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Research

# Safety and Comfort of Wearing Medical Masks in Adult Surgical Patients After General Anesthesia During the COVID-19 Epidemic: A Retrospective, Observational Cohort Study

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## ABSTRACT

*Objective:* This study assessed oxygen saturation variation and comfort in adult surgical patients wearing masks in PACU during the COVID-19 epidemic.
*Design:* Retrospective observation was applied in this study.
*Methods:* One hundred thirty-seven patients wearing no medical masks (Group A, aged from 20 to 87) and 136 patients wearing medical masks (Group B, aged from 18 to 91) were selected in this retrospective study after extubation in PACU. After extubation their pulse oxygen saturation, noninvasive mean blood pressure and heart rate were recorded at two different time points (treated with 40% $O_2$ oxygen therapy for 10 minutes and breathing room air for 10 minutes). The comfort, arterial blood gas data, complications and duration of patients were also reviewed in PACU.
*Findings:* There were no significant differences in the pulse oxygen saturation between the two groups after inhaling 40% $O_2$ or air. Compared with Group A, patients in Group B have lower comfort (6 [4-7] vs 7 [6-8]; $P < .001$), with shortened duration after extubation in PACU (50 [45-55] vs 56 [48-60]; $P < .001$). No significant differences were found in heart rate, noninvasive mean blood pressure, arterial blood gas data and complications. And no hypoxemia and respiratory adverse events happened in two groups.
*Conclusions:* Wearing medical masks does not reduce oxygen saturation in adult surgical patients during recovery from general anesthesia. The discomfort caused by masks is the concern in PACU.


Coronavirus disease 2019 (COVID-19), caused by severe acute respiratory syndrome coronavirus 2 (SARS-COV-2) virus, is the causative agent of a potentially fatal disease, with great global public health concern.[1-3] The World Health Organization has assessed that COVID-19 can be characterized as a pandemic by March 11, 2020. As of December 29, 2020, more than 79.2 million cases and more than 1.7 million deaths have been documented globally.[4]

The main means of person-to-person transmission are droplets spread through coughing or sneezing, and direct contact with an infected person infected with SARS-CoV-2.[5,6] Facial masks (medical masks, surgical masks and N95 respirators in Figure 1) can effectively reduce person-to-person infection through droplet transmission.[7,8] For health care workers and the general public, self-isolation with masks is recommended during the COVID-19 epidemic.[9,10] Compared with N95 masks and surgical masks, the effectiveness of medical masks in preventing viral respiratory infections is not inferior to that of surgical masks.[8,11] So medical masks can be used effectively, especially when there is a shortage of N95 masks and surgical masks.

With the use of masks, people are interested in its safety. Many researchers have reported that health care providers wearing a mask may experience headaches and nasal pressure,[12,13] and N95 respirators can reduce $PaO_2$ in patients with end-stage renal disease.[14] In healthy subjects, wearing masks during short-term moderate-intensity aerobic exercise is associated with an increase in end-tidal carbon dioxide ($EtCO_2$).[15]

The perianesthesia nursing areas have been impacted by COVID-19.[16] A high risk of potential infection from exposure to respiratory droplets or aerosols during airway management by anesthesia providers and nurses occurs.[17] Coughing and bucking are common and

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**Figure 1.** Three types of masks. (A) Medical mask; (B) surgical mask; (C) N95 respirator. Medical and surgical masks are designed to protect wearers from microorganism transmission and fit loosely to users' face. N95 respirators are designed to prevent users from inhaling small airborne particles and must be attached to the wearer's face. The straps for an N95 respirator, or a surgical mask, should be placed on the crown of the head (top tie) and base of the neck (bottom tie); for a medical masks, the loops should be hooked appropriately behind the ears. This figure is available in color online at www.jopan.org.

unpredictable events during extubation. Therefore, during the COVID-19 epidemic, postanesthesia care units (PACU) recommended that patients undergoing general anesthesia should wear masks after extubation.[18] As respiratory adverse events such as hypoxemia are important and common postoperative complications after extubation,[19] PACU nurses should detect and care for patients when they are at greatest risk of developing respiratory complications.[20] Unfortunately, there is little information about the impact of wearing medical masks on patients in PACU.

