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Pressure injuries during the SARS-CoV-2 pandemic: A retrospective, case-control study

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ABSTRACT

Aim of study: The main objective of this study was to ascertain whether severe alterations in hypoxemic, inflammatory, and nutritional parameters in patients diagnosed with SARS-CoV-2 infection were associated with the occurrence and severity of developed dependency-related injuries. The secondary objective was to determine whether there were prognostic factors associated with the occurrence and severity of developed dependency-related injuries during the SARS-CoV-2 pandemic.

Material and methods: A retrospective, single-centre, case-control study was conducted to compare SARS-CoV-2 patients who developed dependency-related injuries after the first 48 h after admission with a control group made up of SARS-CoV-2 patients without dependency-related injuries. The cases of the 1987 patients diagnosed with SARS-CoV-2 infection during the study period were reviewed. Data from 94 patients who developed dependency-related injuries and from 190 patients who did not develop them during hospital admission were analysed.

Results: High baseline dependency levels, prolonged hospital stays, and low oxygen saturation levels on arrival in emergency department triage were associated with the occurrence of dependency-related injuries among patients diagnosed with SARS-CoV-2 infection.

Conclusions: SARS-CoV-2 infection can lead to complications such as dependency-related injuries. Although there are several non-modifiable variables associated with the occurrence of dependency-related injuries in these patients, it is essential to conduct further research and introduce consensus guidelines to reduce their incidence and prevalence.

1. Introduction

In December 2019, a novel coronavirus called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (also called COVID-19 infection) was responsible for an outbreak of acute respiratory disease in Wuhan in the province of Hubei, China. Soon after, in February 2020, the virus spread around the world. On March 11, 2020, the World Health Organisation (WHO) declared it a pandemic [1]. This pathogen causes clinical manifestations that can range from mild to severe and lead to the deaths of large numbers of patients [2]. It has not yet been ascertained whether the origin of the infection was zoonotic or environmental. However, it is well-known that subsequent transmission of the virus has

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occurred from SARS-CoV-2-infected individuals to others through saliva droplets spread by coughing, sneezing and speaking, or through contact with fomites [3].

SARS-CoV-2 infection primarily affects the lungs and the cardiovascular system [4,5], but it can also cause a systemic inflammatory response that creates imbalances in the coagulation system, which, in turn, can lead to serious conditions with a poor prognosis, such as myocardial infarction, cerebrovascular accidents, thromboembolism, and disseminated intravascular coagulation [6–10]. Neurological and ophthalmological alterations have also been reported, albeit less frequently, as well as skin alterations in the form of erythematous rashes, hives, and small blisters in the distal extremities [11,12].

SARS-CoV-2 has a wide range of clinical features that may include: fever, cough, dyspnoea, asthenia, headache, nasal congestion, sputum production, dizziness, odynophagia, chills, nausea, vomiting, diarrhoea, ataxia, epilepsy, hyposmia, and hypogeusia [13,14].

Several predictors of a poor prognosis of the disease have been reported, such as old age, being male, having chronic pulmonary and/or coronary heart disease, or having diabetes mellitus [2]. In addition, it has recently been discovered that alterations in eight genes involved in the autoimmune mechanisms of interferon may constitute a risk factor for severe cases of COVID-19 among young patients without comorbidities [15,16].

In exceptional health emergency situations, patients may develop skin injuries due to the severity of the infection and prolonged stays in healthcare facilities. Advances in basic research and questions raised by clinicians with regard to categorising injuries prompted the Spanish National Advisory Group for the Study of Pressure Ulcers and Chronic Wounds (GNEAUPP) to change its conceptual framework. In 2014, the GNEAUPP developed and presented a new theoretical model where they categorised up to seven types of dependency-related injuries (DRIs). The model allows four different types of injuries to be identified: pressure injuries (PIs), moisture-related injuries, friction-related injuries, and skin tears [17].

PIs are the most prevalent type of injury: as well as representing a public health problem that affects the quality of life of individuals suffering from them, they are also costly to treat [18]. The European Pressure Ulcer Advisory Panel (EPUAP), National Pressure Injury Advisory Panel (NPIAP) and Pan Pacific Pressure Injury Alliance (PPPIA), defined PIs as a localised damage to the skin and/or underlying tissue, usually over a bony prominence, as a result of pressure, shearing forces, and/or friction, or a combination of these [19].

