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Symptomless multi-variable apnea prediction index assesses adverse outcomes in patients with Corona Virus Disease 2019

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A B S T R A C T

Purpose: To explore the relationship between symptomless multi-Variable apnea prediction (sMVAP) index and adverse outcomes of patients with Corona Virus Disease 2019 (COVID-19).

Methods: According to the sMVAP quartiles, we divided all patients into four groups. The clinical electronic medical records, nursing records, laboratory findings, and radiological examinations for all patients with laboratory confirmed Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) infection were reviewed. Cox proportional hazard ratio (HR) models were used to determine the risk factors associated with in hospital death.

Results: A total of 97 patients were included in this study. The “Quartile 4” group’s ICU transfer rate was significantly higher than the “Quartile 1” group. Coronary heart disease, high d-dimer and sMVAP at admission were associated with increased odds of death.

Conclusions: Using the sMVAP index for obstructive sleep apnea hypopnea syndrome (OSAHS) risk assessment, and then predicting the adverse outcomes of COVID-19 patients, is an effective method. Therefore, the use of sMVAP index for OSAHS screening for inpatients with COVID-19 should be vigorously promoted, and high-risk patients should be effectively managed.

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1. Introduction

The outbreak of COVID-19 has lasted for more than half a year and has been steadily spreading at the global level, World Health Organization (WHO) had called it pandemic. During the epidemic, due to cross-infection issues, PSG has not been widely used in patients with COVID-19, which makes the impact of OSAHS on patients with COVID-19 unknown. At the same time, due to the lack of sufficient attention to OSAHS, many patients were not collected for OSAHS-related clinical manifestations such as neck circumference, snoring, and daytime sleepiness, Therefore, it is difficult to use the STOP-Bang questionnaire [1] and NoSAS questionnaire [2] to perform OSAHS screening for COVID-19 patients. The sMVAP index has proved to be an effective tool for screening OSAHS [3], including only parameters such as gender, age and body mass index (BMI). This study explored the relationship between sMVAP index and adverse outcomes of patients with COVID-19, trying to reveal the effect of OSAHS on COVID-19.

2. Methods

2.1. Study design and participants

This single-center, retrospective, observational study was done at Wuhan Union Hospital (Wuhan, China). We retrospectively analyzed patients from Jan 29, 2020, to Mar 23, 2020, who had been diagnosed with COVID-19, according to WHO interim guidance [4]. Laboratory confirmation of SARS-CoV-2 infection was performed by the local health authority.
2.4. Statistical analysis

The purpose of this study is to explore the relationship between sMVAP and adverse outcomes in patients with COVID-19. There were, therefore, no formal hypotheses being implemented to drive the sample size calculation and we included the maximum number of patients who met the inclusion criteria.

The sMVAP index is calculated as: $sMVAP = e^{X}/(1 + e^{X})$, where $e$ is natural constant (Its value is about 2.718281828459) and $X = -10.784 + 0.203 \times (\text{BMI}) + 0.043 \times (\text{Age}) + 1.004 \times (\text{Gender: 0 = female, 1 = male})$ [3]. The sMVAP ranges from 0 to 1, with higher values indicating higher OSAHS risk. To provide clinically-relevant interpretations, we based analyses on sMVAP quartiles (patients were divided into four groups). We expressed descriptive data as mean (SD) or median (IQR) for continuous variables and number (%) for categorical variables. We assessed differences between different groups using one-way ANOVA or kruskal-wallis H test depending on parametric or nonparametric data for continuous variables and Fisher’s exact test for categorical variables. Cox proportional HR models were used to determine HRs and 95% CIs between individual factors on mortality. Previous studies have shown blood levels of d-dimer and history of coronary heart disease associated with adverse clinical outcomes in patients with COVID-19 [17,18]. Some laboratory findings, including alanine aminotransferase (ALT), lactate dehydrogenase, high-sensitivity cardiac troponin I, and d-dimer, might be unavailable in emergency circumstances. Therefore, we chose d-dimer, coronary heart disease, and sMVAP index as the three variables for our multivariable Cox proportional HR models. Survival curves were developed using the Kaplan–Meier method with log-rank test. Time to events (death) were defined as the time from hospital admission to events. Since the P value of the log-rank test between the four groups was $>$0.05, we only performed survival analysis on the “Quartile 1” and “Quartile 4” group.

