



Thoracoscopic Sublobar Resection for small and non-palpable Pulmonary Nodules Using RFID Marking System

Department of Surgery II, Yamagata University Faculty of Medicine

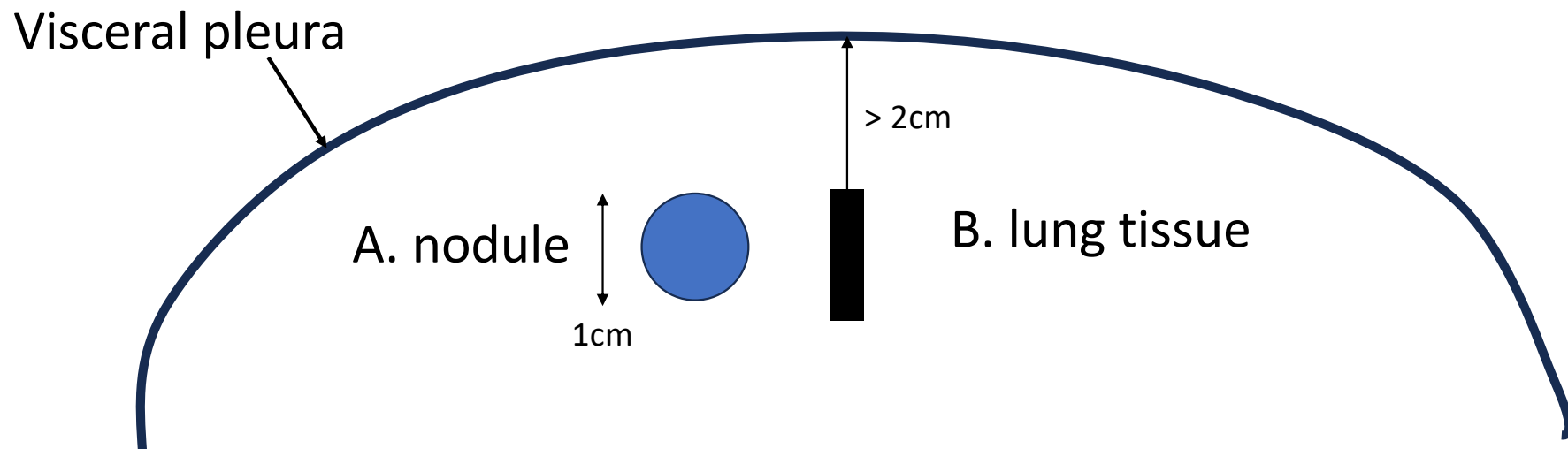
JUN SUZUKI, SATOSHI SHIONO, HIKARU WATANABE
KOHEI ABE, KAZUMASA HOSHIJIMA, SARI YASUTA, TETSURO UCHIDA



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Difficult intra-operative palpation / location

- <1cm
- Lesion with high GGO percentage
- Distant from lung periphery
(especially when deeper than 2 times the lesion diameter)



How to remove it?

- Minimum invasive surgery

Marking → Wedge resection

Segmentectomy

- Open

Palpation → Wedge resection



- Wait until the tumor grows larger?

Pulmonary Nodules Localization Techniques without the need for palpation

Techniques	Traditional route	Advantages	Complication	Potential Contraindication
Hookwire	Percutaneous placement	Widely used	Puncture-associated complication; dislodgement	Apical diaphragmatic, or mediastinal lesions; multiple lesions
Metallic fiducials	Percutaneous placement / ENB	Multi-site localization	Puncture-associated complication; fiducials migration	No
Dye	Percutaneous placement	Easy to perform	Puncture-associated complication; contrast medium migration	Deep and posterior nodules
Radionuclide labelling	Percutaneous placement	Multi-site localization; also locate sentinel node	Puncture-associated complication; contrast medium migration	Deep and posterior nodules
Radionuclide labelling	Intraoperative use	Non-invasive; defect occult nodule; helps to define pathology	radiation exposure No	Operator dependent emphysema

