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SCIENTIFIC LETTER

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Direct endoscopic visualization of small peripheral lung nodules using a miniaturized videoendoscopy probe

To the Editors:

In the past two decades, advanced bronchoscopy techniques have been developed for the diagnosis of peripheral lung nodules. Technologies such as ultrathin bronchoscopy, radial-endobronchial ultrasound (r-EBUS), electromagnetic and non-electromagnetic navigation and more recently robotic bronchoscopy have improved the ability to reach the lung target. However, these procedures provide a diagnostic yield that plateaus at about 70%, with a significant gap between navigational yield (the possibility to reach the target) and the diagnostic yield provided by sampling. To date, only r-EBUS can confirm, in real time, that a peripheral lesion has been reached.[1] The main limits of r-EBUS to visualize the nodule are the size of the nodule, the nature of the nodule such as ground-glass opacities (GGOs) and the presence of atelectesia which could mimick a lung lesion.[2,3]

Recently, a reusable miniaturized videoendoscopy probe of 1.3 mm (4 Fr), using CMOS technology with a definition of 160,000 pixels (400 × 400) (Iriscope® probe Lys Medical, Charleroy, Belgium) has been developed, and is so far the thinnest videoendoscopy probe available. The probe has been used in association with the navigational endoscopic technique to describe one case of emphysema,[4] showing distorted alveolar structures.

Here, we report the use of the technique for direct endoscopic visualization of small peripheral lung nodules.

This retrospective study included all consecutive patients who had r-EBUS + Iriscope® exploration in our centre for the diagnosis of peripheral nodules from January to February 2024. The study was approved by the Institutional Review Board (agreement number E2024-10) with oral informed consent obtained in each case. The r-EBUS procedure was conducted as previously described[1]: the procedure was performed without navigation system or fluoroscopy, using a virtual bronchoscopy software planner to identify the optimal bronchial path to the lesion (LungPoint® planner, Broncus Medical Inc., San Jose, CA, USA), and a r-EBUS probe (1.4 mm UM-S20-17S probe, Olympus, Tokyo Japan) in a guide sheath (1.9-mm-diameter guide catheter, K401, Olympus) as described elsewhere.[5,6] R-EBUS nodule views were characterized as 'centred', when the radial probe image appeared within and completely surrounded by the lesion, and 'tangential' when the probe was adjacent to the lesion. Once a ultrasound (US) signal characteristic to the nodule was obtained, the r-EBUS probe was removed. Then, the Iriscope® probe was inserted within the lesion through the guide sheath for direct endoscopic visualization of the peripheral tumour. Secretions were cleared from the guide sheath using a small amount of saline before and during Iriscope® imaging. The technique also allowed the adjustment of the guide sheath within the tumour. The Iriscope® images were recorded for further analysis. After removing the Iriscope® probe, sampling, including cytological brush and forceps biopsies, was performed through the guide sheath. Incidentally, the Iriscope® probe was pushed into the normal part of the lung in some cases, providing visualization of non-tumoural parts of the distal lung.

Chest radiographs after the procedure were not systematically performed.

Specimens were considered diagnostic when a cytological, histological or microbiological diagnosis was confirmed and consistent with the clinical presentation.

The images from Iriscope® were analysed after the procedure, blindly from the diagnosis and the patient's chart, by one endoscopist who did not perform the procedure (LT), and classified the images into 'tumoural' (visualization of tumoural tissue), suspicious (stenosis), non-specific (inflammation, secretion and haemorrhage), or normal (Table 1).

A total of 23 procedures were performed. The median diameter of the lesion measured on CT was 15 mm in long axis (IQR = 6–35 mm) and 11 mm in short axis (IQR = 5–25 mm). All nodules had a solid appearance on CT. Twelve nodules measured less than 20 mm. The median distance between the nodule and the pleura was 10 mm (IQR = 0–30 mm), and 20 lesions were in the upper lobes. The procedure was performed under local anaesthesia without sedation in 20/23 patients. No complication occurred during or after the procedure.

US visualization with r-EBUS was 100% (10 centred and 13 tangential views). A final diagnosis was obtained in 87% (20/23) including 4 infections, 1 aspergilloma and 15 lung

TABLE 1 Characteristics and diagnosis of nodules.