Tests were two-sided with significance set at $\alpha$ less than 0.05. The SPSS 24.0 software (IBM SPSS) was applied for all analyses.

3. Results

A total of 97 patients were included in this study (Fig. 1). The average age of all patients was 58 years (IQR 42.5–67.0), with 78.7% males (Table 1). 36.1% of patients had hypertension, while 15.5% of patients had Diabetes. 77.3% of patients had bilateral infiltrates on chest x-ray. The most common symptoms were cough (72.2%), fatigue (42.3%) and fatigue (23.7%). About four-fifths of patients (78.4%) were general disease status on admission, whereas 17.5% of patients should transfer to Intensive care unit (ICU) and required invasive mechanical ventilation. 58 (59.8%) patients received antibiotics and 84 (86.6%) received antivirals (Table 2). 73 (75.3%) patients were treated with high-flow nasal cannula, three (3.1%) with extracorporeal membrane oxygenation (ECMO), eight (8.2%) patients were treated with continuous renal replacement therapy (CRRT). The proportion of patients in the “Quartile 4” group using invasive mechanical ventilation was significantly higher than that in the “Quartile 1” group. There was no significant difference in the proportion of non-invasive mechanical ventilation (NIMV) between groups.

There were 82 patients (84.5%) discharged before the cut-off date. Although the mortality of the “Quartile 4” group is almost eight times that of the “Quartile 1” group, there was no significant difference in mortality between groups. The “Quartile 4” group’s ICU transfer rate was significantly higher than the “Quartile 1” group. The median time of hospital length of stay was 22 days (IQR 15–34.5) and there was no significant difference in that between groups. The most common complications was secondary infection (10.3%), acute kidney failure (8.2%) and respiratory failure (8.2%) (Table 2).

In univariable analysis, odds of in-hospital death was higher in “Quartile 4” group (Table 3). Old age, male sex, coronary heart disease, lactate dehydrogenase, high-sensitive cardiac troponin I, prothrombin time and d-dimer were also associated with death (Table 3). In the multivariable Cox proportional HR models, we found that coronary heart disease, high d-dimer and sMVAP at admission were associated with increased odds of death (Table 3). For the primary outcome, among 97 patients with SARS-CoV-2 infection, 15 (15.5%) patients had died before the cut-off date, and the mean duration from hospital admission to death was 67.8 days (IQR 54.7–81.0) in “Quartile 4” group (Fig. 2).

![Fig. 1. Study flow diagram.](image-url)
Table 1
Demographic, clinical, laboratory, and radiographic findings of patients on admission.

