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Original article

Prevalence of obesity and hypovitaminosis D in elderly with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)

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**ARTICLE INFO

**Summary**

**Background & aim:** Verify the prevalence of hypovitaminosis D and obesity in elderly patients infected by new coronavirus. The patients developed severe symptoms and were admitted to intensive care unit (ICU) to receive invasive ventilation due to diagnosis of acute respiratory distress syndrome (ARDS).

**Methods:** A cross-sectional descriptive study composed of elderly (age ≥ 60 years) admitted to the ICU. Were collected demographic (sex, age), anthropometric data, presence of comorbidities (hypertension, diabetes, heart disease, lung, neurological and oncological diseases), severity score in ICU (SAPS III), PaO2/FiO2 ratio, analysis of C-reactive protein (CRP) and serum dosage of 25-hydroxy vitamin D (25 OHD) in the first day of hospitalization to identify elderly with hypovitaminosis D (< 30 ng/mL). The diagnosis of obesity in elderly was determined by calculating the body mass index (BMI) ≥ 30 kg/m².

**Results:** A total of 176 elderly met the inclusion criteria. 54% were elderly men and mean age of 72.9 ± 9.1 years. The median BMI was 30.5 (28.1 – 33) kg/m² with 68.7% having a nutritional diagnosis of obesity and 15.3% had BMI ≥ 35 kg/m². The most prevalent comorbidities were hypertension (72.2%) and diabetes (40.9%). Prevalence of hypovitaminosis D with values of 25 OHD < 30 ng/mL, < 20 ng/mL and < 10 ng/mL was 93.8%, 65.9% and 21% respectively. The prevalence of hypovitaminosis D (< 30 ng/mL) in obese elderly was 94.2%. There was a negative and significant bivariate correlation between BMI and levels of 25 OHD (r = -0.15; p = 0.04).

**Conclusion:** Hypovitaminosis D and obesity in elderly have a high prevalence in critically ill patients in ICU infected by the new coronavirus. Laboratory investigation of vitamin D becomes important, especially in obese elderly patients.

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1. Introduction

The pandemic caused by the new coronavirus (SARS-CoV-2) emerged in Wuhan province, China, in November 2019, and has caused infections with varied clinical presentations, ranging from asymptomatic patients, mild flu syndrome to severe respiratory failure. There is still no complete data on how this new human infection behaves, however, based on data from China, the epicenter of the epidemic, it is estimated that 80% of contaminated patients develop infections with mild symptoms and 5% may develop an acute respiratory distress syndrome (ARDS) that requires hospitalization in the intensive care unit (ICU) [1,2], usually after 3 – 4 days of infection. In Brazil, mortality is estimated at 5.3% [3] and it has already been identified that individuals at higher risk, such as the elderly, obese and chronic diseases (diabetes, hypertension and cancer), confer a high risk for developing severe respiratory infection and consequently evolving to ARDS [4].

ARDS is a clinical condition characterized by an intense systemic inflammatory state and refractory hypoxemia, which can progress to multiorgan failure and death [5]. There is an excessive release of pro-inflammatory cytokines, activation of pro-coagulating factors and increased oxidative stress [6,7]. Consequently, the alveolar edema produced reduces lung compliance, explaining the need to use invasive mechanical ventilation. The systemic inflammatory...
The prevalence of vitamin D deficiency reaches 50% of patients admitted to the ICU, and this is associated with worse clinical outcomes, such as increased infection/sepsis rate and increased mortality [12]. Therefore, the adequacy of this vitamin to recommended levels can recover the immune system after infectious outbreaks, in addition to supporting better immune protection against viral infections [13,14].

In addition to vitamin D deficiency, obesity is also related to worse outcomes in ICU, explained by changes in the immune response, both acquired and innate and by the perpetuation of a low-grade chronic inflammatory state [15]. In addition, obesity worsens the various comorbidities related to the COVID-19 (Coronavirus Disease - 2019): hypertension, diabetes, lung, and heart diseases [16].

