INTERNATIONAL JOURNAL OF SCIENCE, TECHNOLOGY AND DESIGN

ULUSLARARASI
BİLİM, TEKNOLOJİ VE TASARIM DERGİSİ

ISSN: 2757-8127, https://dergipark.org.tr/tr/pub/istd

Anestezik İnhalasyon Ajanlarının Etkisinin Bazı Biyokimyasal ve Hematolojik Parametreler ile Araştırılması

Fatma ARI ABACI[1], Egemen DERE[2]

[1] *Bursa Yüksek İhtisas Eğitim ve Araştırma Hastanesi, Bursa, TÜRKİYE, ORCID ID 0009 0001 8950 6731*
[2] *B.U.Ü., Fen Edebiyat Fakültesi, Biyoloji Bölümü, Moleküler Biyoloji Anabilim Dalı, Bursa, TÜRKİYE, ORCID ID 0000 0001 9572 1051*

Corresponding Author: Egemen DERE, edere@uludag.edu.tr

Özet

Bu çalışmada, sevofluran, desfluran ve izofluran'ın Türkiye'de 4 farklı hastanede çalışan personel üzerindeki etkisi, bazı biyokimyasal ve hematolojik parametreler ile araştırılmıştır. Toplam 42 ameliyathanede çalışan 60 anestezi teknikeri, anestezik ajana maruz kalma süresine göre 6-10, 11-15 ve 16-20 yıl olacak şekilde 3 deney periyoduna ayrılmıştır. Deney grubu ile aynı yaş aralığında, farklı mesleklere sahip 60 birey kontrol grubu olarak seçilmiştir. Kan örneklerinde, ALT, AST, ALP, CK, CK-MB, LDH, GST, ve amilaz aktiviteleri ile Na^+, K^+, glukoz, üre, total protein, total bilirubin, total kolesterol, trigliserid, lökosit, eritrosit ve trombosit miktarları ölçülmüştür.

Çalışılan 120 bireyde zaman zaman normal sınırların dışında değerler görülmesine rağmen, 1 yıl boyunca ölçülen bütün parametrelerin ortalamasının, gerek kontrol gerekse deney grubunda normal değerler içerisinde olduğu görülmüştür. Çalışma sürelerine bağlı olarak kadınlarda LDH, erkeklerde ise ALT enziminin kontrol grubuna göre anlamlı artışlar gösterdiği, Na ve K'un ise sadece erkeklerde anlamlı artışlar gösterdiği saptanmıştır ($p<0.05$).

Article Info

Research Article
Received: 28/02/2025
Accepted: 21/03/2025

Anahtar Kelimeler

Desfluran, enzim, izofluran, sevofluran, sodyum, potasyum

Öne Çıkanlar

1-Kan örneklerinde enzim aktiviteleri, elektrolit seviyeleri ve hematolojik değerler ölçülmüştür.
2-Kadınlarda LDH, erkeklerde ALT ile Na ve K anlamlı değişiklikler göstermiştir.
3-Halsizlik, yorgunluk, unutkanlık, baş ağrısı, sinirlilik, dalgınlık gibi belirtiler sıkça saptanmıştır.

Investigation of the effects of anesthetic inhalation agents with certain biochemical and hematological parameters

Abstract

In this study, the effects of sevoflurane, desflurane and isoflurane on personnel working in 4 different hospitals in Turkey were investigated with some biochemical and hematological parameters. A total of 60 anesthesia technicians working in 42 operating rooms were divided into 3 experimental periods, 6-10, 11-15, and 16-20 years, depending on the duration of exposure to the anesthetic agent. 60 individuals with different professions, in the same age range as the experimental group, were selected as the control group. In blood samples, ALT, AST, ALP, CK, CK-MB, LDH, GST and amylase activities and Na+, K+, glucose, urea, total protein, total bilirubin, total cholesterol, triglyceride, leukocyte, erythrocyte, and platelet amounts were measured.

Although values outside the normal limits were occasionally observed in the 120 individuals studied, the average of all parameters measured for 1 year was found to be within normal values in both the control and experimental groups. Depending on the study period, it was determined that LDH in females and ALT in males showed significant increases compared to the control group, while Na and K showed significant increases only in males ($p<0.05$).

Keywords

Desflurane, enzyme, isoflurane, sevoflurane, sodium, potassium

Highlights

1- Enzyme activities, electrolyte levels, and hematological values were measured in blood samples.

2- LDH in females, ALT, Na, and K in male showed significant changes.

3- Symptoms such as weakness, fatigue, forgetfulness, headache, irritability, and absent-mindedness were frequently detected

1. Introduction

Although today considerable progress has been made in the fields of anesthesiology and reanimation, the search for an ideal anesthetic application and anesthetic agent still continues [1]. The anesthetic agents frequently used in operation rooms are sevoflurane, desflurane, and isoflurane. Although the gases used are released into the atmosphere through waste gas collection systems, there is also significant anesthetic gas pollution [2].

