Air entry in infant resuscitation: oral or nasal routes?

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Wilson-Davis, S. L., L. S. Tonkin, and T. R. Gunn. Air entry in infant resuscitation: oral or nasal routes? J. Appl. Physiol. 82(1): 152–155, 1997.—The current recommendation for resuscitation of infants is to blow air into both the nose and mouth. We have observed that mothers cannot cover both the nose and mouth of their infants. We compared postmortem tracheal and esophageal air entry by using the nose, combined nose and mouth, and mouth routes in eight infants. Air entry into the trachea occurred at lower pressures ($P < 0.05$) via a nose mask than via a combined nose and mouth mask. Air entry into the trachea occurred at lower pressures ($P < 0.05$) via the nose route in the neutral and extended neck positions compared with the flexed position. We were unable to demonstrate an effect of the route of air entry on esophageal air entry. The findings indicate that the nasal route of air entry is more effective than the combined nose and mouth or mouth routes and that neck flexion impedes air entry. We recommend that parents are taught to blow air into their infants’ noses if the infant stops breathing.

tracheal air entry; esophageal air entry; postmortem; neck position

There has been a fall in the rate of sudden infant death syndrome (SIDS) in several countries during the 1990s (11). However, apparently healthy infants continue to die in our communities. The major tool in the prevention of death in infants who have come to medical attention is the home monitor that alerts on the detection of apneic episodes. The effectiveness of the home monitor is dependent on parents being skilled in effective resuscitation of their infants. It is recommended that resuscitation of an infant is carried out by the resuscitator covering both the nose and mouth of the infant with his or her mouth (1). We have observed that mothers are unable to simultaneously cover both the mouth and nose of their infants (10). A mother may force the infant’s jaw posteriorly in an attempt to obtain a seal between her mouth and the mouth and nose of her infant and thus obstruct the airway.

In eight infants at postmortem, we have compared the ease of air entry into the trachea and esophagus when positive pressure is applied to a mask covering 1) the nose, 2) the nose and mouth, and 3) the mouth in the neutral, flexed, and extended neck positions.

METHODS

This study was approved by the University of Auckland Human Subjects Ethics Committee and by the Auckland City coroner. Informed consent was obtained from the parents of all subjects. Eight infants who had died unexpectedly and had been referred to the coroner for examination were studied (Table 1).

The upper airway was suctioned via the mouth and nose, the lower anterior neck was dissected, and the trachea and esophagus were cannulated. Both cannulas were connected via two-way taps to oil-filled (specific gravity 1.0) manometers. With the infant supine, the head was placed in the midline in a neutral position so that the line from the external auditory canal (EAC) to the outer canthus (OC) was at a 90° to the axis of the thoracic spine (12). First, a circular mask (3 cm ID) was placed firmly over the nose to create an airtight seal, and air was forced into the mask by using a 50-ml syringe (Fig. 1). Mask and tracheal and esophageal pressures were monitored during air entry. The mask pressure at which mask and tracheal pressures equalized was the airway-opening pressure; the mask pressure at which mask and esophageal pressures equalized was the esophageal-opening pressure. When the airway remained closed at mask pressures $>20$ cmH$_2$O, the seal between the mask and face could often no longer be maintained; therefore, a value for opening pressure of 20 cmH$_2$O was used in the statistical analysis. The procedure was repeated three times, and the median opening pressure was determined for the air entry via the nose. Second, a circular mask (4 cm ID) was placed over both the nose and mouth, and mask pressure was determined for the air entry via the mouth (Fig. 2). Third, a circular mask (3 cm ID) was placed over the mouth, and airway- and esophageal-opening pressures were determined. The mouth mask was omitted in two infants because of time constraints. When the mouth mask was pressed against the face to obtain an airtight seal, the infant’s mandible was readily displaced posteriorly. In two infants, the determination of opening pressures for air entry via the mouth was repeated, with a second investigator supporting the angle of the mandible.

The position of the infant’s head was then changed to 1) the flexed posture, with the line from EAC to OC at 45° to the axis of the thoracic spine, and 2) the extended posture, with the line from EAC to OC at 135° to the axis of the thoracic spine. The airway- and esophageal-opening pressures for air entry via the nose, combined nose and mouth, and mouth were redetermined in each posture.

Airway-opening pressures were compared among the three routes of air entry by using one-way repeated-measures analysis of variance for the neutral and flexed neck positions. Pairwise comparisons were made by using the Student-Newman-Keuls test where there was a significant difference among routes. For the extended neck position, the data failed tests of normality and equal variance; airway-opening pressures were compared by using the Kruskal-Wallis one-way analysis of variance on ranks. Esophageal-opening pressures were compared among the three routes of air entry by using the Kruskal-Wallis one-way analysis of variance on ranks.

