



# The effect of surgical masks on vital signs and EtCO<sub>2</sub> in patients on oxygen therapy

Alten Oskay<sup>1</sup> · Mehmet Uluturk<sup>1</sup> · Hazan Cevirme<sup>1</sup> · Tulay Oskay<sup>2</sup> · Hande Senol<sup>3</sup> · Mert Ozen<sup>1</sup> · Murat Seyit<sup>1</sup> · Atakan Yilmaz<sup>1</sup> · Ibrahim Turkcuer<sup>1</sup>

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## Abstract

**Background** There are conflicting data on the effects of masks on vital signs and end-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) values in the literature.

**Aims** This study aims to evaluate the changes in the vital parameters and EtCO<sub>2</sub> values of the patients who were administered oxygen through nasal cannula (NC) and simple oxygen mask (SOM) and wore surgical masks (SM) on top during their treatment.

**Methods** The prospective, observational study was conducted from January 2021, over consecutive 30 days, in the emergency department of a tertiary-care university hospital. The vital signs and EtCO<sub>2</sub> values of the subjects administered O<sub>2</sub> were noted at the time of arrival and at the 30th and 120th minutes of treatment. Changes in vital signs and EtCO<sub>2</sub> values were compared with regard to NC-SM and SOM-SM applications over a 120-min study period.

**Results** Sixty-eight subjects were included in two groups (NC-SM [*n* = 49] and SOM-SM [*n* = 19]). At the 120th minute, a decrease in systolic and diastolic blood pressure, heart rate, and respiratory rate and an increase in oxygen saturation were observed in the group including all subjects. After decreasing slightly in the first 30 min, the EtCO<sub>2</sub> value remained stable.

**Conclusions** NC-SM and SOM-SM applications do not affect adversely, and even seem to lead to recovery of, the vital signs and EtCO<sub>2</sub> values during 120 min in subjects with acute complaints.

**Keywords** End-tidal carbon dioxide · Nasal cannula · Simple oxygen mask · Surgical mask · Vital signs

## Introduction

End-tidal CO<sub>2</sub> (EtCO<sub>2</sub>) is a parameter reflecting the alveolar CO<sub>2</sub> pressure and plays an important role in evaluating the adequacy of ventilation and perfusion. It is measured non-invasively from expired air. As there is a strong correlation between the EtCO<sub>2</sub> and arterial partial CO<sub>2</sub> pressure (PaCO<sub>2</sub>) and HCO<sub>3</sub> [1, 2], it is used in emergency departments (EDs), critical care units, intensive care units, and

operating rooms to confirm the location of the endotracheal tube, to follow up intubated patients, to evaluate the success of resuscitation, to monitor the depth of sedation in patients with spontaneous breathing, and to determine the severity of various metabolic and trauma patients [3–6]. It is known that low EtCO<sub>2</sub> levels are associated with mortality in trauma patients and that it is a decision parameter in the termination of resuscitation [7].

Since the beginning of 2020, the SARS CoV-2 virus pandemic has reminded the importance of mask, distance, and hygiene both to healthcare professionals and the community. Cloth masks and face shields produced at home have become widespread among people. In hospitals, the use of surgical masks, FFP2 and FFP3 (N95 and N99) masks, eyeglasses, and face shields have increased among healthcare professionals. The patient care was provided with some modifications made to masks and devices as a quick and easy solution, especially in the first period of the pandemic [8, 9]. Not only implementing increasing personal protection measures,

✉ Alten Oskay  
oskayten@gmail.com

<sup>1</sup> Department of Emergency Medicine, School of Medicine, Pamukkale University, Kinikli Campus, 20700 Denizli, Turkey

<sup>2</sup> Division of Cardiology, Bucak State Hospital, 15300 Burdur, Turkey

<sup>3</sup> Department of Biostatistics, School of Medicine, Pamukkale University, Kinikli Campus, 20700 Denizli, Turkey

but also avoiding aerosol-generating applications as much as possible or performing them in negative pressure rooms have been suggested to confine the virus [10, 11]. Oxygen administration methods (oxygen administration with a nasal cannula [NC] or simple oxygen mask [SOM], high-flow nasal oxygen [HFNO] administration, etc.) were reviewed again, and surgical masks (SMs) were worn over masks or cannulas [11, 12].