Zhao ZR et al., J Thorac Dis 2016;Mar;8 (S3):S319 - 27

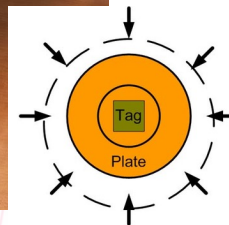


RFID (Radio Frequency Identification)

e.g. Conveyor Belt Sushi Restaurant



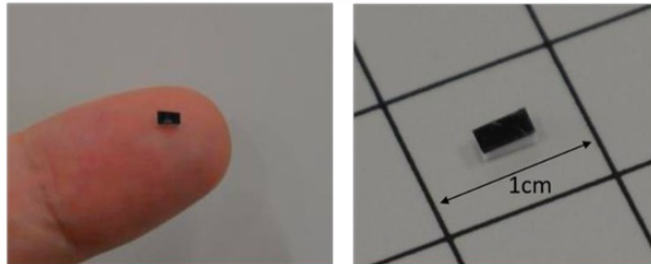
The detector reads the RFID tag embedded in the dish and instantly makes a calculation.



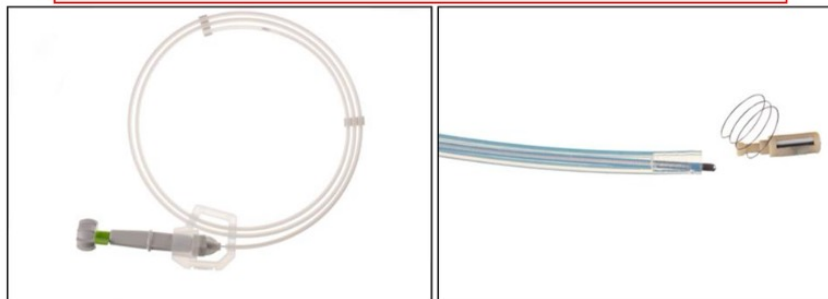
RFID marking system using wireless communication

