RESEARCH ARTICLE
Araştırma Makalesi

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Geliş Tarihi / *Received* : March 08, 2025
Kabul Tarihi / *Accepted* : April 22, 2025

Bu makalede yapılacak atıf
Cite this article as
Oluş F, Babun H.
Low and Minimal-flow Anesthesia in Oral and Maxillofacial Surgery Patients: Which One is Ideal?

Akd Med J 2026;12: 1-8

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Low and Minimal-flow Anesthesia in Oral and Maxillofacial Surgery Patients: Which One is Ideal?

Oral ve Maksillofasiyal Cerrahi Hastalarında Düşük ve Minimal Akım Anestezi: İdeal Olan Hangisi?

ABSTRACT
Objective
Low and Minimal-flow Anesthesia, despite its advantages, including cost and pollution reduction and less heat/moisture loss, has limited prevalence due to concerns of complications and the need for closer monitoring. The objective of this study was to assess the benefits and risks of low- and minimal-flow anesthesia in patients undergoing oral and maxillofacial surgery.

Material and Methods
Conducted at Akdeniz University, 149 ASA 1-2 class patients were categorized into four Fresh Gas Flow (FGF) groups post-anesthesia induction. Data collected included vital signs, complications, operation and awakening times, and gas use.

Results
There were no significant differences in demographics or ASA classification. However, variations in oxygen, air and sevoflurane use across the various FGF groups were identified ($p<0.05$). Usage increased significantly from minimal to high-flow groups. Sevoflurane use was lowest at minimal-flow, increasing through to high-flow. The study found no significant difference in sevoflurane use between low and medium-flow groups. A progressive increase in recovery times was observed from high to minimal-flow groups, with no differences in operation times or hemodynamic parameters and complications.

Conclusion
The study suggests that low- and minimal-flow anesthesia can be safely used in patients undergoing oral and maxillofacial surgery with detailed monitoring. With similar gas usage and cost between low and medium-flow anesthesia, minimal-flow is recommended as the more rational choice.

Key Words
Low-flow Anesthesia, Minimal-flow Anesthesia, Maxillofacial Surgery, Oral Surgery

DOI: 10.53394/akd.1652997

ÖZ

Amaç

Düşük ve Minimal Akımlı Anestezi, maliyetin düşmesi ve çevre kirliliğinin azaltılması ve daha az ısı/nem kaybı gibi avantajlarına rağmen, komplikasyon endişeleri ve daha dikkatli yakın monitörizasyon ihtiyacı nedeniyle yaygın değildir. Bu çalışmanın amacı, anestezide oldukça önemli olan hava yolunu cerrahi ekip ile paylaştığımız Oral ve Maksillofasiyal Cerrahi hastalarında Düşük ve Minimal Akımlı Anestezinin faydalarını ve risklerini ortaya koymaktır.

Gereç ve Yöntemler

Akdeniz Üniversitesi Diş Hekimliği Fakültesi Ağız, Diş ve Çene Cerrahisi Anabilim Dalı'nda gerçekleştirilen bu çalışmada, 149 ASA 1-2 sınıfı hasta anestezi indüksiyonu sonrası dört farklı Taze Gaz Akımı (TGA) grubuna ayrıldı. Hastaların vital bulguları, komplikasyonları, ameliyat ve uyanma süreleri ve gaz kullanım miktarlarını içeren veriler toplanılarak analiz edildi.

Bulgular

Hastaların demografik özelliklerinde veya ASA sınıflandırmasında anlamlı bir fark bulunmadı. TGA grupları arasında oksijen, hava ve sevofluran kullanımında istatistiksel olarak anlamlı farklar bulundu ($p<0.05$). Kullanım minimalden yüksek akım grubuna doğru anlamlı şekilde artmaktaydı. Sevofluran kullanımı minimum akımda en düşük seviyedeydi ve yüksek akıma doğru artış gösterdi. Düşük ve orta akım grupları arasında sevofluran kullanımında anlamlı bir fark bulunmamıştır. Ameliyat sürelerinde veya hemodinamik parametrelerde ve komplikasyonlarda herhangi bir fark yok iken yüksek akımdan minimal akıma doğru uyanma sürelerinde ilerleyici bir artış gözlenmiştir.

