



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Original Article

Management of sleep apnea in New York City during the COVID-19 pandemic



Michael Thorpy^{a,*}, Mariana Figuera-Losada^a, Imran Ahmed^a, Renee Monderer^a,
Monica Petrisko^a, Chris Martin^a, Jamal Akhtar^a, Jacqueline Thorpy^b, Carver Haines^b

^a Sleep-Wake Disorders Center, Montefiore Medical Center and Albert Einstein College of Medicine, New York, USA

^b University of Arkansas for Medical Sciences Northwest, Fayetteville, Arkansas, USA

ARTICLE INFO

Article history:

Received 12 May 2020

Received in revised form

6 July 2020

Accepted 9 July 2020

Available online 18 July 2020

Keywords:

COVID-19

Obstructive sleep apnea

CPAP

Mortality

Morbidity

New York

ABSTRACT

Background: With the onset of the COVID-19 outbreak there has been concern that patients with obstructive sleep apnea (OSA) who develop COVID-19 may be at risk of greater morbidity and mortality than patients without OSA. COVID-19 is associated with an increased mortality in the elderly and particularly those with obesity, hypertension and diabetes, features which are typically seen in patients with OSA. This article describes the COVID-19 environment in New York City in which patients were evaluated and treated for OSA.

Methods: A telephone questionnaire survey of 112 OSA patients determined the occurrence of COVID-19 in the sleep apnea population and the patients' perspective on sleep apnea Positive Airway Pressure (PAP) management during the COVID-19 outbreak. The three main objectives of the survey were as follows: (1) To discover how patients were coping with COVID-19 pandemic in terms of their sleep apnea and PAP use, (2) To determine whether PAP usage changed after the onset of the outbreak in terms of adherence, and (3) To find out if patients were concerned about whether they were at greater risk of contracting COVID-19 because of their sleep apnea and, if they became infected, whether COVID-19 might result in greater complications because of the presence of sleep apnea.

Results/Conclusions: The adjustment in clinical management of OSA patients is described both during the peak of the outbreak in New York State (NYS), as well as the proposed modifications that will be instituted in order to return to full sleep center activities.

© 2020 Elsevier B.V. All rights reserved.

1. Introduction

In December of 2019 a series of viral pneumonia cases were reported in China. Analysis of patient samples by deep sequencing showed that a novel coronavirus, severe acute respiratory syndrome-coronavirus-2 (SARS-CoV-2), was the cause of the illness which was later named coronavirus disease 2019 (COVID-19) [1,2].

Clinical features of COVID-19 include fever, cough, shortness of breath or difficulty breathing, chills, shaking, headaches, muscle aches, loss of sense of smell or taste [3]. As of the end of April 2020, it has been reported that about 80% of people infected by the novel coronavirus had mild flu-like symptoms and recovered without having to seek medical attention [4]. However, severe illness and

hospitalization has been reported in patients with comorbidities such as chronic lung disease, diabetes, heart conditions, hypertension, chronic kidney disease, obesity, age 65 years and older, immunocompromised, and liver disease [5–7].

Notably, many of the COVID-19 severe illness risk factors are also well-known co-morbidities of obstructive sleep apnea (OSA), a highly prevalent sleep-related breathing disorder estimated to affect over 29 million people in the U.S. alone. OSA is characterized by reduced breathing or breathing cessation during sleep and is more often seen in older obese adults with a prevalence of approximately 13% in males and 9% in females [8–11]. The comorbidities associated with death in patients with COVID-19 commonly occur in patients with OSA, including hypertension, diabetes mellitus, hyperlipidemia, and obesity. In addition, OSA patients have compromised breathing. This suggests that OSA patients on PAP may have greater concerns than the general population about being infected with COVID-19.

* Corresponding author. Sleep-Wake Disorders Center, Montefiore Medical Center, Albert Einstein College of Medicine, 111 East 210th Street, Bronx, NY 10467, USA.
E-mail address: michael.thorpy@einsteinmed.org (M. Thorpy).

This manuscript documents how the COVID-19 pandemic affected patients with OSA on PAP in the epicenter of the illness as was found in New York City. Information obtained from a survey indicated whether patients with OSA who were on a PAP device, were concerned enough to ensure their OSA was being effectively treated during this time. The survey also indicated the degree of concern that patients with OSA had that they might be more susceptible to get COVID-19 because of their OSA, and asked whether patients were concerned that by having OSA they might be more likely to have more severe complications of COVID-19 because of their OSA.

