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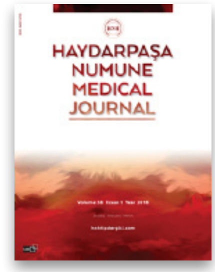

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ORIGINAL ARTICLE

Preoxygenation in the Elderly: Comparison of 3-min and Four Deep Breath Techniques

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Abstract

Introduction: Preoxygenation with 100% O_2 before anesthesia induction is a standard procedure in anesthesia practice. With preoxygenation, alveolar washout of air mixture in functional residual volume provides higher alveolar oxygen concentration up to 100% which leads to increased alveolar oxygen reserve, so during apnea, time to desaturation levels is delayed. We studied two different preoxgenation methods in elderly patients and compared four deep breath and 3-min techniques to decide which one is more efficient in this patient group.

Methods: A total of 30 patients over 60 years were included in the study. Electrocardiography, systolic artery pressure (SAP), heart rate (HR), and SpO_2 were monitored. Data were recorded before preoxygenation, after anesthesia induction, after intubation, and when SpO_2 reached to 93%. Blood gas analysis was also performed at the same time points. Time to reach to SpO_2 levels of 97%, 95%, and 93% was also recorded. Group I (n=15) patients were asked to breath normally for 3 min after the mask was tightly applied to the patients' face. In Group II (n=15), the patients were asked to take four deep breaths when ordered by the anesthetist and then breath normally. Anesthesia induction was performed after the completion of preoxygenation. Following the induction of anesthesia and complete muscular paralysis, entubation of the trachea was performed. The distal end of the tube was left open, the patients were not ventilated until SpO_2 levels reached to 93%, and, then they were ventilated with 100% oxygen and the study ended.

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Results: The study was completed with 29 patients. There were no difference in demographic variables, Hg levels and time to apnea ($p>0.05$). Median age of the patients was 65, 8 years (61–76) in Group I and 65. 2 years (60–74) in Group II. The HR were different in two groups at the time points of SpO_2 97%, 95%, and 93%, and time to reach these desaturation points was significantly different in four deep breath group of patients ($p<0.001$, $p<0.01$, and $p<0.05$).

Discussion and Conclusion: The physiological changes affect lung capacities and reserves in elderly patients. We conclude that, as the effectiveness of vital capacity breaths was decreased in these patients, 3 min of tidal breaths should be the method of choice for preoxygenation in this patient group.

Keywords: Elderly; preoxygenation; technique.

Preoxygenation with 100% O_2 before general anesthesia induction is a standard practice. Using the preoxygenation method, the air mixture containing nitrogen and water vapor in the functional residual capacity (FRC) is washed out. Thus, the oxygen reserve in the lungs is increased and the time until the formation of hypoxia after the onset of apnea increases [1-3].

Various techniques of preoxygenation have been tried. Inspi-

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ration of 100% oxygen at different time points within 2–10 min is the technique that is generally applied. It has been said that the four deep breath techniques recommended to gain time may provide an equivalent oxygenation [4].

The comparison of these different groups was performed on young and ASA Group I and II patients. Physiological changes in the respiratory system of geriatric patient group and these methods have been investigated in a limited number of patients.

In our study, we aimed to compare these two groups, namely tidal respiration for 3 min and four deep breath techniques in a group of geriatric patients frequently encountered in anesthesia practice.

Materials and Methods

Approval for the study was obtained from the hospital institutional board, and a group of patients older than 60 who were hospitalized to undergo abdominal surgery were included in the study. Patients with clinically evident cardiovascular, respiratory, neurological, endocrine, neuromuscular, and similar systemic diseases, obesity (body mass index >30), and those with suspicion of difficult intubation (Mallampati >2) were excluded from the study. ASA I-II group with minor comorbid disease under control was selected so as to be able to evaluate physiological changes. Thirty patients who met the selected criteria were included in the study. Except for the three cases with hypertension, there were no significant comorbidities in the patients. Patients were randomly divided into Groups of 3-min (n=15) and four deep breath (n=15) groups. Before the patients were taken to the operating room, the specified premedication method was described and practiced. No premedication was applied. Radial artery catheterization was performed with a 20-gauge branule followed by Allen test. Patients were followed up using electrocardiography, measurements of peripheral oxygen saturation (SpO_2), and invasive artery protocols (protocol systems, Pro-PAQ 104).