| Demographics and clinical characteristics | Overall (n = 97) | sMVAP quartile |
|------------------------------------------|-----------------|----------------|
|                                          | Quartile 1 (n = 24) | Quartile 2 (n = 25) | Quartile 3 (n = 26) | Quartile 4 (n = 22) | P value |
| **Age, years**                           | 58.0 (42.5–67.0)  | 40.0 (30.0–50.5)  | 57.4 (13.9)\(^b\) | 61.3 (12.5)\(^b\) | 62.8 (14.2)\(^e\) | <0.001 |
| **Sex**                                  |                 |                |                |                |                |        |
| Male                                     | 43 (44.3%)      | 1 (4.2%)       | 7 (28%)        | 17 (65.4%)\(^b,d\) | 18 (81.8%)\(^e,d\) |        |
| Female                                   | 54 (55.7%)      | 23 (95.8%)     | 18 (72%)       | 9 (34.6%)        | 4 (18.2%)         | <0.001 |
| **BMI, kg/m²**                           | 24.1 (3.5)\(^a\) | 22.3 (2.6)     | 23.1 (3.2)     | 24.2 (2.9)       | 26.9 (3.7)         | <0.001 |
| sMVAP                                    | 0.05 (0.03–0.09) | 0.01 (0.01)    | 0.03 (0.01)\(^b\) | 0.07 (0.06–0.08)\(^b,d\) | 0.12 (0.11–0.18)\(^b,d\) | <0.001 |
| **Chronic medical illness**              |                 |                |                |                |                |        |
| Hypertension                             | 35 (36.1%)      | 4 (16.7%)      | 7 (28%)        | 15 (57.7%)\(^b\) | 9 (40.9%)          | 0.018  |
| **Imaging features**                     |                 |                |                |                |                |        |
| Critical findings of patients on admission. |              |                |                |                |                |        |
| **Disease severity status**              |                 |                |                |                |                |        |
| Mild                                     | 1 (1%)          | 1 (4.2%)       | 0              | 0              | 0              | 0.475  |
| General                                  | 76 (78.4%)      | 21 (87.5%)     | 20 (80%)       | 22 (84.6%)      | 13 (59.1%)        | 0.113  |
| Severe                                   | 3 (3.1%)        | 1 (4.2%)       | 1 (4%)         | 1 (3.8%)        | 0              | 1      |
| Critical                                 | 17 (17.5%)      | 1 (4.2%)       | 4 (16%)        | 3 (11.5%)       | 9 (40.9%)\(^b\) | 0.012  |
| **Laboratory findings**                  |                 |                |                |                |                |        |
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Data are mean (SD), median (IQR) or n (%). BMI, body mass index; sMVAP, symptomless multi-variable apnea prediction; ALT, alanine aminotransferase; CRP, C-reactive protein; BNP, brain natriuretic peptide.

\(^a\) Compared with the “Quartile 2” group, P value of the “Quartile 1” was <0.05.
\(^b\) Compared with the “Quartile 3” group, P value of the “Quartile 1” was <0.05.
\(^c\) Compared with the “Quartile 4” group, P value of the “Quartile 1” was <0.05.
\(^d\) Compared with the “Quartile 2” group, P value of the “Quartile 3” was <0.05.
\(^e\) Compared with the “Quartile 2” group, P value of the “Quartile 4” was <0.05.
\(^f\) Compared with the “Quartile 3” group, P value of the “Quartile 4” was <0.05.
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4. Discussion

This retrospective cohort study identified the relationship between OSAHS risk and the mortality and ICU transfer rate in patients in Wuhan who were hospitalised with COVID-19. In particular, coronary heart disease, d-dimer levels greater than 0.5 µg/L, and higher sMVAP on admission were associated with higher odds of in-hospital death. Additionally, elevated ICU transfer rate and the incidence of complications were more commonly seen in higher sMVAP patients. To our knowledge, this is the first study to explore the association between sMVAP index and COVID-19.

During the COVID-19 pandemic, considering that SARS-CoV-2 was highly contagious, sleep monitoring for inpatients was inconvenient to carry out. A multi-center study from Europe pointed out that the number of polysomnography in Lab fell by more than 70% during the pandemic [9]. The Canadian Chest Association also recommends that patients should not be tested for sleep disordered breathing during the pandemic unless a clinician determines that a case is “extremely urgent” [10]. At the same time, despite the lack of clinical trials, based on the pathophysiology of OSAHS, some scholars believe that OSAHS could lead to increased risk of COVID-19 infection and severity [11–13]. We have noticed that there are two small sample studies showing that 21%–28.6% of critically ill COVID-19 patients were accompanied by OSAHS on admission [14,15]. Although the above studies did not analyze the impact of OSAHS on the prognosis of critically ill COVID-19 patients, one of the studies pointed out that patients with coexisting conditions were at risk for severe disease and poor outcomes after ICU admission [14], which indirectly reflects the negative impact of OSAHS on the progress of COVID-19. At this time, it is particularly important to choose a simple and accurate OSAHS screening tool, such as STOP-Bang questionnaire and NoSAS questionnaire. However, in the early stage of the epidemic in Wuhan, in the face of a large number of patients, medical staff may have no time to pay attention to the patients’ OSAHS history, such as snoring and sleepiness, and they also have no time to measure patients’ neck and abdominal circumference. Therefore, we cannot use the above questionnaires to assess patients’ OSAHS risk.