Patients	Greater diameter of the nodule (mm)	Distance between nodule and pleura (mm)	r-EBUS image	Endoscopic interpretation by blinded reviewer	Conclusion by blinded reviewer	Final diagnosis
1	13	5	Tangential	Normal	Normal	Infection
2	30	5	Centred	Circumferential whitish friable tissue	Tumoural	Squamous cell carcinoma
3	27	33	Centred	Stenosis + inflammation	Suspicious	Adenocarcinoma
4	16	6	Centred	Secretions	Non specific	Infection
5	25	5	Centred	Localized mucosal outgrowth	Tumoural	Adenocarcinoma
6	10	10	Centred	Stenosis + whitish friable tissue	Tumoural	Squamous cell carcinoma
7	23	4	Tangential	Stenosis + Secretion	Suspicious	Infection
8	7	10	Tangential	Secretion	Non specific	Uncertain
9	6	10	Centred	Secretion	Non specific	Infection
10	35	0	Tangential	Mucosal outgrowth	Tumoural	Squamous cell carcinoma
11	10	30	Tangential	Stenosis + whitish friable tissue	Tumoural	Adenocarcinoma
12	26	0	Centred	Mucosal outgrowth	Tumoural	Squamous cell carcinoma
13	15	19	Tangential	Inflammation + secretion	Non specific	Uncertain
14	12	18	Tangential	Stenosis + inflammation	Suspicious	Carcinoid tumour
15	15	4	Tangential	Stenosis + mucosal outgrowth	Tumoural	Adenocarcinoma
16	26	10	Tangential	Whitish friable tissue	Tumoural	Aspergilloma
17	33	18	Tangential	Whitish friable tissue	Tumoural	Squamous cell carcinoma
18	9	25	Tangential	Stenosis + mucosal outgrowth	Tumoural	Adenocarcinoma
19	18	0	Tangential	Stenosis + whitish friable tissue	Tumoural	Adenocarcinoma
20	15	27	Tangential	Inflammation + secretion	Non specific	Uncertain
21	15	10	Centred	Stenosis + mucosal outgrowth	Tumoural	Squamous cell carcinoma
22	10	5	Centred	Stenosis + mucosal outgrowth	Tumoural	Adenocarinoma
23	15	10	Centred	Stenosis + mucosal outgrowth	Tumoural	Squamous cell carcinoma

cancers including one carcinoid tumour. The three patients without a final diagnosis are submitted to follow-up.

The blinded review of Iriscope® imaging found a 'tumoural' aspect, such as haemorrhagic parietal mucosal outgrowth or circumferential whitish friable tissue ('fish flesh' appearance), in 14 cases, including 13 invasive cancers and 1 aspergilloma. Bronchial stenosis, classified as 'suspicious' was found in three cases, including one lung cancer, one carcinoid tumour and one infection. A normal or non-specific image was found in six cases, which corresponded to three patients without a final diagnosis and to three infectious nodules that regressed spontaneously on follow-up (Table 1 and Figure 1). The positive predictive value of a 'tumoural' classification on Iriscope® was 100% for a diagnostic biopsy, and 93% for a diagnosis of cancer, the false positive case being an aspergilloma.

To our knowledge this is the first study to assess the use of a miniaturized videoendoscopy probe to explore small peripheral lung nodules in real time, in vivo including subpleural small nodules. Kinoshita and colleagues recently described the use of a 0.97 mm fiberoptic probe, in three explanted lobes from lung cancer patients, and were able to visualize the peripheral tumour in one the cases.[7] Besides the use of these devices, ultrathin bronchoscopes (2.8 mm diameter and 1.2 mm working channel)[8,9] or robotic bronchoscopy (3.5 and 2 mm working channel)[10] allow the direct visualization of peripheral nodules at most to the middle third of the lung, the majority of these procedures using fluoroscopy or cone beam CT.

