ISSN: 2717-8161 RESEARCH ARTICLE

New Trends in Medicine Sciences

New Trend Med Sci 2025; 6(1): 17-21. https://dergipark.org.tr/tr/pub/ntms

Evaluation Of Preoxygenation At Three Different Altitudes Using Blood Gas Results: A Multicenter Prospective Observational Study

Özgür Özmen[1,6], Elzem Şen[2], Muhammet Ahmet Karakaya[3], Merve Ümran Yılmaz[4], Canan Atalay[1,2], Ayşenur Dostbil[1,6], Mehmet Aksoy[1,6], İlker İnce[5,6]

[1]School of Medicine, Department of Anesthesiology and Reanimation, Ataturk University, Erzurum, Türkiye
[2]School of Medicine, Department of Anesthesiology and Reanimation, Gaziantep University, Gaziantep, Türkiye
[3]Department of Anesthesiology and Reanimation, Acıbadem Ataşehir Hospital, İstanbul, Türkiye
[4]School of Medicine, Department of Anesthesiology and Reanimation, Koç University, İstanbul, Türkiye
[5]Department of Anesthesia and Perioperative Medicine, Milton S. Hershey Medical Center, Penn State University, Pennsylvania, USA
[6] Anethesiology Clinical Research Office, Atatürk University, Erzurum, Türkiye

Article History
Received 10 Dec 2024
Accepted 13 Jan 2025
Published Online 31 Jan 2025

******Corresponding Author***
Özgür Özmen
School of Medicine
Department of Anesthesiology and Reanimation
Ataturk University, Erzurum, Türkiye
Phone: +90 5424002477
E-mail: dr.ozgurozmen@yahoo.com.tr

Doi:10.56766/ntms.1598661

Authors' ORCIDs
Özgür Özmen
https://orcid.org/0000-0003-2014-0468
Elzem Şen
https://orcid.org/0000-0003-3001-7324
Muhammet Ahmet Karakaya
https://orcid.org/0000-0001-8026-4783
Merve Ümran Yılmaz
https://orcid.org/0009-0007-4754-8056
Canan Atalay
https://orcid.org/0000-0002-4859-4616
Ayşenur Dostbil
https://orcid.org/0000-0002-7167-901X
Mehmet Aksoy
https://orcid.org/0000-0003-0867-8660
İlker İnce
https://orcid.org/0000-0003-1791-9884

Abstract: Protecting patients from hypoxia during anesthesia induction is crucial for those undergoing coronary artery bypass surgery. High altitude does not change the inspired O2 concentration (%21), but reduced barometric pressure leads to decreased partial alveolar pressure and arterial PaO2. We aim to evaluate the effects of preoxygenation in the operating room at three different altitudes. After obtaining ethical approval, patients aged 40 and above, living in the same city for at least 10 years, and scheduled for coronary artery bypass surgery will be included in the study. A total of 60 patients will be divided into three groups: Group 0, Group 800, and Group 1900, with 20 patients in each group corresponding to three different altitudes. Before anesthesia induction, patients will receive 12 L/min of 80% O2 for 3 minutes via a face mask. During preoxygenation, arterial blood gas values will be recorded at the 0th, 1st, 2nd, and 3rd minutes. PaO2 values from arterial blood gas results will be evaluated at these time points across the three altitudes. There were no statistically significant differences between the groups regarding height, weight, age, and ASA classifications. There were no statistically significant differences in PaO2 values between the 0th, 1st, 2nd, and 3rd-minute blood gas measurements across all groups (p>0.05). Preoxygenation before anesthesia induction for coronary artery bypass surgery patients produced similar results at all three altitudes. ©2025 NTMS.
Keywords: Blood Gas; Preoxygenation; Different Altitudes.