Although the American Academy of Sleep Medicine (AASM) has made theoretical recommendations for the management of OSA during the pandemic this manuscript describes the clinical practice that occurred in a sleep center that continued to operate during the COVID-19 pandemic, although in a reduced capacity, and the steps that were taken from a practical aspect to treat patients during this time.

We believe the information obtained from our experience will be found useful by other sleep centers that are in early stages of the pandemic, or may be facing a similar pandemic in the future.

2. New York COVID-19 outbreak, morbidity, and mortality

The COVID-19 outbreak pandemic has been particularly devastating to the vulnerable populations that are well represented in New York State (NYS), New York City (NYC) and the Bronx. NYC was the major epicenter of the COVID-19 outbreak in the USA. The first case of COVID-19 was detected in NYC on March 1st 2020 in a 39 year old female healthcare worker [12]. The outbreak spread rapidly throughout the city and state and by April 25th there were 288,045 positive cases in NYS. The positivity rate peaked on April 14th. NYC hospital admissions were at a peak on April 6th and daily deaths peaked on April 7th [13]. The NYC death rate affected a higher percentage of Blacks and Hispanics [13].

The number of deaths related to COVID-19 in NYS peaked on April 26th with 59.6% males and 40.3% females, and older age (≥ 65 years) and the presence of comorbidities were associated with a more severe course. Of those that died due to complications of COVID-19, hypertension, diabetes mellitus, hyperlipidemia, and coronary artery disease were the most common comorbidities [14]. Surprisingly, obesity was not reported as a comorbidity.

Even though the sex distribution for positive cases in NYC was roughly the same for males and females (51.8% males and 47.7% females), nearly 60% of fatalities constitute male patients. Similarly, lower socioeconomic status has been associated with increased mortality. The Bronx population is a lower income working class population [15].

3. Sleep center activity at a hospital in NYC

The Sleep-Wake Disorders Center (SWDC) of Montefiore Medical Center (MMC) is located in the Bronx, a borough of New York City in one of the highest prevalence areas of COVID-19 in NYS and the USA.

Patients with sleep apnea continued to be treated throughout the COVID-19 outbreak, although the patient management was adjusted because of COVID-19. Many sleep disorders centers in NYC closed completely during the outbreak in part because of being situated in the main building of the hospital and because staff were redeployed to other areas of the hospitals to manage COVID-19 patients.

The aim of this article is to describe the COVID-19 environment in which the SWDC was operating, the patient population, and the adjustment in clinical management of OSA patients on a positive airway pressure device (PAP) [continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP) or Adaptive

servoventilation (ASV). The SWDC operating modifications are described both during the peak of the outbreak in NYS, and the proposed modifications that will be instituted in order to return to full sleep center activities.

4. Sleep apnea services during the COVID-19 pandemic

In the Bronx public health insurance is more common (16%) while 12% of patients have Private Health Insurance, 10% Employer-based Health Insurance, 9% Medicare, and 10% Medicaid [16]. As of April 26th, 2020 the Bronx had 34,970 confirmed positive COVID-19 cases and 2325 related deaths.

Montefiore Health System (MHS) comprises 10 hospitals (including a pediatric hospital) in the greater New York Area. MMC is the largest teaching hospital in the Bronx with 756 hospital beds. The number of COVID-19 admissions to MMC peaked at 563 on April 11th and had declined to 337 on April 27th.

The SWDC of MMC is located on the ground floor of an office building adjacent to the main hospital. It has easy access directly from outside the building for staff and patients, who do not have to pass through the body of the hospital to reach the SWDC.

The SWDC patient population comprises approximately 80% patients with obstructive sleep apnea syndrome (OSA) with the remainder being patients with narcolepsy, insomnia, parasomnias, and other sleep disorders.

