

Original Article

A Prospective Observational Study Comparing Nasal Prongs and Eight Deep Breaths for Preoxygenation Before Induction of Anaesthesia

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Abstract

Background: Preoxygenation increases the pulmonary oxygen reservoir and delays desaturation during apnoea. Rapid deep-breathing and nasal-prong techniques may be useful when conventional preoxygenation is impractical or time is limited. **Objectives:** To compare nasal-prong oxygen for three minutes with eight deep breaths of 100% oxygen over 60 seconds before induction of general anaesthesia. **Methods:** This prospective observational study included 40 adults undergoing elective surgery. Twenty received oxygen by nasal prongs at 5 L/min for three minutes and 20 took eight deep breaths through a well-fitting face mask over 60 seconds. The primary outcome was end-tidal oxygen concentration (EtO₂) immediately before induction. Secondary outcomes were time to SpO₂ <94%, achievement of EtO₂ ≥85%, and immediate adverse effects. **Results:** Mean EtO₂ was higher with eight deep breaths than with nasal prongs (79.6 ± 5.6% versus 73.2 ± 6.1%; p=0.001). Mean time to SpO₂ <94% was 4.2 ± 1.1 versus 3.7 ± 1.0 minutes (p=0.141). EtO₂ ≥85% was achieved by 10/20 (50.0%) and 6/20 (30.0%) patients, respectively. Adverse effects were uncommon. **Conclusion:** Eight deep breaths produced greater immediate denitrogenation than low-flow nasal prongs, although the observed prolongation of apnoea tolerance was not statistically significant. The illustrative dataset requires verification before clinical or publication use.

Keywords: preoxygenation; nasal prongs; deep breathing; end-tidal oxygen

Introduction

Preoxygenation is a routine safety intervention before induction of general anaesthesia because airway obstruction, difficult laryngoscopy, or delayed tracheal intubation may produce an unavoidable period of apnoea. Breathing a high inspired oxygen concentration replaces nitrogen within the functional residual capacity with oxygen and creates an alveolar reservoir that sustains oxygen uptake after ventilation stops [1,2]. Adequate preoxygenation can therefore postpone movement onto the steep portion of the oxyhaemoglobin dissociation curve and provide additional time for airway management [3].

Traditional preoxygenation consists of tidal breathing of 100% oxygen through a tightly fitting face mask for approximately three minutes. Rapid techniques using four or eight vital-capacity breaths have also been studied and can achieve acceptable denitrogenation in cooperative adults when oxygen flow and mask seal are adequate [4-6]. Effectiveness is commonly assessed by end-tidal oxygen concentration; an EtO₂ of at least 85-90% is generally regarded as evidence of satisfactory denitrogenation [1,2].

Nasal prongs are comfortable, leave the face accessible, and can remain in place during laryngoscopy. However, conventional low-flow prongs deliver a variable inspired oxygen fraction because room air entrainment depends on inspiratory flow, mouth opening, respiratory pattern, and cannula flow [7]. Their value for apnoeic oxygenation is

established physiologically, particularly at higher flows, but low-flow nasal oxygen may not equal sealed-mask preoxygenation [8,9]. The present study compared nasal prongs at 5 L/min for three minutes with eight deep breaths of 100% oxygen over 60 seconds. The primary objective was to compare pre-induction EtO₂; secondary objectives were to compare time to SpO₂ <94%, the proportion attaining EtO₂ ≥85%, and immediate adverse effects.

Materials and Methods

A prospective observational, two-group study was designed in the Department of Anaesthesiology of a tertiary-care hospital over one year. The preoxygenation method used in routine practice was observed without random allocation. The report follows the supplied study results. The institution name, ethics committee approval number, registration status, and consent documentation must be inserted from source records before submission.

Forty adult patients aged 18-70 years who were scheduled for elective surgery under general anaesthesia were included. Eligible patients had American Society of Anesthesiologists (ASA) physical status I-III and were able to understand and perform the assigned breathing manoeuvre. Exclusion criteria were refusal or inability to cooperate, haemodynamic instability before induction, facial trauma or another condition preventing use of the oxygen interface, severe respiratory failure requiring immediate ventilatory support, and a change in the planned anaesthetic technique before outcome assessment.

Preoperative assessment

A routine pre-anaesthetic assessment documented age, sex, body mass index (BMI), ASA physical status, airway findings, relevant investigations, and baseline peripheral oxygen saturation. Standard monitoring comprised electrocardiography, non-invasive blood pressure, and pulse oximetry. Patients were observed in two equal groups according to the technique received.

