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The Effect of Surgical Masks on Blood Oxygen Saturation Level, Heart Rate and Respiration Rate

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Abstract

Background: Using surgical masks during surgical procedures is imperative to mitigate the spread of infections. Nevertheless, extended use of these masks can potentially impact vital signs. This study aims to examine the impact of surgical masks on oxygen saturation, respiratory rate, and heart rate among surgeons and operating room personnel.

Methods: This before-after study involved 51 participants, consisting of operating room technicians and surgeons. The participants were required to wear a surgical mask continuously for at least 30 *min*, with strict guidelines against removing or adjusting the mask. The study assessed various metrics, including heart rate, oxygen saturation, respiratory rate, and well-being scale before and after mask usage. Data analysis was conducted using SPSS 23.

Results: The study found that the average age of the participants was 44 years old, with a standard deviation of 11.58 years. Of the participants, 58.8% were male and 41.2% were female. Wearing a surgical mask was shown to have a significant impact on oxygen saturation ($p=0.003$), respiratory rate ($p<0.001$), and heart rate per *min* ($p<0.001$). These physiological changes were not significantly correlated with age, gender, body mass index, or duration of surgery ($p>0.05$).

Conclusion: Overall, the results indicate that wearing a surgical mask can lead to changes in oxygen saturation and respiratory and cardiovascular parameters, regardless of individual characteristics or surgical factors.

Keywords: Body mass index, Heart rate, Masks, Oxygen, Saturation, Respiratory rate, Vital signs

Introduction

The use of surgical masks in medical settings, particularly in operating rooms, is essential to prevent the transmission of infections and ensure the safety of both patients and medical personnel. However, medical staff may encounter challenges when wearing these masks. One significant issue is the physical discomfort from prolonged mask use, resulting in skin irritation, minor wounds, or rashes in contact areas with the mask (1). Furthermore, mask straps can lead to pain and discomfort. Shortness of breath is also prevalent; healthcare workers may struggle to breathe while wearing a mask, particularly during lengthy surgical procedures or in scenarios that necessitate deep breathing (2). One issue that arises from prolonged mask usage is the fatigue and mental strain it can cause. This can decrease comfort and heightened stress, particularly for medical personnel required to work extended *hr*. The decline in comfort levels may impact concentration and productivity, ultimately leading to decreased accuracy and an elevated risk of errors (3). Respiratory issues can be linked to the wearing of surgical masks. Heat and moisture build-up within the mask can cause discomfort and respiratory strain. Furthermore, limited airflow within the mask can result in a sensation of oxygen deprivation or heightened carbon dioxide levels, particularly during strenuous physical exertion (4).

Surgeons who wear masks for prolonged periods during operations may encounter symptoms such as weakness, fatigue, and decreased performance, prompting some to discontinue masks (5,6). Similarly, doctors who wear personal protective equipment during surgery may experience heightened resistance to airflow, elevated facial skin temperature, and physical discomfort, ultimately resulting in fatigue and diminished surgical performance. Despite air conditioning in operating rooms, these challenges persist (7).

With limited research on the factors contributing to the discomfort and reduced performance experienced by medical staff while wearing masks, this study seeks to explore the effects of surgical masks on the health and overall well-being of surgeons and operating room personnel.

Materials and Methods

In this before-after study conducted in 2024, 51 surgeons and operating room personnel at Aria Hospital in Mashhad, Iran, were examined to assess the impact of wearing masks. This study underwent a thorough review by the Ethics Committee of the Faculty of Medicine at Islamic Azad University, Mashhad Medical Sciences Unit. Approval was granted with the code IR.IAU.MSHD.REC.1401.145.

The participants were required to wear surgical masks continuously for a minimum of 30 *min* during the initial morning surgery to meet the inclusion criteria. Those who removed or adjusted their masks were excluded from the study. Throughout the research period, only one brand of surgical mask was utilized (a three-layer surgical mask of the UNI brand produced by Behdad Pouyan Salamat company-manufacturing license 54359320) to eliminate potential errors from using different mask brands. Following an explanation of the project's objectives, the participants were instructed to rest for 5 *min* without a mask and refrain from any physical activity to reach their baseline Heart Rate (HR) and oxygen saturation (SpO_2) levels, which were measured using a pulse oximeter device (Pouyandegan Raah Saadat brand, Alborz B9 model). The Respiratory Rate (RR) was determined by observing and counting breaths for one *min*. It is important to emphasize that each participant wore a mask with securely fastened straps, ensuring complete coverage of the mouth and nose. The participants were divided into two groups based on the duration of their surgeries: one group was involved in surgeries lasting less than 1.5 *hr*, while the other group was involved in surgeries lasting 1.5 *hr* or more. It is important to note that surgeries with severe complications beyond the typical surgical scope were excluded from the study to prevent any undue influence on the results. Subsequently, HR, RR, and SpO_2 were measured at the end of surgery before removing the mask.

