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Research Article / Araştırma

The Effect of One-Lung Ventilation on Cerebral Oxygenation and Neurocognitive Functions

Tek Akciğer Ventilasyonunun Serebral Oksijenizasyon ve Nörokognitif Fonksiyonlar Üzerine Etkisi

Kübra Taşkın,[1] Gülten Arslan,[1] Fatih Doğu Geyik,[1] Cansu Akın,[2] Recep Demirhan,[3] Banu Çevik[1]

[1]**Department of Anesthesiology and Reanimation, University of Health Sciences, Istanbul Kartal Dr. Lütfi Kirdar City Hospital, Istanbul, Turkey**
Sağlık Bilimleri Üniversitesi, İstanbul Kartal Dr. Lütfi Kırdar Şehir Hastanesi, Anesteziyoloji ve Reanimasyon Kliniği, İstanbul, Türkiye

[2]**Department of Anesthesiology and Reanimation, University of Health Sciences, Fatih Sultan Mehmet Training and Research Hospital Hospital, Istanbul, Turkey**
Sağlık Bilimleri Üniversitesi, Fatih Sultan Mehmet Eğitim ve Araştırma Hastanesi, Anesteziyoloji ve Reanimasyon Kliniği, İstanbul, Türkiye

[3]**Department of Thoracic Surgery, University of Health Sciences, Istanbul Kartal Dr. Lütfi Kırdar City Hospital, Istanbul, Turkey**
Sağlık Bilimleri Üniversitesi, İstanbul Kartal Dr. Lütfi Kırdar Şehir Hastanesi, Göğüs Cerrahisi Kliniği, İstanbul, Türkiye

ABSTRACT

Objectives: It is aimed to show the effect of one-lung ventilation (OLV) on cerebral oxygenation and neurocognitive functions.

Methods: Fifty ASA I-III patients who will undergo thoracic surgery and OLV for more than 1 h were included in the prospective study. Standardized Mini-Mental State Examination (SMMSE) was applied to evaluate the pre-operative neurocognitive functions. The patients were divided into two groups as non-desaturation (n=32) and desaturation (n=18). The same test was repeated on the 3rd and 7th post-operative days.

Results: Considering the mean age, ASA score, and duration of surgery and OLV of the desaturation group, it was found that the basal rSO_2 values were significantly higher than the non-desaturation group. In both groups, a decrease was observed in the SMMSE values on the post-operative 3rd day, but the decreases were found to be significant on the 3rd and 7th days in the desaturation group. In the desaturation group, a statistically significant correlation was found between the percentage changes in the post-operative 3rd and 7th days according to the pre-operative SMMSE values and the percentage changes in rSO_2 compared to the baseline. There was a significant positive correlation between mean arterial pressure and rSO_2 in the lateral decubitus position in both groups.

Conclusion: As a result, many conditions may cause cerebral desaturation in OLV; it is thought that this should be followed up closely by cerebral oximetry and thus post-operative neurocognitive dysfunction and other complications can be prevented.

Keywords: Cerebral oxygen saturation, one-lung ventilation, post-operative cognitive dysfunction, thoracic surgery

ÖZ

Amaç: Bu çalışmada, tek akciğer ventilasyonunun serebral oksijenizasyon ve nörokognitif fonksiyonlar üzerine etkisinin gösterilmesi amaçlandı.

Yöntem: Prospektif planlanan bu çalışmaya torasik cerrahi geçirecek, bir saatten uzun süre tek akciğer ventilasyonu uygulanacak ASA I-III 50 hasta dahil edildi. Preoperatif nörokognitif fonksiyonları değerlendirmek için standardize mini mental test uygulandı. Hastalar nondesatüre (n=32) ve desatüre (n=18) olmak üzere iki gruba ayrıldı. Postoperatif üçüncü ve yedinci gün aynı test tekrarlandı.