The increase in the use of masks has caused concerns about the symptoms and complications masks may cause, both for healthcare professionals and patients. Most of the conducted studies were performed on healthy or patient volunteers during normal working days, domestic life, regular outpatient control, and routine treatment applications. Although the symptoms caused by various mask applications appear to be similar, the reflections of this similarity on vital signs or blood parameters show conflicting results [13–15].

The aim of this study is to evaluate the changes in the EtCO<sub>2</sub> values and vital parameters of the subjects who applied to the ED and who were given oxygen by NC or SOM during their treatment, with medical masks worn over the cannula and masks.

## Methods

### Procedure

It is a single-center, prospective, observational, and cross-sectional study. The data were collected in January 2021–February 2021, over a 30 day consecutive period, in the ED of a tertiary-care university hospital with approximately 100,000 patient admissions annually. All subjects who presented during the 8 h daytime shift, who were 18 years of age or older, who were administered oxygen therapy with NC or SOM, and who cooperated with this practice were included in the study. Informed consent was obtained from all individual participants included in the study. Exclusion criteria were patients unwilling to give consent, unstable patients requiring resuscitation, intubated patients, and patients not completing the 120 min study period in the ED. Demographic data of subjects, their coexisting diseases, smoking habits, vital signs, and their EtCO<sub>2</sub> values measured at the 0th–30th–120th minutes, hospitalization or discharge information, and final diagnoses were noted in the study form.

The study personnel were immediately informed about the patients who were admitted to the ED and planned to be administered oxygen therapy by their primary physician. Primary physicians of the patients freely decided on the oxygen treatment method appropriate for the patient. Then, the patients were evaluated according to the

exclusion criteria (Fig. 1) and the participants' own masks were changed with the 3-ply masks of the study by the study personnel. Following, EtCO<sub>2</sub> and vital sign measurements were performed immediately. The same measurements were repeated at the 30th and 120th minutes during oxygen administration. Afterwards, no re-measurements were taken, and only the diagnosis and outcome information of the patients when they were discharged from the ED were noted.

### Mask application

All the masks with various features (medical, cloth, etc.) used by all the study subjects were removed and each was given EN14683 Type IIR surgical mask. These masks were applied in a manner to cover the mouth and nose over the NC and SOM. There was not any specific recommendation concerning mouth opening or closing during the experimentation. Study subjects were requested not to remove their masks for 120 min. It was stated that they could use pipettes for their essential needs such as drinking water.

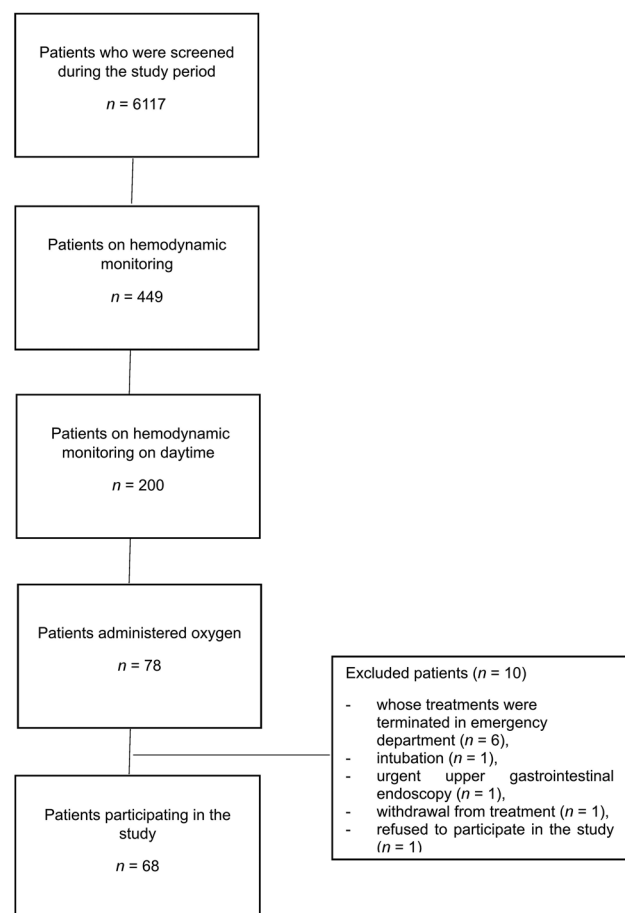


Fig. 1 Flow diagram of the study

## EtCO<sub>2</sub> measurement

EtCO<sub>2</sub> measurement was made with the sidestream capnography method. When the value measured on the monitor (GE Medical Systems, USA) became constant, or after 2 min, the result was noted.

