Acta Anaesthesiol Scand 2009; **53**: 436–442
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ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2008.01882.x

Comparison between intubation and the laryngeal mask airway in moderately obese adults

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Background: Obesity is a well-established risk factor for perioperative pulmonary complications. Anaesthetic drugs and the effect of obesity on respiratory mechanics are responsible for these pathophysiological changes, but tracheal intubation with muscle relaxation may also contribute. This study evaluates the influence of airway management, i.e. intubation vs. laryngeal mask airway (LMA), on postoperative lung volumes and arterial oxygen saturation in the early postoperative period.

Methods: We prospectively studied 134 moderately obese patients (BMI 30) undergoing minor peripheral surgery. They were randomly assigned to orotracheal intubation or LMA during general anaesthesia with mechanical ventilation. Premedication, general anaesthesia and respiratory settings were standardized. While breathing air, we measured arterial oxygen saturation by pulse oximetry. Inspiratory and expiratory lung function was measured preoperatively (baseline) and at 10 min, 0.5, 2 and 24 h after extubation, with the patient supine, in a 30° head-up position. The two groups were compared using repeated-measure analysis of variance (ANOVA) and *t*-test analysis. Statistical significance was considered to be $P < 0.05$.

Results: Postoperative pulmonary mechanical function was significantly reduced in both groups compared with preoperative values. However, within the first 24 h, lung function tests and oxygen saturation were significantly better in the LMA group ($P < 0.001$; ANOVA).

Conclusions: In moderately obese patients undergoing minor surgery, use of the LMA may be preferable to orotracheal intubation with respect to postoperative saturation and lung function.

Accepted for publication 12 November 2008

General anaesthesia exerts several negative effects on lung function.[1,2] Relaxation and mechanical ventilation lead to an increased Va/Q mismatch,[3] and up to 90% of healthy adult patients develop a measurable amount of atelectasis.[4] Obesity increases the likelihood of atelectasis.[5] Increased BMI correlates with loss of perioperative functional residual capacity (FRC), expiratory reserve volume and total lung capacity, up to 50% of preoperative values.[6] These findings suggest that adverse respiratory events are significantly more frequent in the obese. Most of these events occur in the post-anaesthesia care unit (PACU).[7]

Despite a number of controversial studies, many anaesthetists prefer the complete airway control that orotracheal intubation offers in the obese patient. Positive end-expiratory pressure (PEEP) and vital capacity (VC) manoeuvres can easily be applied to prevent atelectasis, although airway irritation[8] and the effects of muscle relaxation[9] may be disadvantageous. In contrast, the laryngeal mask airway (LMA) does not interfere with the larynx or the normal expiratory 'laryngeal' resistance, and muscle relaxation is unnecessary. Normal diaphragmatic tonicity is thus maintained and may help to prevent lung collapse.[10,11] The aim of our study was to evaluate the impact of the operative airway management (LMA vs. orotracheal intubation) on early postoperative lung function tests and pulse oximetry values in moderately obese adults.

Methods

Study population

The study was approved by the Ethics Committee of the University of Marburg. Informed written consent was obtained from each patient. We prospectively included 134 moderately obese adult patients (BMI 30–35, ASA II–III) scheduled for minor peripheral surgery (Table 1). No operations requiring abdominal insufflation (laparoscopy) or head-down tilt were included. The minimum surgery time was set to be at least 40 min up to 120 min. All patients were allocated on a random basis either to the intubation or to the laryngeal mask group (ProSeal® Laryngeal Mask – LMA Group, Bonn, Germany). We excluded patients who had gastro-oesophageal reflux disease or a hiatus hernia, airway physical examination that may suggest the presence of a difficult intubation, pregnancy, asthma requiring therapy, cardiac disease associated with dyspnoea >NYHA II or severe psychiatric disorders.