Sonuç

Çalışmamız, düşük ve minimal akım anestezinin oral ve maksillofasiyal cerrahi hastalarında yakın dikkatli monitörizasyon ile güvenle kullanılabileceğini göstermektedir. Düşük ve orta akım anestezi arasında benzer gaz kullanım miktarları olması nedeni ile minimal akım anestezi kullanımı daha akılcı olacaktır.

Anahtar Kelimeler

Düşük Akım Anestezi, Minimal Akım Anestezi, Maksillofasiyal Cerrahi, Oral Cerrahi

INTRODUCTION

Despite the fact that most modern anesthesia machines are fully compatible with minimal-flow, the prevalence of low FGF techniques in clinical practice is still not as high as expected. Low-flow anesthesia is based on the re-inhalation of at least 50% of the inhaled air. The technique involves the return of expired air to the lungs after passage through carbon dioxide absorbers (1).

John Snow's (1850) studies demonstrated that the narcotic effects could last much longer than expected, providing that the release of the anesthetic vapor could be stopped (2). These studies constituted the beginning of the idea of rebreathing systems in the presence of carbon dioxide absorption. Subsequently, there has been a marked increase in the level of interest in the development of rebreathing systems with carbon dioxide absorbers (3-5). Studies on this subject have shown that low-flow anesthesia reduces heat and moisture loss in the respiratory system, reduces the cost of anesthetic gas and minimizes gas pollution in the operating room environment (6). Chlorinated hydrocarbon anesthetics are destroyed by ultraviolet radiation, releasing chlorine atoms that damage the ozone layer. Although chlorine-free halogenated anesthetics such as sevoflurane and desflurane are less damaging to the ozone layer, this risk can be further reduced with low-flow anesthesia (7). Although the use of explosive gases such as acetylene and cyclopropane made rebreathing anesthesia systems widespread, rebreathing systems were abandoned in the years following the use of trichloroethylene, which was incompatible with carbon dioxide absorbents, and halothane, which was poorly compatible with fresh air gas flows (8).

Baker et al. classified the flow rates of gases in anesthesia circuits as follows (9): Metabolic Flow <250 mL/min -1, Minimal-flow 250-500 mL/min -1, Low-flow 500-1000 mL/min -1, Medium-flow 1-2 L/min -1, High-flow 2-4 L/min -1, Very High-flow >4 L/min -1. In the context of metabolic flow, the patient's oxygen requirements are met by the administration of oxygen alone, while in other flow applications, additional oxygen, nitrous oxide or air is used with varying amounts of metabolic oxygen.

The potential risks of low-flow anesthesia include hypoxic gas mixtures and the inability to provide depth of anesthesia. However, gases with low solubility in blood and tissues, such as sevoflurane and desflurane, can establish a rapid equilibrium between the alveoli and the brain even at low flow. There is no definite contraindication for low-flow in elective general anesthesia. In minimal-flow anesthesia, the risk of accumulation of endogenous gases is increased in heavy smokers, in cases of massive transfusion and/or hemolysis, which may lead to carbon monoxide accumulation. Patients with uncontrolled diabetes or severe malnutrition may also experience acetone accumulation. Finally, using low flow can be risky in malignant hyperthermia, severe bronchial asthma and septicemia (10).

This study aimed to illuminate the advantages and potential hazards of Low- and Minimal-flow Anesthesia in the context of Oral and Maxillofacial Surgery, where the airway is managed cooperatively with the surgical team. To the best of our knowledge, there is a notable paucity of studies specifically addressing the feasibility and safety of low-flow techniques in this surgical context. This study aims to contribute original data and insight into this underexplored area, emphasizing both clinical applicability and patient safety.

