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Negative pressure drainage relieves respiratory discomfort for patients with medical face masks under ocular surgeries during COVID-19

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COVID-19 疫情期间采用气体负压引流缓解眼科手术中患者佩戴医用口罩导致的呼吸不适

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摘要

目的:报告 COVID-19 疫情期间局部麻醉下眼科手术的预防措施,评估眼科手术中佩戴医用口罩患者的呼吸情况。

方法:招募 60 例需要眼科手术治疗的中国患者,在眼科局部麻醉手术期间给予医用口罩作为 COVID-19 预防措施之一。采用吸氧和气体负压引流的方法缓解患者佩戴口罩存在的潜在呼吸不适感,并进行呼吸舒适度评分。

结果:佩戴医用口罩患者出现轻到中度呼吸不适,总体平均得分为 2.34±0.73 分。吸氧和气体负压引流缓解了呼吸不适(总平均得分为 0.15±0.75 分,$P<0.001$)。呼吸不适或呼吸不适缓解度不存在性别和手术时间差异。术中出现负压气体引流失败会导致严重呼吸不适。

结论:吸氧和气体负压引流可维持局部麻醉下佩戴医用口罩患者的呼吸循环。在 COVID-19 疫情期间建议接受眼科局部麻醉手术的患者佩戴医用口罩,以保护眼科医护人员。

关键词:COVID-19;眼科手术;医用口罩;气体负压吸引

Abstract

• AIM: To report our precaution practices for ocular surgeries under local anesthesia during COVID - 19 outbreak and evaluate the respiration situation among the patients with medical face masks under ocular surgeries.

• METHODS: Sixty Chinese patients needed eye surgery treatment were recruited and given medical face masks as one of the COVID - 19 precaution practices during eye surgery with local anesthesia. Oxygen supplementation and negative pressure drainage were applied to relieve the potential respiratory discomfort, and the respiratory comfort score was evaluated.

• RESULTS: Patients with medical face masks experienced mild to moderate respiratory discomfort with an overall mean score of 2.34 ± 0.73. Supplementation of oxygen together with negative pressure drainage relieved this discomfort (overall mean score of 0.15 ± 0.75; $P<0.001$). There is no gender and operation time difference on respiratory discomfort or discomfort relieve. Failure in negative pressure drainage led to severe respiratory discomfort.

• CONCLUSION: Negative pressure drainage could maintain the respiratory circulation in patients with medical face mask under eye surgery with local anesthesia. Application of medical face masks in patients under surgeries is recommended to protect the medical practitioners during the operations within COVID - 19 outbreak.

• KEYWORDS: COVID - 19; eye surgery; medical face masks; negative pressure drainage

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INTRODUCTION

Coronavirus disease 2019 (COVID-19) pandemic by a novel severe acute respiratory syndrome (SARS) coronavirus (SARS-CoV)-resembled virus (SARS-CoV-2)[1] has been spread over 210 countries/territories with more than 60 million confirmed cases. It is believed that person-to-person transmission of COVID-19 is mainly due to the infection by SARS-CoV-2 through respiratory droplets and close contact[2]. Medical face masks have been suggested as the first-line defense to prevent the transmission and inhalation of the infectious respiratory droplets from COVID-19 suspects or patients. Yet, we recently identified the expression of SARS-CoV-2 receptor *ACE2* and *TMPRSS2* in cornea tissue[3], which imposes the risk of SARS-CoV-2 infection and COVID-19 transmission through the ocular route among ophthalmologists, nurses and medical practitioners in eye clinics and hospitals. Proper protection with goggles has been recommended to prevent the exposure of the infectious droplets through the ocular route[4]. However, ophthalmic surgery is operated with fine surgical procedures under the microscope, and goggles could interfere the operation efficiency of the surgeons. Herein we report the implementation of the precaution practices in our hospital for the patients with eye surgery under local anesthesia during the period of COVID-19 outbreak. In addition, we evaluated the respiratory discomfort from the patients with medical face mask under eye surgery and the efficacy of oxygen supplementation with negative pressure drainage to relieve the respiratory discomfort.

