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SHORT COMMUNICATION

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## Preoxygenation—the importance of a good face mask seal

P. MCGOWAN AND A. SKINNER

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### Summary

We have studied 16 healthy volunteers whose lungs were preoxygenated six times each in order to assess the amount of room air entrained during tidal volume preoxygenation if a good seal is not maintained between the face mask and the face. With a fresh gas flow of 10 litre  $\text{min}^{-1}$ , we found that using gravity alone to hold the face mask in position, more than 20 % room air was entrained; if the face mask was held adjacent to the face, more than 40 % room air was entrained. (*Br. J. Anaesth.* 1995; **75**: 777–778)

### Key words

Anaesthetic techniques, preoxygenation. Equipment, masks anaesthesia.

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Preoxygenation is commonly performed before induction of general anaesthesia [1] in order to produce a reservoir of oxygen in the functional residual capacity (FRC) of the lungs [2] and allow an increase in duration of apnoea which a patient may safely tolerate [2, 3]. A commonly used method of preoxygenation is to allow normal tidal breathing of 100 % oxygen for 3 min using a tightly fitting face mask [2]. Any leaks in the breathing system allow ingress of room air, impeding preoxygenation [2, 3]. However, some anaesthetists fail to use a tightly applied face mask as many patients find this unpleasant.

The purpose of this study was to determine in the clinical setting how much room air is entrained during preoxygenation with a face mask when a tight seal around the face is not maintained.

### Methods and results

Sixteen healthy volunteers agreed to take part in this study, which had received Ethics Committee approval. The lungs of each were preoxygenated using a black antistatic rubber face mask (East Healthcare) which had been tested previously for an airtight seal around their face. A total fresh gas flow of 10 litre  $\text{min}^{-1}$  was chosen to enable the calibration markings of the anaesthetic machine flowmeter to be used when altering the composition of the fresh gas flow. A Magill circuit (Mapleson A) with a reservoir bag of 4 litre was used; this was filled with the appropriate gas mixture before preoxygenation.

The lungs of each subject were preoxygenated six times in the supine position as follows: using a tight fitting face mask while breathing (1) 100 % oxygen;

(2) 92.1 % oxygen (90 % oxygen, 10 % air); (3) 84.2 % oxygen (80 % oxygen, 20 % air); (4) 68.4 % oxygen (60 % oxygen, 40 % air) and also (5) 100 % oxygen with gravity alone holding the face mask against the face; and (6) 100 % oxygen with the face mask lifted just clear of the face using two small foam rubber insertions (1 cm wide) at the nose and chin ends of the face mask. The height of the insertions was increased until the face mask was not longer in contact with the volunteer's face at any point. For each volunteer the separation between the closest part of the face mask and the face was no more than 2 mm. Each period of preoxygenation lasted 5 min and 15 min was allowed between each experiment for the subject to equilibrate with room air.

End-tidal oxygen concentration was recorded at 20-s intervals using a Capnomac Ultima gas analyser (Datex Instrumentarium Corporation) [4, 5]. The nose of each subject was clamped and a shortened Guedel airway was inserted into the mouth. Gas was sampled through a fine tube inserted into the lumen of the Guedel airway to allow closer approximation of the end-tidal gas being measured to that of alveolar gas.

The volunteers (10 males) had mean ages, weights and heights of 33.8 (range 22–53) yr, 69.1 kg and 171.8 cm, respectively.

End-tidal oxygen concentration ( $F_{E'O_2}$ ) when breathing 100 % oxygen increased exponentially to reach a plateau ( $F_{E'O_2} > 0.9$ ) by 5 min (fig. 1). This is consistent with previous findings [4]. Correspondingly lower plateaux were reached when lower oxygen concentrations were inspired. Three subjects, all of whom were male, did not reach an  $F_{E'O_2}$  of 0.9 after 5 min of breathing 100 % oxygen; this is also consistent with other studies [4, 5]. The mean time to reach an  $F_{E'O_2}$  of 0.9 for the remainder was 140 (SD 20) s.