MATERIAL and METHOD

All patients were examined before anesthesia and fasted for 6 hours. The groups in the study were determined as 1-Minimal-flow (250-500 mL/min), 2-Low-flow (500-1000 mL/min), 3-Medium-flow (1-2 L/min), and 4-High-flow (2-4 L/min). Patients were pre-oxygenated for 3 minutes before induction of anesthesia. A standard anesthesia induction protocol was followed. According to this protocol, intravenous (IV) fentanyl (2 mcg/kg) followed by propofol (2 mg/kg) was administered. IV rocuronium (0.6 mg/kg) was administered for neuromuscular block. Mask ventilation (FiO_2 0.6) was performed. After sufficient muscle relaxation was achieved (with a 2 min wait), an appropriately sized endotracheal tube (ETT) was used to perform orotracheal or nasotracheal intubation and secure the airway. After ETT placement was confirmed, the lungs were ventilated with 2-4 L/min FGF (60:40 air-oxygen mixture) in the high-flow group. In the medium-flow group, the lungs were ventilated with 1-2 L/min FGF (a 50:50 air-oxygen mixture). In the low-flow group, the lungs were ventilated with 0.5-1 L/min FGF (40:60 air and oxygen mixture). In the minimal-flow group, the lungs were ventilated with 250-500 mL/min of FGF (30:70 air-oxygen mixture). Sevoflurane was administered to all groups at a MAC of 1 to maintain anesthesia. The minimal- and low-flow group underwent a 10-minute "wash-in period" (FGF at 4 L/min, 4% sevoflurane), while the high- and medium-flow groups did not. Tidal volume was set to 6-8 ml/kg according to ideal body weight, PEEP was set at 5 cmH_2O, and the respiratory rate was adjusted to maintain an $EtCO_2$ of 35-45 mmHg. Following termination of the operation, sevoflurane administration was discontinued, and an FGF of 4 L/min (a 25:75% air-oxygen mixture) was applied; the time elapsed from this point until the patient's extubation was recorded. The GE HealthCare (General Electric Company, USA) Carestation 620 model was used as an anesthesia machine. Sugammadex was administered to patients undergoing operations lasting less than 1 hour and to those with inadequate muscle strength. During the operation, data on gas consumption, vital parameters, complications, operation time, and recovery time were recorded. As this was a retrospective study, all data were obtained from patient medical records and anesthesia follow-up charts stored in the hospital's digital archive system. Data collection was conducted in accordance with institutional ethical guidelines.

Study Design

The Ethics Committee of Akdeniz University formally endorsed the present study on March 22, 2023 (KAEK-252). A retrospective, single-center study was conducted. In our study, 149 patients who underwent surgical procedures under general anesthesia in the Akdeniz University Faculty of Dentistry Operating Room between June 2022 and November 2022 by the Department of Oral, Dental and Maxillofacial Surgery were retrospectively evaluated. Inclusion criteria were ASA 1-2 patients, patients aged 18-65 years, and patients who underwent general anesthesia maintenance with sevoflurane. Data excluded from the study were ASA 3 and above patients, surgeries performed under sedation, hypothyroidism and neuromuscular diseases, morbidly obese patients, patients with an expected difficult airway, and records of patients with missing data and information in their files.

Sample Size;

In accordance with the primary research hypotheses, the study design involved the comparison of three or more independent groups. In this research, using the "G. Power-3.1.9.2" program, the following hypotheses may be employed in order to calculate the sample size at 95% confidence level and the sample size calculation that yields the highest number in line with similar studies were taken as basis (11). As a result of the analysis, with $\alpha=0.05$, the standardized effect size was calculated to be 0.6293, based on a similar study previously conducted in this field. The minimum sample size for each group was calculated as 15, targeting a theoretical power of 0.95 (12).