General anaesthesia

Twenty-four hours before surgery, patients were premedicated with chlorazepat 20 mg per os. After 3 min of breathing 100% oxygen by face mask, anaesthesia was induced with fentanyl 2–3 μg/kg and propofol 2 mg/kg, followed by a continuous infusion of propofol 5–10 mg/kg/h. Subsequent dosages of remifentanil (0.1–0.2 μg/kg/min) and propofol were adjusted according to haemodynamic variables and BIS values within a range between 40 and 60 (BIS Quatro™; Aspect Medical Systems, Freising, Germany). To facilitate orotracheal intubation, a single dose of rocuronium (0.5 mg/kg ideal body weight) was given; no further neuromuscular blocking agent was given. Patients were manually ventilated with 100% oxygen via a facemask. Respiratory settings were standardized. Immediately after intubation or placement of the laryngeal mask, the lungs were mechanically ventilated with a tidal volume of 8 ml/kg and the ventilation rate was adjusted to maintain an end-tidal CO_2 pressure of approximately 4–4.7 kPa. A maximum peak pressure of 30 cmH_2O (25 cmH_2O LMA) was set to be tolerable. The inspiration to expiration ratio was adjusted to 1 : 1.5. A PEEP of 10 cmH_2O was used in the intubation group. The cuff pressure was continuously adjusted to 30 cmH_2O (LMA 50 cmH_2O). Eighty percent oxygen in nitrogen was given during maintenance of anaesthesia. The peripheral arterial oxygen saturation was monitored continuously by pulse oximetry. The TOF ratio was controlled via a peripheral nerve stimulator, ensuring a TOF ratio >0.90[12] before extubation. When the patient was fully awake and breathing sponta-

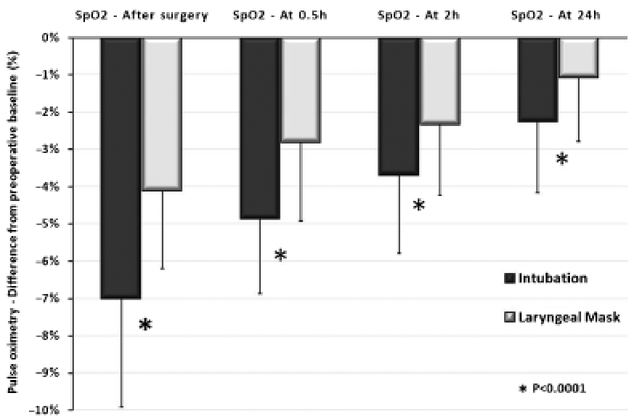

Fig. 1. Postoperative pulse oximetry – difference from preoperative baseline. Changes within the study groups are significant (P<0.0001). For abbreviations, see text.

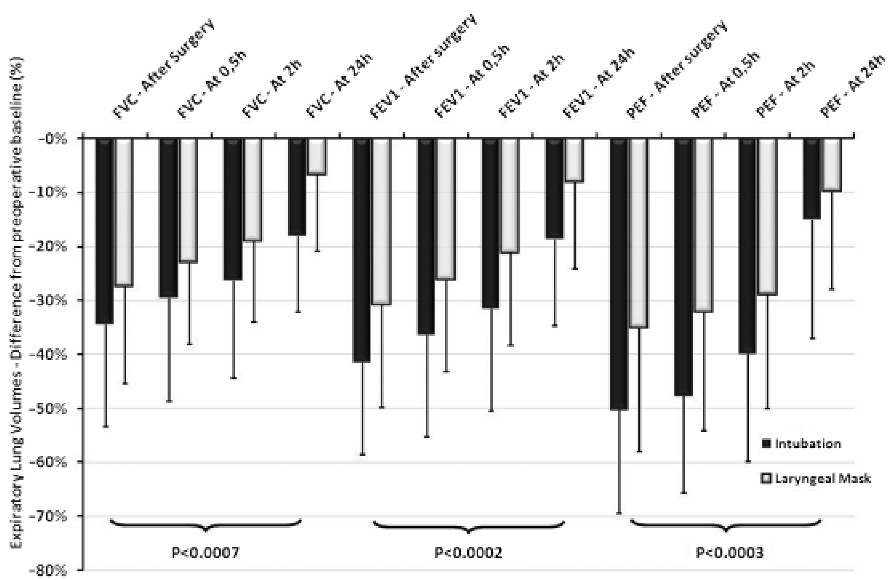

Fig. 2. Postoperative expiratory lung function values – difference from preoperative baseline. Changes within the study groups are significant (P<0.001). For abbreviations, see text.