A comprehensive assessment of patients' health is required to prevent deterioration of skin integrity. It is thus essential to take into account the intrinsic and extrinsic factors that can favour the development of DRIs [20]. The literature reviewed shows that it is necessary to consider factors such as the microclimate of the skin [21], malnutrition [22], age, level of consciousness, prolonged exposure to friction, general weakness, low blood pressure, fever, low blood perfusion, the use of multiple vasopressors, and the use of various types of clinical devices (such as endotracheal tubes, rectal probes, venous and arterial accesses, etc.) [23–25].

DRI prevention and treatment is challenging during a pandemic. On the one hand, healthcare teams and institutions have had to adapt to an exceptional public health emergency. In some settings, this has led to situations that place additional stress on health systems, such as the training of teams with different levels of experience in treating infectious diseases like COVID-19, insufficient physical infrastructure, lack of professionals in optimal conditions for exercising their skills, and the use of inadequate personal protective equipment (PPE) given the high demand [26]. On the other hand, the need for a whole host of clinical devices, particularly for patients admitted to intensive care units (ICUs), and the presence of certain risk factors for developing DRI among the clinical features of SARS-CoV-2 may have influenced the development of this type of injury.

Given the considerable increase in the number and severity of PIs, especially among patients admitted to the ICU during the pandemic, we decided to conduct this study to identify the factors that are likely to influence the development of DRIs among patients admitted to ICUs and conventional hospitalisation units with a primary diagnosis of SARS-CoV-2 infection.

The main objective of this study was to ascertain whether severe alterations in hypoxemic, inflammatory, and nutritional parameters in patients diagnosed with SARS-CoV-2 infection were associated with the occurrence and severity of DRIs. The secondary objective was to determine whether there were prognostic factors associated with the occurrence and severity of DRIs during the SARS-CoV-2 pandemic.

2. Material and methods

2.1. Design and participants

A retrospective, single-centre, case-control study was conducted to compare SARS-CoV-2 patients who developed DRIs after the first 48 h after being admitted to our hospital, with a control group made up of SARS-CoV-2 patients without DRIs.

The study included all patients who were diagnosed with SARS-CoV-2 infection from the time the Spanish population went into full lockdown on March 14, 2020 to May 18, 2020, when lockdown measures began to be lifted in the healthcare district where our hospital is located. Patients aged under 18 and those with DRIs originating in the community were excluded. The diagnostic criteria for SARS-CoV-2 infection included 1) testing positive for SARS-CoV-2 in a reverse transcriptase-polymerase chain reaction (PCR) assay using nasopharyngeal swabs, and/or 2) having respiratory symptoms consistent with SARS-CoV-2 infection and presence of opacities and ground-glass opacities on chest X-ray or computed tomography imaging. The guidelines set out in the 2014 GNEAUPP Technical Document Series No. II [17] were used to diagnose DRIs. This document included the following types of DRI: PIs (the most common), moisture-related injuries, friction-related injuries, and skin tears [17].

The study was approved by the Drug Research Ethics Committee (CEIm) at the hospital where the research was conducted (reference number: 2020/592).

Patients with SARS-CoV-2 infection were identified using the list drawn up by the hospital's infection control department. The list was arranged in chronological order by the date on which a positive PCR test result was confirmed or a patient was medically diagnosed as positive. Data for the study variables were obtained from paper or computerised clinical records. To preserve patient anonymity, the database was anonymised by an external IT professional using an algorithm. A total of 1987 cases of patients diagnosed with SARS-CoV-2 infection were analysed. A case:control ratio of 1:2 was applied. An accidental sampling method in chronological order of diagnosis was used. Once the cases had been identified, an automated system was used to select the controls by identifying the two patients who were chronologically closest to each identified case, so that the circumstances in which the patients were cared for would be as similar as possible, avoiding selection bias in the process.

