

Patient outcomes with positive pressure versus spontaneous ventilation in non-paralysed adults with the laryngeal mask

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Purpose: To compare patient outcomes for positive pressure ventilation (PPV) and spontaneous ventilation (SV) in non-paralysed patients with the LMA using either isoflurane or sevoflurane anaesthesia.

Methods: One hundred and sixty four adult patients were studied. Anaesthesia was with fentanyl/propofol and N₂O 66% in O₂ with 0.75 MAC isoflurane or sevoflurane and either PPV or SV. Positive pressure ventilation was with tidal volumes of 6-8 ml·kg⁻¹. Peak airway pressures were < 15 cm H₂O. Patients were evaluated for airway problems, cardiorespiratory effects, and anaesthesia emergence times.

Results: There were no failed episodes of PPV or SV. Gastric insufflation was not detected by epigastric auscultation. Airway problems and cardiovascular effects were similar among groups. During maintenance: SpO₂ was greater in the PPV group than in the SV group (98.4 vs 97%, $P < 0.001$); also, (P_{ET}CO₂) (34 vs 43 mmHg) and the respiratory rate (RR) (15 vs 19 min⁻¹) were higher and the minute ventilation (MV) (5.7 vs 7.2 L) were lower in the SV groups ($P < 0.0001$). Shorter times to LMA removal and orientation were observed in the sevoflurane groups ($P < 0.0001$).

Conclusions: Patient outcome is similar for SV and PPV in non-paralysed adult patients with the LMA. Isoflurane and sevoflurane at 0.75 MAC provide suitable conditions for maintenance and emergence, but emergence is more rapid with sevoflurane.

Objectif : Comparer l'évolution du patient lors de la ventilation en pression positive (VPP) et de la ventilation spontanée (VS) chez des patients non curarisés utilisant l'anesthésie avec ML sous isoflurane ou sévoflurane.

Méthodes : On a étudié cent soixante-quatre patients adultes. L'anesthésie s'est faite avec le fentanyl et le propofol et N₂O à 66 % dans O₂ avec une CAM d'isoflurane ou de sévoflurane à 0,75 et la VPP ou la VS. La ventilation en pression positive était maintenue à des volumes courants de 6-8 ml·kg⁻¹. Les pressions de pointe ventilatoires étaient < 15 cm H₂O. On a évalué chez les patients les problèmes des voies aériennes, les effets cardiorespiratoires et les temps de réveil.

Résultats : Il n'y a eu aucun échec de la VPP ou de la VS. On n'a pas détecté d'insufflation gastrique à l'auscultation épigastrique. Les problèmes des voies aériennes et les effets cardiovasculaires étaient semblables dans les deux groupes. Pendant le maintien de l'anesthésie, la SpO₂ était plus élevée dans le groupe sous VPP que dans le groupe en VS (98,4 vs 97 %, $P < 0,001$); on a aussi noté que la (P_{ET}CO₂) (34 vs 43 mmHg) et la fréquence respiratoire (FR) (15 vs 19 min⁻¹) étaient plus élevées et que la ventilation minute (VM) (5,7 vs 7,2 L) était plus basse dans le groupe en VS ($P < 0,0001$). On a observé des temps de retrait du ML et de retour à la conscience plus courts dans le groupe qui a reçu du sévoflurane ($P < 0,0001$).

Conclusion : Avec l'utilisation du ML, l'évolution des patients adultes non curarisés est similaire pour la VS et la VPP. L'isoflurane et le sévoflurane, avec une CAM de 0,75, fournissent des conditions adéquates de maintien de l'anesthésie et de réveil, bien que le réveil soit plus rapide avec le sévoflurane.

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THE laryngeal mask airway (LMA) has been widely used for positive pressure ventilation (PPV) during anaesthesia¹ but there are concerns about the risk of failed ventilation and/or gastric insufflation.² Published data suggest that the LMA/PPV technique is safe and effective.^{1,3-5} However, most studies were performed in paralysed patients and there are no comparative data obtained with spontaneous ventilation (SV). In addition, no studies have evaluated the clinical efficacy of isoflurane or sevoflurane with the LMA. Therefore, we compared PPV and SV using the LMA in non-paralysed patients receiving equipotent doses of either isoflurane or sevoflurane to determine if any technique offered advantages in terms of airway problems, cardiorespiratory effects and emergence times.