In this report, we aim to share our experience by reporting the perioperative characteristics and impact on oxygen saturation of medical masks worn by adult surgical patients following general anesthesia in PACU during the COVID-19 epidemic.

## Methods

### *Research Design*

We conducted a retrospective database review at the First Affiliated Hospital of Chongqing Medical University from January 1 to January 27, 2020 (patients wearing no medical masks after extubation, group A) and from March 1 to March 18, 2020 (patients wearing medical masks after extubation, group B) in PACU. This study was approved by the Institutional Ethics Committee of our hospital on April 15, 2020 (approval number: 20201601). And the study was registered prior to patient enrolment at http://www.chictr.org.cn (registration number: ChiCTR2000032213). Informed consents have been obtained from all participants.

### *Inclusion Criteria*

Patients aged over 18 undergoing elective non-cardiac surgery in general anesthesia within 3 hours, who were enrolled after extubation in PACU.

### *Exclusion Criteria*

Patients in thoracic surgery with emergency anesthesia, operation time over 3 hours, and direct intubation to intensive care unit (ICU) after anesthesia in our hospital were excluded, with preoperative hypoxemia as acute respiratory pathology, and patients who had no complete arterial blood gas data in PACU were also excluded from the study.

### *Data Collection*

The following pre-existing conditions already existed in the data base: (1) age, (2) sex, (3) body mass index (BMI), (4) smoking status, (5) difficult airway history, (6) comorbidities, (7) American Society of Anesthesiology (ASA) classification, (8) chest CT scans, (9) throat swab testing for COVID-19, (10) type of surgery, (11) laparoscopic surgery. After extubation, pulse oxygen saturation, heart rate (HR), noninvasive mean blood pressure (MBP) were compared for all patients at two different time points (treated with 40% $O_2$ oxygen therapy for 10 minutes and breathing room air for 10 minutes), duration and complication in PACU, and arterial blood gas (ABGs) data before leaving PACU.

### *Treatment in PACU*

The patients in Group A receiving general anesthesia were transferred from operating room (OR) to PACU with supplemental oxygen. Then, we treated by the general principles of guidelines for the management of tracheal extubation.[21] After arrival in PACU, airway patency, vital signs, oxygenation, and level of consciousness were assessed immediately and recorded every 5 minutes. After extubation, the patients were allowed to inhale 40% $O_2$ at 10 L $min^{-1}$ by anesthetic facial masks,[22] and then inhaled in the room air until peripheral capillary hemoglobin oxygen saturation ($SpO_2$) remained stable. When $SpO_2$ was less than 94%, 40% $O_2$ was given again. If the patient had a radial artery cannulation during surgery, ABGs was routinely checked before leaving PACU. As an assessment tool, PACU nurse can determine a patient's acid-base status and initiate prompt and appropriate nursing intervention and medical consultation through ABGs.[23]

During the COVID-19 epidemic, the patients in Group B received general anesthesia after elective noncardiac surgery, with negative reverse transcription-polymerase chain reaction (RT-PCR) and chest CT scans for COVID-19 before surgery arrived the PACU in our hospital at a distance of at least 2 m (6 ft) between the two of them.[24] The anesthesiologists and nurses wore personal protective equipment (PPE) with medical gowns, medical gloves, eye protection shields, disposable surgical caps, and surgical masks in PACU, complied with infection control measures, with alcohol-based cleaners installed at the bedside. One nurse only took care of one patient at the same time and changed medical gloves before contacting another patient. The appointment of a nurse in charge was to ensure that optimal staffing can be provided at all times, including an appropriate response to emergencies.

We have tried to avoid extubation during mild anesthesia. To minimize coughing during extubation, patients received dexmedetomidine (1$\mu$g $kg^{-1}$ i.v.) for over 10 minutes.[25] The patient's tracheal intubation and pharynx were both thoroughly aspirated before extubation. And after extubation, we placed a medical mask over the patient's nose and mouth immediately to ensure that there was no gap between the facial mask and face, keeping a tight seal,[26] then anesthetic face-mask was put above the medical mask to take in 40% $O_2$ at 10 L $min^{-1}$. We were much more careful in monitoring and oxygen therapy as wearing medical masks in PACU during the COVID-19 epidemic. After meeting all PACU discharge criteria, the patients with medical masks were transferred from PACU to their ward by nurses with a portable monitor. Other treatments accorded to patients in Group A.