2.2. Data collection

Nurses in the institutional DRI improvement group were responsible for reviewing the medical and nursing records of the 1987 patients diagnosed with SARS-CoV-2 during the study period. In order to reduce observer bias, the principal investigator and one member of the research team explained the items on the data collection form to the other members and made sure that the variables and their response options were properly understood. A number of cases were jointly analysed. Discrepancies were discussed in groups until a consensus was reached.

The study classified variables into nine domains for analysis. The following data were collected: data regarding demographic variables

such as age and sex; data regarding dates of admission to the hospital and/or the ICU; data on infrastructure and the characteristics of the professionals who cared for the patients; data relating to the injuries sustained by the patients, such as date of occurrence, type, category, treatment, and progression. Similarly, patients' baseline comorbidities were analysed using the Charlson Comorbidity Index [27], their history of allergies, and their level of baseline dependency using the Barthel scale [28]. One domain covered variables relating to SARS-CoV-2 infection, including the date the diagnosis was confirmed, PCR test results, symptoms at the onset of the disease, and any complications associated with the progression of the disease. The following data were also collected: data regarding any pharmacological and supplemental oxygen treatments received by the patient; data on variables relating to vital signs, the results of complementary imaging tests (such as chest X-rays and/or CT scans), and the results of laboratory tests: D-dimer (ng/mL), LDH (U/L), absolute lymphocytes/mL, creatinine (mg/dL), c-reactive protein (CRP) (mg/dL), Hb (g/dL), ferritin (ng/L), total protein (g/L), and serum albumin (g/L). Data on these clinical variables were collected at two points in time: first, at the onset of symptoms of SARS-CoV-2 infection and, second, at the time the injury was detected. For patients in the control group, the second collection point for these variables was set approximately halfway through their hospital stay.

Descriptive statistics were analysed as follows: quantitative variables were described using means and standard deviations or medians and the 25th and 75th percentiles, depending on the nature of the distribution of the data. Qualitative variables were described using absolute and relative frequencies. Groups were compared using *t* tests for independent means, the Mann-Whitney *U* test, ANOVA, chi-squared tests, or Fisher's exact test, depending on the parametric or non-parametric nature of the variables. In order to explore the relationships of the variables collected with the prognoses of the patients, a multivariate regression analysis was also performed with the variables that were found to be statistically significant ($p < 0.2$) in the univariate analysis. Variables with a maximum of 15 % missing data were reported in the study. All analyses were performed using the statistical package IBM® SPSS® Statistics version 21.0.

3. Results

3.1. Descriptive data

The study population comprised the 1987 patients diagnosed with SARS-CoV-2 infection who were treated at the hospital during the study period. The study sample was made up of 284 patients from the aforementioned population: 94 cases (patients with at least one DRI) and 190 controls (patients without DRIs). A total of 170 (59.9 %) patients were male. The mean age was 67.91 years [25−103] and the mean number of days in hospital was 18.74 [2–106]. Of the 284 patients in the sample, 177 (62.3 %) presented with bilateral pneumonia on admission, 33 (11.6 %) patients presented with severe complications secondary to SARS-CoV-2 infection, and 71 died as a result of the infection during the study period, resulting in a mortality rate of 25 %. With regard to the physical condition of patients, the mean comorbidity value was 1.89 [SD 2.05] as measured using the Charlson scale. A total of 104 (36.7 %) patients in the sample required high levels of oxygen, 18 (6.3 %) required a tracheostomy, and 25 (8.8 %) required prone positioning. The symptomatological profile on admission included cough in 127 of patients (44.7 %), fever in 202 (71.1 %), dyspnoea in 141 (49.6 %), gastrointestinal symptoms in 59 (10.8 %), and other symptoms such as arthralgia or myalgia in 115 (40.5 %). The most frequent drug treatment consisted of antimalarials in 247 patients (87.0 %), antiretrovirals in 75 (26.4 %), antibiotics in 236 (83.1 %), and corticosteroids in 93 (32.7 %). Table 1 shows the characteristics of the 136 injuries documented in the 94 cases.

Table 1
Description of the dependency-related injuries detected.