Methods

Ethics committee approval and informed consent were obtained. One hundred and sixty four consecutive ASA 1-2 adult patients scheduled for peripheral musculoskeletal surgery (>30 min) in the supine position were randomly assigned to one of four ($n = 41$) equal sized groups. In group 1 (Iso/PPV), anaesthesia was with isoflurane 0.9% (0.75 MAC) and PPV. In group 2 (Iso/SV), anaesthesia was with isoflurane 0.9% and SV. In group 3 (Sev/PPV), anaesthesia was with sevoflurane 1.5% (0.75 MAC) and PPV. In group 4 (Sev/SV), anaesthesia was with sevoflurane 1.5% and SV. Patients were excluded if they had respiratory tract pathology, a body mass index (BMI) > 30, or were at risk of aspiration.

Premedication was with 7.5 mg midazolam *po*. Anaesthesia was induced with 1-3 $\mu\text{g}\cdot\text{kg}^{-1}$ fentanyl and 2.5 - 3.5 $\text{mg}\cdot\text{kg}^{-1}$ propofol. The LMA (size #4: female, size #5: male⁶) was inserted, fixed and removed according to the manufacturer's instructions⁷ by an experienced LMA user. Positive pressure ventilation was with tidal volumes of 6-8 $\text{ml}\cdot\text{kg}^{-1}$ and peak airway pressures (PAP) were limited to 15 $\text{cm}\cdot\text{H}_2\text{O}$. Respiratory rate was adjusted to maintain $P_{\text{ET}}\text{CO}_2$ within the normal range. Patients in the SV groups underwent manually assisted ventilation until SV resumed. Maintenance was with N_2O 66% in O_2 and the randomized volatile agent. Epigastric auscultation was performed during maintenance to detect gastric insufflation. A circle anaesthetic breathing system was used with fresh gas flow of 6 $\text{L}\cdot\text{min}^{-1}$. Anaesthesia was continued until the completion of surgery. The LMA removal time (open mouth to command) and orientation time (correct date of birth) were determined by repeatedly (every 30 sec) questioning the patient. Pharyngolaryngeal morbidity was determined by blinded structured interview 18-24 hr postoperatively.

Cardiorespiratory data were collected every minute during induction/emergence and every five minutes during maintenance. Problems were documented during each phase of anaesthesia (unblinded: induction/maintenance; blinded: emergence). Respiratory problems included failed insertion (failed placement within 20 sec), failed PPV ($\text{SpO}_2 < 95\%$ with FiO_2 33%, $P_{\text{ET}}\text{CO}_2 > 40$ mm Hg), failed SV ($\text{SpO}_2 < 95\%$ with FiO_2 33%, $P_{\text{ET}}\text{CO}_2 > 75$ mm Hg) and any other adverse airway event. Haemodynamic problems included hyper/hypotension ($\pm 20\%$ preinduction baseline values), tachy/bradycardia (> 100 and < 60 min^{-1}) and other dysrhythmias. Significance was taken as $P < 0.05$.

Results

The mean \pm SD age and body mass index were 40 ± 13 yr and 24 ± 3 $\text{kg}\cdot\text{m}^{-2}$ respectively. The male:female ratio was 95:69. There were 39 smokers. The mean (SD) duration of surgery was 54 ± 21 min. There were no demographic or surgical differences among groups. There were no failed insertion attempts, episodes of failed PPV or failed SV. No gastric insufflation was detected by auscultation. Requirements for additional drugs (fentanyl, propofol) were similar among groups. Problems occurring during each phase of anaesthesia and postoperatively were similar among groups (Table I). During maintenance and emergence the mean SpO_2 was greater in the PPV group than in the SV group ($P < 0.001$). There were no episodes of coughing, retching, hypertension or tachycardia during induction or maintenance. There were no episodes of laryngospasm, bronchospasm, regurgitation, aspiration or other dysrhythmias. The mean $P_{\text{ET}}\text{CO}_2$ and the respiratory rate were higher and the minute volume lower in the SV group compared with the PPV group ($P < 0.0001$), but otherwise cardiorespiratory data was similar (Table II). Shorter times to LMA removal (6 *vs* 12 min) and orientation (9 *vs* 16 min) were observed in the sevoflurane groups compared with the isoflurane groups ($P < 0.0001$). Removal and orientation times were similar for SV and PPV. SV resumed more rapidly with sevoflurane (Iso/PPV: 5 *vs* Sev/PPV: 2 min, $P < 0.01$).