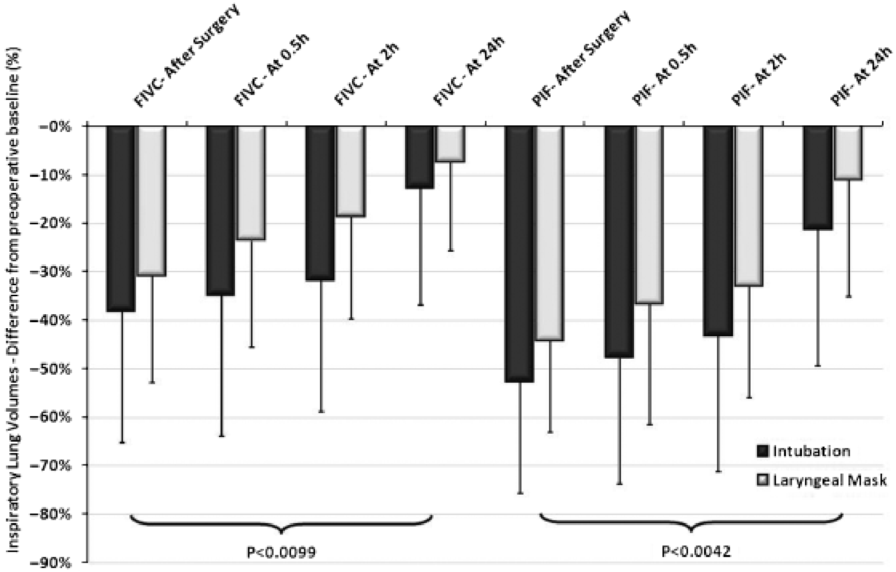

Fig. 3. Postoperative inspiratory lung function values – difference from preoperative baseline. Changes within the study groups are significant (P < 0.01). For abbreviations, see text.

Table 1

Basic data for 134 patients undergoing elective minor peripheral surgery.

	Intubation ($n = 67$)	Laryngeal mask ($n = 67$)
Age (years)	53 (SD 12)	49 (SD 12)
BMI	32 (SD 3.7)	30 (SD 3.2)
Surgery time (min.)	81 (SD 21)	89 (SD 19)
Postoperative pritramide(mg) consumption (within 24 h)	10 (SD 5.9)	11 (SD 6.3)
Knee arthroscopy	$n = 16$	$n = 12$
Minor breast surgery	$n = 35$	$n = 41$
TUR-prostata	$n = 9$	$n = 11$
Hand surgery	$n = 7$	$n = 3$

neously, the trachea was extubated, without previous suction, in a head-up position, with a positive pressure of 10 cmH_2O, using 100% O_2. Patients were transferred to the PACU, while breathing room air during transport. The peripheral arterial oxygen saturation was continuously monitored by pulse oximetry. Each patient was placed in the head-up position during the PACU stay.

Postoperative pain management

Both groups received basic non-opoid analgesia with intravenous (i.v.) paracetamol 1 g and metamizol 1 g i.v. Analgesia was supplemented with intermittent piritramide (i.v.) application when the visual analogue scale (VAS) was >4.

Spirometry and pulse oximetry

Spirometry and pulse oximetry were standardized, and the investigator was blinded, with each patient in a 30° head-up position[13] after breathing air without supplemental oxygen for 5 min. At the pre-anaesthetic visit, a baseline spirometry measurement and pulse oxymetry were taken (T0) after a thorough demonstration of the correct technique. VC, forced vital capacity (FVC), forced expiratory volume in 1 s (FEV1) mid-expiratory flow (MEF25–75), peak expiratory flow (PEF), peak inspiratory flow and the forced inspiratory vital capacity were measured and the FEV1/FVC ratio was calculated. At each assessment, spirometry was performed at least three times to be able to meet the criteria of the European Respiratory Society, and the best measurement was recorded.[14] On arrival in the recovery room, at about 5–10 min after extubation, we repeated spirometry (T1) as soon as the patient was alert and fully cooperative (Fast Track Score >10);[15] pain and dyspnoea during coughing were assessed using the Fast Track Score (>10)[15] before and, if necessary, after analgesic therapy. All patients met this criterion within 20 min of extubation.

Spirometry and pulse oximetry assessments were repeated in the PACU at 0.5 h (T2), 2 h (T3) and 24 h (T4) after extubation. Before each measurement, all patients were free from pain during coughing and had a Fast Track Score >10. Overall piritramide consumption was documented within the first 24 postoperative hours. Factors that interfered with breathing (e.g. pain, shivering) were eliminated or at least minimized to produce reliable measurements.