Given the above considerations, this study has as main objective to verify the prevalence of obesity and hypovitaminosis D in elderly patients admitted to the intensive care unit due to SARS-CoV-2.

2. Materials and methods

2.1. Study population

This is a cross-sectional descriptive study and data were collected in the first 24 h of admission to the ICU, at Sancta Maggiore Hospital (Prevent Senior Private Operative, São Paulo, Brazil) in the period from March 15 to April 15, 2020. The healthcare protocols for COVID-19 started in the emergency department and they were continued in the ICU. Patients were consecutively included in the study as they were admitted to the ICU when they met the inclusion criteria.

The inclusion criteria were all consecutive patients admitted in ICU; age equal to or older than 60 years; data collected in the first day of ICU admission; diagnosis of acute respiratory distress syndrome defined as a ratio of arterial oxygen tension over fractional inspired oxygen - PaO2/FiO2 < 300; positive swab from the nasal cavity and oropharynx for detection of viral RNA (ribonucleic acid) for COVID-19 using the reverse-transcription polymerase chain reaction (RT-PCR) technique; computed tomography (CT) scan of the chest showing bilateral interstitial infiltrate pulmonary with a typical “ground-glass” pattern. The exclusion criteria were patients under 60 years old; negative swab for COVID-19 (RT-PCR); patients who had previously used cholecalciferol or calcitriol for any reason in the last month and or went through dialysis. The study was reviewed and approved by the Research Ethics Committee of the Prevent Senior Institute (CAAE 30608020.9.0000.8114). All procedures were performed following the Declaration of Helsinki.

2.2. Variables and measures

Data of interest were collected for analysis of the population affected by COVID-19: demographic data (sex, age); anthropometric data such as weight (kilograms) and height (meters); severity score in the ICU such as SAPS III (Simplified Acute Physiology Score III) [17]; measurement of the PaO2/FiO2 ratio after orotracheal intubation and mechanical ventilation; the presence of comorbidities (systemic arterial hypertension, diabetes mellitus, chronic kidney disease, chronic obstructive pulmonary disease, asthma, heart diseases, neurological, oncological and immunosuppressed diseases or who use immunosuppressants); CRP (C-reactive protein) measurement in the first day of hospitalization. The data on weight and height were obtained from a survey with the family member or companion who lived with the elderly. From these data, body mass index (BMI) was calculated by dividing weight by height squared (kg/m²). Then, the BMI was stratified according to the cutoff points suggested by the Pan American Health Organization (Organización Panamericana de la Salud, OPS 2002) [18] for the elderly: BMI ≤ 23 kg/m² (low weight), 23–28 kg/m² (normal weight), 28 to 30 kg/m² (overweight) and ≥ 30 kg/m² (obesity).

The test requested for the analysis of vitamin D levels was the serum dosage of 25-hydroxy vitamin D (25 OHD), measured by liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS). The definition of hypovitaminosis D was standardized according to the criteria of the Brazilian Society of Endocrinology and Metabolism (SBEM) defined by a serum level < 20 ng/mL for general population and < 30 ng/mL for individuals at risk [19]. As the individuals eligible for this study were all classified as high risk of clinical complications, the cutoff level defined in the study for hypovitaminosis was 25 OHD < 30 ng/mL [20]. Severe deficiency was defined by 25 OHD < 10 ng/mL [20].

2.3. Statistical analysis

For descriptive analysis, the variables were tested for normality using the Shapiro–Wilks test, normal distribution data expressed as mean and standard deviation (SD) and categorical data expressed as a percentage of frequency. Non-parametric data were described as median and interquartile range (IQR). Spearman correlation test was performed between non-parametric variables. Statistical significance was set at p < 0.05 and 95% confidence interval. Observational data were statistically analyzed using SPSS 24.0 software (version 24.0, SPSS Inc, Chicago, IL).