Baseline measurements were performed including measurements of systolic arterial pressure (SAP), heart rate (HR), SpO_2, and blood gas sample values (PaO_2, $PaCO_2$, and SaO_2) while the patient was breathing air. A suitable face mask was used, and semi-closed circuit was connected to the system and the system was washed with 100% O_2. The full gas flow was kept constant at 10/lt/min and reservoir bag was full using flush system to prevent rebreathing. The patients in the 3-min (Group I) group were told to continue their normal breathing after the mask had been applied tightly without air leakage. However, in the four deep breath group (Group II), the face mask was applied tightly, and the patients were told to breath maximally for 4 times at requested time points within a total of 30 sec. Then, they were asked to resume their normal breathing.

Immediately after the preoxygenation was completed, anesthesia induction was performed with thiopental (5 mg/kg) and vecuronium (0.1 mg/kg), and at the same time, the second group of data were recorded. Second arterial blood samples were collected from the patients for blood gas measurements.

Patients were not ventilated until the end of the study.

After the induction of anesthesia and 60–90 s after complete muscle paralysis, intratracheal intubation was performed and the tube was left open to air.

For the 3rd time point, data were recorded and blood gas samples were obtained immediately after intubation. After intubation, arrhythmia was observed in one patient who was then ventilated with 100% O_2. This patient was not included in the study. Additional doses of thiopental (2 mg/kg) were administered to the patients for the maintenance of anesthesia until the inhalational anaesthetics were administered.

The decrease in the arterial oxygen saturation was recorded in minutes and seconds. At the time SpO_2 was reduced to 93%, the last data were recorded, and the last blood gas-samples were taken. Then, the lungs were ventilated with 100% O_2. Blood gas analyzes were evaluated with GEM-Stat Mallinckrodt Sensor Systems. Age, weight, height, hemoglobin and hematocrit values of the patients, SAP, HR, SaO_2, blood gas values in the air, after preoxygenation and after intubation, apnea times, time to reach 97%, 95%, 93% saturation levels and SAP, HR, and SaO_2 values in these desaturation points were statistically evaluated with student's t-test. The level of statistical significance was determined as $p<0.05$.

Results

The study was completed with 29 patients. None of the patients had hemodynamic problems except for one patient who had arrhythmia after intubation and excluded from the study. There were no significant differences between the two groups in terms of demographic data and Hg-Htc levels ($p>0.05$). Mean age was 65.8 (61–76) for Group I and 65.2 (60–74) for Group II. After completion of the study and delivery of 100% O_2, all saturation values reached peak levels within a short time, and the time from anesthesia induction to complete muscle relaxation-apnea was comparable in both the groups ($p>0.05$).

SAP, HR, SpO_2, and blood gas values taken after preoxygenation and intubation are shown in Tables 1, 2 and 3. Similarly, there was no difference between the two groups in terms of hemodynamic data at time points where 97%, 95%, and 93% saturation levels were measured ($p>0.05$).

Time intervals elapsed to reach desaturation levels of 97%, 95%, and 93% were summarized in Tables 4 and 5 and Figure 1. There were significant differences in decrease in desaturation rates between the 3-min and four deep breath techniques in the group aged over 60 years. The median times to the onset of drop to 97%, 95%, and 93% desaturation rates were 304.2 sec and 201 sec ($p<0.05$), 356 sec and 236.98 sec ($p<0.01$), and 379 sec and 254 sec ($p<0.01$), in Groups I and II, respectively. These temporal differences were both statistically and clinically significant.