Table 2
Treatments and outcomes.

| Overall (n = 97) | sMVAP quartile | | | | | P value |
|-----------------|----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Treatments | | Quartile 1 (n = 24) | Quartile 2 (n = 25) | Quartile 3 (n = 26) | Quartile 4 (n = 22) |
| Antibiotics | 58 (59.8%) | 18 (75%) | 14 (56%) | 14 (53.8%) | 12 (54.5%) | 0.378 |
| Antiviral treatment | 84 (86.6%) | 17 (70.8%) | 21 (84%) | 26 (100%)\(a\) | 20 (90.9%) | 0.013 |
| Corticosteroids | 36 (37.1%) | 5 (20.8%) | 7 (28%) | 11 (42.3%) | 13 (59.1%) | 0.037 |
| Intravenous immunoglobulin | 22 (22.7%) | 4 (16.7%) | 5 (20%) | 6 (23.1%) | 7 (31.8%) | 0.084 |
| High-flow nasal cannula oxygen therapy | 73 (75.3%) | 14 (58.3%) | 23 (92%)\(b\) | 21 (80.8%) | 15 (68.2%) | 0.037 |
| Invasive mechanical ventilation | 17 (17.5%) | 1 (4.2%) | 4 (16%) | 3 (11.5%) | 9 (40.9%)\(c\) | 0.012 |
| Non-invasive mechanical ventilation | 9 (9.3%) | 0 | 3 (12%) | 2 (7.7%) | 4 (18.2%) | 0.167 |
| ECMO | 3 (3.1%) | 0 | 1 (4%) | 0 | 2 (9.1%) | 0.134 |
| CRRT | 8 (8.2%) | 0 | 2 (8%) | 1 (3.8%) | 5 (22.7%) | 0.032 |
| Prognosis | | | | | | |
| Discharge from hospital | 82 (84.5%) | 23 (95.8) | 21 (84%) | 23 (88.5%) | 15 (68.2%) | 0.084 |
| Death | 15 (15.5%) | 1 (4.2%) | 4 (16%) | 3 (11.5%) | 7 (31.8%) | 0.084 |
| Outcome | | | | | | |
| Any stay in ICU | 17 (17.5%) | 1 (4.2%) | 4 (16%) | 3 (11.5%) | 9 (40.9%)\(c\) | 0.012 |
| Hospital length of stay, days | 22.0 (15.0–34.5) | 24.7 (10.3) | 16 (12–30) | 25.7 (11.8) | 28.2 (12.4) | 0.132 |
| Complications | | | | | | |
| Septic shock | 4 (4.1%) | 0 | 0 | 0 | 4 (18.2%) | 0.002 |
| Secondary infection | 10 (10.3%) | 0 | 3 (12%) | 0 | 7 (31.8%)\(c\) | <0.001 |
| Acute kidney failure | 8 (8.2%) | 0 | 3 (12%) | 1 (3.8%) | 4 (18.2%) | 0.091 |
| DIC | 2 (2.1%) | 0 | 1 (4%) | 0 | 1 (4.5%) | 0.475 |
| Pneumothorax | 1 (1%) | 0 | 0 | 0 | 1 (4.5%) | 0.227 |
| Stress ulcer | 2 (2.1%) | 1 (4.2%) | 1 (4%) | 0 | 0 | 0.726 |
| ARDS | 4 (4.1%) | 1 (4%) | 1 (3.8%) | 2 (9.1%) | 0.453 |
| Respiratory failure | 8 (8.2%) | 0 | 3 (12%) | 2 (7.7%) | 3 (13.6%) | 0.299 |
| Heart failure | 1 (1%) | 0 | 0 | 0 | 1 (4.5%) | 0.227 |
| Sepsis | 1 (1%) | 0 | 0 | 0 | 1 (4.5%) | 0.227 |
| Acidosis | 2 (2.1%) | 0 | 0 | 0 | 2 (9.1%) | 0.050 |
| Viral myocarditis | 3 (3.1%) | 0 | 1 (4%) | 2 (7.7%) | 0 | 0.615 |
| Hypoproteinemia | 2 (2.1%) | 0 | 1 (4%) | 1 (3.8%) | 0 | 1 |
| Coagulopathy | 1 (1%) | 1 (4.2%) | 0 | 0 | 0 | 0.474 |