Statistical Method

In the study, descriptive statistics for the data (count, percentage, mean, standard deviation, median, minimum, and maximum) were provided. The reliability of the scales utilised in the study was assessed. As an initial step in the statistical analysis, the assumption of normality was assessed using the Shapiro-Wilk test, and the homogeneity of variance was examined using Levene's test. In instances where the data originated from three or more independent groups that did not follow a normal distribution, the Kruskal-Wallis test was used to conduct a comparative analysis. To identify the group or groups causing the difference, Post Hoc Bonferroni-corrected analyses were used. When examining the relationships between categorical variables, the Pearson Chi-squared analysis was employed when the requisite sample size assumption was met (expected value $\geq$ 5), and the Fisher's Exact test was employed when it wasn't (expected value < 5). Analyses were performed using IBM SPSS 25 software ($p<0.05$).

RESULTS

Mean age of patients: 37.6±14.53. The youngest patient is 18 years old, and the oldest is 65 years old. According to the FGF, the average age between the groups is not statistically significant (Table I).

Of the patients, 69 (46.3%) are female, and 80 (53.7%) are male. According to the FGF, there is no statistically significant difference between the groups in terms of gender

(Table I). According to the ASA classification, 102 patients (68.5%) are ASA 1, and 47 (31.5%) are ASA 2. There are no patients in the ASA 3-6 group. According to the FGF, there is no statistically significant difference between the groups regarding ASA (Table I). According to the FGF, there is no statistically significant difference between the groups in average height and average weight (Table I). Statistically significant differences were found between the mean oxygen, air, and sevoflurane use in the first hour, second hour, and at the end of the operation, according to the FGF groups (p<0.05) (Table II).

Table I. Demographic characteristics according to FGF (Fresh Gas Flow) groups

	Minimal (n=43)	Low (n=36)	Medium (n=36)	High (n=34)	Test Statistic	P
Gender, n (%)						
Female	20 (46.5)	17 (47.2)	16 (44.4)	16 (47.1)	0.071	0.995
Male	23 (53.5)	19 (52.8)	20 (55.6)	18 (52.9)		
ASA, n (%)						
1	26 (60.5)	27 (75)	29 (80.6)	20 (58.8)	5.887	0.117
2	17 (39.5)	9 (25)	7 (19.4)	14 (41.2)		
Age, Mean ±S.D. (M)	36.56±14.2(36)	35.58±13.73(33.5)	35.83±15.16(32)	42.97±14.41(40.5)	6.367	0.095
Height(cm), Mean ±S.D. (M)	169.81±8.76(170)	172.92±9.12(169.5)	171.22±9.46(170)	173.26±9.07(171.5)	3.315	0.346
Weight(kg), Mean ±S.D. (M)	70.56±12.09(71)	73.39±13.49(74)	70.5±13(71)	76.82±16.5(79)	4.640	0.200

*p<0.05, ASA (The American Society of Anesthesiologists physical status classification)

Table II. Gas usage averages according to FGF (Fresh Gas Flow) groups

Mean.±S.D. (M)	Minimal (n=43)	Low (n=36)	Medium (n=36)	High (n=34)	Test Statistic	P
O_2 Hour 1	29.74±3.7(29)	35.61±1.71(35)	51.78±9.26(50)	73.47±11.33(76)	130.271	0.000*
Air Hour 1	38.23±4.79(37)	44.5±1.9(45)	59.25±5.08(60)	93.18±6.97(93)	130.050	0.000*
Sevo Hour 1	10.67±1.74(11)	13±1.8(12.5)	10.94±2.96(10)	25.59±7.96(28)	89.006	0.000*
O_2 Hour 2	44.86±5.2(45)	59.94±1.85(59)	97.56±15.68(99)	126.44±33.9(122,5)	61.425	0.000*
Air Hour 2	50.68±8.79(50)	67.94±1.82(69)	120.5±12.6(120.5)	168.69±25.01(162)	64.423	0.000*
Sevo Hour 2	17.5±2.82(17.5)	23.29±3.58(23)	21.31±3.86(20)	48.31±15.53(52)	48.005	0.000*
O_2 End	85.86±25.08(80)	92.56±30.62(85,5)	117.81±38.11(113)	140.91±52.94(126,5)	39.294	0.000*
Air End	68.98±22(62)	79.36±25.27(74)	122.56±43.75(115.5)	161.44±61.91(154.5)	78.433	0.000*
Sevo End	19.65±9.26(17)	24.72±13.86(22)	21.36±9.89(20)	47.5±23.17(41.5)	45.366	0.000*