The chlorinated hydrocarbon anesthetics and the nitrogen protoxide released into the atmosphere lead to depletion of the ozone layer [3]. Halothane, enflurane, and isoflurane have UV absorption in wavelength of 200-350nm, whereas desflurane and sevoflurane don't, whatsoever. Atmospheric half-lives vary between 4 and 150 years dependent on OH^- and UV photolysis. In this sense, they also cause serious environmental problems [4].

It has been long argued that undesirable side effects have been observed in patients given anesthesia. In these patients, side effects such as muscle, bronchial, tracheal and larynx spasms have been noticed. Furthermore, all inhalation agents trigger malignant hyperthermia, but they rarely cause genetic damage [5,6]. There are a lot of factors that may lead to the contamination of the medical personnel with the anesthetic substance before, during, and after the anesthesia application period. The most important of the factors is a potential leak from any part of the high-pressure system stretching from the anesthetic agent cylinder till the flow meter. Similarly, this situation is valid for the period when anesthesia is not given. There may be a leak in electricity flow from a wrongly-placed facemask or from the various connections in the low-pressure system, which begins from the flow meter and ends in the patient himself. Nitrous oxide and halogenated substances such as sevoflurane, desflurane, isoflurane and enflurane are found in the waste gases. It has been stressed that the medical personnel working in operation rooms are subject to certain adverse effects of these gases such as headache, nervousness, nausea, exhaustion, fatigue, insomnia, difficultly in decision-making, lack of coordination, liver and kidney diseases. Besides, it has been argued that the gases mentioned above are effective on birth defects, frequency of cancer cases, genetic damage, and lack of concentration [7].

It has been reported that isoflurane is a more reliable agent compared with others in terms of chronic and acute toxicity, desflurane and sevoflurane cause little damage to hepatocytes, but transaminases increase after desflurane anesthesia [8, 9]. Sevoflurane ($C_4H_3F_7O$) is metabolized in the body at a rate of 3-5%. Desflurane ($CF_3CFHOCF_2H$), a methyl ether, differs from isoflurane ($C_3H_2ClF_5O$) in that the alpha ethyl radical contains a fluorine atom instead of a chlorine atom. This change reduces the solubility of the molecule in the blood. Desflurane is defluorinated in the liver by an isoform of the 2E1 fraction of cytochrome P450. Almost all studies conducted so far appear to include results obtained through the analysis of the blood parameters of experiment animals and patients given anesthesia. As there are few studies dealing with the personnel in operation rooms, in this study the effects of sevoflurane, desflurane, and isoflurane on the anesthesia technicians working in the operation rooms of four different hospitals in Bursa were examined based on results from biochemical parameters [glutathione S-transferase (GST), lactate dehydrogenase (LDH), amylase, alkaline phosphatase (ALP), aspartat aminotransferase (AST), alanine aminotransferase (ALT), creatine kinase (CK), creatine kinase-myocardial band (CK-MB), total bilirubin, sodium (Na), potassium (K), total cholesterol, triglyceride, total protein, glucose, urea] and hematologic parameters [leucocytes, erythrocytes, thrombocyte]. Therefore, this study has aimed to make a distinct contribution to the researches carried out to investigate how much the personnel exposed to anesthetic agents because of their profession are affected by anesthetic inhalation agents.

2. Material and method

2.1. Material

42 operation rooms in total in 4 different hospitals located in Bursa have been the subject of this study. The hospitals have been selected, taking into consideration their similarity in the number of personnel, in the devices used, and in the conditions in operation rooms. Anesthesia technicians (30 males and 30 females) were selected as the experiment group. As permission was obtained from the hospital chief doctor, anesthesia technicians were talked to, and individuals were made to sign "Informed Consent Forms for Applications". Experimental groups were created by applying a survey to selected individuals. In control group 30 males and 30 females from various occupations but at the same age as those in the experiment group, who had not been given anesthesia before, whatsoever were selected. All permissions related to the research were obtained and experiments were started.

2.2. Method

A questionnaire was applied to the individuals in question. The individuals who were subject to trial were studied under 3 periods which are those below 30 years of age (6-10 years of experience), those between 31-40 years of age (11-15 years of experience), and those above 41 years of age (16-20 years of experience).

Blood samples were taken 4 times (March, June, September, and December) in periods of 3 months during the whole year from individuals selected to take part in the study, between 08:00 - 09:00 in the morning after 8 hours on fasting stomach. Special attention was paid to the fact that individuals hadn't taken any drug, nor had they suffered any acute disease over a period of 10 days before the blood-taking procedure. Biochemical parameters (LDH, ALP, Amylase, ALT, AST, CK, CK-MB, glucose, urea, total bilirubin, sodium, potassium, total cholesterol, triglyceride, total protein) were measured in Dade Behring brand device (RXL Dimension), whereas hematological parameters (erythrocytes, leucocytes, thrombocyte) were measured in Beckman Coulter brand blood counting device (HMX Hematology). GST enzyme activity, on the other hand, was determined in the CECIL5000 brand spectrophotometer [10].

The reference intervals in clinic laboratories were determined according to the recommendations of the National Committee for Clinical Laboratory Standards (NCCLS) and the International Federation of Clinical Chemistry (IFCC). The data obtained were assessed, using SPSS 10.0 statistics programme. The relation between control and experiment groups was established through an independent t-test and $p<0.05$ values were accepted as statistically significant. Values were given as mean ± standard error.