Data are mean (SD), median (IQR) or n (%). sMVAP, symptomless multi-variable apnea prediction. ECMO, extracorporeal membrane oxygenation; CRRT, continuous renal replacement therapy; ICU, intensive care unit; DIC, disseminated intravascular coagulation; ARDS, acute respiratory distress syndrome.

\(a\) Compared with the “Quartile 2” group, P value of the “Quartile 1” was ≤0.05.

\(b\) Compared with the “Quartile 3” group, P value of the “Quartile 1” was ≤0.05.

\(c\) Compared with the “Quartile 4” group, P value of the “Quartile 1” was ≤0.05.
Previous studies reported that old age, male sex and obesity are independent risk factors for COVID-19 mortality [16–18]. Although the above indicators are also risk factors for OSAHS, it is relatively one-sided to use one or two alone to evaluate the risk of OSAHS. The sMVAP index proves to be a practical OSAHS screening tool [3], including parameters such as age, gender, and BMI that only need to be extracted from the patient’s electronic medical record. In this current study, the increased D-dimer and history of coronary heart disease were associated with poor prognosis, reflecting the direct effect of patients’ coagulation function and cardiac dysfunction on mortality, consistent with previous reports [19,20].

This study has several limitations. First, due to the specificity of SARS-CoV-2, none of the patients underwent PSG test, so the efficacy of SMVAP index in screening OSAHS could not be evaluated. Secondly, since this study is a retrospective study, we cannot collect this information of sequential organ failure assessment (SOFA) score and acute physiology and chronic health evaluation II (APACHE II) score.

### Table 3
Risk factors associated with in-hospital death.

| Demographics and clinical characteristics | Univariable HR (95% CI) | p value | Multivariable HR (95% CI) | P value |
|------------------------------------------|------------------------|---------|---------------------------|---------|
| Age, years                               |                        |         |                           |         |
| <65                                      | 1 (ref)                |         |                           |         |
| ≥65                                      | 3.35 (1.19–9.43)       | 0.022   |                           |         |
| Male sex (vs female)                     | 5.62 (1.59–19.93)      | 0.008   |                           |         |
| BMI, kg/m²                               |                        |         |                           |         |
| <28                                      | 1 (ref)                |         |                           |         |
| ≥28                                      | 0.80 (0.18–3.52)       | 0.762   |                           |         |
| Current smoker (vs nonsmoker)            | 3.20 (0.88–11.64)      | 0.078   |                           |         |
| Comorbidity present (vs not present)     | 1.39 (0.49–3.90)       | 0.534   |                           |         |
| Chronic obstructive pulmonary disease     | 5.09 (0.67–38.91)      | 0.117   |                           |         |
| Coronary heart disease                   | 3.57 (1.01–12.68)      | 0.049   | 15.40 (3.09–76.92)        | 0.001   |
| Diabetes                                 | 1.45 (0.41–5.14)       | 0.565   |                           |         |
| Hypertension                             | 2.13 (0.77–5.88)       | 0.143   |                           |         |