*p<0.05, O_2 (Oxygen), Sevo (Sevoflurane)

Statistically significant differences have been identified between minimal-flow and low-flow, medium-flow, high-flow usage averages; between low-flow and medium-flow, high-flow usage averages; and between medium-flow and high-flow usage averages in the first hour oxygen usage averages (p=0.007, p=0.000, p=0.000, p=0.000, p=0.000 and p=0.016). The usage averages for low, medium, and high-flow are higher than the usage average for minimal-flow; medium- and high-flow usage averages are higher than the usage average for low-flow; and the usage average for high-flow is also higher than the usage average for medium-flow. Average air use in the first hour, statistically significant differences have been identified between minimal-flow and low, medium, high-flow; between low-flow and medium, high-flow; and between medium-flow and high-flow (p=0.008, p=0.000, p=0.000, p=0.001, p=0.000 and p=0.003). The usage averages for low, medium, and high-flow are higher than the usage average for minimal-flow;

medium- and high-flow usage averages are higher than the usage average for low-flow; and the usage average for high-flow is also higher than the usage average for medium-flow. Statistically significant differences have been identified between minimal-flow and low-flow usage averages, and between low-flow and minimal-, medium-, and high-flow-usage averages, in the first-hour sevoflurane usage averages (p=0.002, p=0.000, p=0.002, p=0.000, and p=0.000). The usage averages of low and high-flow are higher than the usage average of minimal-flow; the usage average of low-flow is higher than the usage averages of medium and minimal-flow; and the usage average of high-flow is higher than the usage average of low-flow.

In terms of average oxygen usage in the second hour, statistically significant differences were identified between minimal-flow and low, medium, and high-flow usage averages; as well as between low-flow and medium and high-flow usage averages (p=0.020, p=0.000, p=0.000, p=0.018 and p=0.001). Low, medium, and high-flow usage averages are higher than minimal-flow usage average; medium and high-flow usage averages are higher than low-flow usage average. When examining the average air usage in the second hour, statistically significant differences were found between minimal-flow and low, medium, and high-flow usage averages; as well as between low and high-flow usage averages (p=0.028, p=0.000, p=0.000, and p=0.000). Low, medium, and high-flow usage averages are higher than the minimal-flow average; the high-flow usage average is higher than the low-flow usage average. According to tests of the average usage of sevoflurane in the second hour, statistically significant differences were found between minimal-flow and both low- and high-flow, as well as between high- and medium-flow (p=0.002, p=0.000, p=0.000, and p=0.011). Low and high-flow usage averages are higher than the minimal-flow average; the high-flow usage average is also higher than the medium-flow usage average.
At the end of the operation, statistically significant differences in average oxygen usage were detected between minimal and low-flow, as well as between medium and high-flow (p=0.001, p=0.000, p=0.021, and p=0.000). Medium and high-flow usage averages are higher than low and minimal-flow usage averages. At the end of the operation, statistically significant differences were observed in air usage averages: between minimal and low-flow usage, as well as between medium and high-flow usage (p=0.000, p=0.000, p=0.000, and p=0.000). Medium and high-flow usage averages are higher than low and minimal-flow usage averages. At the end of the operation, statistically significant differences in average sevoflurane usage were identified between high-flow and minimal, low, and medium-flow usage (p=0.000, p=0.000, and p=0.000). The high-flow usage average is higher than the minimal-flow usage average; the low and medium-flow usage averages are higher than the minimal-flow usage average.