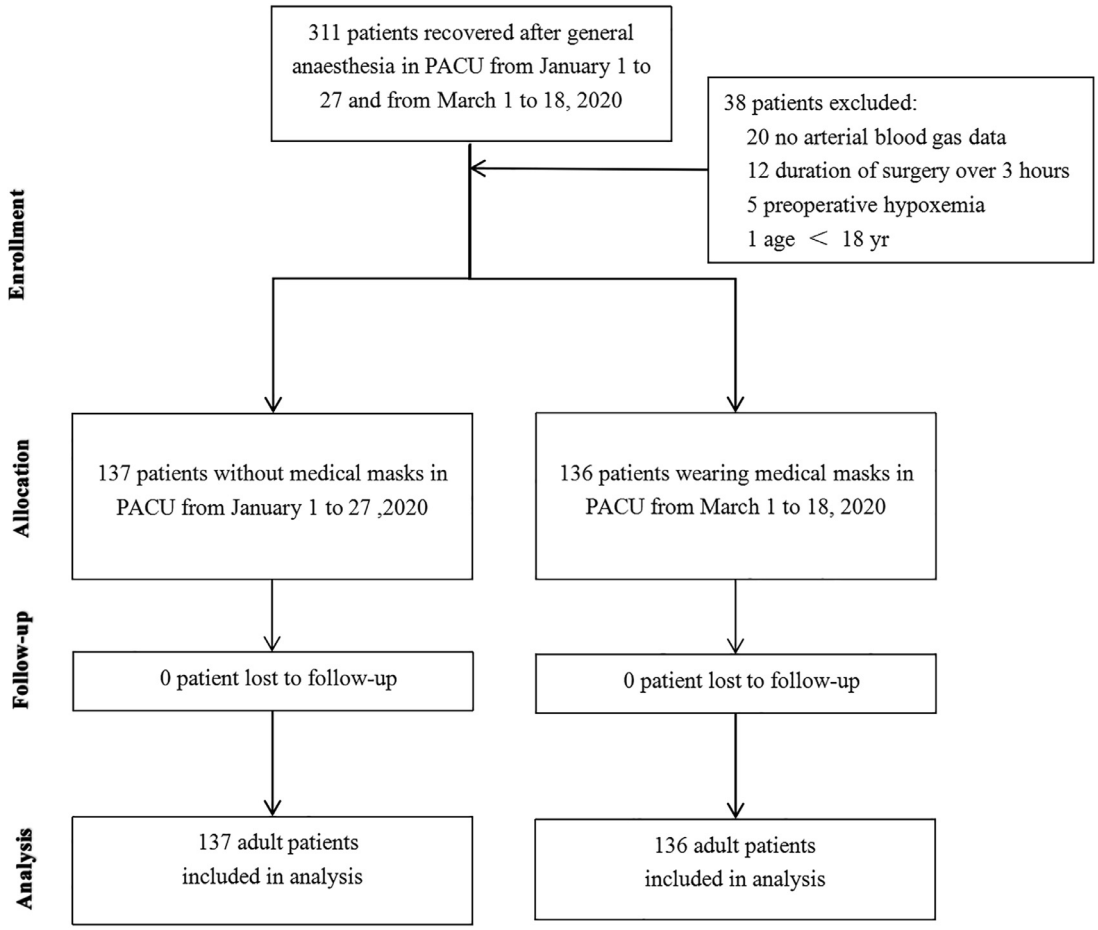


**Figure 2.** Flow diagram of patients included in the analysis in postanesthesia care unit (PACU).

*Primary Outcome*

The primary outcome of the study was the oxygen saturation of patients at two different time points (treated with 40% $O_2$ oxygen therapy for 10 minutes and breathing room air for 10 minutes) in PACU.

*Secondary Outcome*

The secondary outcomes we assessed were:

1 Arterial blood gas data and patient comfort before leaving PACU.
2 HR and MBP variation after 10 minutes at two different time points.
3 Duration and complications after extubation in PACU.