3. Result and discussion

The sizes of the operation rooms numbered 42 in total in hospitals A, B, C, and D range from 15 to 50m^2. AMS 8500 as an anesthesia machine is used in all hospitals; in hospital A, the AMS 6200 machine is used as well. While mostly closed and occasionally semi-closed systems are used in hospitals A, B, C, in hospital D closed system is generally used, but for patients who are children under weight of 10 kg semi-closed one is preferred. In all studied hospitals, sevoflurane, desflurane, and isoflurane are used as anesthetic agents. Consequent on the questionnaire applied on both male and female individuals in the experiment group, it was noticed that the mutual complaints were dizziness, debility, oblivion, fatigue, headache, nervousness, and lack of concentration, while in some individuals, anemia, panic attack, uneasiness, and skin damage were observed. Though values beyond normal limits were occasionally seen in 120 individuals who were subjects of the study, the averages of all parameters measured throughout a whole year, whether in the control group or in experiment one, were found to be within acceptable limits. From the enzymes examined in the study, only LDH enzymes were seen to have significant results in female individuals compared to those of the control group, whereas in male individuals, only ALT enzyme yielded significant results compared to those of the control group. Na and K, on the other hand, were seen to be significant only in males (Table 1 and 2, $p<0.05$). However, the lowest AST activity in female was recorded as 23.33±1.30 U/L in the control group working for 11-15 years, while the highest value was recorded as 30.44±0.88 U/L in people working for 16-20 years (Table 1). No statistically significant variations were observed in the activity of GST, which is one of the most important detoxification enzymes known (Table 2).

Patients undergoing operation are acutely exposed to such agents once or several times in their lives, whereas medical personnel in operation rooms are chronically exposed to these agents via inhalation. Furthermore, a patient is affected only by several of the agents; medical personnel, on the other hand, are chronically affected by each of them. According to the data at hand, significant differences between the level of serum glucose and exposure to anesthetic agents have not been observed ($p>0.05$ Table 1). However, in their study dealing with the effects of anesthesia with sevoflurane on the secretion of insulin and glucose metabolization in pigs, Shozo et al noted that the levels of catecholamine rose during anesthesia, and further determined that the level of cortisol in the group given anesthesia was also considerably high [11]. Studies conducted with desflurane anesthesia have suggested that there is a certain increase in fasting serum glucose at the end of the operation, but it returns to normal values after 24 hours [12,13]. A study with sevoflurane and desflurane showed that insulin levels were normal in the first minutes, but there were significant increases at 2 hours [14]. Gonzales et al. applied isoflurane to rabbits and showed significant increases in glucose, AST, urea, and creatinine levels [15].

In our study, no significant difference was observed in the average levels of the serum urea of the individuals from the experiment group compared to those of the individuals

from the control group ($p>0.05$ Table 1). While neither proteinuria nor glycosuria was detected in 24-hour urine collected from young volunteers exposed to low-flow anesthesia (1-2 Ldk^{-1}), namely, to 3% sevoflurane inhalation, a rise was noted in the enzymes indicating kidney damage (N-acetyl-β-D-glucose aminidase, α-GST). Another study showed that there was no significant difference in urinary protein and glucose excretion and serum creatine urea and creatinine clearance at 24 and 72 hours in sevoflurane and desflurane applications and that there was no nephrotoxicity even in applications lasting 17 hours in low-flow sevoflurane anesthesia [16].

In our study, significant rises in the average of AST enzyme in female individuals of the group exposed to anesthetic agents for a period of 11-15 years as well as the rise in the average of ALT enzyme in males of the same group were established ($p<0,05$ Table 1). Similarly, a significant increase in the average of LDH enzyme in female individuals of the group exposed to anesthetic agents for a period of 6-10 years was also seen ($p<0.05$ Table 2). We suppose that these rises result from a reduction of the hepatic blood flow of inhalation agents. The change in oxidation and hepatic blood flow is considered to be an important factor in the development of liver disruption. Although it was already shown, through experimental studies, that there is a potential for damage to the kidney tubes associated with the duration of anesthesia and toxicity levels of the degradation product, and that changes ranging from deterioration of reabsorption capacity of proximal tubes to necrosis may occur during excretion of sevoflurane and metabolites from kidneys, trials on human are still debatable. We can say that desflurane can be safely applied when appropriate monitoring conditions and an adequately equipped anesthesia machine are provided during the application of low-flow anesthesia, while sevoflurane can only be applied with utmost care. One study suggested that desflurane is a safer inhalation agent than sevoflurane [17]. Topal et al. observed that serum AST, ALT, and GGT activities increased significantly after anesthesia was given to 3 groups administered halothane, isoflurane, and sevoflurane, while an increase was observed between days 2 and 7 in the isoflurane group. They found that at the end of the 14th day, all dogs recovered without any signs of hepatic damage or adverse effects, and they subsequently concluded that sevoflurane and isoflurane were safer anesthetics than halothane [18]. In another study, serum SOD, glutathione peroxidase (GSH-px), selenium, zinc, and copper levels were examined in 30 people who had not been exposed to any anesthetic agent in their lives and in a group consisting of surgical and anesthesia personnel. It was observed that plasma and erythrocyte antioxidants and trace element levels of surgical personnel were significantly lower compared to controls. It was suggested that the antioxidant defense systems of the personnel were affected by free radicals [19].

