The Influence of Head and Neck Position on Oropharyngeal Leak Pressure and Cuff Position with the Flexible and the Standard Laryngeal Mask Airway

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We conducted a randomized, cross-over study of 20 paralyzed anesthetized adult patients to test the hypothesis that oropharyngeal leak pressure and cuff position (assessed fiberoptically) vary with head and neck position for the flexible (FLMA) and standard laryngeal mask airway (LMA). Both devices were inserted into each patient in random order. Oropharyngeal leak pressure and fiberoptic position (including degree of rotation) were documented in four head and neck positions (neutral first, then flexion, then extension and rotation in random order) for each device. The size 5 was used for all patients, and the intracuff pressure was set at 60 cm H₂O in the neutral position. All airway devices were inserted at the first attempt. Oropharyngeal leak pressure was similar for the FLMA and LMA in the neutral (22 vs 21 cm H₂O), flexed (26 vs 26 cm H₂O), and extended positions (19 vs 18 cm H₂O) but was slightly higher for the LMA when the head was rotated (19 vs 22 cm H₂O; P = 0.04). Compared with the neutral position, oropharyngeal leak pressure for the FLMA was higher with flexion (26 vs 21 cm H₂O; P = 0.0004) and lower with extension (18 vs 21 cm H₂O; P = 0.03) but similar with rotation. Compared with the neutral position, oropharyngeal leak pressure for the FLMA was higher with flexion (26 vs 22 cm H₂O; P = 0.0001) and lower with extension (19 vs 22 cm H₂O; P = 0.03) and rotation (19 vs 22 cm H₂O; P = 0.03). The difference in oropharyngeal leak pressure between flexion and extension was 7 and 8 cm H₂O for the FLMA and LMA, respectively. Fiberoptic position was similar between devices and was unchanged by head and neck position. Rotation was not detected fiberoptically. We conclude that there are small changes in oropharyngeal leak pressure but no changes in cuff position in different head and neck positions for the FLMA and LMA. Oropharyngeal leak pressure may be improved by head and neck flexion and by avoiding extension.

Implications: There are small changes in oropharyngeal leak pressure but no changes in cuff position in different head and neck positions for the flexible and standard laryngeal mask airways. Oropharyngeal leak pressure may be improved by head and neck flexion and by avoiding extension.

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The standard laryngeal mask airway (LMA) and flexible laryngeal mask airway (FLMA) devices are used for surgery in different head and neck positions, including extension for tonsillectomy (1), thyroid surgery (2), laser pharyngoplasty (3) and tracheostomy (4), rotation for otological surgery (5), and flexion for tracheal resection (6). The two laryngeal mask devices are identical in all respects, except that the airway tube of the FLMA is longer, narrower, and more flexible. This latter design feature allows the tube to be moved without displacing the cuff, but it reduces the force transmitted along the shaft. The cuff portion of both devices sits in the pharynx, where it forms a seal for ventilation and prevention of aspiration from above the cuff. However, the shape of the pharynx changes during head and neck movement (7), and there is probably also a change in the force transmitted to the cuff along the airway tube. There is evidence that the LMA can be displaced with rotation (8) and that the efficacy of the seal increases with flexion (9). In the following randomized cross-over study, we tested the hypothesis that oropharyngeal leak pressure and cuff position (assessed fiberoptically) vary with head and neck position for the FLMA and standard LMA.