## Body temperature, blood pressure, fingertip SO<sub>2</sub>, heart rate, and respiratory rate measurement

Body temperature was measured from the forehead with an infrared thermometer by following the manufacturer's recommendations (Dodo Thermo, IT-122). Blood pressure and other vital signs' measurements were performed in the position where the subject was comfortable (semi-recumbent or seated). None of the subjects had changed their body position during the 120 min follow-up.

## Statistical analysis

All statistical analyses were performed using SPSS 25.0 software (IBM SPSS Statistics 25 software [Armonk, NY: IBM Corp.]). Continuous variables were expressed as mean  $\pm$  standard deviation (SD) and categorical variables were expressed as frequencies and percentages. The Shapiro–Wilk test was used for testing normality. When parametric test assumptions were met, an independent samples *t* test was used for comparisons among groups. When parametric test assumptions were not met, the Mann–Whitney *U* test was used for independent group comparisons. For pairwise comparisons, repeated measures ANOVA was used for the parametric test (post hoc: Bonferroni test), and Friedman test (post hoc: Wilcoxon signed rank test with Bonferroni correction) was used for the non-parametric test. In addition, differences between categorical variables were analyzed using a chi-square test. *p* values  $\leq 0.05$  were considered statistically significant.

## Results

The study group consisted of 68 subjects (27 female, 41 male). The median age of the subjects was 72.5 (min. 52, max. 91) years, and their age mean was determined as 72.63  $\pm$  10.2 years (74.44  $\pm$  10.58 in female; 71.44  $\pm$  9.89 in male). The commonest coexisting disease was hypertension (52.94%), then chronic obstructive pulmonary disease (COPD) (39.71%), coronary artery disease (29.41%), chronic renal failure (20.59%), and others. Most of the subjects were/are still smokers. None of these demographic data was different among the NC-SM and SOM-SM groups.

Ten subjects were excluded from the study. The details of these patients are as follows: 6 patients' ED treatment ended

before the 120 min study period and the patients left the ED, and 1 patient was unstable at the time of admission and was intubated immediately. One patient presented with a prediagnosis of gastrointestinal bleeding and was excluded due to the removal of their mask early during endoscopy, 1 patient withdrew their consent before completing the study, and 1 patient did not consent for participating in the study (Fig. 1). The flow diagram of the study is summarized in Fig. 1.

Oxygen was administered to 49 (72%) study subjects by NC-SM and 19 (28%) by SOM-SM. Demographic data, coexisting diseases, smoking habits, and the ED departure outcomes of the subjects who were treated with NC-SM and SOM-SM were similar (Table 1). Lifetime smoking rates were 33.02  $\pm$  58.44 and 40.28  $\pm$  42.06 pack-years among the NC-SM and SOM-SM groups, respectively, and there is no statistical difference between them (*p* = 0.257).

Vital sign measurements of the NC-SM and SOM-SM groups at the time of admission, at the 30th minute, and at the 120th minute are given in Table 2. For all subjects at the 120th minute, systolic blood pressure, diastolic blood pressure, heart rate, and respiratory rate per minute decreased and fingertip SO<sub>2</sub> increased. However, the EtCO<sub>2</sub> value decreased in the first 30 min but no statistically significant change was detected afterwards. The change in the first 30 min is significant in SO<sub>2</sub> and respiratory rate. The change in other parameters at the 120th minute is significantly different from the baseline measurement. Changes between measurements in the NC-SM group and SOM-SM groups were similar between both groups (Table 3).

