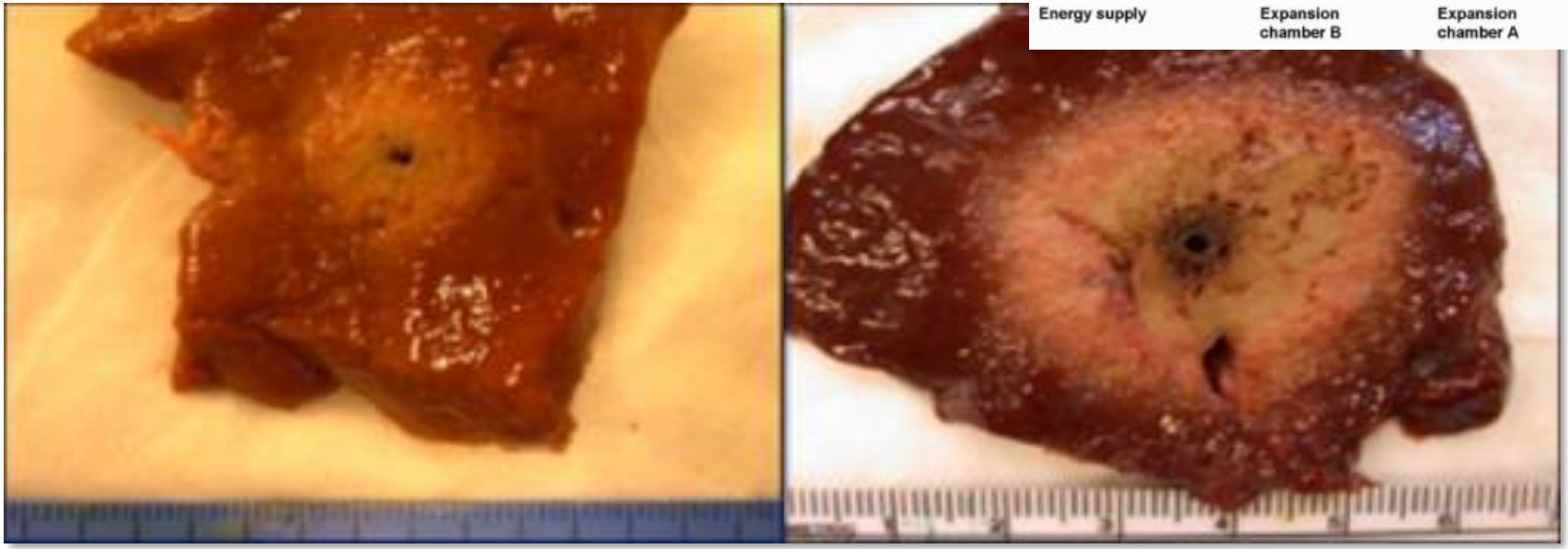
Peri - Ablation



Post - Ablation

HybridTherm Probes

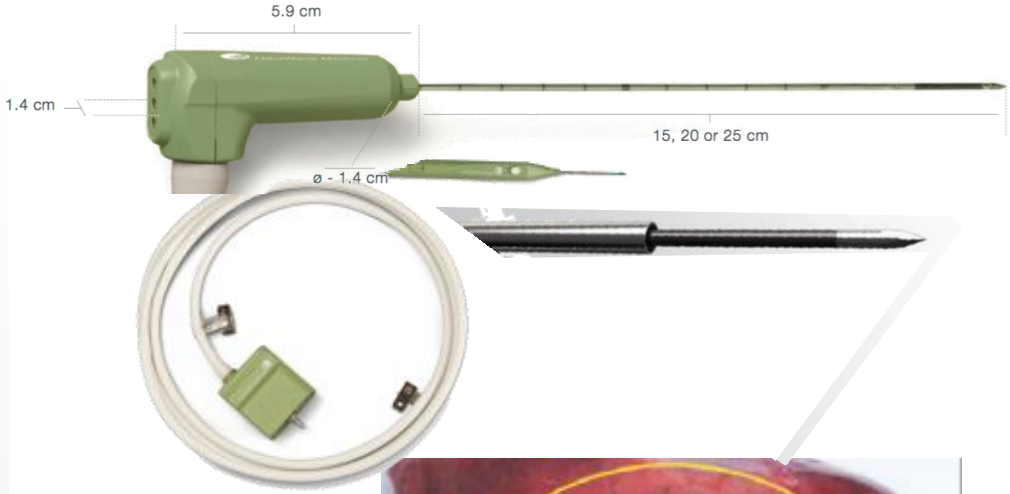


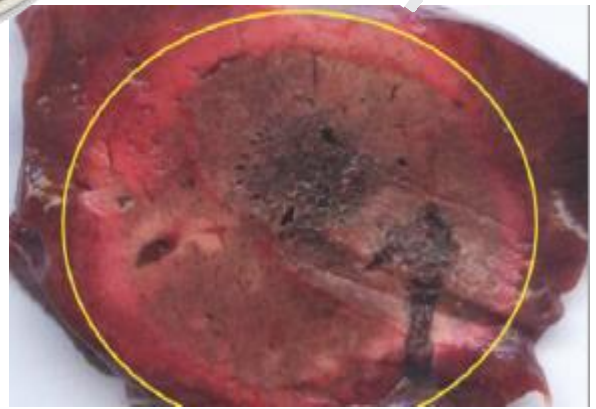


RF without Cryo
(Ø ≈ 1.5 cm)

RF with Cryo
(Ø ≈ 3.6 cm)

Microwave Ablation





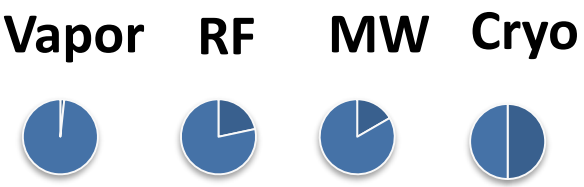
Microwave Ablation

unpublished data