The rates of rise in $PaCO_2$ values at different measurement times in the groups were shown in Figure 2. $PaCO_2$ values measured after preoxygenation showed a small difference in favor of four deep breath technique (37.93±4.71 mmHg

Table 1. Baseline measurements during breathing air

	3-min	Four deep breaths	p
SAP (mmHg)	152±25.9	143.06±18.4	>0.05
HR (min)	78.46±14.4	77.06±11.26	>0.05
SpO_2	96.4±1.18	96.4±1.8	>0.05
PaO_2	84.06±12.7	91.9±14.5	>0.05
$PaCO_2$ (mmHg)	38.3± 5.68	39.26±4.43	
SaO_2 (%)	95.22±2.38	95.6±2.22	

Table 2. Measurements after preoxygenation

	3-min	Four deep breaths	p
SAP (mmHg)	153.53±20.9	143.26±21.33	>0.05
HR (min)	78.9±12.4	79.93±10.89	>0.05
SpO_2 (%)	99.1±0.51	99.3±0.61	>0.05
PaO_2, (mmHg)	258.06±78.65	208.2±61.37	>0.05
$PaCO_2$, (mmHg)	37.93±4.71	33.76±6.69	
SaO_2 (%)	99.75±0.24	99.58±0.41	

Table 3. Measurements after intubation

	3-min	Four deep breaths	p
SAP (mmHg)	166.8±28.09	165.13±32.76	>0.05
HR (min)	103.33±15.89	85.66±13.47	>0.05
SpO_2 (%)	98.53±1.12	98.46±0.7	>0.05
PaO_2, (mmHg)	197.56±84.9	185±6.45	>0.05
$PaCO_2$, (mmHg)	44.1±12.1	42.2±6.69	
SaO_2 (%)	98.04±3.39	97.79±1.92	

Table 4. Time to drop in saturation levels down to 97%, 95%, and 93%

	Duration (mean; sec)		
	97%	95%	93%
3-min	304.2	356	379
Four deep breaths	201.2	236.98	254
p	<0.05	<0.01	<0.01

Table 5. SAP and HR values (sec) when saturation drops to 97, 95, and 93%

	SAP (mean; mmHg) HR (mean; min)		
	97%	95%	93%
3-min	167.26/98.9	172.4/98	176/98.6
Four deep breaths	164.4/80.5	163.9/79.26	166.3/83.06
p	>0.05/<0.01	>0.05/<0.001	>0.05/<0.05

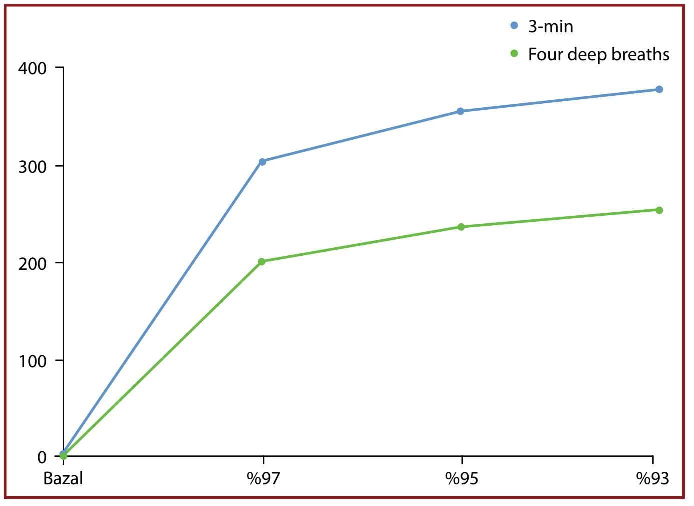

Figure 1. Time to drop in saturation down to 97, 95, and 93%.

