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The Effect of Using the Surgical Mask on the Status of Cerebral Oxygen Saturation and End-Tidal Carbon Dioxide in Health Care Workers

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Abstract

Background: With the outbreak of the new coronavirus (SARS-COV-2), one of the challenges ahead has been to control the prevalence of the disease in the world. However, because the main way the virus enters the host is through the respiratory tract, the use of a mask is more necessary than in other cases. The medical staff who are in contact with these patients in closed environments in the operating room and other places are forced to use the mask continuously to prevent infection.

Aim: Considering the necessity of using a mask in the prevalence of COVID 19, especially in the medical staff and the possible effects of this use on tissue oxygen and exhaled carbon dioxide, the present study investigates the effect of using a mask on health care. the present study investigates the effect of using a mask on health care.

Methods: Twenty healthy members of the medical staff (staff working at Masih Daneshvari Hospital in Tehran) entered the study voluntarily according to the inclusion criteria. Everyone wore a mask for 2 hours a day. Brain oxygen delivery percentage was measured using cerebral oximetry and $petCO_2$ with capnogram at 0, 60 and 180 minutes. Demographic information of participants about the age, sex and underlying diseases were also recorded in a pre-prepared questionnaire. Independent t-test, paired t-test and chi-square were used to compare the clinical features of the participants. P-value less than 0.05 was considered to show statistical significance.

Results: The average of $petCO_2$ in time 2 was significantly higher than time 1 and zero (P=0.001). Likewise, the average $petCO_2$ factor at time one is significantly higher than at time zero. The relationship between BMI and changes in the studied indices shows that the left cerebral oxygenation factor, at times 0-60’ and 30’-60’ and also the right cerebral oxygenation factor at times 0’-60’, have a direct and significant relationship with BMI.

Conclusion: Based on the results of the present study, it can be said that the use of surgical masks has significantly increased $petCO_2$ in individuals, while the Pao2 index in some individuals has been associated with a downward trend.

Conflict of Interest: The authors declare no conflict of interest.
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Introduction

With the outbreak of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), one of the challenges ahead around the world has been to control the prevalence of the disease. The most important measures that can be effective in preventing the transmission of infection are hand washing and maintaining social distance, face masks, and the use of personal protective clothing (1, 2).

However, because the main way the virus enters the host is through the respiratory tract, the use of a mask is more necessary than in other cases. During the spread of infectious diseases, vaccination and the use of other antiviral products play an important role in preventing the spread of infection. However, using methods to prevent the transmission of infection to others is the first step in controlling the disease.

Many studies have confirmed the role of mask use in preventing the transmission of infection to other people. Also, in many cases where vaccines cannot be used promptly or have limited access, the use of a mask can be considered an effective intervention. In such circumstances, in many countries, strict regulations are imposed for the public use of masks and severe punishments are considered for violators (3).

The medical staff that are in contact with these patients in closed environments in the operating room and other places are forced to use the mask continuously to prevent infection. Different types of masks are used in society, each of which is different in terms of effectiveness and protection that they create (3). It has been shown that the air leak in the surgical mask is more than the N95 mask and the N95 mask probably provides a better method of protection (3).

An important feature of a mask is its ability to prevent the transmission of respiratory infections and other transmitted particles (4). However, the risks and challenges of using these masks are discussed.

Cerebral somatic oximetry is a common non-invasive procedure that shows oxygen saturation in the target tissue of the brain and limbs (5). This procedure was initially performed in cardiac surgery to monitor the proper oxygen content of the brain, but may be useful in other surgeries and medical conditions (6). Thus, due to the sensitivity and high need of the brain to the oxygen, any change in its level occurs more severely and rapidly (7).

It was shown earlier that in long-term use of surgical masks during long operations, a decrease in arterial oxygen and an increase in heart rate compared to the preoperative state have been observed (8).

Considering the necessity of using a mask, especially in the medical staff, and the effects that this use has on tissue oxygen and exhaled carbon dioxide which may responsible for some discomforts such as headache or dizziness, the present study will deal with the probable effects of using a mask on the health care workers.