SUBJECTS AND METHODS

Study Subjects From February 24th to May 15th 2020, a total of 60 Chinese patients received eye surgery treatment were recruited at our hospital. All study subjects received regular examinations before surgery, including chest X-ray, electrocardiogram and biochemical blood test, so as to ensure proper physical conditions and exclude those with severe respiratory diseases and heart disease. All study subjects received local anesthesia for the eye surgery. Demographic data was retrieved from the electronic medical record. The study protocol was approved by the Institutional Ethics Committee for Human Medical Research, which is in accordance with the tenets of the Declaration of Helsinki. Written informed consent was obtained from all study subjects before inclusion into the study.

COVID-19 Precaution Practices We implemented the precaution practices for COVID-19 in our eye hospital as follows: 1) Body temperature was measured for all persons intended entering to the hospital. Only those with body temperature lower than 37.3℃ were allowed to enter to the hospital and those with fever were sent to the fever clinic of the designated hospitals; 2) All persons needed to provide their travel records for past 14d shown by a government-launched mobile phone link before visiting the outpatient clinics for the ophthalmic examinations and biochemical tests.

Figure 1 Precaution practices with medical face mask and negative pressure drainage for patients under ocular surgery.

The risk of potential infection was evaluated; 3) The patients needed eye surgeries required to test for SARS-CoV-2 in the nasopharyngeal swab specimen by reverse transcription-polymerase chain reaction (RT-PCR) and evaluated with thoracic X-ray scan before the admission to the in-patient clinic of the hospital. Only those with the absence for SARS-CoV-2 and the sign of pneumonia were allowed to admit to the hospital for the eye surgery; 4) According to the regulations by the China government, every person needs to wear masks in the public places all the time. Since hospitals are regarded as the public places, all patients need to put on the face masks unless the patients' condition does not permit. Before the operation, each patient was given an ear-loop medical face mask. In order to maximize the sterilization area, the mask was pulled down slightly and just covered the mouth and the nose (Figure 1). The ear loop needed to be adjusted in order to slightly loosen the covered area. When the mask was oriented in a correct position, the upper side of the mask was fixed by the medical adhesive tape to prevent the movement of the mask by the facial muscle contaminating the sterilized skin during the operation.

The patients for the eye surgery are in supine position. Each patient was given an ear-loop medical face mask. The mask was pulled down slightly and just covered the mouth and the nose in order to maximize the sterilization area. The ear loop needed to be adjusted in order to slightly loosen the covered area. When the mask was oriented in a correct position, the upper side of the mask was fixed by the medical adhesive tape to prevent the movement of the mask by the facial muscle contaminating the sterilized skin during the operation. The oxygen tube and the suction tube were inserted into each of the 2 sides of the mask for approximately 5 cm long and placed over the mouth and the nose. The oxygen flow was adjusted to 2-3 L/min, and negative pressure drainage was maintained at 0.02 MPa. The respiratory comfort score was recorded at 2 time points: 1) After the coverage of the medical face mask (before insertion of oxygen and drainage

Table 1 The respiratory comfort scale

Score	Description
0	Not sensing any respiratory discomfort
0.5	Just sensing slightly respiratory discomfort
1	Very mild respiratory discomfort
2	Mild respiratory discomfort
3	Moderate respiratory discomfort
4	Slightly severe respiratory discomfort
5	Severe respiratory discomfort
6	Between 5 and 7
7	Very severe respiratory discomfort
8	Between 7 and 9
9	Extremely severe respiratory discomfort
10	Maximum respiratory discomfort

tubes); 2) Within 30min after the operation.

