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Original Article

French multicentre observational study on SARS-CoV-2 infections intensive care initial management: the FRENCH CORONA study

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Abbreviations: ICU, intensive care unit LOS, length of stay ARDS, acute respiratory distress syndrome SAPS II, Simplified Acute Physiology Score SOFA, Sequential Organ Failure Assessment RRT, renal replacement therapy ECMO, extra corporeal membrane oxygenation IMV, invasive mechanical ventilation NIV, non-invasive ventilation HFNC, high-flow nasal cannula

ABSTRACT

Aim: Describing acute respiratory distress syndrome patterns, therapeutics management, and outcomes of ICU COVID-19 patients and identifying risk factors of 28-day mortality.

Methods: Prospective multicentre, cohort study conducted in 29 French ICUs. Baseline characteristics, comorbidities, adjunctive therapies, ventilatory support at ICU admission and survival data were collected.

Results: From March to July 2020, 966 patients were enrolled with a median age of 66 (interquartile range 58–73) years and a median SAPS II of 37 (29–48). During the first 24 h of ICU admission, COVID-19 patients received one of the following respiratory supports: mechanical ventilation for 559 (58%), standard oxygen therapy for 228 (24%) and high-flow nasal cannula (HFNC) for 179 (19%) patients. Overall, 721 (75%) patients were mechanically ventilated during their ICU stay. Prone positioning and neuromuscular blocking agents were used in 494 (51%) and 460 (48%) patients, respectively. Bacterial co-infections and ventilator-associated pneumonia were diagnosed in 79 (33%) and 411 (43%) patients, respectively. The overall 28-day mortality was 18%. Age, pre-existing comorbidities, severity of respiratory failure and the absence of antiviral therapy on admission were identified as independent predictors of 28-day outcome.

Conclusion: Severity of hypoxaemia on admission, older age (> 70 years), cardiovascular and renal comorbidities were associated with worse outcome in COVID-19 patients. Antiviral treatment on admission was identified as a protective factor for 28-day mortality. Ascertaining the outcomes of critically ill COVID-19 patients is crucial to optimise hospital and ICU resources and provide the appropriate intensity level of care.

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1. Introduction

Since December 2019, a new agent, the SARS-CoV-2 coronavirus, has been spreading originally from the region of Wuhan in China, and rapidly overseas, causing an international outbreak of respiratory illnesses, designated as COVID-19 by the World Health Organization (WHO). In France, the first cases of COVID-19 have been reported at the end of January 2020. The increasing numbers of patients requiring intensive care urged local health and government officials to significantly increase ICU beds capacity to face COVID-19 patients [1].

While the outbreak has progressed, it appeared that SARS-CoV-2 was responsible for a very specific disease leading to a severe acute respiratory failure. Despite sharing a similar aetiology, COVID-19 patients may present quite different patterns from severely hypoxaemic patients to normally breathing hypoxaemic patients with or without associated hypercapnia and inconsistent response to prone position as an example [2,3]. It is therefore difficult to identify which patients could benefit from one therapy to another. Currently, a variety of therapeutic strategies to manage COVID-19 patients in ICU have been suggested from supportive care alone to prescribing unproven medications. Apart from corticosteroids and tocilizumab, evidence from randomised clinical trials that potential therapies could significantly improve outcomes in patients suffering from severe COVID-19 is still needed [4–6]. Clinical features of hospitalised COVID-19 patients have been described in China, Europe and the United States [7–10]. Although male gender, older age, comorbidities such as diabetes, immunosuppression and severe obesity appear as the most common risk factors of COVID-19 outcome worldwide, a great heterogeneity in COVID-19 features is reported amongst countries limiting potential extrapolation from other countries [11].

Accordingly, the primary objective was to perform a prospective, multicentre, observational study to provide a detailed description of the initial management of COVID-19 patients admitted to French ICUs. The secondary objective was to identify risk factors associated with 28-day mortality in a large cohort of ICU patients. These could promote an individualised therapeutic approach for COVID-19 patients during the current and potential future coronavirus-related outbreaks.