Patient comfort was evaluated by a verbal numeric rating scale (VNRS). All patients were asked to rate comfort on a 0- to 10-point VNRS, where "0" was "no comfort" and "10" was "the most comfortable" before leaving PACU.[27]

*Statistical Analysis*

Continuous variables were expressed as mean (standard deviation or interquartile range) for normally distributed data and median (interquartile range) for non-normal distributions. Categorical variables were reported as the number and percentage. $\chi^2$ or Fisher's exact test were used for categorical data, and patients' *t*-test and Mann-Whitney *U*-test were used for continuous data in compared subjects. All statistical analyses were conducted in SPSS 21.0 statistical (SPSS, Inc. Chicago, IL, USA). $P < .05$ was considered statistically significant.

## Results

*Patients' Characteristics*

In this study, 151 patients who were extubated in PACU between March 1 and March 18 in 2020 were identified, of which, 9 were excluded for lacking arterial blood gas data for the study period, 5 for the duration of surgery over 3 hours, and 1 for hypoxemia before surgery. The rest (n = 136 patients) were assigned to Group B. In addition, 160 patients who were extubated in PACU between January 1 and January 27 in 2020 were also identified, of which, 11 patients were excluded for lacking arterial blood gas data, 7 for the duration of surgery over 3 hours, 4 for preoperative hypoxemia, and 1 for aging 17. The rest (n = 137 patients) were assigned to Group A (Figure 2).

In total, 273 patients were selected in this study, including 137 patients (aged from 20 to 87) without masks (Group A) and 136 patients (aged from 18 to 91) with masks (Group B). No patients were confirmed with COVID-19 by RT-PCR and chest CT scans before surgery, with no statistically significant in age, BMI, smoking status, history of chronic obstructive pulmonary disease (COPD), ASA classification, type of surgery, which might be the

**Table 1**
Clinical Characteristics of Patients Wearing Medical Mask or Not in PACU (N = 273)

| Patients Characteristics | Group A (*n* = 137) | Group B (*n* = 136) | *P* Value |
|---|---|---|---|
| Age, mean (IQR), y | 55.20 (46-67) | 55.10 (45-65.75) | .655 |
| Age ≥65, y | 42 (30.7%) | 40 (29.4%) | .895 |
| | n (%) | n (%) | |
| Sex | | | |
| Male | 58 (42.3%) | 61 (44.9%) | .715 |
| Female | 79 (57.7%) | 75 (55.1) | |
| BMI, mean (SD), kg/m$^2$ | 23.59 (3.28) | 23.19 (3.06) | .345 |
| BMI > 35 kg/m$^2$ | 0 (0%) | 0 (0%) | - |
| Smoking status | 29 (21.2%) | 33 (24.3%) | .665 |
| Difficult airway history | 0 (0%) | 0 (0%) | - |
| Comorbidities | | | |
| Hypertension | 28 (20.4%) | 28 (20.5%) | .975 |
| COPD | 13 (9.5%) | 12 (8.8%) | .849 |
| Diabetes | 8 (5.8%) | 5 (3.7%) | .401 |
| Coronary heart disease | 6 (4.4%) | 3 (2.2%) | .315 |
| Stroke history | 2 (1.5%) | 2 (1.5%) | .994 |
| Other | 6 (4.4%) | 10 (7.3%) | .296 |
| Positive RT-PCR for COVID-19 | - | 0 (0%) | - |
| Positive chest CT for COVID-19 | - | 0 (0%) | - |
| ASA classification | | | |
| Ⅰ | 28 (20.4%) | 37 (27.2%) | .130 |
| Ⅱ | 89 (65.0%) | 72 (52.9%) | |
| Ⅲ | 20 (14.6%) | 27 (19.9%) | |
| Type of surgery | | | |
| Head and neck surgery | 23 (16.8%) | 16 (11.8%) | .224 |
| Chest surgery | 7 (5.1%) | 15 (11.0%) | |
| Abdominal surgery | 83 (60.6%) | 84 (61.8%) | |
| Limbs and spine surgery | 24 (17.5%) | 21 (15.4%) | |
| Laparoscopic surgery | 58 (42.3%) | 47 (34.6%) | .214 |

IQR, interquartile range; PACU, postanesthesia care unit; RT-PCR, reverse transcription-polymerase chain reaction; SD, standard deviation.
Data are presented as mean (SD or IQR) or n (%). Group A, patient wearing no medical mask; Group B, patient wearing medical mask.

risks of postoperative hypoxemia in PACU between the two groups[19,28,29] (Table 1).

