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Original Article

Effects of High-Flow Oxygen Application on Respiratory Parameters and Compilation After Percutaneous Nephrolithotomy Operation

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ABSTRACT

Objective: We aimed to compare vital parameters, arterial blood gases, postoperative recovery levels, and lung-related complications in patients with mask oxygen or high-flow nasal oxygen during the postoperative early period.

Methods: This study included 60 patients over 18 years old with a risk score of the American Society of Anesthesiologists (ASA) I–II–III planned for percutaneous nephrolithotomy surgery. Patients were separated randomly as high-flow oxygen group (group HF, n=30) and mask oxygen group (group mask, n=30). During surgery and after wake up and after postoprative first hour O_2 treatment, arterial blood gases were evaluated. Heart rate, SpO_2, arterial blood pressure, and respiratory rate of two groups were compared in the postoperative early period. QoR-40 survey was used for postoperative recovery.

Results: There was no statistical difference between groups in terms of demographic data. In arterial blood gas analysis at postoperative 1 h, SpO_2 levels were higher and PaO_2 and SaO_2 increases were statistically significant in the high-flow group (p=0.01, p<0.001, p=0.03, respectively). Lower respiratory rate and pH increase were statistically significant in the high-flow group after 1-h of oxygen therapy when we compared blood gases at post-extubation versus after 1 h oxygen therapy (p<0.001 vs p=0.007, respectively). There was no statistically significant difference in $PaCO_2$ levels. We did not see any difference in systolic–diastolic blood pressure, heart rate, recovery level in postoperative 24 h, postoperative lung complications, mortality, hospital stay, and reintubation rate between the two groups.

Conclusion: High-flow oxygen therapy increases oxygenation and pH in blood gases and decreases respiratory rate in the postoperative early period. There is no difference in terms of postoperative recovery and lung complications.

INTRODUCTION

Patient satisfaction and recovery quality can provide information about the quality of surgery and anesthesia applied. The patient's quality of recovery and continuing life without sequela are also added to these factors today.[1] Dry and cold air is irritant for the respiratory tract and causes nasal inflammation.[2]

Percutaneous nephrolithotomy (PNL) surgery is on the kidneys, and the proximity of the upper pole of the kidneys to the diaphragm poses a risk for pulmonary functions. Also, the high amount of surgical irrigation fluid used can pass into the systemic circulation, and edema development can be seen in the lungs.[3] These patients also tend to develop acidosis after PNL surgery.[4]

The prone position is preferred in spinal surgery, craniotomies, and surgeries involving the posterior extremity. The aim in the prone position is to avoid abdominal compression and to minimize vena cava compression and related physiological changes. The cardiac index decreases most frequently in the prone position. The reason for this decrease is decreased left ventricular compliance due to increased intrathoracic pressure and decreased venous return to the heart. Compression of the vena cava, decrease in blood pressure, venous stasis, and increase in pressure in the epidural venous plexus develop due to abdominal compression. In addition, due to abdominal compression, the diaphragm shifts upward, pulmonary compliance decreases, and peak airway pressures increase.

Prone position can be beneficial for lung functions when there is no abdominal compression. Normal people experience increased functional residual capacity and improved spontaneous breathing in the prone position. Improvement in oxygenation is seen in patients who are mechanically ventilated in the intensive care unit.

High-flow oxygen therapy is a system consisting of an oxygen/air mixer, active humidifier, a heated tube, and a nasal cannula. It is thought to have advantages over standard oxygen therapy: reduction of anatomical dead space, PEEP, constant FiO_2, and well-humidified air. It decreases the respiratory load and the number of minute breaths.[5] We planned to compare postoperative lung complications, mortality, and hospital stay.

MATERIALS AND METHODS

After Ethics Committee approval (Decision no: 2019/514/145/3) and obtaining the written consent of the patients, we studied 60 patients over the age of 18 years, who were planned to have a PNL operation in ASA I–II–III class. Patients who were less than 18 years of age, who had ASA <4, who used anticoagulant drugs, who had hypersensitivity reactions to any anesthetic drug to be used in the study, who were breastfeeding, or who were illiterate were excluded from the study. Through randomization, the mask oxygen group (n=30) and the high-flow oxygen group (n=30) were organized.

After the operation, early period mask oxygen or high-flow oxygen was applied and the vital values of the patients were compared. The QoR-40 questionnaire was applied for postoperative recovery.