The entire system consists of the following 3 components

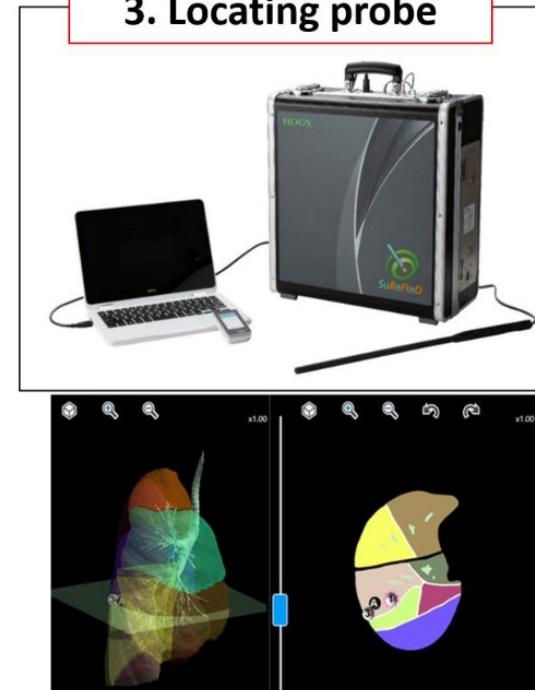
1. RFID micro-tip



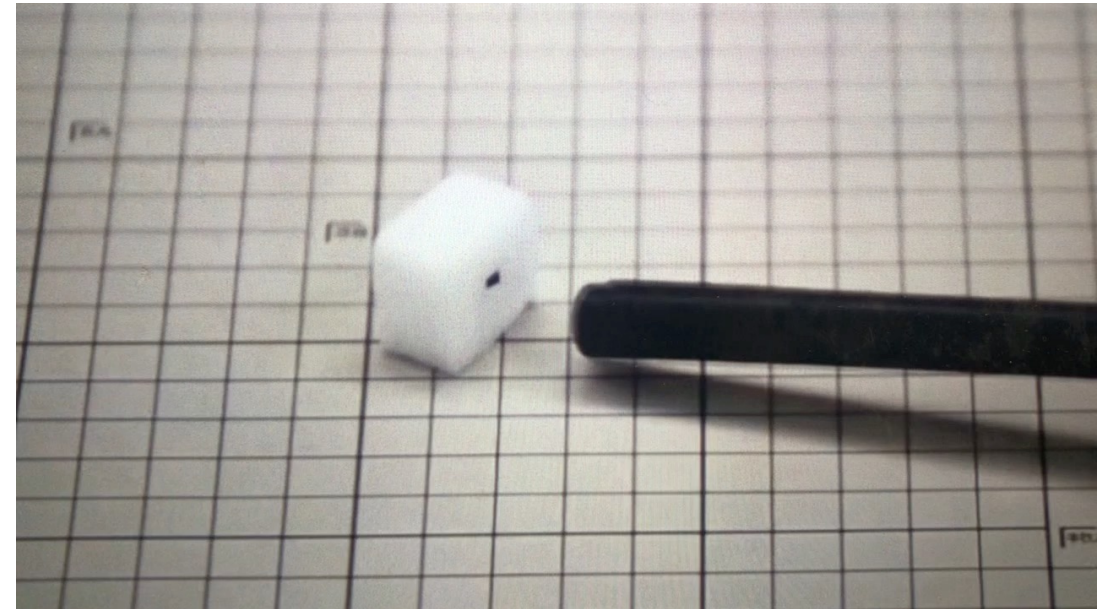
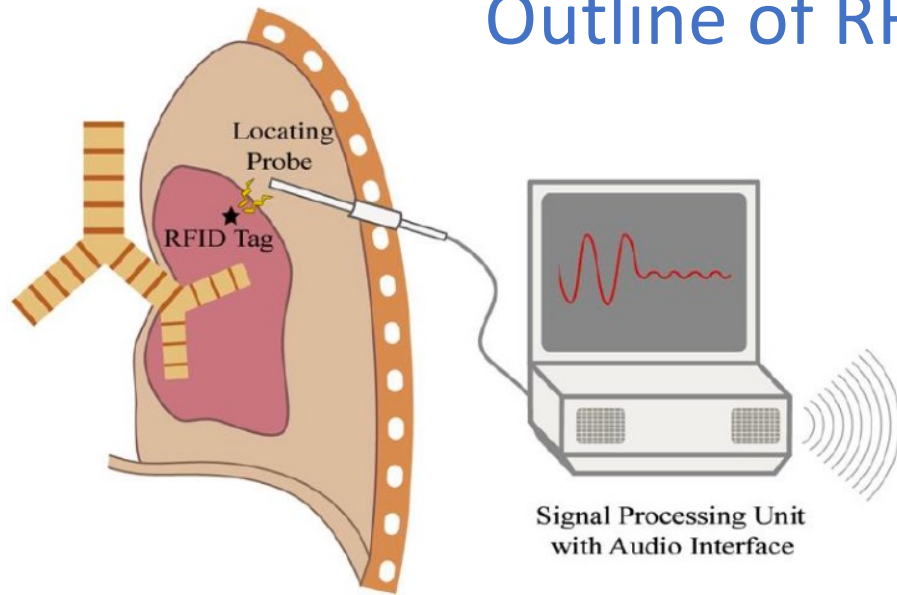
2. Delivery device via bronchoscopy



3. Locating probe



Outline of RFID marking system



1. RFID micro-tips are activated by a probe acting as both the power supply and receiver antenna.
2. The distance to the marker is converted to five gradual changes in sound pitch.
3. The effective range is 30 mm.