To reduce the risk of SARS-CoV-2 infection among the medical practitioners and respiratory depression in the patients with medical facial masks, we adopted a strategy of oxygen supplementation with negative pressure drainage to maintain the respiratory circulation of the patient. First, the oxygen flow was adjusted to 2-3 L/min, and negative pressure drainage was maintained at 0.02 MPa. If the pressure is high, the noise of negative pressure might disturb the operation by the surgeon. Both oxygen flow and negative pressure drainage needed to be checked and confirmed. Once the face mask was fixed, the oxygen tube and the suction tube were inserted into each of the 2 sides of the mask for approximately 5 cm long and placed over the mouth and the nose (Figure 1). The position of the tubes was fixed by the tape. After tube insertion, the nurses asked the patients on the comfort score. For the suction tube, multiple pores needed to be created to avoid the skin of the patient being sucked, which would injure the patient and abolish the drainage system, if there was only 1 hole on the suction tube. Once the tubes were fixed, the patients were sterilized and covered by the surgical drape, and the operation could begin. During the operation, the effect of the negative pressure drainage needed to be monitored and the changes in blood oxygen level should also be monitored. At the end of the operation, the oxygen tube and the suction tube were withdrew and discarded, and the patients were asked for the feedbacks on the respiratory circulation system.

Respiratory Comfort Score The respiratory comfort scale was categorized into 12 levels (Table 1). Score 0 represents the patients not sensing any respiratory discomfort, whereas score 0.5 represents the patients just sensing slightly respiratory discomfort. Score 1 represents the patients feeling very mild respiratory discomfort, whereas scores 2 and 3 represent mild and moderate respectively. Score 5 or above represents severe respiratory discomfort. The respiratory comfort score was recorded at 2 time points: 1) after the coverage of the medical face mask (before insertion of oxygen and drainage tubes); 2) within 30min after the operation.

Statistical Analysis Continuous variables were expressed as $\bar{x}\pm s$ deviation, and compared by t-test. The distribution of the comfort score scale was expressed as percentage and compared by χ^2 test. All statistical analyses were performed by the commercially available software (IBM SPSS Statistics 22; SPSS Inc., Chicago, IL). Significance was defined as $P<0.05$.

RESULTS

Total 60 subjects were recruited in thisstudy with the mean age of 59.8±15.0 years (Table 2). The average surgical time of these 60 operations was 27.1±19.2min. There were 26 male and 34 female subjects. There was no statistically significant differences in age distribution (male: 57.8±15.3 years, female: 61.2±14.8 years; $P=0.383$) and surgical time (male: 31.7±21.4min, female: 24.0±17.0min, $P=0.111$) between male and female subjects.

With the medical face mask application, 48.3% ($n=29$) of study subjects scored 2 and 38.3% ($n=23$) scored 3 (Table 3), with an overall mean score of 2.34±0.73 (Figure 2A), before tube insertion. No study subjects scored 0. This indicated that medical face masks could lead to respiratory discomfort in the patients under eye surgery. After oxygen supplementation with negative pressure drainage, 93.3% ($n=56$) of study subjects scored 0, with an overall mean score of 0.15±0.75. Both score scale ($P<0.001$) and score distribution ($P<0.001$) after oxygen supplementation with negative pressure drainage were significantly different from that before its application, indicating that oxygen supplementation with negative pressure drainage can effectively relieve the respiratory discomfort after medical face mask application.