Characteristic	N (%) (n = 136 injuries)
Type of injury	
Pressure injury	99 (72.79%)
Moisture-related injury	24 (17.65%)
Friction-related injury	4 (2.94%)
Skin tear	4 (2.94%)
A combination of the above	5 (3.68%)
Category	
Mild (without involvement of deep tissues)	122 (89.71 %)
Severe (with involvement of deep tissues)	14 (10.29 %)
Location	
Sacrum	63 (46.32%)
Heels	17 (12.50%)
Skin folds	17 (12.50%)
Gluteal muscles	8 (5.88%)
Occipital bone	5 (3.68%)
Elbow	2 (1.47%)
Malleolus	1 (0.74%)
Shoulder blades	1 (0.74%)
Trochanter	1 (0.74%)
Other (related to clinical devices)	21 (15.44%)
Progression	
Unfavourable, slow (>72 h)	40 (29.41%)
Unfavourable, rapid (<72 h)	22 (16.18%)
Favourable	74 (54.41%)
Infection	
Yes	9 (6.62%)
Debridement	
Yes	19 (13.97%)

3.2. Univariate analysis

Table 2 shows the values of the study variables for both cases and controls. The sociodemographic profile differed slightly between the two groups. No statistically significant differences were observed between the values for several laboratory variables or between the clinical variables relating to vital signs.

3.3. Multivariate analysis (regression models)

The multivariate analyses produced a regression model in which three variables were associated with the occurrence of DRIs. As shown in Table 3, the variables were as follows: the Barthel index value on admission, the value of oxygen saturation on room air on admission to the emergency department triage system, and the number of days in hospital.

This means that for every point lower on the Barthel scale, the risk of developing a DRI increased by 1.028; for every point lower in oxygen saturation in triage, the risk increased by 1.071; and for every additional day of admission, the risk increased by 1.088.

4. Discussion

In this study, several variables were found to be associated with the occurrence of DRIs among patients diagnosed with SARS-CoV-2 infection. High baseline dependency levels, prolonged hospital stays, and low oxygen saturation levels on arrival in emergency department triage were associated with the occurrence of this type of injury.

In a retrospective study by Bly et al. [29] of a sample of 159 PIs, five risk factors were found to be predictive of the occurrence of a PI: leaving the ICU for a procedure; spending more than two days without a bed with a pressure redistribution system; long-term use of mechanical ventilation (taking into account oxygen pressure and saturation values); using more than one type of vasopressor; and low blood pressure (systolic pressure <90 mmHg). Although hypoxia was not found to be statistically significant in their multivariate analysis, Bly et al. stressed the need to consider variables such as fever (a body temperature >38 °C),

Table 2
Univariate analysis.

Variable	Control group		Case group		p-value
	No. of patients	**$\bar{X}$ (SD)**	**No. of patients**	**$\bar{X}$ (SD)**	
Sociodemographic variables					
Sex (male)	107	56.3 %	63	67.0 %	0.116[c]
Age	190	65.18 (15.21)	94	73.41 (13.86)	<0.001[a]
Braden	41	14.49 (2.42)	44	12.68 (2.68)	0.004[a]
Barthel	190	88.87 (23.93)	94	64.52 (35.48)	<0.001[a]
Charlson	184	1.56 (1.81)	89	2.56 (2.35)	<0.001[a]
Laboratory variables					
D-dimer (ng/mL) on admission	190	3132.81 (12231.6)	94	7347.72 (18248.8)	0.006[a]
Creatinine (mg/dL) on admission	177	0.980 (0.934)	84	1.025 (0.869)	0.053[a]
LDH (U/L) on admission	40	248.5 (147.01)	25	336.0 (158.85)	0.097[a]
Absolute lymphocytes/mL on admission	190	1.28 (0.88)	83	1.41 (2.00)	0.009[a]
Ferritin (ng/L) on admission	63	601.3 (690.76)	35	804.6 (1767.34)	0.096[a]
Hb (g/dL) on admission	173	137 (19.89)	85	133 (21.84)	0.156[a]
C-reactive protein (CRP) (mg/dL) on admission	83	8.54 (28.48)	41	12.32 (11.56)	0.145[a]
D-dimer (ng/mL) during hospitalisation	146	5306.78 (31669.9)	72	5449.33 (11906.3)	<0.001[a]
Creatinine (mg/dL) during hospitalisation	171	0.840 (0.78)	88	0.920 (1.46)	0.021[a]
LDH (U/L) during hospitalisation	124	276.5 (1507.42)	60	295.0 (164.88)	0.069[a]
Absolute lymphocytes/mL during hospitalisation	190	1.58 (2.76)	94	1.59 (2.71)	0.007[a]
Ferritin (ng/L) during hospitalisation	190	673.3 (10711.65)	94	902.05 (1103.74)	0.073[a]
Hb (g/dL) during hospitalisation	169	124.32 (18.31)	88	118.97 (19.99)	0.033[a]
C-reactive protein (CRP) (mg/dL) during hospitalisation	190	5.795 (15.85)	94	8.110 (8.72)	0.3523[a]
Clinical variables					
Body temperature (°C) in triage	185	36.95 (1.03)	93	36.64 (0.95)	0.018[a]
Oxygen saturation on room air (%) in triage	180	94.03 (4.91)	90	91.72 (7.98)	0.04[a]
Diastolic pressure (mmHg) in triage	184	74.27 (14.40)	92	70.93 (14.74)	0.073[b]
Respiratory rate (breaths/min) in triage	190	21.09 (6.16)	94	22.64(6.70)	0.180[b]
Body temperature (°C) during hospitalisation	190	36.46 (0.91)	94	36.52 (0.88)	0.665[a]
Oxygen saturation on room air (%) during hospitalisation	190	94.60 (3.07)	94	93.80 (3.98)	0.144[a]
Respiratory rate (breaths/min) during hospitalisation	30	23.53 (7.85)	18	26.83 (9.53)	0.038[b]