All patients were provided 18G or 20G cannulas. After 1 min preoxygenation with a 100% oxygen 6 L/min flow, midazolam 0.05 mg/kg, propofol 2 mg/kg, fentanyl 1 mcg/kg, and rocuronium 0.6 mg/kg were applied in induction. Tracheal intubation was performed with a spiral cuffed intubation tube with an internal diameter of 7.0–8.0. In perioperative period, 5 mL/kg/h crystalloid solution was given during surgery.

Blood pressure regulation was achieved with remifentanil infusion such that mean arterial blood pressure was not allowed to decrease to <60 mmHg. Body temperature of the patients was kept constant at 37°C with blood and fluid warmer. Muscle relaxations were monitored with the train of four (TOF). When it was observed that the TOF ratio was above 0.9, the patient was extubated.

After anesthesia induction, patients underwent radial artery cannulation with the 20G branch. Blood gas was removed after 20 min. The patients were turned into prone position.

As an analgesic agent, tramadol 100 mg and paracetamol 1 g were administered intravenously. At the end of the surgical procedure, the patients were turned into a supine position and extruded and taken to the postoperative recovery unit. Vital values and blood gas samples were reevaluated in the recovery unit. Oxygen support was provided to patients with a simple mask at a flow rate of 6 L/min in the mask group. After 1 h, blood gas and vital values were recorded.

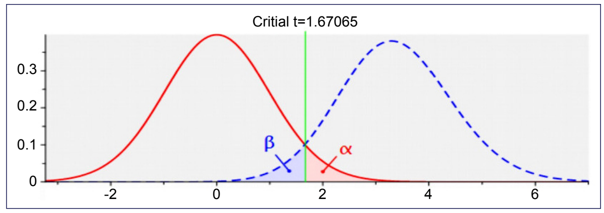

Figure 1. Power analysis.

At 24 h postoperatively, the QoR-40 questionnaire was performed and the level of recovery was evaluated.

For the high-flow oxygen group, in the postoperative recovery unit, the Fisher & Paykel Healthcare AIRVO 2 high-flow oxygen device at 37°C FiO_2: 40%, 60 L/min flow was used. First hour of blood gases, vital values, QoR-40 recovery questionnaire, discharge time, and complications related to pulmonary diseases were evaluated.

The G*Power program (G*Power 3.1.9.2 for Windows 10) was used to calculate the sample size. When the confidence level is 95%, that is, the alpha level is 5%, the margin error is 5% and the effect size is 0.40 (medium), and the number of patients required for each group is 31. The total number of patients required was found to be 62 (Fig. 1).

The program on the website https://www.randomizer.org/ was used for randomization, and patients were randomized into two groups. However, after randomization, one patient from each group wanted to leave the study before the end of the study although they provided their consent to the study. Therefore, the results were evaluated on 30 patients for both groups.

For correlation analysis between parameters, the Pearson correlation coefficient was used, assuming the data was normally distributed.

RESULTS

There was no statistical difference between the groups in terms of demographic characteristics (p>0.05) (Table 1).

There was no difference between the groups in terms of heart rate, systolic blood pressure, and diastolic blood pressure (p>0.05). While the respiratory rate was not different between groups before induction, it was found to be statistically higher in the mask group after wake-up and postoperative first-hour O_2 treatment (p=0.01 and p<0.001, respectively).

While the course of heart rate, systolic, and diastolic blood pressures did not differ significantly between groups when evaluated all the time (p>0.05), the change in fingertip saturation was significantly higher in the high-flow group, especially after awakening (p=0.02) (Fig. 2). Similarly, the decrease in respiratory rate was statistically significantly higher in the high-flow group than in the mask O_2 group (p<0.001). A comparison of the groups in terms of physiological condition after awakening and after 1 h of O_2 treatment is shown in Table 2.

Considering the blood gas results taken before and after

Table 1. Demographic characteristics of the patients

	Total	Group HF (n=30)	Group mask (n=30)	p
Age (years)	49.4±12.6	50.9±11.6	47.8±13.5	0.347
Gender (M/F)	40/20	22/8	18/12	0.273
Length (cm)	168.7±7.3	170.3±7.3	167.2±7.0	0.09
Weight (kg)	81.8±14.3	85.1±13.0	78.6±15.0	0.07
BMI (kg/m^2)	28.7±4.8	29.3±4.4	28.1±5.3	0.338
ASA (I/II/III)	10/41/9	4/21/5	6/20/4	0.495
Proportion of patients with pulmonary risk factors (%)	18 (30)	21 (30)	21 (30)	NA
Smoking history (%)	14 (23.3)	6 (20)	8 (26.7)	0.542
Duration of the surgery (dk)	138.9±40.8	143.0±44.9	134.8±36.5	0.443
Surgical washing fluid (L)	10.0±4.3	10.8±4.6	9.2±4.0	0.166
Anesthesia maintenance fluid (L)	1.9±0.5	2.1±0.5	1.6±0.4	0.001*
Preoperative albumin level (g/L)	37.9±5.6	38.4±6.0	37.3±5.7	0.471