We think that minimizing the exposure time to these toxic agents may have a certain effect on protection from damage. In separate studies, it has been shown that anesthetic agents taken for a long time can cause deterioration of antioxidant balance by reducing blood flow to the liver and that vitamins E, C, and GSH-px activity are low [20, 21]. Reactive Oxidant Species (ROS) form as a result of normal metabolic activities occurring

endogenetically in the body. By reacting with certain important molecules in the cell (lipid, protein, DNA) ROS induces oxidative damage. Antioxidants have the property to render ROS inactive, thus providing protection against oxidative damage. Sodergen et al also supported the method of giving antioxidants in order to reduce damage to the liver induced by anesthetic agents as well as to provide protection against their harmful effects [22]. In a trial conducted on rats, Özer and Özer showed that the antioxidant property of leucopenia could be used to counter the adverse effects of sevoflurane on the organs as well as to regulate the morphological alterations formed thereupon [23].

In our study, no significant differences were detected in the values of amylase, ALP, and total bilirubin either in males or females exposed to anesthetic agents when compared to those of the control groups ($p<0.05$ Table 2). However, a study showed that isoflurane increased AST and ALP values and increased AST values even more 24 hours after surgery [24]. The average Na values in male subjects in the group exposed to anesthetic agents for a period of 6-10 years, and the average K values in males in the group exposed to anesthetic agents for a period of 16-20 years were found to have significantly increased ($p<0.05$ Table 2). In another study, the glucose, urea, Na, K, and Cl values in the blood samples of patients exposed to sevoflurane and isoflurane were compared and it was determined that the values related to the measurements of the respiratory and circulatory systems and the data related to the biochemical values were within the normal reference ranges in all time periods [25]. No significant difference was established when CK and CK-MB data obtained from all individuals studied were compared to those of the control ($p>0.05$ Table 2). Similarly, Hemmerling et al. showed that serum CK-MB values did not change in sevoflurane and desflurane groups [26]. Sevoflurane protects the heart against chemically induced ATP depletion, oxidative stress, and calcium influx through the formation of reactive oxygen particles and in other many ways [27, 28]. In our study, no significant change was observed in the cholesterol, triglyceride, and total protein values measured in all subjects in the group exposed to anesthetic agents compared to the control group ($p>0.05$, Table 2). Some studies have suggested that anesthetics disrupt the membrane structure and increase the amount of serum total protein [29, 30].

In our study, the values of GST activity measured in both male and female subjects exposed to anesthetic agents were seen to be insignificant when compared to the values of the control group ($p>0.05$, Table 2). Wissing and Kuhn suggested that the changes in GST activity after anesthesia are associated with the occurrence of short-term hepatocellular damage [31]. In our study, no significant difference was observed in the values of leukocytes, erythrocytes, and platelets in male or female subjects exposed to anesthetic agents compared to the control group ($p>0.05$, Table 2). In an in vitro study by Horn and Rossi, it was determined that sevoflurane disrupted platelet aggregation [32], while another study suggested that desflurane had no effect on platelets [33]. Another study showed that sevoflurane, although ineffective in female rats, repaired erythrocyte deformation in male rats. It was thought that testosterone may have an effect on the flexibility of erythrocytes [34].

When the results of the questionnaire applied to 60 anesthesia technicians were analyzed, it was found that the average complaints were weakness, dizziness, fatigue, forgetfulness, headache, irritability, and lack of concentration; It was observed that some individuals expressed complaints such as anemia, panic attacks, restlessness and skin damage. We think that the factor contributing to all these complaints is closely related to the long stay in operating rooms known as closed places, the increase in the amount of CO_2 released in operating rooms, and the waste of anesthetic agents. Studies have shown that agents such as desflurane and sevoflurane release CO_2 into the environment [35]. The fact that similar results were seen in both patients and operating room personnel suggests that the precautions taken were insufficient or the devices used were quite old.

It has been observed that operating room personnel exposed to such anesthetics for a long time may have adverse effects such as malignancy, neuropathy, bone marrow toxicity, infertility, and miscarriage. Moreover, it has been suggested that it may cause suppression of the immune system and some hormonal disorders [36]. The mutagenic effects of inhalation anesthetics commonly used today have been investigated in bacterial and mammalian cell structures. Some studies have shown that inhalation anesthetics (nitrous oxide, halothane, enflurane, isoflurane, sevoflurane, and desflurane) have no mutagenic potential and do not cause DNA damage [37]. However, genetic differences between individuals may affect the pharmacodynamics of the toxicant. A low dose may be ineffective in one person but life-threatening in another [38].