[a] Mann-Whitney *U* test.
[b] Student's *t*-test.
[c] McNemar's test.

Table 3
Univariate and multivariate predictors of DRIs.

Risk factors	Unadjusted		Adjusted	
	OR (95 % CI)	***p* value**	**OR (95 % CI)**	***p* value**
Age (years)	1.042 (1.022–1.062)	<0.001	–	–
Braden	0.738 (0.598–0.911)	0.005	–	–
Barthel	0.974 (0.966–0.983)	<0.001	0.973 (0.96–0.98)	<0.001
Charlson	1.232 (1.091–1.391)	0.001	–	–
D-dimer (ng/mL) on admission	1.00 (1.00–1.00)	0.137	–	–
Absolute lymphocytes/ml on admission	1.072 (0.992–1.289)	0.460	–	–
D-dimer (ng/mL) during hospitalisation	1.00 (1.00–1.00)	0.970	–	–
Absolute lymphocytes/ml during hospitalisation	1.003 (0.913–1.101)	0.953	–	–
Hb (g/dL) during hospitalisation	0.986 (0.972–.0999)	0.039	–	–
Body temperature (°C) in triage	0.734 (0.566–0.951)	0.020	–	–
Diastolic pressure (mmHg) in triage	0.983 (0.966–1.001)	0.060	–	–
Oxygen saturation (%) in triage	0.943 (0.903–0.984)	0.007	0.934 (0.88–0.98)	0.017
Respiratory rate (breaths/min) during hospitalisation	1.047 (0.974–1.125)	0.214	–	–
Length of stay (days)	1.063 (1.042–1.085)	<0.001	1.067 (1.04–1.09)	<0.001

haemoglobin values, saturation values < 90 %, serum glucose levels >180 mg/dL, and hypoalbuminaemia [29]. In a retrospective study in a sample of 1587 patients admitted to critical care units, Sala et al. [30] found that average blood pressure lower than 60 mmHg and low values (<18) on the Braden scale predicted the appearance of PIs 2 weeks before they appeared. Some of these variables, such as fever, haemoglobin values, or low blood pressure (low diastolic pressure), are consistent with the results of the univariate analysis in our study. In the same vein, Senturán et al. argued that oxygenation and perfusion issues are variables that must be taken into account in the prevention and/or treatment of DRIs [24]. Moreover, Deng et al. found that patients with saturation values ≥ 90 % had severe complications [2], and Xie et al. concluded that saturation values were a risk factor for mortality [31]. Given that these symptoms (fever, hypoxia, and altered haemoglobin values) are generally associated with COVID-19 [32], it is important to take these variables into account to prevent the occurrence of PIs in patients diagnosed with SARS-CoV-2 infection.