Methods

In this cross-sectional study, which was carried out with the approval of the ethics committee in biomedical research of Masih Daneshvari Hospital in Tehran (IR.SBMU.NIRTLD.REC.1399.214), 20 healthy operating room members entered the study voluntarily based on inclusion criteria. All subjects wore the surgical mask continuously for at least 3 hours daily in room atmosphere.

The percentage of brain oxygenation was measured using cerebral oximetry and petCO_2 using a capnogram at 0, 30, 60, and 90 minutes. Demographic information of the participants such as age, sex, and the underlying diseases was also recorded in a pre-prepared questionnaire.

Meanwhile, more than 20% of changes in the level of cerebral oximetry were determined as an indicator of effectiveness.

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Inclusion criteria:

- Healthy people who were operating room staff
- 18 < age <60

Exclusion criteria:

- Respiratory or brain diseases, diabetes, and uncontrolled blood pressure
- Lack of cooperation or consent to participate in the study

The collected data were summarized as descriptive profiles by using mean, median, standard deviation, and variance. Independent t-test, paired t-test, and chi-square were used to compare the clinical features of participants. A p-value of less than 0.05 was considered to indicate statistical significance.

All the statistical analyses were performed by the Statistical Package for Social Sciences (SPSS Inc., Chicago, Illinois, USA) version 26.0.

Results

According to the results of the present study, the average age of participants was 34.78 years, and men (66.7%) were almost twice as many as women (33.3%). Based on what is seen in Table 1 and according to the p-values obtained, the trend of changes in $petCO_2$ factor is significant in three times, so the average of petCO2 in time 2 was significantly higher than time 1 and zero. Likewise, the average $petCO_2$ factor at time one is significantly higher than at time zero.

Since the PR changes are generally close to the significant level, using the Friedman rank test, the p-value of 0.05 is obtained, so the study of the two-by-two changes in the measurement times using the Wilcoxon test shows that a significant difference is observed between the changes in times 1 and 2.

Table 1. Evaluation of Petco2, Pao2, RR, PR indices at different times after using the surgical mask

Variables	Mean± SD	p-value
PetCO2 (0')	31.76±3.70	
Pet. CO_2 (60')	34.33±3.26	<0.0001
PetCO2 (180')	35.65±2.78	
PaO_2 (0')	96.29±1.27	
PaO_2 (60')	96.48±1.66	0.886*
PaO_2 (180')	96.25±1.59	
CerebralO_2. (0'). L	72.14±11.11	
Cerebral O_2. (60'). L	69.10±8.11	0.136
Cerebral O_2. (180'). L	67.90±9.01	
Cerebral O_2. (0'). R	70.71±7.71	
Cerebral O_2. (60'). R	72.29±6.96	0.653
Cerebral O_2. (180'). R	70.20±9.59	
RR. (0')	18.33±4.45	
RR. (60')	18.86±4.22	0.300
RR. (180')	19.40±4.65	
INDEX. (0')	9.10±1.48	
INDEX. (60')	9.33±0.80	0.487*
INDEX. (180')	9.10±0.79	
PR. (0')	82.50±10.82	
PR. (60')	83.62±6.93	0.058
PR. (180')	78.40±6.82	

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According to the results in Table 2, the left hemisphere of the participants was much more affected by the hypoxia caused by the use of the mask than the right hemisphere. Thus, 5 (25%) of the participants experienced a change of more than 20% of the PaO_2 level of the left side of the brain, while in 3 of them (15%) these changes were decreasing (decreased over time).