1. Introduction

Preoxygenation is an important technique that delays the development of hypoxia and increases oxygen reserves during anesthesia. In particular, adequate oxygenation is critical in minimizing complications and

Cite this article as: Özmen Ö, Şen E, Karakaya MA, Yilmaz MÜ, Atalay C, Dostbil A, Aksoy M and İnce İ. Evaluation of Preoxygenation at Three Different Altitudes Using Blood Gas Results: A Multicenter Prospective Observational Study. *New Trend Med Sci.* 2025; 6(1):17-21. Doi:10.56766/ntms.1598661.

accelerating the recovery process in cardiovascular surgeries. Preoxygenation aims to reduce the risk of hypoxia by increasing patients' oxygen levels before anesthesia, especially in major surgeries like coronary artery bypass grafting (CABG) [1,2].

This study aims to evaluate the effects of preoxygenation in the operating room on patients undergoing coronary artery bypass grafting (CABG) surgery at three different altitudes. In recent years, the ability of high-fraction inspired oxygen (FiO2), or preoxygenation, to delay the onset of arterial oxyhemoglobin desaturation due to apnea before anesthesia induction and tracheal intubation has gained significant importance. Preoxygenation replenishes the body's oxygen reserves and increases functional residual capacity, which is crucial for maintaining oxygenation during surgery.

Although the inspired oxygen concentration (%21) remains unchanged at high altitudes, the decreased barometric pressure reduces partial alveolar pressure and arterial PaO2. For instance, PaO2, normally around 100 mmHg at sea level, decreases to 74 mmHg at 2000 meters. As altitude increases, PaO2 declines exponentially [3]. Despite the known effects of altitude on oxygenation, to our knowledge, no study has specifically addressed the impact of altitude on preoxygenation efficacy.

Considering the importance of protecting patients from hypoxemia, optimizing the duration of preoxygenation based on altitude is crucial for improving patient safety, especially in environments with varying atmospheric pressures. This study aims to fill the gap in the literature and evaluate how preoxygenation, depending on the altitude, can contribute to maintaining adequate oxygenation during surgery.

2. Material and Methods

The study was initiated after obtaining approval from the Faculty of Medicine, Clinical Research Ethics Committee, Ataturk University (protocol number: B.30.2.ATA.0.01.00/8, date: 05.11.2020). The study was supported by the Scientific Research Projects Coordination Unit, Ataturk University (04.03.2021, Project Number: TAB-2021-9143, ID: 9143). The study will include adult patients aged 40 and above who have been living in the city where the surgery is performed (altitude) for at least 10 years and are scheduled for coronary artery bypass grafting (CABG) surgery. Preoperative assessment will include patients with ASA II-III physical status, and the study is planned to be conducted on at least 80 patients. Patients with pneumonia or other signs of infection, hemodynamic instability, respiratory distress, FEV1 < 60%, FEV1/FVC < 60%, VC < 50% before surgery, BMI ≥ 40, patients who have received a blood transfusion before surgery, and patients who refuse or are unable to decide to participate in the study will be excluded.

The study will begin when patients are admitted to the operating room for elective CABG surgery without premedication. Upon entering the operating room, patients undergo heart rate measurements, peripheral oxygen saturation (SpO2), and non-invasive arterial blood pressure using a 5-electrode electrocardiogram (ECG). Continuous invasive blood pressure measurements will be obtained using a radial artery catheter. Immediately before anesthesia induction, patients will receive 12 L/min of 80% oxygen via a face mask for 3 minutes. During the anesthesia phase, preoxygenation will be applied using a face mask that perfectly fits the patient's face to prevent gas leakage. During this period, patients will be instructed to breathe normally (tidal volume) for 3 minutes with the face mask (Baillard et al.). The fraction of inspired oxygen (FiO2) and expired oxygen (FiO2) will be measured with a calibrated gas analyzer on the ventilator during preoxygenation.

The study will be conducted in operating rooms in three cities with different altitudes (1900 m—Erzurum, 800 m—Gaziantep, 0 m—Istanbul). During preoxygenation, arterial blood gas values will be recorded at the 0th, 1st, 2nd, and 3rd minutes. Among these arterial blood gas measurements, PaO2 (partial arterial oxygen pressure) values will be evaluated at the three different altitudes. The data obtained will allow the examination of how the effects of preoxygenation change depending on environmental conditions.