3. Results

Between March 15 and April 15, 2020, 25 OHD levels were analyzed in 176 elderly patients admitted to the ICU diagnosed with acute respiratory distress syndrome coronavirus 2 (SARS-CoV-2). The mean age was 72.9 ± 9.1 years and 54% were men, according to the baseline characteristics of elderly who required invasive mechanical ventilation demonstrated in Table 1.

The nutritional diagnosis provided by the BMI showed the prevalence rate of obesity (BMI ≥ 30 kg/m²) in 68.7% of the elderly and median BMI of 30.5 (IQR 28.1–33) kg/m². The findings show that 15.3% of all elderly patients in ICU with SARS-CoV-2 had BMI ≥ 35 kg/m².

The serum dosage of 25 OHD performed at the admission to the ICU showed a median value of 16 (IQR 10–21) ng/mL. The prevalence of 25 OHD < 30 ng/mL was 93.8%, 25 OHD < 20 ng/mL was 65.9% and 25 OHD < 10 ng/mL (severe deficiency) was 21%. The prevalence of 25 OHD < 30 ng/mL among the obese elderly was 94.2%.
There was a negative correlation between BMI and the serum dosage of 25 OHD with statistical significance ($r = -0.15; p = 0.04$).

There was no correlation between serum 25 OHD and SAPS III and CRP.

Fig. 1 shows the various prevalence rates of vitamin D levels ($25 \text{OHD} < 10 \text{ng/mL}; < 20 \text{ng/mL}; < 30 \text{ng/mL}$) among the nutritional profiles according to the BMI among severe elderly in the ICU due to SARS-CoV-2.

Regarding the presence of comorbidities, arterial hypertension (72.2%), diabetes mellitus (40.9%), heart disease (27.3%) and lung diseases like asthma or chronic obstructive pulmonary disease (27.3%) showed the highest prevalence among patients admitted to ICU. Chronic kidney disease (13.1%), neurological diseases (17%) and oncological diseases (7.4%) had a lower prevalence.

4. Discussion

In our study, there was a high prevalence rate of low serum levels of 25 OHD (93.8%) and nutritional diagnosis of obesity using BMI (68.7%) among severe elderly patients admitted to ICU by SARS-CoV-2. According to these data, it is suggested that obesity and vitamin D deficiency should be investigated in the evolution of severe cases of COVID-19 requiring ICU admission and mechanical ventilation assisted by ARDS due to the high prevalence of hypovitaminosis D and obesity in elderly patients in critical condition infected by SARS-CoV-2.

Hypovitaminosis D is a common condition among the elderly. Worldwide data show that 5%–25% of the independent elderly population and 60–80% of institutionalized patients are deficient or insufficient in vitamin D [21]. Vitamin D deficiency is also highly prevalent among obese elderly [22].

Many factors contribute to a higher prevalence of hypovitaminosis D among the elderly. There is a decrease in cutaneous vitamin D synthesis after sun exposure due to atrophic changes of the skin itself [23]. Consequently, there is a reduction in the concentration of 7-dehydrocholesterol in the epidermis, resulting in a reduction in

![Fig. 1. Prevalence of different degrees of hypovitaminosis D (%) according to the results of serum 25-hydroxy vitamin D (25 OHD) measurements distributed between obeses or not obeses stratified by body mass index (BMI).](image)
the formation of pre-vitamin D₃ close to 50% [24,25]. Also, the
absence of sun exposure due to mobility problems, fragility, and
social isolation are frequent [26].

