

## Case Report

# Dye-Marking via Electromagnetic Navigation Bronchoscopy (ENB): A New and Interdisciplinary Approach to the Management of Suspicious Pulmonary Nodules

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- Video-assisted thoracoscopy
- Diagnostic thoracotomy

**Abstract**

**Background:** Electromagnetic Navigation Bronchoscopy (ENB) is generally implemented as a diagnostic tool in the investigation of suspicious pulmonary nodules. The use of this technique to mark pulmonary nodules (using dye) prior to surgical resection could result in better outcome for patients by minimizing the risks related to surgery.

**Materials und Methods:** We present a clinical case where ENB was used as part of an interdisciplinary approach in the management of a suspicious pulmonary nodule. We analyzed the indication for this approach as well as the subsequent endoscopic procedure and post-interventional outcome.

**Results:** In a female patient (with a history of cervix carcinoma), ENB was used to mark a 2 mm sub-pleural nodule. The nodule was not palpable intra-operatively. The dye-marked pleural spot enabled the surgeon to perform a parenchyma-sparing wedge resection via Video-Assisted Thoracoscopy (VATS). The pathological findings ruled out malignancy.

**Conclusion:** Dye-Marking via ENB presents an interesting and new bronchoscopic technique which, as part of an interdisciplinary approach, may have a useful role in the management of suspicious pulmonary nodules. In the described case, therapy planning was successful and no procedure-related complications were observed.

**ABBREVIATIONS**

ENB: Electromagnetic Navigation Bronchoscopy; VATS: Video-Assisted Thoracoscopy; CT: Computerized Tomography

**INTRODUCTION**

Screening trials for the early detection of lung cancer using Computerized Tomography (CT) often result in findings of pulmonary lesions which are difficult to classify [1-4]. According

to the guidelines, patients with suspicious pulmonary nodules should undergo a surgical wedge resection thereby allowing a firm diagnosis, with escalation to a curative anatomical resection and lymph node dissection in the case of malignancy. Data from the National Lung Screening Trial (NLST) showed that 96.4% of the positive results in the low-dose CT group and 94.5% of those in the radiography group were false positive results [1]. The high number of false positive findings in screening CT scans has several implications on the strategy chosen to deal

with detected pulmonary nodules. It has been discussed that in order to maximize cost-effectiveness, risk stratification should be established to identify the patients with a high risk of developing lung cancer [5,6]. Specific criteria therefore need to be established, in order to identify those patients in whom further invasive evaluation of pulmonary nodules would be justified and beneficial. Further to this, strategies need to be in place which guarantee identification of the nodule during surgery and allow a parenchyma sparing resection for the frozen section. The management of small suspicious pulmonary nodules can often lead to a management dilemma. Indeed, in some cases, intrapulmonary nodules detected by CT may not be palpable intra-operatively, making parenchyma sparing resections impossible and leading to larger wedge resections or anatomical segment or lobe resections. Marking the pulmonary nodules beforehand, could facilitate the surgical procedure.

Electromagnetic Navigation Bronchoscopy (ENB) is a new minimally invasive bronchoscopic technique which was developed as a diagnostic tool for the biopsy of small pulmonary nodules. Previous studies have shown that ENB is able to allow diagnostic biopsies of small peripheral pulmonary nodules in about 75.5% of cases [7]. It could be shown that ENB is associated with a very low rate of complication (namely pneumothorax or intrapulmonary bleeding). This combination of high technical precision and low complication rate begs the question if the ENB technique has a use in the therapeutic side of management as well. ENB guided dye-marking of small pulmonary nodules may better allow a parenchyma sparing wedge resection, particularly in cases where the nodules are non-palpable. Feasibility and complication rates have not yet been analyzed for this multidisciplinary approach.

## CASE PRESENTATION

### Material and methods

We present a clinical case where dye-marking was used as part of an interdisciplinary approach to the management of a pulmonary nodule. The patient gave her consent for the interventional and surgical procedures. For the scientific analysis a waiver of consent was granted by the Institutional Review Board (IRB), University of Witten/Herdecke, Germany. All relevant patient data were analyzed including biological baseline data, lung function status, findings of clinical investigations, computerized tomography, histological findings and complications.

Prior to ENB, CT data are used to simulate a virtual bronchoscopy in the bronchial tree. Using the ENB-software, the ideal bronchoscopic navigation path to reach a predefined target is determined. These pre-calculated navigation data are subsequently applied whilst performing a real-time bronchoscopy on the patient. During ENB, an electromagnetic field is created around the patient's thorax. The electromagnetic field not only detects the ENB-probe - which is guided bronchoscopically to the target - but also breath-cycle related changes in the configuration of the thorax, the bronchial tree and the lungs. The latter allows rapid adaption of the virtual data to the real-time data received by the ENB-probe.

Dye-marking was performed under sedation with disoprivan and spontaneous breathing conditions using a flexible

bronchoscope (flexible 180-video-bronchoscope, Olympus, Hamburg, Germany). ENB was performed using the i-logic system (Covidien, Mansfield, USA) based on data of a chest computerized tomography (1.6mm slides, 2.0mm overlap). The correct probe position was verified using fluoroscopy control once the target point of navigation was reached.