*P<0.05. M: Male; F: Female; BMI: Body mass index; ASA: American Society of Anesthesiologists; HF: High flow; NA: Not applicable.

induction, after prone position, after wake-up, and after postoperative first-hour O_2 treatment, only arterial O_2 level was found to be statistically higher in the high-flow group after wake-up and postoperative first-hour O_2 treatment (p=0.003, p=0.05). There was no difference between the groups in terms of other values.

The increases in SaO_2 levels after awakening and after 1 h of O_2 intake were statistically significantly higher in the high-flow group than in the O_2 group (Fig. 3). There was no difference between the groups in terms of pulmonary diseases consultation (p=0.612).

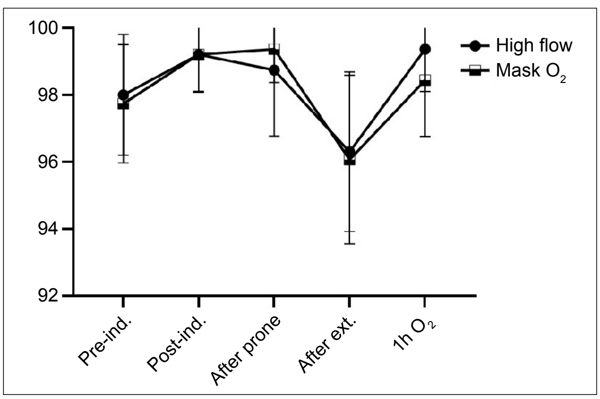

Figure 2. Change of fingertip saturation.

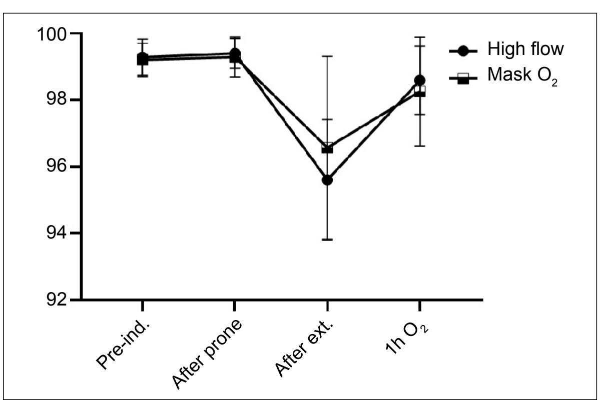

Figure 3. Change of arterial SaO_2.

Table 2. Comparison of the groups in terms of physiological condition after awakening and after 1 h of O_2 treatment

	Group HF	Group mask	p
HR (beat/min)			
After extubation	68.8±8.9	71.2±11.4	0.376
After 1 h O_2	65.8±8.5	69.6±11.8	0.167
SBP (mmHg)			
After extubation	133.2±18.9	125.3±20.8	0.142
After 1 h O_2	146.4±24.2	137.0±21.6	0.139
DBP (mmHg)			
After extubation	75.1±14.6	72.5±12.4	0.473
After 1 h O_2	80.8±15.0	78.1±13.6	0.475
SpO_2 (%)			
After extubation	96.3±2.3	96.0±2.5	0.714
After 1 h O_2	99.3±1.2	98.4±1.6	0.01
Respiratory rate			
After extubation	11.5±2.1	13.1±2.7	0.01
After 1 h O_2	9.9±1.3	13.2±2.7	<0.001

HR: Heart rate; SBP: Systolic blood pressure; DBP: Diastolic blood pressure.

There was a negative correlation between surgical washing fluid and bicarbonate values after awakening and 1 h later. There was a positive correlation between the amount of surgical flushing fluid and surgical time.

When the QoR-40 scores were examined, there was no difference between the groups in terms of comfort, mood, patient support, physical independence, pain, and the total score (Table 3).