Kojima, T. et al. J Thorac Cardiovasc Surg. 2014 Apr;147(4):1384-9.
Y Yutaka, T. et al. Surg Endosc. 2017 Aug;31(8):3353-3362.
Y Yutaka, T. et al. Semin Thorac Cardiovasc Surg. 2018;30(2):230-237.

How to place the Tag in the exact location

Before surgery in the Bronchoscopy Room with fluoroscopy



Same day as surgery, after induction of anesthesia in the Hybrid OR with Coan Beam CT



How to place the Tag in the exact location

Before surgery in the Bronchoscopy Room with fluoroscopy



Same day as surgery, after induction of anesthesia in the Hybrid OR with Coan Beam CT



Yamagata University Hospital



RFID marking is conducted in the hybrid operating room using a Cone Beam CT and fluoroscopy after the induction of anesthesia in the Hybrid OR



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Small Nodule

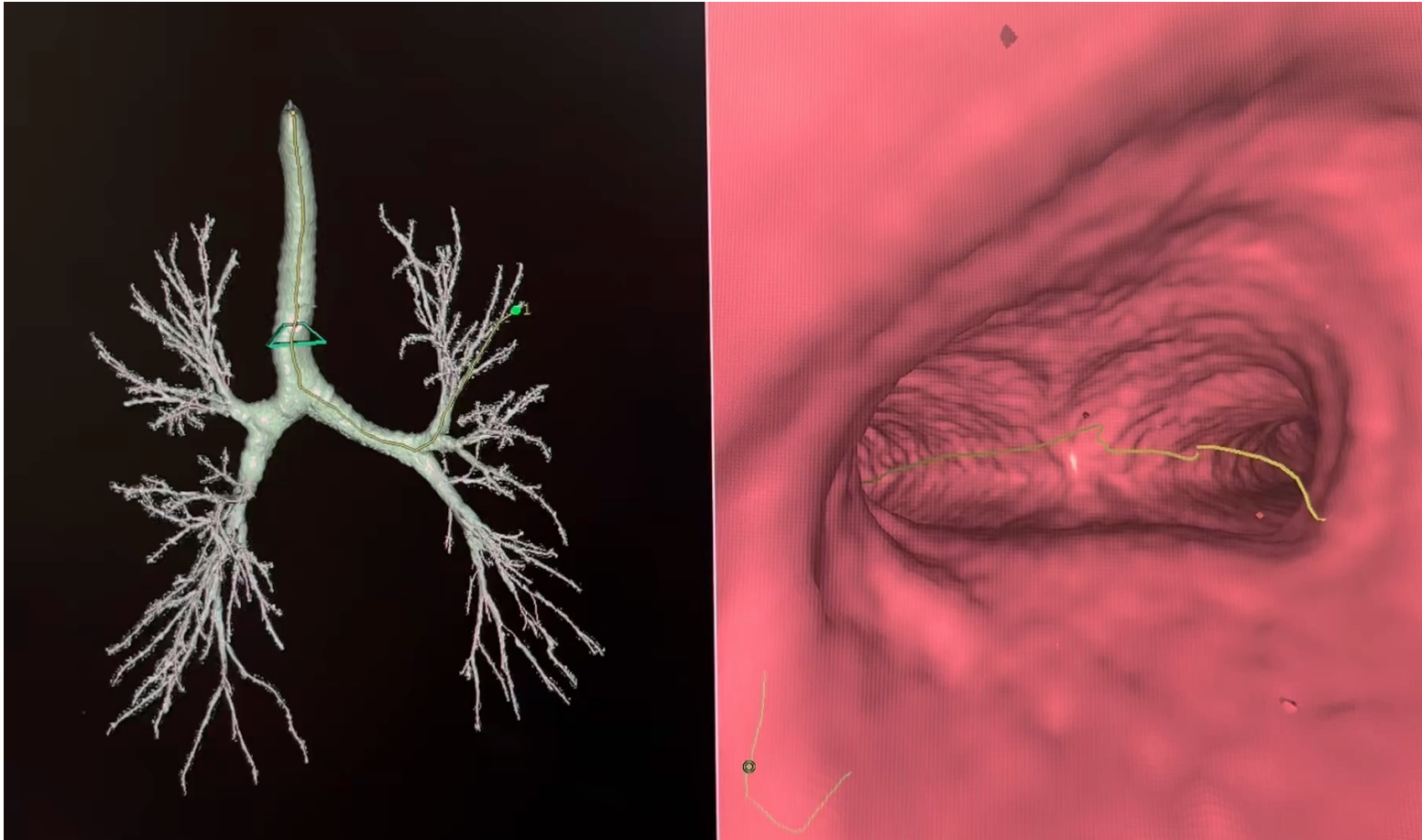


2.4cm

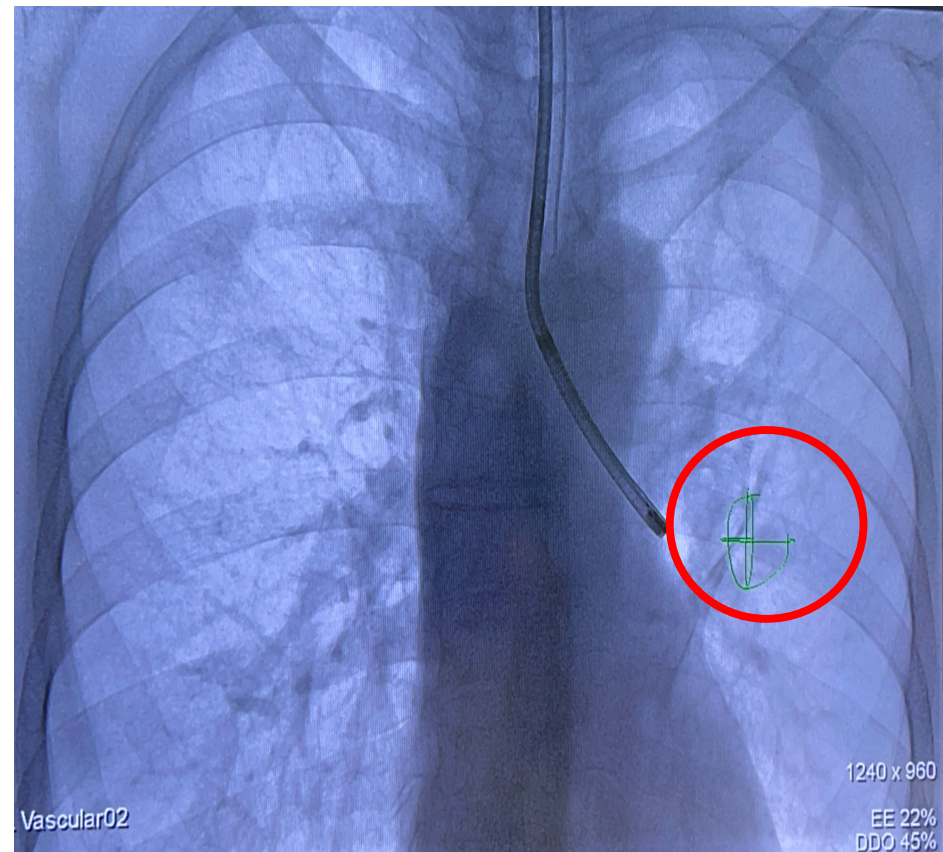
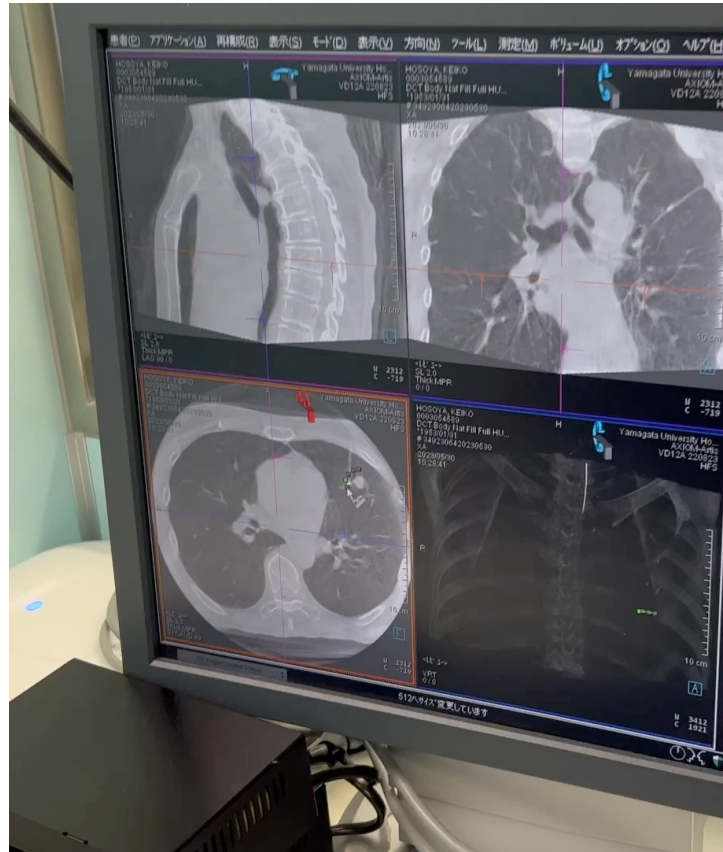