Discussion

These data suggest that PPV with the LMA is comparable to SV in non-paralysed adult patients undergoing peripheral musculoskeletal surgery. The higher $P_{\text{ET}}\text{CO}_2$ and lower SpO_2 in the SV group are in keeping with the known ventilatory depressant effects of anaesthesia and did not cause any clinical problems. Despite intracuff pressure adjustment up to 60 cm

TABLE I Respiratory, haemodynamic and postoperative problems during each phase of anaesthesia.

Group	ISO/PPV	ISO/SV	Sev/PPV	Sev/SV
Induction				
Hiccough	2 (5%)	1 (2.4%)	2 (5%)	0
Hypotension	5 (12%)	4 (10%)	5 (12%)	4 (10%)
Bradycardia	12 (29%)	10 (24%)	10 (24%)	11 (27%)
Maintenance				
Hiccough	0	0	0	0
Hypotension	1 (2.4%)	0	1 (2.4%)	1 (2.4%)
Hypertension	0	0	0	0
Bradycardia	5 (12%)	4 (10%)	4 (10%)	4 (10%)
Emergence				
Cough	1 (2.4%)	1 (2.4%)	2 (5%)	1 (2.4%)
Retching	0	0	0	0
Hiccough	0	0	0	0
Increased salivation	0	0	0	0
Biting	10 (24%)	11 (26%)	11 (26%)	13 (31%)
Shivering	7 (17%)	9 (22%)	5 (12%)	8 (19%)
Hypotension	0	0	0	0
Hypertension	3 (7%)	4 (10%)	3 (7%)	3 (7%)
Bradycardia	1 (2.4%)	2 (5%)	2 (5%)	1 (2.4%)
Tachycardia	3 (7%)	2 (5%)	3 (7%)	3 (7%)
Postoperative				
Mild sore throat	2 (5%)	3 (7%)	3 (7%)	2 (5%)
Hoarseness	0	0	1 (2.4%)	0
Nausea	1 (2.4%)	2 (5%)	2 (5%)	2 (5%)
Vomiting	0	0	0	0

Iso = isoflurane Sev = sevoflurane PPV = positive pressure ventilation SV = spontaneous ventilation

TABLE II Respiratory data for all groups during each phase of anaesthesia. Mean \pm SD

Group	ISO/PPV	ISO/SV	Sev/PPV	Sev/SV
Induction				
Range SpO ₂ (%)	96-100	96-99	96-99	96-100
Mean SpO ₂ (%)	98.5 \pm 0.6	98.0 \pm 0.6	97.9 \pm 0.6	98.1 \pm 0.7
Maintenance				
Range SpO ₂ \pm %	97-100	95-98	96-99	96-99
Mean SpO ₂ (%)	98.3 \pm 0.6	96.8 \pm 0.8	98.4 \pm 0.7	97.4 \pm 0.6
P _{ET} CO ₂ (mmHg)	34 \pm 2	43 \pm 5	33 \pm 2	44 \pm 5
RR (min ⁻¹)	16 \pm 1	18 \pm 2	15 \pm 1	20 \pm 3
MV (L)	7.0 \pm 0.9	5.6 \pm 0.7	7.3 \pm 0.8	5.8 \pm 0.8
Emergence				
Range SpO ₂ (%)	96-99	96-100	95-100	95-100
Mean SpO ₂ (%)	98.5 \pm 0.6	97.2 \pm 0.6	98.2 \pm 0.5	97.0 \pm 0.6

Iso = isoflurane Sev = sevoflurane SV = spontaneous ventilation
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H₂O, ventilation was adequate in all patients in the PPV group. This may be related to accurate placement of the device, the fixation technique, the low RMI or the use of large LMAs. Gastric insufflation with the LMA is uncommon,¹ is a pressure dependant phenomenon⁸ and is unlikely to occur with PAP < 20 cm H₂O.⁸ There were no cases of gastric insufflation in the current study. The times required for command response and orientation were approximately 50% shorter after sevoflurane. This is in keeping with the low blood/gas solubility of sevoflurane compared with isoflurane and comparative data from paralysed intubated patients.⁹ The incidence of sore throat with the LMA is approximately 10%, but varies between 0-50% and the incidence of hoarseness is approximately 5%.¹⁰ The low incidence of sore throat and hoarseness in our study probably reflects the high first time placement rate, use of the standard insertion technique and adoption of low intracuff pressures.