In this study, the Iriscope® aspect of malignant nodules seemed characteristic compared to infectious or nonspecific nodules, and were associated with a very high sampling diagnostic rate, in patients with centred or tangential r-EBUS images. This study did not test the difference between subsegmental atelectasis and lung cancer, and did not include GGO nodules which represent limitations in interpreting our results. From our recent experience, this miniaturized videoendoscopy probe appears to be a simple tool to confirm the localization of a guide sheath in a peripheral lung nodule before sampling, and therefore may improve the diagnostic yield of the procedure. Theoretically, it could also allow to adjust the diagnostic strategy, such as re-endoscopy or another sampling approach, in case of negative sampling despite a direct visualization of the tumour, and in the future to improve

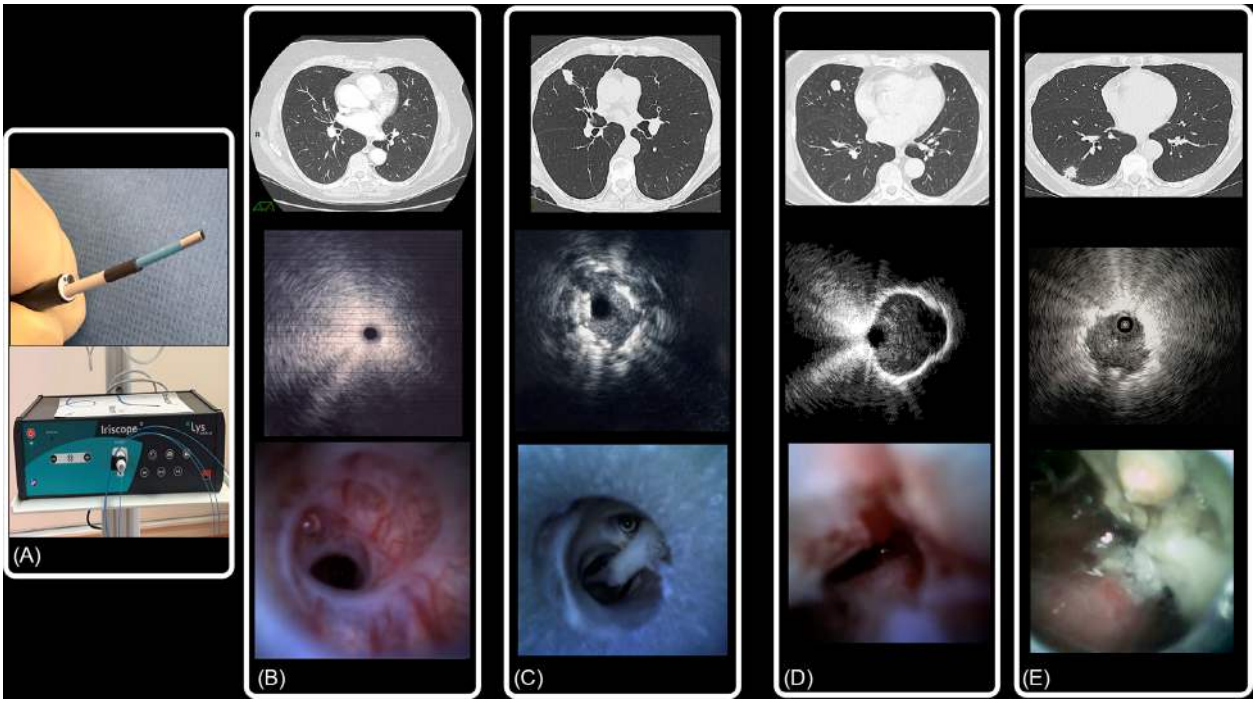

FIGURE 1 Iriscope® images. (A) Miniaturized videoendoscopy probe of 1.3 mm (4 Fr) (Iriscope® probe Lys Medical, Charleroy, Belgium) inside a guide sheath, inside a 4 mm bronchoscope with a 2.2 mm working channel; lower panel: Iriscope® processor. (B) Upper panel: CT-scan image of normal lung from the patient illustrated in (D); middle panel: 'Snow storm' r-EBUS image, corresponding to normal lung; lower panel: Iriscope® image of a normal part of the distal lung; (C) Upper panel: CT scan image of a middle lobe nodule; middle panel: Centred r-EBUS image of the nodule; lower panel: 'Non-specific' inflammation with secretion aspect on Iriscope® (final diagnosis: Infection). (D) Upper panel: CT scan image of a middle lobe nodule; middle panel: Tangential r-EBUS image of the nodule; lower panel: 'Suspicious' stenosis aspect on Iriscope® (final diagnosis: Carcinoid tumour). (E) Upper panel: CT scan image of a right lower lobe nodule; middle panel: Centred r-EBUS image of the nodule; Lower panel: Tumoural aspect with 'fish flesh' appearance on Iriscope® (final diagnosis: Adenocarcinoma).

the accuracy and safety of endoscopic treatment of distal lung nodules.