0.9cm

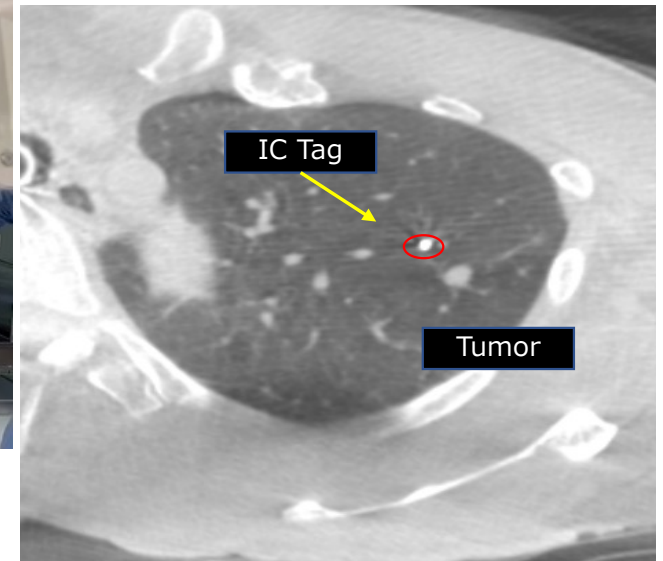
Virtual Bronchoscope



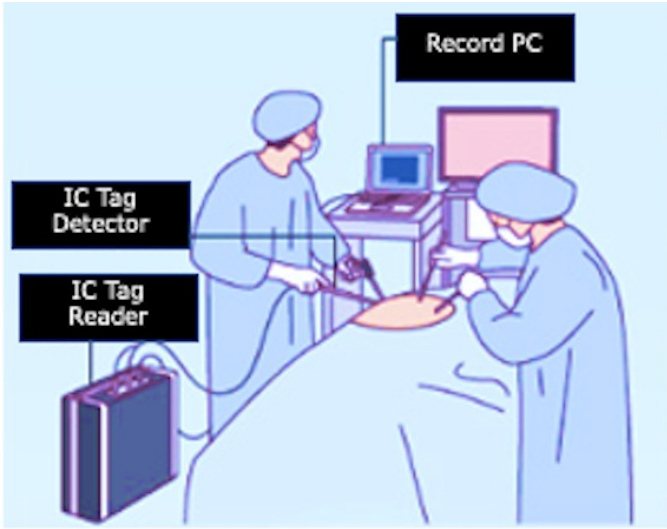
Display nodule location from CoanBeam CT image to fluoroscopic image



