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Margaux Petitjean, Émilie Béquignon, Françoise Zerah, Maxime Fieux, Bruno Louis, et al.. Covid-19 pandemic: do surgical masks impact respiratory nasal functions?. International Forum of Allergy and Rhinology, 2022, Online ahead of print. 10.1002/alr.23013 . inserm-03676709

HAL Id: inserm-03676709

https://inserm.hal.science/inserm-03676709

Submitted on 24 May 2022

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Covid-19 pandemic: do surgical masks impact respiratory nasal functions?

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Keywords: Covid-19; face mask; nasal respiratory functions; rhinomanometry; nasal mucosa.

Running head: surgical masks and nasal respiratory functions

Funding: This study was not sponsored by any external financial support.

Disclosure statement: All the authors have read and approved the paper's content. No authors have financial or personal conflicts to disclose. Neither the work nor any part of its essential substance, tables or figures have been or will be published or submitted to another scientific journal or are being considered for publication elsewhere.

Word count: 900

Introduction

Because of Coronavirus disease 19 (COVID-19), the use of surgical masks has become a worldwide recommendation [1], which has however encountered some resistance in the general population, justified by complaints of nasal discomfort [2]. To date, the functional and architectural impacts of wearing a surgical mask on nasal respiratory functions have not been investigated.

The objective of this prospective study was to evaluate any consequences of surgical mask use on nasal respiratory functions and geometry, measured by rhinomanometry, acoustic rhinometry and nasal compliance.

Methods

We conducted a prospective monocentric study including adult volunteers without septal perforations or complete nasal obstruction (medical and paramedical staff of a French teaching hospital, and patients scheduled for rhinomanometry) between January and April 2021.

Questionnaires and measurements were performed three times: i) T1, after 30 minutes of wearing a mask and with the mask still on, each volunteer was asked to complete a visual analogue scale (VAS) questionnaire of nasal discomfort symptoms (nasal obstruction, rhinorrhea, pruritus, shortness of breath, sweating and mouth breathing), followed by nasal entrance temperature anterior rhinomanometry, acoustic rhinometry and nasal compliance measurements immediately after the mask was removed; ii) T2, the volunteer then spent 30 minutes without a mask on, and, thereafter, completed the same questionnaires and measurements; and iii) T3, the volunteer put the mask back on and immediately underwent anterior rhinomanometry to assess the barrier resistance generated by the surgical mask itself

(supplementary **Figure 1**). As recommended in the Riga conference consensus [3], the logarithmic effective resistances (LReff) were chosen to evaluate the pressure flow recorded by anterior rhinomanometry (Low and very low LReff < 0.89 $Pa.mL^{-1}.s$; High and very high LReff > 1.09 $Pa.mL^{-1}.s$). Methods are detailed in Supporting Information.

Results

For the 50 adult volunteers included, (characteristics in supplementary **Table 1)**, the nasal obstruction VAS (/10) for the right nasal fossa was significantly higher at T1, compared to the VAS at T2: 1.8 ± 2.1 and 1.3 ± 1.9 respectively (p = 0.012). The VAS of other symptoms (headaches, mouth breathing, sweating, respiratory oppression, pruritus and rhinorrhea) (/10) were significantly higher at T1 than at T2 (**Table 1**). LReff at T1 were significantly reduced (right = 0.89 ± 0.33 $Pa.mL^{-1}.s$; left = 0.84 ± 0.37 $Pa.mL^{-1}.s$) compared to LReff at T2 (right = 1.12 ± 0.36 $Pa.mL^{-1}.s$; left = 1.09 ± 0.33 $Pa.mL^{-1}.s$) [Right and left nasal fossae: p < 0.001]. LReff with the masks re-donned (T3) were significantly increased (right = 1.64 ± 0.48 $Pa.mL^{-1}.s$; left = 1.56 ± 0.46 $Pa.mL^{-1}.s$) compared to LReff at T2 [Right and left nasal fossae: p < 0.0001] (**Figure 1**)**.**

The MCA-1 at T1 was significantly larger (right = 0.62 ± 0.21 cm^2; left = 0.67 ± 0.21 cm^2) than that at T2 (right = 0.48 ± 0.18 cm^2; left = 0.52 ± 0.26 cm^2) [Right and left nasal fossae: p < 0.0001] (supplementary **Figure 2**).

