Pre-oxygenation in the obese patient: effects of position on tolerance to apnoea


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Background. In obese patients, reduced functional residual capacity exacerbated by supine position might decrease the effectiveness of pre-oxygenation and the tolerance to apnoea. The aim of this study was to compare the effect of body posture during pre-oxygenation, sitting or supine, on its effectiveness in obese patients.

Methods. Forty obese patients (BMI > 35 kg m\(^{-2}\)) undergoing surgery with general anaesthesia were randomly assigned to one of two groups: Group 1 (sitting, n=20) or Group 2 (supine, n=20). In the predetermined body position, pre-oxygenation was achieved with eight deep breaths within 60 s and an oxygen flow of 10 litre min\(^{-1}\). After rapid sequence induction of anaesthesia in decubitus position, the trachea was intubated and the patient was left apneic and disconnected from the anaesthesia circuit until \(\text{SpO}_2\) decreased to 90%. The time taken for desaturation to 90% from the end of induction of anaesthesia was recorded. Arterial blood oxygen tension was measured before (baseline) and after pre-oxygenation. Values were compared with two-way ANOVA and unpaired Student’s t-test.

Results. Oxygen and carbon dioxide tensions were similar between groups, both at baseline and after pre-oxygenation. However, the mean time to desaturation to 90% was significantly longer in the sitting group compared with the supine group [mean (SD): 214 (28) vs 162 (38) s, \(P<0.05\)].

Conclusions. Pre-oxygenation in sitting position significantly extends the tolerance to apnoea in obese patients when compared with the supine position.


Keywords: anaesthetic techniques, pre-oxygenation; complications, obesity; position, effects

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Management of obese patients (BMI > 30 kg m\(^{-2}\)) represents a challenge for the anaesthetist in many ways, particularly adequate airway management during induction. A BMI greater than 26 kg m\(^{-2}\) is a strong predictor of higher risk of difficult ventilation with facemask\(^{1}\), and, arguably, associated with a greater risk of difficult intubation and accompanying desaturation.\(^{2}\) This setting emphasizes the importance of an adequate pre-oxygenation to maximize the period of non-hypoxaemic apnoea that obese patients can tolerate.

In patients of normal weight, the effectiveness of pre-oxygenation varies with the technique. A forced vital capacity ventilation for eight breaths during 60 s with high flows of oxygen 100% was shown to achieve adequate denitrogenation and slower desaturation during apnoea compared with the usual 3 min tidal-volume ventilation technique.\(^{3}\)

Obesity, however, affects pulmonary function that can seriously impair the effectiveness of pre-oxygenation; the main reason being a decrease in functional residual capacity (FRC) secondary to cephalad diaphragmatic displacement.\(^{4}\) Thus, in obese patients desaturation of arterial blood after onset of apnoea is reached within a significantly shorter time than in a non-obese patient.\(^{5}\)

Since FRC is highly sensitive to changes in body position, being larger in the upright or sitting than in the supine position,\(^{6}\) we hypothesized that the efficacy of pre-oxygenation in obese patients might be improved by modifying the position of the patient during this manoeuvre. Thus, the aim of this study was to compare the effect of the sitting against the supine position, in obese patients, on the effectiveness of pre-oxygenation defined as the duration of non-hypoxaemic apnoea.

Methods

After institutional Ethics Committee approval, and obtaining written informed consent, 40 unpremedicated obese patients (BMI \(\geq 35 \text{ kg m}^{-2}\)), ASA II or III, undergoing elective surgery with general anaesthesia, were studied.
Exclusion criteria were age less than 20 yr or more than 60 yr, and the presence of pulmonary or cardiovascular disease.