With gender stratification, 57.7% ($n=15$) of the 26 male subjects scored 2 and 30.8% ($n=8$) scored 3 (Table 3, with an overall mean score of 2.17±0.68 (Table 2), before tube insertion, and 88.5% ($n=23$) of them scored 0, with an overall mean score of 0.23±0.98 after oxygen supplementation with negative pressure drainage. There was significant difference before and after the supplementation of oxygen with negative pressure drainage in male subjects ($P<0.001$; Figure 2B). For the 34 female subjects, 41.2% ($n=14$) scored 2 and 44.1% ($n=15$) scored 3, with an overall mean score of 2.47±0.75, before tube insertion, and 97.1% ($n=33$) subjects scored 0, with an overall mean score of 0.09±0.51 after oxygen supplementation with negative pressure drainage. Similarly, there was also significant difference before and after oxygen supplementation with negative pressure drainage in female subjects ($P<0.001$). However, neither before ($P=0.117$) nor after ($P=0.470$) oxygen supplementation with negative pressure drainage (Table 2) as well as their changes ($P=0.590$) showed statistically significant differences in score distribution between male and female subjects. There was also no significant interaction of gender with before and after respiratory circulation application ($P=0.090$).

Table 2 Demographic data and respiratory comfort score of the study subjects

Parameters	All subjects	Male	Female	P
Number (n, %)	60	26 (43.3)	34 (56.7)	–
Age ($\bar{x}\pm s$, y)	59.8±15.0	57.8±15.3	61.2±14.8	0.383
Surgical time ($\bar{x}\pm s$, min)	27.1±19.2	31.7 ± 21.4	24.0±17.0	0.111
Respiratory comfort score (before, $\bar{x}\pm s$)	2.34±0.73	2.17±0.68	2.47±0.75	0.117
Respiratory comfort score (after, $\bar{x}\pm s$)	0.15±0.75	0.23±0.98	0.09±0.51	0.470

Table 3 The respiratory comfort score for patients with medical face masks before and after the supplementation of oxygen with negative pressure drainage

Parameters	0	0.5	1	2	3	4	5
All patients							
Before (n, %)	0 (0.0)	1 (1.7)	5 (8.3)	29 (48.3)	23 (38.3)	2 (3.3)	0 (0.0)
After (n, %)	56 (93.3)	2 (3.3)	0 (0.0)	0 (0.0)	1 (1.7)	0 (0.0)	1 (1.7)
P							<0.001
Male							
Before (n, %)	0 (0.0)	1 (3.8)	2 (7.7)	15 (57.7)	8 (30.8)	0 (0.0)	0 (0.0)
After (n, %)	23 (88.5)	2 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	1 (3.8)
P							<0.001
Female							
Before (n, %)	0 (0.0)	0 (0.0)	3 (8.8)	14 (41.2)	15 (44.1)	2 (5.9)	0 (0.0)
After (n, %)	33 (97.1)	0 (0.0)	0 (0.0)	0 (0.0)	1 (2.9)	0 (0.0)	0 (0.0)
P							<0.001