Nasal compliance at C1 was significantly higher at T1 than T2 (0.02 ± 0.019 and 0.017 ± 0.013 cm^2/cmH_20 respectively; p = 0.036) (supplementary **Figure 3**).

The temperature at the nasal entrance was significantly higher at T1 (31.2 ± 1.00 °C) than it was at T2 (27.9 ± 1.60 °C), p < 0.0001.

Discussion

Wearing a surgical mask provides positive effects on functional nasal respiratory parameters. Indeed, LReff were significantly reduced after wearing a mask for 30 minutes, while MCA-1 and compliance at the nasal valve were significantly higher. Rarely (if ever) the cross-sectional nasal areas and rhinomanometry scores are off kilter when people are complaining about mask usage. People complained about subjective matters as expected [4].

Scarano et al. reported increased humidity behind masks [5] and we reported significantly warmer temperatures (mean +3.4 °C). When the nose is exposed to cool, dry air, the nasal mucosa releases vasoactive amines and leukotrienes [6,7] that increase both superficial mucosal blood flow, which, in turn, leads to increased nasal resistances [8]. When wearing a mask, the exhaled air, instead of being cooled away from the nasal vestibule, warms newly inhaled air. As a result, LReff and areas of sections are decreased when wearing a mask.

The VAS-assessed worsening of rhinologic symptoms when wearing a mask in our study is in line with the meta-analysis performed by Kisielinski et al. [9]. These observations point to a discordance between the discomfort expressed by a subject when wearing a mask for 30 minutes (lower VAS score) and the aforementioned positive effects of doing so on the subject's nasal mucosa (significantly reduced LReff in between T2 and T1). This paradoxical result may be explained by the fact that the first LReff measurements (T1) were performed with no tissue interposing between the nasal fossa and the rhinomanometer. At T3, the rhinomanometer applied on the mask reduced the effective surface used to breath which explain the increase of LReff.

There are some limitations to our study. Firstly, we chose healthy volunteers as subjects, among which a majority of healthcare workers, more used to wear surgical masks for hours per day. Secondly, the measurements' sequence (T1, T2, T3) was not randomised. Indeed, regarding the worldwide sanitary crisis (mask required to enter the hospital), it was

impossible to make measurements before any mask use. Prospective studies in patients with chronic rhinologic symptoms or other types of masks (cloth, surgical masks, N95, KN95, …) and about the longer-term impacts of wearing face masks and the related physiological changes on nasal mucosa are required.

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Table 1: VAS (visual analogic scale) evaluation of subjective symptoms with and without a mask for 30 minutes.

Evaluation item, VAS	**With a mask for 30 minutes**	**Without a mask for 30 minutes**	**p-value**
Headache	0.72 ± 1.70	0.18 ± 0.77	0.009
Mouth breathing predominant	2.70 ± 3.18	0.46 ± 1.03	< 0.0001
Sweating	2.38 ± 2.91	0.22 ± 0.91	< 0.0001
Respiratory oppression	1.60 ± 2.24	0.10 ± 0.36	< 0.0001
Pruritus	1.28 ± 1.94	0.06 ± 0.31	< 0.0001
Rhinorrhea	1.68 ± 2.29	0.48 ± 1.22	0.001

Legend: VAS scored for a maximum of 10. Values presented as mean ± standard deviation (SD).

Tables and figures

Table 1: VAS (visual analogic scale) evaluation of subjective symptoms with and without a mask for 30 minutes.

Legend: VAS scored for a maximum of 10. Values presented as mean ± standard deviation (SD).