Preoxygenation procedures

In Group A, oxygen was delivered through standard nasal prongs at 5 L/min for three minutes while the patient breathed spontaneously. The prongs remained correctly positioned throughout the intervention. In Group B, 100% oxygen was delivered through a well-fitting face mask, and each patient was instructed to take eight deep, slow breaths over approximately 60 seconds. Particular attention was paid to maintaining a mask seal. Immediately before induction, EtO₂ was recorded when a reliable capnographic trace was available. Induction, airway management, and ventilation followed routine clinical requirements; study measurements did not delay rescue ventilation.

Outcome measures

The primary outcome was EtO₂ immediately before induction. Secondary outcomes were the time from onset of apnoea until SpO₂ fell below 94%, the proportion of patients achieving EtO₂ ≥85%, and immediate adverse effects attributable to the interface or breathing manoeuvre. The desaturation threshold was selected conservatively to permit ventilation before clinically important hypoxaemia.

For comparison of two independent means, the supplied calculation assumed a common standard deviation of 5 percentage points, a clinically relevant EtO₂ difference of 5 percentage points, a two-sided alpha of 0.05, and 80% power. This yielded approximately 16 patients per group. Allowing about 20% for non-evaluable measurements produced a target of 20 participants per group (total n=40).

Continuous variables were summarized as mean $\pm$ standard deviation and categorical variables as frequency and percentage. Independent continuous outcomes were compared using Welch's t-test, which does not require equal variances. Categorical outcomes were assessed using the chi-square test or Fisher's exact test, as appropriate. A two-sided p value <0.05 was considered statistically significant. Effect estimates and confidence intervals could not be independently reconstructed because patient-level data were unavailable.

Results

All 40 patients represented in the dataset were analysed, with 20 patients in each group. No loss after group classification was reported. Baseline age, sex, BMI, ASA status, and SpO₂ were similar between groups (Table 1), reducing concern for major measured baseline imbalance, although residual confounding remains possible in a non-randomized study.

Table 1 Baseline characteristics of the study groups

Variable	Nasal prongs (n=20)	Eight deep breaths (n=20)	p value
Age, years	43.1 $\pm$ 12.7	44.0 $\pm$ 12.4	>0.05
Male sex	12 (60%)	11 (55%)	>0.05
BMI, kg/m ²	25.0 $\pm$ 3.3	25.2 $\pm$ 3.5	>0.05
ASA I / II / III	8 / 11 / 1	9 / 10 / 1	>0.05
Baseline SpO ₂ , %	98.1 $\pm$ 0.8	98.0 $\pm$ 0.9	>0.05

The primary outcome differed significantly between techniques. Mean EtO₂ immediately before induction was 73.2 $\pm$ 6.1% with nasal prongs and 79.6 $\pm$ 5.6% with eight deep breaths, an unadjusted mean difference of 6.4 percentage points. Welch's t statistic was -3.46 with 37.7 degrees of freedom (p=0.001). Neither group, on average, reached the usual 85-90% target, but the deep-breath group achieved greater denitrogenation (Table 2).

Table 2 Primary and secondary oxygenation outcomes

Outcome	Nasal prongs (n=20)	Eight deep breaths (n=20)	Statistical comparison
EtO ₂ before induction, %	73.2 $\pm$ 6.1	79.6 $\pm$ 5.6	t=-3.46; df=37.7; p=0.001
Time to SpO ₂ $<94\%$, min	3.7 $\pm$ 1.0	4.2 $\pm$ 1.1	t=-1.50; df=37.7; p=0.141
EtO ₂ $\geq 85\%$	6 (30.0%)	10 (50.0%)	Descriptive difference: 20 percentage points

Mean time from onset of apnoea to $\text{SpO}_2 < 94\%$ was 3.7 ± 1.0 minutes with nasal prongs and 4.2 ± 1.1 minutes with eight deep breaths. The 0.5-minute observed difference did not reach statistical significance ($p=0.141$). Adequate preoxygenation defined as $\text{EtO}_2 \geq 85\%$ was achieved by 6/20 (30.0%) patients receiving nasal-prong oxygen and 10/20 (50.0%) using eight deep breaths. Overall, 16/40 (40.0%) attained this threshold. The supplied results did not provide a p value for this categorical comparison; it is therefore reported descriptively.

Table 3 Immediate adverse effects

Immediate adverse event	Nasal prongs (n=20)	Eight deep breaths (n=20)	Total (n=40)
No adverse event	18 (90.0%)	19 (95.0%)	37 (92.5%)
Nasal or mask discomfort	1 (5.0%)	1 (5.0%)	2 (5.0%)
Nausea or retching	1 (5.0%)	0	1 (2.5%)

Immediate tolerance was good in both groups (Table 3). Thirty-seven patients (92.5%) had no reported adverse event. One patient in each group reported interface discomfort, and one patient in the nasal-prong group experienced nausea or retching. No serious intervention-related event was documented in the supplied dataset.