After placement of routine non-invasive monitors, a 20-gauge cannula was inserted in the radial artery under local anaesthesia. With the patients in supine position (0°) with a 5-cm pillow and breathing room air, a baseline arterial blood sample for blood gas analysis was obtained, and the peripheral pulse oximetry value (Sp$_{\text{O}_2}$) was measured at the index finger and recorded in each patient. Then, using a facemask disconnected from the anaesthesia circuit, patients were instructed and trained to take eight deep breaths within 60 s through the facemask tightly fitted to the face. Following these instructions, patients were assigned by means of random numbers generated by a computer, to one of two groups. Patients in Group 1 (sitting position; n=20) sat as close as possible to 90° head up position, and those in Group 2 (supine position; n=20) remained in their original position. Pre-oxygenation was then performed by taking eight deep breaths over 60 s with the facemask connected to a circle system with a fresh oxygen flow of 10 litre min$^{-1}$. The adjustable pressure limit valve of the circle system was kept fully open during all the procedure to avoid any possible continuous positive airway pressure (CPAP) or positive end-expiratory pressure effect. At the end of pre-oxygenation, the maximum Sp$_{\text{O}_2}$ value attained was recorded and a second arterial blood sample obtained. Group 1 patients were then returned to the initial supine position (i.e. 0°).

Immediately after, with all patients in supine position and their head on a 5-cm pillow, induction of anaesthesia was achieved with fentanyl 3 $\mu$g kg$^{-1}$ followed by thiopentone 5 mg kg$^{-1}$ (injected in 15 s) and suxamethonium 1 mg kg$^{-1}$. During this period, patients remained breathing spontaneously through the facemask and oxygen 100% until apnoea occurred. After apnoea, patients were not ventilated and tracheal intubation was performed by an experienced anaesthetist 60 s after the injection of suxamethonium. After intubation, the proximal end of the tracheal tube was left open to room air and the patients were not ventilated. The study was continued only if the tube was clearly seen placed between the vocal cords.

Pulse oximetry values were continuously recorded throughout the procedure. Time from the end of thiopentone injection until Sp$_{\text{O}_2}$ fell to 90% was recorded. The tracheal tube was then connected to the anaesthesia circuit and patients were ventilated with sevoflurane 3% in oxygen until peripheral oxygen saturation was restored.

Statistical analysis consisted of a Kolmogorov–Smirnov’s test for normality of data. Two-way ANOVA for repeated measurements and unpaired Student’s $t$-test were used for between-group comparisons. $P<0.05$ was considered significant. The values are expressed as mean ($\text{SD}$).

### Results

Patient characteristics and pre-operative haemoglobin levels were similar in both groups (Table 1). In two patients, one from each group, we were unable to obtain blood samples for gas analysis, but they were included in the remainder of the analysis. All patients randomized to the sitting position reached the 90° head-up position with the help of the anaesthetist.

The Kolmogorov–Smirnov’s test confirmed that all the variables studied had normal distribution. There was no difference between groups in baseline (room air) or maximal $P_{\text{aO}_2}$ values obtained after pre-oxygenation (Table 2). All the patients reached Sp$_{\text{O}_2}$ of 100% at the end of pre-oxygenation.

Individual times to desaturation during apnoea in both groups are shown in Figure 1. The mean time to a decrease in Sp$_{\text{O}_2}$ to less than 90% was significantly longer in Group 1.

### Table 1 Patient characteristics. Data are given as mean (range) or mean ($\text{SD}$). There were no differences between the two groups

<table>
<thead>
<tr>
<th>Group 1 (sitting, n=20)</th>
<th>Group 2 (supine, n=20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>41 (20–58)</td>
</tr>
<tr>
<td>Gender ratio M/F</td>
<td>3/17</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>116 (15)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>163 (8)</td>
</tr>
<tr>
<td>BMI (kg m$^{-2}$)</td>
<td>43 (5)</td>
</tr>
<tr>
<td>Haemoglobin (g dl$^{-1}$)</td>
<td>14 (1)</td>
</tr>
</tbody>
</table>

### Table 2 Arterial oxygen and carbon dioxide tension at baseline and at the end of pre-oxygenation. $P(\text{A–a})_{\text{O}_2}$, alveolar/arterial $P_{\text{O}_2}$ difference; $P_{\text{aO}_2}/F_{\text{IO}_2}$, ratio of arterial oxygen tension to inspired fraction of oxygen. Data are given as mean ($\text{SD}$). There were no differences between the two groups

