The Safety of Laryngeal Mask Airway-Assisted Bronchoscopy versus Standard Nasal Bronchoscopy

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Keywords

Laryngeal mask · Bronchoscopy · Oxygen saturation · Cutaneous carbon dioxide tension · Blood pressure · Sedation

Abstract

Background: The use of laryngeal mask airway (LMA) for fiberoptic bronchoscopy was first described in 1982. The LMA was found to be beneficial in operator view, flexibility, and also in maintaining stable oxygen saturation. Despite its advantages, the use of LMA has not become widespread. **Objective:** The aim of this paper was to evaluate the safety of LMA-assisted bronchoscopy compared to standard nasal bronchoscopy. **Methods:** We conducted a prospective randomized trial. The study group included 105 patients prospectively randomized to undergo either LMA-assisted (53 patients) or standard nasal bronchoscopy (52 patients). The data collected included continuous monitoring of respiratory and hemodynamic parameters and medication doses. **Results:** The LMA group had a significantly lower percentage

of desaturation (pulse oximetry saturation [SpO₂] <88%) events compared to the non-LMA (NLMA) group (37 vs. 63.4%; $p = 0.008$). The median percentage of time with SpO₂ >88%, from the total procedure time, was 100% (IQR 98–100) in the LMA group and 98% (IQR 96–98) in the NLMA group ($p = 0.003$). Sedation in the LMA group required significantly higher doses of propofol ($p < 0.001$). The mean systolic blood pressure values were significantly lower in the LMA group, but this difference did not result in a higher percentage of clinically significant hypotension. **Conclusion:** The use of LMA allows for better airway support, stable oxygen saturation, and a more convenient port of entry during flexible fiberoptic bronchoscopy. These results, together with the known advantages of the laryngeal mask, should lead to more widespread use in the evolving field of interventional pulmonology, in particular in high-risk patients and complicated procedures.

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Introduction

Fiberoptic bronchoscopy is commonly used for the diagnosis and management of a variety of lung diseases [1, 2]. Desaturation during the procedure is common and requires saturation monitoring and, when needed, oxygen supplementation [3, 4]. Older age, comorbidities, type and severity of the baseline chronic lung disease, and the type of procedure all influence the frequency and severity of desaturation [5–8]. Stable airway control may be achieved with the use of an endotracheal tube, and while this option is used in high-risk or already intubated patients, it is not practical for ambulatory and stable, hospitalized patients. Therefore, a simpler and less invasive solution is needed for a better airway support during bronchoscopy.

The laryngeal mask airway (LMA), first presented in 1983, had a profound impact on airway management [8, 9]. The use of LMA for airway management during flexible fiberoptic bronchoscopy (FFB) was first introduced in 1989 and since then has been described as a safe and convenient tool for airway control during bronchoscopy in both adult and pediatric populations [10–13]. Its advantage compared to the endotracheal tube is the use of a larger diameter conduit, allowing a better view and flexibility [14, 15].

LMA has been successfully used in some specific FFB procedures, such as balloon dilation, brachytherapy, bronchial stenting, and foreign body extraction [16–18].

Notwithstanding its advantages over nasal bronchoscopy, LMA has not been widely used, and to our knowledge, no study has compared the use of LMA-assisted bronchoscopy to standard nasal bronchoscopy. In this study, we sought to evaluate the use of LMA during FFB by monitoring the hemodynamics, pulse oxygen saturation (SpO_2), transcutaneous PCO_2 , and complications.

Methods

A prospective randomized study was conducted at a tertiary medical center from February to September 2016. The study group included 105 patients scheduled for FFB under local anesthesia with sedation.

Inclusion criteria were age >18 years, $\text{SpO}_2 >95\%$ in room air, and hemodynamic stability at the beginning of the procedure. We included both ambulatory and hospitalized patients. All subjects provided written informed consent for bronchoscopy, and the study has been approved by the local ethics committee (ClinicalTrials.gov, identifier: NCT02698007). Exclusion criteria for the study were inability or refusal to provide informed consent, bronchoscopy through an artificial airway, such as endotracheal tube

or tracheostomy. Alternating patient randomization was used to assign each patient to either LMA or nasal bronchoscopy. An anesthesiologist was present throughout each procedure and was in charge of monitoring the patients and the sedation protocol that was identical in all patients and included administration of fentanyl (50–100 μg), midazolam (1–5 mg), and propofol according to the procedure length. The bronchoscope was inserted through a swivel adapter, and visual confirmation was done by the performing pulmonologist. The LMA was connected to a self-inflating resuscitation bag (Ambu with oxygen reservoir) that was used according to the anesthesiologist discretion.