Although no significant differences were observed in biochemical and hematological values in our study, we cannot assume that these toxic agents do not harm our bodies. In a study conducted by Sezen et al., aiming to investigate the effects of subanesthetic concentrations of desflurane and sevoflurane on the behavior of rats, their liver and kidney toxicity, and biochemical and histopathological changes, 24 rats were exposed to anesthetic gases in an anesthesia room between 09:00 and 13:00 for 4 months. For anxiety assessment, the "Plus Maze Test" was applied, and blood samples were analyzed for urea, creatinine, and GGT levels before and after the experiment. At the end of the experiment, the rats were sacrificed, and their liver and kidneys were examined histopathologically. As a result, they concluded that the use of sevoflurane and desflurane at subanesthetic concentrations increased anxiety in rats and that sevoflurane at these concentrations could cause subclinical damage to the liver and kidneys [39].

4. Conclusion

Mostly closed systems and occasionally semi-closed ones were in use in the four hospitals, which were the subject of our study. The anesthetic inhalation agents given to the patients were made inhaled into their respiratory system via a catheter during the application of anesthesia. In a closed system, the air exhaled by the patient is transferred to the waste system through a hose, from which waste gas is released into the atmosphere. The effect of the gases released into the atmosphere upon the environment is a matter of

debate, too. However, much attention to the application of closed-systems in operation rooms is paid today, and anesthetic agents, though in trace amounts, are certainly released into the surrounding air. What's more, the risk is thought to be much higher in patients who are children. Only now, people who have been doing professional engagement with anesthetic agents for a long time benefit from the new techniques developed. The reliability of the systems in the past is still an issue of debate. According to the American Occupational Health and Safety Administration, especially anesthesiologists, surgical nurses, obstetricians, and surgeons have claimed that they are at risk of contracting various work-related diseases because they are frequently exposed to waste anesthetic gases [40]. To conclude, the medical personnel should not put their health at risk, while trying to provide health care to others [2].

Conflict of interests

Egemen DERE is Fatma ARI ABACI's doctoral thesis advisor. Our article does not contain the data of any person. The authors do not have any conflict of interest regarding the content of this article.

We declare that we have transferred all rights to the publication.

The study was not supported by any financial source. The doctoral thesis topic was accepted by Bursa Uludağ University, Institute of Science and Technology, and as a result of the exam held on June 30, 2008, it was accepted as a doctoral thesis study and the title of doctorate in Biology was given by our Institute of Science with the decision dated 21/08/2008 and 2008/17/1a.

Acknowledgment

We would like to thank the Chief Doctor and Biochemistry Laboratory of Bursa SSK Hospital

Table 1. The average of certain biochemical parameters measured in terms of exposure and age group

Parameters		-30 old, 6-10 years *of experience*		31-40 old, 11-15 years *of experience*		41- old, 16-20 years *of experience*	
	Sex	Control (n=22) Ort ± SE	Experiment (n=22) Ort ± SE	Control (n=26) Ort ± SE	Experiment (n=26) Ort ± SE	Control (n=12) Ort ± SE	Experiment (n=12) Ort ± SE
Glucose (70-110 mg/dl)	♂	86.31±1.73	82.04±1.89	84.31±1.80	83.71±1.81	84.69±3.55	87.38±3.27
	♀	83.86±2.45	80.42±1.56	87.85±3.2	84.46±2.15	87.75±2.04	87.78±2.36
Urea (10-52 mg/dl)	♂	27.75±2.13	30.33±2.69	26.77±2.46	29.69±2.19	41.44±0.74	33.31±4,33
	♀	29.53±3.02	28.67±3.07	25.67±2.43	32.00±2.72	32.25±3.52	32.31±3.42
AST (15-37 U/L)	♂	26.58±1.02	26.57±0.2	26.06±0.28	27.35±0.81	27.32±1.06	29.19±0.36
	♀	26.19±1.35	26.28±0.64	23.33±1.30	26.94±0.89	29.47±1.49	30.44±0.88
ALT (30-65 U/L)	♂	38.25±0.90	39.27±0.66	41.90±0.94	43.52±0.72*	49.31±0.50	49.69±0.79
	♀	39.25±1.17	39.31±0.70	40.87±0.89	42.23±0.66	46.66±1.08	48.28±1.39
CK (38-65 U/L)	♂	91.02±6.43	94.88±6.61	85.40±6.53	83.81±7.91	109.44±19.56	98.63±9.31
	♀	74.31±7.46	81.50±7.46	77.18±7.74	83.03±6.25	61.06±5.21	85.31±6.58

CK-MB	♂	16.17±0.92	16.77±1.15	16.02±1.19	17.48±1.06	16.88±2.69	18.44±1.13
(0-24 mg/dl)	♀	18.31±1.20	17.31±1.63	15.17±1.34	17.33±1.31	16.06±2.15	20.59±0.96
Total bilirubin	♂	0.69±0.05	0.86±0.08	0.73±0.05	0.69±0.07	0.67±0.11	0.86±0.08
(0-1.0 mg/dl)	♀	0.66±0.06	0.72±0.07	0.65±0.05	0.69±0.06	0.66±0.06	0.72±0.08
Sodium	♂	138.00±0.29	140.48±0.59*	139.27±0.59	140.25±0.65	138.94±1.28	139.88±0.8
(136-145 mmol/L	♀	139.06±0.43	139.78±0.73	140.17±0.69	140.19±0.46	140.34±0.86	140.25±0.3
Potassium	♂	4.08±0.09	4.16±0.09	4.08±0.08	44.20±0.08	3.82±0.15	4.46±0.28*
(3.5-5.1 mmol/L	♀	4.09±0.07	4.04±0.08	4.07±0.11	4.18±0.12	4.12±0.09	4.53±0.03