| Laboratory findings                      |                        |         |                           |         |
| White blood cell count, × 10⁹ per L      |                        |         |                           |         |
| <4                                       | 0.34 (0.04–2.70)       | 0.309   |                           |         |
| 4–10                                     | 1 (ref)                |         |                           |         |
| >10                                      | 2.65 (0.89–7.90)       | 0.082   |                           |         |
| Lymphocyte count, × 10⁹ per L             | 1.09 (0.99–1.19)       | 0.075   |                           |         |
| Platelet count, × 10⁹ per L              |                        |         |                           |         |
| <100                                     | 3.54 (0.99–12.70)      | 0.052   |                           |         |
| 100–300                                  | 1 (ref)                |         |                           |         |
| >300                                     | 0.40 (0.05–3.10)       | 0.380   |                           |         |
| ALT, U/L                                 |                        |         |                           |         |
| <40                                      | 1 (ref)                |         |                           |         |
| >40                                      | 2.12 (0.77–5.85)       | 0.146   |                           |         |
| Lactate dehydrogenase, U/L               |                        |         |                           |         |
| <245                                     | 1 (ref)                |         |                           |         |
| >245                                     | 28.78 (3.91–226.74)    | 0.001   |                           |         |
| High-sensitive cardiac troponin I, ng/mL |                        |         |                           |         |
| ≤28                                      | 1 (ref)                |         |                           |         |
| >28                                      | 4.07 (1.31–12.64)      | 0.015   |                           |         |
| Prothrombin time, s                      |                        |         |                           |         |
| ≤16                                      | 1 (ref)                |         |                           |         |
| >16                                      | 15.04 (4.11–55.02)     | <0.001  |                           |         |
| D-dimer, mg/L                            |                        |         |                           |         |
| ≤0.5                                     | 1 (ref)                |         |                           |         |
| >0.5                                     | 3.44 (1.09–10.79)      | 0.035   | 4.47 (1.22–16.35)         | 0.024   |
| Procalcitonin, ng/mL                     |                        |         |                           |         |
| ≤0.5                                     | 1 (ref)                |         |                           |         |
| >0.5                                     | 2.03 (0.27–15.40)      | 0.496   |                           |         |

| Others                                    |                        |         |                           |         |
| sMVAP                                     |                        |         |                           |         |
| Quartile 1                                | 1 (ref)                |         |                           |         |
| Quartile 2                                | 4.19 (0.47–37.45)      | 0.200   | 6.52 (0.68–62.13)         | 0.103   |
| Quartile 3                                | 2.96 (0.31–28.50)      | 0.347   | 4.82 (0.46–50.38)         | 0.189   |
| Quartile 4                                | 8.83 (1.09–71.80)      | 0.042   | 17.11 (1.70–172.65)       | 0.016   |

CI, confidence interval; HR, hazard ratio; BMI, body mass index; sMVAP, symptomless multi-variable apnea prediction; ALT, alanine aminotransferase.
5. Conclusions

In conclusion, this study confirms that using the sMVAP index for OSAHS risk assessment, and then predicting the adverse outcomes of COVID-19 patients, is an effective method. Therefore, the use of sMVAP index for OSAHS screening for inpatients with COVID-19 should be vigorously promoted, and high-risk patients should be effectively managed.

Disclosure statement

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CRediT authorship contribution statement

Sun Zhang: Methodology, Software, Writing - original draft. Yuanda Xu: Conceptualization, Methodology. Jieying Li: Methodology. Kang Wu: Formal analysis. Tao Wang: Formal analysis. Xiaofen Su: Investigation. Qian Han: Methodology. Yin Xi: Investigation, Resources. Yong Gao: Resources. Hongbo Wang: Data curation. Yu Hu: Resources. Chunli Liu: Visualization, Conceptualization. Pixin Ran: Supervision. Nuofu Zhang: Writing - review & editing. Nanshan Zhong: Project administration.