Soon after the outbreak of COVID-19 in NYC the SWDC altered its procedures accordingly, and moved to telemedicine with video telehealth for new patients so patients did not need to physically visit the SWDC. New patient appointments were mainly done from the physician's home by video televisits, and patient follow-up appointments were mainly by telephone televisits, but a small number also had video televisits. A proprietary video system called, Montefiore First, was established for patient scheduling and appointments by video televisits. The secretarial staff maintained the schedule, and relayed telephone calls to the clinicians for televisits. All staff followed appropriate Centers for Disease Control and Prevention (CDC) and American Academy of Sleep Medicine (AASM) COVID-19 guidelines for environmental and patient care practices.

Most in-lab sleep studies were stopped and only studies and procedures deemed essential were performed, such as those requiring titration with adaptive servoventilation, or essential patients who required an abbreviated daytime sleep study (PAP-NAP) for PAP optimization. No patients with COVID-19 symptoms or recently infected patients were evaluated in the SWDC lab. To reduce the possibility of aerosolization a viral filter was installed on the exhaust tubing of the in-lab PAP devices and full personal protection equipment (PPE) was used by the technicians. Continuous positive airway pressure (CPAP) masks, tubing, filters, and water chamber are used once per patient. The CPAP unit itself is cleaned/disinfected after each patient. A HEPA filter used during the titration study is kept on for a minimum of 15 exchanges, but typically >18 air exchanges (ie ~ 3 h or more) after the study is completed with the room door closed. The room is vented by opening the windows for several hours and not used for 24–48 h once the study is completed.

Most patients were evaluated for their sleep apnea by Home Sleep Testing (HST), and subsequently prescribed autoCPAP to reduce the number of in-lab PAP titrations. Each HST device was only used every fourth day and underwent intensive sanitization before and after use.

5. Patient survey methods

A telephone questionnaire survey of 112 OSA patients determined the occurrence of COVID-19 in the sleep apnea population

and the patients' perspective on sleep apnea PAP management during the COVID-19 outbreak (Table 1). 112 mainly English speaking patients (97%) at the SWDC between the ages of 20 and 82 years of age, were selected at random from patients who were under treatment for OSA using a PAP device. Patients were contacted by their sleep medicine clinician either for routine follow-up consults or to inquire about the progress of their OSA management during the pandemic. Patients gave consent verbally over video or telephone calls to participate in the survey.

There were three main objectives of the survey: (1) To discover how patients were coping with COVID-19 in terms of their sleep apnea and PAP use, (2) To determine whether PAP usage changed after the onset of the outbreak in terms of adherence, and (3) To find out if patients were concerned about whether they were at greater risk of contracting COVID-19 because of their sleep apnea and, if they became infected, whether COVID-19 might result in greater complications because of the presence of sleep apnea. In addition, at the time of the survey information was given to ensure; the PAP device was being used effectively, adequate supplies were available, appropriate mask, tubing and PAP machine sanitization, and to encourage regular adherence to nightly PAP use and that patients were following CDC guidelines.

6. Patient survey results

A total of 112 patients (mean age 60.6 years, range 20–82 years, Male 46 (41%), Female 66 (59%), Mean BMI: $36.2 \pm 7.3 \text{ kg/m}^2$) who were using PAP therapy were selected at random for the telephone survey from the patient records of those under treatment for OSA at the SWDC of MMC. The information collected over two weeks from April 27th 2020 until May 8th 2020 became part of the patient's clinical record. The study was approved by the Montefiore Medical Center Institutional Review Board – Einstein IRB # 2020-11618.

Not every question in the survey applied to all patients therefore the number of patients responding to each question differs slightly. 10 patients (9%) indicated that they had had a positive test for COVID-19. The symptoms reported by the patients with COVID-19 included fever, cough, shortness of breath, myalgia, and phlegm. Two out of 10 COVID-19 patients were hospitalized within a few days of the survey.

Table 1
COVID-19 and sleep apnea survey.