Values in the table are the averages of the measurements performed in different months
* Values are significant when compared to those of the control group ($p<0.05$)

Table 2. The Average of Certain Biochemical Parameters Measured in Terms of Exposure and Age Group

Parameters		-30 old, 6-10 years *of experience*		31-40 old, 11-15 years *of experience*		41- old, 16-20 years *of experience*	
	Sex	Control (n=22) Ort ± SE	Experiment (n=22) Ort ± SE	Control (n=26) Ort ± SE	Experiment (n=26) Ort ± SE	Control (n=12) Ort ± SE	Experiment (n=12) Ort ± SE
LDH	♂	137.35±1.46	137.54±1.36	143.21±2.00	144.81±1.59	153.38±1.93	153.50±1.57
(100-190 U/L)	♀	134.28±1.32	138.39±1.49*	145.25±1.60	146.19±1.49	151.81±1.72	153.94±1.85
AmylASE	♂	60.15±5.31	61.15±4.98	67.75±6.53	69.15±5.04	65.56±8.25	76.31±10.
4(25-115 U/L)	♀	65.81±5.25	69.30±5.58	63.65±4.90	68.46±5.45	68.15±6.17	69.75±7.70
ALP	♂	92.60±5.19	90.82±4.91	94.15±4.65	86.92±4.11	90.19±12.46	83.50±12.64
(50-136U/L)	♀	73.94±3.57	78.44±4.16	78.90±3.945	82.38±3.61	73.87±4.85	84.22±6.52
Total cholesterol	♂	148.6±58.80	160.01±6.80	159.17±5.92	165.88±6.20	158.31±20.91	175.44±8.98
(0-200 mg/dl)	♀	150.92±8.62	164.19±5.60	157.13±9.05	163.02±6.93	152.38±21.51	169.09±7.08
Triglyceride	♂	100.27±2.56	107.33±4.11	95.44±2.83	100.96±3.59	99.81±5.18	95.56±2.27
(30-150 mg /dl)	♀	104.78±4.31	94.25±2.73	98.94±4.13	103.09±3.77	101.81±3.24	106.19±7.15
Total protein	♂	7.38±0.05	7.38±0.04	7.39±0.06	7.57±0.05	7.51±0.01	7.33±.0.04
(6.4-8.2 gr/dl)	♀	7.54±0.07	7.38±0.09	7.36±0.07	7.41±0.05	7.45±0.06	7.50±0.06
Leukocyte	♂	7.59±0.28	7.52±0.21	7.43±0.29	7.73±0.22	7.63±0.24	7.82±0.39
(4-10x10^{3}mm^3)	♀	7.70±0.22	7.43±0.30	7.19±0.19	7.37±0.32	7.10±0.19	7.41±0.12
Erytrocyte	♂	5.20±0.07	5.22±0.07	5.24±0.10	5.17±0.12	5.30±0.27	5.08±0.10
(mm^3) (♂4.7-6.2x10^6) (♀4.2-5.4x10^6)	♀	4.23±1.13	4.41±0.41	4.47±0.11	4.40±0.11	4.37±0.12	4.37±0.12
Thrombocyte	♂	250.31±21.2	243.61±22.76	230.48±18.3	234.02±16.2	256.19±35.71	266.44±30.3
(130-400x10^3 mm^3)	♀	211.08±18.6	254,50±26.73	230.09±19.9	231.09±19.4	230±30.27	234.34±32.3
GST	♂	1.260±0.087	1.094±0.07	1.007±0.065	1.222±0.058	1.023±0.075	1.140±0.138
U/mg protein	♀	1.191±0.126	1.146±0.103	1.308±0.054	1.123±0.09	1.249±0.128	0.978±0.095

Values in the table are the averages of the measurements performed in different months
* Values are significant when compared to those of the control group ($p<0.05$)

5. References

[1] Seger C., Cannesson M. Recent advances in the technology of anesthesia F1000Research, 18:9:F1000 Faculty Rev-375(1), (2020). doi:10.12688/f1000research.24059.1

[2] Kiani F., Jorfi S., Soltani F., Ghanbari S., Rezaee R., Mohammadi M.J. Exposure to anesthetic gases in the operating rooms and assessment of non-carcinogenic risk among health care workers. Toxicology Reports 11:1-8, (2023). doi:10.1016/j.toxrep.2023.06.007

[3] Köner Ö. Anesthetic gases do harm to the environment, Is it time for a change? Turk Journal Anaesthesiology and Reanimation. 50:1 6–7, (2022). doi:10.5152/TJAR.2022.7222

