Vital capacity and tidal volume preoxygenation with a mouthpiece

S. Winship and A. Skinner

Summary
We have measured oxygen wash-in in 20 volunteers undergoing preoxygenation with a face mask, mouthpiece alone and a mouthpiece with a noseclip, in a crossover study. Tidal volume breathing and maximal deep breath techniques were studied with each type of equipment. When tidal volume breathing was used, the face mask and mouthpiece with noseclip were comparable, but the mouthpiece alone achieved a lower end-expiratory oxygen concentration than the two other methods after 3 min ($P<0.001$ and $P<0.01$), and after 5 min ($P<0.05$ in each case). Conversely, during preoxygenation with vital capacity breaths, the mouthpiece and mouthpiece with noseclip were comparable, and both were more effective than the face mask ($P<0.001$). In a second study, 20 patients who had undergone preoxygenation before induction of anaesthesia were asked later if they would have preferred the face mask or mouthpiece for this procedure. Significantly more patients (14 of 18 who expressed a preference) favoured the mouthpiece ($P<0.05$; confidence limits $0.56–0.92$). (Br. J. Anaesth. 1998; 81: 787–789).

Keywords: anaesthetic techniques, preoxygenation; equipment, face mask; equipment, mouthpiece; measurement techniques, oxygraphy

Arterial desaturation is common during induction of anaesthesia and can be prevented by preoxygenation. However, preoxygenation with a face mask is inefficient unless it is applied firmly. Some patients are afraid of firm application of the mask, in some the mask fits poorly because of the shape of the face or dentition, and in others a mask cannot be applied because of facial burns or trauma. Thus it is important to offer an alternative.

In this study, first, we investigated in volunteers the effectiveness of a nebulizer-type mouthpiece, with and without a noseclip, compared with a face mask, for vital capacity and tidal volume preoxygenation. Second, we asked if patients preferred a mouthpiece.

Methods and results
After obtaining approval from the Ethics Committee, we studied 20 healthy volunteers allocated sequentially to receive 100% oxygen from each of three types of breathing apparatus: face mask (East Healthcare), mouthpiece (Intersurgical) or a mouthpiece with a noseclip (Speedo) occluding the nares. The noseclip was also used with the face mask. Tidal volume breathing was used for 5 min, and vital capacity breathing for a total of 5 breaths. Oxygen 10 litre min$^{-1}$ was given to each subject from a standard anaesthetic machine via a Mapleson A breathing system with a 4-litre reservoir bag.

Using a Capnomac Ultima gas analyser (Datex Instrumentarium Corporation), calibrated between each set of measurements, inspiratory and expiratory oxygen and carbon dioxide concentrations were measured from each subject’s oral cavity via a catheter which was held within a bite-block when the face mask was used, and within the mouthpiece when it was used, both lying 2.5 cm within the subject’s mouth. Adequacy of oxygen supply was confirmed by achievement of an inspiratory oxygen concentration of 100%, and adequacy of ventilation by a normal capnogram trace. Between each recording from the same subject, the lungs were allowed to equilibrate with room air.

During tidal volume breathing, end-expiratory oxygen concentration ($F_{\text{E}2}$) was recorded every 20 s during the 5 min of preoxygenation, enabling a wash-in curve to be drawn. During vital capacity breathing, $F_{\text{E}2}$ was recorded at the end of each breath.

As this was a cross-over study, each subject undergoing preoxygenation using all six techniques, they acted as their own controls. A Kruskal–Wallis test was used to analyse $F_{\text{E}2}$ results between all three groups at 180 and 300 s of tidal volume breathing. The mouthpiece and mouthpiece with noseclip results were then independently compared with the face mask results using a Mann–Whitney $U$ test. Data from the fourth and fifth vital capacity breaths were analysed in the same way.

At 180 and at 300 s, $F_{\text{E}2}$ was similar using the face mask or mouthpiece with noseclip when tidal volume breathing was used. However, the results of the mouthpiece alone were significantly less ($P<0.001$ in both cases at 180 s; at 300 s, $P<0.01$ compared with the face mask and $P<0.05$ compared with the mouthpiece and noseclip) (fig. 1). Thirteen of the subjects (designated subgroup A) achieved an $F_{\text{E}2}$ concentration of 90% or above with the mouthpiece alone at some point during the study, while seven subjects (subgroup B) never achieved this concentration. Application of the noseclip improved the results of subgroup B, which were not significantly different from the face mask results of subgroup B.

