Comparison of preoxygenation efficiency with intersurgical economy and intersurgical quadralite anaesthetic face masks

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Abstract

Background: Sufficient preoxygenation prevents arterial oxygen desaturation prior to intubation. An optimally sealed facemask is necessary for fast preoxygenation.

Aim: to compare the efficiency of preoxygenation using two different facemasks.

Materials and methods: In 2018 a prospective study was conducted. Patients were classified into groups: Group A – Intersurgical Economy facemasks, Group B – Intersurgical QuadraLite masks. The circuit was flushed with 100% O_2 for 30s, preoxygenation started with flow of 8l/min, $FiO_2$100. Patients were asked to breathe deeply. Fentanyl (1-2 mcg/kg) was administered to increase mask toleration. End-tidal oxygen concentration (EtO_2) ≥ 90% was the goal. EtO_2 was monitored after 30, 60, 90, 120, 180, 210, 240, 270 and 300 seconds. Data analyzed using Independent-Samples T-test, Mann-Whitney-U test.

Results: 12 patients were enrolled in group A and 19 in group B. Differences in gender, age, BMI and Mallampati class in the groups were statistically insignificant (p=0.13, 0.39, 0.65, 0.43 respectively). Patients assigned to ASA I – 25.8% (n=8->2/6), ASA II – 71.0 % (n=22->10/12), ASA III- 3.2% (n=1->0/1), p=0.64. The success rate of preoxygenation to $EtO_2$90 within 5 min was statistically significantly different in the groups with 33.3% in group A and 94.7% in group B (p<0.01). Mean time to $EtO_2$90 was 228.3 ± 104.0/164.4 ± 84.3. Mean EtO_2 after: 30s- 56.0 ± 13.5/69.3 ± 11.2 (p<0.01); 60s- 63.8 ± 15.3/76.1 ± 11.7 (p=0.02), 90s– 67.8 ± 17.7/80.7 ± 10.1 (p=0.03); 120s–69.6 ± 18.2/83.4 ± 10.0 (p=0.03), 150s–71.1 ± 19.0/87.1 ± 6.5 (p=0.01); 180s– 72.9 ± 16.8/88.5 ± 5.3 (p=0.01), 210s– 72.6 ± 18.0/89.2 ± 5.1 (p<0.01); 240s- 74.17 ± 15.4/90.0 ± 4.3 (p<0.01), 270s-76.3 ± 16.3/90.2 ± 3.6; 300s- 77.8 ± 14.6 / 90.2 ± 1.5 (p<0.01).

Conclusions: Preoxygenation was significantly more efficient and faster with Intersurgical QuadraLite facemasks.

Introduction

Preoxygenation, also known as denitrogenation, is a routine procedure performed prior to the induction of general anaesthesia. Room air is replaced with oxygen and its reservoir in the lungs is created [1]. Proper preoxygenation prolongs safe apnea time during airway instrumentation and also helps to avoid arterial desaturation if unanticipated difficult airway is encountered [2]. It is well established that arterial desaturation is the risk factor of arrhythmia, hemodynamic decompensation, hypoxic brain injury, and also death [3].

Sufficient preoxygenation is defined as reaching the end-tidal oxygen (EtO_2) concentration of ≥ 90% [4,5]. An indicator of incomplete preoxygenation is EtO_2 lower than 90% at the functional residual capacity level. 3 to 5 minutes of breathing 100% oxygen or 8 deep breaths within 1 min is thought to be sufficient to reach 90% of EtO_2 [6].

Ineffective face mask seal is the most common cause of insufficient preoxygenation [7]. An optimally sealed facemask that prevents entrainment of operating room air into the circuit and leaks is necessary for fast and efficient preoxygenation [8].

A new type of anaesthesia face mask (QuadraLite, produced by Intersurgical) has recently been introduced, which in contrast to the regular face mask, has a soft edge instead of an air-filled cushion. The new face mask is comfortable for patients and is said to provide a superior seal in a variety of different face anatomy [9]. Therefore, we conducted a prospective randomised study to compare preoxygenation efficiency using the regular anaesthesia face mask with air-filled cushion and the new type anaesthesia face mask.

Materials and Methods

A prospective study was conducted at Vilnius University Hospital Santaros Clinics in July - August, 2018. Permission from the institutional bioethics committee was obtained and every subject consented to participate.