The ED outcomes of the subjects are as follows: 42 (61.8%) were hospitalized, 24 (35.3%) were discharged, 2 (2.9%) withdrew from treatment before the decision to hospitalize or discharge from the ED. The final diagnoses of the subjects were 25% (*n* = 17) congestive heart failure, 22% (*n* = 15) pneumonia, 20% (*n* = 14) COPD, 9% (*n* = 6) lung malignancies, and 24% (*n* = 19) other reasons, respectively. Among other diagnoses, there was one subject with traumatic pneumothorax, and one with spontaneous pneumothorax.

## Discussion

Due to the sudden worsening of their underlying disease or their nascent diseases, patients presenting to the ED are more vulnerable to various interventions than healthy volunteers. For this reason, it is important to closely monitor the effects of NC-SM and SOM-SM treatments. One way to monitor adverse effects is to evaluate changes in patients' vital signs and EtCO<sub>2</sub> values. In the NC-SM and SOM-SM applications in our study, it was observed that there was a decrease in systolic and diastolic blood pressures, regression in tachycardia and tachypnea, and an increase in SO<sub>2</sub>

**Table 1** Demographic and clinical information of nasal cannula + surgical mask and simple oxygen mask + surgical mask groups

		Technique		Total	p value
		NC-SM	SOM-SM		
Gender	Male	27 (55.1%)	14 (73.68%)	41 (60.29%)	0.16
Age	Female	74.86 ± 9.17	72.60 ± 16.79	74.44 ± 10.59	0.783
	Male	71.67 ± 11.02	71.00 ± 7.59	71.44 ± 9.89	0.841
Obese + overweight	Yes	25 (51.02%)	8 (42.11%)	33 (48.53%)	0.509
Coexisting diseases					
Diabetes mellitus	Yes	12 (24.49%)	6 (31.58%)	18 (26.47%)	0.552
Hypertension	Yes	29 (59.18%)	7 (36.84%)	36 (52.94%)	0.098
Chronic obstructive pulmonary disease	Yes	19 (38.78%)	8 (42.11%)	27 (39.71%)	0.801
Coronary artery disease	Yes	13 (26.53%)	7 (36.84%)	20 (29.41%)	0.402
Chronic renal failure	Yes	10 (20.41%)	4 (21.05%)	14 (20.59%)	1.000
Congestive heart failure	Yes	9 (18.37%)	4 (21.05%)	13 (19.12%)	1.000
Thyroid disease	Yes	2 (4.08%)	2 (10.53%)	4 (5.88%)	0.31
Rheumatic disease	Yes	2 (4.08%)	0 (0%)	2 (2.94%)	1.000
Malignancy	Yes	5 (10.2%)	2 (10.53%)	7 (10.29%)	1.000
Others	Yes	17 (34.69%)	7 (36.84%)	24 (35.29%)	0.868
Smoking habits	Never	21 (43.75%)	6 (33.33%)	27 (40.91%)	0.729
	Ex-smoker	21 (43.75%)	9 (50%)	30 (45.45%)	
	Current smoker	6 (12.5%)	3 (16.67%)	9 (13.64%)	
Emergency department outcome	Discharged	18 (36.7%)	6 (31.6%)	24 (35.3%)	0.449
	Hospitalized	29 (59.2%)	13 (68.4%)	42 (61.8%)	
	Other	2 (4.1%)	0 (0%)	2 (2.9%)	

NC-SM, nasal cannula-surgical mask; SOM-SM, simple oxygen mask-surgical mask

Data are presented as mean ± standard deviation (SD) or number (%) of the patients

in the general study population. All these changes were in the values which are accepted as physiological. The decrease in EtCO<sub>2</sub> values in the first 30 min has not continued afterwards. No changes in the body temperature were observed.

Studies conducted so far have mostly included healthy volunteers, outpatients who come to the clinic for control, or stable patients under routine treatment [14–16]. In the study they conducted on 39 patients during hemodialysis, Kao et al. observed that the partial oxygen pressure of patients wearing N95 masks decreased, their respiratory rate increased, and they had chest discomfort [14]. In 97 COPD patients who applied to the regular outpatient clinic, it has been observed that if the N95 mask is used, the SpO<sub>2</sub> of the patients during the effort decreased, the PEtCO<sub>2</sub> increased, and the feeling of discomfort worsened proportional to the severity of the disease [15]. The results of these studies can be attributed to the fact that the N95 mask causes greater air resistance. It also shows that oxygen-carbon dioxide exchange through masks is affected in chronic illnesses. Montiel et al. evaluated 21 patients who were on HFNO in the intensive care unit during acute illness. With the usage of a surgical mask over the HFNO, SpO<sub>2</sub> and PaCO<sub>2</sub> values in the blood gas of the patients increased, and the SpO<sub>2</sub> value decreased with the removal of the SM [12]. This finding