Bulgular: Desatüre grubun yaş ortalaması, ASA skoru, cerrahi ve tek akciğer ventilasyonu süresi nondesatüre gruptan istatistiksel olarak anlamlı derecede yüksek, bazal rSO_2 değerleri ise düşük bulundu ($p<0,05$). Her iki grupta postoperatif üçüncü günde standardize mini mental test değerlerinde düşme gözlendi ancak düşmeler desatüre grupta üçüncü ve yedinci günlerde anlamlı bulundu ($p=0,002$, $p=0,014$). Desatüre grupta preoperatif standardize mini mental test değerlerine göre postoperatif üçüncü ve yedinci gündeki yüzde değişimler ile bazale göre rSO_2'de yüzde değişimler arasında istatistiksel olarak anlamlı korelasyon saptandı. Kalp atım hızı ve end tidal CO_2 değerleri de desatüre grupta düşük bulundu ($p<0,05$). Her iki grupta lateral dekübit pozisyonda ortalama arter basıncı ile rSO_2 arasında pozitif yönde anlamlı korelasyon gözlendi.

Sonuç: Tek akciğer ventilasyonunda birçok mekanizmanın serebral desatürasyona sebep olabileceğini; bunun serebral oksimetre ile yakın takibinin gerektiğini ve böylelikle postoperatif nörokognitif disfonksiyonun ve diğer komplikasyonların önüne geçilebilir.

Anahtar sözcükler: Postoperatif kognitif disfonksiyon, serebral oksijen satürasyonu, tek akciğer ventilasyonu, torasik cerrahi

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Address for correspondence: Kübra Taşkın, MD. Sağlık Bilimleri Üniversitesi, Kartal Dr. Lütfi Kırdar Şehir Hastanesi, Anesteziyoloji ve Reanimasyon Kliniği, İstanbul, Türkiye

Phone: +90 534 644 81 34 **E-mail:** drkubrataskin@gmail.com

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Introduction

One-lung ventilation (OLV); it is a standard approach that provides lung isolation that allows surgical operation in pulmonary and other thoracic surgeries.[1] OLV, lateral decubitus position (LDP) given to the patient and existing diseases of the patient; it makes anesthesia management special. Excessive strain and hypoxia in the lung ventilated with a OLV can cause serious complications in patients.[2]

One of the complications resulting from hypoxemia during OLV is cerebral desaturation. The incidence of cerebral oxygen desaturation in thoracic surgery is similar to cardiac surgery.[3] In general, anesthesia management can be performed by evaluating the adequacy of cerebral oxygenation with indirect methods such as heart rate (HR), blood pressure, and peripheral oxygen saturation (SpO_2). However, even if there is no change in these routine intraoperative monitoring measurements, a decrease in brain oxygenation can be seen. This decrease can result in cognitive and neurological damage, long hospital stay, and increased hospital costs.[4] Therefore, non-invasive measurement of cerebral oximetry device and near-infrared spectroscopy can be added to monitoring methods for close monitoring of cerebral oxygenation in special operations such as thoracic surgery.[5] With this method, drops can be seen instantly and can be intervened in a short time. Thus, it is thought that cerebral desaturation and related post-operative neurocognitive dysfunction can be prevented.

The aim of the study is to observe the effect of OLV on cerebral oxygenation, neurocognitive functions, and hemodynamic parameters in patients who will undergo thoracic surgery and OLV for at least 1 h.

Methods

The study was approved by Health Sciences University, Hamidiye International Faculty of Medicine Kartal Dr. Lütfi Kırdar City Hospital Ethics Committee approval (Decision no: 2017/514/105/5, Date: April 12, 2017). After the approval of the ethics committee, the prospectively planned study; 50 patients aged between 21 and 70 who were in the ASA I–III risk group who had undergone thoracic surgery were included in the study. It is planned to include lobectomy, chest wall resection, VATS operations among thoracic surgery cases, and exclude pneumonectomy cases from the study. Although FiO_2 was increased during OLV, cases with SpO_2 below 90%, inoperable, hearing and understanding difficulties, cases with OLV duration <1 h, cases with previously known dementia, and a history of cerebrovascular disease were excluded from the study. Standardized Mini-Mental State Examination (SMMSE) was applied 1 day before the operation to evaluate the cognitive functions of the patients. After the electrocardiography, peripheral SpO_2, non-invasive blood pressure monitoring of the patients taken to the operation room, and the cerebral SpO_2 measuring device (INVOS™ 5100C) (Covidien, CO, USA) sensors on the right and left sides of the frontal region, the Bispectral Index™ (BIS™, Covidien) is inserted and the values recorded. Values before premedication at room air were taken as baseline values.