Patient demographics and body measurements:				
Age:	Sex:	Weight:	Height:	BMI:
A. COVID-19 and OSA:				
Have you tested POSITIVE for COVID-19 Virus (CV)? (if yes, complete B below)				Yes/No
Are you USING a PAP device?				Yes/No
Have you STOPPED using PAP because of CV?				Yes/No
Are you using the PAP MORE since the CV outbreak?				Yes/No
Are you MORE CONCERNED about CV because you have apnea?				Yes/No
Do you think you are at GREATER RISK of getting CV because you have apnea?				Yes/No
Do you think apnea makes you more likely to have GREATER MEDICAL PROBLEMS because of CV?				Yes/No
Have you taken any ADDITIONAL measures to use your PAP machine?				Yes/No
If so, What measures; new mask, new CPAP, etc.?				
B. Do you have any of the following conditions? (Read all and circle):				
Cardiovascular disease:	Hypertension	Arrhythmia	Coronary artery disease	Congenital heart disease
Obesity	Diabetes mellitus	Asthma	Immunocompromised	Chronic obstructive pulmonary disease
Kidney impairment		Liver impairment		
C. Coronavirus history and PAP use:				
Explain coronavirus history:				
Did you feel a need to USE PAP when you had CV? If so, why?				

These patients ranged in age from 43 to 77 years of age, and 100% were overweight or obese, 30% had diabetes mellitus, 80% had cardiovascular diseases, and 20% had asthma. Two patients increased their use of PAP device at least in the early stages of the illness. Six patients reported not using their PAP device because of difficulty breathing.

Of all patients surveyed, 85 (88%) continued to use their PAP device during the COVID-19 outbreak. 11 (11%) of patients surveyed indicated that they had ceased to use their PAP device. 21 (20%) indicated that they were using their PAP device more during the outbreak. Patients were concerned about the presence of OSA if they were to get COVID-19 and believed that using the PAP device more often and/or for a longer time would be of clinical benefit at this time.

In sum, 41 (38%) patients indicated that they were concerned about getting COVID-19 because they had OSA. Furthermore, 29 (29%) felt that they were at greater risk of getting COVID-19 because they had underlying OSA, even though there is no evidence that they would be more vulnerable to acquire COVID-19. Moreover, 63 (63%) patients were concerned that the presence of OSA made them more likely to have greater medical complications if they were to get COVID-19.

Many patients indicated that they were concerned about COVID-19 because of their associated comorbidities. Comorbidities were: obesity 77%, asthma or COPD 31%, diabetes 24%, and cardiovascular disease 83% including hypertension (59%), arrhythmias (8%) or coronary artery disease (11%).

7. SWDC plan to return to full activities

A two-phase plan was devised for return to full SWDC activities as resolution of COVID-19 allows.

The first phase will be the return of clinical and technical staff who are currently redeployed to COVID-19 activities in the hospital. All returning clinical staff will have COVID-19 testing before seeing patients in the SWDC.

Patients with any type of sleep disorder will be evaluated either in the office, or by telehealth. Baseline sleep studies, PAP titrations, PAP-NAP tests, Multiple Sleep Latency Tests (MSLT) and Maintenance of Wakefulness (MWT) tests will resume on a limited basis.

All new patients under aged 70 years at initial sleep evaluation will be seen on the SWDC premises and appointments will be scheduled at 1–2 per hour maximum to allow for social distancing. Clinicians will be on site one day per week on a staggered schedule with only one clinician present at any one time. Patients older than 70 years of age would be evaluated only by Telehealth.

All follow-up appointments will be by telehealth from the clinician's home. If a physical exam or hands-on PAP or PAP mask education is deemed necessary for follow-up patients they will be seen in the SWDC. No patients with COVID-19 would be seen within three weeks of onset of symptoms.

The office environment will be modified so that Plexiglass shields would surround all secretarial desks. Masks, hand sanitizers and disinfectant wipes would be fully available to staff and patients. Staff will wear N95 masks and use gloves at all times. All patients seen at the SWDC will be required to wear a mask and gloves. If a patient presents without a mask, a surgical mask will be provided as well as plastic one-time-use gloves. Patient forehead temperatures would be checked and saliva viral tests, when available, performed by the clerical staff. The office waiting room would allow for 6 feet social distancing. If a patient refuses to comply, the patient would be scheduled for a televisit appointment.

For sleep studies in the SWDC, the technicians will be required to use N95 masks, gloves, eye shields and when necessary, gowns when interacting with patients. A COVID-19 test would be taken on all patients prior to arriving for sleep lab evaluation.

Plastic vertical split screens would be placed outside the doors to PAP titration rooms to minimize aerosolization, and a HEPA air purifier installed in each room. Several rooms will have fans installed in the walls to create a negative pressure environment.