Discussion

The principal finding was that eight deep breaths of 100% oxygen through a well-fitting face mask produced a higher pre-induction EtO_2 than oxygen delivered by nasal prongs at 5 L/min for three minutes. The 6.4-percentage-point difference was statistically significant. The proportion attaining $\text{EtO}_2 \geq 85\%$ was also numerically greater with eight deep breaths. However, the observed half-minute prolongation in time to $\text{SpO}_2 < 94\%$ was not statistically significant. Thus, this small dataset supports better immediate denitrogenation with the deep-breath technique but does not establish a clinically important improvement in apnoea tolerance.

These findings are physiologically credible. A sealed face mask supplied with 100% oxygen can minimize entrainment of room air, whereas conventional nasal prongs provide variable FiO_2 . At 5 L/min, the oxygen delivered through prongs mixes with ambient gas, particularly when inspiratory flow exceeds oxygen flow or the patient breathes through the mouth [7]. Eight deep breaths increase alveolar ventilation and accelerate nitrogen washout, provided that the patient cooperates, inspires close to vital capacity, and maintains a leak-free mask seal [4-6]. Earlier work has shown that rapid deep-breath techniques may approach three-minute tidal-volume preoxygenation under optimized conditions, but their reliability declines with inadequate flow or mask leakage [4,5].

End-tidal oxygen is more informative than pulse oximetry for assessing preoxygenation because SpO_2 may remain 100% despite incomplete denitrogenation. Reviews recommend using EtO_2 as an objective endpoint, usually targeting at least 85-90% [1,2]. In the present dataset, mean EtO_2 remained below 85% in both groups, and only 40% of all participants achieved the prespecified threshold. This suggests that delivery conditions may not have been optimal even in the better-performing group. Potential explanations include mask leakage, an insufficient fresh-gas

flow, shallow execution of the instructed breaths, sampling error, or patient factors that promote ventilation-perfusion mismatch.

The relationship between EtO_2 and duration of safe apnoea is important but not one-to-one. Oxygen reserve is influenced by functional residual capacity, alveolar oxygen fraction, haemoglobin concentration, cardiac output, oxygen consumption, airway patency, shunt, and body habitus [2,3]. Consequently, a higher average EtO_2 may not yield a statistically detectable difference in desaturation time in a sample of only 20 patients per group. The conservative endpoint of $\text{SpO}_2 < 94\%$ also differs from thresholds of 90% or 92% used in other studies, limiting direct comparison.

Nasal oxygen retains practical advantages. It is generally comfortable, does not cover the mouth, and can be continued through laryngoscopy to provide apnoeic oxygenation. Nasal apnoeic oxygenation has reduced desaturation in several airway-management settings, while high-flow nasal oxygen can generate pharyngeal oxygen enrichment, modest positive airway pressure, and prolonged apnoea time [8-11]. Patel and Nouraei demonstrated prolonged apnoea using high-flow humidified nasal oxygen in difficult-airway patients, but that technique and flow are fundamentally different from standard nasal prongs at 5 L/min [10]. Benefits attributed to high-flow systems should therefore not be extrapolated to low-flow cannula preoxygenation.

Clinical selection should reflect risk. Cooperative, non-hypoxaemic adults may use an eight-deep-breath technique when rapid preoxygenation is required. Patients with obesity, pregnancy, critical illness, reduced functional residual capacity, or anticipated difficult airway may desaturate quickly and merit head-up positioning, a tight mask, high inspired oxygen, positive airway pressure when indicated, and nasal oxygen continued during intubation [2,3,11,12]. Irrespective of technique, clinicians should confirm a good interface seal, use adequate fresh-gas flow, and measure EtO_2 when possible rather than relying on elapsed time alone.

The low rate of immediate adverse effects is reassuring but should be interpreted cautiously. The study was not powered for safety outcomes, observation was brief, and discomfort may have been under-recorded. The eight-breath manoeuvre also requires comprehension and physical ability, whereas nasal prongs may be easier for anxious or poorly cooperative patients. These usability differences were not formally quantified.

Conclusion

In this prospective observational comparison, eight deep breaths of 100% oxygen over 60 seconds achieved a significantly higher mean EtO_2 than oxygen delivered through nasal prongs at 5 L/min for three minutes. Although apnoea time to $\text{SpO}_2 < 94\%$ was numerically longer with eight deep breaths, the difference was not statistically significant. Both techniques were well tolerated. A sealed-mask deep-breath method appears more effective for rapid denitrogenation than low-flow nasal prongs alone, while nasal oxygen may remain valuable as an adjunct during airway instrumentation. These conclusions are provisional because the supplied dataset is explicitly illustrative and requires verification.

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