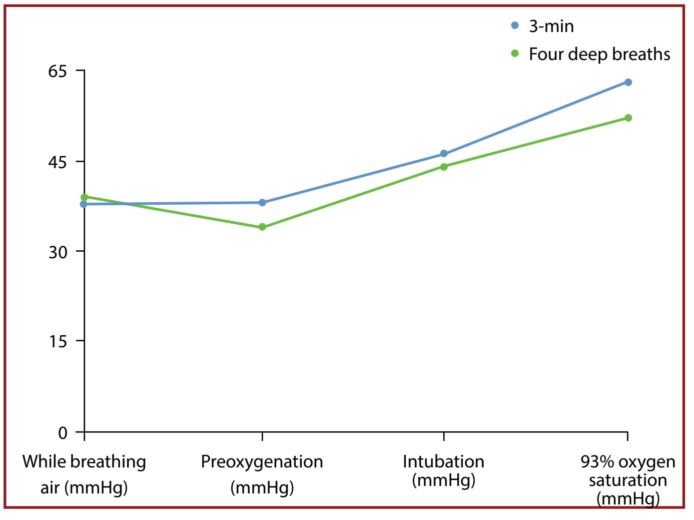

Figure 2. $PaCO_2$ values at measurement times.

and 33.76±6.69 mmHg). This difference was maintained at $PaCO_2$ pressures at 57.86±12.49 mmHg and 51.73±5.78 mmHg at 93% desaturation level. This difference was not found to be statistically significant (p>0.05).

Discussion

During anesthesia induction, many factors (such as airway obstruction, hypoventilation, and anesthesia-induced apnea) may cause hypoxia [4].

Drummond and Park showed that hypoxia (SpO_2 76–95%) developed in 60 sec after inhalation of air before induction of anesthesia following the bolus doses of thiopental and succinylcholine. Towards the beginning of the 1990s, Dillon and Darsie, who observed a similar result, emphasized that oxygen administration before the induction of anesthesia prevented hypoxia and preoxygenation should be done for 5 min before the endoscopy and anesthesia induction.

Preoxygenation is a process of 100% oxygen inhalation of the patient to increase the amount of usable oxygen by replacing the oxygen with nitrogen in the lung volume and thus to prevent hypoxia during induction. Considering that the air in the volume of FRC is completely replaced by 100% oxygen, and also considering the total body oxygen consumption rate, it can theoretically be estimated that the desaturation time would be approximately 5 times longer (21–100%) than breathing the room air.

In individuals with normal lung function, oxygen wash-out of the lung (denitrogenization) depends on the oxygen concentration inspired by the minute volume of the respiration. Theoretically, an increase in minute volume with vital capacity breathing is expected to increase oxygen wash-out rate. The air mixing with the exspired air reduces the FiO_2 (rebreathing) and decreases this wash-out rate [5-7]. Hamilton and Eastwood have shown that, in a person who was breathing with a tidal volume from the circuit anesthesia system containing 5 L of fresh oxygen gas flow, denitrogenization would be completed within 2–3 min [3, 4, 8]. Taking this study as an example, 3–5 min of preoxygenation is usually recommended in the anaesthesia practice [3, 5].

Haller and Watson suggested that oxygen should be inhaled for at least 3–4 min to increase the PaO_2 from 78 mmHg to 300 mmHg, but they also demonstrated that PaO_2 could be increased from 95 mmHg to 400 mmHg within 30 sec by controlled ventilation method [3,13].

These findings led to Gold et al. to perform a preoxygenation experiment of 4 maximal breaths within 30 sec. This study was carried out in patients who did not have any pathology. Oxygen tensions and oxygen contents were found to be similar in patients who were not under anesthesia after tidal volume breathing following 4 times maximal inspiration (Vital capacity breaths) and following the inspiration of 100% oxygen in 130 sec. There may not be enough time for an oxygenation lasting 3–5 min in some emergency conditions. Therefore, it is clear that, if the same effect can be achieved with four deep breaths in 30 sec, this will be apparently beneficial.