Airway-opening pressures via the nasal mask were compared among the three neck postures by using the Kruskal-Wallis one-way analysis of variance on ranks.

RESULTS

Air entry in the neutral neck position. The airway-opening pressures in the neutral neck position are summarized in Fig. 2 and depicted graphically in Fig. 3. The nose route for air entry was open at pressures $<20$ cmH$_2$O in all eight infants (100%); in six infants (aged
3–11 mo), mask pressure was transmitted to the trachea at atmospheric pressure; in two infants (both aged 1 mo), the airway opened when the mask pressure reached 4.0 and 15.0 cmH₂O, respectively. The combined nose and mouth route of air entry was open at pressures <20 cmH₂O in five of eight infants (62%). The mouth route of air entry was open at pressures <20 cmH₂O in three of six infants (50%). In two infants in whom the airway was closed to the mouth mask at pressures up to 20 cmH₂O, support of the angle of the mandible resulted in opening of the airway at mouth mask pressures of 0 and 8.0 cmH₂O. There was a significant difference in airway-opening pressure among the three routes of air entry (P = 0.036). Pairwise comparisons indicated that air entered the trachea at a significantly lower pressure when the nose mask was used compared with the combined nose and mouth mask (P < 0.05) and when using the nose mask compared with the mouth mask (P < 0.05).

The esophagus was open at the mask pressure at which air entered the trachea in two of eight infants (25%) with the nose mask, in two of eight infants (25%) with the combined nose and mouth mask, and in one of three infants (33%) with the mouth mask. There was no significant difference in esophageal air entry among the three routes of air entry.

Air entry in the flexed neck position. The airway-opening pressures in the flexed neck position are summarized in Fig. 2. The nose route for air entry was open at pressures <20 cmH₂O in six of eight infants (75%). The combined nose and mouth route of air entry was open at pressures <20 cmH₂O in four of seven infants (57%). The mouth route of air entry was open at pressures <20 cmH₂O in two of six infants (33%). There was no significant difference in airway-opening pressure among the three routes of air entry.

The esophagus was open at the mask pressure at which air entered the trachea in one of five infants

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### Table 1. Details of the infants studied postmortem

<table>
<thead>
<tr>
<th>Infant No.</th>
<th>Age at Death, mo</th>
<th>Sex</th>
<th>Weight, kg</th>
<th>Cause of Death at Autopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>F</td>
<td>10.6</td>
<td>SIDS</td>
</tr>
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<td>2</td>
<td>6*</td>
<td>M</td>
<td>5.0</td>
<td>SIDS</td>
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<tr>
<td>4</td>
<td>4</td>
<td>M</td>
<td>5.9</td>
<td>SIDS</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>M</td>
<td>7.0</td>
<td>SIDS</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>M</td>
<td>4.3</td>
<td>Congenital heart disease</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>M</td>
<td>6.7</td>
<td>SIDS</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>M</td>
<td>5.9</td>
<td>Subdural hemorrhage</td>
</tr>
</tbody>
</table>

M, male; F, female; SIDS, sudden infant death syndrome. *29 wk gestation.

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Fig. 1. Diagram of procedure used to determine mask pressure (P) at which changes in mask pressure are transmitted to trachea (trach) and esophagus (oeso). Air is forced into a mask sealed about nose. Mask pressure at which pressure within trachea (or esophagus) first follows mask pressure is airway- (or esophageal-) opening pressure.

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Fig. 2. Summary of findings for the 3 routes of air entry in 3 neck postures. N, nose; N/M, combined nose and mouth; M, mouth. *Study not completed in 2 subjects. **Study not completed in 1 subject.

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Fig. 3. Number of infants in whom airway was open to trachea at pressures at or <20 cmH₂O in neutral neck posture is compared among the 3 routes of air entry, i.e., nose, combined nose and mouth, and mouth.
Air entry in the extended neck position. The airway-opening pressures in the extended neck position are summarized in Fig. 2. The nose route for air entry was open at pressures < 20 cmH₂O in all eight infants (100%). The combined nose and mouth route of air entry was open at pressures < 20 cmH₂O in all eight infants (100%). The mouth route of air entry was open at pressures < 20 cmH₂O in six of seven infants (86%). In one infant in whom the trachea was closed to the mouth mask at pressures up to 20 cmH₂O, support of the angle of the mandible resulted in opening of the trachea at a mouth mask pressures of 6.0 cmH₂O. There was no significant difference in tracheal-opening pressure among the three routes of air entry.

The esophagus was open at the mask pressure at which air entered the trachea in two of eight (25%) infants with the nose mask, in one of six infants (17%) with the combined nose and mouth mask, and in two of seven infants (29%) with the mouth mask.