[4] Andersen M.P.S., Nielsen O.J., Wallington T.J., Karpichev B., Sander S.P. Assessing the impact on global climate from general anesthetic gases. Anesthesia & Analgesia, 114:5 1081-1085, (2012). doi:10.1213/ANE.0b013e31824d6150

[5] Andemeskel Y., Elsholz T., Gebreyohannes G. Undesirable postoperative anesthesia outcomes at two national referral hospitals: A cross-sectional study in eritrea Anesthesiology Research and Practice, 9 1-8, (2020). doi:10.1155/2020/9792170

[6] Panditrao M.M., Panditrao M.M. Anaesthesia and genetics: still, the uncharted territories. Journal of Anesthesia & Critical Care: Open Access. 4:1 16-19, (2016). doi: 10.15406/jaccoa.2016.04.00123

[7] NIOSH. Waste anesthetic gases-occupational hazards in hospitals. National Institue for Occupational Safety and Healthy 151 1-9, (2007).

[8] Brioni J.D., Varughese S., Ahmed R., Bein B. A clinical review of inhalation anesthesia with sevoflurane: from early research to emerging topics. Journal of Anesthesia. 31:5 764-778, (2017). doi:10.1007/s00540-017-2375-6

[9] Aslan E., Gönen C., Saltürk A., Güzelbulut F. Hepatotoxicity after desflurane anesthesia. Haydarpasa Numune Medical Journal. 58:4 224-226, (2018). doi:10.14744/hnhj.2018.44265

[10] Habig W.H., Pabst M.J., Jakoby W.B. Glutathione S-transferases. Journal of Biological Chemistry. 249:22 7130-7139, 1974.

[11] Shozo S., Yoshitami K., Teruko S., Junko M., Takeshi T., Nozomu Y. The effects of sevoflurane anesthesia on insulin secretion and glucose metabolism in pigs. Anesthesia & Analgesia 84:6 1359-1365,1997. doi:10.1097/00000539-199706000-00034

[12] Weiskopf R.B., Eger E.I., Ionescu P., Yasuda N., Cahalan M.K., Freire B., Peterson N., Lockhart S.H., Rampil I.J., Laster M. Desflurane does not produce hepatic or renal injure in human volunteers. Anesthesia & Analgesia. 74:4 570-576, 1992. doi:10.1213/00000539-199204000-00018.

[13] Fanga X., Xiaa T., Xua F., Wua H., Maa Z., Zhaoa X., Gua X. Isoflurane aggravates peripheral and central insulin resistance in high-fat diet/streptozocin-induced type 2 diabetic mice. Brain research 1727, 2020. doi:10.1016/j.brainres.2019.146511

[14] Özdemir H., Kaymak Ç., Kılınç A.Ş., Uncugil F., Takmaz S.A., Karabıyık L., Dikmen B. The assessment of stress response under desflurane and sevoflurane anesthesia. Turkiye Klinikleri Journal of Anesthesiology Reanimation. 451-457, 2006

[15] Gil A.G., Silvan G., Illera J.C. Pituitary-adrenocortical axis, serum serotonin and biochemical response after halothane or isoflurane anesthesia in rabbits. Labaratory Animals. 41:4 411-419, 2007. doi:10.1258/002367707782314274

[16] Kharasch E.D., Frink E.J., Artru A., Michasowski P., Rooke G.A., Nogami W.N. Long duration low-flow sevoflurane and isoflurane effect on postoperative renal and hepatic

function. Anesthesia & Analgesia. 93:6 1511-1520, 2006. doi:10.1097/00000539-200112000-00036.

[17] Soliman R., Yacoub A., Abdellatif M. Comparative effect of desflurane and sevoflurane on liver function tests of patients with impaired hepatic function undergoing cholecystectomy: A randomized clinical study. Indian Journal Anaesthesia. 64:5 383–390, 2020. doi:10.4103/ija.IJA_168_20

[18] Topal A., Gül N., İlçöz Y., Görgül O.S. Hepatic effects of halothane, isoflurane or sevoflurane anesthesia in dogs. Journal of veterinary medicine. A, Physiology, pathology, clinical medicine. 50:10 530-533, 2003. doi: 10.1111/j.1439-0442.2004.00589.x.

[19] Türkan H., Ayfın A., Sayal A. Effect of volatil anesthetics on oxidative stress due to occupational exposure. World Journal of Surgery. 29:4 540-542, 2005. doi: 10.1007/s00268-004-7658-z.

[20] Karakıcık A.Z., Hayat A., Zerin M., Cay M. Effect of intraperitoneally injected selenium and vitamin E in rats anesthetized with halothane. Journal of Trace Elements in Medicine and Biology. 17 33-38, 2003. doi:10.1016/S0946-672X(03)80043-3.

[21] Dikmen B., Ünal Y., Pampal H.K., Nurlu N., Kurtipek O., Canpolat O., Ozoğul C., Kavutcu M. Effects of repeated desflurane and sevoflurane anesthesia on enzymatic free radical scavanger system Molecular and Cellular Biochemistry. 294:1-2 31-36, 2007. doi:10.1007/s11010-006-9207-6. Epub 2006 Nov 29.