indicates that SM application may be beneficial during oxygen administration. Again, as a result of this study, a slight increase in the carbon dioxide pressure is observed [12]. The faster recovery of oxygen saturation and respiratory parameters than other vital signs in our study may be due to surgical mask application, similarly. Contrary to that study, the EtCO<sub>2</sub> value of our patients decreased at first and was stable afterwards. We consider that if the follow-up period had been longer in both our study and Montiel et al., the change in EtCO<sub>2</sub> could have been put forward more clearly.

It is argued that, in people using face masks, together with exertion-induced stress, there may be hypoxia-hypercarbia, increase in reactive oxygen radicals, premature depolarizations leading to arrhythmias, and sudden cardiac death due to hypoxia [17, 18]. Chandrasekaran et al. reported in the study they conducted on healthy volunteers that face masks caused shortness of breath, hypoxemia, hypercarbia, acidosis, and consequently headache, anxiety, and rhythm disorders [18]. Roberge et al. reported that both symptoms and hypercarbia may occur in masks with exhalation valves even in a 1-h effort in the workplace [19]. It was observed that new-onset headache occurred in 81% of healthcare personnel using personal protective equipment, and in 91% of those who had pain previously, the headache worsened

**Table 2** Change of vital signs and EtCO<sub>2</sub> over time in groups of nasal cannula + surgical mask and simple oxygen mask + surgical mask

	All participants (n = 68)	NC-SM (n = 49)	SOM-SM (n = 19)	Intergroup p value
SysBP (mmHg)_0 min	148.18 ± 30.68 <sup>a</sup>	147.63 ± 30.41 <sup>b</sup>	149.58 ± 32.17	0.584
SysBP (mmHg)_30 min	141.38 ± 24.68 <sup>a</sup>	140.55 ± 22.86 <sup>b</sup>	143.53 ± 29.43 <sup>b</sup>	0.692
SysBP (mmHg)_120 min	135.96 ± 20.87	134.69 ± 19.52	139.21 ± 24.28	0.415
Intragroup p value	<b>0.003</b>	<b>0.028</b>	<b>0.031</b>	
DiaBP (mmHg)_0 min	81.44 ± 17.67 <sup>b</sup>	80.78 ± 17.48	83.16 ± 18.52	0.621
DiaBP (mmHg)_30 min	77.49 ± 12.55	77.43 ± 12.02	77.63 ± 14.19	0.869
DiaBP (mmHg)_120 min	76.29 ± 11.06	76.55 ± 10.79	75.63 ± 12.02	0.761
Intragroup p value	<b>0.023</b>	0.155	0.067	
HR (/min)_0 min	97.12 ± 23.80 <sup>a</sup>	94.45 ± 23.21 <sup>b</sup>	104.00 ± 24.54 <sup>b</sup>	0.143
HR (/min)_30 min	95.65 ± 22.13 <sup>a</sup>	94.27 ± 23.00	99.21 ± 19.81 <sup>b</sup>	0.187
HR (/min)_120 min	93.25 ± 23.65	91.2 ± 23.93	98.53 ± 22.69	0.180
Intragroup p value	<b>0.0001</b>	<b>0.014</b>	<b>0.007</b>	
RR (/min)_0 min	28.81 ± 9.83	27.96 ± 8.68	31.00 ± 12.31	0.488
RR (/min)_30 min	25.28 ± 8.44 <sup>c</sup>	24.47 ± 7.44 <sup>c</sup>	27.37 ± 10.55 <sup>c</sup>	0.212
RR (/min)_120 min	23.94 ± 7.54 <sup>c</sup>	22.86 ± 6.15 <sup>c</sup>	26.74 ± 9.96 <sup>c</sup>	0.150
Intragroup p value	<b>0.0001</b>	<b>0.0001</b>	<b>0.0001</b>	
BTemp (°C)_0 min	36.55 ± 0.29	36.59 ± 0.28	36.45 ± 0.30	0.068
BTemp (°C)_30 min	36.51 ± 0.28	36.5 ± 0.26	36.53 ± 0.32	0.994
BTemp (°C)_120 min	36.53 ± 0.26	36.53 ± 0.26	36.51 ± 0.27	0.780
Intragroup p value	0.434	0.765	0.537	
SO <sub>2</sub> (%)_0 min	89.26 ± 5.90	89.27 ± 6.24	89.26 ± 5.09	0.701
SO <sub>2</sub> (%)_30 min	94.78 ± 3.76 <sup>c</sup>	94.69 ± 3.57 <sup>c</sup>	95.00 ± 4.32 <sup>c</sup>	0.531
SO <sub>2</sub> (%)_120 min	94.97 ± 3.34 <sup>c</sup>	94.73 ± 3.01 <sup>c</sup>	95.58 ± 4.10 <sup>c</sup>	0.150
Intragroup p value	<b>0.0001</b>	<b>0.0001</b>	<b>0.0001</b>	
EtCO <sub>2</sub> (mmHg)_0 min	30.94 ± 7.34 <sup>d</sup>	30.9 ± 7.75	31.05 ± 6.35	0.939
EtCO <sub>2</sub> (mmHg)_30 min	28.59 ± 7.42	28.53 ± 7.63	28.74 ± 7.04	0.919
EtCO <sub>2</sub> (mmHg)_120 min	29.74 ± 8.59	30.41 ± 9.31	28 ± 6.26	0.348
Intragroup p value	<b>0.024</b>	0.135	0.179	