Another aspect to consider is the severity of the injuries identified in our research. Fourteen severe IPs (categories III and IV) were detected, representing 10 % of the total 136 injuries. The level of patient dependency has traditionally been linked to the severity and risk of occurrence of DRIs [33,34]. This is the case for elderly patients, in whom reduced mobility and the physiology of the skin favour the occurrence of this type of injury [35], and patients with severe spinal cord injuries or neurological problems, in whom injuries occur gradually depending on various nutritional and nursing care parameters [36,37]. Also, patients with severe baseline comorbidities (such as degenerative or neurological pathologies), the use of vasopressors and the presence of medical complications that lengthen the patient's admission to intensive care units are linked to more severe PIs [38–40]. In light of our results, it is safe to say that the level of patient dependency is a noteworthy variable in the development of severe PIs. It was also surprising how rapidly PIs

developed in patients with SARS-CoV-2.

Another relevant finding of our research is the association between the occurrence of DRIs and a prolonged stay in healthcare facilities. This association had already been noted in the scientific literature on DRIs. Over time, there has been a decline in the quantity and severity of DRIs thanks to basic research findings, the application of evidence-based practice in nursing care, and improvements in pharmaceutical products. However, there are a number of non-modifiable variables, such as age, gender, and length of stay, which are associated with the development of DRIs [41]. Prolonged stays are an independent prognostic factor in the development of IPs [42] and are often associated with the severity of the disease process experienced by the patient [25,38].

There is scientific evidence of the association between prone positioning and the occurrence of DRIs [43]. Our results do not demonstrate this association. However, research on previous epidemics caused by other diseases such as SARS [43] and the most recent research on SARS-CoV-2 show that most of patients who were admitted to the ICU and required prone positioning developed PIs [44,45]. Two aspects must be considered in relation to this finding: first, it is essential to inform and implement strategies for DRI monitoring and prevention in ICU patients requiring prone positioning, and second, these DRI prevention strategies should include the use of repositioning devices, skin care, maintenance of the skin's microclimate, and clinical devices such as carefully selected dressings (polymer-based when possible) that take thermal properties into account [46,47].

Another finding of our study shows that patients with SARS-CoV-2 have high mortality rates. This is in line with previous studies, as observed in the literature review, with mortality rates ranging from 15 % [8] to 25.7 % [31].

Studies on the occurrence of DRIs in general and PIs in particular may be classified into two main currents. In the first, study authors maintain that DRIs are entirely preventable and that prevention is linked to the quality of the nursing care provided [48]. In the second, they argue that DRIs are inevitable, but that it is possible to influence them by reducing their incidence [49]. In light of the results of our study, we believe that although nursing care is intended to have a positive impact by reducing the incidence of DRIs, the effectiveness of this care should not be called into question. However, it is essential that international consensus documents are put in place to prevent this type of injury during the SARS-CoV-2 pandemic, bearing in mind that there are unchangeable, potentially harmful factors linked to the disease process or to the patient's baseline condition despite the wide range of procedures and interventions implemented by nursing professionals. In the current context of the pandemic, it has become clear that the aggressiveness of the pathogen can exacerbate the quantity and severity of the injuries sustained by patients with SARS-CoV-2. Therefore, the scientific community and nursing professionals must continue to explore potential strategies to reduce the impact of the virus on DRIs and on quality of life. In addition, efforts should be aimed at alleviating the additional stress and pressure that most health systems have as a result of the SARS-CoV-2 pandemic.

5. Conclusions

SARS-CoV-2 infection can lead to complications such as DRIs. There are several non-modifiable variables associated with the occurrence of DRIs in these patients. However, in order to reduce their incidence and prevalence, it is essential to provide extensive nursing care to the following: patients with low levels of saturation on arrival in the emergency department, patients with high levels of dependency, and patients whose severity requires prolonged hospitalisation. In addition, emergency triage guides should consider these risk factors in order to alert health professionals to the risk of suffering this type of injury and take special measures to reinforce prevention.

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Declaration of competing interest

There are no conflicts of interest in this project.

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