Cerebral oxygen desaturation was accepted as a 15–20% decrease in the basal cerebral SpO_2 value measured in the room air before the patient went to sleep. Anesthesia induction of the patients was routinely provided with 1.5-2 mg/kg 1% propofol (Propofol Lipuro 1%, B. Braun Irengun, Turkey), 2 mcg/kg fentanyl (fentanyl 0.05 mg/ml, Johnson and Johnson, Turkey), and 0.6 mg/kg rocuronium (Myocron, Vem Ilaç, Istanbul, Turkey). Maintenance of anesthesia was provided by infusion of 50% O2/air mixture, 1-1.5% sevoflurane, and 0.05 mcg/kg/min remifentanil in 3 lt/min fresh gas flow with a BIS monitoring value between 40 and 60. After intubation with a Robertshaw double lumen tube, the location of the tube was confirmed with FOB.

After the patients were placed in the LDP, the location of the tube was checked again with FOB and OLV was started. In OLV, in volume-controlled ventilation mode, the tidal volume was adjusted to keep the tidal volume 4-6 ml/kg, PEEP 5 cmH_2O, and respiratory frequency $PaCO_2$ between 35 and 45 mmHg. FiO_2 was titrated at the lowest concentration to be SpO_2 >90. Maximum FiO_2 was set to 0.7, and patients with continued low saturation despite this were excluded from the study.

HR, mean arterial pressure, SpO_2 and end-tidal CO_2, BIS, and temperature values before induction (pre-ind), after induction (post-ind), after intubation (post-int), in LDP, two-lung ventilation head (TLV0), and two-lung ventilation 10 min (TLV10), OLV head (OLV0) and every 10 min (OLV10, OLV20, OLV30, OLV40, OLV50, OLV60, OLV70, OLV80, and OLV90) and at the end of OLV (end-OLV), at the end of surgery (end-surg), and at the end of extubation (end-ext) were recorded separately. Arterial blood gas measurements were performed at TLV0, OLV10, and every 1/2 h thereafter.

The right and left basal cerebral SpO_2 values (rSO_2) of the patients before induction were recorded separately, and they were recorded with the INVOS trend monitor throughout the operation. The decrease in cerebral oxygenation compared to basal value was recorded as 0-15 and 15-20. According to the drops in the cerebral oximeter, the patients were divided into two groups as non-desaturation and desaturation. It was planned to intervene and exclude patients with a decrease of more than 20%.

Non-desaturation Group

Those whose cerebral oximetry values fall between 0 and 15 compared to the basal value.

Desaturation Group

Those whose cerebral oximetry values fall between 15 and 20 compared to the basal value 30 min before the end of the operation, to all patients iv 0.15 mg/kg and 1000 mg paracetamol, morphine (Parol 10 mg/ml, Atabey, Turkey) were performed for post-operative analgesia. Neostigmine (0.05 mg/kg) and atropine sulfate (0.015 mg/kg) combination was administered to antagonize the muscle relaxant effect. He was followed up in the recovery room for 1 h by giving 4-6 lt/min oxygen with a mask. Patients were reevaluated with SMMSE on post-operative 3rd and 7th days.

For statistical analysis, IBM SPSS Statistics 22 (IBM SPSS, Turkey) program is used. For the comparison of quantitative data for the two groups, Student's t-test was used for parameters showing normal distribution, and Mann-Whitney U-test was used for parameters that did not show normal distribution. Fisher's exact test, Fisher-Freeman-Halton test, and continuity (Yates) correction were used to compare qualitative data. Paired samples test was used for the evaluation of the parameters showing normal distribution in the evaluations within the groups, and the Wilcoxon sign test was used for the evaluation of the parameters that did not show normal distribution. While Pearson's correlation analysis was used to examine the relationships between parameters suitable for normal distribution, Spearman's rho correlation analysis was used to examine the relationships between parameters not compatible with normal distribution. Significance was evaluated at the level of $p<0.05$.

Results

The cases in the study were examined under two groups, 32 (64%) non-desaturation and 18 (36%) desaturation, according to the decrease in cerebral oximetry values (Table 1). The demographic and some clinical characteristics of the cases are also shown in Table 1.

The post-ind, post-int, LDP, TLV0, TLV10, OLV0, OLV20, OLV30, OLV40, OLV50, OLV60, OLV70, OLV80, end-OLV, and end-surg HR values were found to be statistically significantly higher than the desaturation group (Table 2).