There is no statistically significant difference in mean operation time according to FGF groups.
There is a statistically significant difference between the average recovery times according to FGF groups (p<0.05). According to the tests conducted, statistically significant differences have been determined between high- and medium-flow and low- and minimal-flow, as well as between low- and minimal-flow (p=0.000, p=0.000, p=0.010, p=0.000, and p=0.009). The average wake-up times of patients in the low- and minimal-flow groups are higher than those of patients in the high- and medium-flow groups. The average wake-up time of patients in the minimal-flow group is higher than that of patients in the low-flow group (Table III). There is no statistically significant difference in hypotension and hypertension incidences across FGF groups (Table IV).

Table III. Mean operation time and recovery time according to FGF (Fresh Gas Flow) groups

	Minimal (n=43)	**Low (n=36)**	**Medium (n=36)**	**High (n=34)**	**Test Statistic**	**p**
Operation Time, Mean.±S.D. (M)	132.44±70.18(120)	127.64±65.22(109.5)	117.11±41.01(113)	113.26±42.62(105.5)	0.890	0.828
Recovery Time, Mean.±S.D. (M)	14.05±4.24(13)	10.19±3.12(10)	7.83±3.48(7)	6.32±1.93(6)	78.496	0.000*

*p<0.05

Table IV. Incidence of Hypo/Hypertension according to FGF (Fresh Gas Flow) groups

	Minimal (n=43)	Low (n=36)	Medium (n=36)	High (n=34)	Test Statistic	p
Hypotension, n (%)						
-	41 (95.3)	33 (91.7)	36 (100)	33 (97.1)	3.069**	0.373
+	2 (4.7)	3 (8.3)	0 (0.0)	1 (2.9)		
Hypertension, n (%)						
-	41 (95.3)	35 (97..2)	36 (100.0)	33 (97.1)	1.733**	0.845
+	2 (4.7)	1 (2.8)	0 (0.0)	1 (2.9)		

**Fisher's Exact test

DISCUSSION

In the domain of medicine, the need for cost awareness and the development of strategies to reduce expenses are becoming increasingly imperative. Low-flow anesthesia is one such strategy. Nevertheless, concerns about potential complications associated with this approach, along with the need for close monitoring, have thus far impeded its widespread adoption. The present study provides original evidence supporting the feasibility and safety of low-flow anesthesia in oral and maxillofacial surgical procedures in which airway management poses a particular challenge. By demonstrating successful outcomes with careful monitoring, this research addresses a gap in the existing literature and encourages broader consideration of low-flow techniques in similar clinical settings.

Eger et al. found that reducing FGF significantly lowered gas usage costs (13). Lindqvist and Jakobsson classified the patients into 4 groups (0.3 L/min, 0.5 L/min, 0.7 L/min, 1 L/min) according to the FGF rate and reported that sevoflurane use increased in parallel with increasing FGF, without any perioperative complications (14). In our study, we obtained results supporting the finding that the use of air, oxygen, and sevoflurane, along with their associated costs, increases with the FGF rate. We attribute the similar results of the 1st hour, 2nd hour, and end of the operation sevoflurane usage averages in the low and medium-flow group to the wash-in period used in the low-flow group, but not in the medium-flow group. The purpose of the wash-in period is to quickly reach the sevoflurane equilibrium state, which would otherwise develop very slowly in the minimal- and low-flow groups, thereby establishing the patient's volatile-gas anesthesia. During the wash-in period, the anesthesia machine's gas pool is quickly filled, and gas usage increases rapidly. Although gas usage averages move away from the effect of the wash-in period in cases longer than 2 hours, the choice between low and medium-flow in terms of sevoflurane usage in cases shorter than 2 hours will be affected by oxygen and air usage costs. In addition, the leakage reliability of the anesthetic machine and ventilator circuits, and the consequent need for close monitoring, are other important considerations when making this choice. While the wash-in period has widespread clinical use, its effectiveness and necessity, especially in low-flow anesthesia, are controversial in the literature (15). If the wash-in period is not used in low-flow anesthesia, the difference with medium-flow anesthesia in terms of gas usage will become significant. We believe more research is needed on this subject.