In all cases, monitoring included continuous electrocardiography, pulse oximetry, transcutaneous PCO_2 , and automated noninvasive blood pressure recordings every 5 min. All patients received supplemental nasal oxygen at 2–5 L/min. The duration of bronchoscopy was calculated from the administration of sedation until the flexible bronchoscope was removed from the tracheobronchial tree.

Study Outcomes

The primary outcome was any event of desaturation $<88\%$ and was obtained with constant pulse oximetry monitoring. We also evaluated the percentage of procedure time with $\text{SpO}_2 >88\%$. Secondary outcomes were a cutaneous carbon dioxide tension (PccO_2) rise >55 mm Hg, SpO_2 and PccO_2 levels, blood pressure, doses of drugs used for sedation, and complications.

Statistical Analysis

The baseline characteristics and secondary outcomes were compared with the Student t test, χ^2 test, and the Mann-Whitney U test, as appropriate. The primary outcome was analyzed as a dichotomous variable with the χ^2 test and also as percentage of the procedure time with $\text{SpO}_2 >88\%$ with the Mann-Whitney U test.

Results

The LMA group consisted of 53 patients, and the non-LMA (NLMA) group consisted of 52 patients. Table 1 shows the background and clinical characteristics of the 2 groups. There were no significant between-group differences in demographics, type of procedure, and baseline hemodynamic and respiratory parameters. The LMA group had a higher percentage of male patients and a longer procedure time, but these differences were not significant.

Primary Outcome

Overall the LMA group had 20 (37%) patients with a drop of $\text{SpO}_2 <88\%$ at any time during the procedure in comparison to 33 (63.4%) patients in the NLMA group ($p = 0.008$). The median percentage of time with $\text{SpO}_2 >88\%$, from the total procedure time, was 100% (interquartile range [IQR] 98–100) in the LMA group and 98% (IQR 96–98) in the NLMA group ($p = 0.003$). Table 2 and

Table 1. Background and clinical characteristics of 109 patients undergoing bronchoscopy

	All patients	LMA group	NLMA group	<i>p</i> value
Patients	105	53	52	
Age, years	62.3±14.23	62.05±14.46	62.67±14.13	0.82
Males/females	62/43	36/17	26/26	0.06
BMI	25.1±5.4	25.37±5.21	24.92±5.8	0.46
Comorbidities				
HTN	34 (32.4)	16 (30.2)	18 (34.6)	0.62
IHD	15 (14.3)	8 (15.1)	7 (13.5)	0.81
Asthma	1 (1)	0	1 (1.9)	0.49
COPD	23 (21.9)	13 (24.5)	10 (19.2)	0.51
Smoker	21 (20)	10 (18.9)	11 (21.2)	0.77
Lung malignancy	30 (28.6)	17 (32.1)	13 (25.0)	0.42
Lung transplantation	21 (20)	13 (24.5)	8 (15.4)	0.26
Two or more comorbidities	25 (22.9)	14 (24.6)	11 (21.2)	0.67
Procedure				
Bronchoalveolar lavage	105	53	52	
Transbronchial biopsy	39	23	16	
Cryobiopsy	29	17	12	
Endobronchial biopsy	23	10	13	
Mechanical dilatation	11	3	8	
Laser	10	4	6	
Bronchial brushings	8	5	3	
EBUS	4	4	0	
Brachytherapy	1	1	0	
Bronchography	2	1	1	
Stent placement	2	1	1	
Baseline parameters				
PcCO ₂ , mm Hg	38.34±6.36	38.84±7.22	37.84±5.38	0.44
SpO ₂ , %	98.58±2.07	98.31±2.34	98.88±1.69	0.37
SBP, mm Hg	135.63±18.98	133.75±19.02	137.54±18.93	0.31
DBP, mm Hg	76.92±16.24	78.46±11.34	75.38±19.98	0.33
HR, bpm	77.38±16.47	77.26±18.34	77.5±14.51	0.94

Values are presented as *n*, *n* (%), or mean ± standard deviation. LMA, laryngeal mask airway; NLMA, non-LMA; BMI, body mass index; HTN, hypertension; IHD, ischemic heart disease; COPD, chronic obstructive pulmonary disease; EBUS, endobronchial ultrasound; PcCO₂, cutaneous carbon dioxide tension; SpO₂, pulse oximetry saturation; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate.