When gravity alone was used to hold the face mask against the face, mean  $F_{E'O_2}$  was just less than that when breathing 20 % air in oxygen. With the mask lifted clear of the face, mean  $F_{E'O_2}$  was just less than that when breathing 40 % air in oxygen (fig. 1).

Compared with face masks used with a tight seal, face masks with an inadequate seal produced  $F_{E'O_2}$  curves with greater standard error values and a more erratic nature.

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P. MCGOWAN\*, FRCA, A. SKINNER, FRCA, Department of Anaesthesia, Whiston Hospital, Merseyside L35 5DR. Accepted for publication: June 30, 1995.

\*Present address: Department of Anesthesiology, Texas Tech University Health Science Center, Lubbock, TX 79430, USA.

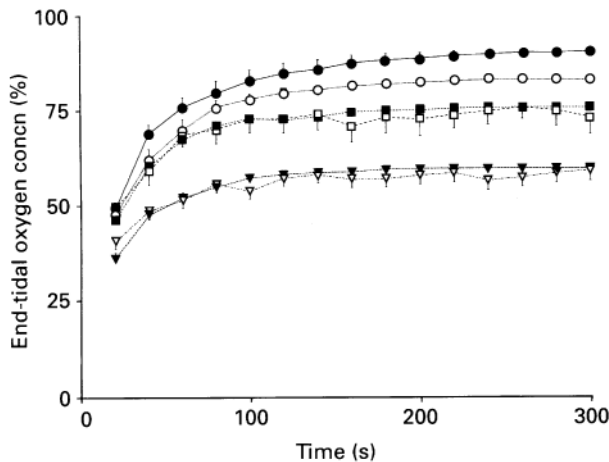


Figure 1 End-tidal oxygen values when breathing: 100 % oxygen with a tight face mask seal (●); 92.1 % oxygen with a tight face mask seal (○); 84.2 % oxygen with a tight face mask seal (■); 68.4 % oxygen with a tight face mask seal (▼); 100 % oxygen with gravity alone maintaining the face mask seal (□); and 100 % oxygen with the face mask lifted just off the face (▽).

## Comment

This study emphasizes the need to maintain a good seal between the face mask and the face to optimize preoxygenation. The observation that using gravity alone to maintain the seal allows approximately 20 % room air into the patient's inspiratory gas flow suggests that additional external pressure should be applied to ensure a good seal.

Patients often dislike having a face mask applied tightly to their faces and in an effort to allay their anxiety anaesthetists may allow the face mask to be held lightly against or adjacent to the patient's face. Furthermore, an assistant who does not appreciate the importance of a good seal may heed a patient's request to move the face mask. If a patient cannot tolerate the application of a face mask an alternative approach to preoxygenation may be considered, such as using a Hudson mask with a very high fresh gas flow [6].

Berthoud, Read and Norman [2] showed that allowing inspiration of even a small amount of room

air during preoxygenation had a marked effect on denitrogenation. Drummond and Park [3] showed that opening a fixed diameter hole in the face mask during preoxygenation caused more patients to desaturate to less than 90 %. However, no study has previously attempted to quantify the effect of the types of leak found in everyday clinical practice.

The two curves associated with face mask leaks in this study displayed greater intersubject variability than the remainder of the curves. This is likely to be caused partly by differences in peak inspiratory flow rate between subjects and partly by differences in facial morphology. Those with a higher peak inspiratory flow rate are predisposed to draw in more room air as they exceed the fresh gas flow rate of 10 litre  $\text{min}^{-1}$ . Also, those whose facial shape is less ideally suited to forming a good seal with the face mask would be more likely to draw in room air through leaks.

The use of vital capacity breaths for preoxygenation was not examined in this study but it is likely that a greater amount of room air would be entrained through any leaks because of higher peak inspiratory flow rate. Furthermore, this technique produces less efficient denitrogenation of the FRC than 3 min of tidal breathing.

## References

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