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During preoxygenation with vital capacity breaths, the mouthpiece was significantly better than the face mask, whether or not the noseclip was used \( (P<0.001) \) at both the fourth and fifth breaths in both instances. Results from subgroup A and subgroup B during vital capacity breathing were similar, and both were significantly higher when using the mouthpiece compared with the face mask \( (P<0.01) \) and \( P<0.05 \), respectively, after the fourth vital capacity breath; \( P<0.001 \) and \( P<0.01 \), respectively, after the fifth vital capacity breath) (table 1).

In the second part of the study, 20 patients who had undergone preoxygenation before uncomplicated surgery within the preceding few days were shown a Magill breathing system with interchangeability of equipment, and asked if they had any preference. The results were analysed using the binomial distribution of probabilities. Of the 20 patients (12 females), 14 preferred the mouthpiece and noseclip, four the face mask and two had no preference. The results were analysed using Fisher’s exact test, and the mean results recorded for the mouthpiece alone fluctuated, probably representing lapses in concentration on the part of some subjects, one-third of whom were unable to achieve an \( \text{FeO}_2 \) of 90% or more.

Conversely, the mouthpiece was more effective than the face mask for vital capacity preoxygenation. This was probably because of the mechanics of deep breathing. When taking a maximal inspiratory breath it is easier to breathe through the mouth, rather than through the nose, as it presents less resistance. There may be the tendency to purse one’s lips at the same time, improving the seal of the lips around the mouthpiece. The poor performance of the face mask during deep breathing is difficult to explain: it may be the tendency to purse one’s lips at the same time, improving the seal of the lips around the mouthpiece. It is reassuring to note that volunteers in subgroup B, during tidal volume breathing, the face mask is more reliable than the mouthpiece alone. This is probably because of inadvertent nasal breathing, as application of a noseclip improved \( \text{FeO}_2 \). There may also have been leaks around the mouthpiece if the lips were not firmly sealed around it. After the initial increase in \( \text{FeO}_2 \), the mean results recorded for the mouthpiece alone fluctuated, probably representing lapses in concentration on the part of some subjects, one-third of whom were unable to achieve an \( \text{FeO}_2 \) of 90% or more.

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Comment
Preoxygenation creates an oxygen reservoir within the patient’s lungs. Three and 5 min of tidal volume breathing have variously been recommended. Four maximal deep breaths cause a similar increase in arterial oxygen tension compared with former techniques, but provide less protection from apnoea. Nonetheless, this technique still provided a considerable “apnoea time” in all subjects and was less time-consuming and widely accepted. It is only in cases of anticipated difficult intubation or upper airway obstruction that 3 min of preoxygenation is considered essential. End-tidal oxygen concentration correlates with alveolar partial pressure of oxygen, and is well established as a measure of preoxygenation.

Everatt and Ng recently investigated the mouthpiece for preoxygenation, although they studied its use only during tidal volume breathing. Our results confirm their findings that during tidal volume breathing, the face mask is more reliable than the mouthpiece alone. This is probably because of inadvertent nasal breathing, as application of a noseclip improved \( \text{FeO}_2 \). There may also have been leaks around the mouthpiece if the lips were not firmly sealed around it. After the initial increase in \( \text{FeO}_2 \), the mean results recorded for the mouthpiece alone fluctuated, probably representing lapses in concentration on the part of some subjects, one-third of whom were unable to achieve an \( \text{FeO}_2 \) of 90% or more.

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In summary, for a vital capacity preoxygenation technique in volunteers, the mouthpiece was more effective than the face mask and, given the greater patient acceptance, it could be considered the technique of choice. If a 3-min period of tidal volume breathing is to be used, the mouthpiece must be used with a noseclip, unless oxymetry is available to demonstrate adequate oxygen wash-in.

Table 1
Mean values for end-expiratory oxygen concentration (%) at 3 and 5 min of tidal volume breathing, and at the fourth and fifth vital capacity breaths. For “all groups”, the mouthpiece and mouthpiece with noseclip were compared with the face mask. For “subgroup B”, who never achieved an \( \text{FeO}_2 \) greater than 90% using the mouthpiece, the mouthpiece and mouthpiece with noseclip were compared with the face mask. *\( P<0.05 \), **\( P<0.01 \) and ***\( P<0.001 \).

<table>
<thead>
<tr>
<th>All groups</th>
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<td>Face mask</td>
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<td>91.4 (85–95)</td>
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<td>91.3 (85–95)</td>
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<td>91.4 (85–95)</td>
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Figure 1
Mean values for end-expiratory oxygen concentration during (0–300 s) and after (320–440 s) administration of 100% oxygen, using the three pieces of equipment for tidal volume preoxygenation.
Acknowledgement

We thank Dr Stephen Raftery, FFARCSI, for invaluable assistance with the statistics.

References