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Abbreviations list

COVID-19  Corona Virus Disease 2019  
SARS-CoV-2  Severe Acute Respiratory Syndrome Coronavirus 2  
WHO  World Health Organization  
PSG  polysomnography  
OSAHS  obstructive sleep apnea hypopnea syndrome  
sMVAP  symptomless multi-variable apnea prediction  
BMI  body mass index  
IRB  institutional review board  
ALT  alanine aminotransferase  
AST  aspartate aminotransferase  
CRP  c-reactive protein  
BNP  brain natriuretic peptide  
DIC  disseminated intravascular coagulation  
ARDS  acute respiratory distress syndrome  
DVT  deep venous thrombosis  
ECMO  extracorporeal membrane oxygenation  
CRRT  continuous renal replacement therapy  
IMV  invasive mechanical ventilation  
NIMV  non-invasive mechanical ventilation
Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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.2020.08.031.

References

[1] Chung F, Yegneswaran B, Liao P, et al. STOP questionnaire: a tool to screen patients for obstructive sleep apnea. Anesthesiology 2008;108(5):812–21.
[2] Marti-Soler H, Hirotsu C, Marques-Vidal P, et al. The NoSAS score for screening of sleep-disordered breathing: a derivation and validation study. Lancet Respir Med 2016;4(9):742–8.
[3] Lyons MM, Keenan BT, Li J, et al. Symptomless multi-variable apnea prediction index assesses obstructive sleep apnea risk and adverse outcomes in elective surgery. Sleep 2017;40(3).
[4] WHO. Clinical management of COVID-19. May 27, 2020. https://www.who.int/publications-detail/clinical-management-of-severe-acute-respiratory-infection-when-novel-coronavirus-(ncov)-infection-is-suspected.
[5] 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.
[6] Khwaja A. KDIGO clinical practice guidelines for acute kidney injury. Nephron Clin Pract 2012;120:c179–84.
[7] Ranieri VM, Rubenfeld GD, Thompson BT, et al. Acute respiratory distress syndrome: the Berlin Definition. JAMA 2012;307:2526–33.
[8] National Health Commission of the People’s Republic of China. Chinese guideline for COVID-19 (version 7.0). Mar 3 2020. in Chinese), http://www.nhc.gov.cn/yzwj/s7653p/202003/ 4c65294a7dfe4cefb0dc755912b1989/files/cc1e695f32e45350a8ce964.pdf. [Accessed 3 March 2020].
[9] Grote L, McNicholas WT, Hedner J, et al. Sleep apnoea management in Europe during the COVID-19 pandemic: data from the European sleep apnoea database (ESADA), Eur Respir J 2020;55(6).
[10] Ayas NT, Fraser KL, Giannouli E, et al. Key highlights from the Canadian thoracic society’s position statement on optimizing the management of sleep disordered breathing during the COVID-19 pandemic. Chest 2020.
[11] 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;16(8):1425–6.
[12] Salles C, Mascarenhas Barbosa H. COVID-19 and obstructive sleep apnea. J Clin Sleep Med 2020. https://doi.org/10.5664/jcsm.8605.
[13] McBhrdy D, Malhotra A. Potential influence of obstructive sleep apnea and obesity on COVID-19 severity. J Clin Sleep Med 2020. https://doi.org/10.5664/jcsm.8538.
[14] Bhattach PU, Ghassemieh BJ, Nichols M, et al. Covid-19 in critically ill patients in the seattle region - case series. N Engl J Med 2020;382(21):2012–22.
[15] Arentz M, Yim E, Klaff L, et al. Characteristics and outcomes of 21 critically ill patients with COVID-19 in Washington state. JAMA 2020.
[16] Yu C, Lei Q, Li W, et al. Clinical characteristics, associated factors, and predicting COVID-19 mortality risk: a retrospective study in wuhan, China. Am J Prev Med 2020;59(2):168–75.
[17] Sattar N, McInnes IB, McMurray J. Obesity a risk factor for severe COVID-19 infection: multiple potential mechanisms. Circulation 2020;142(1):4–6.
[18] 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 2020;71(15):856–7.
[19] Zhou F, Yu T, Du R, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 2020;395(10229):1054–62.
[20] Barman HA, Atic A, Sahin I, et al. Prognostic significance of cardiac injury in COVID-19 patients with and without coronary artery disease. Coron Artery Dis 2020. https://doi.org/10.1097/MCA.0000000000000914.