0.2 ml of indigo carmine dye was used to mark both the intra-parenchymal nodule and a spot on the overlying visceral pleural with the shortest distance to the nodule. Indigo carmine dye was applied using a bronchoscopy catheter (diameter 1.6 mm; MTW, Wesel, Germany) less than 24 h prior to surgery.

### Results

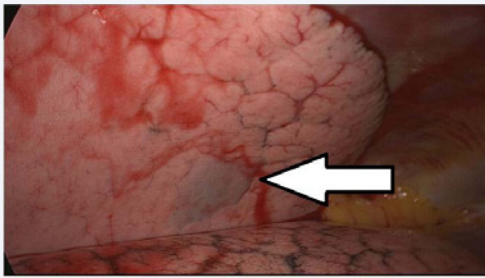
A 42 year old female patient with a history of cervix carcinoma was admitted to our hospital in 2012. A hysterectomy had been performed in 2012 as treatment for the cervix carcinoma. A chest computerized tomography was subsequently performed for the purpose of staging (Figure 1). The radiological finding described a sub-pleural pulmonary nodule in the middle lobe with a diameter of 2 mm. The consulting thoracic surgeon estimated that this nodule would be non-palpable intra-operatively. The patient requested a definite exclusion of malignancy via surgery. She was a never-smoker with a body mass index of 24 kg/m<sup>2</sup> (height 172 cm, weight 72 kg). Laboratory tests were normal. Lung function evaluation showed no functional impairment (Forced expiratory volume in 1 second 112% predicted, forced vital capacity 137 % predicted, residual volume 153% predicted, Diffusing capacity of the Lung for Carbon Monoxide (DLCO) using the single breath method 89% predicted). ENB guided application of indigo carmine was used to mark the pulmonary nodule as well as a spot on the overlying visceral pleural with the shortest distance to the nodule. The dye-marked pleural spot enabled the surgeon to perform a parenchyma-sparing wedge resection via VATS (Figure 2). The pathological findings ruled out malignancy and described a small flat bulla with surrounding fibrotic pleuraparenchymal residuals (Figure 3). No procedure-related complications occurred after bronchoscopy or surgery.

### Discussion

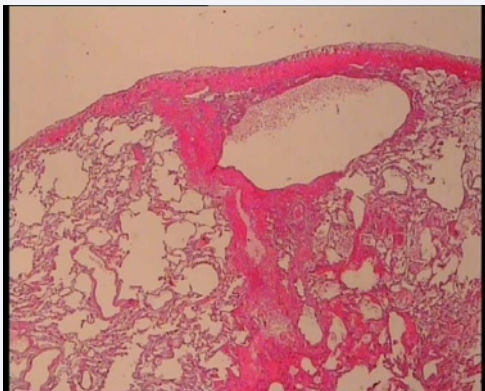
The finding of small, suspicious pulmonary nodules can lead to a dilemma in management. In cases where a surgical approach is feasible, a wedge resection with instantaneous frozen section



**Figure 1** Chest Computerized Tomography, =>: Small intrapulmonary nodule in the middle lobe.



**Figure 2** Intraoperative situs, =>: dye-marked pleural spot.



**Figure 3** Histology of a wedge resection showing a small flat bulla with surrounding fibrotic pleuraparenchymal residuals (Hematoxylin-eosin-staining, original magnification x 400).

analysis is the favored procedure. However in many cases, the nodules may be so small as to be non-palpable intra-operatively. In such cases, an interdisciplinary approach with pre-operative marking of the pulmonary nodule with lung marking wires, fiducial markers, colored collagen or dye-marking may allow a parenchyma-sparing wedge resection [8-11]. CT-guided percutaneous marking of the nodule is associated with a relevant risk of pneumothorax and bleeding. Conventional bronchoscopy often fails to reach the targeted nodule to allow accurate marking. The presented case shows that ENB can be an attractive option displaying high precision and a low complication rate. In this case, ENB guided dye-marking of a pulmonary nodule allowed a parenchyma-sparing wedge resection although the nodule was non-palpable intra-operatively. In the future, prospective studies have to analyze whether the use of this technique can reduce the number of non-diagnostic resections and whether there is a benefit in outcome in terms of lung function, when nodules are dye-marked prior to surgery. Dye-marking may be especially attractive in cases of metastasectomy, where multiple nodules have to be resected.

Because no puncture techniques were applied, bleeding or pneumothorax was not observed. The distance between the pulmonary nodule and the targeted point of marker placement was calculated in real-time using the ENB software. This allowed precise planning and execution of dye-marking using a real-time virtual three-dimensional planning software during the bronchoscopy.

## CONCLUSION

ENB-guided dye-marking is a new technique which may be applicable in patients with small pulmonary nodules allowing a surgical parenchyma-sparing wedge resection even in cases where the nodules are not palpable intraoperatively.

The described technique may offer a promising interdisciplinary therapeutic approach in cases where the standard procedures for intrapulmonary nodules fail.

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