To assess the participants' well-being, each individual completed a questionnaire that inquired about symptoms such as headaches, shortness of breath, sweating, fatigue, and thirst. The questionnaire utilized a scoring system as follows: 0 points for no symptoms, 1 point for mild symptoms that disrupted no daily activities, 2 points for moderate symptoms that did not disrupt daily activities, 3 points for moderate symptoms causing slight disruption to daily activities, 4 points for severe symptoms interfering with daily activities, 5 points for severe symptoms significantly interfering with daily activities, and 6 points for symptoms leading to cessation of work (with accurate reporting of the work interruption time required).

In the data analysis phase, normality of the data was assessed using the one-sample Kolmogorov-Smirnov test with Lilliefors modification. If the data was found to be normally distributed, parametric methods such as the paired T-test were employed. For non-normally distributed data, non-parametric tests such as the Wilcoxon and Mann-Whitney U tests were utilized. For descriptive analysis of normally distributed data, the mean and standard deviation were used; for non-normally distributed data, the median and IQR were used. The Chi-square test was applied for data analysis involving nominal scales, while Fisher's exact test was used when more than 20% of the expected frequencies in a table were less than 5 (Cochran). Multivariate analysis techniques were employed to explore relationships between the variables. The research utilized SPSS version 23 software (IBM Corp, Armonk, NY, USA) for data analysis, with a significance level set at $p<0.05$.

Results

This study included 51 surgeons and operating room technicians from Aria Hospital in Mashhad with an average age of 44±11.58 years. The youngest participant was 25 years old, while the oldest was 72. Among the participants, 58.8% were male and 41.2% were female. Additionally, 49% of the participants were operating room technicians, while the remaining individuals were surgeons specializing in general surgery, ENT, urology, gynecology, and orthopedics. The subjects' average Body Mass Index (BMI) was 25.82±3.01 kg/m^2. The lowest recorded BMI was 20.86, while the highest was 33.66 kg/m^2.

Analysis in table 1 revealed that nearly half of the

Table 1. Well-being index in the participants

	Conditions	Number	Percentage
Well-being index	No symptoms	10	19.6
	Limited symptoms, acceptable work, and no disruption	24	47.1
	Moderate symptoms, work without disruption	11	21.6
	Moderate symptoms, with slight work disruption	6	11.8
	Severe symptoms significantly interfering with daily activities	0	0
	Symptoms leading to cessation of work	0	0
	Summation	51	100

Table 2. Comparison of SpO_2, HR, and RR before and after using the mask

Variable		Average	Standard deviation	p-value
SpO_2	Before	97.43	1.06	0.003
	After	96.84	0.97	
HR	Before	81.90	10.32	<0.001
	After	88.04	12.43	
RR	Before	12.90	1.24	<0.001
	After	13.80	1.38	

HR: Heart Rate, RR: Respiratory Rate

Table 3. Comparison of SpO_2, HR, and RR before and after using the mask in the operation duration of less and more equal to 90 *min*

Duration of operation	Variable		Average	Standard deviation	p-value
Less than 90 *min*	SpO_2	Before	97.48	1.01	0.026
		After	96.94	0.94	
	HR	Before	82.20	10.84	<0.001
		After	88.20	11.29	
	RR	Before	13.06	1.30	0.044
		After	13.71	1.49	
More equal to 90 *min*	SpO_2	Before	97.43	1.06	0.034
		After	96.84	0.97	
	HR	Before	81.90	10.32	0.032
		After	88.04	14.43	
	RR	Before	12.90	1.24	0.002
		After	13.80	1.38	

HR: Heart Rate, RR: Respiratory Rate

Table 4. Comparison of the difference in SpO2, HR, and RR before and after using the mask according to the age, sex, and BMI