Comparison of air entry in the trachea among the three neck postures. There was a significant difference in airway-opening pressure among the three neck postures when the nasal route of air entry was used (P = 0.006). Pairwise comparisons indicated that air entered the trachea at a significantly lower pressure in the neutral compared with the flexed position (P < 0.05) and in the flexed compared with the flexed position (P < 0.05).

Comparison of air entry into the esophagus between the three neck postures. The esophagus was open to nose mask at pressures < 20 cmH₂O in three of eight (38%) infants in the neutral posture, one of eight (13%) infants in the flexed posture, and four of eight (50%) infants in the extended posture. There was no significant difference in esophageal-opening pressure between the three neck postures when the nose, combined nose and mouth or, mouth masks were used.

**DISCUSSION**

Air entry into the trachea occurred at significantly lower mask pressures when a nose mask was used than when either a combined nose and mouth mask or mouth mask was used. The findings are similar to those of Segedin et al. (5), who studied 4-mo-old infants during anesthesia and found that all of 20 infants were successfully ventilated by the nasal route but only four were successfully ventilated by the oral route. We were unable to demonstrate the advantage of the nose mask when the infants were in an extreme neck flexed or extended posture. However, the combination of nasal mask and neck extension was uniquely associated with an open airway from mask to trachea in all infants.

In this study, the upper airway was patent in the neutral neck posture at a similar range of pressures (0–15 cmH₂O) to those measured in a previous postmortem study of the infant airway by Wilson et al. (12). As previously noted, the airway-opening pressure is in the range of pressures recorded in the pharyngeal airway of quietly breathing infants at rest (3). In this research, we have assumed that the postmortem findings can be extrapolated to the living apneic infant. There are several problems with this assumption. Although we can assume that in both circumstances there is no active or reflex muscle activity, postmortem the tissues are cold, and tissue compliance is altered. Furthermore, rigor mortis also alters tissue properties, and the viscosity of airway fluid changes with temperature. The presumed site of airway closure postmortem is in the oropharynx, on the basis of measurements of upper airway dimensions during deflation with a catheter passed through the nose into the upper airway (4).

We made no attempt to close the mouth when using the nasal mask and did not assess air leak through the mouth. However, the airway was open by the nasal route in all infants with the neck in the neutral or extended position. Air leak through the open mouth may be significant when a nasal mask is used to inflate the lungs in the clinical setting if the mouth is not closed.

The nasal airway appears to be the physiological route of air entry during quiet breathing in the infant younger than 1 mo; nasal breathing is obligatory or at least strongly preferential in infants (8). In the neutral neck posture, we found that in all infants except the two youngest, who were under 2 mo old, the nasal airway to the trachea was open before any additional mask pressure was applied. We have previously demonstrated, using timed inspiratory radiographs of the upper airway (2), that the nasal and not the oral airway is patent on inspiration during quiet waking or sleep in newborn and 6-wk-old infants.

Pressure applied to the mouth mask to achieve a seal over the contours of the face led to an impediment to air entry into the trachea, which was reversed by anterior replacement of the mandible in two infants. This finding highlights the problems that arise when the mask (or resuscitator’s mouth) does not mold readily to the shape of the face. Posterior displacement of the mobile jaw, which is more likely to occur during attempts at resuscitation via the mouth route, may be more difficult to avoid in this group.

Air entry into the trachea occurred at significantly lower pressures via the nose route in the neutral and extended neck positions compared with the flexed position. Impairment of upper airway patency in the flexed posture has been previously reported postmortem (4, 12) and in the sleeping preterm infants (7).

Air entry into the esophagus frequently occurred at the same or similar mask pressures as those associated with tracheal inflation. We were unable to demonstrate a significant effect of the route of air entry on esophageal air entry.

Neonatal and infant resuscitation guidelines should be different from those for older individuals (1). The data from this postmortem study support the view that the “kiss of life” using mouth-to-mouth route of air entry is less satisfactory than the mouth-to-nose route in infants because of obstruction to airflow. A mother’s...
mouth in most instances is only large enough to make a seal around the nose or the mouth but not both (10). Therefore, a mother must choose where to obtain an airtight seal. The data suggest that the route for resuscitative air entry should be through the nose. Not only is an airtight seal readily obtained but also this route for air entry is effective, and there is little likelihood that the jaw will be displaced posteriorly in an attempt to obtain an airtight seal. To prevent air leak through the mouth, it is advisable to close the mouth of the infant during nasal ventilation.

We recommend that the nasal route of air entry be taught to parents, so that they may effectively resuscitate their infants if breathing stops.

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