In conclusion, the LMA is effective for both SV and PPV in non-paralysed adult patients, but P_{ET}CO₂ is higher during SV and SpO₂ higher during PPV. Isoflurane 0.9% end-tidal or sevoflurane 1.5% provide suitable conditions for maintenance and emergence, but emergence is more rapid with sevoflurane. Neither technique offers advantages in terms of cardiovascular effects or airway problems.

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Discussion

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Hypotension	1 (2.4%)	0	1 (2.4%)	1 (2.4%)
Hypertension	0	0	0	0
Bradycardia	5 (12%)	4 (10%)	4 (10%)	4 (10%)
Emergence				
Cough	1 (2.4%)	1 (2.4%)	2 (5%)	1 (2.4%)
Retching	0	0	0	0
Hiccough	0	0	0	0
Increased salivation	0	0	0	0
Biting	10 (24%)	11 (26%)	11 (26%)	13 (31%)
Shivering	7 (17%)	9 (22%)	5 (12%)	8 (19%)
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Hypertension	3 (7%)	4 (10%)	3 (7%)	3 (7%)
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Tachycardia	3 (7%)	2 (5%)	3 (7%)	3 (7%)
Postoperative				
Mild sore throat	2 (5%)	3 (7%)	3 (7%)	2 (5%)
Hoarseness	0	0	1 (2.4%)	0
Nausea	1 (2.4%)	2 (5%)	2 (5%)	2 (5%)
Vomiting	0	0	0	0

Iso = isoflurane Sev = sevoflurane PPV = positive pressure ventilation SV = spontaneous ventilation

TABLE II Respiratory data for all groups during each phase of anaesthesia. Mean \pm SD

Group	ISO/PPV	ISO/SV	Sev/PPV	Sev/SV
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Range SpO ₂ (%)	96-100	96-99	96-99	96-100
Mean SpO ₂ (%)	98.5 \pm 0.6	98.0 \pm 0.6	97.9 \pm 0.6	98.1 \pm 0.7
Maintenance				
Range SpO ₂ \pm	97-100	95-98	96-99	96-99
Mean SpO ₂ (%)	98.3 \pm 0.6	96.8 \pm 0.8	98.4 \pm 0.7	97.4 \pm 0.6
P _{ET} CO ₂ (mmHg)	34 \pm 2	43 \pm 5	33 \pm 2	44 \pm 5
RR (min ⁻¹)	16 \pm 1	18 \pm 2	15 \pm 1	20 \pm 3
MV (L)	7.0 \pm 0.9	5.6 \pm 0.7	7.3 \pm 0.8	5.8 \pm 0.8
Emergence				
Range SpO ₂ (%)	96-99	96-100	95-100	95-100
Mean SpO ₂ (%)	98.5 \pm 0.6	97.2 \pm 0.6	98.2 \pm 0.5	97.0 \pm 0.6

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H₂O₂ ventilation was adequate in all patients in the PPV group. This may be related to accurate placement of the device, the fixation technique, the low BMI or the use of large LMAs. Gastric insufflation with the LMA is uncommon,¹ is a pressure dependant phenomenon⁸ and is unlikely to occur with PAP < 20 cm H₂O.⁸ There were no cases of gastric insufflation in the current study. The times required for command response and orientation were approximately 50% shorter after sevoflurane. This is in keeping with the low blood/gas solubility of sevoflurane compared with isoflurane and comparative data from paralysed intubated patients.⁹ The incidence of sore throat with the LMA is approximately 10%, but varies between 0-50% and the incidence of hoarseness is approximately 5%.¹⁰ The low incidence of sore throat and hoarseness in our study probably reflects the high first time placement rate, use of the standard insertion technique and adoption of low intracuff pressures.

In conclusion, the LMA is effective for both SV and PPV in non-paralysed adult patients, but P_{ET}CO₂ is higher during SV and SpO₂ higher during PPV. Isoflurane 0.9% end-tidal or sevoflurane 1.5% provide suitable conditions for maintenance and emergence, but emergence is more rapid with sevoflurane. Neither technique offers advantages in terms of cardiovascular effects or airway problems.

References

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