Statistical analysis
We tested the null hypothesis (H_0) that postoperative pulse oximetry values were comparable to preoperative values. The postoperative values were calculated as a percentage of preoperative. To compare the study groups at each measurement point, we performed Student's *t*-test with a type-I error of 5% (Table 3). We also performed a repeated-measure analysis of variance within the study groups during the first 24 postoperative hours (Figs 1–3). H_0 was rejected at an adjusted P of <0.0125 due to multiple testing. One hundred and thirty four patients were included with four values each. The results were all analysed using StatView 4.57 for Windows (Abacus Software, Heidelberg, Germany) and expressed as mean ± standard deviation (SD).

Results

We recruited 162 patients; the mean duration of surgery was 80 (SD 20) min, range 40–120 min. Acceptable ventilation was achieved in all, but five subjects declined to continue with the protocol. Measurements were unsatisfactory in 16 (nine in the LMA group, and seven in the intubation group), in whom the Fast Track Score was <10 within 20 min of surgery. Laryngo-/bronchospasm occurred in four patients; three were in the intubation group (NS). Placement of the laryngeal mask was unsatisfactory in three patients, who were excluded from the study. Reversal of muscle relaxation was not necessary in any patient. Thus, we present data for 134 patients with 67 individuals per group (Table 1).

Pulse oximetry
Preoperative saturations were within the normal range and did not differ between the study groups (Table 2). In both groups, the lowest values were found immediately after extubation in the PACU after achieving a Fast Track Score >10. Oxygen saturation decreased more in the intubation group at all stages than in the LMA group (Fig. 1, Table 3; $P<0.0001$).

Spirometry measurements
Preoperative inspiratory and expiratory spirometric values were within the normal range (Table 2). Postoperatively, the LMA group fared significantly better ($P<0.01$) (Fig. 2, Table 3). However, throughout the

Table 2
Preoperative pulse oximetry and lung function values (baseline = 100%).

	SpO2 before premed.	SpO2 after premed.	FVC	FEV 1	PEF	MEF 25-75	MEF 75	MEF 50	MEF 25	FIVC	PIF
(1) ITN	97.2% (SD 1.1)	96.7% (SD 1.5)	3.56 l (SD1.1)	2.77 l (SD 0.9)	5.71 l (SD 2.4)	2.79 l (SD 1.2)	5.22 l (SD 2.1)	3.50 l (SD 1.5)	1.35l (SD 0.7)	3.48 l (SD 1.3)	3.34 l (SD 1.7)
(2) LMA	97.5% (SD 1)	96.9% (SD 1.2)	3.62 l (SD 1)	2.79 l (SD 0.8)	5.76l (SD 2.2)	2.72l (SD 1.2)	5.27l (SD 2.0)	3.61 l (SD 1.4)	1.16l (SD 0.6)	3.41l (SD 1.1)	3.08 l (SD 1.3)
t-test P<0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

ITN, intubation group; LMA, laryngeal mask airway; , NS, no significance for further abbreviations see text.

Table 3

Postoperative pulse oximetry and lung function values.