Table 2. Cardinal hemodynamic, respiratory, and medication monitoring during the procedure

	LMA	NLMA	<i>p</i> value
SpO ₂ <88%	20/53	33/52	0.008
SpO ₂ >88% (percentage from procedure time)	100; 98–100	98; 96–100	0.003
PcCO ₂ >55 mm/Hg	30/47	28/48	0.58
SBP <90 mm Hg	7/52	7/53	0.96
Propofol dosage, mg	200; 165–300	120; 70–200	<0.001
Midazolam dosage, mg	1; 1–1	1; 1–3	0.21
Fentanyl dosage, µg	100; 100–100	100; 100–100	0.07
Duration of procedure, min	20; 15–27.5	20; 15–25	0.055

Values are presented as *n* or median; interquartile range. LMA, laryngeal mask airway; NLMA, non-LMA; SpO₂, pulse oximetry saturation; PcCO₂, cutaneous carbon dioxide tension; SBP, systolic blood pressure.

Table 3. Monitoring of SpO₂, PccO₂, heart rate, and systolic blood pressure during bronchoscopy

Time, min	LMA					NLMA					<i>p</i> value			
	<i>n</i>	SpO ₂ , % (median; IQR)	PccO ₂ , mm Hg (mean ± SD)	HR (mean ± SD)	SBP, mm Hg	<i>n</i>	SpO ₂ , % (median; IQR)	PccO ₂ , mm Hg (mean ± SD)	HR (mean ± SD)	SBP, mm Hg	SpO ₂ , %	PccO ₂ , mm Hg	HR	SBP, mm Hg
5	53	99; 96–100	44.73 ± 8.3	81.07 ± 18.36	125.3 ± 21.2	52	99; 90–100	44.5 ± 7.84	80.48 ± 14.79	134.88 ± 22.58	0.44	0.88	0.85	0.02
10	53	100; 97–100	50.91 ± 9.23	80.69 ± 15.44	114.77 ± 22.35	52	96; 90–99	51.02 ± 10.43	85.76 ± 18.37	25.51 ± 3.57	<0.001	0.95	0.12	<0.001
15	52	100; 98–100	52.63 ± 10.55	80.26 ± 15.99	112.81 ± 19.66	45	96; 90–100	54.35 ± 13.98	86.3 ± 18.92	129.53 ± 27.4	<0.001	0.5	0.09	0.001
20	40	100; 99–100	55.83 ± 12.46	82.15 ± 15.89	116.78 ± 18.47	31	99; 93–100	54.75 ± 12.73	88.75 ± 19.15	125.87 ± 27.38	0.003	0.73	0.11	0.12
25	18	100; 98.75–100	58.58 ± 10.35	85.88 ± 15.53	116.0 ± 19.01	13	98; 91.5–99.5	54.15 ± 7.88	87.0 ± 17.24	122.71 ± 28.43	0.014	0.21	0.85	0.43
After procedure	53	100; 98–100	50.12 ± 10.01	79.69 ± 16.34	118.56 ± 17.47	52	100; 99–100	49.37 ± 10.7	83.0 ± 17.19	124.31 ± 20.86	0.59	0.71	0.31	0.14

SpO₂, pulse oximetry saturation; IQR, interquartile range; PccO₂, cutaneous carbon dioxide tension; LMA, laryngeal mask airway; NLMA, non-LMA; SBP, systolic blood pressure; HR, heart rate.

Fig. 1. Procedure time with SpO₂ > 88% represented by the percentage from procedure time.

Figure 1 display the rate of desaturation events and the percentage of procedure time with SpO₂ > 88%.