RFID placement in Hybrid OR



Surgery



Patient characteristics. (June2020~March2023)

	Number of cases or Median (IQR)
Number of cases	15
Pulmonary nodules	15
Age	69 (58 - 72)
Sex (male / female)	8 / 7
Tumor location	
Right upper lobe	5
middle	-
lower	3
Left upper lobe	5
lower	2
Imaging Findings	
Pure GGN	2
Solid	13
CT Tumor diameter (cm)	1.1 (0.9 – 1.4)
Distance from pleural surface to tumor (cm)	1.3 (0.7 – 2.1)

Result

	Number of cases or Median (IQR)
True tumor diameter (cm)	0.9 (0.9 – 1.7)
Distance between tumor and tag location (cm)	0.7 (0.2 – 1.2)
Time to tag Replacement <=to operation start> (min)	32 (26 - 55)
Time to tag detection (sec)	10 (5 – 18)
Type of Surgery	
Wedge	14
Segmentectomy	1
Surgery time (min)	121 (92 – 157)
Surgical margin (cm)	1.2 (0 – 1.8)
Pathology	
Lung cancer	8
Metastatic lung tumor	6
Non-malignant	1
Resection rate	(15 / 15) 100%



Result (summary)

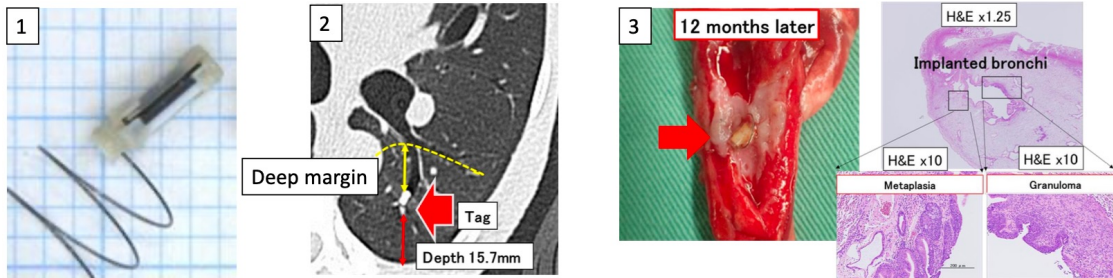
- June 2020 – March 2023
- Guidance for RFID: CBCT + Fluoroscope
- Type of procedure
 - Wedge resection 15
 - Segmentectomy 1
- CT Tumor size 1.1cm
- Distance from pleural surface to tumor 1.3 cm
- Distance from lesion to Tag 0.7 cm
- Resection rate 100%**

Discussion

A novel surgical marking system for small peripheral lung nodules based on radio frequency identification technology: Feasibility study in a canine model

Kojima, T. et al. J Thorac Cardiovasc Surg. 2014 Apr;147(4):1384-9.

Preclinical Studies of RFID Marking System



1. NiTi(Nickel Titanium) coil anchor (bronchus $\leq 3.3\text{mm}$)
2. Secure deep margins under VATS
3. Long-term safety of marker placement in the lung

札幌医科大学附属病院、山形大学医学部附属病院、
聖路加国際病院、信州大学医学部附属病院、
京都大学医学部附属病院、天理よろづ相談所病院、
近畿大学病院、福岡大学病院、
産業医科大学病院、福岡山王病院



Approved clinical use in Japan in December 2018



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Discussion



Advantage

- The location is easily identifiable and distinguishable.
- Allowing for the deep margin assessment.
- **There is no possibility of air embolism, a potentially fatal complication.**