KEYWORDS
bronchoscopy, lung cancer, peripheral pulmonary nodule, radial endobronchial ultrasound, videoendoscopic probe, virtual bronchoscopy planner

AUTHOR CONTRIBUTIONS

Samy Lachkar: Conceptualization (lead); data curation (lead); formal analysis (lead); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (lead); writing – review and editing (equal). **Inès Duparc:** Conceptualization (equal); data curation (lead); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Nicolas Piton:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Edouard Dantoing:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Luc Thiberville:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Florian Guisier:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal). **Mathieu Salaün:** Conceptualization (equal); data curation (equal); formal analysis (equal); funding acquisition (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (equal); writing – review and editing (equal).

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CONFLICT OF INTEREST STATEMENT

None declared.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are not publicly available due to their containing information that could compromise the privacy of research participants but are available from Samy Lachkar on request.

HUMAN ETHICS APPROVAL STATEMENT

This study was performed in accordance with the Declaration of Helsinki and approved by the Institutional Review Board for non-interventional research of our centre (protocol agreement #E2024-10): E2024-10. All adult participants provided written informed consent to participate in this study.

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REFERENCES

1. Lachkar S, Perrot L, Gervereau D, de Marchi M, Morisse Pradier H, Dantoing E, et al. Radial-EBUS and virtual bronchoscopy planner for peripheral lung cancer diagnosis: how it became the first-line endoscopic procedure. Thorac Cancer. 2022;13(20):2854–60.
2. Chen H, Yu Y, Yu X, Li S, Zheng L, Zhang S, et al. An innovative method: predicting the visibility of radial endobronchial ultrasound for peripheral pulmonary nodules by virtual bronchoscopic navigation. Technol Cancer Res Treat. 2022;21:153303382211417.
3. Sagar A-ES, Sabath BF, Eapen GA, Song J, Marcoux M, Sarkiss M, et al. Incidence and location of atelectasis developed during bronchoscopy under general anesthesia: the I-LOCATE trial. Chest. 2020; 158(6):2658–66.
4. Mahiat C, Bondue B, Taton O, Leduc D. Emphysema seen through a mini-camera during an electromagnetic navigation bronchoscopy guided by cone-beam computed tomography. Respiration. 2023; 102(7):523–5.
5. Kikuchi E. Endobronchial ultrasonography with guide-sheath for peripheral pulmonary lesions. Eur Respir J. 2004 [cited 2022 Jan 4]; 24(4):533–7.
6. Lachkar S, Guisier F, Roger M, Obstoy B, Bota S, Lerouge D, et al. Assessment of per-endoscopic placement of fiducial gold markers for small peripheral lung nodules < 20 mm before stereotactic radiation therapy. Chest. 2018;153(2):387–94.
7. Kinoshita T, Terai H, Ikemura S, Takada N, Fukui T, Irie H, et al. Observation of peripheral airways using ultra-thin fiberscope. Respirology. 2023;28(9):881–4.
8. Oki M. Ultrathin bronchoscopy for diagnosing peripheral pulmonary lesions. Respir Investig. 2023;61(6):711–9.
9. Kim SH, Kim J, Pak K, Eom JS. Ultrathin bronchoscopy for the diagnosis of peripheral pulmonary lesions: a meta-analysis. Respiration. 2023;102(1):34–45.
10. Ortiz-Jaimes G, Reisenauer J. Real-world impact of robotic-assisted bronchoscopy on the staging and diagnosis of lung cancer: the shape of current and potential opportunities. Pragmat Obs Res. 2023;14: 75–94.

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