2.1. Statistical Analysis

Analyzes were made with IBM SPSS 20 statistical analysis program. Data will be presented as mean, standard deviation, median, minimum, maximum, percentage and number. Normal distribution of continuous variables will be examined with Shapiro-Wilk test, Kolmogorov-Simirnov test, Q-Q plot, skewness and kurtosis. In comparing continuous variables with more than two independent groups, the ANOVA test will be used if the normal distribution condition is met, and the Kruskal Wallis test will be used if it is not met. Chi square test will be used for comparisons between categorical variables. The statistical significance level will be set at $p < 0,05$.

3. Results

There were no statistically significant differences in the patient's demographic characteristics, such as age, gender, height, weight, and ASA classifications, between the groups ($p>0.05$). Table 1 presents the demographic data regarding the patient's age, gender, height, weight, and ASA classifications (Table 1).

3.1. Blood Gas Values

There were no significant differences in the PaO2 values measured at 0, 1, 2, and 3 minutes between the groups ($p>0.05$). The detailed SpO2, PaO2, and PaCO2 values measured for each groups ($p> 0,05$) (Table 2, Table 3, Table 4, Table 5).

The data presented in the tables above show that there were no significant differences in PaO2 and PaCO2 values between the groups during the 0th, 1st, 2nd, and

3rd minutes of preoxygenation. The results indicate that preoxygenation had similar effects across the three groups, suggesting that altitude did not significantly impact the preoxygenation process.

Table 1: Demographic Data.

	Group 0	Group 800	Group 1900	P
Age (years)	60.42	61.75	61.12	0.22
Gender (M/F) (n)	15/5	17/3	16/4	0.42
Height (cm)	168	170.2	169.4	0.68
Weight (kg)	74	72.6	75.8	0.44
ASA (II/III) (n)	2/18	3/17	4/16	0.45

All data are represented as n (number). Chi square test and ANOVA test.

Table 2: Blood Gas Values at 0 Minute.

	Grup 0	Grup 800	Grup 1900	P
SpO2 (%)	94.45±1.7	93.66±0.9	92.88±1.1	0.21
PaO2 (mmHg)	77.6±6.42	75.4±5.47	76.5±7.35	0.15
PaCO2 (mmHg)	35.4±4.01	33.1±3.47	34.9±2.45	0.33

Data are represented as mean ± standard deviation. ANOVA test.

Table 3: Blood Gas Values at 1 Minute.

	Grup 0	Grup 800	Grup 1900	P
SpO2 (%)	99.2±0.21	99.3±0.07	99±0.15	0.42
PaO2 (mmHg)	172.25±21.4	176.4±20.3	169.41±18.6	0.66
PaCO2 (mmHg)	35.5±1.14	36.45±2.11	34.6±1.75	0.43

Data are represented as mean ± standard deviation. ANOVA test.

Table 4: Blood Gas Values at 2 Minutes.

	Grup 0	Grup 800	Grup 1900	P
SpO2 (%)	100	99.4±0.33	99.6±0.32	0.47
PaO2 (mmHg)	211.4±27.54	220.47±24.4	215.43±28.43	0.13
PaCO2 (mmHg)	37.8±2.7	39.5±3.5	40.4±2.24	0.18

Data are represented as mean ± standard deviation. ANOVA test.

Table 5: Blood Gas Values at 3 Minutes.

	Grup 0	Grup 800	Grup 1900	P
SpO2 (%)	100	100	99.5±0.14	0.65
PaO2 (mmHg)	224.32±21.21	232.23±24.30	226.47±22.14	0.54
PaCO2 (mmHg)	36.4±1.45	38.4±1.37	38.2±2.02	0.33

Data are represented as mean ± standard deviation. ANOVA test.

4. Discussion

This study aimed to investigate the effects of preoxygenation at different altitudes (0 m, 800 m, 1900 m) on arterial blood gas values in patients undergoing elective coronary artery bypass grafting (CABG) surgery. Despite the differences in altitude, no significant differences were found in PaO2 values between the groups during the 0th, 1st, 2nd, and 3rd minutes of preoxygenation. These findings suggest that the impact of altitude on preoxygenation, at least in terms of PaO2 and PaCO2, is minimal in the context of elective CABG surgeries.