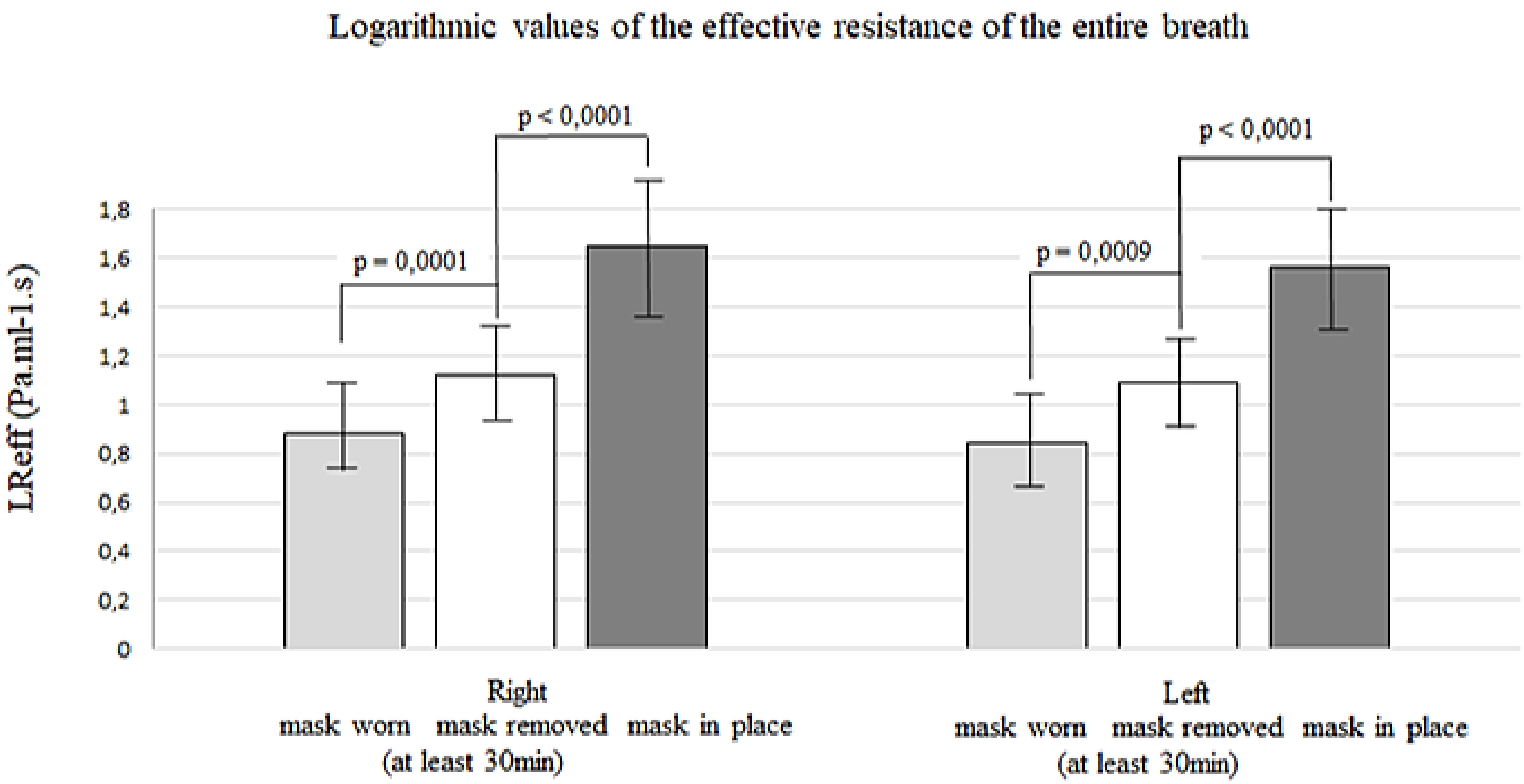

Logarithmic values of the effective resistance of the entire breath
LReff (Pa.ml-1.s)
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
p = 0,0001
p < 0,0001
p = 0,0009
p < 0,0001
Right
mask worn
mask removed
mask in place
(at least 30min)
Left
mask worn
mask removed
mask in place
(at least 30min)

Figure 1: Logarithmic values of the effective resistance of the entire breath (LReff) in patients with a mask for thirty minutes (T1) compared to LReff values without a mask for thirty minutes (T2), and to LReff values with a face mask covering the nose (T3), n = 50.

Legend: Results plotted as means ± SD (error bars).