In the high-flow group, pH decreased after wake-up compared with postinduction, while 1 h after the wake-up flow increased after O_2. Both changes were statistically signifi-

Table 3. QoR-40 score results of the patients in the groups

	Group HF (n=30)	Group mask (n=30)	p
QoR-40 confort	53.9±5.7	55.3±4.1	0.273
QoR-40 mood	42.3±3.0	43.1±3.0	0.357
QoR-40 patient support	34.6±1.0	34.5±1.0	0.811
QoR-40 physical independence	21.4±3.3	22.2±1.5	0.228
QoR-40 pain	32.3±2.0	32.0±1.7	0.457
QoR-40 total	184.5±12.4	187.2±8.6	0.333
QoR-40 comfortable breathing	4.6±0.8	4.6±0.6	1.000
QoR-40 oropharyngeal pain	9.6±0.6	9.2±1.3	0.110

cant ($p<0.001$, $p=0.007$, respectively).

In the high-flow group, HCO_3 decreased after wake-up compared with postinduction, while 1 hour after the wake-up flow increased after O_2. While the decrease after wake-up compared with postinduction was statistically significant ($p<0.001$), the increase after 1 h high-flow O_2 after wake-up was not significant ($p=0.307$).

In the oxygen mask group, the pH decreased after wake-up compared with postinduction, while 1 h after wake-up increased after mask O_2. While the decrease after wake-up compared with postinduction was statistically significant ($p<0.001$), the increase after 1 –h mask O_2 after wake-up was not significant ($p=0.345$).

In our study, the pulmonary complication rate was 6.6%, while the extrapulmonary complication rate was 18.3%. Only one had an ASA score of 3 and the others had an ASA score of 2. Smoking history was present in only half of those who developed pulmonary complications. None of them had chronic lung disease. Pleural effusion developed in 3 patients who developed pulmonary complications, and pain atelectasis developed in 1 patient. Pneumothorax, pneumonia, and other pulmonary complications were not seen in any of the patients.

DISCUSSION

General anesthesia, duration of surgery, and postoperative pain can have important effects on the respiratory system. Muscle paralysis caused by general anesthesia reduces functional residual capacity and may induce atelectasis. Atelectasis affects about 10% of the lung close to the diaphragm. Oxygen supplementation for postextubation hypoxemia is a common practice. Noninvasive ventilation may be difficult due to equipment problems in operating rooms and incompatibility that may exist in patients. Although high-flow oxygen therapy improves hypoxemia, it does not apply as high pressure as non invasive ventilation (NIV), so its effectiveness is poor in lung-related complications such as atelectasis. This is why high-flow oxygen should be considered as a mid-level auxiliary respiratory support between NIV and standard oxygen therapy.[6]

In a study,[3] pulmonary complications were significantly less developed in patients undergoing PNL in the right kidney. Pulmonary complications were significantly higher in young patients. There are publications in PNL surgery that the presence of kidney upper pole and multiple interventions increase complications.[7,8] However, in a previous study,[3] no significant difference was found between the upper pole approach and others. No significant difference was found in terms of chronic lung disease, smoking history, surgical washing fluid amount, duration of surgery, blood transfusion, and ASA score in terms of postoperative pulmonary complications. In a study evaluating post-major abdominal surgery in patients with moderate-advanced risk for pulmonary complications,[9] the rate of postoperative high-flow oxygen therapy and hypoxemic patient at the first hour after surgery in standard oxygen treatment groups were found similar. In our study, the complication associated with the lung was 6.6%, while the nonlung complication rate was 18.3%.

In the study of Palnizky et al.,[3] pulmonary complications developed in 8% of the patients although it was not statistically significant after PNL procedure in 100 patients, and nonpulmonary complications developed in 5% postoperatively. Atelectasis and pulmonary edema developed in only one of 8 patients who developed pulmonary complications. Pneumothorax developed in the remaining 7 patients. Only one patient died in the postoperative period due to pulmonary complications. The other two died of sepsis and cardiac arrest. Pulmonary complications developed significantly less in patients who underwent PNL operation in the right kidney. The prevalence of pulmonary complications in younger patients was again statistically significant. Netto et al.[8] and Shilo et al.[10] have published reports that the presence of kidney upper pole and more than one intervention in PNL surgery increases complications. However, in the study of Palnizky et al.,[3] no significant difference was found between the upper pole approach and the others. No significant difference was found in terms of chronic lung disease, smoking history, amount of surgical washing fluid, duration of surgery, blood transfusion, and ASA score in terms of postoperative pulmonary complications.