Disadvantage

Cost (Not covered by Japanese insurance)

Main unit: 4.65 million yen (complete set)

Placement device: about 50,000 yen

Tag detector 100,000 yen

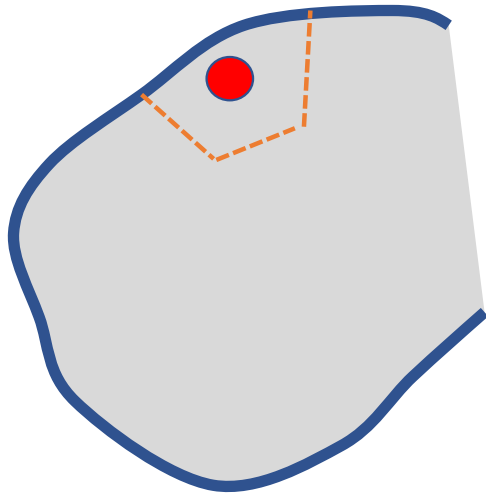
Time-consuming (Still) Time to tag Replacement (32min)

Radiation exposure (How many cone-beam CTs are taken to ensure precise placement?)

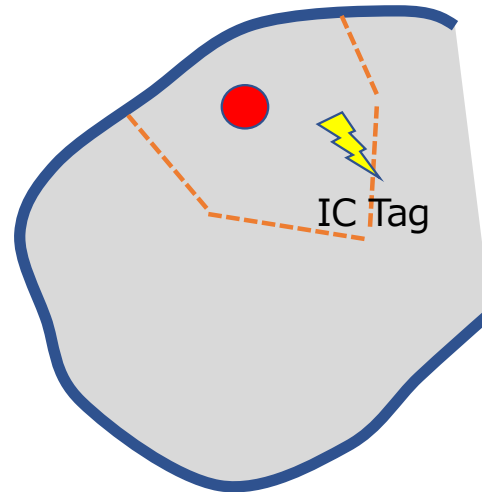


Points to note

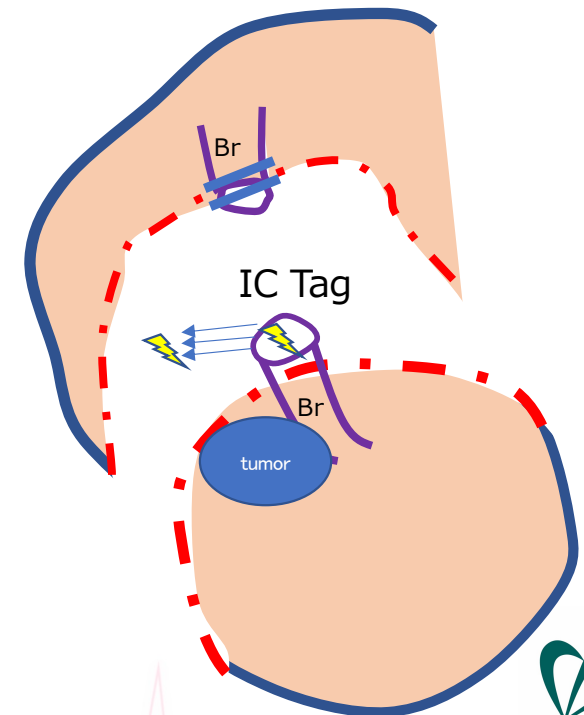
Ideal Partial Resection Dissection Line



Implantation of IC tags in the central region increases the extent of resection for their retrieval.



Possibility of tag falling out of implanted bronchus



Conclusion

- RFID markers provided the precise location of small lung lesions.
- This novel marking technique enabled precise sublobar resection for deeply located small lung lesions with sufficient deep margins.

Thank you for your attention !



YAMAGATA



Jun Suzuki

Mail to junno58@med.id.yamagata-u.ac.jp