Preoxygenation is a crucial intervention that replenishes the body's oxygen reserves and increases functional residual capacity [4,5]. This process is particularly important in patients undergoing coronary surgery, where protecting against hypoxemia is essential for optimal outcomes. It is well-established that high altitude does not alter the inspired oxygen concentration (21%), but the reduced barometric pressure decreases both partial alveolar pressure and arterial PaO2. For instance, PaO2, which is normally around 100 mmHg at sea level, has been reported to decrease to 74 mmHg at 2100 meters above sea level.

As altitude increases, PaO2 declines exponentially [6-8]. In our study, while we observed no significant differences in PaO2 levels across the different altitudes (0 m, 800 m, 1900 m) during preoxygenation, the impact of altitude on oxygenation remains a significant consideration in clinical practice. Although the preoxygenation procedure may offer some protective effect in maintaining oxygen levels, it is crucial to recognize that at higher altitudes, the body's ability to compensate for reduced oxygen availability may be limited, particularly in patients with comorbidities or those undergoing high-risk surgeries like CABG.

Preoxygenation is a critical step in anesthesia, providing oxygen reserve to delay the onset of hypoxia in patients undergoing surgery. Studies have shown that preoxygenation effectively increases oxygen reserve in healthy individuals and those with various underlying conditions. In high-altitude areas, the lower atmospheric pressure could theoretically reduce the oxygen available to the patient, potentially affecting the efficacy of preoxygenation. However, our study suggests that preoxygenation had comparable effects on arterial oxygen levels within the altitudes considered (Erzurum at 1900 m, Gaziantep at 800 m, and Istanbul at 0 m). It is well established that altitude can affect oxygen partial pressure and the ability to maintain adequate oxygen levels in tissues. However, it has been shown that the body adapts to hypoxic conditions over time through increased red blood cell production and improved tissue oxygen utilization [9,10]. This adaptation may explain why this study found no significant difference in PaO2 despite varying altitudes. It is important to note that this study included patients with ASA II-III physical status, which may have limited the influence of altitude on preoxygenation [11]. In healthy individuals, the effects of altitude may be more pronounced, especially in those with pre-existing respiratory or cardiovascular conditions. Our exclusion criteria, which ruled out patients with significant respiratory or hemodynamic instability, ensured that the results were not confounded by these factors.

The study's methodology, including using a calibrated gas analyzer to measure FiO2 and FiO2 during preoxygenation, provided accurate data on oxygen levels and allowed for precise comparisons across different altitudes. The findings suggest that preoxygenation, even in higher altitudes, does not lead to significant changes in PaO2, indicating that this practice remains effective across varying environmental conditions. However, this study has some limitations. The sample size was relatively small, and the findings might differ with a larger cohort, especially considering the inclusion of patients with different comorbidities or those undergoing more complex surgeries. Additionally, the focus was solely on arterial oxygen levels, and other factors such as tissue oxygenation or recovery time were not evaluated. Further research is needed to investigate these aspects and to determine whether altitude has a more significant impact on other physiological parameters.

This study optimized preoxygenation duration based on altitude to protect patients from hypoxemia. To our knowledge, no study specifically addresses the effects of preoxygenation performed before anesthesia induction at different altitudes on patients' PaO2 values. Our study compared preoxygenation techniques applied at three different altitudes and found no significant differences in PaO2 values between the groups. Based on these results, we conclude that the preoxygenation technique and duration applied are suitable and effective across all altitudes.

These findings are particularly relevant in patients undergoing coronary surgery, where adequate oxygenation is critical. Although the effects of altitude on oxygenation, particularly PaO2, are well-documented, our results suggest that preoxygenation, when performed appropriately, can mitigate the potential impact of altitude on arterial oxygen levels. Given that preoxygenation did not significantly alter PaO2 levels at any altitude in our study, this supports the notion that the current preoxygenation protocol can be safely applied to patients, regardless of the altitude at which the surgery is performed.