Table 1. Comparison of demographic and clinical characteristics between groups

Parameters	Non-desaturation group (n=32%) Mean±SD	Desaturation group (n=18%) Mean±SD	Total (n=50%) Mean±SD	p
Age (years)	40.91±14.07	57.89±9.14	47.02±14.9	[1]0.000*
Surgery duration (min)	109.06±27.28	141.67±55.23	120.8±42.18	[2]0.045*
OLV duration (min)	89.06±27.28	121.67±55.23	100.8±42.18	[2]0.045*
Gender, n (%)				
Male	28 (87.5)	11 (61.1)	39 (78)	[3]0.041*
Female	4 (12.5)	7 (38.9)	11 (22)	
ASA class, n (%)				
I	24 (75)	4 (22.2)	28 (56)	[4]0.001*
III	8 (25)	14 (77.8)	22 (44)	
Surgery				
Chest wall resection	1 (3.1)	0 (0)	1 (2)	
Right lower lobectomy	3 (9.4)	3 (16.7)	6 (12)	
Right metastasectomy	0 (0)	2 (11.1)	2 (4)	
Right middle lobectomy	1 (3.1)	0 (0)	1 (2)	
Right upper lobectomy	4 (12.5)	9 (50)	13 (26)	[5]0.001*
Right VATS lobectomy	12 (37.5)	0 (0)	12 (24)	
Left metastasectomy	2 (6.3)	0 (0)	2 (4)	
Left VATS lobectomy	9 (28.1)	4 (22.2)	13 (26)	
LDP, n (%)				
Right	11 (34.4)	4 (22.2)	15 (30)	[4]0.563
Left	21 (65.6)	14 (77.8)	35 (70)	

[1]Student's t-test; [2]Mann-Whitney U-test; [3]Fisher's exact test; [4]continuity (Yates) correction; [5]Fisher-Freeman-Halton test. *$p<0.05$. n: Number; SD: Standard deviation; OLV: One-lung ventilation; VATS: Video assisted thoracic surgery; LDP: Lateral decubitus position

Table 2. Comparison of heart rate between groups

Heart rate	Non-desaturation group Mean±SD (beats/min)	Desaturation group Mean±SD (beats/min)	p
Pre-ind	80.03±17.48	81.61±12.42	0.737
Post-ind	91.56±18.62‡	79.61±10.23	0.005*
Post-int	96.44±14.2‡	86.44±11.56	0.014*
LDP	88.03±13.42‡	77.39±13.49	0.010*
TLV0	86.78±16.88‡	75.72±11.26‡	0.017*
TLV10	90.59±13.9‡	75.28±13.56	0.000*
OLV0	87.56±14.69‡	73.94±9.2‡	0.001*
OLV10	85.31±13.13	80.67±11.09	0.211
OLV20	88.31±14.51‡	79.11±9.79	0.010*
OLV30	86.44±14.56	76.72±9.78	0.007*
OLV40	88.69±16.25‡	73.39±8.86‡	0.000*
OLV50	85.31±14.76	71.78±7.68‡	0.000*
OLV60	84.14±13.48	69.19±9.06‡	0.000*
OLV70	80.75±13.88	69.64±9.44‡	0.018*
OLV80	78.71±14.06	66.2±5.73‡	0.008*
OLV90	78.83±13.9	69.6±5.99‡	0.065
End-OLV	82.97±14.86	70.94±8.06‡	0.003*
End-surg	81±14.16	72.67±10.7‡	0.035*
End-ext	88.88±13.61‡	84.17±14.86	0.261

Student's t-test; ‡paired samples test; *p<0.05. Pre-ind: Before induction; Post-ind: After induction; Post-int: After intubation; LDP: Lateral decubitus position; TLV0: Two-lung ventilation head; TLV10: Two-lung ventilation after 10 min, one-lung ventilation head (OLV0) and every 10 min (OLV10, OLV20, OLV30, OLV40, OLV50, OLV60, OLV70, OLV80, and OLV90); End-OLV: End of OLV; End-surg: End of surgery; End-ext: End of extubation.

The TLV0, TLV10, OLV0, OLV10, OLV20, OLV30, OLV40, OLV50, OLV60, OLV70, OLV90, end-OLV, and end-surg $EtCO_2$ values were found to be statistically significantly higher than the desaturation group (Table 3).