2. Methods

2.1. Study design and population

This study is reported in accordance with the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines [12]. The AZUREA group, a French research network, conducted a prospective, observational, multicentre cohort study in 16 French university and 13 general hospitals. The study was approved by the “Comité de Protection des Personnes – Sud Méditerranéen IV” (2020-A00797-32) for prospective (from the 2rd of April to the 3rd of July 2020) data collection and the Institutional Review Board of Nimes University Hospital for retrospective (from the 4th of March to the 1st of April) data collection, respectively. This study was registered in ClinicalTrials.gov on the 9th of April 2020, NCT04340466. According to French law, written informed consent was waived due to the non-interventional design of the study [13]. Patient or his/her surrogate decision-maker received an information letter prior to patient enrolment when possible.

All patients admitted to the intensive care unit for a diagnosis of probable or confirmed SARS-CoV-2 infection were enrolled into the study according to the predefined following criteria:

- Age ≥ 18 years.
- Patient presenting a confirmed SARS-CoV-2 infection (defined as positive result by reverse transcriptase polymerase chain reaction (RT-PCR) testing of a nasopharyngeal or lower respiratory tract swab) OR a probable SARS-CoV-2 infection (defined as a severe acute respiratory infection associated with inconclusive or unavailable RT-PCR testing) according to WHO guidance. This guidance was implemented locally with the adjunct of consistent COVID-19 CT scan imaging to classify
SARS-CoV-2 infection as probable (https://www.who.int/publications-detail/global-surveillance-for-human-infection-with-novel-coronavirus-(2019-ncov)).

Were not included:

- Patient presenting a severe acute respiratory syndrome with negative SARS-CoV-2 PCR and CT scan results.
- Patient already enrolled in the present study.
- Patient refusal to participate to the present study.

2.2. Data collection

For each included patient, the following data were recorded: demographic data (age, gender, weight, height), clinical data (admission diagnosis, comorbidities, Charlson score [14]), severity scores (SAPS II (Simplified Acute Physiology Score) [15], SOFA (Sequential Organ Failure Assessment) [16] scores) at ICU admission, and at day 7 and 14 for SOFA. Additionally, biological data (including serum creatinine concentration, lactate, ferritin, troponin, CRP, WBC count, haemoglobin, o-dimers, fibrinogen), infection data including clinical symptoms, antimicrobial therapy modalities (timing of initiation, dosing regimen, combination therapy), sedatives and respiratory support mode (invasive mechanical ventilation (IMV), non-invasive mechanical ventilation (NIV), oxygen mask, high-flow nasal cannula oxygen), adjunctive therapies, microbiological and imaging data (chest X-ray, thoracic CT scan, US exam) were collected. Moreover, complications (pulmonary embolism, acute kidney injury, cardiac arrhythmias, myocarditis, ventilator-associated pneumonia (VAP), liver failure) were recorded until hospital discharge or death. VAP was diagnosed based on French VAP/HAP guidelines and microbiological cultures [17]. Date of death was recorded and mortality at day 7, at ICU discharge and at day 28 as well as organ support requirement during 28-day follow-up were also reported.

ARDS was graded according to the Berlin Definition for patients receiving mechanical ventilation on ICU admission [18]. Mild ARDS was defined as a PaO2/FiO2 ratio of ≤ 300 mmHg to 200 mmHg with PEEP or continuous positive airway pressure of ≥ 5 H2O, moderate ARDS was defined as PaO2/FiO2 ratio of ≤ 200 mmHg to 100 mmHg with PEEP ≥ 5 H2O and severe ARDS defined as PaO2/FiO2 ≤ 100 mmHg with PEEP ≥ 5 cm H2O.

2.3. Data management

Data collection was performed by trained staff at each participating centre. Data were entered into a structured electronic password-protected and secured web-based case report form (eCRF). The eCRF was developed using the REDCap Data Management Platform designed to support data capture for research studies [19]. Data monitoring was handled by the coordinating Centre (Nîmes University Hospital, France). Outstanding queries regarding the completion of the CRF were undertaken with each participating centre when necessary to ensure accuracy of data.

2.4. Study outcomes

The primary outcome was all-cause mortality determined from patient medical chart at day 28. The secondary outcomes were ICU and hospital mortality, ICU and hospital length of stay (LOS), all-cause mortality at day 7 and requirement of organ support.