Secondary Outcomes

The percentage of patients who had a rise of the PccO₂ level > 55 mm Hg or a drop of the systolic blood pressure < 90 mm Hg was similar (Table 2). The median SpO₂ at 5 min intervals were significantly higher in the LMA group for procedure minutes 10–20 ($p < 0.001$, $p < 0.001$, and $p = 0.003$ for procedure minutes 10, 15 and 20, respectively); the SpO₂ level remained high beyond 20 min, but the number of patients was not sufficient for statistical analysis, since procedure time was, in most cases (71.2%), ≤ 20

min (Table 3, Fig. 2). Sedation required a significantly higher dose of propofol in the LMA group. The median propofol dosage was 200 mg (IQR 165–300) in the LMA group and 120 mg (IQR 70–200) in the NLMA group ($p < 0.001$). There was no between-group difference in midazolam and fentanyl doses. The mean systolic blood pressure values were significantly lower in the LMA group in the first 15 min of the procedure ($p = 0.02$, < 0.001 , and 0.001 for procedure minutes 5, 10, and 15, respectively). The blood pressure values remained lower for the LMA group beyond 15 min, but the difference did not reach statistical significance. There were no between-group differences in the mean PccO₂ level (Fig. 3) and heart rate during the procedure. Table 3 presents SpO₂, PccO₂, heart rate, and systolic blood pressure monitoring during FFB.

Adverse Events

Overall 6 patients suffered an adverse event, 3 in the LMA group and 3 in the NLMA group. Adverse events in the LMA group were throat pain, lip trauma, and bronchospasm. In the NLMA group, 2 patients suffered from nose bleeding, and 1 patient suffered severe desaturation during the procedure and was intubated. None of the patients had severe arrhythmia during or after the procedure.

Discussion

The present study evaluated the efficacy and safety of LMA use for FFB. The results showed that LMA use is associated with a significantly higher SpO₂ level throughout

Fig. 2. Median SpO₂ at 5-min intervals. Solid line, laryngeal mask airway; dashed line, nonlaryngeal mask airway.

Fig. 3. Mean PccO₂ at 5-min intervals. Solid line, laryngeal mask airway; dashed line, nonlaryngeal mask airway.

the procedure and a significantly lower rate of desaturation (SpO₂ <88%) events. These results are compatible with earlier studies, which evaluated the use of LMA in specific procedures [16–19]. Stable oxygen saturation for a prolonged time enables longer procedures, less interruption for oxygen enrichment, and ventilation and improved safety, especially for patients with comorbidities.

LMA insertion requires deeper sedation. Expected adverse events for higher doses of sedative drugs include oxygen desaturation, reduced systolic blood pressure, and severe hypotension (systolic blood pressure <90 mm Hg) [20–22]. Thus, LMA use is controversial in patients with multiple comorbidities. Our study did not exclude patients with comorbidities and was therefore eligible to assess the safety of LMA use in these patients. As expected, LMA use was associated with a significantly higher dose of propofol. In accordance, blood pressure monitoring during the procedure showed significantly lower systolic blood pressure values in the LMA group. Nevertheless, this difference did not result in a higher percentage of clinically significant hypotension. Moreover, even with a higher propofol dosage, no differences in the heart rate and PccO₂ values were noted. It is important to note that the patients in both groups were breathing spontaneously throughout the procedure and that the Ambu bag that

was connected to the LMA was used only for additional ventilation during desaturation events. Overall 25 patients in the cohort had 2 comorbidities or more, and we did not see a higher frequency of adverse events in this group.

Our results show that LMA-assisted bronchoscopy enables higher levels of saturation even in prolonged procedures. Since the LMA is easy to insert and allows for a more convenient port of entry, it may be used even in simple procedures, but it will be most valuable in high-risk patients who would otherwise require protective intubation for the procedure and for long and complicated procedures such as endoscopic volume lung reduction, endobronchial ultrasound [23], and bronchial thermoplasty.

In conclusion, the use of LMA allows for better airway support, stable oxygen saturation, and a more convenient port of entry during FFB. These benefits should present as most useful in difficult cases and more prolonged procedures. In light of these benefits and the already known advantages of the laryngeal mask, more widespread use in the evolving field of interventional pulmonology is expected.

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