Precise sublobar resection using radiofrequency identification wireless localization technique for small pulmonary lesions

Objective:
We developed a novel wireless localization technique using radiofrequency identification (RFID) markers for small pulmonary lesions. Micro-RFID microchips (3.2×1.6×0.8 mm) with 5-mm nickel-titanium coils that can pass through the 2-mm working channel of a bronchoscope are designed to be placed from subsegmental bronchi to the peripheral parenchyma. Surgeons determine the resection line under thoracoscopy without lung palpation based on the strength of wireless signals emitting from the microchip placed in the vicinity of the tumor. We have successfully introduced this wireless localization technique since a first-in-human use in September 2019. We prospectively investigated the feasibility of this technique.

Methods:
Consecutive 89 patients with 97 lesions who underwent sublobar resection using 100 RFID marking from September 2019 to March 2022 in our institution were enrolled. Patients were assigned to undergo RFID marking either in a bronchoscopic suite with fluoroscopy (F) under intravenous anesthesia, or in a hybrid operation theater with cone-beam computed tomography (CBCT) under general anesthesia (GA). Virtual bronchoscopy navigation (VBN) or electromagnetic navigation bronchoscopy (ENB) were utilized to place markers just central to the lesion for wedge resection or lateral to the lesion for segmentectomy.

Results:
Totally one hundred markers were placed for 97 lesions (median size: 7.9 mm (IQR, 5.5–10.1); median depth from the pleura: 15.6 mm (IQR, 9.9–23.2)). All surgeries were conducted as planned without any complications associated with the preoperative RFID marking procedures. Fifteen lesions were marked with 18 RFID markers by VBN-CBCT, 2 lesions with 2 markers by VBN-F, 41 lesions with 41 markers by ENB-F, and 39 lesions with 39 markers by ENB-CBCT. Although ENB enabled one-on-one marking for each lesion, VBN required 2 markers for one lesion in three patients due to inaccessibility to the target. The median marker–lesion distance, and the median marker-pleura distance was 10.8 mm (IQR, 4.8–16.4), and 15.9 mm (IQR, 8.7–23.7), respectively. Regarding ENB, the median marker–lesion distance was 8.9 mm (IQR, 2.8–12.4) under CBCT versus 15.0 mm (IQR, 6.8–18.3) under F (p=0.00009). The surgeries comprised 64 video-assisted thoracoscopic surgery (VATS) wedge resections, 16 VATS segmentectomies, two robot-assisted thoracoscopic surgery (RATS) wedge resections, and 15 RATS segmentectomies. The pathological examination showed 4 benign lesions including 2 atypical adenomatous hyperplasia, 23 p-Tis, 20 p-Tim, 25 p-IA1, 6 p-T1b, and 19 metastatic lesions. The tumor resection rate was 97.9% (95/97) with a median surgical margin of 11.6 mm (IQR, 9.4–13.4).

Conclusions:
RFID marker placement provided sufficient surgical margins in sublobar resection for small pulmonary lesions. RFID placement using ENB appeared to be more effective than the one using VBN. ENB-CBCT provided more precise marker placement than ENB-F.

Figure legend
Radiofrequency identification (RFID) lung marking system. 
(A) Passive RFID tag with nitinol coil (13.56 MHz; 3.2 × 1.6 × 0.9 mm). (B) RFID delivery device which is used through a bronchoscope with a 2-mm working channel. (C) Detection probe (diameter, 10 mm) with a signal-processing device. (D) Sublobar resection using the wireless localization technique. (E) Resected lung specimen. The yellow arrow indicates the placed RFID marker, and the white arrow suggests the tumor.
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