We can conclude that a lower number of patients included in this study, a single type of surgery, and a short duration of high-flow application are the limitations of our study.

In a meta-analysis,[11] it was observed that the duration of hospital stay was shorter in the group that received high oxygen treatment compared with the group that received conventional oxygen therapy. However, there was no difference in terms of postoperative mortality. It has been reported to be weakly related to reintubation and pulmonary complications in the postoperative period.

Corley et al.[12] showed no significant difference in atelectasis in patients who received standard oxygen therapy on the first and fifth days after cardiac surgery in patients with a body mass index above 30 and high-flow oxygen therapy. Parke et al.[13] found that cardiac surgery patients had higher postoperative high-flow oxygen therapy compared with those receiving standard care.

In an earlier study, there was no significant change in PaO_2 in patients who underwent a high-flow oxygen treatment for carbon monoxide poisoning compared with mask oxygen at 1 h.[11]

We linked this to surgeons being more aggressive in young patients. In the study of Palnizky et al.,[3] pulmonary complications were significantly less developed in right kidney surgery. In our study, we attribute no statistically significant difference in the number of lung complications.

Consistent with one study investigating the interventions from different localizations in the kidney in PNL, it was significant that the rate of lung complications was higher in the kidney upper pole interventions.[7] Anatomically, we think that the upper pole of the kidneys is closer to the diaphragm, which is the reason for this situation.

Although it was reported that multiple interventions to the kidney increased complications in PNL surgery in the study of staghorn stones,[7,8] lung complication in multiple interventions was not statistically significant in our study although it developed more. We think this depends on the small number of patients.

In one study, a comparison was made at the postoperative week 1,[9] and in our study, oxygen therapy was applied for 1 h in the postoperative period and then oxygenation was examined. Contrary to the study of the log arcs,[11] we attributed the partial oxygen pressure increase in the high-flow group to carbon monoxide with a hemoglobin affinity 300 times greater than oxygen so that our patient groups had no contact. Thus, there was no difficulty in binding oxygen to hemoglobin in our study.

The increase in PaO_2 and SaO_2 at 1 h after wake-up was similar to the study of Corley et al.[12] We think that this is due to the higher air leakage, lower airflow, and the lack of PEEP due to the mask not fitting the face properly in the treatment of oxygen.

Similar to several studies,[13,14] SpO_2 was significantly higher 1 h after the high-flow oxygen therapy. We believe that these results are consistent with our study as a reflection of the increase in oxygenation in the blood.

There was no statistical difference in blood gas at the lactate level, similar to the study of Yu et al.[15] in both groups. The first response of cells to hypoxia is anaerobic metabolism. Although lactic acid, which is the result of anaerobic metabolism, is an indirect indicator of hypoxia,[16] we normally accepted the absence of a significant lactate change at the postoperative first hour, as the patients in both groups did not have any serious postoperative hypoxemia.

In terms of mortality, there was no significant difference between the groups in several studies[3,9] similar to our study. The reason for the lack of difference in mortality has been attributed to the absence of blood oxygenation disorder between the two groups that would disrupt tissue oxygenation. Contrary to one study,[8] we attribute no difference in mortality between the two groups to the fact that we did not compare after a major surgery related to the cardiopulmonary system.

In our study, although high-flow oxygen increases oxygenation and decreases the number of respiration at the postoperative first hour, we predict that there will be no difference in the need for care and therefore no significant difference in hospital expenses because there is no significant difference in recovery at the 24th hour.

In our study, similar to one study[17] in both groups, a negative correlation was found between the amount of surgical washing fluid and bicarbonate values after waking and after 1 h of oxygen supplementation. In other words, as the washing fluid level increased, the bicarbonate level decreased. There was a positive correlation between the amount of surgical flushing fluid and surgical time. In other words, the amount of surgical flushing fluid increased with the increase in the surgical time. We attributed this relationship between bicarbonate and surgical laundering time to the more frequent systemic circulation and diluting the intravenous volume as the surgical laundering fluid used throughout the surgery.

Similar to one study,[4] the decrease in systolic and diastolic arterial pressure before induction and after awakening was significant in both groups. Contrary to this study, we found a decrease in heart peak before and after induction in both groups. We thought this was related to the drugs used in anesthesia that tend to hypotension and bradycardia.