Variable	Age	Average	Standard deviation	p-value
SpO_2	<40 years	-0.318	1.36	0.281
	≥40 years	-0.793	1.29	
∆HR	<40 years	6.18	13.31	0.587
	≥40 years	6.10	5.73	
∆RR	<40 years	1.36	1.25	0.07
	≥40 years	0.552	1.61	
	Sex			
SpO_2	Male	-0.533	1.28	0.402
	Female	-0.67	1.43	
∆HR	Male	4.77	6.99	0.378
	Female	8.09	12.42	
∆RR	Male	1.36	1.25	0.811
	Female	0.552	1.61	
	BMI			
SpO_2	<25	-0.809	1.57	0.484
	≥25	-0.433	1.135	
∆HR	<25	8.90	12.08	0.07
	≥25	4.20	7.06	
∆RR	<25	1.19	1.47	0.65
	≥25	0.70	1.53	

HR: Heart Rate, RR: Respiratory Rate

Table 5. Comparison of the difference in SpO2, HR, and RR before and after using the mask according to the duration of the operation

Variable	Duration of operation	Average	Standard deviation	p-value
SpO_2	<90 *min*	-0.543	1.38	0.668
	≥90 *min*	-0.687	1.25	
∆HR	<90 *min*	6	8.27	0.668
	≥90 *min*	6.43	12.4	
∆RR	<90 *min*	0.657	1.61	0.871
	≥90 *min*	0.437	1.15	

HR: Heart Rate, RR: Respiratory Rate

participants (47.1%) experienced limited symptoms with no functional impairment, while only 11.8% reported moderate symptoms and ongoing work impairment. Furthermore, a comparison of SpO_2, HR, and RR before and after using the mask demonstrated a significant decrease in SpO_2 and an increase in HR and RR ($p<0.05$), as shown in table 2.

Out of the 51 participants, 35 (68.6%) were involved in surgeries lasting less than 90 *min*, while 16 (31.4%) were engaged in surgeries lasting 90 *min* or more. The SpO_2, HR, and RR changes were analyzed before and after the mask usage. For surgeries lasting less than 90 *min*, a T-test was performed after confirming data normality. The results revealed a significant difference in SpO_2, HR, and RR before and after mask usage ($p<0.05$). The Wilcoxon non-parametric test was utilized for surgeries lasting 90 *min* or more due to non-normal data distribution, showing a significant relationship between SpO_2, HR, and RR before and after mask usage (Table 3).

Subjects were categorized into two age groups: less than 40 years and 40 years or older. The Mann-Whitney U test was employed due to group distribution abnormalities, revealing no significant correlation between age and changes in SpO_2, HR, and RR ($p>0.05$). Similarly, gender and BMI were found to have no significant impact on the changes ($p>0.05$) (Table 4). Additionally, the duration of mask usage (less than 90 *min* and 90 *min* or more) was compared using the Mann-Whitney U test, indicating no significant relationship with changes in SpO_2, HR, and RR ($p>0.05$) (Table 5).

Discussion

The present study revealed that wearing a mask during surgery can increase HR and RR, as well as a decrease in SpO_2. These findings are consistent with previous research in the field. For instance, a study conducted in Turkey with 53 surgeons examined and compared SpO_2 and HR levels before and after surgery. The study demonstrated that the surgeons' HR increased during and after surgery when wearing a surgical mask, while the SpO_2 levels decreased by 1% after an hour (6). A study conducted with 20 oral and maxillofacial surgeons suggested that wearing a surgical mask during surgery increased HR and decreased average SpO_2 from 97.5 to 94% (7). Furthermore, another study indicated that prolonged use of a surgical mask for 150 *min* led to elevated heart rate and decreased oxygen saturation levels (8). A study conducted by Yang *et al* in China in 2022 involving 121 anesthesiologists reported that using surgical masks led to an increase in RR and a decrease in SpO_2 but showed no significant difference in HR (9). Anesthesiologists do not experience an increased HR, possibly since they are used to wearing masks during surgery. Their long work hours and chronic stress can lead to fatigue and reduced responses to stress (10,11). These factors may elucidate the disparities in HR fluctuations observed in this study compared to prior investigations, acknowledging that certain studies have presented results which differ from the current study's findings is crucial. For example, a study conducted in Nigeria in 2021 discovered that the use of surgical or N95 masks had no significant impact on SpO_2 levels (12). Similarly, another study in Nigeria, which observed the effects of masks on healthcare center employees over 8 weeks, also concluded that using surgical masks or N95 masks did not significantly affect SpO_2 levels (13). Furthermore, a study that examined SpO_2 levels in two groups of health workers while using a treadmill found no significant difference in SpO_2 levels between those who wore masks and those who did not (14).