In the non-desaturation group, the SMMSE values performed on the pre-operative, post-operative 3rd day, and on the post-operative 7th day were found to be statistically significantly higher than the desaturation group (Table 4).

In the desaturation group, when compared with the pre-operative SMMSE values, the decreases in the post-operative 3rd day and post-operative 7th day SMMSE values were statistically significant (p1:0.000 and p2:0.014) (Table 4).

Compared with the pre-operative SMMSE value of the non-desaturation group, the percentage changes in the post-operative 3rd day SMMSE value were found to be statistically significantly lower than the desaturation group (p:0.005) (Table 5).

In the desaturation group, when compared with the pre-operative SMMSE value, there is a positive, 50.9% statistically significant relationship between the percentage changes in the SMMSE value observed on the post-operative 3rd day and the percentage changes in the rSO_2 mean value according to the baseline value (p:0.031) (Table 6).

When compared with the pre-operative SMMSE value, there is a positive, 48.6% statistically significant relationship between the percentage changes in the post-operative 7th day SMMSE value and the percentage changes in the rSO_2 mean value relative to the baseline value (p:0.041) (Table 6).

There is an inverse and statistically significant relationship between SMMSE values and age, duration of surgery, and OLV duration (p:0.000) (Table 7).

Discussion

In recent years, some clinical and experimental studies have been conducted for post-operative cognitive dysfunctions (POCDs), which are one of the most serious complications of post-operative anesthesia. In the previous studies, age, pre-operative cognitive dysfunction, premedication (such as anticholinergic drugs), and perioperative factors (such as hypoxia and hypotension) were found to be risk factors for POCD.[6] In addition, the pathogenesis of POCD is still not fully known,[7] but it is thought that hypoxemia due to single-lung ventilation causes POCD.[8]

The diagnosis of POCD today is mostly based on neuropsychological tests, but there is no definite opinion about which test to use.[9] Commonly used tests are the Mini-Mental Status Examination (MMSE), the Wechsler Adult Intelligence Scale, and the Wechsler Memory Scale. MMSE is considered to be the most effective cognitive dysfunction screening test due to its short application time and easy re-

Table 3. Comparison of $EtCO_2$ between groups

$EtCO_2$ (mmHg)	Non-desaturation group Mean±SD (beats/min)	Desaturation group Mean±SD (beats/min)	p
Post-int	36.91±3.7	35.89±2.89	0.320
LDP	36.66±3.75	36.33±2.66	0.725
TLV0	36.44±3.86	34.5±2.77‡	0.046*
TLV10	36.69±4.1	34.39±2.43‡	0.016*
OLV0	37.13±3.79	34.28±1.87‡	0.001*
OLV10	37.59±3.81	35.33±1.5	0.005*
OLV20	37.69±3.53	35.56±1.79	0.007*
OLV30	37.5±3.51	35.11±1.6	0.002*
OLV40	37.75±3.86	34.72±1.6	0.000*
OLV50	37.59±3.76	34.44±1.46‡	0.000*
OLV60	38±4.13	34.75±1.48	0.001*
OLV70	37.25±3.71	34.21±1.37	0.007*
OLV80	36.57±3.84	34.08±1.83	0.055
OLV90	36.67±3.17	34.1±1.66	0.032*
End-OLV	36.19±3.38	34.78±1.31	0.042*
End-surg	36.13±3.19	34.17±1.5‡	0.005*

Student's t-test; ‡paired samples test; *p<0.05. Post-int: After intubation; $EtCO_2$:End-tidal carbon dioxide; LDP: Lateral decubitus position; TLV0: Two-lung ventilation head; TLV10: Two-lung ventilation after 10 min, one-lung ventilation head (OLV0) and every 10 min (OLV10, OLV20, OLV30, OLV40, OLV50, OLV60, OLV70, OLV80, and OLV90); End-OLV: End of OLV; End-surg: End of surgery.

Table 4. Comparison of SMMSE scores between groups

SMMSE	Non-desaturation group Mean±SD	Desaturation group Mean±SD	p
Pre-operative	29.38±0.83	28.17±1.25	0.000*
Post-operative 3rd day	28.5±1.22‡	26.89±1.91‡	0.002*
Post-operative 7th day	29.16±1.05	27.83±1.69‡	0.003*

Mann-Whitney U-test; ‡Wilcoxon sign test; *p<0.05. SMMSE: Standardized Mini-Mental State Examination.