The second phase, when the risk of COVID-19 is further reduced, would entail all new patients, including those over the age of 70 years, being physically seen in the SWDC. Full clinical staff attendance will occur one to two days per week. Patients with a history of COVID-19 would be excluded, unless shown to be cleared by viral testing before attending the SWDC. Appointments will be at intervals of 30 min minimum to allow for social distancing. Most patients evaluated by in-lab polysomnography with the remainder having HST as determined by the clinician or health insurance. Masks, gloves, and gowns would be discretionary depending upon the consideration of potential risk of COVID-19 from the patient. Telehealth would be utilized for patient follow-up appointments, and initial evaluation of patients especially those who live more than approximately 100 miles from the SWDC.

8. Discussion

With the onset of the COVID-19 outbreak there has been concern that patients with OSA who develop COVID-19 may be at risk of greater morbidity and mortality than patients without OSA. COVID-19 is associated with difficulty in breathing and the development of a pneumonia that has led to an increased mortality in the elderly and particularly those with obesity, hypertension and diabetes [17–19]. There is currently no data on the prevalence of OSA in COVID-19 patients, however the profile of those with greater likelihood of death associated with COVID-19 is similar to our random sample of 112 PAP using OSA patients many of whom have cardiovascular disease, hypertension, obesity, and diabetes mellitus.

OSA is a risk to negative outcomes (such as ICU admission, assisted ventilation, or death) in COVID-19 patients and could act as a facilitator of COVID-19 infection [20]. OSA in patients with COVID-19 could produce a higher incidence of cardiovascular complications, such as arrhythmias, cardiac ischemia, and hypercoagulability states, leading to an unfavorable clinical progression. Sleep

deprivation has also been suggested as adding to the severity of the pulmonary inflammatory process of COVID-19 [21].

Untreated OSA patients are at risk of under-aeration of the lungs and associated hypoxemia which could exacerbate the clinical course of COVID-19. Contamination fears from using nasal positive airway pressure may also be a contributing factor to deterioration in some OSA patients [22]. PAP therapy in the early stages of COVID-19 was reported by some of our patients to be helpful prior to hospitalization, and positive end expiratory pressure has been shown to be helpful for COVID-19 patients on admission to hospital.

Our patients reported concern for complications due to COVID-19 because of their OSA and most were adherent to treatment during the time of the COVID-19 outbreak. In addition, 9% of our OSA patients had been infected with COVID-19 and some of these patients reported to have increased their use of PAP, at least in the early stages of their COVID-19 illness. Many patients believed they were not at increased risk of contracting COVID-19 because of the OSA, however they did believe that they could have a more complicated medical course if they were to get COVID-19.

Whether a PAP would be helpful to prevent complications of COVID-19 is unknown. However it would seem reasonable to suspect that the use of a PAP device may help alleviate some of the breathing difficulty associated with sleep apnea and COVID-19, at least initially in the course of the illness. Some patients with COVID-19 increased their use of PAP while infected and one patient indicated he used it 24 h a day as he believed it helped his breathing.

Because of concern regarding COVID-19 cross infection, patients typically have not been studied for OSA either in the laboratory or by HST during the COVID-19 outbreak. In fact, there has been concern about studying OSA patients with PAP devices because of the potential for aerosolization of the COVID-19 virus. Partly for these reasons many sleep laboratories ceased sleep evaluation activities during the COVID-19 outbreak. However, PAP machines were sometimes modified for use in hospitalized patients to help prevent the need for, or in the absence of a standard ventilators [23,24].

Management of OSA patients during the COVID-19 pandemic has been complicated by the closing of sleep centers due to concern over COVID-19 infection of staff or patients, and the need for clinical staff to attend to COVID-19 patients in other settings. The ability to telehealth patients during the outbreak was reassuring to many OSA patients and the ability to perform HST and place patients on autoCPAP were measures that greatly increased the ease of access to therapy for OSA patients.

The lack of appropriate physical measures to prevent the spread of COVID-19 was a factor in preventing many labs from evaluating and treating patients with OSA. Non-invasive ventilation (NIV), including CPAP, is a high-risk aerosol-generating procedure that could put healthcare workers and family members at increased risk [2,3,25]. There has been reported comparable viral load detection in nasal and throat swabs of symptomatic and asymptomatic patients, suggesting PAP-induced aerosolization from asymptomatic patients may pose risks for viral transmission to family members or clinical staff [6].