Multiples reports cite that adequate levels of vitamin D can
reduce the risk of viral infections [14,27,28]. The main mechanisms
involve the improvement of natural immunity, acquired immunity
and physical barriers since vitamin D contributes to the main-
tenance of the cell tight junctions, gap junctions and adherence
junctons [29]. The immunomodulatory functions of vitamin D have
received considerable attention because, in addition to its classic
role in bone homeostasis involving calcium and phosphorus,
vitamin D is a potent immunoregulatory. Vitamin D is thought to
modulate immune responses by selective suppression of effector
functions, such as the production of inflammatory cytokines and
leukocyte infiltration, minimizing inflammation [30,31]. Recent
findings also indicate a complex interaction between viral in-
fecions and vitamin D, including the induction of antiviral status,
fungal and bacterial infections, and vitamin D, including the induction of antiviral status, functional immunoregulatory characteristics, induction of auto-
phagy and apoptosis [32].

Jakovac H. shows that vitamin D has significant protective ef-
fects on SARS-CoV-2 since immune evasion mechanisms initially
occur followed by immune hyperreactivity and “cytokine storm”, a
common pathogenic mechanism in the development of acute res-
piratory distress syndrome (ARDS) and the systemic inflammatory
response syndrome (SIRS) [33]. Vitamin D can also mitigate the
scope of acquired immunity and regenerate the endothelial epithelium, which can be beneficial in reducing the alveolar dam-
age caused by ARDS [34].

In a review article, Wimalawansa S. showed that micronutrient
deficiency, especially hypovitaminosis D, increases the risk of
developing viral infections, including coronaviruses [35]. In ad-
dition, he proposes as an effective strategy, daily supplementation of
vitamin D to maintain serum levels of 25 OHD greater than 30 ng/ 
ml.

Another observation from our study was the high prevalence of
obesity among critically ill patients with SARS-CoV-2. According to
Simonnet A. et al., the prevalence of obesity in patients with SARS-
CoV-2 was 47.6% (BMI > 30 kg/m²) and 28.2% (BMI > 35 kg/m²), but
not all of these patients required mechanical ventilation [36]. In our
study, the prevalence was 68.8% (BMI ≥ 30 kg/m²), but all our
patients were elderly people and we included only mechanically
ventilated patients with PaO₂/FiO₂ < 250 ratios.

Obesity-induced inflammation and insulin resistance in adipose
tissue can further complicate this scenario [37,38]. The resistance
and the lipolytic effects of catecholamines and natriuretic peptide
in obese patients mediated by a low amount of beta-2 adrenergic
receptors in adipocytes can lead to a reduction in the release of
vitamin D stored in adipose tissue [39], explaining the correlation
between hypovitaminosis D and obesity.

Low levels of 25 OHD are known to be highly frequent in obese
patients. Many explanations are proposed such as altered vitamin D
metabolism, behavioral factors such as reduced sun exposure, or
reduced intake of foods enriched with vitamin D. In addition, the
increase in body fat mass can act as a storage place for vitamin D,
since that it is a lipophilic hormone [40]. In a recent meta-analysis
involving 35 studies (including 17,245 patients) showed that
vitamin D is inversely associated with body fat mass [41].

5. Conclusion

This present study shows an exploratory data with the objective of
recording and analyzing the characteristics and the occurrence of
hypovitaminosis D and obesity in elderly patients in critical con-
dition by COVID-19. In view of the above considerations, we can
conclude that there is a high prevalence of hypovitaminosis D and
obesity among elderly patients and these factors should be inves-
tigated in the evolution of severe cases of COVID-19 requiring ICU
admission and mechanical ventilation assisted by ARDS. In addi-
tion, further investigations are needed to establish an association
between obesity and hypovitaminosis D and clinical outcomes in
this specific population.

Authorship statement

None of the authors of this manuscript has any financial or
personal relationship with other people or organizations that could
inappropriately influence this work.

Financial support

Prevent Senior Institute, São Paulo, Brazil.

Declaration of competing interest

None of the co-authors have direct or indirect, financial or other
conflicts of interest related to the subject of our report. There is no
conflict of interest regarding sponsorship and financing.

Acknowledgements

The authors wish to thank the volunteers for their participation.

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