Advantages of Thermal Vapor Ablation for Lung Lesions (TVA-LL)

Faster

- Other modalities 10-30 min
- Vapor 10 seconds



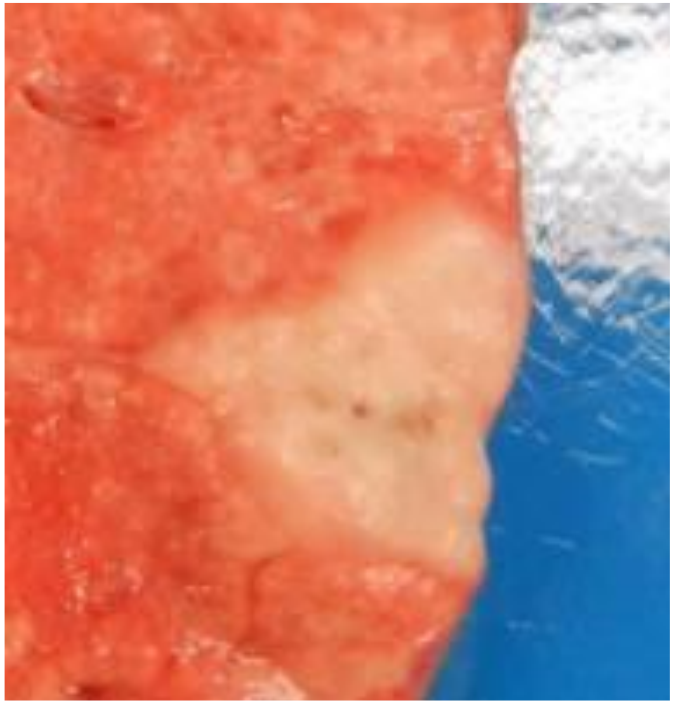
Easier/Safer

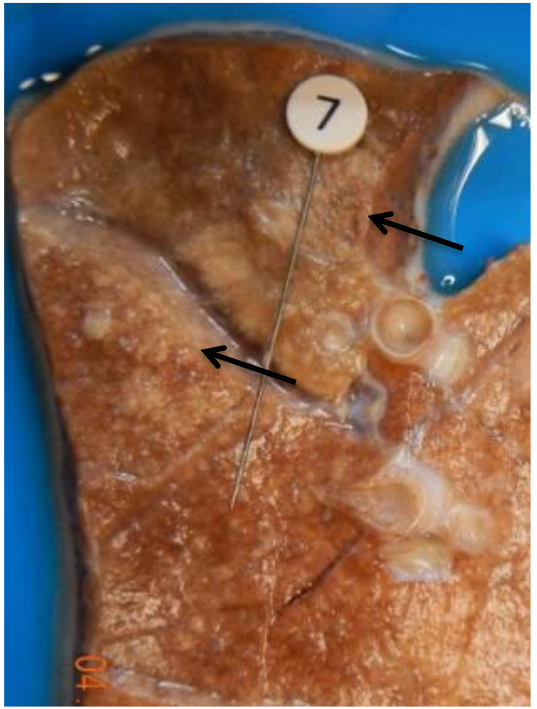
- No pleura or parenchyma puncture
- Reduced accuracy requirement
- Treat from airway, easy for bronchoscopist