Table 2. Comparison of the function of the two hemispheres of the brain in the studied patients

ID	PaO2 in left of brain						PaO2 in right of brain					
	Time 0	Time 60	Time 180	Percent Change (0-60)	Percent Change (60-180)	Percent Change (0-180))	Time 0	Time 60	Time 180	Percent Change (0-60)	Percent Change (60-180)	Percent Change (0-180))
1	67	66	64	1.49	3.03	4.48	79	76	66	3.80	13.16	16.88
2	70	71	73	1.43	2.82	4.29	65	76	62	16.92	18.42	18.03
3	97	65	64	32.99	1.54	34.02*	73	79	66	8.22	16.46	14.71
4	70	69	68	1.43	1.45	2.86*	66	79	74	19.70	6.33	12.12
5	77	75	73	2.60	2.67	5.19	68	75	78	10.29	4.00	5.33
6	57	64	70	12.28	9.38	22.81	61	68	72	11.48	5.88	4.00
7	74	59	51	20.27	13.56	31.08*	74	73	69	1.35	5.48	4.17
8	52	59	51	13.46	13.56	1.92	71	67	61	5.63	8.96	4.00
9	65	69	59	6.15	14.49	9.23	50	73	52	46.00	28.77	2.60
10	76	72	72	5.26	0.00	5.26	79	76	72	3.80	5.26	0.00
11	69	56	62	18.84	10.71	10.14	65	60	61	7.69	1.67	3.23
12	95	86	76	9.47	11.63	20.00*	84	89	84	5.95	5.62	4.62
13	56	58	62	3.57	6.90	10.71	62	62	60	0.00	3.23	6.15
14	67	78	82	16.42	5.13	22.39	75	71	78	5.33	9.86	6.76
15	74	69	76	6.76	10.14	2.70	75	65	79	13.33	21.54	8.22
16	62	62	56	0.00	9.68	9.68	74	69	59	6.76	14.49	9.59
17	78	72	NA	7.69	9.20	0.00	65	63	NA	3.08	NA	8.86
18	80	84	72	5.00	14.29	10.00	73	79	67	8.22	15.19	14.08
19	76	68	78	10.53	14.71	2.63	72	67	75	6.94	11.94	16.46
20	79	72	70	8.86	2.78	11.39	77	75	79	2.60	5.33	20.27

Increasing the duration of using the mask causes a significant increase in pet.CO2. These changes are also noticeable in the short-term relative to each other (figure 1). The course of changes in oxygen saturation has been decreasing over time (Figure 2).

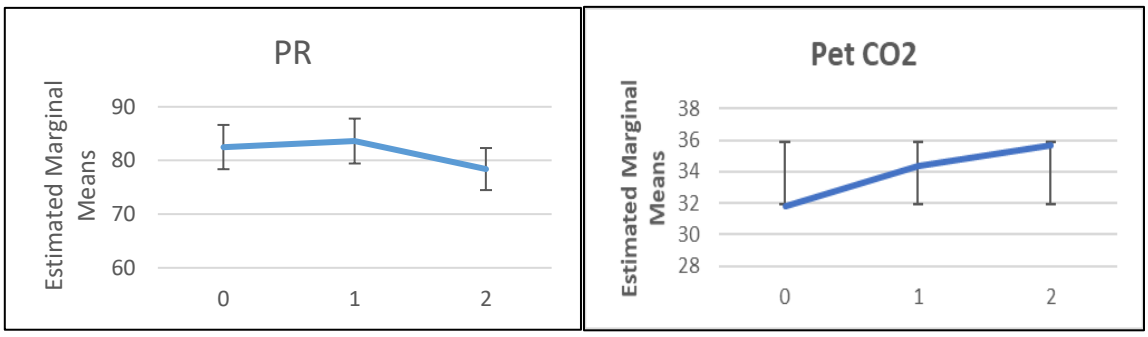

Figure 1: Diagram of the relationship between the duration of using a surgical mask on PetCO 2 and PR indices

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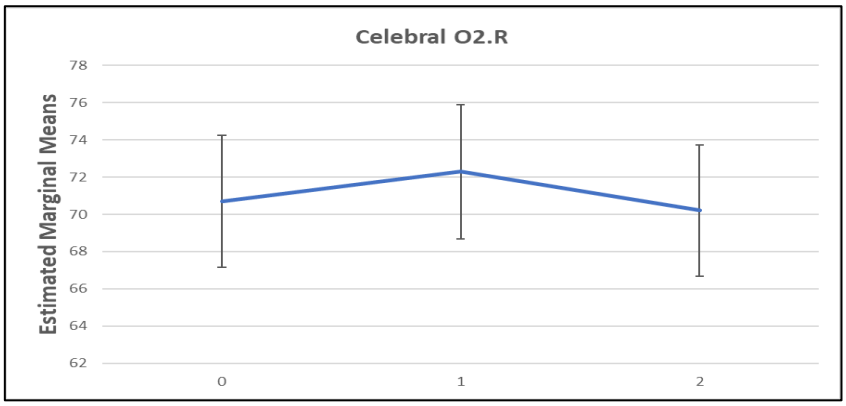