Methods

Ten consecutive male and ten female adult patients (aged 18–80 yr, ASA physical status I or II) participated in this randomized cross-over trial. Ethical committee approval and informed consent were obtained.
Patients were excluded if they were at risk of aspiration, had limited head and neck movement, or the LMA or FLMA were otherwise contraindicated. A standard anesthesia protocol was followed. Anesthesia was induced with propofol 2.5 mg/kg, and anesthesia was maintained with sevoflurane 1%–2% in oxygen. Muscle relaxation was achieved with rocuronium 0.6 mg/kg. A size 5 device was used for all patients (10). All LMAs and FLMAs were in routine clinical use, had been through at least 20 autoclave cycles, and passed the preuse check tests. Both devices were inserted into each patient in random order. A single experienced FLMA and LMA user (>1000 uses each device) inserted/ fixed each device according to the manufacturer’s recommended technique (11). The insertion technique included full deflation of the cuff, careful placement of the cuff flat against the hard palate, and pushing the device into and along the posterior palatopharyngeal curve using the index finger. Both devices were fixed by taping the tube over the chin. The number of attempts made to place the device was recorded. A failed attempt was defined as removal of the device from the mouth. The intracuff pressure was adjusted to 60 cm H2O using a digital cuff pressure monitor (Mallinckrodt Medical, Athlone, Ireland) with the head and neck in the neutral position before each measurement. Care was taken to avoid displacement of the LMA or transmission of force along the tube during testing. Oropharyngeal leak pressure and fiberoptic position were documented by a second anesthetist with the head and neck in four randomly selected positions: neutral (occiput resting on standard firm pillow 7 cm in height), maximal flexion, maximal extension, and maximal right rotation. The second anesthetist was blinded to the position of the head and neck during oropharyngeal leak pressure measurements. Readings were taken 30–60 s after adjustment of the head and neck position. The fiberoptic position was scored as 4 (only vocal cords visible), 3 (vocal cords plus posterior epiglottis visible), 2 (vocal cords plus anterior epiglottis visible), and 1 (vocal cords not seen) (12). The degree of rotation was scored by noting the angle between the mask aperture bars and vocal cords: nil (<10°), mild (10–45°), moderate (46–90°), and severe (>90°). Oropharyngeal leak pressure was measured by closing the expiratory valve of the circle system at a fixed gas flow of 3 L/min and noting the airway pressure at which the dial on a calibrated aneroid manometer (accurate to ±0.5 cm H2O) reached equilibrium. The interobserver reliability and accuracy of this measuring system have recently been validated (13). The same aneroid manometer and anesthesia machine were used for all the patients.

Sample size was selected to detect a projected difference of 25% between the groups with respect to oropharyngeal leak pressure for a type I error of 0.05 and a power of 0.9. The power analysis was based on data from a pilot study of 10 patients in which oropharyngeal leak pressures and fiberoptic score were measured for the FLMA and LMA in the four head and neck positions. The distribution of data was determined using Kolmogorov-Smirnov analysis. Statistical analysis was with paired t-test (normally distributed data) and χ² test (non-normally distributed data). Unless otherwise stated, data are presented as mean (95% confidence intervals). Significance was taken as P < 0.05.

Results

The mean age, height, and weight were 36 (30–42) yr, 171 (168–176) cm, and 73 (63–82) kg, respectively. All airway devices were inserted at the first attempt. The oropharyngeal leak pressure was similar for both devices in the neutral, flexed, and extended position, but oropharyngeal leak pressure was higher for the LMA when the head was rotated (Table 1). Compared with the neutral position, oropharyngeal leak pressure for the LMA was higher with flexion (P = 0.0004) and lower with extension (P = 0.03) but similar with rotation. Compared with the neutral position, oropharyngeal leak pressure for the FLMA was higher with flexion (P = 0.0001) and lower with extension (P = 0.03) and rotation (P = 0.03). The difference in mean oropharyngeal leak pressure between flexion and extension was 7 and 8 cm H2O for the FLMA and LMA, respectively. Fiberoptic position was similar between devices and was

Table 1. Oropharyngeal Leak Pressure and Fiberoptic Position for the Flexible Laryngeal Mask Airway (FLMA) and Standard Laryngeal Mask Airway (LMA)

<table>
<thead>
<tr>
<th></th>
<th>Oropharyngeal leak pressure (cm H₂O)</th>
<th>Fiberoptic position 4/3/2/1 (n)</th>
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<tbody>
<tr>
<td></td>
<td>FLMA</td>
<td>LMA</td>
</tr>
<tr>
<td>Flexion</td>
<td>26 (23–29)</td>
<td>26 (23–29)</td>
</tr>
<tr>
<td>Rotation</td>
<td>19 (17–21)</td>
<td>22 (20–24)</td>
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<tr>
<td>Extension</td>
<td>19 (16–22)</td>
<td>18 (16–21)</td>
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</table>

Values are mean (95% confidence interval).