BTemp, body temperature; DiaBP, diastolic blood pressure; EtCO<sub>2</sub>, end-tidal carbon dioxide; HR, heart rate; NC-SM, nasal cannula + surgical mask; RR, respiratory rate; SOM-SM, simple oxygen mask + surgical mask; SO<sub>2</sub>, fingertip oxygen saturation; SysBP, systolic blood pressure. <sup>a</sup>p < 0.005 vs\_120 min; <sup>b</sup>p < 0.05 vs\_120 min; <sup>c</sup>p < 0.001 vs\_120 min; <sup>d</sup>p < 0.05 vs\_30 min. Data are presented as mean ± standard deviation (SD)

moderate-to-severely [20]. Moreover, the probability of N95 to cause headaches was 4 times higher in those who used it for more than 4 h daily [20].

Beder et al. observed that the heart rate of surgeons increased, and their SO<sub>2</sub> values decreased after the operation performed with SMs [21]. However, the decrease experienced in SO<sub>2</sub> was also detected in doctors who performed the procedure without a mask after operations lasting less than 30 min [21]. In a study involving 32 volunteer pilot instructors, cloth masks and paper/surgical masks were compared. Heart rate and CO<sub>2</sub> values of volunteers measured by capnograph were found to be significantly higher before the mask was worn and when the mask was first put on later [22]. Although this study was conducted on healthy volunteers, heart rate and capnography values showed similar

results to our study. The increase in the SO<sub>2</sub> of our subjects is an expected result since we already aimed to support oxygenation by giving external oxygen in our study. We consider that the mask may even have contributed to this in a positive way, both by decreasing room air entrainment and increasing oxygen concentration in the front portion of the mask. When pilot instructors were asked to evaluate their comfort levels, they mentioned that cloth masks made them feel safer. The most common complaints were subjective symptoms such as fogging in eyeglasses, feeling uncomfortable and hot, feeling tired, and restriction of movement [22]. We did not question our subjects in terms of comfort after the mask. We expect that the improvement in vital parameters of these patients, who applied to the ED with an active complaint, may also recover subjective symptoms. Since the use of a mask may

**Table 3** Investigation of the change in values obtained from vital signs and EtCO<sub>2</sub> according to the groups of nasal cannula + surgical mask and simple oxygen mask + surgical mask