[22] Sondergen E., Cederberg J., Vessby B., Baus S. Vitamin E reduced lipid peroxidation in experimental hepatotoxicity in rats. European Journal of Nutrition. 40:1 10-16, 2001. doi:10.1007/pl00007381.

[23] Özer A.B., Özer S. 2007. The effect of likopen on histopatological changes in rats induced by sevoflurane. Fırat Üniversitesi Sağlık Bilimleri Tıp dergisi. 21:3 103-108, 2007.

[24] Oladimeji M.A., Desalu I., Adekola O.O., Akanmu O., Adesida A.A. A Comparison of the Effect of Isoflurane and Propofol on Liver Enzymes. Journal of West African College of Surgeons. 12:2 28–33, 2022. doi:10.4103/jwas.jwas_69_22.

[25] Işık B., Pamukcu Z., Alagöz A., The effect of sevoflurane and isoflurane on cognitive functions in early post-operative period. Inönü University Magazine of faculty of Medicine. 14:5 149-155, 2007.

[26] Hemmerling T., Prietio M.D.I., Basık F., Noiseux N. Desflurane causes more atrial fibrillation and tachycardia after off-pump aorta-coronary bypass grafting (OPCAB) than sevoflurane. Canadian Journal of Anesthesia. 53:1 26414, 2006. doi:10.1007/BF03017017

[27] Cromheeck S., Broecke P.W., Hendrickx E., Meeus R., Hert S.G. Incidence of atrial fibrillation early after cardiac surgery: Can choice of the anesthetic regimen influence the incidence? Acta Anaesthesiologica Belgica. 56:2 147-154, 2005.

[28] De Ruijter, W., Musters R.J.P., Boer C., Steinen G.J.M., Simonides W.S., de Lange J.J. The cardioprotective effect of sevofluranee depends on protein kinase C activation, opening of mitochondrial K(+)ATP channels, and the production of reactive oxygen species. Anesthesia & Analgesia. 97:5 1370-1376, 2003. doi:10.1213/01.ANE.0000081786.74722.DA.

[29] Franks N.P., Lieb W.R. Molecular and cellular mechanism of general anesthesia. Nature. 367 607-614, 1994. doi:10.1038/367607a0.

[30] Boscan P., Watson Z., Steffey E.P. Plasma colloid osmotic pressure and total protein trends in horses during anesthesia. Veterinary Anesthesia Analgesia. 34:4 275-283, 2007. doi:10.1111/j.1467-2995.2006.00326.x.

[31] Wissing H., Kuhn I. The effect of desflurane on liver function markers in infants and children. Acta Anaesth Scandinavica. 44 1149-1153, 2000. doi:10.1034/j.1399-6576.2000.440920.x

[32] Horn N.A., Rossi L. Sevofluranee inhibits unstimulated and agonist. Induced platelet antigen expression and platelet function in whole blood in vitro. Anesthesiology. 95 1220-1225, 2001. doi:10.1097/00000542-200111000-00028

[33] Türkan H., Beyan L., Karabıyık L., Güner D., Kaptan K. The effects of desflurane on human platelet aggregation in vitro. International Journal of Hematology. 80:1 91-93, 2004. doi:10.1532/ijh97.e0309.

[34] Yerer M.B., Aydogan S., Comu F.M., Gender-related alerations in erythrocyte mechanical activities under desflurane or sevoflurane anesthesia. Clinical Hemorheology Microcirculation. 39:1-4 423-427, 2008. doi.org10.3233/CH-2008-1113

[35] Coppens M.J., Versichelen .LF.M., Rolly G., Mortier E.P., Struys M.M. The mechanisms of carbon monoxide production by inhalation agents. Anesthesiology. 61:5 462-468, 2006. doi:10.1111/j.1365-2044.2006.04536.x.

[36] Rosenberg P.H., Varitinnen H. Occupational hazards to reproduction and health in anaesthetics and paediatricians. Acta Anaesthesiologica Scandinavica. 22:3 202-207, 1978. doi:10.1111/aas.1978.22.3.202

[37] Khan K.S., Hayes I., Buggy D.J. Pharmacology of anaesthetic agents II: Inhalation anaesthetic agents. Continuing Education in Anaesthesia Critical Care & Pain, 14:3 106-111, 2013. doi:10.1093/bjaceaccp/mkt038

[38] Nair A.S. Pharmacogenomics of inhalational anesthetic agents. Medical Gas Research. 9:1 52–53, 2019. doi: 10.4103/2045-9912.254641

[39] Sezen G., Demiraran Y., Kocaman A.B., Aksoy A. Subanestezik konsantrasyonlarda solutulan desfluran ve sevofluranın sıçanlarda karaciğer ve böbrek toksisitesi ile davranışları üzerine etkileri. Türk Anestezi ve Reanimasyon Dergisi. 35:2 83-89, 2007.

[40] Miarta A., Lestari M.I., Zulkifli. Waste anesthetic gase: A forgotten problem. Journal Anesthesiology and Clinical Research. 1 15-25, 2020. doi.org/10.37275/jacr.v1i1.134