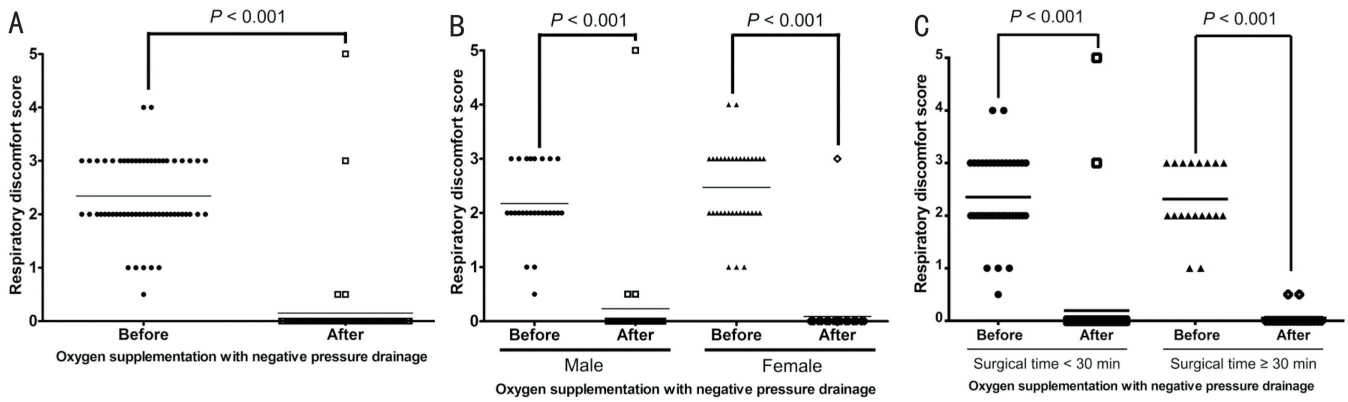

Figure 2 Respiratory comfort score for patients with medical face masks before and after the supplementation of oxygen with negative pressure drainage A: The respiratory comfort score for all study subject. Black circle: before the supplementation of oxygen with negative pressure drainage; White square: after the supplementation of oxygen with negative pressure drainage. Line: Mean; B: The respiratory comfort score with gender stratification; C: The respiratory comfort score with stratification of surgical time. Black circle: male subjects or subjects with surgical time <30min before the supplementation of oxygen with negative pressure drainage; White square: male subjects or subjects with surgical time <30min after the supplementation of oxygen with negative pressure drainage. Black triangle: female subjects or subjects with surgical time ≥30min before the supplementation of oxygen with negative pressure drainage; White diamond: female subjects or subjects with surgical time ≥30min after the supplementation of oxygen with negative pressure drainage. Line: Mean respiratory comfort score.

With stratification of surgical time, 48.8% (n=20) of the 41 subjects with surgical time <30min scored 2 and 36.6% (n=15) scored 3, with an overall mean score of 2.35±0.76 (Table 4), before tube insertion, and 95.1% (n=39) of them scored 0, with an overall mean score of 0.20±0.90 after oxygen supplementation with negative pressure drainage. There was significant difference before and after the supplementation of oxygen with negative pressure drainage in male subjects (P<0.001; Figure 2C). For the 19 subjects with surgical time ≥30min, 47.4% (n=9) scored 2 and 42.1% (n=8) scored 3, with an overall mean score of 2.32±0.67, before tube insertion, and 89.5% (n = 17) subjects scored 0, with anoverall mean score of 0.05 ± 0.16 after oxygen supplementation with negative pressure drainage. Similarly, there was also significant difference before and after oxygen supplementation with negative pressure drainage in female subjects (P<0.001). Neither before (P=0.910) nor after (P=0.462) oxygen supplementation with negative pressure drainage (Table 3) as well as their changes (P = 0.556) showed statistically significant differences in score distribution

Table 4 Demographic data and respiratory comfort score of study subjects stratified with different surgical times

Parameters	All subjects	Surgical time		*P*
		<30min	≥30min	
Number (*n*, %)	60	41 (68.3)	19 (31.7)	-
Age ($\bar{x}\pm s$, y)	59.8±15.0	62.6±13.8	53.6±16.0	0.019
Gender				
M (*n*, %)	26 (43.3)	14 (34.1)	12 (63.2)	0.035
F (*n*, %)	34 (56.7)	27 (65.9)	7 (36.8)	
Respiratory comfort score (before, $\bar{x}\pm s$)	2.34±0.73	2.35±0.76	2.32±0.67	0.910
Respiratory comfort score (after, $\bar{x}\pm s$)	0.15±0.75	0.20±0.90	0.05±0.16	0.462

among subjects with different surgical times. Although there were significant differences in age ($P=0.019$) and gender ($P=0.035$) between the 2 sub-groups, no significant interaction of surgical time with before and after respiratory circulation application was found ($P=0.709$).