The study subjects were patients undergoing general anaesthesia for elective surgery. Subject exclusion criteria were as follows: pulmonary comorbidities; modified Mallampati score III (soft palate and base of uvula visible) - IV (only hard palate visible); potentially compromised mask seal (≥ 2 of the following: missing teeth, snoring, bearded, obese) [5,10]. Prior to anaesthesia, subjects were randomly

assigned to two groups according to the mask to be used. Group A - Economy anaesthetic face mask; group B – QuadraLite anaesthetic face mask, both produced by Intersurgical Ltd., UK. Appropriate mask size was chosen based on manufacturer instructions [9,11]. GE Avance cS2 anaesthesia machines equipped with Datex-Ohmeda differential paramagnetic sensor were used for gas measurement.

The operating room table was set at 10º reverse Trendelenburg position for preoxygenation. After flushing the breathing circuit with 100% O_2 for 30 seconds, patient preoxygenation was initiated with FiO_2 100% at 8L/min. All the subjects were preoxygenated by a single anaesthesiologist using EC clamp face mask holding technique. Patients were instructed to breathe long, deep breaths. Meanwhile, 1-2 mcg/kg of fentanyl was administered to increase mask toleration. End-tidal oxygen concentration (EtO_2) was recorded every 30 seconds for a total of 5 minutes of preoxygenation. $EtO_2 \geq 90\%$ was set as the benchmark for optimal preoxygenation. In cases of suboptimal preoxygenation during the 5 minutes, additional maneuvers were employed to achieve optimal EtO_2 values in order to prevent any potential harm to the patient.

Subject sex, age, body mass index (BMI), Mallampati score and ASA class were also collected. Statistical analysis was performed in IBM SPSS Statistics 25.0. Demographic data were analysed using Fisher's exact test due to small sample size. The independent-samples T test and Mann-Whitney U test were used to compare EtO_2 values between groups.

Results

A total of 31 patients were enrolled in the study. 12 patients were assigned to group A and 19 to group B. There were no statistically
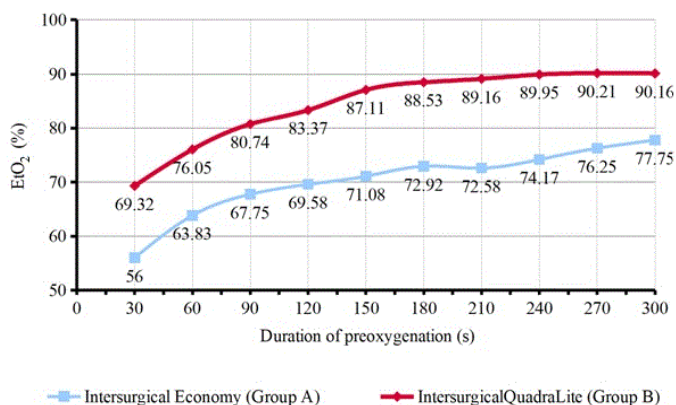
Figure 1. Comparison of EtO_2 at different duration of preoxygenation[*]

Table 1. Comparison of demographic data

		Intersurgical Economy	Intersurgical QuadraLite	P
Sex	Male	50% (n=6)	21.1% (n=4)	0.127
	Female	50% (n=6)	78.9% (n=15)	
Age		59.83 ± 11.5	55.16 ± 16.24	0.393
BMI		27.01 ± 4.13	26.45 ± 2.47	0.655
Mallampati Score	I	83.3% (n=10)	68.4% (n=13)	0.433
	II	16.7% (n=2)	31.6% (n=6)	
ASA class	I	16.7% (n=2)	31.6% (n=6)	0.644
	II	83.3% (n=10)	63.2% (n=12)	
	III	0	5.3% (n=1)	

significant differences in sex, age, BMI, Mallampati score and ASA class between the groups (Table 1).

After 3 minutes, optimal preoxygenation was achieved in 17 of 31 patients (54.8%), with success rates of 33.33% and 68.4% in groups A and B respectively (p=0.07). After 5 minutes, $EtO_2 \geq 90\%$ was achieved in 22 of 31 patients (70.97%), with the same success rate of 33.33% in group A and 94.73% in group B (p<0.001).

A comparison of mean EtO_2 values at different durations of preoxygenation is shown in Table 1. In addition to the markedly increased success rate, preoxygenation in group B was also faster and less variable: 228.33 ± 104.03s vs. 164.37 ± 84.31s to $EtO_2 \geq 90\%$. A comparison of EtO_2 values at different durations of preoxygenation is shown in Figure 1. EtO_2 was statistically significantly higher in group B after each 30s interval (p = 0.006; 0.018; 0.034; 0.032; 0.01; 0.01; 0.006; 0.003; 0.004; 0.004).