2.5. Statistical analysis

Simple descriptive statistics were used to characterise the study population; continuous data were summarised by median and interquartile range or median and (min; max), categorical data as n (%). Comparisons between survivors and non-survivor patients at 28 days were performed using Student’s t-test for quantitative variables, or the Mann–Whitney U test when the distribution of variables was non-Gaussian, and the Chi-square test for qualitative variables. We used a mixed logistic regression model with a centre-specific random intercept to assess relationships with mortality at day 28, considering the clustered structure of the data.

A primary analysis focused on patients’ characteristics at inclusion: age, gender, BMI (> 40 vs. ≤ 40), SOFA score without respiratory SOFA score component (< 2 vs. > = 2), chronic obstructive pulmonary disease, chronic heart failure, chronic kidney failure, cancer, arterial hypertension (with or without angiotensin-receptor blockers or ACE inhibitors treatment), and partial oxygen arterial blood pressure (PaO2) to fraction of inspired oxygen (FiO2) ratio (PaO2/FiO2 ratio).

A secondary analysis focused on care at admission with adjustment on characteristics at admission. Care parameters included in the model were: type of respiratory support, anti-coagulants, antiviral therapy, hydroxychloroquine and corticosteroids.

Sensitivity analyses were made using generalised estimating equation (GEE) model with an exchangeable correlation matrix and Cox proportional hazards model with gamma frailty distribution. Statistical analyses were performed at the conventional two-tailed α level of 0.05 using SAS statistical software, version 9.4 (SAS Institute Inc).

3. Results

Between the 4th of March and the 3rd of July 2020, data from 966 patients admitted to 29 ICUs were analysed (Fig. 1, study flow diagram). The distribution of included patients among the different participating hospitals is shown in Table S1 (Supplemental data). Baseline characteristics of the study cohort are presented in Table 1. Among patients under mechanical ventilation on admission, 44 (4%) presented mild ARDS, 249 (47%) moderate ARDS and 224 (42%) severe ARDS. The main symptoms at ICU admission were fever (71%, n = 691), shortness of breath (69%, n = 666) and cough (58%, n = 565). Lymphopenia, elevated o-dimer, fibrinogen and ferritin levels were the most frequent biological abnormalities observed at ICU admission. Most patients underwent CT scan (76%, n = 740) and/or PCR testing (98%, n = 944) for SARS-CoV-2 infection diagnosis (Table 2).

3.1. Microbiology

Microbiological samples were obtained from 963 (97%) patients with 96% of lower respiratory tract samples. For 857 (92%) patients, SARS-CoV-2 infections were proven by RT-PCR (Table 3). For 79 (3%) patients, bacterial co-infection was diagnosed, and during ICU stay, 342 (43%) patients developed ventilator-associated pneumonia (VAP).

3.2. COVID-19 management

Respiratory, haemodynamic and therapeutic COVID-19 initial management are presented in Table 4. More than half of the included patients received mechanical ventilation on ICU admission. For non-intubated patients on admission, median time to intubation and mechanical ventilation was 2 [1–3] days. Overall,
Table 1
Characteristics of COVID-19 patients admitted to ICU.