Compatible

- All peripheral navigation techniques
- Treat as part of biopsy procedure

Efficacy in the survival animals

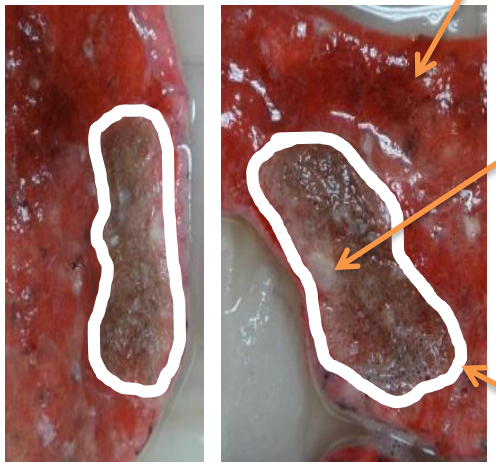


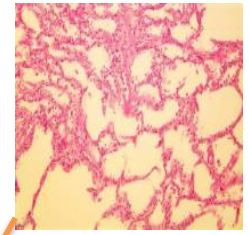


Pathology – First Patient

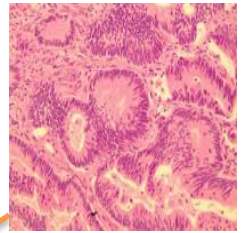
Vapor treatment and immediate resection results:

- “uniform ablation zone”
- “carcinoma 90% immediate ablation … 80% surrounded”
- “focal thermal blood coagulation occlusion”
- Excellent chance of complete kill after secondary pathway effects (3 days later)