Discussion

We did not manage to find any other studies comparing different type anaesthesia face masks during preoxygenation. A study, conducted by Baillard, Depret, *et al.* which evaluates incidence and prediction of inadequate preoxygenation has some similarity [1]. This study enrolled 1050 patients undergoing general anaesthesia, excluding subjects with pulmonary comorbidities, trauma or shock. The authors observed an inadequate preoxygenation (EtO_2 <90% after 3 minutes) in 56% of the patients, while in our study the rate was 45.2% after 3 minutes. The higher rate of preoxygenation success in our study may be related with a face mask type used, smaller subject group and exclusion of patients with several risk factors for difficult face mask seal.

Taking a closer look into the conditions, necessary for effective preoxygenation, tight face mask seal is essential. There are a lot of possible factors predisposing air leakage, for example: inappropriate mask size, patient's obesity (BMI >30), toothlessness, patients snoring, lolly beard, inserted nasogastric tube, etc. [2,5,12]. We excluded patients with two or more risk factors mentioned previously. Baillard and colleagues claim that incomplete preoxygenation is also associated with patient gender (male have increased risk) and age (patients over 55 years old), ASA score of IV [2]. These kind of patients were not excluded so that the study subjects would represent a common population undergoing general anaesthesia for elective surgery. Comparing between the groups, our study showed that in the Economy mask group mean age was lower and in the QuadraLife group there were less males, but these deviations were statistically insignificant.

Another reason for the inward air leak is that patients may feel discomfort from having the anaesthetic face mask tightly applied onto the face, which could result in less pressure applied by the anaesthesiologist and reduced tightness of the mask [12]. We used Fentanyl (1-2 mcg/kg) to increase mask toleration and patient comfort. To reduce possible variations due to human factors, all the subjects were preoxygenated by a single anesthesiologist using classic EC clamp technique for holding of the face mask. There are some studies claiming that EO technique could provide a better mask seal, but the evidence is inconclusive [13,14].

There is no uniform recommendation, concerning the fresh gas flow to be used for preoxygenation. Recently, some authors recommended using 100% oxygen with a high fresh gas flow set to 12-15 l/min [2,6,12]. However, there are studies evaluating preoxygenation efficiency using oxygen flow as low as 5 l/min [15]. Lower oxygen concentration, which may result from lack of tight fit of the mask, rebreathing expired gas

or an anaesthesia machine contour not primed with 100 % oxygen, is associated with incomplete preoxygenation [2,6,12]. In our study we used 8 l/min flow and hypothetically sufficient preoxygenation rate could be higher with a higher flow. On the other hand, high oxygen flow may diminish the influence of inadequate face mask seal. Furthermore, higher oxygen flow needed for preoxygenation means higher expense for the institution and reducement of cost-effectiveness. Therefore, it is reasonable to investigate how to ensure fast and efficient preoxygenation while using less gas supply.

There is also an ongoing debate concerning optimal ventilation technique for preoxygenation. Most authors recommend the classic 3 min preoxygenation with patient breathing spontaneously as we did in the present study [2, 12], while others offer to use 8 deep breaths in 60 seconds   technique [6,16]. The latter technique is used for a faster preoxygenation, usually before a rapid sequence induction. However, this method has limitation for obese or other risk group patients who cannot breathe deeply enough. A different approach is suggested by Hanouz, Jean-Luc, *et al.* They found that more efficient preoxygenation (decreased time to reached EtO_2 at 90%) is achieved with positive pressure support ventilation (PPV) with or without PEEP versus patients who were breathing spontaneously [17]. Meanwhile, Bignami, *et al.* in their systematic review suggest that PSV with PEEP allow for the fastest rise in EtO_2 [18]. It would be reasonable to evaluate the performance of different type anaesthesia face masks in the light of these new ventilation strategies.

Conclusion

In our study new type of anaesthesia face mask (QuadraLite) performed better than the traditional cuffed anaesthesia face mask (Economy). QuadraLite allowed the desired EtO_2 to be achieved faster and showed a higher optimal preoxygenation success rate. Further RCTs involving more subjects should be encouraged to obtain robust evidence.

Institution of the study

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