|                               | Survivors (n = 793) | Non-survivors (n = 173) | All (n = 966) | p-value   |
|-------------------------------|---------------------|-------------------------|---------------|-----------|
| Age, years (n = 966)          |                     |                         |               |           |
| 50–59 years                   | 157 [20%]           | 25 [15%]                | 182 [19%]     |           |
| 60–69 years                   | 278 [35%]           | 47 [27%]                | 325 [34%]     |           |
| 70–79 years                   | 218 [28%]           | 61 [35%]                | 279 [29%]     |           |
| > 80 years                    | 45 [6%]             | 33 [19%]                | 78 [8%]       |           |
| Sex, male (n = 966)           |                     |                         |               |           |
| < 50 years                    | 95 [12%]            | 7 [4%]                  | 102 [11%]     | < 0.0001  |
| Weight, kg (n = 955)          | 85 [74; 97]         | 86 [73; 99]             | 85 [74; 97]   | 0.5119    |
| Body Mass Index, kg.m⁻² (n = 931) | 28.4 [25.2; 32.1] | 29.4 [26.0; 34.2]       | 28.7 [25.2; 32.6] | 0.0523    |
| BMI > 30, kg.m⁻²              | 305 [40%]           | 74 [46%]                | 379 [41%]     | 0.1390    |
| BMI > 40, kg.m⁻²              | 42 [6%]             | 14 [9%]                 | 56 [6%]       | 0.1167    |
| Settings (n = 962)            |                     |                         |               |           |
| Home or emergency department  | 370 [47%]           | 83 [48%]                | 453 [47%]     | 0.3533    |
| Long term care facility       | 6 [1%]              | 2 [1%]                  | 8 [1%]        |           |
| Ward                          | 217 [28%]           | 47 [27%]                | 264 [27%]     |           |
| Transfer from another hospital| 144 [15%]           | 30 [17%]                | 144 [15%]     |           |
| Transfer from another ICU     | 83 [11%]            | 10 [6%]                 | 93 [10%]      |           |
| SAPS II score [15] (n = 957)  | 36 [27; 46]         | 45 [38; 60]             | 37 [29; 48]   | < 0.0001  |
| SOFA score [16] (n = 960)     | 4 [2; 7]            | 7 [4; 9]                | 4 [2; 8]      | < 0.0001  |
| Underlying conditions         |                     |                         |               |           |
| Arterial hypertension (n = 965)| 394 [50%]          | 104 [61%]               | 498 [52%]     | 0.0103    |
| Chronic cardiovascular disease (n = 965) | 439 [55%] | 118 [60%] | 557 [58%] | 0.0014 |
| Diabetes (n = 966)            | 240 [30%]           | 57 [33%]                | 297 [31%]     | 0.4883    |
| Ischaemic heart disease (n = 964) | 65 [8%]            | 18 [11%]                | 83 [9%]       | 0.3246    |
| Chronic heart failure (n = 960) | 25 [3%]           | 18 [11%]                | 43 [5%]       | < 0.0001  |
| Immunosuppression (n = 965)   | 34 [4%]             | 9 [5%]                  | 43 [4%]       | 0.5861    |
| COPD (n = 966)                | 138 [17%]           | 43 [25%]                | 181 [19%]     | 0.0228    |
| Chronic kidney failure (n = 966) | 48 [6%]            | 30 [17%]                | 78 [8%]       | < 0.0001  |
| Cancer (n = 966)              | 70 [9%]             | 31 [18%]                | 101 [10%]     | 0.0004    |
| Charlson score [14] (n = 966)  | 1 [0; 2]            | 2 [1; 4]                | 1 [0; 2]      | < 0.0001  |
| Recent travel (n = 957)       | 33 [4%]             | 8 [5%]                  | 41 [4%]       | 0.8072    |
| Previous medications (n = 966) |                     |                         |               |           |
| Use of angiotensin-receptor blockers | 137 [17%]      | 41 [24%]                | 178 [18%]     | 0.0483    |
| Use of ACE inhibitors         | 159 [20%]           | 41 [24%]                | 200 [21%]     | 0.2667    |
| Anticoagulants                | 53 [7%]             | 25 [14%]                | 78 [8%]       | 0.0007    |
| Antiplatelets                 | 162 [20%]           | 47 [27%]                | 209 [22%]     | 0.0511    |

For continuous variables mean ± standard deviation or median [interquartile-range] are given. For categorical variables, numbers (%) are given. BMI: body mass index. SOFA: Simplified Acute Physiology Score. COPD: Chronic Obstructive Pulmonary Disease. ACE: Angiotensin Converting Enzyme. ICU: Intensive Care Unit.

(a) Wilcoxon test, (b) Chi² test, (c) Student test.
721 (75%) patients were mechanically ventilated during their ICU stay. Four hundred and ninety-four (51%) received prone positioning at a median time of 2 [1–5] days post admission in the ICU. Two-thirds of patients required vasopressor support. Antiviral treatment was prescribed in 242 (25%) patients with lopinavir/ritonavir being the most common used antiviral therapy (Table 4). Among adjunctive therapies, corticosteroids were administered to 212 (22%) patients and hydroxychloroquine to 289 (30%) patients.