	Intubation	Laryngeal mask	*P*-value (*t*-test)
SpO2 after surgery	90.3% (SD 2.8)	93.5% (SD 2.2)	<0.0001
T 0.5 h	92.4% (SD 2.2)	94.7% (SD 2.1)	<0.0001
T 2 h	93.6% (SD 2.3)	95.2% (SD 2.1)	0.0005
T 24 h	95.0% (SD 1.8)	96.5% (SD 1.7)	0.0002
FVC after surgery	2.33 l (SD 0.38)	2.62 l (SD 0.42)	0.0203
T 0.5 h	2.50 l (SD 0.40)	2.78 l (SD 0.41)	0.0150
T 2 h	2.62 l (SD 0.42)	2.93 l (SD 0.44)	0.0075
T 24 h	2.91 l (SD 0.41)	3.37 l (SD 0.43)	<0.0001
FEV1 after surgery	1.62 l (SD 0,27)	1.93 l (SD 0.36)	0.0010
T 0.5 h	1.76 l (SD 0.33)	2.18 l (SD 0.37)	0.0015
T 2 h	1.89 l (SD 0.36)	2.20 l (SD 0.37)	0.0016
T24 h	2.25 l (SD 0.36)	2.58 l (SD 0.40)	0.0003
PEF after surgery	2.83 l (SD 0.62)	3.74 l (SD 0.81)	0.0001
T 0.5 h	2.98 l (SD 0.65)	3.91 l (SD 0.84)	<0.0001
T 2 h	3.43 l (SD 0.72)	4.10 l (SD 0.85)	0.0033
T24 h	4.84 l (SD 1.05)	5.24 l (SD 1.12)	0.1751(NS)
MEF 25-75 after surgery	1.52 l (SD 0.33)	1.79 l (SD 0.35)	0.0028
T 0.5 h	1.63 l (SD 0.40)	1.92 l (SD 0.40)	0.0033
T 2 h	1.79 l (SD 0.48)	2.05 l (SD 0.43)	0.0072
T 24 h	2.32 l (SD 0.51)	2.43 l (SD 0.51)	0.0950 (NS)
MEF 75 after surgery	2.60 l (SD 0.62)	3.57 l (SD 0.89)	<0.0001
T 0.5 h	2.73 l (SD 0.65)	3.71 l (SD 1.01	<0.0001
T2 h	3.16 l (SD 0.79)	3.84 l (SD 0.94)	0.0035
T24 h	4.41 l (SD 1.05)	4.66 l (SD 1.10)	0.2327 (NS)
MEF 50 after surgery	1.90 l (SD 0.45)	2.37 l (SD 0.56)	0.0082
T 0.5 h	2.08 l (SD 0.56)	2.56 l (SD 0.66)	0.0133
T 2 h	2.24 l (SD 0.60)	2.67 l (SD 0.64)	0.0275
T 24 h	2.91 l (SD 0.75)	3.13 l (SD 0.65)	0.4180 (NS)
MEF 25 after surgery	0.76 l (SD 0.18)	0.83 l (SD 0.17)	0.0182
T 0.5 h	0.77 l (SD 0.19)	0.85 l (SD 0.18)	0.0009
T2 h	0.83 l (SD 0.23)	0.91 l (SD 0.19)	0.0006
T24 h	1.09 l (SD 0.25)	1.10 l (SD 0.19)	0.0076
FIVC after surgery	2.14 l (SD 0.57)	2.35 l (SD 0.50)	0.0850
T 0.5 h	2.26 l (SD 0.63)	2.60 l (SD 0.52)	0.0140
T 2 h	2.37 l (SD 0.64)	2.77 l (SD 0.57)	0.0022
T 24 h	3.03 l (SD 0.72)	3.25 l (SD 0.56)	0.1596 (NS)
PIF after surgery	1.57 l (SD 0.36)	1.71 l (SD 0.31)	0.0218
T 0.5 h	1.73 l (SD 0.45)	1.99 l (SD 0.25)	0.0128
T 2 h	1.89 l (SD 0.53)	2.10 l (SD 0.42)	0.0271
T24 h	2.57 l (SD 0.71)	2.81 l (SD 0.61)	0.0065

P-value = *t*-test analysis for each measurement point tested on a significance level of $P<0.05$.
For abbreviations, see text.

measurement period, inspiratory and expiratory lung volumes improved only moderately during the stay in the PACU. Even on the first day after surgery, lung function was reduced by up to 25% of baseline, and inspiratory and expiratory lung volumes were significantly reduced ($P<0.01$; Fig. 2). Both study groups showed a similar recovery pattern over the course of the observation period. *t*-test analysis confirmed the advantage of the LMA in the PACU at all measurement points (Table 3). The difference ceased to be significant at 24 h post-surgery.

Postoperative management

No patient suffered from untreatable postoperative pain. The maximum postoperative pain score on a VAS scale before analgesia was 6 (both groups). Opioid consumption within 24 h was comparable in both groups (Table 2). At each measurement point, every patient was acceptably awake, and free of pain, shivering or nausea.

Discussion

Obesity has considerable negative effects on lung function in the perioperative period, due to a loss of FRC, atelectasis and increased desaturation. Most pulmonary complications occur in the immediate postoperative period, for which there are little data. Although healthy patients may easily compensate for the postoperative impairment of lung function, in the obese and those with pre-existing lung disease, postoperative lung volumes and oxygenation are likely to be significantly affected.

As reported previously [6,16], the maximum changes in spirometry and arterial saturation occurred during the first assessment after extubation. Further measurements in the PACU showed only a slight recovery of postoperative inspiratory and expiratory lung functions within the first 2 h. We attribute this to impaired respiratory mechanics, obesity and atelectasis formation induced by general anaesthesia in the supine position.