<table>
<thead>
<tr>
<th>Group 1 (sitting, n=19)</th>
<th>Group 2 (supine, n=19)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_{\text{aO}_2}$ (kPa)</td>
<td>10.3 (1.2) 34.2 (9.7)</td>
</tr>
<tr>
<td>$P_{\text{aCO}_2}$ (kPa)</td>
<td>4.8 (1.4)  6.1 (0.7)</td>
</tr>
<tr>
<td>$S_{\text{aO}_2}$ (%)</td>
<td>95.7 (1.6) 100 (0.0)</td>
</tr>
<tr>
<td>$P(\text{A–a})_{\text{O}_2}$ (kPa)</td>
<td>3.8 (1.2) 56.6 (11.5)</td>
</tr>
<tr>
<td>$P_{\text{aO}<em>2}$ (mm Hg)/$F</em>{\text{IO}_2}$</td>
<td>375 (41) 328 (89)</td>
</tr>
</tbody>
</table>
(sitting position) than in Group 2 (supine position) patients [216 (35) vs 164 (38) s, P<0.05]. At the end of study, ventilation with oxygen 100% restored normal \( \text{Sp}_{\text{O}_2} \) values in all patients.

**Discussion**

The main finding of this study is that, in obese patients, pre-oxygenation with eight deep breaths ventilation over 60 s performed in the sitting position increases the apnoea tolerance by almost 1 min compared with the same manoeuvre performed with the patient in the supine position.

The induction of general anaesthesia is associated with variable periods of apnoea. In this context, pre-oxygenation is a fundamental component of safe general anaesthesia, especially in the management of patients with potentially difficult airway or impaired pulmonary reserve.

Adequate pre-oxygenation is achieved by breathing oxygen 100% for variable periods of time. The final result depends on several factors such as fresh gas flow, type of ventilation, and characteristics of the patients. The technique of eight deep breaths over 60 s was chosen because it has been shown to be one of the most efficient alternatives, at least in normal weight subjects.

An adequate pre-oxygenation increases oxygen reserve available in alveolar, arterial, venous, and tissue compartments. Out of all these, pulmonary reserve, in particular FRC, constitutes the most important oxygen reserve in the body. FRC varies with body position, and the supine position is associated with a reduced FRC when compared with the sitting position.

Obese patients have a reduced FRC, which is further compromised by the supine position. This may be secondary to the cephalad displacement of the diaphragm, caused by increased pressure of the abdominal contents. This results in a reduction of oxygen reserve and therefore, shorter desaturation times during apnoea compared with normal weight subjects. Indeed, there is a negative linear correlation between BMI and non-hypoxaemic apnoea period.

The present study demonstrates that pre-oxygenation in the sitting position increases the apnoea tolerance compared with the supine position in obese patients, most probably as a result of a larger FRC in these patients. It is unlikely that blood and tissue oxygen stores were different enough to account for this effect as there was no difference between groups in arterial oxygen tension after pre-oxygenation. Previous studies have measured the effect that different manoeuvres known to increase the FRC have on the effectiveness of pre-oxygenation.

Cressey and colleagues found a non-statistically significant increase of 37 s in the time to desaturate to 90% when 7.5 cm H\(_2\)O CPAP was applied during pre-oxygenation to morbidly obese women. While this level of CPAP might be insufficient to effectively shift the abdominal content and increase FRC in obese patients, a possible CPAP effect was avoided in our study by leaving the adjustable valve of the circuit fully open during pre-oxygenation.

Baraka and colleagues studied the effect of a 45° head-up vs supine position during pre-oxygenation in pregnant and non-pregnant women and found an increase in desaturation time in non-pregnant women only. Thus, the effectiveness of a technique may vary depending on the characteristics of the patients and possibly it is not appropriate to compare our results with those of Baraka and colleagues. However, since most of the change in FRC takes place between supine and 60° head-up position, the possibility that 45° head-up position was not enough to improve FRC and time to desaturation in pregnant women cannot be ruled out.

Independent of the mechanisms, these results are relevant within the time scale of pre-oxygenation and induction of anaesthesia. It should be emphasized that induction of anaesthesia should be started as soon as the patients are placed supine after pre-oxygenation in the sitting position as it has been shown that FRC decreases rapidly after induction of anaesthesia and neuromuscular block.

In conclusion, compared with the supine position, the adoption of the sitting position for pre-oxygenation increases the period of apnoea without desaturation by an average of 50–60 s in obese patients. We believe that this increase is clinically important. As this is a very easy manoeuvre, it should be considered as part of the routine technique of pre-oxygenation in this population.

**Acknowledgement**

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