*Primary Outcome*

There was no significant difference in $SpO_2$ between two groups, (100 [99-100] and 99 [98-100], inhaling 40% $O_2$ in 10 L min$^{-1}$) ($P$ = .213) and (98[97-99] and 98[97-99], taking in the air) ($P$ = .923), respectively (Table 2). No patient had hypoxemia ($SpO_2$ < 90%) in two groups. And there were 13 (9.5%) in Group A and 14 (10.3%) in Group B with $SpO_2$ < 95% ($P$ = .824) after taking in the air.

*Secondary Outcomes*

There was no patient with $PaO_2/FiO_2$ < 150 mm Hg in two groups. Patients with $PaO_2/FiO_2$ < 300 mm Hg in two groups were 10 (7.3%) and 11 (8.1%) ($P$ = .807), respectively. $PaCO_2$ > 45 mm Hg were 29 (21.2%) in Group A and 31 (22.8%) in Group B ($P$ = .746; Table 3).

No significant differences were found in heart rate, noninvasive mean blood pressure between oxygen group and nonoxygen group ($P$ > .05; Table 2). The median duration after extubation in PACU was shorter (50 [45-55]) in Group B than (54 [48-60]) Group A ($P$ < .001). There was no significant difference in postoperative complications between the two groups (Table 3).

Patient comfort is depicted in Table 3. Compared with Group A, wearing masks was associated with a lower comfort (6 [4-7] vs 7 [6-8]; $P$ < .001). All patients, anesthesiologists and nurses in this study had no cough, sore throat, myalgia, shortness of breath, and gastrointestinal reaction in the hospital.

## Discussion

This is the first retrospective report to explore the impact of wearing medical masks on oxygen saturation in adult surgical patients undergoing general anesthesia during the COVID-19 epidemic. Compared with patients wearing medical masks or not in PACU after extubation, we did not find a reduction in oxygen saturation in adult patients with or without medical masks after extubation. Nevertheless, wearing medical masks may reduce the patient's comfort in PACU. Arterial blood gas data including $PaO_2$, $PaO_2/FiO_2$, and $PaCO_2$ were not affected by wearing medical masks or not, with no adverse effects in hemodynamics and complication after extubation.

It is recommended that patients with COVID-19 should be sent to an isolation room in the ICU after surgery or be extubated in the operating room, bypassing the PACU.[17] With the control of COVID-19, an increasing number of surgical patients with a negative history of epidemiology, RT-PCR, and chest CT scan will

**Table 3**
Arterial Blood Gas Data, Duration After Extubation, and Complication in Patients Wearing Medical Mask or Not in PACU

| Variable | Group A (*n* = 137) | Group B (*n* = 136) | *P* Value |
|---|---|---|---|
| $PaO_2/FiO_2$, median (IQR), mm Hg | 405 (358.33-480) | 416 (345-494.58) | .675 |
| $PaO_2/FiO_2$ < 300 mm Hg | 10 (7.3%) | 11 (8.1) | .807 |
| $PaO_2/FiO_2$ < 150 mm Hg | 0 (0%) | 0 (0%) | - |
| $PaCO_2$, median (IQR), mm Hg | 42 (37.50-45) | 42 (38-45) | .308 |
| $PaCO_2$ > 45 mm Hg | 29 (21.2%) | 31 (22.8%) | .746 |
| Duration after extubation in PACU, median (IQR), min | 54 (48-60) | 50 (45-55) | <.001 |
| Complication | | | |
| Hypertension | 5 (3.6%) | 4 (2.9%) | .749 |
| VAS > 3 | 4 (2.9%) | 3 (2.2%) | .722 |
| Arrhythmia | 1 (0.7%) | 0 (0%) | 1.000 |
| Nausea | 1 (0.7%) | 0 (0%) | 1.000 |
| Patient comfort | 6 (4-7) | 7[6-8] | <.001 |

IQR, interquartile range; PACU, postanesthesia care unit; SD, standard deviation; VAS, visual analogue scale.
Data are presented as median (IQR) or n (%). Group A, patient without wearing medical mask; Group B, patient wearing medical mask.