### 3.3. Patient outcomes

Overall 28-day mortality, ICU mortality and 7-day mortality were of 18% (173/966), 17% (166/966) and 8% (77/966), respectively. Twenty-eight-day mortality increased with the severity of hypoxaemia on admission (Fig. 2). Among deaths occurring in ICU, 78/166 (53%) were preceded by end-of-life decisions. The median (IQR) time from admission to death was 8 [4–16] days. Among the 793 patients alive at day 28, 250 (32%) patients were still hospitalised. Complications and organ support therapy are described in Table 5. Median time to renal replacement therapy (RRT) and extra corporeal membrane oxygenation (ECMO) support were 5.5 [3–9] days and 5 [0–8] days post ICU admission. Multivariate analysis identified age, chronic kidney failure, chronic heart failure, SOFA score and PaO$_2$/FiO$_2$ at admission as independent risk factors of death at day 28 (Table 6). After adjustment on admission characteristics, antiviral therapy use was significantly associated with a lower risk of death at day 28. Sensitivity analyses confirmed these findings.

### 4. Discussion

#### 4.1. Key findings

This large multicentre observational French cohort reports the initial management of 966 severe COVID-19 patients admitted to ICU over 4 months with complete data on 28-day outcome. The overall 28-day mortality was 18% with age, pre-existing comorbidity...
may partially explain the differences observed in rates of mechanical ventilation in COVID-19 patients with similar median severity scores and similar severity of acute respiratory failure on admission. Although most of patients presented severe hypoxaemia on admission in the present cohort, intubation was not performed in half of cases. Some authors found a beneficial effect of early initial intubation after HFNC, whereas a recent meta-analysis suggested that timing of intubation might have no effect on critically ill COVID-19 patients’ outcome [22,23]. Thus, the optimal timing for intubation in critically ill COVID-19 patients remains uncertain [24]. Performing unnecessary intubation in patients who may have improved without invasive MV can be detrimental, especially in medical resource-limited settings. A recently published cohort of 13,301 Brazilian critically ill patients found that non-invasive respiratory support was associated with improved outcome at day 60 but causal inference remains uncertain due to the observational nature of this study [25]. Additionally, early intubation itself may contribute to ventilator-associated pneumonia (VAP) risk in COVID-19 patients, and consequently had some negative impact on clinical outcomes.

The high rate (43%) of VAP in our cohort is similar to the rate reported in the coVAPid study showing that ventilator-associated lower respiratory tract infections incidence was significantly higher in SARS-CoV-2 patients (36.1%), as compared to influenza patients (22.2%) or patients with no viral infection (16.5%) [26]. Several hypotheses have been formulated to explain the higher rate of secondary infections observed in critically ill COVID-19 patients, such as the use of immunosuppressive agents, the longer duration of mechanical ventilation and the severity of endothelial injury that may promote lung infection [26].

As previously reported, the most common comorbidities found in COVID-19 patients admitted to ICU were arterial hypertension, chronic cardiovascular disease, diabetes and obesity [8,10,27]. Among these comorbidities, chronic heart and kidney failures were associated with 28-day mortality in the present study. The 28-day mortality rate in the present cohort is lower than first published cohorts of critically ill COVID-19 patients with similar median severity score and median age on admission but in line with most recently published cohorts on the same study period [10,25]. The mortality rates reported in the literature widely vary and could be potentially related to rationing of resources in overwhelmed ICUs, differences in respiratory and therapeutic interventions or cohorts reporting incomplete follow-up [28]. The lower mortality rate reported in our cohort could be partially explained by an increased use of corticosteroids compared to the COVID-ICU cohort [20]. Even though this factor was not associated with 28-day mortality in our cohort, the beneficial impact of corticosteroids in severe COVID-19 pneumonia has been demonstrated in a large randomised controlled trial and further confirmed in a meta-analysis [6,29]. At the time of the present study data collection, benefits of corticosteroids were not clearly demonstrated.

Interestingly, after adjusting on patient characteristics on admission, receiving an antiviral treatment was an independent protective factor for 28-day mortality. At the time of enrolment in the study, lopinavir/ritonavir was the most common antiviral therapy used. However, lopinavir/ritonavir alone was not significantly associated with 28-day mortality when this variable was tested in the model. To date, no antiviral therapy has confirmed its efficiency in COVID-19 patients. Due to the observational nature of this study, some residual confounders may play a role in the association between antiviral treatment and outcome so that this association should be interpreted with caution. Finally, severe hypoxaemia (PaO₂/FiO₂ < 100) on admission and age > 70 years have been identified as prognostic factors in the present cohort. Elderly COVID-19 patients have much more severe disease and

### Table 3

Infection-related data from COVID-19 patients admitted to ICU (n = 966).