Figure 2: Diagram of the course of Pao2 changes based on the duration of application of the surgical mask

Discussion

The use of respiratory protection devices can increase tidal volume, respiration rate, CO_2, and O_2 concentration by increasing dead space and limiting the respiratory flow (9). However, our information on the effect of protective coatings on respiratory pressures and blood gas concentrations is not very significant (10). The results of some studies have shown that the use of facial masks increases the carbon dioxide inhaled by people. Based on these findings, with increasing respiration rate and tidal volume, a decrease in alveolar carbon dioxide occurs relative to the capillaries, resulting in the abnormal release of carbon dioxide from the blood (11-14). These adverse effects are not limited to the respiratory system and increasing the speed and depth of respiration will also increase cardiac output (15, 16). In case of inhalation of 1 to 2% carbon dioxide for a maximum of 32 minutes, diastolic and systolic blood pressure increase (17). By increasing the concentration of carbon dioxide to 5%, in a short time, symptoms such as shortness of breath, high blood pressure, headache, and dizziness occur (18-20). If the duration of exposure to this gas is increased to several hours, psychological problems will occur (21, 22). One of the most important and obvious side effects of exposure to carbon dioxide is a headache. Many medical staff suffers from headaches following the use of FFR (23). According to the results of our research, increasing the duration of using the mask causes a significant increase in petCO_2. These changes are also noticeable in the short term relative to each other (Figure 1). On the other hand, although PR does not change significantly, based on Figure 3, it can be said that increasing the duration of mask use reduces this index. Inhaled O_2 concentration correlates with inhaled carbon dioxide. The relative displacement of air gases can lead to a change in the concentration of inhaled O_2, which in turn changes the average concentration of respiratory carbon dioxide. Changes in one gas can affect the ratio of other respiratory gases. The results of a study showed that at 15% inhaled oxygen concentration, travel time increased and this was associated with the highest capillary lactate concentration. This condition results in the use of specific muscle fibers, an increase in type II fibers, a decrease in calcium ions, an increase in muscle fatigue, and an increase in minute ventilation (24). Clinical symptoms such as headache, drowsiness, muscle weakness, shortness of breath, nausea, and dizziness also begin if a person is exposed to a relative oxygen pressure of 17.4% (25). If these conditions continue, psychological and neurological symptoms such as memory impairment, delirium, impaired vision, and hearing, as well as sensitivity to environmental stimuli appear (26). In this study, we showed that although increasing the duration of mask use does not cause significant changes in the level of oxygen saturation (Table 1); however, the course of changes has been

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decreasing over time (Figure 2). We showed that 15% of the subjects were associated with hypoxia and a decrease of more than 20% in PaO2 in the left hemisphere of the brain. Such changes in the left hemisphere of the brain can make it difficult for a person to process information, calculate, and even communicate verbally (27). It has previously been shown that mice with hypoxia in the left hemisphere of the brain were unable to perform their activities accurately (28). However, a study of divers found that those with left hemisphere injuries due to hypoxia had difficulty estimating distances (29). This is important because most medical staff, especially those working in the surgical ward, need functional accuracy and a stable state of consciousness. The effect of hypoxia due to the use of surgical masks on the level of PAO can be a significant issue in people in certain occupations that require high alertness

Conclusion

The use of surgical masks has significantly increased petCO2 in individuals, while the Pao2 index in some individuals has also been associated with a downward trend.

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Conflict of Interest

The authors declare no conflicts of interest.

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Ethics

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