In the study by Doolke et al., while the cost associated with increased sevoflurane use increased with higher FGF, there was no increase in the risk of complications from reducing FGF, unlike in other studies (13, 14, 16). In our study, no complications related to decreased FGF were observed, supporting the literature. To prevent hypoxia and hypercarbia, we think that close monitoring with alarm limits appropriate to these flows, especially in the minimal and low-flow groups, reduced the risk of complications. There is no statistically significant difference between groups in terms of incidence of hypotension and hypertension. We believe that, in addition to the reliability of minimal and low-flow anesthesia, our maxillofacial surgery patient group being ASA 1-2 and having a relatively lower average age is also a significant factor.

In the literature, it has been stated that the negative effects of volatile anesthetics being released into the atmosphere can be reduced by limiting the FGF (17-19). In our study, we observed that as FGF increased, sevoflurane use and, subsequently, its atmospheric emissions also increased. Of course, the most striking result here is the similar sevoflurane usage and associated emissions in the low and medium-flow groups. The most significant difference in atmospheric emissions is between the minimal-flow group and the high-flow group.

In contrast to the literature, our study found that awakening times were longer as FGF decreased (20). The fact that we use minimal and low-flow in our clinic during relatively long-lasting operations to be more effective and useful may also be a factor in this.
A limitation of our study is that the duration of our patients' operations was not long enough to reveal the differences

clearly. The effectiveness and benefits of minimal and low-flow anesthesia increase as the duration of the operation lengthens. Although we routinely use HME filters in our patients to prevent heat and moisture loss, we did not have the opportunity to measure the temperature and humidity of the inhaled gas, which is another limitation of our study. Therefore, we have not had the chance to comment on the preservation of heat and moisture, which is a significant advantage of minimal and low-flow anesthesia. Additionally, the retrospective nature of this study introduces potential biases, as data were collected from existing patient records and anesthesia charts. While this approach offers valuable insights, it is limited by the accuracy and completeness of the data available.

CONCLUSION

In conclusion, although minimal and low-flow anesthesia may not be widely used due to concerns about complications, it can be used safely with close intraoperative monitoring and appropriate alarm limits.

Considering both the economic effects and the environmental impact of minimal- and low-flow anesthesia, the potential risks can be managed with close and careful monitoring.

There are not enough studies in the literature about the use and safety of low-flow anesthesia in oral and maxillofacial surgery patients where the airway is shared with the surgical team by anesthesia. With this study, we obtained results supporting the use of minimal and low-flow anesthesia safely in oral and maxillofacial surgical patients with careful monitoring.

Our results regarding awakening times are particularly interesting. More studies are needed with more patient groups concerning this.

As a result, given the similarity in gas use and cost between low- and medium-flow anesthesia, which may be related to the wash-in period, minimal-flow may represent a more rational option in this context.

Ethics Committee Approval

This research complies with all the relevant national regulations, institutional policies and is in accordance with the tenets of the Helsinki Declaration, and has been approved by the Clinical Research Ethics Committee of Akdeniz University Faculty of Medicine (approval number: KAEK-252).

Informed Consent

As this study was of a retrospective nature, written informed consent was not obtained from the patients.

Author Contributions

Concept – F.O.; Design – F.O., H.B.; Supervision - F.O., H.B.; Resources - F.O.; Materials - F.O., H.B.; Data Collection and/or Processing - F.O., H.B.; Analysis and/ or Interpretation - F.O., H.B.; Literature Search - F.O., H.B.; Writing Manuscript - F.O., H.B.; Critical Review - F.O., H.B.