| BAL | RT-PCR | Rapid Diagnostic Testing | Unknown |
|-----|--------|--------------------------|---------|
| Aspirates | Nasopharyngeal swab | SARS-CoV-2 Test (n = 944) | 4.2. challenged |
| 43 (5%) | 66 (7%) | 822 (88%) | 4.2. Relationship with previous literature |

**Blood cultures**
- Positive: 79 (3%)
- Negative: 80 (9%)

**Microbiological tests on admission (n = 966)**
- Positive: 963 (99.5%)
- Negative: 3 (0.5%)

**Respiratory samples**
- Positive: 318 (33%)
- Negative: 648 (67%)

**PCR Influenza A**
- Positive: 308 (32%)
- Negative: 2 (0.5%)

**PCR Influenza B**
- Positive: 303 (31%)

**Legionella urinary antigen**
- Positive: 8 (2%)
- Negative: 579 (98%)

**Pneumococcal urinary antigen**
- Positive: 425 (44%)
- Negative: 291 (29%)

**Microbiological tests during ICU stay (n = 966)**
- Positive: 550 (57%)
- Negative: 416 (43%)

**Viral PCR**
- Positive: 267 (28%)
- Negative: 699 (72%)

**RT-PCR**
- Positive: 926 (98%)
- Negative: 3 (0.3%)

**Relationship with previous literature**

The pandemic of COVID-19 has dramatically and rapidly challenged the global health care system in terms of hospital resources and patient care management. Reported rates of IMV may vary according to resources available among centres and experience. In this cohort, half of COVID-19 patients were intubated on admission ending to two-thirds of patients under IMV during their ICU stay in line with previous data from 4244 critically ill COVID-19 patients, showing a rate of 63% and 80% of patients mechanically ventilated on admission and during their ICU stay, respectively [20]. The rate of IMV was much higher (82–87%) in Italian and Spanish cohorts compared to reports from China (43%) [8–10]. The lack of experience in the treatment of patients with acute respiratory failure from a previously unknown viral agent and heterogeneity in recommendations might have had an effect on respiratory management of COVID-19 patients [21]. This
show poorer response to treatments than younger patients with reported 6-month mortality rate up to 72% [10,20,30,31]. Consequently, the level of care intensity should be discussed in older patients with severe respiratory failure.

5. Clinical implications

This study provides large outcome data and detailed treatment strategies to establish risk stratification for COVID-19 patients on admission. Identifying prognostic factors on admission such as severity of hypoxaemia, older age, cardiovascular and renal comorbidities may allow the early identification of patients infected with SARS-CoV-2 who are at the highest risk of death to guide initial management and optimise resource allocation. Compared to the reported wave, current critically ill COVID-19 management has evolved with corticosteroids becoming a key component of therapeutic strategy as well as HFNC that was first considered cautiously. In future pandemics, taking into account patient medical conditions and severity of hypoxaemia will help to determine the best therapeutic approach and guide patient admission to appropriate care settings.

6. Study limitations

This study has several limitations. First, due to the design of the study, the reasons determining therapeutic approaches (antiviral agents, corticosteroids) or adjunctive therapies (prone position) used were not analysable and the ventilatory strategy may not be representative of clinical practice in non-pandemic circumstances. Second, due to the critical moment of the pandemic and the limited...
Fig. 2. Kaplan-Meyer survival estimates during the 28 days following intensive care unit admission according to PaO₂/FI0₂ ratio in mmHg at admission. PaO₂: partial oxygen arterial blood pressure. FI0₂: fraction of inspired oxygen

Table 5
Clinical outcomes.