An increase in pH after 1 h of high-flow nasal oxygen was observed in several studies.[17–19] In our study, similar to them, there was a significant increase in pH at the end of postoperative 1 h compared with post-awakening in the high-flow group. Although the patients are not hypercapnic, we think of this increase as the reflection of 60 L/min flow of sweeping carbon dioxide in the respiratory system to the pH in the treatment used in the high-flow oxygen group.

Limitations of the study

We conclude that the limited number of patients, limited type of surgical operations, and short duration of high--flow application in the study are the limitations of the study.

CONCLUSION

In our study, we observed that postoperative high-flow oxygen administration increased oxygenation in the early period and decreased the number of respiration, and increased the pH. We believe that postoperative high-flow oxygen applications should be studied in larger groups.

Ethics Committee Approval

This study approved by the Kartal Dr. Lütfi Kırdar Training and Research Hospital Clinical Research Ethics Committee (Date: 09.01.2019, Decision No: 2019/514/145/3).

Informed Consent

Prospective study.

Peer-review

Internally peer-reviewed.

Authorship Contributions

Concept: F.Y., F.D.G.; Design: F.Y., F.D.G.; Supervision: F.Y., F.D.G., Y.Y., B.Ç., K.T.S.; Fundings: F.Y., F.D.G.; Materials: F.Y., F.D.G.; Data: F.Y., F.D.G.; Analysis: F.Y., F.D.G., Y.Y., B.Ç., K.T.S.; Literature search: F.Y., F.D.G.; Writing: F.Y., F.D.G., Y.Y., B.Ç., K.T.S.; Critical revision: F.Y., F.D.G., Y.Y., B.Ç., K.T.S.

Conflict of Interest

None declared.

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Perkütan Nefrolitotomi Operasyonu Sonrası Yüksek Akım Oksijen Uygulamasının Solunum Parametreleri ve Derlenme Üzerine Etkileri

Amaç: Ameliyat sonrası erken dönemde maske oksijen veya yüksek akımlı nazal oksijen uygulanan hastalarda yaşamsal parametreleri, arteriyel kan gazlarını, ameliyat sonrası derlenme düzeylerini, akciğerle ilişkili komplikasyonları karşılaştırmayı amaçladık.

Gereç ve Yöntem: Bu ileriye yönelik ve randomize çalışma, perkütan nefrolitotomi cerrahisi için planlanan ASA I-II-III risk skoruna sahip 18 yaşın üzerinde, iki cinsiyette 60 hastayı içermektedir. Hastalar rastgele ayrıldı; yüksek akımlı oksijen grubu (Grup HF, n=30), maske oksijen grubu (Grup Maskesi, n=30). Perkütan nefrolitotomi ameliyatı sırasında ve ameliyat sonrası arteriyel kan gazları değerlendirildi. Ameliyat sonrası erken dönemde iki grubun vital parametreleri (kalp hızı, SpO_2, arteriyel kan basıncı, solunum hızı) karşılaştırıldı. Ameliyat sonrası iyileşme için QoR-40 anketi kullanıldı.

Bulgular: Demografik veriler açısından gruplar arasında istatistiksel olarak fark yoktur. Ameliyat sonrası birinci saatte arteriyel kan gazı analizinde yüksek akım grubunda SpO_2 düzeyleri daha yüksek, PaO_2 ve SaO_2 artışları istatistiksel olarak anlamlı bulundu (sırasıyla p=0.01 p<0.001 p=0.03). Ekstübasyon sonrası kan gazları ile bir saatlik oksijen tedavisinden sonraki kan gazlarını karşılaştırdığımızda, bir saatlik oksijen tedavisinden sonra yüksek akım grubunda düşük solunum hızı ve pH artışı istatistiksel olarak anlamlıdır (sırasıyla p<0.001 p=0.007). $PaCO_2$ seviyelerinde istatistiksel olarak anlamlı bir fark yoktur. İki grup arasında sistolik-diyastolik kan basıncı, kalp hızı, ameliyat sonrası 24. saatte iyileşme düzeyi, ameliyat sonrası akciğer komplikasyonları, mortalite, hastanede kalış süresi, yeniden entübasyon oranı açısından herhangi bir fark görmedik.

Sonuç: Yüksek akışlı oksijen tedavisi, ameliyat sonrası erken dönemde kan gazlarında oksijenasyonu ve pH'ı artırır ve solunum hızını azaltır. Ameliyat sonrası iyileşme ve akciğer komplikasyonları açısından bir fark yoktur.

Anahtar Sözcükler: Amaliyat sonrası erken dönem; iyileşme; yüksek akımlı nazal oksijen.