Table 5. Comparison of rSO_2 average values and percentage changes of SMMSE on post-operative 3rd and 7th days between groups

Values	Non-desaturation group Mean±SD	Desaturation group Mean±SD	p
Mean rSO_2	72.84±8.81	54.16±4.61	[1]0.000*
SMMSE post-operative percentage change 3rd day	-1±2.11	-4.64±2.87	[2]0.005*
SMMSE post-operative percentage change 7th day	-0.76±1.46	-1.25±1.82	[2]0.156

[1]Student's t-test; [2]Mann-Whitney U-test; *p<0.05. rSO_2: Regional cerebral oxygen saturation; SMMSE: Standardized Mini-Mental State Examination.

Table 6. Correlation analysis between the decrease in SMMSE and percentage changes in average rSO_2

Group	rSO_2 % change	r and p values	SMMSE post-operative percentage change 3rd day	SMMSE post-operative percentage change 7th day
Non-desaturation	Mean	r	0.233	0.051
	rSO_2	p	0.200	0.780
Desaturation	Mean	r	0.509	0.486
	rSO_2	p	0.031*	0.041*

Pearson's correlation analysis. *p<0.05. rSO_2: Regional cerebral oxygen saturation; SMMSE: Standardized Mini-Mental State Examination.

Table 7. Correlation analysis between SMMSE and age, surgery, and OLV duration

Parameters	SMMSE	
	r	p
Age	-0.831	0.000*
Surgery duration+	-0.517	0.000*
OLV duration+	-0.517	0.000*

Pearson's correlation analysis; +Spearman rho correlation analysis; *p<0.05. OLV: One-lung ventilation; SMMSE: Standardized Mini-Mental State Examination.

peatability. A decrease of more than 2 points in the MMSE score is considered as cognitive dysfunction.[10]

Tang et al.[11] evaluated cerebral oxygenation and cognitive functions in their study on 76 thoracic surgery patients who would be applied OLV for more than 45 min. They measured the post-operative 3rd and 24th h using MMSE for the diagnosis of POCD.

In 23% of the patients at the post-operative 3rd h, in 10% at the 24th h; they found a decrease of more than 2 points in their MMSE. POCD correlated with cerebral oxygenation lower than 65%, 60%, and 55%. This study suggests that there may be a relationship between neurological damage manifested as POCD and cerebral desaturation.

In the study conducted by Suehiro and Okutai[12] with 69 patients, it is seen that the percentage and duration of cerebral desaturation seen in lung ventilation may also be clinically significant. Their studies showed that patients with longer desaturation periods had a significant decrease in MMSE scores.

In this study, patients with cognitive dysfunction or dementia and having SMMSE score below 25 were excluded from the study by applying SMMSE preoperatively, and the study continued with patients with normal cognitive functions.

Since there is no consensus on how to diagnose POCD in the literature, instead of making a definite definition of POCD within the scope of the study, the difference in the cognitive functions of the patients with desaturation compared to those who are not desaturation has been shown. Compared to the preoperatively measured values, a decrease in SMMSE scores was observed on the post-operative 3rd day in both the desaturation and non-desaturation groups. However, the decrease in the desaturation group was more than the decrease in the non-desaturation group (two units); the result was found to be statistically and clinically significant. The decrease seen in the non-desaturation group did not correlate with the clinically significant decrease in units. On the 7th day, SMMSE values increased in both groups; it approached the pre-operative values in the non-desaturation group and continued to be lower in the desaturation group than in the non-desaturation group. However, the difference between the baseline values decreased significantly and this showed that the cognitive dysfunction also reversed for the desaturation group over time. In addition, a significant correlation was found between the decreases in average rSO_2 values in the desaturation group and the percentage decreases in SMMSE.

In the literature, it has been shown that there is a negative correlation between cerebral oxygenation and age. Kishi et al.[13] found a negative correlation between age and rSO_2 values in a study; they conducted in 111 patients who were excluded from the study who were scheduled for elective abdominal, gynecological, and orthopedic surgery and who had a history of cerebrovascular disease. Within the scope of this study, the basal right rSO_2 value was 66.11±7.03 and the left rSO_2 value was 65.61±7.24 in the desaturation group, and 74.78±9.09 and 72.19±8.51 in the non-desaturation group, respectively. The mean age of the desaturation group (57.89±9.14 years) was also found to be significantly higher than the non-desaturation group (40.91±14.07 years).