However, it is important to note that this conclusion is based on the specific patient population in this study, which included individuals with ASA II-III physical status undergoing elective CABG surgery. Further studies with larger sample sizes, including patients with varying comorbidities and from different surgical backgrounds, are needed to confirm these findings and to explore the broader implications of preoxygenation in diverse clinical settings.

5. Conclusion

Preoxygenation before anesthesia induction for coronary artery bypass surgery patients produced similar results at all three altitudes.

Limitations of the Study

There are some limitations to the study. The study can be done on a larger population. Time and conditions for blood gas samples to reach the laboratory.

Acknowledgement

The authors thank all staff who has contributed to the study.

Conflict of Interests

The authors declare that they have no conflict of interest to disclose.

Financial Support

The study was supported by the Scientific Research Projects Coordination Unit, Ataturk University (04.03.2021, Project Number: TAB-2021-9143, ID: 9143).

Author Contributions

Conception, ÖÖ , EŞ , AD and İİ; Design, CA and AD; Supervision, MAK and MA; Materials, ÖÖ; Data collection and processing, ÖÖ , EŞ , MAK and MÜY; Analysis and interpretation ,ÖÖ , EŞ, CA; Literatüre Rewievn , ÖÖ, MA , İİ; Writing, ÖÖ , MAK, EŞ; Critical rewiev, CA , AD..

Ethical Approval

Clinical Research Ethics Committee, Ataturk University (protocol number: B.30.2.ATA.0.01.00/8, date: 05.11.2020).

Data sharing statement

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent to participate

Consent was obtained from the patients participating in the study.

Informed Statement

Informed consent was obtained from all subjects involved in the study.

References

1. Bouroche G, Bourgain JL. Preoxygenation and general anesthesia: a review. *Minerva Anestesiol.* 2015;81(8):910-20.
2. Preusser BA, Stone KS, Gonyon DS, et al. Effects of two methods of preoxygenation on mean arterial pressure, cardiac output, peak airway pressure, and postsuctioning hypoxemia. *Heart & Lung: J Critical Care.* 1988;17(3):290-299.
3. Leissner KB, Mahmood FU. Physiology and pathophysiology at high altitude: considerations for the anesthesiologist. *J Anesth.* 2009;23(4):543-53.
4. Baraka AS, Taha SK, El-Khatib MF, Massouh FM, Jabbour DG, Alameddine MM. Oxygenation using tidal volume breathing after maximal exhalation. *Anesth Analg* 2003; 97: 1533-35.
5. Hamilton WK, Eatwood DW. A study of denıtrogenatıon wıth some ınhalatıon anesthetıc systems. *Anesthesiology.* November 1955;16:861-67.
6. Nimmagadda U, Salem R, Crystal GJ. Preoxygenation: Physiologic Basis, Benefits, and Potential Risks. *Anesth Analg.* 2017;124(2):507-17.
7. Baillard C, Boubaya M, Statescu E, Collet M, Solis A, Guezennec J, Levy V, Langeron O. Incidence and risk factors of hypoxaemia after preoxygenation at induction of anesthesia. *Brit J Anesth.* 2019; 122(3):388-94.
8. Taş Z, Hoşten T, Kuş A, Cesur S, Türkyılmaz N, Arıkan A, Solak ZM. Comparison of tidal volume and deep breath preoxygenation techniques undergoing coronary artery bypass graft surgery: effects of hemodynamic response and arterial oxygenation. *Turk J Med Sci*. 2017;47:1576-82.
9. Peacock AJ. ABC of oxygen: oxygen at high altitude. *BMJ.* 1998;317(7165):1063-66.
10. Mallet RT, Burtscher J, Richalet JP, Millet GP, Burtscher M. Impact of High Altitude on Cardiovascular Health: Current Perspectives. *Vasc Health Risk Manag.* 2021;17:317-35.
11. Hung Tsan S, Viknaswaran N, Lau J, Cheong C, Wang C. Effectiveness of preoxygenation during endotracheal intubation in a head-elevated position: a systematic review and meta-analysis of randomized controlled trials. *Anaesthesiol Intensive Ther.* 2022;54(5):413-24.

NTMS New Trends in Medicine Sciences
https://dergipark.org.tr/tr/pub/ntms