In our study, we tested these two standard techniques in patients above a certain age limit. It was shown that age, Hb level, FEV, FVC, and smoking habits were not effective in desaturation rate after induction of anesthesia, but faster desaturation was demonstrated in obese patients [10]. It was reported that four deep breaths technique would be appropriate for obese population due to mild CO_2 retention seen during the preoxygenation in the 3-min group. In a study conducted in ASA I-II group patients over 65 years using 1–4 min and four deep breaths techniques, it was shown that preoxygenation time of 1 min was too short, but no difference was observed in terms of desaturation times among other groups [11]. In contrast to this study, Valentine et al. showed that preoxygenation with normal tidal breats was superior to four deep breath techniques in the geriatric age, ASA I-II group patients [12]. Our results were in accordance with this study.

In a study performed in patients aged below and above 60 years of age, the patients were followed up with oxygen and CO_2 measurements in expiratory air, besides the periferic oxygen saturation levels during a 3- min preoxygenation test. From 50. sec onwards significantly lower end-tidal O_2 levels were observed in patients over 65 years of age (ETO_2 at 50^{th} to 180^{th} sec: 91.5% to 86.2%; p<0.05) [13].

When the maximal inspiration (four deep breaths) test is performed in the circuit systems, the minute ventilation markedly exceeds the fresh gas flow of 10 L/min [7]. Thus, the expired gasses are inhaled again, and O_2 concentration in the inspirium air falls down. We paid attention to keep the reservoir bag full with this flow rate. In the success of the preoxygenation technique, it is also important that the mask is placed tightly on the patient's face to prevent any gas leakage. As the oxygenation period increases, gas leakage may occur due to the distraction and fatigue of the patient and the patient's exhausting tolerability which leads to reinhalation of the expired gas [2, 4, 14].

In our study, we considered the desaturation level as 93%. This limit can be accepted as 90 [4, 12] and 93% [11] in studies.

Below this limit, desaturation occurs rapidly, which is easily understood when the shape of the oxyhemoglobin curve is considered [15]. Peak saturation with preoxygenation was 99–100% in one patient and 98% in another one. The time to reach 93% saturation level was 85 sec in this patient in the four deep breaths group. In the 3-min group, the shortest time to reach the level of 93% saturation was 195 sec.

Increased partial CO_2 pressure in the apnea period was studied in the patient group over 60 years of age. After 2 min of preoxygenation, $PaCO_2$ increased about 45–50 mmHg within 120 sec after intubation, and this increase was not at a risk level [16]. In our selected patient group who had no cardiopulmonary problems, the time elapsed to decrease the levels to 93% monitorised by peripheral oxygen saturation which is determined as the limit of desaturation was 379±119.38 sec , and 254±46.53 sec in Groups I and II, respectively. At the end of these periods, PCO_2 levels were 57.86±12.4 mmHg and 51.73±94.9 mmHg, respectively. This rate of increase was consistent with the rate of increase in $PaCO_2$ of 3 mmHg/min during apnea in previous studies performed in similar patient groups [16, 17].

In our study, the time to reach the limit of desaturation was shorter in four deep breaths group compared to the group with normal tidal breath for 3 min, and this difference was found to be both clinically and statistically significant. This difference between these two methods can be attributable to physiological changes in the elderly lung. Aging causes structural changes similar to diffuse emphysema in the lung parenchyma. In elderly people, alveolar surface area and arterial oxygen tension decrease in parallel with ventilation perfusion incompatibility.

With the reduction of the total elastic retraction force of the lung, the negative pressure, which keeps the intraparenchymal airways tense, decreases. Thus, the closing volume lower than FRC does not affect alveolar gas exchange; however, if it exceeds FCR, closure of airways in basal segments of the lungs will occur during tidal respiration. In the elderly, this condition disturbs distribution of ventilation and alveolar gas exchange. This is accompanied by respiratory muscle weakness and physiological reduction in all lung volumes of the elderly patient, and consequently, the pulmonary reservoir decreases [18].

In our study, we concluded that these pulmonary physiological changes have negative effects on vital capacity respiration and that tidal volume breaths which will be applied for 3 min will give better results as a preoxygenation technique.

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