	All participants (n = 68)		NC-SM (n = 49)		SOM-SM (n = 19)		Intergroup p value
	Mean ± SD	med. (min–max)	Mean ± SD	med. (min–max)	Mean ± SD	med. (min–max)	
SysBP (mmHg), 0–30 min	6.79 ± 25.73	2 (–38–124)	7.08 ± 28.49	0 (–38–124)	6.05 ± 17.30	2 (–19–47)	0.657
SysBP (mmHg), 0–120 min	12.22 ± 28.97	10 (–50–133)	12.94 ± 31.53	9 (–50–133)	10.37 ± 21.62	10 (–32–52)	0.924
SysBP (mmHg), 30–120 min	5.43 ± 18.66	4.5 (–50–85)	5.86 ± 19.09	5 (–50–85)	4.32 ± 17.96	4 (–31–45)	0.897
DiaBP (mmHg), 0–30 min	3.96 ± 15.85	2 (–40–47)	3.35 ± 16.96	1 (–40–47)	5.53 ± 12.80	4 (–13–40)	0.614
DiaBP (mmHg), 0–120 min	5.15 ± 15.78	2.5 (–29–58)	4.22 ± 16.99	2 (–29–58)	7.53 ± 12.20	4 (–9–43)	0.311
DiaBP (mmHg), 30–120 min	1.19 ± 9.95	2 (–29–30)	0.88 ± 11.16	2 (–29–30)	2.0 ± 5.99	3 (–10–13)	0.596
HR (/min), 0–30 min	1.47 ± 19.25	2 (–81–44)	0.18 ± 19.07	2 (–81–44)	4.79 ± 19.85	5 (–33–43)	0.534
HR (/min), 0–120 min	3.87 ± 20.04	5.5 (–81–48)	3.24 ± 21.77	5 (–81–48)	5.47 ± 15.09	7 (–26–29)	0.498
HR (/min), 30–120 min	2.40 ± 9.60	2.5 (–36–23)	3.06 ± 9.11	3 (–36–23)	0.68 ± 10.84	1 (–18–20)	0.311
RR (/min), 0–30 min	3.53 ± 5.64	2 (–10–26)	3.49 ± 5.41	2 (–10–24)	3.63 ± 6.36	2 (–4–26)	0.912
RR (/min), 0–120 min	4.87 ± 8.22	4 (–16–32)	5.10 ± 7.97	4 (–16–24)	4.26 ± 9.02	2 (–6–32)	0.519
RR (/min), 30–120 min	1.34 ± 5.40	0.5 (–13–18)	1.61 ± 5.78	1 (–13–18)	0.63 ± 4.34	0 (–8–10)	0.506
BTemp (°C), 0–30 min	0.04 ± 0.30	0 (–0.8–1.1)	0.09 ± 0.31	0 (–0.5–1.1)	–0.08 ± 0.27	0 (–0.8–0.3)	0.071
BTemp (°C), 0–120 min	0.03 ± 0.34	0 (–1–1)	0.06 ± 0.31	0 (–0.8–1)	–0.06 ± 0.40	–0.1 (–1–0.8)	0.140
BTemp (°C), 30–120 min	–0.02 ± 0.30	0 (–1–0.8)	–0.03 ± 0.27	0 (–0.7–0.7)	0.02 ± 0.38	0.1 (–1–0.8)	0.323
SO <sub>2</sub> (%), 0–30 min	–5.51 ± 5.99	–4 (–24–5)	–5.43 ± 5.87	–4 (–24–5)	–5.74 ± 6.46	–3 (–20–3)	0.956
SO <sub>2</sub> (%), 0–120 min	–5.71 ± 6.04	–4 (–25–7)	–5.47 ± 5.98	–4 (–25–4)	–6.32 ± 6.34	–6 (–20–7)	0.403
SO <sub>2</sub> (%), 30–120 min	–0.19 ± 2.55	0 (–8–5)	–0.04 ± 2.61	0 (–8–5)	–0.58 ± 2.41	0 (–6–4)	0.438
EtCO <sub>2</sub> (mmHg), 0–30 min	2.35 ± 6.0	2 (–13–22)	2.37 ± 6.39	2 (–13–22)	2.32 ± 5.02	3 (–10–15)	0.621
EtCO <sub>2</sub> (mmHg), 0–120 min	1.21 ± 6.45	1 (–25–16)	0.49 ± 6.93	1 (–25–16)	3.05 ± 4.68	3 (–5–10)	0.122
EtCO <sub>2</sub> (mmHg), 30–120 min	–1.15 ± 5.70	–1 (–18–12)	–1.88 ± 6.26	–1 (–18–12)	0.74 ± 3.36	2 (–6–5)	0.107