DISCUSSION

SARS-CoV-2 could be potentially spread through coughing, sneezing and even normal breathing[5]. SARS-CoV-2 is not only highly infectious, but also shows long latency period. Critically, the infected but asymptomatic individuals make COVID-19 control increasingly difficult. Nevertheless, medical face masks have been suggested as the first-line defense preventing the transmission and inhalation of SARS-CoV-2-containing respiratory droplets from COVID-19 symptomatic or asymptomatic individuals so as to reduce the rate of COVID-19 infection[6]. Before the outbreak of COVID-19, patients with eye surgery need not to wear medical face masks during the operation. However, in order to prevent the transmission of SARS-CoV-2, China government strictly requires individuals wearing face masks in public places, including hospitals. Even though all patients were tested for SARS-CoV-2 before the admission to the hospital, there could be a remote possibility of false negative result from the RT-PCR analysis[7]. Precautions on asymptomatic individuals cannot be avoided. With the implementation of medical face masks, whether eye surgery would be interrupted by the patients with medical face masks due to respiratory depression is a reasonable concern since most of the eye surgeries are operated under local anesthesia and in a restricted area. The fine surgical procedures heavily rely on the cooperation from the patients. Even without medical face masks, the mouth and nose of the patients need to be covered by 4 layers of sterile surgical drape, which makes the patients suffocated. In this study, we showed that close to 90% of the study subjects, within a short period of surgery preparation, were suffered from mild to moderate respiratory discomfort with medial face masks (Figure 2 and Table 3), confirming that medical face masks could have a chance leading to respiratory depression in the patients under eye surgery. Therefore, improvement in respiratory circulation of the patients with medical face masks and, at the same time, reducing the possibility of SARS-CoV-2 infection among the medical practitioners would be a serious challenge needed to be addressed instantly. Negative pressure operating theatre is designed for the patients with airborne transmitted diseases. Its ventilation system can eliminate the infectious aerosol out of the operating theatre. For those hospitals without negative pressure operating theatres, the medical practitioners could be at risk in a closed area[8], especially for the asymptomatic COVID-19 individuals. It has been suggested that enhanced ventilation could be a precaution practice to eliminate SARS-CoV-2 transmission in the hospitals without negative pressure rooms[9]. Negative pressure drainage system is generally used for the removal of blood, sputum, pus or other contaminants from the patients as well as surgical smoke during operations. Upon breathing, carbon dioxide would accumulate under the medical face mask, leading to respiratory discomfort. To eliminate the accumulated carbon dioxide, we believe that oxygen supplementation with negative pressure drainage should also relieve the respiratory discomfort upon medical facial mask usage. Moreover, we postulated that negative pressure drainage should be able to quickly remove any potential infectious respiratory droplets from patients' breathe, which could protect the medical practitioners from the risk of SARS-CoV-2 infection. In this study, we demonstrated that oxygen supplementation with negative pressure drainage can effectively relieve the respiratory discomfort in patients with medical face masks during eye surgery (Figure 2A and Table 3). Nevertheless, 1 male subject scored 3 before and 5 after the surgery, whereas 1 female subject scored 2 and 3 respectively. The failure in respiratory discomfort relief was due to the failure in the negative pressure drainage form the male subject and the incorrect tube connection for the female subject. These again emphasize the effective relief of respiratory discomfort relied on the successful drainage by the vacuum suction. Failure in negative pressure drainage could result in severe respiratory discomfort or even respiratory depression.

There could be few limitations in this study. First, this study did not include a control group, which the subjects received medical face masks but not applied with oxygen supplementation and negative pressure drainage. Yet, we evaluated the respiratory comfort scope with the coverage of medical face mask before insertion of oxygen and drainage tubes, which could reflect the situation without the application of oxygen supplementation with negative pressure drainage although this could not reflect the long-term effect of this situation. Second, the sample size was relative small. Future studies with larger sample sizes could facilitate the establishment of standard operating procedures for COVID-19 precaution practices in eye surgery.

In summary, this study revealed that oxygen supplementation with negative pressure drainage can relieve the respiratory discomfort induced by the medical face masks. We proposed the implementation of medical face masks with negative pressure drainage as the precaution practices during COVID-19 outbreak for patients under eye surgery to protect medical practitioners from the risk of SARS-CoV-2 infection.

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