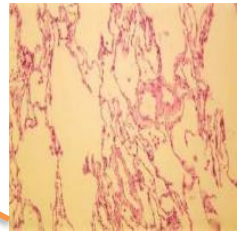




Normal parenchyma



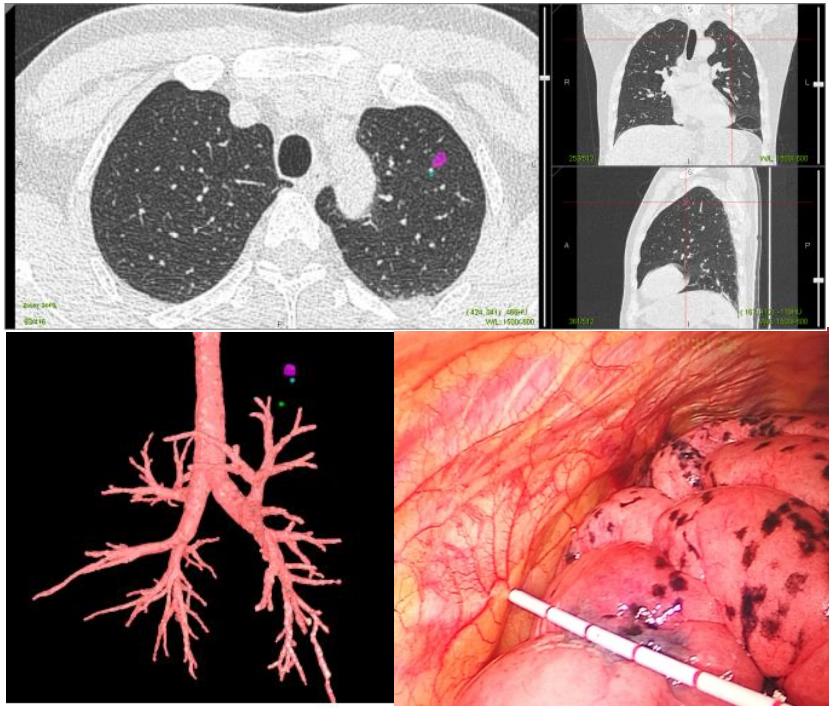
Ablated Tumor



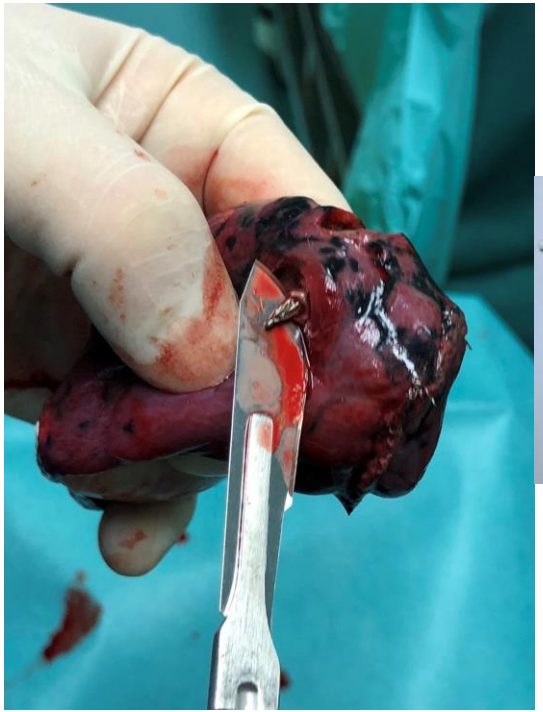
Ablated Parenchyma

Small Nodule Localization

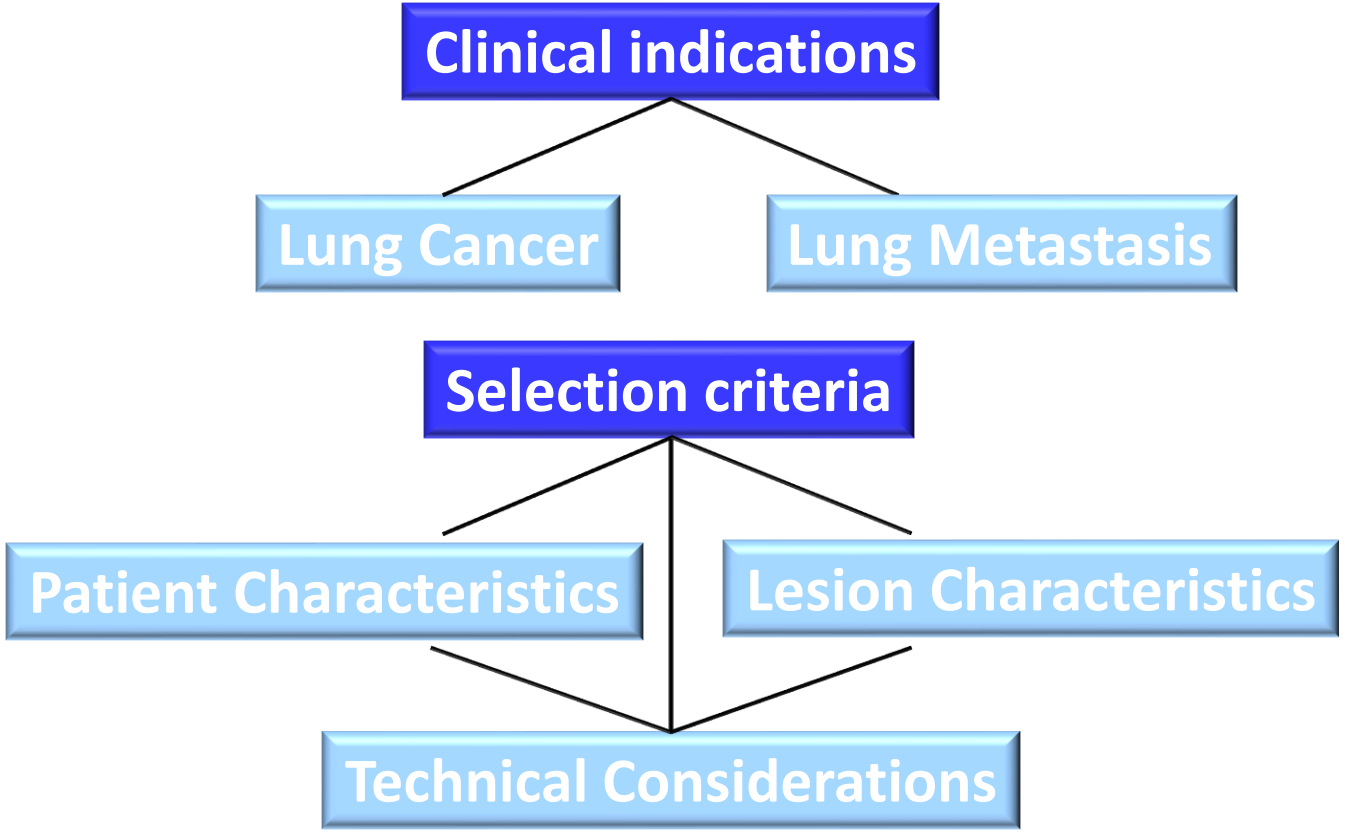
Dye Marking



Fiducial and Surgical Marker



Local Ablation Considerations



Summary

- SPN present an increasing problem
- Classical TBBx technology is suboptimal
- New „guidance“-techniques are necessary /available
- Combination provides the best yield
- Better endoscopic access opens field of endoscopic therapies