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Original Research Article

Contribution of Pleuropulmonary Ultrasound in the Prediction of Pulmonary Exclusion in Thoracic Surgery

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Abstract: ***Introduction*:** Thoracic surgery frequently requires lung exclusion using a double-lumen probe. While bronchoscopy remains the gold standard for verifying probe placement, its logistical and financial constraints have prompted the exploration of alternatives. Pleuropulmonary ultrasound, by detecting pleural sliding, offers a non-invasive and rapid approach. This preliminary prospective study evaluates the performance of pleuropulmonary ultrasound in predicting lung exclusion. ***Patients and Methods*:** Between August and December 2024, 20 adult patients scheduled for thoracic surgery at the Fann University Hospital (Dakar) were included. After intubation with a Carlens tube, exclusion was assessed by clinical auscultation and by lung function testing. The primary outcome was the surgeon's intraoperative assessment (quality of lung collapse). Sensitivity (Se) and positive predictive value (PPV) were calculated for each method. ***Results*:** The cohort (mean age 48 years; sex ratio 1.8) had a satisfactory exclusion rate of 100% according to the surgeon. Auscultation identified exclusion in 14 cases (sensitivity 70%), while percutaneous transurethral resection (PUR) confirmed it in 18 cases (sensitivity 90%). The positive predictive value (PPV) was 100% for both techniques. In the absence of exclusion failures, specificity and negative predictive value could not be determined. ***Conclusion*:** Pleuropulmonary ultrasound has a higher sensitivity than auscultation for confirming pulmonary exclusion. Although bronchoscopy remains essential in cases of doubt, PPE is proving to be a powerful, reproducible, and accessible complementary tool, enhancing anesthetic safety in thoracic surgery.

Keywords: Pleuropulmonary Ultrasound, Pulmonary Exclusion, Thoracic Surgery, Auscultation, Double-Lumen Probe, Fibroscopy.

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INTRODUCTION

Thoracic surgery often requires lung exclusion using a double-lumen tube to optimize the surgical field [1]. Ensuring proper placement of this tube is crucial to avoid intraoperative hypoxia [2]. Although auscultation and capnography are common, they lack the precision to distinguish tracheal intubation from selective bronchial intubation [3].

Fiberoptic bronchoscopy remains the gold standard, with an efficacy close to 100% [4], despite its cost and time-consuming nature. As an alternative, pleuropulmonary ultrasound allows visualization of pleural sliding to confirm ventilation [5]. Our preliminary prospective study evaluates whether this non-invasive method can equal fiberoptic bronchoscopy. The hypothesis rests on the ability of ultrasound to guarantee optimal surgical exclusion, the primary endpoint of this study.

PATIENTS AND METHODS

This prospective, observational, single-center study was conducted between August 1 and December 31, 2024, within the Thoracic and Cardiovascular Surgery (CTCV) department of the Fann University Hospital in Dakar. This center is the national referral center for the management of thoracic pathologies in Senegal.

The primary objective was to evaluate the diagnostic performance of pleuropulmonary ultrasound in verifying the placement of dual-lumen probes (DLPs), compared to clinical auscultation. Of the 27 patients who underwent surgery during the study period, 20 adults scheduled for elective pulmonary or pleural surgery were

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included. Pediatric procedures and emergencies were excluded from the protocol.

The anesthetic protocol was standardized: after induction with propofol, sufentanil, and vecuronium, intubation was performed under direct laryngoscopy with a Carlens tube (size 37 to 41 F). Lung exclusion was achieved by selective inflation of the cuffs and clamping of the lumen of the lung to be operated on, followed by positioning the patient in the lateral decubitus position.

The positioning assessment was based on two methods performed by the same anesthesiologist:

1. Pulmonary auscultation: considered positive for exclusion in case of disappearance of vesicular breath sounds on the operated side.
2. Pleuropulmonary ultrasound: performed with a Sonosite Edge II® device and a linear probe. The examination, systematically divided into four quadrants per hemithorax, aimed to identify the absence of pleural sliding (*sliding sign*) as a marker of successful exclusion.

The primary outcome measure (gold standard) was the surgeon's intraoperative assessment, classifying the quality of lung collapse into three levels: good, average, or none. For statistical analysis, the first two categories were grouped under the term "successful exclusion".

The data, processed using Microsoft Excel 2016, allowed for the calculation of sensitivity, specificity, and positive and negative predictive values for each technique. This methodology aims to determine whether ultrasound, a non-invasive tool available in the operating room, can optimize the safety of lung exclusion in the sample despite the small cohort size.

RESULTS

A. Descriptive Results

The study included 20 adult patients (mean age 48 years, median age 49 years, range 18 to 78 years). The population was predominantly male, with a male-to-female ratio of 1.8 (13 men to 7 women). Regarding their general health status, all patients were classified according to the American Society of Anesthesiologists (ASA) scale: 15 patients were ASA I and the remaining 5 were ASA II.

The main surgical indications were recurrent pneumothorax (55%), followed by aspergillosis (20%). Other diagnoses were also present (detailed distribution in Figure 4). Regarding the procedures, 60% were performed via thoracotomy and 40% via video-assisted thoracoscopic surgery (VATS). The most frequent type of surgery was pleurectomy (40%), followed by lobectomy (35%).