It has been recommended that patients with OSA cease to use home PAP during the COVID-19 pandemic [26], while others have recommended that PAP therapy be continued [27]. Many patients in our survey felt greater health security when using PAP therapy. One patient with COVID-19 was concerned that he was advised not to use CPAP on admission to hospital, whereas he found it helpful at home before hospital admission.

Failure to use PAP at home would lead to a return of symptoms of sleepiness that would affect quality of life and predispose the patient to accidents, and possible increased risk of cardiovascular or

cerebrovascular events. A return of snoring could affect the sleep of family members' sleep at a time of high anxiety over the COVID-19 pandemic. In addition, positive end expiratory pressure (PEEP) during pulmonary edema, atelectasis, or pneumonia has been demonstrated to improve arterial oxygenation by increasing functional residual capacity, and reducing the work of breathing [28].

In order to continue to treat OSA patients during the COVID-19 pandemic sleep laboratories need to undertake modifications to their usual routine, such as we outlined above, in order to safeguard the staff and patients from infection or reinfection.

In summary, sleep apnea is associated with risk factors that are similar to those associated with morbidity and mortality of hospitalized COVID-19 patients. Patients using PAP devices reported comfort in using their device during the pandemic and believed that they were at greater risk of complications from COVID-19 because of their sleep apnea.

Sleep centers are recommended to develop appropriate procedures to continue to diagnose and treat sleep apnea patients during the COVID-19 pandemic. Those that were unable to operate during the pandemic should try to establish procedures to recommence sleep apnea management after the COVID-19 peak as quickly as feasible, depending upon local COVID-19 conditions. Telehealth is a very efficient way to streamline patient care and to avoid unnecessary patient travel, especially for those that are at a higher medical risk of getting COVID-19 due to comorbidities. Additionally, even with the pandemic improvements in the NYC area, it is possible that an outbreak reoccurrence could occur and the presence of telehealth systems will help prevent interruption of patient care.

Conflict of interest

None declared.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: <https://doi.org/10.1016/j.sleep.2020.07.013>.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.sleep.2020.07.013>.