Our data show that the use of an LMA during minor peripheral surgery confers advantages for moderately obese adults in terms of early postoperative lung function and pulse oximetry saturation. Some anaesthetists may be reluctant to use the LMA in moderately obese adults; in our study, ventilation was acceptable in all patients included, and previous studies with sufficient power have confirmed this.[17,18] Most of the problems in the LMA group were caused by inaccurate placement of the laryngeal mask with consecutive leakage. Our findings suggest that there is no difference in major adverse events (e.g. pulmonary aspiration) between our study populations. No aspiration occurred during the study period in either group, although patients with increased risk were excluded. While there is no doubt that orotracheal intubation is the gold standard for these cases, there are no data to suggest that the use of the laryngeal mask to ventilate moderately obese adults is associated with an increased risk for pulmonary aspiration. There was no difference in the incidence of laryngospasm between the groups, although our study lacks the power to demonstrate such a difference.

Orotracheal intubation generates greater airway irritation with subsequent tissue oedema,[8] which could mimic obstructive lung disease. It is uncertain whether this effect contributes to our findings to any significant extent, because the surgical time did not exceed 120 min and the cuff pressure was continuously adjusted to 30 cmH_2O in the intubation group and 50 cmH_2O in the LMA group.

Some patients receiving intraoperative muscle relaxants have a residual neuromuscular block after extubation, which may affect the reliability of the study. To reduce this possibility, the minimum surgery time was 40 min and no additional dose of any muscle relaxant was given, and extubation was performed only after recovery of the train-of-four ratio to >0.90.[12] In view of our measured postoperative inspiratory lung volumes, which showed a similar postoperative recovery in both groups, residual neuromuscular block can be almost entirely excluded. However, our data suggest that the initial muscle relaxation to facilitate orotracheal intubation causes a significant amount of atelectasis. Previous studies indicate that muscle relaxation develop atelectasis by compression of lung tissue rather than by resorption of gas.[9,10] This compression with consequent small airway collapse persists up to 24 h after surgery, shown by a significantly decreased MEF25 in the intubation group, in spite of use of an intraoperative continuous PEEP of 10 cmH_2O Hg to prevent atelectasis.[19–21] The decreases in VC, FVC, FEV1, MEF25–75 and PEF followed the same pattern, and the FEV1/FVC ratio did not change. This suggests a restrictive pattern of respiratory compromise in the immediate postoperative period, as described previously.[16,22–25]

The postoperative impairment of spirometry measurements was probably not caused by a lack of cooperation, because all the patients in this study were alert and fully compliant within 20 min of extubation, and any pain had been treated. Any lack of cooperation and insufficient pain management[6,16,22] would be expected to affect the whole study population to a comparable degree. Nevertheless, our pulse oximetry and spirometry findings indicate that airway management has a greater impact on postoperative lung volumes than previously assumed. The decreased inspiratory capacity might affect the ability to cough effectively, and thus predispose to respiratory complications.

Our findings suggest that moderately obese patients who are scheduled for minor peripheral surgery may benefit from use of the laryngeal mask rather than orotracheal intubation. It is not clear whether this is related to the initial muscle relaxation to facilitate orotracheal intubation, or a specific effect of the LMA. It is also unclear whether this form of airway management reduces postoperative complications; larger studies are needed.

Limitations

One major limitation factor is the preselection of our patients. Only moderately obese patients scheduled for minor peripheral surgery were included. No operations with abdominal insufflations (laparoscopy) or head-down tilt were included. In addition, we excluded patients with gastro-oesophageal reflux disease or a hiatus hernia. Furthermore, the potential for a selection bias was minimized by the support of anesthetists not involved in the study, who were responsible for giving patients preoperative information. Additionally, postoperative spirometry was performed by trained nurses who were unaware of the study hypothesis and were not involved in this study.

Our findings do not allow us to suggest that the LMA should be used routinely for these cases. The primary aim of our study was to examine the potential of different airway regimes for modifying spirometrically measured lung volumes in the immediate postoperative period, when the impacts of surgical trauma and anaesthesia are most likely to trigger postoperative pulmonary morbidity. The reduction of postoperative lung function was significantly greater in the intubation group than in the LMA group. We conclude that the LMA may be considered as an alternative to orotracheal intubation for moderately obese patients undergoing minor surgery. A larger study population is required, however, in order to establish the LMA as the standard procedure for our study population.

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