All patients underwent anesthetic induction using a standard sequence (pre-oxygenation, hypnotic, morphine, and neuromuscular blockade). Selective intubation was performed exclusively using double-lumen Carlens tubes, the size of which (37, 39, or 41 French) was chosen according to the patient. The majority of tubes used were left-handed (n=16), compared to 4 right-handed.

The evaluation of the quality of lung exclusion showed a 100% success rate according to surgical exploration (assessment deemed satisfactory in all 20 cases). Pleuropulmonary ultrasound, performed after exclusion, revealed an absence of pleural sliding in 18 out of 20 cases.

B. Analytical Results

After exclusion of lung disease, the observations from the two evaluation methods were as follows:

- Pulmonary auscultation: The absence of vesicular breath sounds was noted in 14 out of 20 cases.
- Pleuropulmonary ultrasound: The absence of pleural sliding *sign* was observed in 18 out of 20 cases.

Due to the complete absence of intubation failures in our study cohort, it was not possible to evaluate certain key statistical parameters. Therefore, specificity, false-positive, and true-negative rates could not be determined for auscultation and ultrasound techniques.

Table I: The Auscultation Data Are Described in the Table

	Correct intubation (surgical exploration)	Intubation failure (surgical exploration)
Vesicular murmurs -	(VP) 14/20	(FP) 0/20
Vesicular murmur +	(FN) 6/20	(VN) 0/20

Table II: Ultrasound Data

	Correct intubation (surgical exploration)	Intubation failure (surgical exploration)
Ultrasound -	(VP) 18/20	(FP) 0/20
Ultrasound +	(FN) 2/20	(VN) 0/20

Table III: Comparison of Diagnostic Performance between Auscultation and Ultrasound

	Sensitivity	Specificity	VPP	VPN
Auscultation	70%	ND	100%	ND
Ultrasound	90%	ND	100%	ND

DISCUSSION

This preliminary study highlights the potential value of pleuropulmonary ultrasound (PPE) as an alternative to bronchoscopy for verifying the placement of double-lumen endotracheal tubes (DLTs). Although some teams already incorporate PPE into their presurgical routine, the study by Sustić *et al*., [6], confirms its clinical utility thanks to its excellent sensitivity.

In the context of standard intubation, auscultation fails to diagnose selective intubation in one-third of cases [7], while ultrasound proves more sensitive and specific [8]. Similar observations are reported for the placement of airway obstructions [9, 10]. While auscultation retains practical advantages, its reliability remains limited. Yet, percutaneous transthoracic echocardiography (PTE) is now a validated diagnostic tool in the management of pneumothorax and respiratory distress [10-12]. Paradoxically, few studies have yet evaluated its specific contribution in thoracic anesthesia for the control of airway obstructions [5-13].

The ultrasound sensitivity observed in our cohort (90%) is comparable to the data reported by Durand *et al*., [14], for bronchoscopy (90%), with an identical positive predictive value (PPV) of 100%. The most reliable parameter remains the absence of pleural sliding (*sliding sign*), observed in 90% of cases after exclusion. The excellent quality of exclusion, as judged by the surgeon, explains the uncertainty in the specificity and negative predictive value (NPV), which is potentially enhanced by the combination of clinical examination and ultrasound.

Combining electrophysiological studies (EPS) with clinical examination appears superior to clinical examination alone. Sustić *et al*., [6], reported a specificity increase from 22% to 50% with this combination. Another study confirms this performance gain, with sensitivity increasing from 75% to 88% and specificity jumping from 18% to 75% [2]. However, in obese individuals, EPS loses diagnostic performance compared to clinical examination alone [15].

Despite these advantages, EPP does not appear sensitive enough to detect precise malpositions. In this regard, capnography remains a reference tool for confirming tracheal intubation (sensitivity 93%, specificity 97%) [16], but proves insufficient to distinguish tracheal from bronchial intubation [3]. Bronchoscopy therefore remains the *gold standard* (specificity of 100%) [4-8], essential in cases of clinical uncertainty or desaturation.

The limitations of this study lie in its single-center design and small sample size. Furthermore, the choice of surgical evaluation as the reference criterion allows for judging the quality of lung collapse but does not provide information on the exact anatomical position of the probe (e.g., contralateral lobar atelectasis due to subsidence). The integration of spirometry (insufflation pressures) and the bubble test could, in the future, refine the detection of malpositions. If these results are confirmed on a larger scale, lung pulmonary edema (LPE) could reduce the routine use of bronchoscopy, a costly and time-consuming procedure.

CONCLUSION

This pilot study suggests that pleuropulmonary ultrasound is a more sensitive method than traditional auscultation for confirming intraoperative lung exclusion in thoracic surgery. Its positive predictive value appears excellent. Although it does not replace bronchoscopy as the gold standard for accurately verifying the positioning of the double-lumen probe, it is a valuable, rapid, non-irradiating, and easily repeatable complementary tool. Its integration into the intraoperative verification algorithm, in conjunction with clinical examination, could improve the safety and efficiency of procedures.

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Conflicts of Interest: No conflicts of interest related to this article.

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