* P = 0.04.
unchanged by head and neck position. Rotation was not detected fiberoptically. The epiglottis moved toward the mask aperture bars during flexion in three patients.

Discussion

Isserles and Rozenberg (9) showed that flexion of the head and neck increased oropharyngeal leak pressure with the LMA, but Berry et al. (10) were unable to confirm this finding with 15 degrees of flexion from the neutral position. We have shown that oropharyngeal leak pressure is higher for the LMA and FLMA with maximum flexion and lower with maximum extension compared with the neutral position. Though the average improvement in seal is only moderate, flexing the head and neck and avoiding extension may be useful adjuncts to other strategies used to improve seal such as adjusting cuff volume, repositioning the mask, changing size or applying gentle pressure to the front of the neck (10). We postulate that there is a change in the degree of conformity of the cuff with the pharynx, or a change in the pressure exerted by the cuff against the pharyngeal mucosa in different head and neck positions. Isserles and Rozenberg (9) suggested that neck flexion removes the longitudinal tension in the anterior pharyngeal muscles, allowing them to settle down onto the mask to form a better seal. Neck flexion causes a reduction in the antero-posterior diameter of the pharynx, and neck extension increases the antero-posterior diameter by raising the hyoid and the laryngeal inlet. The changes in oropharyngeal leak pressure with flexion and extension are probably unrelated to forces transmitted along the tube, since they occurred with both devices and force cannot be transmitted along the shaft of the FLMA. The lower oropharyngeal leak pressure with head rotation for the FLMA may be related to a lack of transmitted force along the shaft, since it did not occur with the LMA. It is unlikely that any of these differences are due to distention of the esophagus because the mean oropharyngeal leak pressure at which gastric insufflation occurs with the size 5 is 5–12 cm H2O higher than the mean oropharyngeal leak pressures obtained in our study (14). A further study has shown that gastric insufflation only occurs in 5% of patients when peak airway pressures are 30 cm H2O (15). We used the size 5 LMA in all our patients, per recent recommendations. It is likely that our findings can be extrapolated to other appropriately selected sizes of mask, but they may not necessarily apply to situations in which the selected size is too small.

Perhaps insertion of the FLMA is more difficult than the LMA, because no force can be transmitted along the shaft (16), and a variety of introducer tools have been described to aid placement (17,18). There has also been a report of head and neck rotation causing positional changes with the FLMA (8). Our data suggest that the difference in tube structure does not necessarily affect insertion or final position if the standard recommended technique is used. Unlike some other insertion techniques, the standard technique does not require force to be transmitted along the shaft for successful placement, making the rigidity of the tube irrelevant for insertion (19). Our data also suggest that the anatomic position of both devices does not vary with head and neck position, but radiological studies are required to confirm this finding. Our data support the use of the LMA and FLMA for surgery in which head and neck positional adjustments are required. The value of fiberoptic position as a means of assessing anatomic position has been questioned by Asai (20), who considered that the view provided no measure of the functional seal. However, Berry et al. (10) and Joshi et al. (21) have shown that there is a correlation between the fiberoptic position and oropharyngeal leak pressure.

We conclude that there are small changes in oropharyngeal leak pressure but no changes in cuff position in different head and neck positions for the FLMA and LMA. Oropharyngeal leak pressure may be improved by head and neck flexion and by avoiding extension.

References