References

- [1] Coronaviridae Study Group of the International Committee on Taxonomy of V. The species Severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat Microbiol* 2020;5:536–44.
- [2] Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet* 2020;395:497–506.
- [3] Symptoms of coronavirus. United States Center for Disease Control. <https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html> [accessed 30.04.20].
- [4] Novel Coronavirus Pneumonia Emergency Response Epidemiology, T. [The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19) in China]. *Zhonghua Liu Xing Bing Xue Za Zhi* 2020;41:145–51.
- [5] Groups at Higher Risk for Severe Illness. United States Center for Disease Control. <https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/groups-at-higher-risk.html> [accessed 30.04.20].
- [6] Richardson S, Hirsch JS, Narasimhan M, et al., the Northwell, C.-R. C. Presenting characteristics, comorbidities, and outcomes among 5700 patients hospitalized with COVID-19 in the New York City area. *JAMA* 2020 Apr 22;323(20):2052–9.
- [7] Yang J, Zheng Y, Gou X, et al. Prevalence of comorbidities and its effects in coronavirus disease 2019 patients: a systematic review and meta-analysis. *Int J Infect Dis* 2020;94:91–5.
- [8] Franklin KA, Lindberg E. Obstructive sleep apnea is a common disorder in the population—a review on the epidemiology of sleep apnea. *J Thorac Dis* 2015;7:1311–22.
- [9] Garvey JF, Pengo MF, Drakatos P, et al. Epidemiological aspects of obstructive sleep apnea. *J Thorac Dis* 2015;7:920–9.
- [10] Hidden Health Crisis Costing America Billions. Underdiagnosing and undertreating obstructive sleep apnea draining healthcare system. <https://aasm.org/resources/pdf/sleep-apnea-economic-crisis.pdf> [accessed 30.04.20].
- [11] Peppard PE, Young T, Barnet JH, et al. Increased prevalence of sleep-disordered breathing in adults. *Am J Epidemiol* 2013;177:1006–14.
- [12] Goldstein J, McKinley J. Coronavirus in NY: Manhattan woman is first confirmed case in state. *The New York Times* March 1, 2020. Published March 2, 2020.
- [13] NYSDOH COVID-19 Tracker. New York Department of Health. <https://COVID19tracker.health.ny.gov/views/NYS-COVID19-Tracker/NYSDOHCOVID-19Tracker-Map> [accessed 30.04.20].
- [14] Petrilli CM, Jones SA, Yang J, et al. Factors associated with hospitalization and critical illness among 4,103 patients with COVID-19 disease in New York City. *medRxiv* 2020;2020. <https://doi.org/10.1101/2020.04.08.20057794>.
- [15] Census Quick facts: Bronx, NY, United States Census Bureau. <https://www.census.gov/quickfacts/fact/table/bronxcountybronxboroughnewyork/PST045218> [accessed 30.04.20].
- [16] NY Health Insurer Data. Vista health solutions. <https://www.nyhealthinsurer.com/new-york-bronx-health-insurance/> [accessed 29.04.20].
- [17] Sattar Naveed, McInnes Iain B, McMurray John JV. Obesity a risk factor for severe COVID-19 infection: multiple potential mechanisms. *Circulation* 2020;120:047659.
- [18] Simonnet A, Chetboun M, Poissy J, et al. Lille Intensive Care COVID-19 and Obesity study group. High prevalence of obesity in severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) requiring invasive mechanical ventilation. *Obesity* (Silver Spring) April 9, 2020. <https://doi.org/10.1002/oby.22831> [Epub ahead of print].
- [19] Lighter J, Phillips M, Hochman S, et al. Obesity in patients younger than 60 years is a risk factor for COVID-19 hospital admission. *Clin Infect Dis* April 9, 2020. <https://doi.org/10.1093/cid/ciaa415> [Epub ahead of print].
- [20] Tufik S, Gozal D, Ishikura IA, et al. Does obstructive sleep apnea lead to increased risk of COVID-19 infection and severity? *J Clin Sleep Med* 2020 May 22. <https://doi.org/10.5664/jcsm.8596>. Online ahead of print.
- [21] Salles C, Mascarenhas Barbosa H. COVID-19 and obstructive sleep apnea. *J Clin Sleep Med* 2020 Jun 2.
- [22] McSharry D, Malhotra A. Potential influences of obstructive sleep apnea and obesity on COVID-19 severity. *J Clin Sleep Med* 2020 May 1. <https://doi.org/10.5664/jcsm.8538>. Online ahead of print.
- [23] Kryger M, Thomas R. Home PAP devices in COVID-19 infected patients. *J Clin Sleep Med* 2020 Apr 8. <https://doi.org/10.5664/jcsm.8490> [Epub ahead of print] PubMed PMID: 32268933.
- [24] Radovanovic D, Rizzi M, Pini S, et al. Helmet CPAP to treat acute hypoxemic respiratory failure in patients with COVID-19: a management strategy proposal. *J Clin Med* 2020 Apr 22;9(4). <https://doi.org/10.3390/jcm9041191>. pii: E1191. PubMed PMID: 32331217.
- [25] Tran K, Cimon K, Severn M, et al. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. *PLoS One* 2012;7:e35797. <https://doi.org/10.1371/journal.pone.0035797>. pmid:http://www.ncbi.nlm.nih.gov/pubmed/22563403 CrossRefPubMedGoogle Scholar.
- [26] Society BT. Guidance regarding coronavirus (COVID-19) and obstructive sleep apnoea (OSA): for people who routinely use continuous positive airway pressure (CPAP), their families and health care workers. 2020. Available, <https://www.brit-thoracic.org.uk/media/455098/osa-alliance-cpap-COVID-19-advice-20-3-20-v10.pdf>.
- [27] Baker JG, Sovani M. Case for continuing community NIV and CPAP during the COVID-19 epidemic. *Thorax* 2020 May;75(5):368. <https://doi.org/10.1136/thoraxjnl-2020-214913>. Epub 2020 Apr 9. PubMed PMID: 32273336.
- [28] Dewan NA, Nieto FJ, Somers VK. Intermittent hypoxemia and OSA: implications for comorbidities. *Chest* 2015 Jan;147(1):266–74. <https://doi.org/10.1378/chest.14-0500>. Review. PubMed PMID: 25560865; PubMed Central PMCID: PMC4285080.