Conflict of Interest

The authors have no conflict of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

REFERENCES

1. Baum J, Aitkenhead A. Low-flow anaesthesia. Anaesthesia. 1995;50:37-44.
2. Snow J. On narcotism by the inhalation of vapours. Part XV. The effects of chloroform and ether prolonged by causing the exhaled vapour to be reinspired. London Medical Gazette. 1850;11:749-54.
3. Jackson D. A new method for the production of general analgesia and anaesthesia with a description of the apparatus used. J Lab Clin Med. 1915;1:1-12.
4. Jackson D. The employment of closed ether anesthesia for ordinary laboratory experiments. J Lab Clin Med. 1916;2:94.
5. Sword BC. The Closed Circle Method of Administration of Gas Anesthesia.*. Anesthesia & Analgesia. 1930;9(5):198-202.
6. Waters RM. Clinical Scope and Utility of Carbon Dioxid Filtration in Inhalation Anesthesia.*. Anesthesia & Analgesia. 1924;3(1):20-2.
7. Baxter AD. Low and minimal flow inhalational anaesthesia. Canadian journal of anaesthesia. 1997;44:643-53.
8. JL O, editor The early history of low-flow anaesthesia. The history of anesthesia Third International Symposium, Proceedings; 1992: Wood Library-Museum of Anesthesiology.
9. Baker A. Low flow and closed circuits. SAGE Publications Sage UK: London, England; 1994. p. 341-2.
10. Brattwall M, Warrén-Stomberg M, Hesselvik F, Jakobsson J. Brief review: theory and practice of minimal fresh gas flow anesthesia. Canadian Journal of Anesthesia/Journal canadien d'anesthésie. 2012;59:785-97.
11. Cohen J. Statistical power analysis for the behavioural sciences. Hillsdale, New Jersey: L. Lea. 1988;56:102.
12. Elmacioglu MA, Goksu S, Kocoglu H, Oner U. Effects of flow rate on hemodynamic parameters and agent consumption in low-flow desflurane anesthesia: An open-label, prospective study in 90 patients. Current therapeutic research. 2005;66(1):4-12.
13. Eger EI, White PF, Bogetz MS. Clinical and economic factors important to anaesthetic choice for day-case surgery. Pharmacoeconomics. 2000;17:245-62.
14. Lindqvist M, Jakobsson J. Minimal flow anaesthesia for short elective day case surgery; high vaporiser settings are needed but still cost-effective. Ambul Surg. 2011;17:27-9.
15. Arslan M, Gişi G, Öksüz G, Öksüz H, Bilal B, Boran ÖF, et al. Are high fresh gas flow rates necessary during the wash-in period in low-flow anesthesia? The Kaohsiung Journal of Medical Sciences. 2020;36(10):834-40.
16. Doolke A, Cannerfelt R, Anderson R, Jakobsson J. The effects of lowering fresh gas flow during sevoflurane anaesthesia: a clinical study in patients having elective knee arthroscopy. Ambulatory Surgery. 2001;9(2):95-8.
17. Andersen MPS, Nielsen OJ, Wallington TJ, Karpichev B, Sander SP. Assessing the impact on global climate from general anesthetic gases. Anesthesia & Analgesia. 2012;114(5):1081-5.
18. Sherman J, Le C, Lamers V, Eckelman M. Life cycle greenhouse gas emissions of anesthetic drugs. Anesthesia & Analgesia. 2012;114(5):1086-90.
19. Feldman JM. Managing fresh gas flow to reduce environmental contamination. Anesthesia & Analgesia. 2012;114(5):1093-101.
20. Öterkuş M, Dönmez İ, Nadir AH, Rencüzoğulları İ, Karabağ Y, Binnetoğlu K. The effect of low flow anesthesia on hemodynamic and peripheral oxygenation parameters in obesity surgery. Saudi Medical Journal. 2021;42(3):264.