Wearing a mask can cause breathing in more carbon dioxide and reduce oxygen levels in blood, leading to an increase in HR and RR. It can also make breathing harder, forcing your respiratory muscles to work harder and increasing the oxygen your body needs. Ultimately, wearing a mask can put more strain on the heart and respiratory system (15,16). These findings are consistent with the discussions presented in this study. The different findings on mask-wearing's impact on SpO_2, HR, and RR are due to factors like the type of mask, how long it is worn, participant characteristics, environment, stress levels, measuring methods, study designs, and cultural differences. For instance, anesthesiologists may react differently to masks than others, and studies in high-stress environments may show different results than in low-stress settings. Various methods and study designs can also cause varying outcomes. Cultural and geographical differences can affect research findings due to lifestyle, health practices, and work environment variations. To understand these discrepancies, it is essential to carefully analyze and compare the methodologies and conditions of each study. Conducting more comprehensive studies considering these factors can help researchers better understand the results.

In the current study, a well-being questionnaire was examined. The findings revealed that nearly half of the participants experienced limited symptoms with no dysfunction (47.1%), while only 11.8% reported moderate symptoms that affected their work performance. These results suggest that surgical masks do not significantly impact the performance quality of surgeons and other individuals. A study conducted in 2020 utilized thermographic imaging to investigate mask discomfort. The study demonstrated that wearing a mask for an hour increased skin temperature in covered areas, which returned to normal levels within 5 *min* of mask removal (17). Additionally, Nwosu *et al* found that health workers experienced more symptoms with N95 masks than surgical masks. The tightness of N95 mask straps was a common complaint, along with difficulty breathing, facial irritation, and communication challenges (12). Similarly, a study in India highlighted the impact of tight mask straps on healthcare workers and excessive sweating and breathing difficulties during activity (18). Studies by Shenal *et al* (19) and Rebmann *et al* (20) reported that discomfort from mask use increased with longer durations of wear. These findings align with this study results, indicating a consistent pattern across various research studies.

The present study revealed that using masks during surgeries lasting less than 90 *min* or more equal to 90 *min* resulted in decreased SpO_2 and increased HR and RR ($p<0.05$). Beder *et al*'s research also showed that surgeons performing surgeries under 30 *min* without masks experienced a drop in SpO_2 (6). This led to the hypothesis that stress may be a contributing factor to the decrease in SpO_2. Interestingly, in the current study, no correlation was found between the duration of surgery and the decrease in SpO_2 or the increase in HR and RR. In contrast, a study on anesthesiologists revealed that SpO_2 decreased and RR increased after 2 *hr* of continuous mask use. Additionally, prolonged mask usage worsened symptoms such as dizziness and headache (9).

In the findings, it was observed that there was no significant correlation between age and the decrease in SpO_2, as well as the HR and RR. However, Bader *et al* noted that surgeons over 35 experienced a more pronounced decline in SpO_2 than their younger counterparts. Additionally, the study indicated that HR increased faster in surgeons under 35 years old, a statistically significant difference compared to surgeons over 35 years old (6).

The study intended to examine the type of surgery and the surgeon's specialty as independent variables. Still, due to the limited sample size, the data obtained in this regard could not be evaluated and examined.

Conclusion

Wearing a surgical mask results in a decrease in SpO_2 and an increase in RR and HR. However, these physiological changes do not appear to be significantly influenced by age, gender, BMI, or the duration of the surgical procedure.

Ethical approval

The present study has a code of ethics with an ID number IR.IAU.MSHD.REC.1401.145. All the procedures performed in the study were in accordance with the ethical standards and the 1964 Helsinki Declaration.

Informed consent statement

Informed consent was obtained from all the individual participants included in the study.

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Conflict of Interest

There was no conflict of interest in this manuscript.

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