BTemp, body temperature; DiaBP, diastolic blood pressure; EtCO<sub>2</sub>, end-tidal carbon dioxide; HR, heart rate; NC-SM, nasal cannula + surgical mask; RR, respiratory rate; SOM-SM, simple oxygen mask + surgical mask; SO<sub>2</sub>, fingertip oxygen saturation; SysBP, systolic blood pressure  
Data are presented as mean ± standard deviation (SD) and median (minimum–maximum)

cause subjective symptoms such as headache, drowsiness, visual difficulties, shortness of breath, palpitations, confusion, and difficulty in communication in cases where the oxygen-carbon dioxide exchange is not affected, we preferred to evaluate the objective and measurable results [13].

The majority of the patients in our study consisted of those with respiratory problems such as COPD, pneumonia, congestive heart failure, and lung malignancy. In the study conducted by Chan et al. which they performed by excluding diseases such as COPD and CHF, which may cause respiratory problems, they requested geriatric patients to use nonmedical masks in their daily lives. They found that these masks did not cause significant changes in the SO<sub>2</sub> values of the individuals. They also warned that using a mask on patients with a disease that may cause respiratory problems may lead to complications [15, 23]. Dirol et al. performed the 6 min walking test on a group of 100 volunteers without cardiopulmonary disease. In the mask-wearing group, heart rate, respiratory rate, and EtCO<sub>2</sub> values increased after exertion, while SO<sub>2</sub> values decreased significantly [16]. In volunteers, who used cloth and SMs during exertion and 32% of which

had comorbidities, the CO<sub>2</sub> level was not affected and a slight increase in the heart rate was noted by Shein et al. [24]. There are conflicting data, in patients with or without comorbidity, stating that the use of surgical masks during exertion causes different EtCO<sub>2</sub> values. Our study group consisted of patients who applied to the ED for an acute reason. Measurements were taken while the patients were at rest. However, they had a certain amount of stress, both because of their illness and ED admissions. Therefore, it would be unrealistic to compare our study group with patients or volunteers at rest and with changes in acute exertion. However, as the intervention period progressed, the improvement of the changes in the vital signs of our patient group may also be associated with feeling safer in the hospital and the response to the treatments given.

Since we conducted our study with a surgical mask, it is highly likely that we did not see results such as hypoxemia and hypercarbia that may occur during stress in chronic patients using N95 [15] in our own subject group. In addition, the average age of most of the study groups in the studies we evaluated was lower than our group. Our results are also valuable in this respect.

The limited number of patients may be considered among the limitations of our study. The reason for this is primarily the change in the number and characteristics of patients who applied to the EDs due to the increased use of personal protective measures and curfew restrictions due to the pandemic. The second reason is that the number of patients admitted to our hospital is less than that of state hospitals because our hospital provides tertiary health care. Due to the limited number of patients, it was not possible to evaluate patients by creating a disease-based subgroup. Our third limitation is that the results cannot be fully attributed to NC-SM and SOM-SM applications since our study was observational and there was no control group, and the treatment processes of the patients continued. But it has also a positive aspect, that is to say, in most cases, diagnosis and treatment processes are carried out simultaneously in EDs. The fact that the application of NC-SM and SOM-SM together with the treatment is not associated with worsening of vital signs in the acute period eases the burden of the physician in the first period of intervention.

## Conclusion

NC-SM and SOM-SM applications do not affect the vital parameters and EtCO<sub>2</sub> adversely in 120 min time in patients who present to the emergency department with acute complaints and are administered oxygen. In addition, these applications even seem to lead to a recovery in these vital parameters.

**Author contribution** Conceptualization: AO, TO, MO; methodology: AO, HS; formal analysis and investigation: MU, HC, HS, MS, AY; writing—original draft preparation: AO, TO, MO; writing—review and editing: AO, TO; resources and supervision: IT.

## Declarations

**Ethics approval** This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Medical Research Ethics Committee of Pamukkale University (PAÜ 19.01.2021/02).

**Conflict of interest** The authors declare no competing interests.

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