| Day-28 status | Alive (n = 793) | Dead (n = 173) | All (n = 966) | p-value |
|---------------|----------------|----------------|----------------|---------|
| SOFA score at day 7 (n = 828) | 4 [2–7] | 8 [5–12] | 4 [2–8] | < 0.0001 (a) |
| SOFA score at day 14 (n = 686) | 3 [0–6] | 7 [5–10] | 3 [1–7] | < 0.0001 (a) |
| Overall complications (n = 966) | 576 (73%) | 143 (83%) | 719 (74%) | 0.0002 (b) |
| Mechanical ventilation | 484 (61%) | 137 (79%) | 621 (64%) | < 0.0001 (b) |
| Vasopressor support | 342 (43%) | 69 (40%) | 411 (43%) | 0.4344 (b) |
| VAP/HAP | 15 (2%) | 8 (5%) | 23 (2%) | 0.0488 (d) |
| Myocarditis | 18 (2%) | 28 (16%) | 46 (5%) | < 0.0001 (b) |
| Cardiac arrest | 106 (13%) | 32 (19%) | 138 (14%) | 0.0806 (b) |
| Pulmonary embolism | 201 (25%) | 86 (50%) | 287 (30%) | < 0.0001 (b) |
| AKI | 63 (31%) | 7 (8%) | 70 (24%) | < 0.0001 (b) |
| AKIN 1 score [32] (n = 287) | 41 (20%) | 20 (24%) | 61 (21%) | < 0.0001 (b) |
| AKIN 2 score [32] (n = 287) | 97 (48%) | 58 (68%) | 155 (54%) | < 0.0001 (b) |
| RRT | 99 (13%) | 43 (25%) | 142 (15%) | < 0.0001 (b) |
| RRT mode (n = 136) | 19 (20%) | 14 (34%) | 33 (24%) | 0.2344 (b) |
| CVVH | 12 (13%) | 2 (5%) | 14 (10%) | < 0.0001 (b) |
| CVVHD | 35 (37%) | 13 (32%) | 48 (35%) | < 0.0001 (b) |
| CVVHD CI-Ca | 29 (31%) | 12 (29%) | 41 (30%) | < 0.0001 (b) |
| Duration to RRT (days) | 5 [3–10] | 6 [3–9] | 5 [3–9] | < 0.0001 (b) |
| ECMO (n = 966) | 43 (5%) | 20 (12%) | 63 (7%) | < 0.0001 (b) |
| Mode (n = 62) | 2 (5%) | 6 (30%) | 8 (13%) | < 0.0001 (b) |
| VA | 40 (95%) | 14 (70%) | 54 (87%) | < 0.0001 (b) |
| Duration to ECMO (days) (n = 63) | 5 [0–18] | 4 [0–15] | 5 [0–18] | 0.1088 (a) |
| Liver dysfunction | 46 (6%) | 15 (9%) | 61 (6%) | 0.1597 (b) |
| No complication | 263 (33%) | 19 (11%) | 282 (29%) | < 0.0001 (b) |

ICU: intensive care unit, LOS: length of stay, SOFA: Sequential Organ Failure Assessment, VAP/HAP: ventilator/healthcare-associated pneumonia, AKI: acute kidney injury, AKIN: acute kidney injury network, RRT: renal replacement therapy. CVVH: continuous veno-venous haemofiltration, CVVHD: continuous veno-venous haemodialysis, CVVHDF: continuous veno-venous haemodiafiltration. ECMO: Extra Corporeal Membrane Oxygenation. VA: venous-arterial. VV: Veno-venous.

For continuous variables median [interquartile-range] are given. For categorical variables, numbers (%) are given.

(a) Wilcoxon test, (b) Chi² test, (d) Fisher’s exact test.
resources to conduct research at that time, some variables have missing data and 400 critically ill COVID-19 patients admitted to participating ICUs could not be included and may differ from the study cohort in terms of outcome. However, our multivariable model included 908 (94%) patients of the cohort, which is higher than previously reported [20]. Third, as the participating ICUs were exclusively located in different French regions, these results may not be extrapolated to other countries. Still, this cohort provides an interesting national overview of the initial management of COVID-19 patients.

7. Conclusion

Severity of hypoxaemia, older age (> 70 years), cardiovascular and renal comorbidities are prognostic factors for COVID-19 patients. Identifying the determinants of outcomes of critically ill COVID-19 patients is crucial to optimise hospital and ICU resources and provide the appropriate intensity level of care.

Ethics approval and consent to participate

The study was approved by the “Comité de Protection des Personnes – Sud Méditerranée IV” (2020-A00797-32).

According to French law, written informed consent was waived due to the non-interventional design of the study. Patient or his/her surrogate decision-maker received an information letter prior to patient enrolment when possible.

Disclosure of interest

The authors declare that they have no competing interests.

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Authors’ contributions

CR and BA contributed to study design, data collection, data analysis and drafting the manuscript. LM and JYL contributed to study design, data collection and data interpretation. OC, OAA, LT,
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