Karzai et al.[14] reported POCD in 26.1% of the patients, Li et al.[15] found similarly in 28%. Although attempts to prevent hypoxemia in OLV, undesirable effects can be seen in 5-10% of patients.[16] Cerebral oxygen monitoring is recommended to prevent these side effects and to intervene early. Li et al.[15] showed that age and rSO_2 are independent risk factors for the development of POCD. In the International Post-operative Cognitive Dysfunction Study 2, the group over 60 years old was compared with the group between 40 and 60 years old, and the incidence of POCD at the 7th day and 3rd month after the operation was found to be higher in the elderly group. It has been suggested that this may be due to decreased central nervous system functions and hemodynamic regulation in elderly patients.[17] Similar to the aforementioned studies, a negative correlation was observed between MSSE values and mean age, duration of surgery, and OLV duration within the scope of this study. In addition, the pre-operative MMSE values of the desaturation group were found to be 28.17±1.25, and it was found to be statistically significantly lower than the non-desaturation group (29.38±0.83). It is thought that the desaturation group's advanced age and having low basal rSO_2 values are the effects of this difference.

Cerebral oxygenation can also be affected by physiological and hemodynamic changes that occur during OLV.

Among the risk factors that cause hypoxemia during OLV, it has been shown in some studies that the right side is operated (since hypoxia is more in the right lobectomies because the right lung is larger than the left lung), which disrupts oxygenation more.[18] In this study, the incidence of desaturation was found to be higher in the right upper lobectomies.

Brinkman et al.,[19] in their study comparing cerebral desaturation with hemodynamic parameters in OLV, showed that there was a link between HR and cerebral oxygenation and that patients with desaturation had lower HRs. Within the scope of this study, a significant decrease was observed in the HR of the desaturation group compared to the non-desaturation group in all time periods except OLV10 and OLV90.

Gersten et al.[20] measured $EtCO_2$ and rSO_2 levels simultaneously in their study on mild breathing exercises and showed that even a small increase in CO_2 caused a significant increase in cerebral oxygenation. In this study, when the $EtCO_2$ levels were compared for the two groups, it was observed that the levels were higher in the non-desaturation group for most of the time periods. However, $EtCO_2$ and $PaCO_2$ did not go beyond the physiological limit in both groups.

Brinkman et al.[19] and Hemmerling et al.[21] also observed an unexpected and alarming correlation between SpO_2 and cerebral saturation during OLV. Most of the cerebral desaturations in their study occurred when the SpO_2 level was 98%. Based on this, they suggested that when FiO_2 titration in OLV is performed according to peripheral SpO_2, cerebral hypoxia may occur or be exacerbated. This draws attention to the importance of monitoring of cerebral oxygenation in addition to standard monitoring in thoracic operations, which are special cases. Within the scope of this study, no significant correlation was observed between cerebral oxygenation and peripheral SpO_2, supporting this situation, and cerebral desaturation occurred even though peripheral SpO_2 did not fall below 94% of any patient.

In addition, this study, unlike other studies, 100% FiO_2 was not used at any stage during OLV. High oxygen concentrations are associated with "absorption atelectasis" and increased pulmonary capillary permeability. Within the scope of the study, absorption atelectasis that may be caused by high FiO_2 values was tried to be prevented by applying the lowest FiO_2 values that could be sufficient in both groups. Patients were extubated at the end of the operation without any need for post-operative mechanical ventilation.

The study also has a number of limitations. The first is that the sample size is small and the reliability of statistical validity is low at some points. Therefore, studies with a higher number of patients are needed. Another point is that the cognitive functions of the patients are not followed in the long term. However, due to the improvement in test results on the 7th day, it is thought that it is possible to have an idea about the long-term results.

Based on these results, it is thought that the use of regional cerebral oximetry measurement during thoracotomy and other surgical procedures where there is a risk of brain damage could be a guide for both patient safety and anesthesiologist, and also, it can prevent post-operative neurocognitive dysfunction and other complications.

Disclosures

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Informed Consent: Written informed consent was obtained from all patients.

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