**Table 2**
Oxygen Saturation, Heart Rate (HR), and Noninvasive Mean Blood Pressure (MBP) in Patients Wearing Medical Mask or Not in PACU

| Variable | Inhaling 40% $O_2$ in 10 L min$^{-1}$ | | | Taking in the Air | | |
|---|---|---|---|---|---|---|
| | Group A (*n* = 137) | Group B (*n* = 136) | *P* Value | Group A (*n* = 137) | Group B (*n* = 136) | *P* Value |
| $SpO_2$, median (IQR), % | 100 (99-100) | 99 (98-100) | 0.213 | 98 (97-99) | 98 (97-99) | .923 |
| $SpO_2$ < 95% | 0 (0%) | 0 (0%) | - | 13 (9.5%) | 14 (10.3%) | .824 |
| $SpO_2$ < 90% | 0 (0%) | 0 (0%) | - | 0 (0%) | 0 (0%) | - |
| HR, median (IQR), beats/min | 77 (67.50-82) | 72 (67-79) | 0.109 | 75 (67.5-82) | 71 (66-79) | .050 |
| MBP, median (IQR), mm Hg | 92 (85-101) | 88 (82-99.75) | 0.115 | 92 (84.50-101) | 90 (81-98) | .063 |

IQR, interquartile range; PACU, postanesthesia care unit; SD, standard deviation.
Data are presented as median (IQR) or n (%). Group A, patient wearing no medical mask; Group B, patient wearing medical mask

either be in low-risk infected areas or undergo surgery and recover in PACU.[30] However, to avoid nosocomial transmission of the virus, the medical and nursing staff should always use PPE, and the patients should wear masks during the entire stay. In spite of this, all the PACU staff have to comply with infection control measures, including hand cleansing and changing gloves in time. To shorten the length of stay in PACU during the COVID-19 epidemic, we transferred the patients to ward when they met the standards for leaving PACU.

During the COVID-19 pandemic, health care workers and the general public are recommended for self-isolation with wearing masks,[9,10,31] which can be also used in patients after extubation to reduce the risk of contamination in PACU, as a risk of affecting the respiratory system as well. Hypoxemia is one of the most adverse respiratory events in PACU,[32] which could increase 1-year postoperative mortality.[33] In our study, we did not found that wearing medical masks could reduce oxygen saturation after extubation. No more hypoxemia and $SpO_2 < 95\%$ happened in these patients. According to Fikenzer, ventilation could be reduced by wearing surgical masks during exercise in healthy individuals.[34] Furthermore, wearing masks at rest or brisk walking is safe for cardiopulmonary capacity in children.[35] Intensifying monitoring and nursing is also essential to prevent hypoxemia in PACU, especially when patients were wearing masks.

Generally, wearing masks dose increase the resistance to breathing, resulting an increase in $CO_2$ in the mask's dead zone. Although recent research have demonstrated that short-term moderate-strenuous aerobic physical activity with masks is associated with an increase in $EtCO_2$,[15] variation of $PaCO_2$ has not found in our study. It was useful to reduce dead space by making sure no gaps between the medical mask and face.

In the present study, wearing medical masks reduced patient comfort. Clinical study has suggested a consistent and significant increase in negative ratings for all items of discomfort (humidity, heat, breathing resistance, itchiness, tightness, saltiness, feeling unfit, odor, fatigue, and overall discomfort) from surgical masks to FFP2/N95 masks.[34] Despite discomfort, compliance can still be achieved by understanding the benefits and need, which can be further reduced by effective communication with patients who will have a positive attitude toward personal protection.

There are clearly multiple limitations in this study. First, we just compared the data in adult patients, and did not include other patients at high risks (preoperative acute respiratory pathology, BMI $> 35\ kg\ m^{-2}$, duration of surgery over 3 hours) of postoperative hypoxemia; therefore, we cannot address whether hypoxemia increase in these patients or not. Second, headaches, dyspnea, pressure on nose, and rash on face variations were not recorded, as these symptoms often occur with wearing masks. Additionally, studies on the prolonged use of surgical masks after general anesthesia and qualitative studies to assess the impact of mask use in children and the aged will have to be undertaken.

## Conclusions

In summary, the median $SpO_2$ we reported in adult surgical patients with medical masks after general anesthesia did not reduce. Wearing medical masks may be safe without more hypoxemia and adverse respiratory events in PACU during the COVID-19 epidemic. Our report can contribute valuable data to the rational use of masks in perioperative COVID-19 defense.

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